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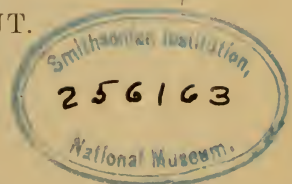
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ART. I.—*A new Harmonic Analyzer*; by A. A. MICHELSON
and S. W. STRATTON. (With Plate I.)

EVERY one who has had occasion to calculate or to construct graphically the resultant of a large number of simple harmonic motions has felt the need of some simple and fairly accurate machine which would save the considerable time and labor involved in such computations.

The principal difficulty in the realization of such a machine lies in the accumulation of errors involved in the process of addition. The only practical instrument which has yet been devised for effecting this addition is that of Lord Kelvin. In this instrument a flexible cord passes over a number of fixed and movable pulleys. If one end of the cord is fixed, the motion of the other end is equal to twice the sum of the motions of the movable pulleys. The range of the machine is however limited to a small number of elements on account of the stretch of the cord and its imperfect flexibility, so that with a considerable increase in the number of elements the accumulated errors due to these causes would soon neutralize the advantages of the increased number of terms in the series.

It occurred to one of us some years ago that the quantity to be operated upon might be varied almost indefinitely, and that most of the imperfections in existing machines might be practically eliminated. Among the methods which appeared most promising were addition of fluid pressures, elastic and other forces, and electric currents. Of these the simplest in practice is doubtless the addition of the forces of spiral springs.

The principle upon which the use of springs depends may be demonstrated as follows :

Let a (Fig. 1) = lever arm of small springs, s . (but one of which is shown in the fig.)

b = lever arm of large counter-spring, S .

l_0 = natural length of small springs.

L_0 = natural length of large springs.

$l+x$ = stretched length of small springs.

$L+y$ = stretched length of large springs.

e = constant of small springs.

E = constant of large springs.

n = number of small springs.

p = force due to one of the small springs.

P = force due to the large spring.

then
$$p = \frac{e}{l_0} (l+x - \frac{a}{b} y)$$

$$P = \frac{E}{L_0} (L+y)$$

$$a \sum p = b P.$$

whence

$$y = \frac{\sum x}{n \left(\frac{l}{L} + \frac{a}{b} \right)}$$

From this it follows that the resultant motion is proportional to the algebraic sum of the components, at least to the same order of accuracy as the increment of force of every spring is proportional to the increment of length.

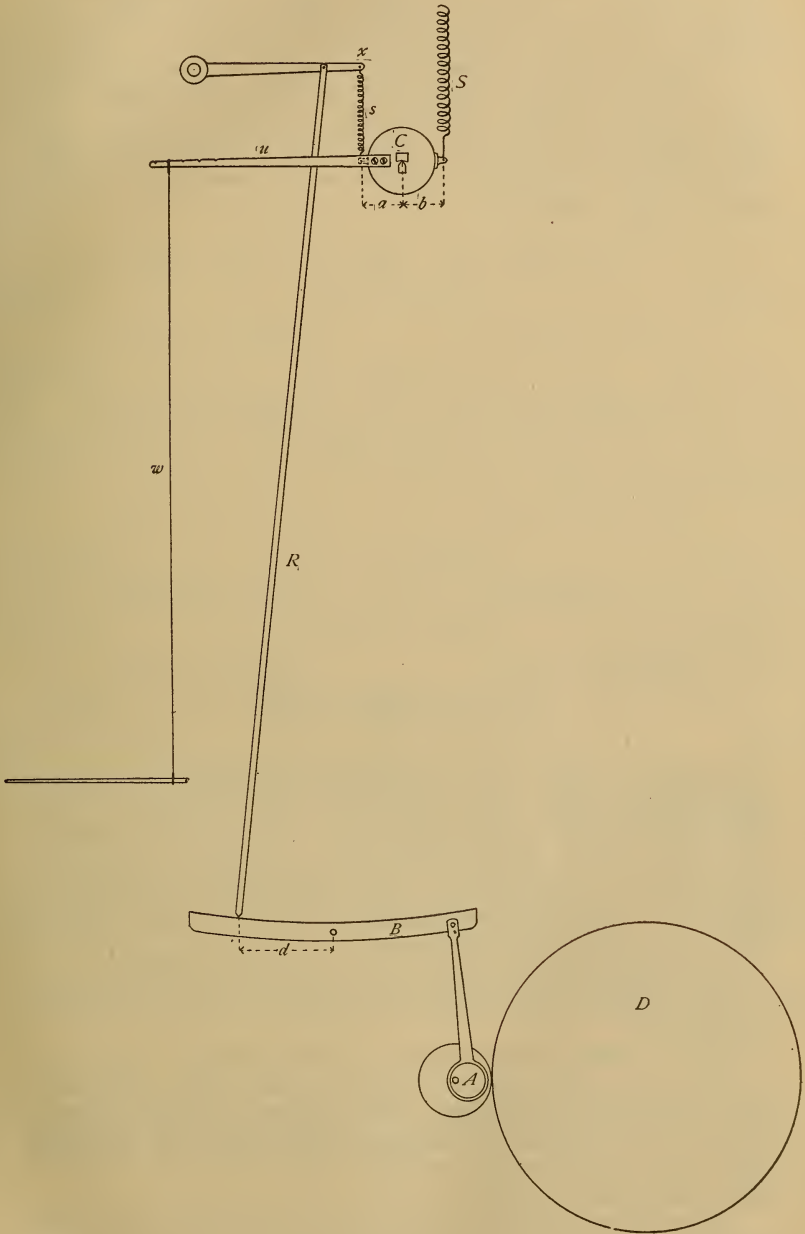
To obtain the greatest amplitude for a given number of elements, the ratios $\frac{l}{L}$ and $\frac{a}{b}$ should be as small as possible, but of course a limit is soon reached, when other considerations enter.

About a year ago a machine was constructed on this principle with twenty elements and the results obtained* were so encouraging that it was decided to apply to the Bache Fund for assistance in building the present machine of eighty elements.

Fig. 1 shows the essential parts of a single element. s is one of eighty small springs attached side by side to the lever C , which for greater rigidity has the form of a hollow cylinder, pivoted on knife edges at its axis. S is the large counter-spring. The harmonic motion produced by the excentric A , is communicated to x by the rod R and lever B , the amplitude of the motion at x depending on the adjustable distance d .

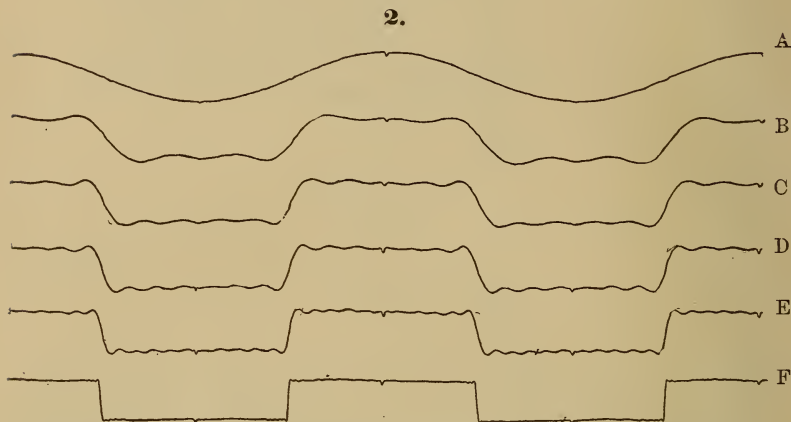
* Paper read before the National Academy of Science, April, 1897.

1.



The resultant motion is recorded by a pen connected with u by a fine wire w . Under the pen a slide moves with a speed proportional to the angular motion of the cone D . (Plate I.)

To represent the succession of terms of a Fourier series the excentrics have periods increasing in regular succession from one to eighty. This is accomplished by gearing to each excentric a wheel, the number of whose teeth is in the proper ratio. These last are all fastened together on the same axis and form the cone D . (Plate I.)



A, one term; B, five terms; C, nine terms; D, thirteen terms; E, twenty one terms; F, seventy-nine terms.

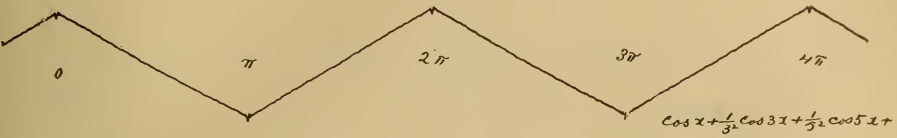
Turning the cone will produce at the points (x) motions corresponding to $\cos \theta$, $\cos 2\theta$, $\cos 3\theta$, etc., up to $\cos 80\theta$, and whose amplitudes depend on the distances d . The motion of the elements may also be changed from sine to cosine by disengaging the cone and turning all of the excentrics through 90° by means of a long pinion which can be thrown in gear with all of the excentric wheels at once.

The efficiency and accuracy of the machine is well illustrated in the summation of Fourier series shown in the accompanying figures.

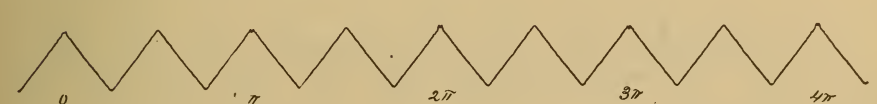
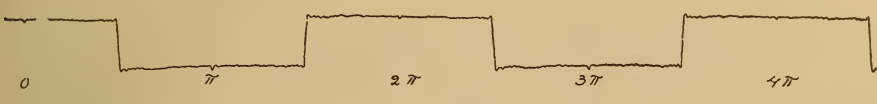
Figure 2 shows the dependence of the accuracy of a particular function on the number of terms of the series. Figures 3, 4, 5, 6 and 7 are illustrations of a number of standard forms, and 8, 9 and 10 illustrate the use of the machine in constructing curves representing functions which scarcely admit of other analytical expression.

The machine is capable not only of summing up any given trigonometrical series but can also perform the inverse process

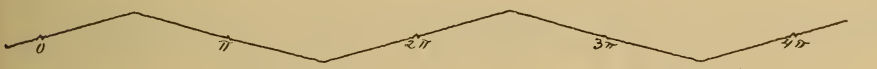
3.



$$\cos x + \frac{1}{32} \cos 3x + \frac{1}{52} \cos 5x + \dots$$

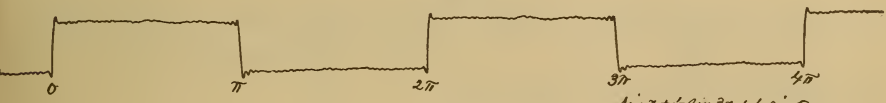


$$\cos 4x + \frac{1}{32} \cos 12x + \frac{1}{52} \cos 20x + \dots$$

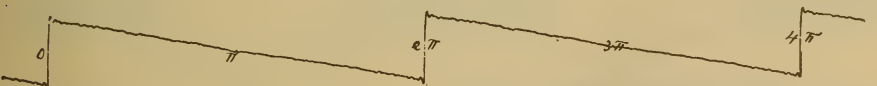


$$\sin x - \frac{1}{32} \sin 3x + \frac{1}{52} \sin 5x - \dots$$

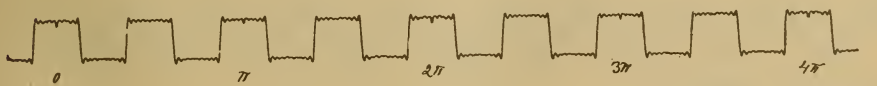
4.



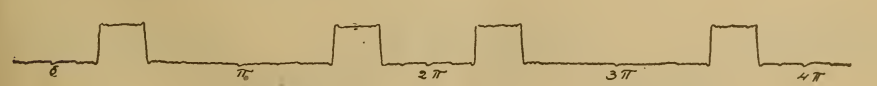
$$\sin x + \frac{1}{32} \sin 3x + \frac{1}{52} \sin 5x + \dots$$



$$\sin x + \frac{1}{2} \sin 3x + \frac{1}{3} \sin 5x + \dots$$

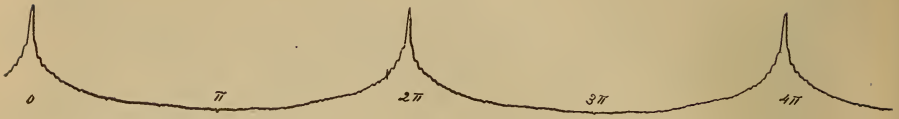


$$-\cos 4x - \frac{1}{32} \cos 12x + \frac{1}{52} \cos 20x + \dots$$

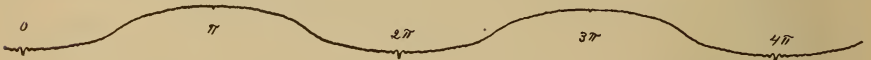


$$\sum_{n=1}^{\infty} (\sin \frac{1}{2} n\pi - \sin \frac{3}{4} n\pi) \frac{1}{n} \cos nx$$

5.



$$\cos x + \frac{1}{2} \cos 2x + \frac{1}{3} \cos 3x +$$



$$-\cos x + \frac{1}{3} \cos 3x - \frac{1}{5} \cos 5x +$$

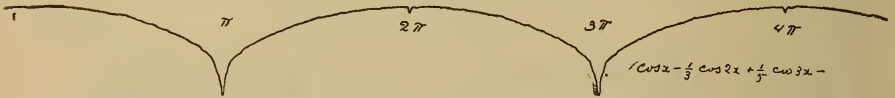


$$1 - \cos x + \frac{1}{3} \cos 2x +$$

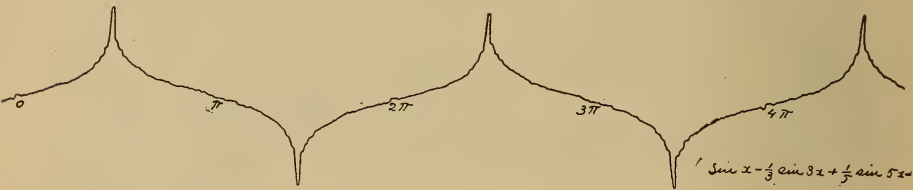


$$\cos x + \frac{1}{3} \cos 3x + \frac{1}{5} \cos 5x +$$

6.



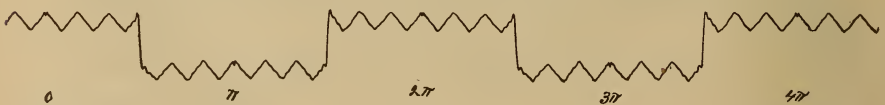
$$\cos x - \frac{1}{3} \cos 2x + \frac{1}{5} \cos 3x -$$



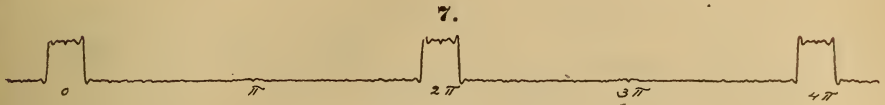
$$\sin x - \frac{1}{3} \sin 3x + \frac{1}{5} \sin 5x +$$



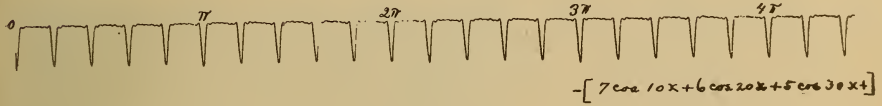
$$\cos 4x + \frac{1}{3} \cos 12x + \frac{1}{5} \cos 20x + \frac{1}{7} \cos 28x +$$



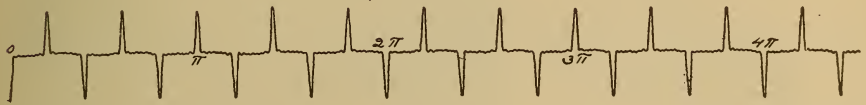
$$\cos x - \frac{1}{3} \cos 3x + \frac{1}{5} \cos 5x + \frac{1}{7} [\cos 12x + \frac{1}{3} \cos 36x +]$$



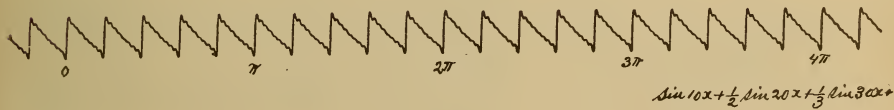
$$\sum \frac{\sin 2n\pi}{1n\pi} \cos 2nx.$$



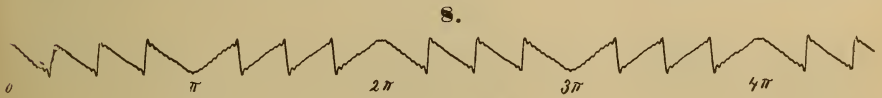
$$-[7 \cos 10x + 6 \cos 20x + 5 \cos 30x + \dots]$$



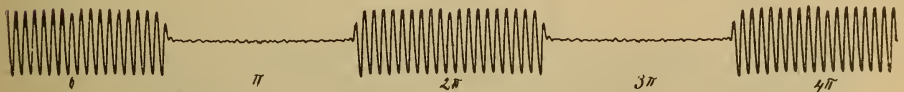
$$[8 \cos 5x + 7 \cos 15x + 6 \cos 25x + \dots]$$



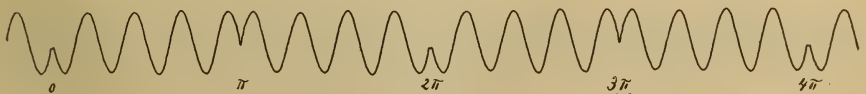
$$\sin 10x + \frac{1}{2} \sin 20x + \frac{1}{3} \sin 30x + \dots$$



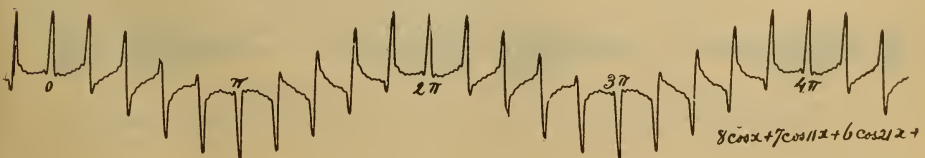
$$a_n = -\frac{1}{n} \left[\sin n \frac{\pi}{4} + 3 \sin 2n \frac{\pi}{4} + 5 \sin 3n \frac{\pi}{4} \right] + \frac{4}{n\pi} [1 - \cos n\pi]$$



$$1.5 \cos 40x + \left\{ \begin{array}{l} -\frac{1}{3} \cos 43x - \frac{1}{5} \cos 45x - \\ + \cos 39x - \frac{1}{3} \cos 37x + \frac{1}{5} \cos 35x - \end{array} \right\}$$

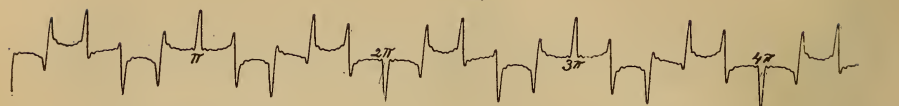


$$\sum \frac{\cos nx}{n^2-8} \text{ odd terms.}$$

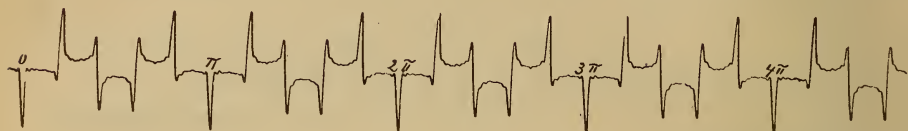


$$8 \cos 2x + 7 \cos 11x + 6 \cos 21x + \dots$$

9.



$$-[8\cos 3x + 7\cos 13x + 6\cos 23x +]$$



$$-[8\cos 4x + 7\cos 14x + 6\cos 24x +]$$

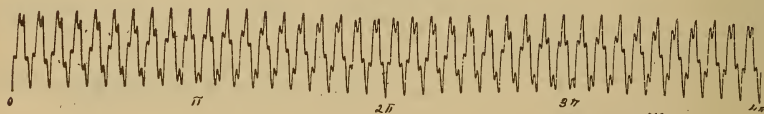


$$\cos x + 7\cos 2x + 4\cos 5x + 2\cos 8x + 1\cos 16x +$$

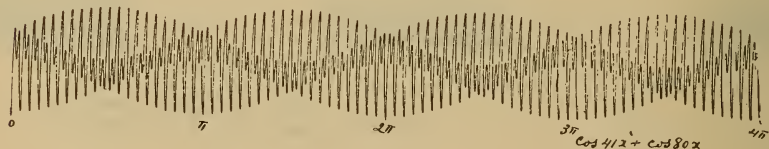


$$\cos x + 7\cos 2x + 4\cos 4x + 2\cos 8x + 1\cos 16x +$$

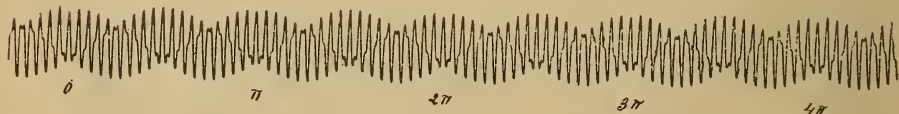
10.



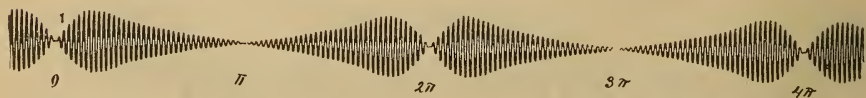
$$\cos 20x + \cos 77x$$



$$\cos 412x + \cos 80x$$



$$\cos 40x + \frac{1}{2}\cos 76x$$



$$\cos 74x + \frac{1}{2}\cos 73x +$$

$$-\cos 76x - \frac{1}{2}\cos 77x -$$

of finding for any given function the coefficients of the corresponding Fourier series.

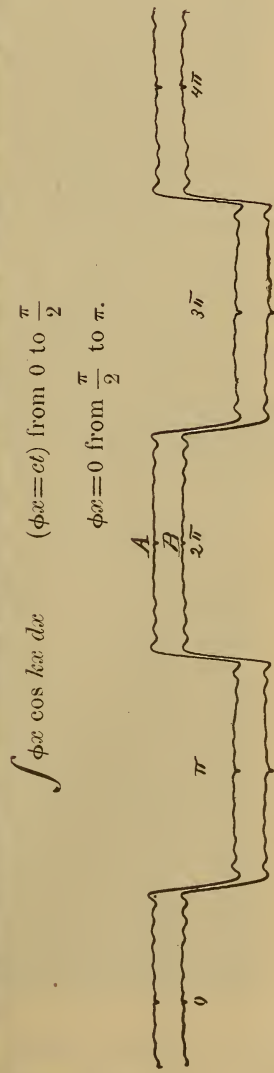
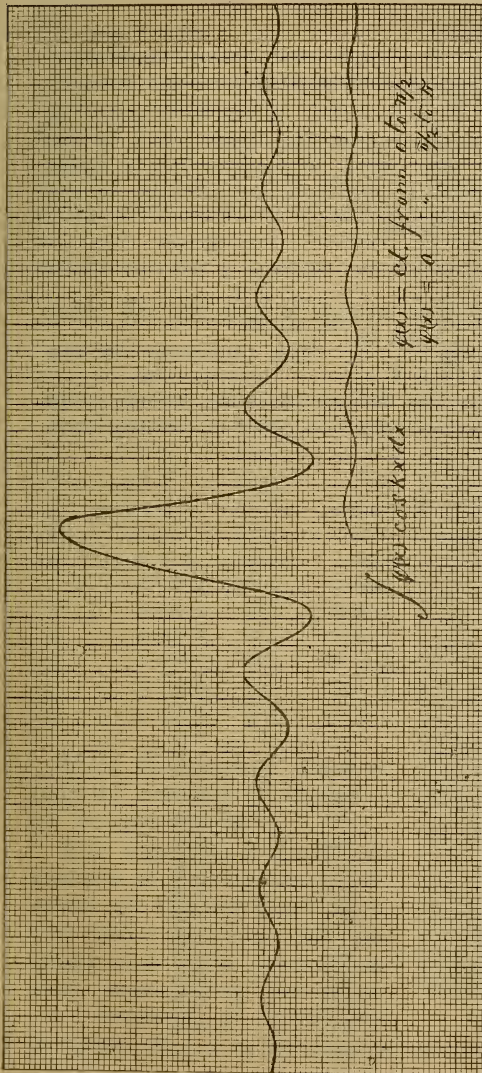
Thus if

$$f(x) = a_0 + a_1 \cos x + a_2 \cos 2x +$$

we have

$$a_k = \frac{2}{\pi} \int_0^{\pi} f(x) \cos kx \, dx$$

11.



A_1 is calculated curve for 25 terms.
 B_1 is observed " " " "

On the other hand, if n is the number of an element of the machine and a the distance between any two elements, and the

amplitude d (fig. 1) is proportional to $f(na)$, the machine gives

$$\sum_0^m f(na) \cos n\theta = \sum_0^m f(x) \cos \frac{m}{\pi} \theta x$$

which is proportional to a_k if $k = \frac{m}{\pi} \theta$. Hence to obtain the integral, the lower ends of the vertical rods R (Plate I) are moved along the levers B to distances proportional to the ordinates of the curve $y = f(na)$.

The curve thus obtained for a_k is a *continuous* function of k which approximates to the value of the integral as the number of elements increases. To obtain the values corresponding to the coefficients of the Fourier series, the angle $\theta = \pi$, or the corresponding distance on the curve, is divided into m equal parts. The required coefficients are then proportional to the ordinates erected at these divisions.

Figure 11 gives the approximate value of $\int \varphi(x) \cos kx \, dx$ when $\varphi(x) = \text{constant}$ from 0 to a , and is zero for all other values. The exact integral is $\frac{\sin ka}{k}$. The accuracy of the approximation is shown by the following table, which gives the observed and the calculated values of the first twenty coefficients for $a = 4.0$.

$$\int_0^a \cos kx \, dx$$

n.	obs.	calc.	Δ
0	100.0	100.0	0.0
1	65.0	64.0	1.0
2	0.0	0.0	0.0
3	-20.0	-21.0	1.0
4	0.0	0.0	0.0
5	12.5	13.0	-0.5
6	-1.5	0.0	-1.5
7	-9.0	-9.0	0.0
8	0.0	0.0	0.0
9	6.0	7.0	-1.0
10	0.0	0.0	-2.0
11	-6.0	-6.0	0.0
12	0.0	0.0	-0.0
13	4.0	5.0	-1.0
14	-2.0	0.0	-2.0
15	-4.0	4.5	0.5
16	0.5	0.0	0.5
17	8.5	4.0	-0.5
18	-1.0	0.0	-1.0
19	-3.5	-3.0	0.5
20	0.0	0.0	0.0

The average error is only 0.65 of one per cent. of the value of the greatest term.

The accuracy of the result is also shown in curves A and B (fig. 11). The former gives the summation of the calculated terms and the latter of the observed.

Another illustration is given in figure 12 in which

$$\varphi(x) = e^{-a^2 x^2}$$

For $a=1$ the following are the values of the coefficients of the first twelve terms of the equivalent Fourier series.

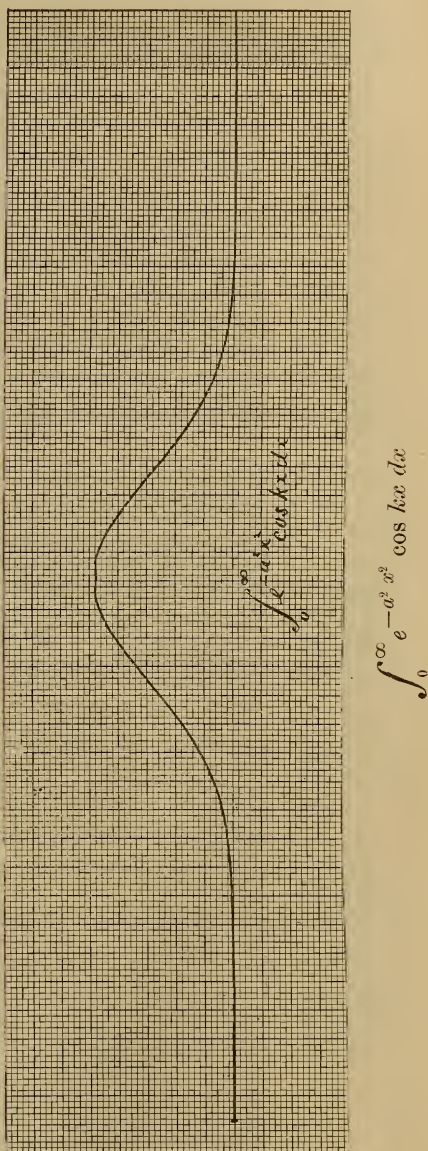
n.	obs.	calc.	Δ
0	100.0	100.0	0.0
1	95.0	96.0	-1.0
2	85.0	86.0	-1.0
3	70.0	70.0	0.0
4	53.0	54.0	-1.0
5	38.0	38.0	0.0
6	25.0	25.0	0.0
7	16.0	15.0	1.0
8	8.8	8.0	-0.8
9	5.0	4.5	0.5
10	3.6	2.0	1.6
11	2.4	1.0	1.4
12	1.6	0.5	1.1

Here the average error is only 0.7 per cent of the value of the greatest term.

The complete cycle of operations of finding the coefficients of the complete Fourier series (sines and cosines) and their recombination, reproducing the original function, is illustrated in figure 13.

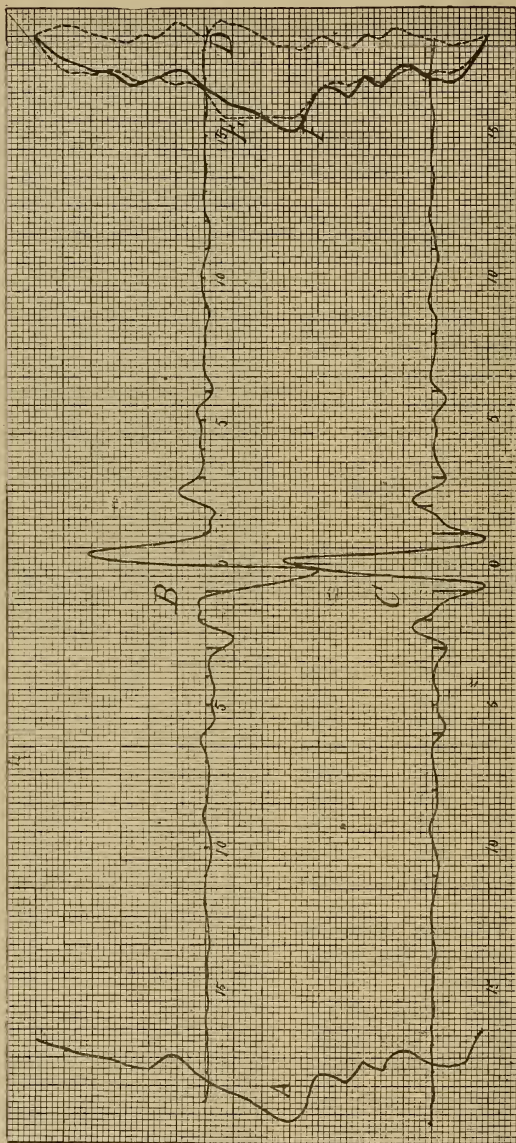
A is the original curve. B and C are the values of $\int \varphi(x) \sin kx dx$ and $\int \varphi(x) \cos kx dx$ respectively. Their in-

12.



13.

$$\begin{aligned}
 F = \phi(x) = & 15 \sin \theta - 75 \cos \theta & -2 \sin 11 \theta - 10 \cos 11 \theta & F = \phi(x) = & -8 \sin 6 \theta - 18 \cos 6 \theta & -2 \sin 16 \theta - 1 \cos 16 \theta \\
 & -10 \sin 2 \theta + 21 \cos 2 \theta & -5 \sin 12 \theta + 1 \cos 12 \theta & & + 4 \sin 7 \theta - 1 \cos 7 \theta & + 1 \sin 17 \theta + 0 \cos 17 \theta \\
 & + 20 \sin 3 \theta - 24 \cos 3 \theta & + 4 \sin 13 \theta + 0 \cos 13 \theta & & + 2 \sin 8 \theta - 8 \cos 8 \theta & + 3 \sin 18 \theta + 3 \cos 18 \theta \\
 & + 8 \sin 4 \theta - 3 \cos 4 \theta & + 0 \sin 14 \theta + 0 \cos 14 \theta & & - 5 \sin 9 \theta + 1 \cos 9 \theta & - 2 \sin 19 \theta + 0 \cos 19 \theta \\
 & + 10 \sin 5 \theta - 8 \cos 5 \theta & + 1 \sin 15 \theta + 0 \cos 15 \theta & & + 6 \sin 10 \theta - 2 \cos 10 \theta & + 0 \sin 20 \theta + 0 \cos 20 \theta
 \end{aligned}$$



$$\begin{aligned}
 A &= \phi(x) & B &= \int \phi(x) \sin kx \, dx & C &= \int \phi(x) \cos kx \, dx \\
 D &= \sum_0^{20} B \sin n\theta & E &= \sum_0^{20} C \cos n\theta & F &= D + E
 \end{aligned}$$

tersections with the ordinates midway between the heavier ordinates, give the coefficients of the sine and cosine series respectively. The sums of the first twenty terms are represented by the curves *D* and *E*, and finally the sum of these two curves produces the curve *F*, which agrees sufficiently well with the original to be easily recognizable.

It appears, therefore, that the machine is capable of effecting the integration $\int \varphi(x) \cos kx \, dx$ with an accuracy comparable with that of other integrating machines; and while it is scarcely hoped that it will be used for this purpose where great accuracy is required, it certainly saves an enormous amount of labor in cases where an error of one or two per cent is unimportant.

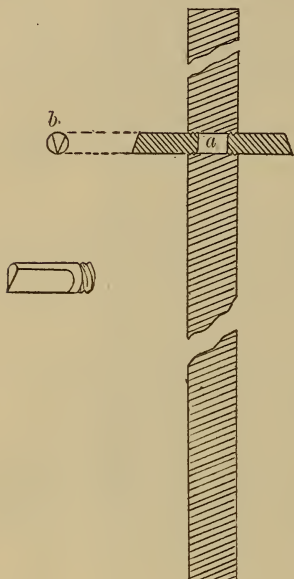
The experience gained in the construction of the present machine shows that it would be quite feasible to increase the number of elements to several hundred or even to a thousand with a proportional increase in the accuracy of the integrations.

Finally it is well to note that the principle of summation here employed is so general that it may be used for series of any function by giving to the points (*p*) the motions corresponding to the required functions, instead of the simple harmonic motion furnished by the excentrics. A simple method of effecting this change would be to cut metal templates of the required forms, mounting them on a common axis. In fact the harmonic motion of the original machine was thus produced.

Ryerson Physical Laboratory, University of Chicago.

ART. II. — *A New Form of Physical Pendulum;* by
JAMES S. STEVENS.

IN the determination of g by the common form of physical pendulum an error is introduced on account of the fact that the knife-edges and clamp affect the moment of inertia and the center of gravity of the pendulum, and in consequence the period. A form of pendulum in which these errors are eliminated has been found satisfactory in my laboratory work. A hole was bored through a brass cylindrical rod, about 8 cms. from one end. The knife-edges for the support of the pendulum were screwed a little way into the hole, and their mass adjusted so that they offset the mass of the brass bored out. This is represented at a in the sketch. In this manner the center of gravity of the system remains at the position of the center of gravity of the original bar.



The source of error would be entirely removed if the center of oscillation of the triangular knife-edges were in the same horizontal plane as that of the removed cylinder. If

we call the radius of the cylinder r , the distance of the center of oscillation to the point of suspension is in the case of the triangle $\frac{5}{4}r$, and in the case of the cylinder $\frac{3}{2}r$. Allowing for the relative densities of the steel and brass, the knife-edges may be so constructed and inserted that this result may be brought about. If, however, this error is neglected, the effect will be a raising of the center of oscillation in the region from which the brass has been removed, of $\frac{1}{4}r$.

In the pendulum used r is about one-half a centimeter. The bar is one meter long and therefore the true length of the pendulum may be taken as approximately sixty-two centimeters. Therefore the error in g due to the error under consideration would not exceed 0.03 cm. This is of an order more precise than is usually obtained by any method of finding g in the laboratory.

ART. III.—*The Protostegan Plastron*; by GEORGE R. WIELAND. (With Plate II.)

OWING to the fact that the bones of the plastron of the turtles from the older formations are usually fragile and are made up of many parts, we have but few restorations of this portion of the testudinate skeleton from pre-Tertiary species. And so far as the gigantic turtles of the American Cretaceous are concerned we lack a complete restoration entirely, though Hay has given a partial restoration of *Protostega gigas* Cope.*

The present contribution may in some degree fill up this gap. It is based on two specimens of the turtle closely related to *Protostega*, which I have described as *Archelon ischyros*,* both of which I collected near the Cheyenne River in South Dakota from the very uppermost Fort Pierre Cretaceous.

As these plastras, though fairly well preserved, were broken into hundreds of pieces while yet in place, it has not been thought advisable to indicate fractures. Nor has it been deemed necessary to indicate in the illustrations that the external spines of the left hypo- and hypo-plastron have been in part determined from those of the corresponding elements of the right side. The fact that all the figures given are from a single specimen, as confirmed by a second, adds to their value.

General Description.

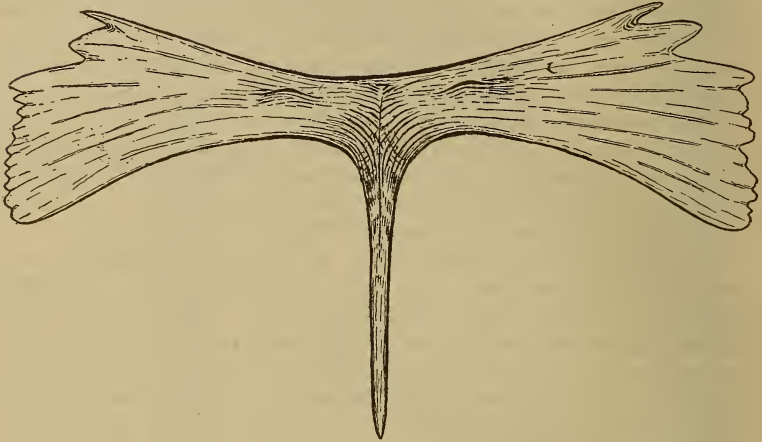
The Entepiplastron (see measurements, p. 19).—The most striking feature of the protostegan plastron is the distinct fusion or lack of separation of the three anterior plastral elements,—that is, of the entroplastron and the two epiplastra. This single element is a feature hitherto unobserved in the Testudinata and may be described as the *entepiplastron* or *paraplastron*. It is a rather heavy and a very shapely bilaterally symmetrical T-shaped bone, gracefully curving outward into two broad alæ which slowly thin out to no more than the thickness of cardboard along their posterior edges. Anteriorly the edge is rounded except in the central portions, where there is a distinct downward and outward-looking external chamfer. At each forward extremity of the alæ there is one distinct spine followed by a second which is flat and thin. The remainder of the outer edge tends toward termination in thin spines. While the outer surface is somewhat convex in general relief, the inner is slightly concave and flat except for two lateral longitudinal bosses about six centimeters long, one centimeter high and twenty centimeters apart, anterior to which are

* Field Columbian Museum Publication 7, Chicago.

† See this Journal for December, 1896.

small furrows. The long medial posterior or entoplastral process is, however, distinctly triangular for the first third of its length, and for the remainder quite round. The entire surface of this bone is striated like the remainder of the plastron, and not like the carapace.

1.



Entoplastron. Upper or internal side. One-tenth natural size.

That we have in this bone a true plastral element was decided from the following reasons and facts:

1. Its size and particularly its form will permit the supposition that it represents the entoplastron and epiplastra.

2. There is the possibility that the epiplastra or their homologue could lie athwart the anterior extension of the hyoplastræ, as is distinctly the tendency in *Sphargis*.

3. I have twice seen this bone in place, and each time it rested directly upon the anterior portions of the hyoplastra and beneath numerous other skeletal parts, while the angular edge of the entoplastral process faced upwards, and therefore inwards as would be expected. Rounded edges and flat faces would probably be exterior.

4. The chances were in favor of the preservation of other plastral elements, rather than of such a free nuchal as this bone would have constituted, had they existed. Especially was this the case in specimen No. II, where the anterior parts were quite undisturbed.

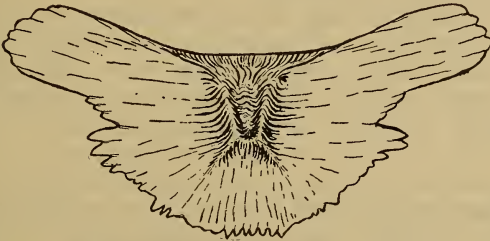
5. There is no process for articulation with the last cervical vertebra as in all living marine testudines.

6. Were this bone to be regarded as the nuchal, and the remainder of the plastron then to be added to proportionally for

anterior plastral elements as in *Tholassocheilus*, etc., the plastron would probably have had a greater length than the carapace.

7. There is an element which I figure and think must be the nuchal. It resembles markedly the nuchal of *Sphargis* and corresponds closely to the bone which Cope believed to be the nuchal of *Protostega gigas*, (Cretaceous Vertebrata of the West, plate XII, fig. 11.) The figure and description is given herewith. The *nuchal* (see meas.) is a flat fan-shaped bone distinctly incurved anteriorly, and spreading out into two broad alæ projecting well forward. These must have con-

2.



Nuchal. Under or internal side. One-tenth natural size.

nected with the marginalia, the anterior pair of which were quite thin, fragments having been recovered. It should be remarked that the thickness laterally and also of the thin posterior fan, the edge of which is slightly notched as if for sutural union with the first neural, as well as striation, all favor the nuchal position for this bone. The latter is especially true of a small dorsal pitting from which radiate several distinct surface striations corresponding to those radiating from the median neural groove* of the carapace. The inferior side is marked by a prominent centrally-placed elevation two centimeters in height, having the shape of an isosceles trapezoid distinctly buttressed at the four corners. The long and anterior base of this trapezoidal ridge has twice the length of the shorter, and a slight central elevation is enclosed. This elevation must have formed a surface for articulation with the last cervical vertebra. This element evidently formed no part of the plastron, and as I have previously described the pygal I can suggest no other than the nuchal position. (See Figure 2.)

Hay, in his publication previously mentioned, figures a portion of the entepiplastron which he says must be regarded as the nuchal. He mentions the grooves of the [upper] surface as internal, that is, facing downward, and presumably representing contact with transverse processes of the last cervical

* See description of carapace, this Journal, Dec. 1896, page 400.

vertebra. But, whether or not it shall transpire that my contention is correct, it must be borne in mind that these markings *faced upwards*. If this element had been the nuchal, whence came they? They were never in contact with any vertebral processes unless such projected downwards.

The Hyoplastron (see measurement).—This element of the plastron is traversed by and marks the end of a continuous heavy ridge beginning with the heavy outer edge of the comparatively narrow xiphiplastron and continuing through the hypoplastron. Considered in its general outline, this ridge strongly suggests the beginning of a reduction resulting in a plastron like that of *Sphargis*.

From its central ridge the hyoplastron, which is broadly elliptical in general outline with the exception of the large brachial notch, grows steadily thinner on both sides until it consists simply of flat ridges marking the emergence of the spines which beset it on every side except the brachial, the edges being no thicker than cardboard.

These spines narrow and thicken toward their middle portions. Those of the inner edge may be roughly divided into an anterior, a medial and a posterior group. The spines of the anterior group, seven to nine in number, are very heavy and rather short and incline to or are distinctly triangular in section with the flat surface beneath. Those of the medial group, six in number, are very long and slender. For their last third they are crescentic in cross section, the concave faces facing in pairs. The last or inferior group consists of rather flat spines. There are nineteen spines in all on the right interior and twenty-one on the left. Where two take the place of one the general symmetry is preserved by a diminution in size.

On the outer edge following the brachial angle there are three broad, heavy and rather short spines, followed by three longer and more slender; the remainder of the outer hyoplastral series being rather broad and flat.

There is absolutely no marginal or surface marking whatsoever suggesting contact with an *epiplastron*. (See Plate II.)

The Hypoplastron (see measurements).—This bone strongly resembles the hyoplastron in general appearance, though the spines are more numerous and less divided into regions, with the exception of the two long posterior extensions which receive the xiphiplastron between them. The right and left inner series overlap considerably. Inner series of spines, right side, 20; left, 17; outer series, 17 in number.

The Xiphiplastron (see measurements).—Except for the slightly dactylated connection between the posterior ends of the xiphiplastrals there are no spiny processes. The outer edge

thickens into a rounded and heavy ridge previously mentioned, while the inner edge thins out as it passes beneath the posterior extension of the hypoplastron. Anteriorly there are two lateral grooves for the reception of the two posterior hypoplastral continuations. This dovetailing makes a very firm joint between these two elements.

Concluding Remarks.—From the further study involved in the reconstruction given herewith I conclude that the genus *Archelon* which I have proposed is unnecessary. *Archelon ischyros* therefore becomes *Protostega ischyra*. Certain differences I pointed out in the processes of the humerus and procoracoscapular together with unusually robust form and increase of size are of distinct specific but not generic value. I may mention that Cope represented the ribs of *Protostega* as free and that Hay with additional material considered this possible. The rib expansions unquestionably united in *gigas* by suture as in *ischyra*, as Professor Cope has since assured me must have been the case.

Cope regarded *Protostega* as the type of a new family which he did not name, but with the idea that the plastral elements were dorsal—an error much more easily made than one might at first think—especially since some of the marginalia do actually develop into thin dorsal spine set extensions.

Of the generic and family relations of these important forms I shall have more to say at a subsequent time.

MEASUREMENTS.

The Entepiplastron.

	M.
Extreme length (lateral)	·94
Antero-posterior length	·45 ±
Greatest breadth of alæ	·28
Least breadth of alæ	·10
Least circumference of alæ	·21
Thickness at least circumference	·05
Greatest thickness in medial line	·06
Length of entoplastral process	·36 ±

The Hyoplastron.

Greatest antero-posterior length inclusive of spines ...	1·03 ±
Greatest oblique length inclusive of spines	1·20 ±
Greatest width inclusive of spines	1·10 ±
Greatest antero posterior length exclusive of spines ..	·92
Greatest width exclusive of spines	·70
Greatest thickness	·048
Length of interior spines	·15—·25
Length of exterior spines	·15—·20

The Hypoplastron.

Greatest length inclusive of spines.....	1.00
Greatest width inclusive of spines.....	1.00±
Greatest length exclusive of the posterior extension..	.65
Greatest width exclusive of spines.....	.65
Greatest thickness.....	.041
Length of interior spines.....	.15—.25
Length of exterior spines.....	.10—.20

The Xiphiplastron.

Greatest length.....	.50
Greatest width.....	.17
Greatest thickness.....	.036
Thickness near terminus.....	.025

The Plastron.

Total width across the hypoplastron.....	2.00+
Total width across the hypoplastron.....	1.86
Total length.....	2.00+

The Nuchal.

Greatest lateral width.....	.64
Antero-posterior length.....	.25
Elevation of articulating surface for the last cervical vertebra.....	.02
Greatest thickness including the process for the cer- vical.....	.035
Width of alæ.....	.09
Thickness of alæ.....	.01—.015

Chester, Pa., Dec. 11, 1897.

ART. IV.—*The Granitic Breccias of the Cripple Creek Region*; by GEORGE H. STONE.

IN his report on the geology of Cripple Creek* Mr. Whitman Cross has devoted considerable space to the fragmental volcanic rocks of the district. In the present paper I wish to record some additional facts as to the dike phenomena of the region in question, the result of observations made in the years 1894-97. The following named dikes include only the more typical localities. They have been purposely selected from outside the central volcanic district, where they are in the midst of granites and the older crystalline rocks. In such situations the dikes are isolated and it is easy to distinguish their deposits from other volcanic matter.

Tuffs and breccias composed chiefly of volcanic rock, sometimes with an admixture of older rocks, have long been known. They are well represented in the Cripple Creek district, and having been well described by the authors above cited, need not here be further mentioned. The fragmental rocks now to be described are remarkable for consisting of non-volcanic rocks. They are of a kind not before recognized, within my knowledge, as of volcanic origin. Their general characteristics are the following.

They are invariably found capping and bordering the outcrop of volcanic dikes, and in no other situations. My conclusion is that this relationship is causal. They consist of fragments of granites, schists, and others of the older rocks that are penetrated by the dikes. The fragments composing them vary in size from rock flour up to four feet or more in diameter, and all are more or less smoothed and rounded, often as much so as the stones on the ocean shore. When the granitic fragments are uncemented they are found at the sides of the dikes, where they overlies uneven surfaces of the granites and schists, proving that the country was already much dissected by erosion at the time of their deposition, and the same is true of all the granitic breccias; and in this case, if there is a breccia of volcanic rock accompanying the granitic gravel, it overlies the latter. When the granitic stones are cemented into a firm grit the positions are reversed; the upper portion of the grit consists wholly or almost wholly of granitic fragments, but as we go down in shafts we find an increasing amount of the volcanic rock mixed with the granitic, until we reach a dike or

* Geology and Mining Industries of the Cripple Creek District, Colorado. By Whitman Cross and R. A. F. Penrose, Jr. Extract from the Sixteenth Annual Report of the U. S. Geological Survey, 1895. See pp. 50, 60-64, 78, 81, 86, 88, 90, 92, 94, 95, 100.

a breccia composed of the fractured upper portion of a dike, and below this the dike. Sometimes in the granitic breccias we find kinds of rock which are known to be common as inclusions in the granite of the region (e. g. the Algonkian quartzite), but which do not on the surface appear in the granite near the dike. Some of the dikes in question reveal the dynamics of the process whereby the granitic grits were made. The same materials which in some cases we find as beds covering the steep slopes of the hills, in other cases are found beneath the surface between walls of granite but always capping volcanic dikes. My inference is that all have the same origin and consist of volcanic ejectamenta that were pushed up slowly and quietly by the dikes.

Some, perhaps most of the facts here recorded, have been revealed by mining operations since the exploration of the district by Messrs. Cross, Penrose, and Mathews.

At first glance one might suppose the granitic breccias are merely a matter of detail. In the sequel they are found to involve questions of stratigraphy, and therefore it becomes necessary to set forth the facts somewhat fully.

1. The case of a dike that did not reach the surface and did not move after solidification. Elevation 9300 feet.

Such a dike is revealed in the Arcadia workings on the Lone Star No. 1 claim, situated in Poverty Gulch, city of Cripple Creek. The 125 feet level shows a dike, much decomposed but probably phonolite, which is about three feet wide at the bottom of the drift. The dike rapidly tapers upward so as to end six feet higher in a rather sharp edge, though it sends out some stringers ten feet or more into the schists above, somewhat in saw-tooth fashion. The dike-rock solidified fast to the walls and still closely adheres to them, hence has never moved relative to the walls since solidification. Above the dike the schistose rock is broken by joints running in every direction, but none of these crevices appear to be predominant or the upward prolongation of the fissure occupied by the dike. The appearance is not as if the earth's crust was bodily broken by a fracture that started from a great depth and extended all the way to the surface instantaneously. The appearance is as if the fracture had been opened progressively by the lava itself as the agent. The lava ended above in a liquid wedge which sent out tongues into every crevice. Then as the liquid rose, according to the law of hydrostatic pressure, it pressed laterally so as progressively to wedge apart the walls, and open the way for the rising lava. Nowhere in the Cripple Creek region has any one discovered proof that the granites, schists, or even the older volcanic rocks, at any depths yet observed, were melted by contact with the liquid lava, though they are usually honey-

combed and more or less decomposed. We therefore cannot admit that the dike fissures were either opened or enlarged by the melting of the older rock and its absorption into the liquid lava.

2. The case of a dike whose upper extremity moved after solidification. Elevation 10,120 feet.

About a mile west of Gillett is a phonolite dike, a mile or more in length. It everywhere pitches to the west, but on the Ed. Wolcott claim, a few hundred feet northeast of the Lincoln mine, it dips less than the average, about 20° below the horizontal. In one of the shafts at a depth of about 30 feet, this dike is seen to be three feet thick and to be frozen fast to the adjacent granite, proving that at this depth there has been no motion of the dike since solidification. The dike is here crossed by cracks in various directions, but the sides of the blocks of fracture are not slickened. Near 50 feet eastward is another shaft which cuts through nine feet or so of somewhat shattered granite, there penetrates a bed of gravel consisting of broken phonolite, and then enters the granite again. The gravel bed dips toward the dike in the more western shaft and evidently is the same dike, but in a broken condition. Most of the pieces of phonolite are subangular in outline, and all are more or less smoothed and rounded at the angles of fracture, but some are quite round and pebble-like.

The interpretation is unmistakable. The front end of the dike solidified while the lower portion still remained liquid. Probably this happened during a pause in the advance of the dike. Whenever the dike moved after solidification, the solid lava would be broken up and the pieces were slickened by their grinding against each other and the uneven granite walls of the dike. The workings do not show the length of the portion of the dike that was pushed forward after solidification. It could not have been more than about 50 feet, that is, the part now beneath the surface of the granite. All this happened beneath the surface of the granite, where there can be no suspicion of ice action or of either surface or subterranean waters to smooth the stones in question. Indeed it is not certain that the dike here reached the surface, though it did for most of its course for a mile or more, and the outcrop is marked by low ridges of phonolite blocks having their original shapes of fracture somewhat modified by their being polished and a little rounded at the angles. On the hill south of the Lincoln mine these smoothed blocks form a crooked double ridge enclosing a hollow between the two ridges. There is thus the most ample proof that the frontal portion of the dike continued its upward motion after solidification. I have not examined the broken portion of the dike with the compound microscope, but under

the simple magnifier it appears devoid of glass and substantially like the ordinary scoriaceous and somewhat cellular phonolite found at the top of many of the dikes in this district. The smoothed blocks that form the outcrop of this dike form low ridges from 200 to 500 feet wide. If there had been a large amount of erosion since their deposition, they would not as now form compact heaps but would have become widely scattered down the hillsides.

3. The Alhambra. Elevation 9730 feet.

This mining claim is situated low down on the southwestern spur of Squaw Mountain.

A granite ridge is here strewn with boulders of a firm sand rock, composed almost wholly of crushed granite. Much of it is somewhat porous by the removal of the feldspar and mica grains by vein waters. In some places the rock is practically quartzite by the replacement of the mica and feldspar with silica. It contains a small proportion of crushed phonolite. The more siliceous and iron rusty parts run high in gold, and some 150 tons of boulders of this class have been picked up on the surface and were shipped as good pay ore.

Several shafts, pits, and trenches, now mostly inaccessible, show that a phonolite dike here rises through the granite, but none of the solid dike reaches the surface. Specimens supposed to come from a depth of 80 feet show that at that depth the phonolite is frozen fast to the granite. Nearer the surface is a body of uncemented phonolite gravel, proving that this portion of the dike was pushed forward and broken up after solidification. Nearer still to the surface is a body of mixed granitic and phonolite gravel, somewhat cemented. At the surface and scattered over the adjacent granite are the boulders of sand rock already described. These boulders have smoothed surfaces, proving that after the sand had become cemented into a solid rock, the rock was fractured by the upward movement of the dike and the blocks then received a secondary grinding. They were piled in a ridge along the line of the dike and in the course of time have become scattered over an area about 300 feet wide. This is proof of a limited erosion since the dike period. This fact together with the finding of gold in the sandstone unite to prove the eruption comparatively recent.

Squaw Mountain rises steeply several hundred feet above the Alhambra, which is thus proved to lie far below any ancient floor of the sea. The sand-rock cannot be a remnant of a marine bed. If it be the remains of a lake bed, where is the rest of the bed? There is no other rock like this within half a mile of the Alhambra, though there are several similar deposits of sand-rock in the town of Victor and vicinity, but

always along the line of dikes. After I learned the secret of the Alhambra rock I was repeatedly able to trace the courses of invisible dikes by "float" consisting of pieces of granitic sand-rock mixed with the other surface wash and debris.

4. Rhyolite dike situated about two and one-half miles southwest of Cripple Creek, on the top of the ridge lying between Pony and Long Hungry gulches. Elevation about 8800 feet.

The country rock is a massive granite containing a few inclusions of black mica schist. No part of a massive dike appears on the surface, but that this is the outcrop of a rhyolite dike is proved by the following facts.

The inevitable prospector has located a mining claim on the formation and dug a hole ten feet deep, now half filled with water. This shows that between walls of granite there is a body of fragmental matter. Most of it consists of granite, but there is also a small admixture of rhyolite. Much of the rhyolite consists of small well worn grains and powder, but here and there are subangular fragments up to two and even three feet in diameter. The rhyolite is somewhat porous. The form of the larger rhyolite fragments is quite irregular, a little inclined to be ovate, but with an uneven surface covered with projecting points and edges barely smoothed at the angles. Many of these rough fragments are scattered over the hillside near: these will be referred to hereafter.

The portion of the breccia consisting of the older rocks consists mostly of granite like that composing the walls of the dike. Some of the larger pieces of granite form cobbles 4 to 6 inches in diameter, as round and smooth as any stones on the ocean shore or in the eskers of New England. Much of the breccia consists of a sandstone cemented in its present position into a firm grit. One very smooth pebble four inches in diameter was composed of a fine granitic sand rock. The most surprising thing is the presence in the mass of numerous pebbles and cobbles of Algonkian quartzite showing the characteristic oölitic appearance of the original sand grains. The rock in the region is largely bare of debris and this makes it easy to find inclusions of the quartzite in the granite if such there were, and none were found. The dike evidently penetrated such an inclusion somewhere in its progress upward. Several of these quartzite cobbles show where, after they had been worn to very round and smooth forms, they had been broken and the new surfaces of fracture had barely begun to be smoothed.

The distance between the granite walls is only about four feet. Five feet below the surface (down to the water) I found granitic grits indistinguishable from the other grits here described. The dump shows nothing but the same fragmental materials, therefore this breccia reaches down at least ten feet. We cannot admit sedimentary action under such conditions.

5. Rhyolite dike situated half a mile southwest of Phonolite Peak, about two miles north and west from Gillett. Elevation about 10,000 feet.

At the outcrop of the dike a shaft has been sunk 15 feet into partially consolidated gravel and cobbles with bowlderets up to 18 inches in diameter, many of the latter being much worn and rounded. Part are of rhyolite, most are of granite, like the country rock. The dike outcrops in a rolling region lying west of the extremities of the ancient glaciers that radiated from Pike's Peak. The surrounding country is covered with disintegrated granite. Neither glaciers nor running streams can account for a local deposit of such round stones, and we cannot postulate a lake a few rods in diameter that could have deposited them.

6. Andesite dike at the reservoir of the Water works, situated on a low spur of Mineral Hill, in the northern part of the city of Cripple Creek. Elevation about 9400 feet.

The excavation of the reservoir exposed a mass of gravel and rounded bowlderets and bowlders up to three feet in diameter. A few are composed of andesite and schists, most are of granite. The gravel is cemented into a hard grit. The existing excavations do not reveal the full size and shape of the deposit. Apparently it is a body of granitic gravel which forms a cap to the dike and spreads out laterally over the adjacent granite to a breadth of 300 feet or more. If the gravel is composed of dike ejectamenta we must suppose that the stones were pushed above the surface as loose or incoherent gravel. By sliding and lateral rain wash this came to overlie the adjacent granite and then was cemented into a firm rock in its present position. This is proved by the fact that there are no smoothed bowlders of the cemented grit as at dikes Nos. 3 and 4. The spaces between the larger stones are filled with crushed granite so compact and firmly cemented that it sometimes requires close examination to determine its fragmental character. The size of the deposit is about 300×600 (or 800) feet.

Mr. Cross (l. c., p. 101) suggests that this gravel was deposited in a local lake. For the following reasons I regard it as a breccia or conglomerate composed of ejectamenta pushed upward by the rising dike.

The stones and bowlders vary much in shape. Some are as round as any beach cobbles, most are only moderately rounded at the angles of fracture, and some preserve almost the original shapes of fracture, being only a little polished and blunted at the angles. Many cobbles are rounder than the stones of small lakes become unless transported by long streams, and we cannot postulate such streams in a small mountain cirque bordered

by moderate slopes. On the shores of the largest lakes in Maine the stones of the unmodified till have not since glacial time become so round as many of these cobbles and boulders at the reservoir. One per cent or so of the pebbles and cobbles show very round outlines, except on certain sides where they have nearly flat surfaces of fracture but little modified. This proves that many of the stones, after having become round as eggs, were broken and the process of grinding was then renewed, but had not gone far when the movement ceased. Several of the rounder stones had been fractured at each end, and in one case the two planes of fracture were inclined to each other 30° . These fractured cobbles were of massive granite, not of fissile schists. All this is just what a dike could be expected to do if it pushed before it a mass of fragments of the rock it was penetrating, they being confined between solid walls. It would grind and roll and round them and from time to time break them, and we would find every stage from fresh fracture forms to the roundest all indiscriminately mixed as we do here.

The difficulties of the lacustral theory are great and, as I believe, insuperable. In dozens of places in the Cripple Creek region the same sort of granitic grits occur underlain invariably by volcanic dikes, and often underlain by breccias composed largely of volcanic rock. We cannot trace any sharp line of demarcation between these volcanic breccias and the overlying granitic grits and boulder beds. They pass into each other by degrees; the shapes of the fragments are the same. We cannot postulate so many local lakes, and if we did they cannot adequately account for the shapes of the fragments or the invariable association with dikes. They occur on the tops of hills as well as in valleys, and at such different elevations they cannot be remains of a once continuous formation. A lake having a surf violent enough to roll and round boulders up to four feet in diameter ought to be able to excavate a beach cliff and terrace and to plane off the rock to water level. Nothing of the kind has been found anywhere in the Cripple Creek region. On the contrary, these granitic grits overlie steep slopes of erosion. On this point my observations accord with Cross's descriptions. But in the case of dikes numbered 3, 4, and 5, the same sort of rounded stones and boulders occur between granite walls and beneath the surface, where there can have been no sedimentation by lakes or streams. The lacustral theory is thus proved to be needless. We can account for everything on the volcanic theory.

7. Rhyolite dike situated about one mile southeast of Mari-gold. Elevation 8000 feet.

This dike is situated on the top of the high ridge that lies

between Cripple Creek and Spring Creek, a small stream that flows southwestward from the south end of Grouse Mountain. It is about half a mile east of Four Mile Creek.

The country rock is granite. The dike both laterally and on the top is covered with a deep body or layer of breccia or conglomerate; a boulder bed would be a better term for it. The fragmental materials consist chiefly of granitic pebbles, cobbles, bowlderets and boulders up to four feet in diameter. Most of them are as round as any boulders to be found anywhere. The spaces between the larger stones are filled with crushed rhyolite and granite mixed. The boulder bed forming the top of the dike rises quite steeply 100 feet above the surrounding granite. It is now cemented into quite a firm rock, yet large blocks have fallen away from the precipitous cliffs and are now found far down the southern slopes toward Spring Creek. One mass 80 feet in diameter may or may not have come from above in this way. On some of the steeper cliffs, where the outer layer above described has broken away, we find a semi-breccia composed of well-rounded granite stones and boulders embedded in the rhyolitic lava itself. None of the massive rhyolite is exposed.

The surface portions consist wholly of fragmental materials. Structurally they are as well entitled to be termed lake beds as the boulder bed at the Cripple Creek reservoir, or any other of the bodies of rounded granitic stones in this district. At the reservoir the granitic gravel was pushed up in a loose condition and was not cemented till after it had reached the surface and had time to spread over the granite at the sides of the dike. But at this dike near Marigold the granitic stones were cemented fast to the top of the dike before it rose above the granite, a very convenient thing for the investigator. The dike and the material it pushed before it as it rose are there now in position to testify to what sort of work the dikes did as they were pushed upward. This dike is about 600×200 feet in area.

8. Phonolite dike on Straub Mountain. Elevation of the grits 9300 feet and from thence rising along rather steep slopes up to 9800 feet.

This very large dike is bordered and in part overlain by a broad mass of grit consisting of subangular granitic sand and gravel and now and then a few fragments of phonolite. Some of the stones are quite smooth and pebble-like. These grits are mapped by Mr. Cross as High Park Lake beds. They, as well as dikes here numbered 9 and 13, have been well described by Cross, and hence need only brief reference here. They overlie uneven slopes of pre-volcanic erosion. Neither in materials nor in shapes of the fragments do they differ from

the grits found at dike No. 4 between granite walls. I consider them as granitic breccias composed of dike ejectamenta.

9. Phonolite and rhyolite dikes on Grouse Mt. Elevation of grits from 9100 up to 9800 feet.

This mountain contains very large dikes of both rhyolite and phonolite and both kinds of dikes are capped and bordered by granitic grits. When the grits cap a phonolite dike they contain some fragments of phonolite; when they cap a rhyolite dike they contain fragments of rhyolite. This is strongly against the sedimentary theory of the origin of these grits, which I regard as granitic breccias like the rest.

10. Phonolite dike on Beacon Hill.

At various points along the western slopes of this hill are found granitic grits indistinguishable from the grits on Grouse and Straub Mountains. If the latter are lake beds, so are these on Beacon Hill. Elevation of the grits about 9500 feet.

11. Andesite dike on the top of Mineral Hill. Elevation 10,150 feet.

The extreme top of this hill consists of a firm grit composed almost wholly of granite but with an admixture of andesite. The fragments are rather more angular than at the other dikes here described. Going down in shafts, we find an increasing proportion of andesite. So also as we go down the surface slopes of the hill we find more and more andesite till we soon reach the characteristic andesitic breccia.

The granitic grit on the top of Mineral Hill is plainly a breccia like the more andesitic breccia that underlies it, and they pass into each other by insensible gradations. We cannot account for the granitic fragments as explosive ejectamenta in such a position, but they can easily be accounted for as dike ejectamenta if we suppose they were cemented immediately after being raised above the original surface. This would preserve the continuity of the granitic gravel as a cap and the andesitic fragments pushed up subsequently as a body of loose gravel would spread laterally underneath the cap and gradually be cemented to it.

12. Andesite dike on the N. W. Spur of Rhyolite Mountain. Elevation 9900 feet.

Here some mining shafts penetrate an andesitic breccia that is so weakly cemented as soon to fall to pieces after being exposed to the weather. They next pass through a stratum of well-rounded granitic gravel, pebbles and cobbles, and then into the granite. These stones have the same shapes as those at the Cripple Creek reservoir. The most probable interpretation is as follows:

The andesite dike was slowly rising through the granite and as it did so it pushed a mass of granite before it, crushing it in

the process, and smoothing the stones. These fragments were not cemented. As the incoherent gravel and cobbles rose above the surface they formed a ridge, which at the base overlay the adjacent granite, probably in this case to a breadth of less than one-eighth of a mile. But the dike continued to rise. As fast as the upper surface of the lava solidified, it was broken and the fragments were pushed upward in substantially the same way as the granitic fragments had been. The andesitic fragments rose through the granitic fragments, pushing them to one side and ultimately forming a ridge which at the sides overlay the granitic gravel and cobbles. Later the andesitic matter was cemented into a breccia. In places there is no cement to speak of.

Similar granitic grits are found at Little Pisgah and other places that might be named, but these will suffice for the present.

It will be noted that granitic breccias have been found above dikes of rhyolite, phonolite, and andesite only. Outcrops of basalt are well exposed on the American Eagles, top of Bull Hill, also on Galena Hill near Grassy and on Signal Hill, a half mile south of Cripple Creek. In none of these cases did I find any granitic breccias, though the conditions were favorable for finding them if they ever existed.

13. Rhyolite dikes at High Park. Elevation about 8,000 feet.

Here are several miles of rhyolite dikes, all capped and bordered by grits that consist mostly of granitic fragments, but with the schists and especially the Algonkian quartzite well represented, also they contain some rhyolite. Cross (l. c.) includes these among his High Park Lake beds. They have the same general character as the grits already described. These remarks are intended to apply only to that portion of the lake beds that covers and borders the dikes. At a distance from the dikes the lake beds differ in materials and in various other respects from the parts above and near the dikes.

Had the grits on Straub and Grouse Mountains and those capping the rhyolite dikes in High Park been examined by the writer without having the other dikes to compare them with, it is not probable that any other interpretation would have occurred to me than that they were of sedimentary origin. I make this personal reference for the express purpose of acquitting my friend Mr. Cross from any carelessness of observation. The disputed questions involved are all matters of interpretation.

We are now prepared to consider more fully the details of the process of making granitic breccias that so closely simulate sedimentary beds.

It is well known that most volcanic regions show that at times the lava flowed as a liquid over the surface, the flows often alternating with layers of explosive ejectamenta, as at Cap Rock a few miles S.W. of Cripple Creek. The internal structure of the Cripple Creek volcanoes is difficult to make out because the surface is so covered with debris. At the margins of a few of the larger lava bodies I have found signs of a limited lateral flow, but in general the volcanic rocks occur as dikes rather than as flows, and their motion was upward.

The dikes numbered 2, 3, and 4 afford conclusive proof that some of the dikes of the Cripple Creek region solidified at the front before reaching the surface, also that they moved after solidification. This gave the first definite clue to the mystery of the granitic breccias.

Dike 1 shows that the melted lava as it was pushed upward ended at the front in a rather blunt liquid wedge which by hydrostatic pressure successively wedged apart the rocks. This probably could only happen near the surface where the rocks were so broken they could thus be moved relative to each other.

We could naturally expect that as the frontal portion of the melted lava cooled and became more viscous, this wedge would become blunter. The time would come when the front of the rising dike solidified or would become so viscous that the pressure forward would become greater than the pressure tending to wedge apart the solid rocks in front. If at this time the pressure on the liquid from below was feeble or if the liquid lava could force another vent, the movement might be arrested at this point. If the upward movement continued, the only way in which the dike could now rise was by pushing before it a mass of the solid rock it was penetrating, crushing it into fragments, and then as the fragments wedged each other apart and ground against each other and the adjacent walls, it gradually rounded and polished them. The friction would be tremendous and would fully account for the large amount of crushed rock. If at this stage of the process the advance should cease for awhile or become very slow, the heated waters from below, where the lava was still liquid, would under the proper conditions cement the crushed granite into a firm sand-rock while still between the granite walls of the dike, and they might charge it with gold. If the motion were then resumed the capping of sand-rock would be broken into blocks, and as they were pushed onward they would become smoothed and rounded, and would finally form a ridge rising above the adjacent granite.

For a time the liquid lava lay not far below the region of crushed granite. In some cases, especially in case of the rhyo-

lite dikes, the liquid now and then spurted in streams or tongues up into or through the mass of crushed granite, as at dike No. 4, and there cooled. The upward movement immediately began to grind and often to crush these injected bodies.

When the upper crust of the lava became sufficiently thick it was broken up and the pieces pushed onward. At first they preserved nearly their original positions relative to each other and they were slickened at the sides and barely blunted at the angles. If this happened near the surface, as at dike No. 2, the smoothed fragments were pushed above the surface before receiving much attrition and there lay in ridges. But if they were pushed far some of them were crushed and then one by one they were rolled until none of them retained their original positions relative to each other. Those stones that happened to be rolled into many positions received the attrition on all sides and became round. At the sides of the moving dike we frequently find bodies of breccia composed of mixed granite and lava, and in some cases this is known to reach a depth of several hundred feet.

The above interpretation leads to many corollaries. It is impossible within the limits of this article to mention more than two. First, erosion has been limited since the close of the volcanic period. In other words, the present outlines of the volcanic ridges and cones of Cripple Creek are substantially the same as they were originally.

Second, a large part of the volcanic action was comparatively slow and non-explosive.

Specimens of all the breccias here described, except from Nos. 1 and 12, have been placed by me in the collections of the University of Colorado at Boulder, also of the University of Denver and of Colorado College at Colorado Springs. Investigators will thus find them easily accessible.

Finally, there is reason to believe that dike ejectamenta of the kind here described are not uncommon.

Colorado Springs, Sept. 17, 1897.

ART. V.—*On the Dispersion and Absorption of Infra-Red Rays in Rock Salt and Sylvine* ;* by H. RUBENS and A. TROWBRIDGE.

A SHORT time ago it was pointed out that it is possible to isolate a narrow band of approximately homogeneous rays from the great number sent out by a source of heat by means of successive reflections from a number of surfaces of the same substance. This isolation follows from the selective reflection of the surfaces used.† In this manner comparatively monochromatic rays, in some cases possessing a very great mean wave length, can be obtained without the use of prism or grating.

Compared with the usual method, where dispersion is obtained by means of a prism or grating, this method has, for some research work, the disadvantage that the wave length cannot be varied at will; as one is limited to well defined wave lengths determined by the substance of the reflecting surfaces. For this reason it is of some interest to state to what extent the prismatic method is applicable in the further infra-red spectrum; or else, what wave length can be attained in a spectrum thrown by a sylvine or rock-salt prism.

There are several properties of a body upon which its fitness as a substance for prisms depends. Next in importance to its occurrence in large clear pieces and the possibility of preparing and preserving plane surfaces, come its dispersion and absorption. We undertook, therefore, to determine with the greatest possible precision, the dispersion and absorption of these bodies for infra red rays of great wave length.

Measurement of Dispersion.

The dispersion of rock salt and sylvine has been compared with that of fluorite as far as the wave lengths 8.86μ and 7.06μ respectively, in a previous investigation undertaken by one of us.‡ For fluorite there exist the careful measurements of its dispersion by Paschen,§ which were made with the help of a Rowland grating especially constructed for this purpose. These measurements extend to the wave length $\lambda = 9.44\mu$ and were made after Langley's method. Several additional points of the dispersion curve of rock salt and sylvine have lately been observed in the extreme infra-red at $\lambda = 20.6\mu$ and $\lambda =$

* Translated by one of the authors from the original in Wiedemann's Annalen.

† H. Rubens and E. F. Nichols, Wied. Ann., ix, p. 418, 1897.

‡ H. Rubens, Wied. Ann., liv, p. 476, 1895.

§ F. Paschen, Wied. Ann., liii, p. 301, 1894.

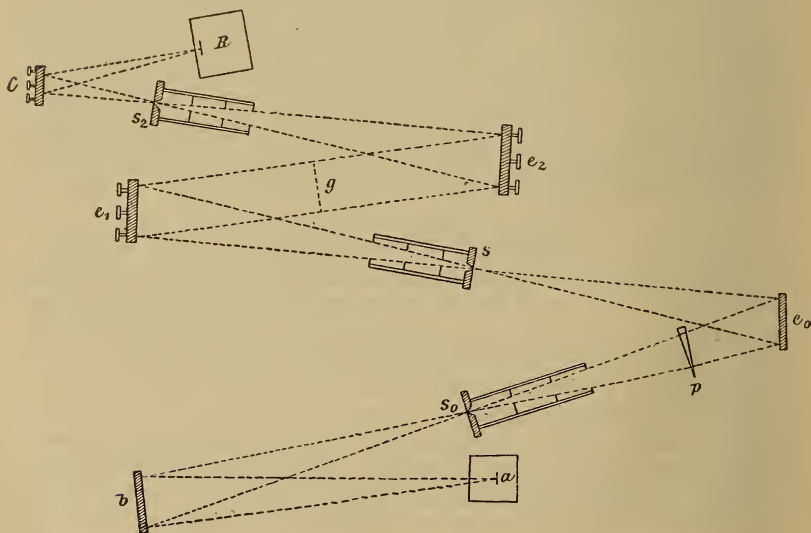
22.3μ , and with the help of these points, together with the above mentioned earlier data, the five constants of the Ketteler-Helmholtz equation

$$n^2 = b^2 + \frac{m_1}{\lambda^2 - \lambda_1^2} - \frac{m_2}{\lambda^2 - \lambda_2^2},$$

have been calculated.* In the first part of this communication we have limited ourselves to the comparison of the results obtained by means of this formula, with the dispersion of rock salt and sylvine for certain points in the large field between $\lambda = 8.86\mu$ and $\lambda = 20.6\mu$ for rock salt and $\lambda = 7.06\mu$ and $\lambda = 20.6\mu$ for sylvine, for which up to the present time no experimental determinations have been made.

We employed a method based on the comparison of the grating spectrum and the prism spectrum which was similar to Langley's† method and which differed from it in only one point. While in Langley's arrangement the dispersion of the rays was obtained first from the grating and then from the prism under examination, in our arrangement the dispersion was brought about in the inverse order. This change was of little importance and was effected by us only because in that way we were able to set up our apparatus more conveniently.

1.



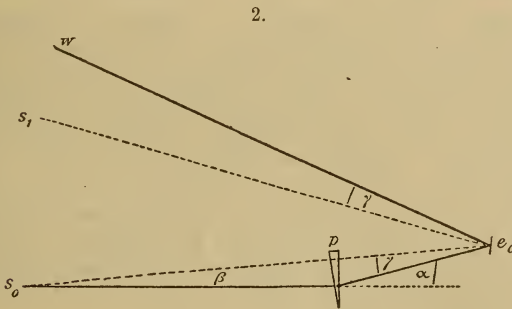
The arrangement of our apparatus is given in figure 1. In it *a* represents the source of heat (Linnemann zircon burner)

* H. Rubens and E. F. Nichols, *Wied. Ann.*, 1, p. 454, 1897.

† Langley, *this Journal*, xxvii, 169; *Wied. Ann.*, xxii, p. 598, 1884.

and b , a concave mirror which concentrates the rays from a on the slit s_0 . Behind the slit s_0 the rays traverse the sharp prism p , made of the substance to be examined, and fall on the concave mirror e_0 . By means of this arrangement a spectrum is thrown in the plane of the slit of the spectrometer $s_1 e_1 e_2 s_2$, out of which spectrum the slit s_1 cuts a narrow band, the mean wave length of which can be varied at will by rotating the mirror e_0 about its vertical axis. On the table of the spectrometer $s_1 e_1 e_2 s_2$ a diffraction grating g of parallel silver wires was mounted for the measuring of the wave lengths of the rays passing through the slit s_1 . The rays emerging from the fixed ocular slit s_2 were concentrated by means of a concave mirror of short focal distance on one wing of a Nichols radiometer.* The window of the radiometer was a chloride of silver plate, about 1^{mm} thick and the wings of the suspension were coated with iron oxide.

The spectrometer $s_1 e_1 e_2 s_2$ is the instrument whose construction and adjustment have been described at length in the above mentioned paper,† and we can in consequence refer to the description there given. However, it is necessary to enter more fully into the theory of the spectral arrangement, consisting of the slits s_0 and s_1 , the prism p and the concave mirror e_0 . Figure 2 represents the path of the middle ray when



the deviation in the prism is 0 (as a dotted line) and, when the deviation is α (as a full line). In order that rays which are deviated in the prism p through the angle α shall fall in the slit s_1 it is necessary to turn the ray e_0 through the angle γ , that is, the mirror e_0 through the angle $\frac{\gamma}{2}$. But $\gamma = \alpha - \beta$ and approximately $\beta : \gamma = e_0 p : p s_0$ —hence $\gamma = \alpha (p s_0 / s_0 e_0)$. The fraction $p s_0 / s_0 e_0$ can be easily determined by measurement to

* E. F. Nichols, Berliner Berichte, p. 1184; Wied. Ann., lx, p. 403, 1897
Physical Review, vol. iv, No. 22, p. 298, 1897.

† Rubens and Nichols, Wied. Ann., lx, p. 422, 1897.

within 0.2 per cent. Greater accuracy cannot be claimed for our measurements on dispersion.

It is evident that this arrangement is only applicable when the angle of the prism is very acute and the angles of deviation a are very small. In our case, the angles of the rock salt and sylvine prisms were approximately 12° ; the observed deviations, between $4\frac{1}{2}^\circ$ and 6° . With angles of this size the simple relation between γ , and a given above, already leads to errors in the deviation γ which may equal one minute. The error becomes, however, very much smaller by reckoning from the minimum deviation of the sodium line instead of from the deviation 0; namely, when one does not attempt the absolute measurement of the deviation a but confines oneself to the determination of the angle of dispersion ($a_D - a_\lambda$). This is, in fact, entirely sufficient, for after determining this angle of dispersion, it is sufficient to know the deviation for the sodium line in order to calculate from this the deviations for all the observed wave lengths.

If the arrangement just described is used, then the error still present in the formula $\gamma_D - \gamma_\lambda = \text{const.} (a_D - a_\lambda)$ is very small and may be completely ignored, if a small correction is applied to the constant $\frac{e_0 p}{ps_0}$.*

The rotation of the mirror e_0 about its vertical axis was effected by means of a spectrometer on the table of which the mirror was mounted. The rotation of the table could be measured to within ten seconds on the graduated circle of the instrument by means of a vernier. As this accuracy was not sufficient for our purpose, we applied a divided micrometer head to the slow motion screw of the instrument, by means of which we were able to attain an accuracy of two seconds for small arcs. The prism p was set at minimum deviation for sodium light and kept throughout the work in this position. Therefore the application of the formula

* Strictly speaking $\beta = \gamma(e_0 p / ps_0)$ is not correct, the correct equation being

$$\beta = \text{arc. tg} \left\{ \frac{e_0 p}{ps_0} \text{tg} \gamma \right\}$$

$$\text{hence} \quad \frac{\delta a}{\delta \gamma} = 1 + \frac{\frac{e_0 p}{ps_0}}{\cos^2 \gamma + \left(\frac{e_0 p}{ps_0} \right)^2 \sin^2 \gamma}$$

If a mean value for γ , say 5° , be substituted in this equation, there appears in the place of the constant $e_0 s_0 / ps_0$ a value for $\frac{\delta a}{\delta \gamma}$ which differs from the constant by 0.1 to 0.2 per cent.

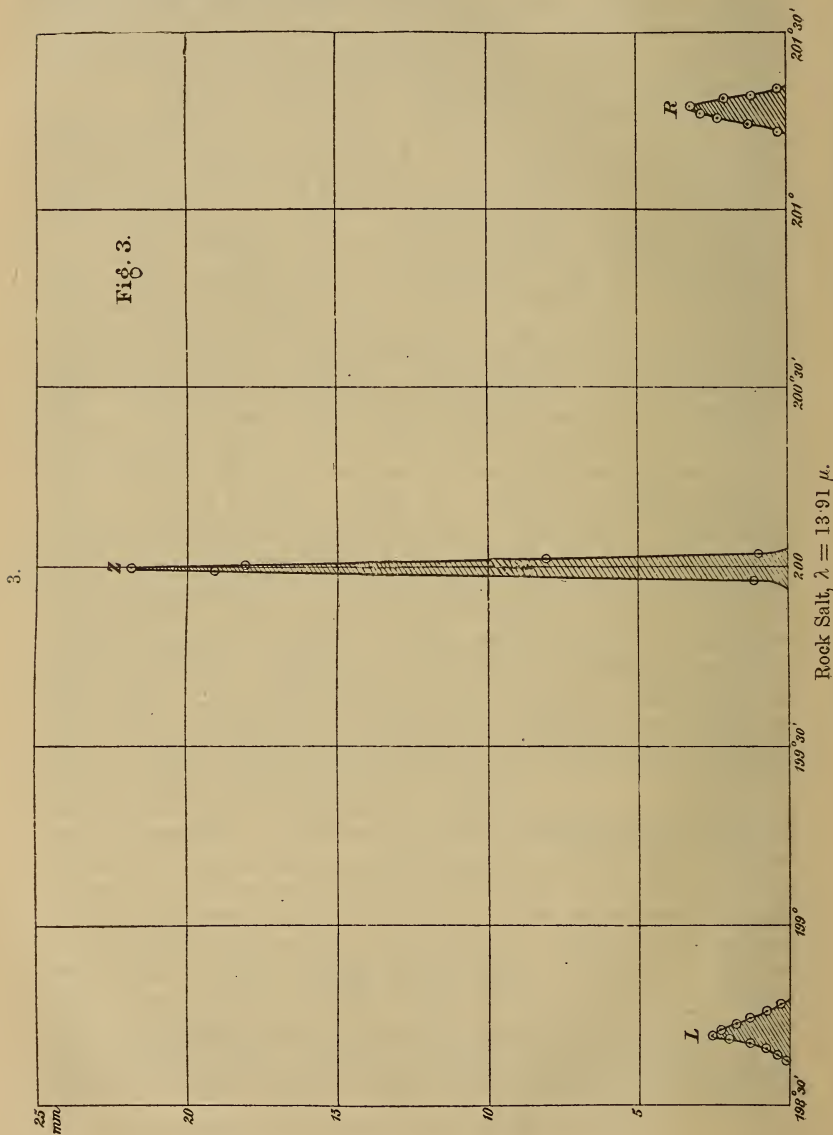
$$n = \frac{\sin \frac{\phi + \alpha}{2}}{\sin \frac{\phi}{2}}$$

to the examined portion of the infra-red spectrum, is not, strictly speaking, permissible, as this formula presupposes minimum deviation. Through calculation, however, it appears, that in our case the error is sufficiently small to be neglected, this being due to the acute angle of the prisms used.

This arrangement, consisting of the slit s_0 , the concave mirror e_0 , and the prism p , made it possible for us to throw on the slit of the spectrometer s_1, e_1, e_2, s_2 , rays of known minimum deviation, and, as the angle of the prism had been previously determined, of given refractive index. The corresponding wave lengths were determined by means of the diffraction grating g . The properties and capabilities of this grating have been minutely enough described in the above mentioned communication* to permit us to omit further description. For the measurement of the wave length, both diffraction images of the first order were always located and the distribution of energy in both carefully determined in this way. We rotated the movable arm of the spectrometer a minute of arc at a time and each time carefully measured and noted the throw of the radiometer for the point in question. In figure 3 such a series for rock salt at the wave length $\lambda = 13.91\mu$ is represented graphically. The readings on the divided circle of the spectrometer s_1, e_1, e_2, s_2 , corresponding to the positions of the movable arm are plotted as abscissas, the corresponding throws of the radiometer as ordinates. It is noticeable that the diffraction images differ to a marked degree in distribution of energy. The right image is considerably narrower and higher than the left. This is not, as might be imagined, an accidental peculiarity of this series, due to inequalities in the intensity of the light source, but on the contrary is common to all the series observed by us. It is explained by the fact that the rays falling on the slit s_1 are not perfectly homogeneous, but are rather of different wave lengths; and, in fact, the distribution of the rays on the slit is such that (looking at the slit s_1 from the mirror e_0) those of shorter wave length fall on the right edge of the slit, those of greater wave length on the left. The same distribution of energy is apparent in the central image of fig. 3, only here right becomes left, and left right. Both the diffraction images appear widened with respect to the central image on account of the dispersion of the grating; however, the distribution of energy, already present in the central image, works on the two

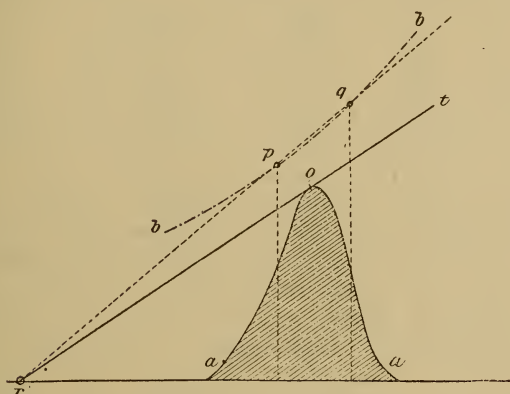
* Nichols and Rubens, Wied. Ann., lx, p. 425, 1897.

diffraction images in an opposite direction. Hence, the left image is more spread out, while the right one, from the same cause, becomes narrower and sharper, since in the first case the dispersions of both prism and grating are added, while in the second case, only the difference of the two dispersions has an effect, as in an achromatic lens.



Besides this asymmetry of form, there exists a slight but at the same time noticeable asymmetry of position of the two diffraction images with respect to the central image.* The total distance between the two diffraction images of the first order, remains, nevertheless, unchanged. On the other hand, a correction for the position of the maximum of the diffraction spectrum is necessary, for the reason that the rays of shorter wave length, falling on the slit s_1 , possess greater energy than those of greater wave length. Because of this, the maximum in both images appears displaced toward the side of the shorter waves.

4.



In order to apply this correction, it is necessary to know the distribution of energy in the spectrum thrown from the source of light with the aid of the slit s_0 , the prism p_1 and the mirror e_0 . This was therefore carefully measured in each separate case with a special series of observations, and by means of the data so obtained, the angle of diffraction was determined at which the maximum of energy should appear, if the spectrum thrown in the plane of the slit s_1 possessed the same amount of energy at all points. This determination is easiest made by using a tangential construction given by Paschen,† the details of which are given in figure 4. The curve a represents the intensity curve of a diffraction image; the curve b gives the distribution curve of energy in the spectrum thrown in the plane of the slit s_1 . Let i and i_1 be two ordinates of the curve b near the maximum of the curve a , and join the points p and q on the curve b corresponding to these ordinates, with a straight line which shall cut the axis of abscissas in a point r , and lay a

* The cause of the presence of this asymmetry lies in the arrangement of the spectrometer s_1, e_1, e_2, s_2 , Rubens and Nichols, Wied. Ann., lx, p. 422, 1897.

† F. Paschen, Wied. Ann., li, p. 1, 1894.

tangent to the curve a through r ; then the abscissa of the point of contact o of this tangent gives the corrected position of the maximum.

The construction given is only admissible if the curve a in its middle portion represents a comparatively clean spectrum; that is, if the width of the central image is considerably less than that of the diffraction image. It is apparent, on considering this point, that this construction may be applied in all cases in which the size of the correction does not equal half the difference between the width of the central image and that of the diffraction image. In making the measurements given below, this limit was never exceeded. The size of the correction differed for each image, corresponding to the different width of each. On the right image it was only a few seconds; on the left in some cases more than a minute. If the slit s_1 were infinitely narrow, s_0 and s_2 having a finite width, both refraction images would appear of equal width, and the correction would be in both cases the same; that is to say, it would be, approximately, the arithmetical mean of the corrections applied by us on the right and left image. We have convinced ourselves of the correctness of this explanation by observations in which, under otherwise similar conditions, the width of the bilateral slit s_1 was varied between the limits 0.2^{mm} and 0.5^{mm} . Here no systematic difference in the results was noticeable.

At the beginning of each series of observations the slit s_0 was illuminated with sodium light and the mirror e_0 was adjusted so that the sodium line fell exactly in the middle of the slit s_1 . As the accuracy of the objective adjustment was found to be insufficient, we substituted an ocular of high power for the slit s_2 , and by this subjective method, were able to adjust the sodium line on the slit s_1 with an accuracy of two seconds of arc. After this adjustment, the mirror e_0 was turned by means of the slow motion screw, through an angle $\delta = \frac{1}{2}(\gamma_D - \gamma_\lambda)$ which corresponded to a change in the minimum deviation of $a_D - a_\lambda$. The wave length was then measured in the manner given above.

The following two tables give the results obtained with a rock salt prism (angle $\phi = 10^\circ 53' 0''$) and a sylvine prism ($\phi = 12^\circ 39' 10''$) together with several indices of refraction and wave lengths taken from the two communications already cited.* The figures of the first column represent the differences between the minimum deviation a_λ for the wave length in question λ , and the minimum deviation of the sodium line

* The series marked with one asterisk * are taken from the work of Rubens; those marked with two asterisks from that of Rubens and Nichols.

α_D . The second column gives the corresponding indices of refraction. In the third are the observed wave lengths of the rays without the application of the correction mentioned above, and in the fourth, the same, corrected. In the fifth column are the values of the wave lengths for the corresponding indices of refraction, calculated from the Ketteler-Helmholtz formula, using the constants given by Mr. Nichols and one of us.

TABLE I.

Rock salt $\phi = 10^\circ 53' 00''$

$\alpha_D - \alpha_\lambda$	n	λ uncorrected.	λ corrected.	λ calculated.
----	1.5441*	0.589 μ	----	0.589
----	1.5030*	8.67	----	8.67
32' 19"	1.4951	9.88	9.95 μ	10.00
41 55	1.4805	11.85	11.88	12.00
53 39	1.4627	13.94	13.96	14.00
1° 7' 55"	1.4410	15.81	15.89	16.00
1 25 9	1.4148	17.87	17.93	18.00
	1.3735**	20.57	----	20.57
	1.3403**	22.3	----	22.3

$$b^2 = 5.1790, \quad M_1 = 0.018496, \quad M_2 = 8977.0, \quad \lambda_1^2 = 0.01621, \\ \lambda_2^2 = 3149.3.$$

TABLE II.

Sylvine $\phi = 12^\circ 39' 10''$.

$\alpha_D - \alpha_\lambda$	n	λ uncorrected.	λ corrected.	λ calculated.
----	1.4900*	0.589 μ	----	0.587 μ
----	1.4653*	7.08	----	7.08
26' 2"	1.4561	9.94	10.01 μ	10.00
41 40	1.4362	13.88	14.14	14.20
1° 1 7	1.4102	17.94	18.10	18.05
----	1.3882**	20.60	----	20.60
----	1.3692**	22.5	----	22.5

$$b_2^2 = 4.5531, \quad M_1 = 0.0150, \quad \lambda_1^2 = 0.0234, \quad M_2 = 10747, \\ \lambda_2^2 = 4517.1.$$

The calculated values of the wave lengths are, for both substances, almost without exception, larger than the observed values; however, the difference is, for the most part, less than $\frac{1}{2}$ per cent. and this $\frac{1}{2}$ per cent lies generally within the limit of error in observation, which must be estimated at from 0.3 to 0.7 per cent. Therefore the equation for the dispersion satisfies the demands made on it in the portion of the spectrum between $\lambda = 10\mu$ and $\lambda = 20\mu$.

*H. Rubens, Berichte der Physikal. Gesellschaft, 6 Nov., 1896.

Measurement of the Absorption.

Several measurements were made a short time ago by one of us, touching on the infra-red absorption spectrum of rock salt and sylvine. A diffraction grating served to produce the spectrum. A zircon lamp was used as a heat source, the rays of which had to pass, before their entrance into the spectrometer, through a thin lamp-blackened chloride of silver plate, whereby the disturbing energy from rays of shorter wave length was removed. In order to overcome the influence of the spectra of higher order, the throws of the bolometer were always observed in the following manner. A fluorite plate 6^{mm} thick was slid into the path of the rays, and after the completion of the throw, again removed. This fluorite plate absorbed completely only the long waves of the spectrum of the first order (12 to 20 μ), while it let through the short waves of the spectra of higher order unweakened, except for the loss of strength due to reflection. The results on the absorption of rock salt and sylvine plates, obtained in this manner, could, on account of the exceedingly small amount of energy in the diffraction spectrum, lay no claims to great accuracy and were of service only as a forerunner of more careful determination. On the other hand, it was possible for us, with the use of the above mentioned acute-angled prisms made of rock salt and sylvine, to produce a doubly dispersed, continuous spectrum which was sufficiently intense and pure, to make possible the measurement of absorption for both substances. To this end, the grating g was removed from the table of the spectrometer s_1, e_1, e_2, s_2 , and in its place the rock salt prism was set up, so that it gave the minimum of deviation for the sodium line. In the adjustment of the apparatus for a given wave length, the mirror e_0 as well as the moveable arm of the spectrometer s_1, e_1, e_2, s_2 , was turned through the proper angle, the value of which, in each case, was calculated from the dispersion of the prisms and the constants of the apparatus.

The plates, the absorption of which was to be determined, were placed directly before the slit s_0 in the path of the rays, by means of a sliding holder. Near the slit s_1 was a shutter, worked with cord and pulley, which could be set from the observer's table so that it either let through or shut off from the slit s_1 the rays coming from the mirror e_0 . This shutter consisted of a plane-parallel glass plate 2^{mm} thick, which let through about 75% of the total radiation of the zircon lamp, but absorbed completely the rays in the field between $\lambda = 8\mu$ and $\lambda = 21\mu$, in which we worked. The advantage which lies in the use of such a glass plate instead of a metal shutter is that the diffuse radiant heat of short wave lengths (the maximum of emission of the zircon lamp lies at about 1.4 μ) which may

be present in the infra-red part of the spectrum, works for the most part, continually on the radiometer, and therefore becomes harmless for the observations.

Because of the small dispersion of our prisms, we could, in our experiments, only determine the general trend of the absorption. In the field between $\lambda = 9.0\mu$ and $\lambda = 20.75\mu$, measurements were taken at twelve different points, on the absorption of a rock salt layer 23.3mm thick and a sylvine layer 10.7mm thick by placing alternately a thick and a thin plate of the material to be examined, in front of the slit s_0 . The ratio of the throws of the radiometer, observed in both cases, gives the transmission for a layer, the thickness of which is equal to the difference in thickness of the two plates.*

In this way the following results were obtained :

TABLE III.

Wave length. λ	Rock salt $d = 23.3\text{mm}$	Sylvine. $d = 10.7\text{mm}$	Wave length. λ	Rock salt. $d = 23.3\text{mm}$	Sylvine. $d = 10.7\text{mm}$
9 μ	98.8	100.2	16 μ	38.1	93.1
10	98.7	98.6	17	21.4	91.6
11	98.9	98.9	18	4.94	85.3
12	98.3	99.4	19	0.1	74.3
13	94.4	99.4	20.7	----	56.3
14	84.7	97.3	23.7	----	13.5
15	67.8	95.0			

In another table we give our results on the transmission of a rock salt plate, a chloride of silver plate† and a fluorite plate, which were obtained by comparison of the direct and transmitted energies. In order to calculate the absorption of the plates, the influence of the reflection must be eliminated from these numbers.

With the help of the figures given in Table III, the following values (Table V) were obtained for the transmission of layers of rock salt and sylvine 1cm thick. For rock salt, from $\lambda = 19\mu$ on, Table V was filled in with the results from Table IV. Similarly, the values given for fluorite were calculated from the values given in Table IV, after using Paschen's measurements on dispersion in eliminating from them the loss of energy due to reflection.

* Since the absorption in rock salt was very considerable beyond 19μ we used only the sylvine prism for the wave lengths $\lambda = 20, 7\mu$ and $\lambda = 23.7\mu$, making the rays monochromatic before their entrance into the slit s_0 , by successive reflection on quartz ($\lambda = 20.7\mu$) and on fluorite ($\lambda = 23.7\mu$).

† The chloride of silver plate used by us is one of those which Schultze-Sellack prepared and tested for transmission of heat rays in 1870.—Pogg. Ann., cxxxix, p. 182, 1870.

TABLE IV.

Wave length. λ	Fluorite $d = 3.40.$	Chloride of silver. $d = 3.08.$	Rock salt. $d = 3.77.$
8 μ	89.5	40.5	92.0
9	77.0	44.8	91.5
10	51.5	51.5	90.9
11	19.8	55.0	92.0
12	2.07	57.8	92.0
13	0.0	59.2	90.5
14	----	60.2	90.5
15	----	59.9	89.5
16	----	63.8	85.6
17	----	67.8	74.7
18	----	----	63.7
19	----	67.9	39.1
20.7	----	64.7	13.4
23.7	----	28.0	1.1

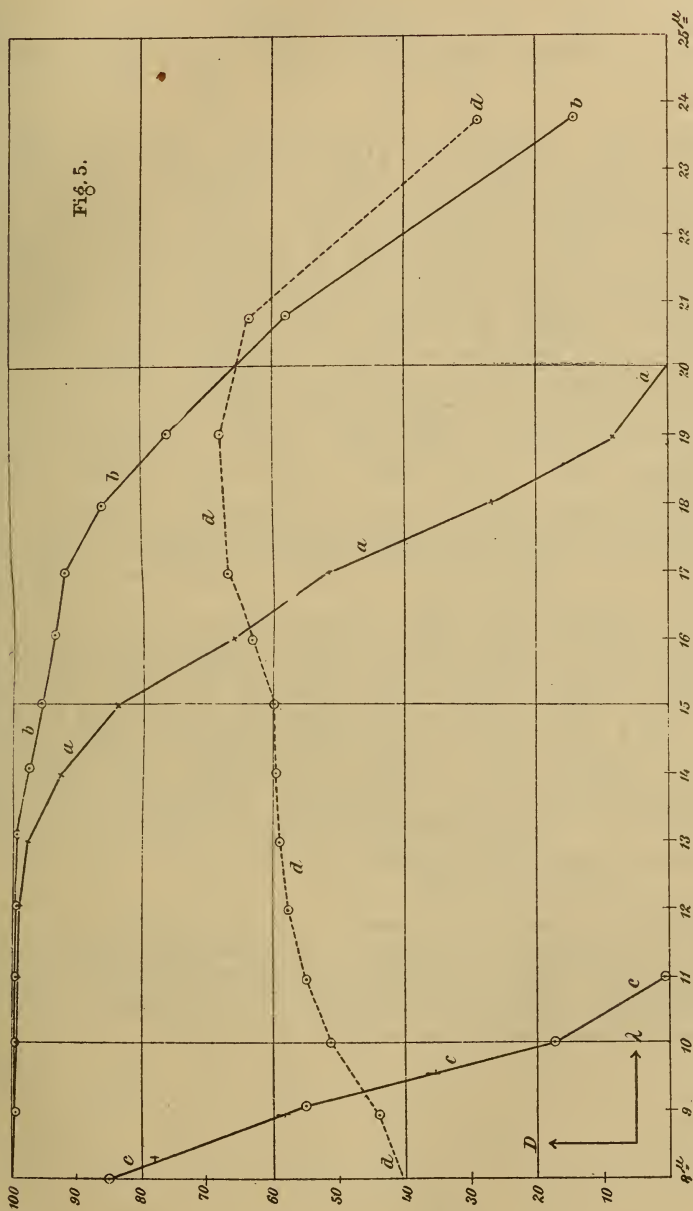
TABLE V.

Wave length λ .	Rock-salt.	Sylvine. Thickness of layer = 1 ^{cm}	Fluorite.
8 μ	----	----	84.4
9	99.5	100.2	54.3
10	99.5	98.8	16.4
11	99.5	99.0	1.0
12	99.3	99.5	0.0
13	97.6	99.5	----
14	93.1	97.5	----
15	84.6	95.4	----
16	66.1	93.6	----
17	51.6	92.2	----
18	27.5	86.2	----
19	9.6	75.8	----
20.7	0.6	58.5	----
23.7	----	15.5	----

On the other hand, we did not calculate values for a layer of chloride of silver 1^{cm} thick, as the chloride of silver plates used by us were not sufficiently clear and homogeneous to seem to us to permit of the application of the law of absorption, with even the roughest approximation. For light rays, the plate was almost completely turbid, so that the increase in its transmission for increasing wave lengths in the field between $\lambda = 8\mu$ and $\lambda = 18\mu$, may possibly be only attributable to the similar* peculiarities observed by Ångström for turbid media. The transmission, as a function of the wave length, of a layer 1^{cm} thick of rock salt, sylvine, and fluorite, is given

* K. Ångström, Wied. Ann., xxxvi, p. 715, 1889.

5.



graphically in figure 5. The curves show in all three cases a very similar character. We notice that rock salt (curve a)

already shows a visible absorption at 12μ for this thickness of layer, and that beyond 20μ the absorption is almost complete. Sylvine (curve *b*) begins first to absorb to a marked degree beyond 13μ and still shows even at $\lambda = 23.7\mu$ the same transmission that rock salt shows at $\lambda = 18.5\mu$. The curve of transmission for fluorite falls sharply and touches the axis of abscissas close beyond $\lambda = 11\mu$. Paschen* has also examined, in the communication cited above, the absorption of a fluorite plate to the wave length $\lambda = 9.43\mu$. If the transmission of a layer 1^{cm} thick is calculated from the data obtained by him, and the points are plotted in fig. 5, they show a very good agreement with the points observed by us. In order to distinguish between the points calculated from Mr. Paschen's values and those obtained from our results, the former have been plotted as crosses (+) and the latter as circles (○).

This agreement furnishes at the same time a proof of the pureness of our spectrum and of the correctness of our measurements on the dispersion of the rock salt and sylvine prisms.†

The dotted line (*a*) in fig. 5 gives the transmission of the chloride of silver plate 3^{mm} thick as a function of the wave length. A correction for the loss of energy due to reflection has not been applied to it.

In reviewing the results communicated in this paper, the conclusion is reached that it is possible with double dispersion, using two acute-angled prisms made of rock salt, to obtain sufficient energy in the infra-red spectrum out as far as $\lambda = 18\mu$, and that using sylvine prisms, one may attain to still greater wave lengths (about $\lambda = 23\mu$). To be sure, the amount of energy obtained after this method is much less than that obtained by repeated reflection on quartz or fluorite surfaces.

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* F. Paschen, Wied. Ann., li, p. 333.

† As a further test of the correctness of our measurements on dispersion, we took, in the above mentioned manner, measurements on the dispersion in an acute angled fluorite prism in the field between $\mu = 9.0\mu$ and $\lambda = 10.0\mu$ which were in good agreement with Mr. Paschen's results. The greatest departure from his values was 0.4 per cent in the wave length.

ART. VI.—*Studies in the Cyperaceæ*; by THEO. HOLM.

VII. On the inflorescence of the genus *Scleria*. With figures in the text.

THIS genus was first established by Bergius upon some plants, which Rolander collected in Surinam in the year 1755. But some species of this same genus were known to earlier authors, as appears from certain descriptions and figures, though previous to Bergius, no attempt had been made to separate these plants as generically distinct from other *Cyperaceæ*. Thus Rheedé, as early as the year 1686, figured a plant, which Dillwyn identified with *Scleria lithosperma*; Morison's "*Cyperus Americanus major Lithospermi semine*" seems also to represent some species of *Scleria*, while Plukenet's plant "*Gramen cyperoides Lithospermi semine, Virginianum*" is of rather doubtful relationship. But Sloane described and figured a true *Scleria* from Jamaica, and Elmgren's "*Schœnus secans*" belongs undoubtedly to this genus. No further record seems to have been given of this peculiar genus, for which Bergius selected the name "*Scleria*."

We might state at the same time, that the derivation of the name, commonly given as "*σκληρία*, hardness, from the indurated fruit," is not correct. It is derived from *σκληρός* in the sense of severe and merciless, since Bergius states that his species *Scleria Flagellum nigrorum* was used as a whip for the punishment of slaves in Surinam. The stems of this species are exceedingly sharp-angled and prickly, and tied together they formed a most cruel and painful instrument of punishment, hence the derivation from *σκληρός*.

Examining the generic diagnosis given by Bergius, it is interesting to notice that he observed the perigynium, alluding to it in the following words: "*Semen, basi cinctum perichætio membranaceo, ciliato-setaceo.*" This term "*perichætium*" was adopted by Bischoff for those membranaceous or setaceous organs which are often observed in female flowers of certain plants. Besides this, Bergius mentions the distichous bracts, the bony, snow-white fruit and the unisexual flowers, which characters are perfectly sufficient for the establishment of the genus. Most peculiar is the structure of the so-called perigynium or discus of the female flower, which Eichler thought might represent abortive stamens. It shows great differences of structure in the various species. In *Scleria pauciflora* Muhl. it is a low triangular disk upon which three pairs of minute wart-like organs are to be observed. We might

define these organs as representing two whorls of rudimentary leaves, three in the exterior and six in the interior whorl, corresponding to Boeckeler's "perigynium duplex." This perigynium varies greatly, as we have stated above. In *S. reticularis* Michx. there are only three, but very distinct, lobes in the inner whorl, while in *S. triglomerata* Michx. these organs are reduced to a minutely papillose cupule. It is, also, to be noted, that while the inferior disk remains with the bracts, the superior falls off with the fruit. The presence of these two whorls of rudimentary organs might warrant the supposition that they represent formations analogous to the dimorphous perianth-leaves, which we described in another article as characteristic of *Fuirena squarrosa* and *scirpoidea*. We feel inclined to consider these organs as perianth-leaves, rather than abortive stamens, inasmuch as the male flower in this genus has but three stamens, or sometimes two or even one only.* A double whorl of true stamens is, according to Pax known only in the genera *Reedia*, *Lepidosperma*, *Elymanthus*, *Evandra* and in a few species of *Gahnia* and *Lamprocarya*.

In regard to the bracts, which belong to the male and female inflorescences, we can state that in *Scleria pauciflora* Muhl. the male spikes are composed of several spirally arranged bracts, each of which subtends a staminate flower, while the one-flowered female spike bears constantly three distichous bracts, of which the two lower ones are empty. In the androgynous spikes the basal female flower is preceded by only one empty bract. It is to be noted, furthermore, that the distichous arrangement of the bracts in the female spike is transverse to that of the supporting leaf, and that the first empty bract succeeding the prophyllon is placed to the right of the rhachis, which is to be seen from the accompanying diagram (fig. 1).

None of the flowers possess any prophyllon, but a clado-prophyllon is constantly developed at the base of each lateral peduncle. This is very short, membranaceous, often emarginate and surrounds the peduncle with its free margins. Examining the inflorescence of *S. pauciflora*, we notice that the flowers are all arranged in spikes, forming together a more or less decomposed inflorescence. These spikes may be situated at the apex of the stem, supported by green leaf-like bracts, or there may also be developed a secondary inflorescence from the axil of one of the lower situated stem-leaves. The composi-

* The male flower is generally described as having from one to two stamens; this statement is, however, not correct, since we have observed three normally developed stamens in our North American species with the exception of *S. reticularis* Michx. and *S. Torreyana* Walp., in which we have only found two.

tion of the inflorescence is, however, the same whether it is developed near the apex or the base of the stem.

While our plant is not commonly diœcious, the flowers show a tendency to develop in separate spikes, as wholly male, as wholly female, or as androgynous. Of these the male spikes are always many-flowered but with an extremely short rachis, while the female have merely one flower. The androgynous ones are composed of several male and one single female flower, which is situated at the base of the spike. As regards the distribution of the sexes, the male spikes are usually gathered at the apex of the inflorescence, terminating the main stem or the lateral branches. Exclusively male plants have not been observed, though we have found several specimens with only female flowers developed, at the same time as the basal inflorescences of monœcious specimens were noticed to be exclusively female. Neutral flowers (reduced females) may accidentally be found in copious-flowered specimens.

A characteristic divergence between the male and female spikes lies in the development of the foliar organs, the bracts, which we have already indicated above. The male flower is subtended by a scale-like bract, which is not preceded by any empty ones, while such occur in the number of two in the female spikes, or of only one in the androgynous. Another and very striking character is that of a spiral arrangement of bracts in the male spike, in contrast to the biserial arrangement of the same organs in the female.

Essaying to demonstrate the general structure of the inflorescence in *Scleria pauciflora*, we may begin with one of the very small lateral ones, which often developed from the axil of the lower stem-leaves.

The accompanying figure 2 represents one of these lateral inflorescences, borne upon a long, slender peduncle (St.), upon which two leaf-like bracts (B^1 and B^2) are to be seen. In the axil of the first bract (B^1) is developed a one-flowered female spike, borne upon a very short peduncle with its prophyllon (P) at the base. This spike consists of two empty bracts (b^1 and b^2), preceding a third (b^3) which subtends the pistillate flower. The first of these bracts (b^1) is usually narrow and almost awl-shaped, while the inner ones are much broader and

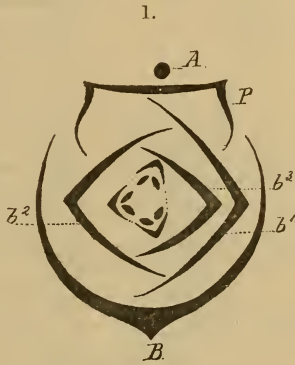


FIG. 1. Diagram of a female spike of *Scleria pauciflora* Muhl. A = the axis; B = the leafy bract, which subtends the spike; P = prophyllon; b^1 and b^2 = empty bracts, b^3 = bract subtending the female flower, of which the two whorls of the perianth has been drawn.

distinctly carinate. The bracts as well as the peduncle are

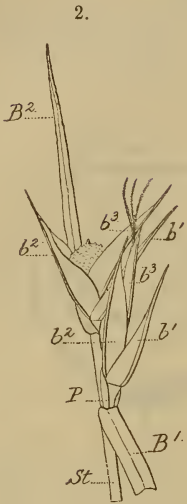


FIG. 2. Basal inflorescence of *S. pauciflora*. Explanation in the text.

more or less hairy, but we have not figured these hairs, since they would make the details of the spikes less distinct. Behind this axillary spike is another one to be seen, which terminates the peduncle and which, therefore, lacks the prophyllon. Just above the bract (B^2) is a short internode, upon which three scale-like bracts follow (b^1 , b^2 and b^3), the innermost of which encloses an almost mature fruit with its characteristic white and warty pericarp. The composition of the female spike becomes then merely reduced to a short rhachis, bearing three distichous bracts and a single flower, which has developed from the axil of the innermost bract. It might appear, according to this and similar depauperate inflorescences, as if the female flower were actually terminal, inasmuch as no rudimentary elongation of the rhachis was to be observed, but in view of the androgynous spikes, it seems most natural to suppose that the flower is axillary rather than terminal. As already stated, some specimens have been observed to be exclusively female, and these showed an arrangement of the flowers corresponding to that above described (figure 2), with the exception that a larger number, three or four, spikes were developed. When the spike is androgynous, the female flower is constantly situated in the axil of the second bract (b^2) as shown in our figure 3, while the first male flower (S) develops in the axil of the third bract (b^3). This last bract attains a larger size than in the female spikes, while the succeeding bracts, all subtending male flowers, decrease in size and texture, the innermost being very narrow and membranaceous. The female flower is thus preceded by only one empty bract in the androgynous spikes, and the first male flower appears immediately within the third bract. This circumstance seems to support our theory of the female flower as being axillary and not terminal. The biseriate arrangement of the bracts in the female spike

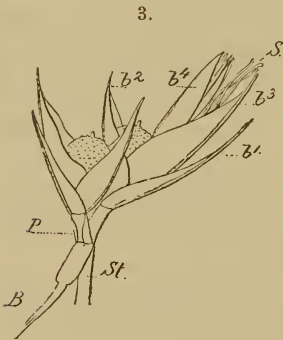


FIG. 3. A female and an androgynous spike of *Scleria pauciflora*. Explanation in the text.

is thus preceded by only one empty bract in the androgynous spikes, and the first male flower appears immediately within the third bract. This circumstance seems to support our theory of the female flower as being axillary and not terminal. The biseriate arrangement of the bracts in the female spike

recurs in the androgynous at least as far as concerns the lower four (b^1 – b^4).

Having examined now the minor inflorescences as they occur in *Scleria pauciflora*, we may transpose these to the larger and fully developed, of which a representation is given in the accompanying figure 4. It may at a first glance seem somewhat difficult to separate the constituents of these fasciculate spikes, but if we bear in mind, that a prophyllon (P) is developed on each of the lateral branches and that the bracts of the pistillate spikes are distichous, the composition of the inflorescence becomes much simplified. Our figure shows the presence of four leafy bracts (B^1 – B^4) each of which subtends lateral inflorescences, decomposed or single. The peduncle, which has developed in the axil of the bract, B^1 , bears a prophyllon (P) and a bract (B^2), which latter subtends a very short peduncle with a young pistillate spike, while a mature female inflorescence terminates the main peduncle, developed from the axil of the bract (B^1). The same becomes repeated if we consider the succeeding inflorescence in the axil of the bract above (B^3). Also here

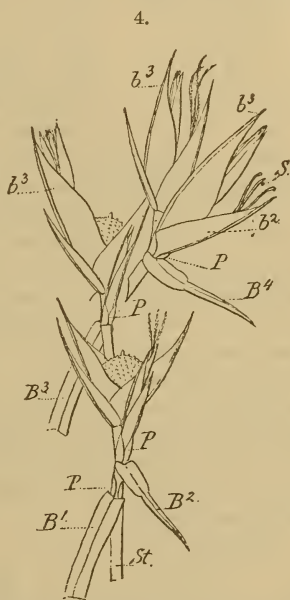


FIG. 4. Inflorescence of *S. pauciflora*. Explanation in the text.

are two spikes, the lateral being very young and exclusively female, the terminal on the contrary androgynous and mature. A single wholly male spike is developed in the axil of the uppermost bract (B^4), and we notice here the usual prophyllon, but no empty bracts. The terminal spike is androgynous and exhibits the same structure shown in our figure 3.

This form of inflorescence seems to be characteristic of the most common North American species of *Scleria*, viz: *S. pauciflora* Muhl. and *S. triglomerata* Michx., besides that we have, also, observed it in *S. ciliata* Michx. and *S. oligantha* Michx. The arrangement of the spikes is principally the same in two other species, *S. reticularis* Michx. and *S. Torreyana* Walp., but the structure of their spikes is somewhat different. There are no androgynous spikes in these two species, but the staminate one (fig. 5) has three empty bracts (b^1 – b^3), which exhibit a distinctly biseriata arrangement like those of the pistillate spike, with which they furthermore agree in size and shape; but no rudiment of any flower was found within these.

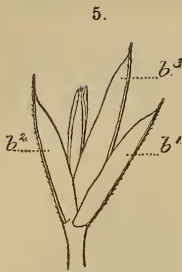


FIG. 5. Staminate spike of *S. reticularis*. Explanation in text.

The inflorescence of *S. Baldwini* Steud. and *S. gracilis* Ell. is principally the same as we have described for *S. pauciflora* Muhl., with the only exception that the spikes are here gathered in compact fascicles at the apex of the stem. *Scleria hirtella* Swtz. and *S. verticillata* Muhl. exhibit, on the other hand, a very different position of the spikes, since these are here situated in sessile, roundish fascicles along the stem with the subtending bracts very short and bristle-shaped. Otherwise the minor structure of the spikes is the same as described for *S. pauciflora*.

The North American representatives of our genus show thus a very uniform arrangement of flowers and minor inflorescences, and they belong to the group "Spicatae" of Boeckeler (l. c.), well distinguished from the other groups "Paniculatae" and "Corymbosae." The structure of the inflorescence in our species of *Scleria* does not therefore furnish characters sufficient for the distinguishing of species. Such characters must be sought in the shape and structure of the pericarp, and in the peculiar perianth, both of which have been described so very carefully by Boeckeler in his work, to which we have so often referred.

Washington, D. C., June, 1897.

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ART. VII.—*X-Rays and Mineral Phosphorescence*; by
JOHN E. BURBANK.

IN January, 1897, while experimenting at Bowdoin College on fluorescent screens for the X-rays, the attention of the writer was attracted by the fluorescence of minerals under the action of these rays.

Doubtless others have experimented on this subject, but the writer has been unable to find more than a brief note stating the mere fact of fluorescence under action of X-rays. Some of the following results, therefore, may be of interest. Fluorite when exposed to X-rays phosphoresces with a bluish white light which continues for a very long time after being removed from the influence of X-rays. It has been placed by some experimenters under the photographic plate in radiography, to increase the effect of the X-rays; but unfortunately it fogs the plate and blurs the outline of the image.

Very many minerals were tried and more than two-thirds were found to be phosphorescent to a greater or less degree. The group of minerals containing Ca were most susceptible to the X-rays. Of 16 specimens tried 12 were phosphorescent, with light varying from pure white to yellowish red. The feldspar group is also susceptible, also others of the silicates; but in general minerals containing ores of the metals are non-phosphorescent.

Of all substances tried fluorite and calcite seemed the most suitable for experimentation, and all the experiments were performed with these minerals, outside the X-ray tube, in a perfectly dark room. It is well known that both light and heat radiations can produce luminous effects in the case of mineral crystals, and these effects are very much like those produced by X-rays; at least far as the eyes can judge; but if we heat the crystals and then expose them to the radiations coming from an X-ray tube, the character of the light is often changed. For example:

Glass, which fluoresces bluish, if sufficiently heated loses its power while hot; but as it cools the light can be seen slowly creeping back over it; when cool it regains its former condition.

With fluorite the effect is similar except that the light, instead of disappearing, is weakened and fades out sooner than that from the unheated, when removed from the influence of the X-rays. If fluorite is heated very hot the phosphorescent light is very much weakened.

With calcite, which phosphoresces a pale reddish yellow, the effect of heat is to brighten very much the light emitted, and

to change its color to white. The effect of heat is very striking with calcite which has been heated to redness and allowed to cool so that it is just invisible; then when exposed side by side with the unheated it is nearly twice as bright as the latter. On cooling it regains its former color and intensity of radiation.

The effect of heat on other crystals in some cases causes increased emission of light, in others diminished effect, and in several cases no effect was observed.

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ART. VIII.—*Phosphorescence produced by Electrification*;
by JOHN TROWBRIDGE and JOHN E. BURBANK.

VARIOUS investigators have stated that the X-rays can communicate an electrical charge to bodies. We were interested to discover whether this statement could be verified by means of the phenomena of phosphorescence. When fluorite, in the state of a comparatively coarse powder, is heated to a low red heat for about an hour, it loses completely its power of phosphorescing under the effect of a low red heat; if it is then electrified by means of the brush discharge of an electrical machine, and then submitted to a low red heat, it suddenly phosphoresces. In this connection it is interesting to note a statement of E. Becquerel upon the effect of electric sparks on phosphorescent bodies. In his work entitled "*La lumière ses Causes et ses Effects*,"* he says, "In order to submit the substances to the action of electric discharges they were placed directly upon an insulated stand, if they were in fragments—or in tubes if they were in the state of powder—in such a manner that the discharge terminals were two or three centimeters apart. One or many electrical discharges are then passed from Leyden jars between the terminals. We then find that not only the bodies in question become phosphorescent after the passage of the discharge; but also, as is seen later, they are made phosphorescent by these electrical discharges when subjected to heat, even if before having been submitted to the action of the discharges, they had been calcined so long as to be entirely deprived of the power of phosphorescence by elevation of temperature. The electric light acts, therefore, like sunlight, but with greater energy by reason of its greater intensity on account of the position of the bodies; and it is capable of making bodies acquire phosphorescence which did not previously possess it. There is no necessity of submitting fluorspar or the diamond to heat immediately after having been exposed to the discharges. The elevation of temperature can take place even after the lapse of some months?"

Becquerel evidently attributed the effects observed to the light of the discharge, for he says further, p. 55 *id.*, "The electric spark acts only by its light, but its action is more energetic than that of sunlight by reason of its great intensity and the proximity of the source."

In an article on luminescence by E. Wiedemann and G. C. Schmidt the conclusion is reached that the violet light alone of

* Paris, 1897, p. 55.

electrical discharges does not cause phosphorescence; but the phosphorescence is due to peculiar discharge rays analogous to cathode rays.* M. W. Hoffmann has confirmed Wiedemann's work.† The latter states that no "Entladungsstrahlen" could be detected in the brush discharge.

With the preparation of fluorite, we have mentioned above, no effect was produced by the light of the electrical discharge. It was submitted, according to the method of Becquerel, to the light of the spark; and it was also exposed to the light of burning magnesium, and to that of the voltaic arc; and no direct phosphorescent effects could be produced, nor by subsequent heating. It phosphoresced, however, on heating after having been electrified by the brush discharge. The phosphorescence was evidently an expression of the electrical energy, which was communicated to the substance, and this energy was suddenly converted into light by the action of the heat in dispelling the electricity. The substance was next subjected to the action of the X-rays, in a brass box, closed by an aluminum window. The box was also connected to the ground. When the substance was taken from the metallic box it showed no phosphorescence, but on being heated it exhibited a bright phosphorescence which quickly disappeared.

The action of the X rays on this mineral was exactly similar to that of electrification; and we cannot but regard our experiments as an evidence of the electrical nature of the action of the X-rays. By them an electrical charge is communicated to a fluorescent and phosphorescent substances. The resulting electrical energy, in being dissipated, produces the phenomenon of light. By heating crystals which have been electrified, we produce a sudden dissipation of the electrical energy which has been communicated to the particles of the phosphorescent substance—either by direct electrification or by the electrification produced by the X-rays.

Most phosphorescent substances, after having been submitted to sunlight or daylight, glow more strongly when heated. The phosphorescence, however, dies out quicker after the process of heating, which seems to cause the energy communicated to the substance by light to become dissipated more quickly. The same thing is true of the state of phosphorescence communicated by the X rays. Can we, therefore, conclude that the phosphorescence excited by sunlight or daylight is due to an electrical condition which can be dissipated by heat? This supposition seems to us not inconsistent with the electromagnetic theory of light, and phosphorescence may be an evidence of the electrical stresses which produce the phenomena of ultraviolet light.

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* Wied. Ann., lvi, 1895, p. 237.

† Wied. Ann., No. 2, 1897, p. 273.

ART. IX.—*Electromotive Force*; by JOHN TROWBRIDGE.

LORD KELVIN in a paper dated April 12, 1860,* entitled *Measurement of Electromotive Force* required to produce a spark, states that "there is a much less rapid variation with distance of the electrostatic force preceding a spark at the greater than at the smaller distance. It seems most probable that at still greater distances the electrostatic force will be found to be sensibly constant, as it was certainly expected to be at all distances."

Having at my command a very much improved Planté rheostatic machine with sixty condensers of 15x80 inches coated surface, I have been enabled to greatly extend my studies of high electromotive force, and to investigate the conditions necessary to produce sparks of great body and forty-eight to fifty inches in length. The accumulator which was used to charge the rheostatic machine in parallel had a voltage of 20,000, and the machine could then give me 1,200,000 volts. The length of spark which corresponds to the voltage is very closely forty-eight inches. Professor Elihu Thomson, by means of transformers, has obtained sparks of fifty to sixty inches in length, and has estimated the necessary voltage to produce a spark of 80^{cm} at 500,000.

This estimate A. Heydweiler† thinks is very much too great and he believes that 100,000 would be nearer the truth. My investigations show conclusively that the estimate of Professor Thomson is far nearer the truth than that of Heydweiler, and instead of being lessened it should be increased.

In a late paper on the tension at the poles of induction apparatus A. Oberbeck‡ states that a potential difference of 60,000 volts under given conditions can produce a spark of more than 10^{cm} in length. It is difficult to obtain consistent results by the use of induction coils and transformers.

My results show that Lord Kelvin's conjecture that the electrostatic force necessary to produce a spark in air remains sensibly constant for all distances beyond the limit he describes, is correct; for when the length of spark is plotted as abscissas and the corresponding electromotive force as ordinates a straight line is obtained. Planté calls attention to the fact that the loss of energy resulting from the transformation of dynamic into static electricity is in the case of his apparatus much less than in induction apparatus. This remark applies with great force to the modern use of transformers for the production of

* Papers on Electrostatics and Magnetism. Macmillan, London, 1872, p. 258.

† Wied. Ann., 48, p. 231, 1893.

‡ Wied. Ann., No. 9, p. 109, 1897.

high tension effects. With the improved form of rheostatic machine which I have had constructed, one-third of a horse-power will produce the effects which have hitherto required the employment of thirty to forty horse-power. The condensers in this apparatus were very uniform in thickness, and the charging and discharging method was a complete departure from that adopted by Planté. All forms of rotating cylinders carrying contact pieces were abandoned and two lever arms were used to charge the condensers in parallel and then to discharge in series. Great uniformity of action was thus secured. The spark produced by the apparatus have very great disruptive effects and produce a report like the discharge of a pistol. The electrostatic field in the neighborhood of the terminals is very intense, and the wires leading to the spark gap emit brush discharges which extend at least twelve inches from the surface of the wire. I was interested to observe the effect of such powerful discharges through Crookes's tubes, and therefore placed a tube which had been exhausted to such a degree that sparks eight inches in length preferred to pass through the air from terminal to terminal of the tube rather than to pass through the rarified space. The disruptive discharge produced by the machine passed readily through such a tube and showed the X-rays with great brilliancy; moreover the degree of rarification of the tube was not sensibly altered by single discharges of such high electromotive force.

The results so far obtained by the employment of this apparatus prove that the length of spark is proportional to electromotive force. Rarified spaces hitherto considered too high vacua to conduct electricity cease to act like such vacua to very high electromotive force.

Jefferson Physical Laboratory.

ART. X.—*Surface Travel on Electrolytes*; by W. E. FISKE
and W. D. COLLINS.

To investigate the availability of Ohm's law for electrolytes when in circuit with alternating currents, has been the object of frequent research. The following are references to articles by Kohlrausch having a bearing on the subject: Pogg. Ann., cxxxviii, p. 370; Wied. Ann., vi, p. 1; xxvi, p. 164. Also in Wied. Ann., xxi, p. 667, E. Cohn gives an elaborate treatment of the matter. All these investigations showed that Ohm's law held in nearly every case, the only exception being that polarization at the electrodes seemed to increase the resistance slightly when the current was of a frequency as low as 100 or less per second. In view of the fact, however, that this work was in no case carried on with a current alternating more than 25,000 times per second, it seemed worth while to examine the resistance of an electrolyte to a current of much higher frequency.

The following work was carried on under the direction of Professor Trowbridge.

The method used was practically that described by Professors Trowbridge and Richards in an article in this Journal (vol. iii, p. 327, April, 1897). The electrolyte replaced the tubes of gas, and its resistance, together with that of the wires used for the standard, was measured with an alternating current.

The electrolyte, a saturated solution of copper sulphate, was contained in a tank a meter long and a square decimeter in cross-section. The electrodes were of sheet copper equaling in area the cross-section of the tank. The distance between them could easily be altered so as to give a column of variable resistance.

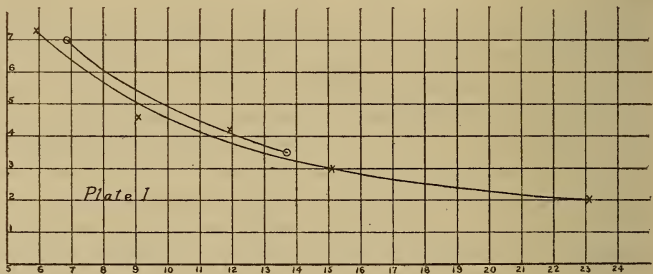
The plan followed was first to measure the resistance of a certain length of the solution on a Kohlrausch bridge. Next, with the solution in series with the spark gap, a photograph of the spark was taken, and the number of half oscillations corresponding to the length in question was plotted against its ohmic resistance. This was done for lengths of the solution of resistance varying from 6 to 24 ohms. The solution was then replaced by manganine wires of different lengths, and the operation repeated. These wires were 0.3^{mm} in diameter and stretched on both sides of thin vulcanite plates in order to eliminate self-induction. The curves thus obtained were then compared.

The result is shown in the four accompanying figures. Here ohms are plotted horizontally and half-oscillations vertically.

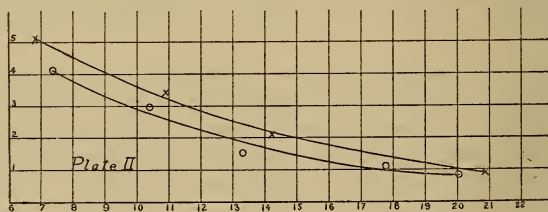
The points on the curves for the wires are indicated by crosses, those on the curves for the solution by circles. Each set of curves was made from a series of continuous observations, since, as may be seen at once by comparing the sets, isolated observations are evidently useless. The observations shown in Plate I were taken May 19, those for Plate II on May 24, and those for Plates III and IV on May 31.

Plates I and II show an apparent inconsistency, the curve for the solution being above that for the wires in Plate I and below it in Plate II. Naturally the curve in Plate I which contains only two points, is less reliable than that in Plate II, which contains six. The fact that in the observations for Plate I the photographs for the wires were all taken first, while in those for Plate II the photographs for the solution were all taken first, may have something to do with this inconsistency. In the case of Plates III and IV the observations were taken thus: first, two photographs for the solution, then two for the wires and so on.

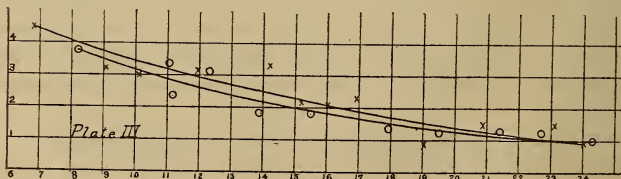
1.



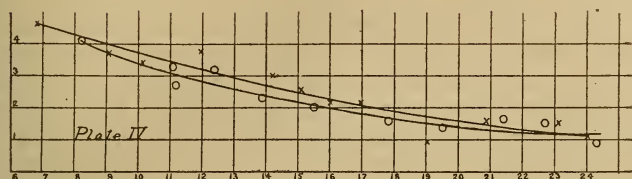
2.



3.



4.



In order to give uniformity to a set of results it was found necessary to scrape carefully the cadmium terminals of the spark gap before taking each photograph. The distance between the terminals was kept constantly at 1.5mm.

The average number of half oscillations of all the isolated sparks on any negative was taken as the representative number. The pilot spark was not counted. The oscillations for Plate III were counted by Mr. Collins, those for the other plates by Mr. Fiske. Plates III and IV were made from the same set of observations.

The free acid in the solution kept the electrodes constantly clean.

The wires themselves show no surface travel. This is indicated by Rayleigh's formula

$$R' = R \left(\pi r \sqrt{\frac{\mu \sigma}{T}} \right) \quad (\text{Phil. Mag. (5) xxi, p. 369, 1886}).$$

or by Stefan's

$$R' = R \left(\pi r \sqrt{\frac{\mu \sigma}{T} + \frac{1}{4}} \right) \quad (\text{Wied. Ann., xli, p. 421, 1890}).$$

Here $\mu = 1$; r , the radius, = .0165cm; σ , the specific conductivity, = $\frac{1}{4000000}$; T , the time of oscillation, = $\frac{1}{8000000}$ sec. approximately Neither of these formulæ holds because the factor in the parenthesis is in each case less than 1.

That the wires exhibit no surface travel was also shown experimentally. Wires of different sizes and materials but of approximately the same resistance, laid parallel to avoid self-induction, were placed in circuit, the sparks photographed, and the number of half-oscillations compared. The following table gives the result:

No.	Material.	Radius.	Resistance.	No. of half-oscillations.	Remarks.
1	German silver	0.36 ^{mm}	8.07 ohms	5	
2	Manganine	0.16	8.07	3.55	Doubtful
3	Iron	0.127	7.75	1.66	"
4	German silver	0.128	8.17	4.73	
5	" "	0.16	8.07	4.8	
6	Like No. 3			1.5	
7	" " 2			5.17	

With the exception of number 2, the negative for which showed only nine sparks, the manganine and German silver wires gave practically the same number of oscillations, namely 5, and we may conclude that there is no surface travel in their case. With the iron wire there is a marked "skin effect," owing doubtless to the large value of μ .

An examination of Plates III and IV, the most reliable results, shows that the points on the solution-curves unquestionably tend to fall below those on the wire curves. The evidence is, then, in favor of a surface travel in the electrolyte.

It is intended to carry this investigation further along the same line, for it seems very likely that, with an apparatus giving a higher period, the existence of a surface travel in electrolytes can be completely established.

Jefferson Physical Laboratory, Harvard University.

ART. XI.—*On Iron Meteorites, as nodular structures in Stony Meteorites*; by H. L. PRESTON.

[Read before the Rochester Academy of Science, Nov. 9th, 1897.]

It is an important fact that of over one hundred falls and finds of siderites or iron meteorites but nine have been seen to fall, while of the aerolites or stony meteorites of over four hundred falls and finds, some two hundred and sixty, or more than one-half, have been seen to fall.

Does this imply that during earlier centuries, the iron meteorites were more prevalent than at the present time, and *vice versa*, that during the present, the aerolites are more prevalent than during the past? This seems improbable, and the writer will present in this paper some suggestions as to the origin of iron meteorites that have occurred to him while handling many scores of these interesting objects.

In the first place, all the nodular masses of the iron meteorites, known as siderites, are believed to be of the same nature as the small specks, or grains of iron that occur in all the stony meteorites, these nodules being, at one time, surrounded by a magma or ground mass of stony matter, as are the specks of iron in the aerolites.

In all igneous rocks, where there is a concretionary structure, we know that the slower the cooling the larger the concretions; for when in a molten state, solidification commences at certain points. The slower the cooling, the greater amount of material gathered around these nuclei, or points of solidification. The law of molecular attraction—the affinity that an

element has for a like substance, requires time in which to act. As its period of action is of necessity confined to the molten condition of the mass, larger nodules would result during a protracted cooling than where solidification occurs more rapidly. The principle applies to meteorites. The degree of crystallization bears the same relation to time. When rocks become solidified beneath the surface, where the temperature is much higher than that of the atmosphere, the crystalline structure is well defined and marked, due to the slowness of solidification; whereas if solidification takes place after eruption, the crystalline structure is not perceptible, due to rapid solidification.

It is probably true that when iron meteorites enter our atmosphere, they are frequently associated with the stony magma in which they were formed, and the atmospheric resistance causing the mass to explode, would tend to separate this magma along planes of the nodular masses of iron, which, owing to their greater specific gravity, would reach the surface of the earth at a different time and place from their accompanying matrix.

The Estherville meteorite, which fell May 10th, 1879, is a case in point. A number of months after the fall and some four miles distant, were found over five thousand nodules of iron, ranging in size from a pea to a pound in weight. Now these are known positively to be portions of the Estherville meteorite, not only by their resemblance to similar masses found in the meteorite, but from the fact that a number of boys herding cattle near a pond, at the time the meteorite passed over them, saw a great shower of what appeared to be hailstones fall. They state that the surface of the water was alive with the falling bodies.

Therefore, if the larger masses of iron could occur only when the process of solidification was most abnormally slow, we would expect that the majority of meteorites reaching us would be those that contained but small nodules or specks of iron.

It seems probable that certain of the stony meteorites that have been found are really the matrices in which some of the iron nodules, found perhaps many miles distant, were embedded at the moment they entered our atmosphere.

Another distinct and most important point is that the rougher the exterior surface of an iron meteorite, and the deeper and larger its pittings, the more marked is its crystalline structure, and the greater the number and the larger the size of the troilite nodules, as disclosed by slicing and etching. On the contrary, if the exterior surface is comparatively smooth, on slicing and etching, we find the Widmanstätten

figures small, many times imperceptible without a lens, and the troilite nodules small in size and few in number.

In the first case we would infer that the process of solidification was a very slow one, permitting the crystalline structure to be large, and the concretionary nodules of the monosulphide, troilite, to be likewise large.

It is well known that the process of solidification, or crystallization of mineral matter, is a purifying one, and that the tendency is for the purest material in the molten mass to become the first crystallized. In the case of siderites, this would, of course, be the kamacite, and the slower the cooling the greater the amount of impure material cast aside, and the larger the crystals; thus giving the monosulphide a chance to segregate during a longer period of time, causing more numerous and larger troilite nodules than in the second instance where solidification has taken place more rapidly, hence giving less time for the purifying process. In the latter case we would expect a smaller number of the troilite nodules, as well as smaller in size.

It may be asked, why in the coarsely crystalline meteorites should the exterior surfaces be marked by large and deep pittings, while on those in which the crystalline structure is scarcely apparent these pittings should be almost entirely absent. The answer is that when the crystalline structure is coarse, the plates of kamacite are long and broad and the bands of tænite thick. Thus the tendency of separation in the mass would be between the plates of kamacite and the bands of tænite, and in its passage through the atmosphere fissures by the expansion due to heat, caused by friction, would be made along these planes, and cause them to separate, and thus masses would fall out. The rough ragged edges, where the separation took place, would be further fused and worn away until the base of the cavity was again comparatively smooth, causing large and deep pittings.

While in the case where the Widmanstätten figures are small, the blades of kamacite are narrow and short, the bands of tænite thin and there would be a much less chance of separation along these planes, and the degree of fusion over the whole surface would be comparatively the same, which would produce smooth, rounded exterior surfaces, with but few and shallow pittings.

In summary the two following points are affirmed :

First. That siderites have originally been encased in stony matter, and

Second. That the exterior surface of a siderite will give strong indications as to its internal structure.

Rochester, N. Y.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *Osmotic Pressure and Electrolytic Dissociation.*—The well-known Van't Hoff theory of osmotic pressure supposes that a substance in solution exercises a pressure equal to that which would be produced if the solvent were entirely removed and the substance left in the state of gas in a volume equal to that originally occupied by the solution. It has been shown by Arrhenius that if P is the osmotic pressure of a solution containing n molecules of a dissolved substance and N molecules of the solvent, d being the density of the solvent, D that of the vapor of the solution and T the absolute temperature, then P is proportional to ndT/ND . If n molecules are contained in unit volume of the solution (or of the solvent if the solution is very dilute) d/M may be substituted for N , where M is the molecular mass of the solvent. If the liquid solvent and its vapor have the same value for M , then at any constant temperature T , this value is a simple constant multiple of D for all solvents. Hence if n is constant, the osmotic pressure is constant, and it follows that n molecules of a dissolved substance in unit volume of any solution have, when the solution is dilute, the same osmotic pressure at constant temperature. COMPTON has now pointed out that the above assumption, i. e. that the liquid solvent and its vapor have the same molecular mass, is not justifiable. While it is true that many liquids are normal or "monomolecular," the molecules of the liquid being the same as those of its vapor, yet in quite as many other cases, liquids are found to be "associated," their molecules being built up of several gaseous molecules. In this case if M is the normal monomolecular mass, the liquid molecular mass will be αM , the value α being the factor of association, and representing the number of normal molecules going to form one molecule of the associated liquid; n normal molecules forming n/α liquid molecules. Hence the question arises, if association takes place in either solvent or dissolved substance, what effect will be produced on the osmotic pressure? Evidently this will be no longer constant but will vary proportionally to α . Now the hydrocarbons and their halogen derivatives, the ethers, most ethereal salts, most aldehydes and ketones and probably the acid anhydrides, may be considered monomolecular; while the alcohols and allied compounds, the organic acids, the oximes, some nitro-compounds, and compounds containing amidogen, may be viewed as associated. In place of using the osmotic pressure itself to test the question, certain relations between this value and certain other properties of solutions were used for the purpose. Thus, if r be the heat of liquefaction of a solvent whose density is d and absolute fusing point T , then for a monomolecular liquid having a normal vapor density, the value rd/T is con-

stant; while if the liquid be not monomolecular this constant must be multiplied by α/a where α is the factor of association of the liquid and a that of the vapor. From tabular results of r , d and T given in the paper, the value rd/T is calculated; and it appears that while the mean value for monomolecular liquids is practically constant at about 0.099, that for associated compounds, while consistent with the theory, is considerably greater, that for water being about 3 and acetic acid 2.71. Similar results are obtained from a study of the lowering of the freezing point. While monomolecular compounds in monomolecular solvents agree well with Van't Hoff's theory, associated compounds in monomolecular solvents, monomolecular compounds in associated solvents and associated compounds in associated solvents, differ from it considerably; though in the last case the values equal those required by the corrected theory when α/a equals α . Hitherto the deviations from Van't Hoff's theory of osmotic pressure obtained by the cryoscopic method have been explained by the hypothesis of electrolytic dissociation. But the above results clearly show that this hypothesis is entirely unnecessary for this purpose. No account has been taken of association in the liquid state, either for the solvent or the dissolved substance, and it is this which has necessitated the introduction by Van't Hoff of the now celebrated coefficient i for aqueous solutions upon which the hypothesis of electrolytic dissociation was founded. The author concludes as follows: "(1) Van't Hoff's law of osmotic pressure does not hold in its original form when either the solvent or the dissolved compound are associated. (2) The latent heat of fusion, melting point on the absolute scale, and density at the melting point, of a liquid, are connected by the expression $rd/T = \text{const.}$ for monomolecular liquids, or $rd\alpha/T\alpha = \text{const.}$ for associated liquids, the value of the constant being 0.099 or roughly 0.1. (3) The molecular reduction of the freezing point for monomolecular compounds in monomolecular solvents is given by Van't Hoff's formula $E = 0.01976T^2/r$ or by the derived formula $E = 0.2Td$. If, however, the dissolved substance or the solvent are associated, this formula no longer applies, but $E = 0.01976T^2\alpha/ra\alpha$, or $E = 0.2 Td/\alpha$. (4) Exceptions to Van't Hoff's formula for the molecular reduction of the freezing point, appear therefore whenever association of either dissolved substance or solvent takes place, and the hypothesis of electrolytic dissociation is not only unnecessary in explanation of these exceptions but inconsistent with what is now known of the nature of liquids. (5) Electrolytes are salts in an approximately monomolecular fluid state, in solution in associated solvents."—*J. Chem. Soc.*, lxxi, 925-946, August, 1897.

G. F. B.

2. *On the Electrolytic Decomposition of Aqueous Solutions.*—A lecture has recently been given by NERNST before the German Chemical Society in which he considers the chemical mechanism of the electrolytic decomposition of aqueous solutions. He showed in 1889 that the potential difference between a metal and

a solution may be calculated from the solution pressure of the metal and the osmotic pressure of the solution; and hence it follows that the electromotive force of a galvanic cell formed by combination of two different electrodes is easily obtained. Conversely, Le Blanc in 1891 determined the minimum electromotive force required to produce sensible electrolysis in a given solution. Since theory and practice were somewhat discordant, Le Blanc considered that in some cases water might act as a primary electrolyte and suffer direct decomposition by the current. According to his measurements 1.68 volts are necessary to do this; while Smale working under Ostwald's direction gives 1.08 volts as the maximum. Investigations made by Glaser in the author's laboratory show that in the case of sulphuric acid and potassium hydroxide solutions, a primary decomposition of water can be effected with an electromotive force of 1.08 volts, provided the positive platinized electrode on which the oxygen separates be large enough. The value 1.68 volts characterizes further decomposition in these solutions. Nernst suggests that possibly there may be dissociation of the water not only into the ions OH and H, but also into H, H and O, and that the latter ions correspond to the lower electromotive force, while the hydroxyl and hydrogen ions are set free by the higher one. An interesting table is given showing the voltage necessary to separate certain cations and anions from solutions of normal concentration. These are: Ag -0.78; Cu -0.34; H 0.0; Pb +0.17; Cd +0.38; Zn +0.74 for cations; and I 0.52; Br 0.94; O 1.08; Cl 1.31; OH 1.68; SO₄ 1.9; HSO₄ 2.6 for anions. To calculate the electromotive force, for example, required to electrolyze a normal solution of zinc bromide we have $0.94 + 0.74 = 1.68$ volts; while to decompose hydrogen chloride there is needed $1.31 + 0 = 1.31$ volts. Moreover from the above values a conclusion can be reached as to the possibility of separating certain ions electrolytically. Electromotive force, however, is only a single factor in these changes; the other factor, ionic concentration, must also be taken into the account.—*Ber. Berl. Chem. Ges.*, xxx, 1547-1563, July, 1897.

G. F. B.

3. *On the Direct production of Iron Carbide.*—As a crystalline carbide of iron Fe₃C has been shown by several observers to exist in fused or annealed steel, MOISSAN has investigated the direct action of carbon on iron in the electric furnace. When pure iron is heated with charcoal from sugar in this way, the mass becomes more and more viscous as the temperature rises, resuming its fluidity as it cools. But only about one per cent of carbon in combination was found in the cold metal. If therefore carbon and iron unite at a high temperature, dissociation must result as the mass cools. The same is true of nickel. In preparing diamonds it had been noticed that the interior of the iron contained brilliant crystals resembling iron boride or silicide. The conditions necessary to ensure combination, apparently, are to avoid saturating completely the iron with carbon, and to pre-

vent the formation of graphite. Hence Swedish iron was heated in a carbon crucible for three minutes by means of an arc given by 900 amperes and 600 volts, and the fused mass poured into water. A very hard, brittle metal resulted, frequently highly crystalline, containing 3 or 4 per cent of combined carbon but very little graphite. To isolate any carbide present, the author used (a) an electrolytic method and (b) the action of very dilute acids, out of contact with air. Normal nitric acid gives a carbide mixed with carbon, but a half normal acid gives practically pure carbide. After separating adhering impurities, iron carbide is obtained in the form of brilliant white crystals having the composition Fe_3C and a specific gravity of 7.07 at 16° . It is apparently identical with the carbide present in steel and is not affected by oxygen at the ordinary temperature, though it is acted on by moist air containing carbon dioxide. In the state of very fine division it ignites in the air below 150° . It becomes incandescent in vapor of sulphur at 500° , in chlorine below 100° , in bromine vapor at about 100° , and is decomposed by iodine at a red heat. Hydrogen chloride decomposes it at 600° with evolution of hydrogen containing traces of hydrocarbons; but heated in a sealed tube, the products of the reaction are hydrogen and methane. Neither water nor solutions of sodium or magnesium chloride have any action on the carbide at 150° .—*C. R.*, cxxiv, 716-722, April, 1897.

G. F. B.

4. *On the Production of Peroxides in Slow Oxidation.*—In order to test the question whether slow oxidation is always accompanied by the formation of peroxides, BACH has made numerous experiments, the results showing that nascent hydrogen, phosphorus, sodium, potassium, zinc, iron, lead, methyl alcohol, ethyl alcohol, isopropyl alcohol, glycerin, formaldehyde, acetaldehyde, benzaldehyde, glucose, acetic, oxalic and tartaric acids, ethyl ether, acetic anhydride, phenol, resorcinol, catechol, tannin, pyrogallol, dimethylaniline, diethylaniline, phenylhydrazine, formamide, acetamide, terebenthene, benzene, petroleum, quinine sulphate, morphine acetate, brucine and strychnine all give peroxides on slow oxidation in the air either in the light or in the dark. Since these compounds belong to very varied groups and since the oxidation involves the splitting up of the oxygen molecule $\text{O}:\text{O}$, it is reasonable to suppose that in the earlier stages of the oxidation, the substances combine with the grouping $\cdot\text{O}\cdot\text{O}\cdot$ to form peroxides, the splitting up of $\text{O}:\text{O}$ into $\cdot\text{O}\cdot\text{O}\cdot$ requiring less energy than into $\cdot\text{O}\cdot$ and $\cdot\text{O}\cdot$. Peroxides are also produced by energetic oxidation, and they may be detected in water on which a flame of hydrogen or carbon monoxide is allowed to play; percarbonic acid being formed in the latter case. Moreover these peroxides, when formed, facilitate further oxidation. When air is passed through a solution of indigo mixed with terebenthene or benzaldehyde the indigo is rapidly oxidized to isatin. Nascent hydrogen liberated from palladium produces a similar effect when oxidized by air, and in this case the indigo is com-

pletely oxidized when the quantity of active oxygen in the liquid is considerably less than that in the hydrogen peroxide that suffices to oxidize the indigo under ordinary conditions. The author regards these results as showing (1) that Hoppe Seyler's view that the nascent hydrogen splits up the ordinary oxygen into one atom with which it combines and another which is set free and is capable of producing energetic oxidations, is not tenable; and (2) that the intermediate product is probably not hydrogen dioxide but hydrogen tetroxide. In the blood the readily oxidizable substances first form peroxides and these oxidize the less readily oxidizable substances, in the same way that the peroxide formed by the terebenthene oxidizes the indigo. The so-called oxidizing ferments in the blood are simply readily oxidizable substances having a special aptitude for forming peroxides.—*C. R.*, cxxiv, 951-954; *J. Chem. Soc.*, lxxii, 401, Sept., 1897. G. F. B.

5. *On the Constitution of Phosphorous acid.*—It has been difficult to decide between the two formulas for phosphorous acid $P(OH)_3$ and $PHO(OH)_2$, since all the various reactions can be interpreted by either of them. MICHAELIS and BECKER have now obtained evidence of the existence of the latter form. On treating lead phosphite $PbHPO_3$ with ethyl iodide at 175° it yields diethyl phosphite $PHO(OEt)_2$; the same substance which Thorpe and North obtained by acting on alcohol with phosphoric oxide. This compound when treated in ethereal solution with sodium and then with ethyl iodide, yields diethyl ethylphosphinite $PEtO(OEt)_2$, which is isomeric with ethyl phosphite $P(OEt)_3$, though it differs from it in all its properties. Thus it boils at 198° , has a specific gravity of 1.025 at 21° and does not reduce mercuric chloride or precipitate magnesium mixture; while ethyl phosphite boils at 191° , has a specific gravity of 1.075 and reduces mercuric chloride. Diethyl ethylphosphinite is also formed when ethyloxychlorophosphine $PEtOCl_2$ is treated with sodium ethoxide. Ethylphosphinous acid stands to phosphorous acid, therefore, in the same relation as ethylsulphonic acid to sulphurous acid.—*Ber. Berl. Chem. Ges.*, xxx, 1003-1009, May, 1897. G. F. B.

6. *On the Manufacture of Ammonium Cyanide.*—It has been shown by LANCE that when ammonia is passed slowly over wood charcoal heated to 1000° - 1100° ammonium cyanide is always formed. The yield of cyanide is a maximum at this temperature and twenty-five per cent of the nitrogen in the ammonia is converted into cyanogen. This yield, however, is greatly increased if the ammonia be mixed with nitrogen and hydrogen, especially when the latter is in excess. Indeed the yield of cyanogen may be nearly 90 per cent of the ammonia when 200° of ammonia is mixed with 5000° of hydrogen and 500° of nitrogen. Under these latter conditions at least 70 per cent of the nitrogen in the ammonium cyanide is derived from the free nitrogen in the gaseous mixture.—*C. R.*, cxxiv, 819-821, April, 1897. G. F. B.

7. *Jahresbericht über die Fortschritte der Chemie und verwandter Theile anderer Wissenschaften.*—Begründet von J. Liebig und H. Kopp. Herausgegeben von F. Fittica. 1891, Viertes Heft, November, 1897; 1896, Erstes Heft. Braunschweig (Friedrich Vieweg & Sohn).—The fourth number for 1891 of this most valuable publication has recently been issued; it contains pages 1441-1920, with table of contents. With this has appeared also the first number for 1896, pages 1-324.

8. *The change of alternating currents into direct.*—This has been accomplished by various mechanical devices, and by employing an alternating current motor to run a direct current dynamo. L. GRAETZ calls attention to a very interesting method of accomplishing this purpose, which depends upon a remarkable property of aluminium. It has long been known that in an electrolytic cell in which one of the electrodes is of aluminum, a remarkable weakening of the current sent through the cell is produced if the aluminum constitutes the anode and if it is in the presence of oxygen, while no weakening of the current results if the aluminum is made the cathode. This phenomenon is variously explained. By some it is supposed to be due to a layer of badly-conducting oxide on the anode, by others to a resistance developed during the passage of the current, by others to a species of condenser working between the electrode and the fluid, and to a kind of dielectric polarization, which is not the common electrolytic polarization. The reason of this last hypothesis is based upon the fact that currents of less electromotive force than 22 volts cannot flow through the cell, and currents of higher electromotive force have their tension reduced to this amount.

The fact that after stopping the current no residual polarization, approximating to the value of the apparent polarization, can be found, is opposed to the idea of electrolytic polarization. A dielectric condenser effect, however, would explain this fact. The other electrode in the cell plays no important part. It can be made out of platinum or other metal. The author uses carbon, and any liquid which will develop oxygen on the electrode: he has especially employed alum solutions. If an alternating current is sent through a series of such cells, and if the number is sufficiently great, so that the anode polarization exceeds or at least is equal to the electromotive force of the alternating current, the positive portion of the current would be stopped by the cells and only the negative portions would pass through. The cells thus separate the positive currents from the negative, and by means of a simple arrangement of the cells an alternating current can be changed into a direct. Under certain conditions as much as 95 to 96 per cent of the energy of the alternating current can be changed into the energy of direct currents.—*Wied. Ann.*, No. 10, 1897, pp. 322-327.

J. T.

9. *Observation of air waves.*—Helmholtz has shown, that if a warmer and lighter layer of air moves over an under layer of

colder and heavier air, the same conditions arise as in the case of the wind blowing over a surface of water. Waves are formed on the surface of the under layer of air, which are perpendicular in direction to the wind and which follow each other at regular distances. These air waves can have very great dimensions. The same wind which would produce waves on water a meter long, could produce in layers of air which differ in temperature 10° , waves two to five kilometers in length. Sea waves five to ten meters in length would be represented by air waves fifteen to thirty kilometers in length. R. EMDEN describes a journey in a balloon from Munich—in November, 1896—and in the course of it he saw below him stretched over Munich great layers of clouds, which looked like giant sausages. Fifteen of these rolls or layers were counted, and they ran at right angles to the direction of the wind. The author discusses Helmholtz's paper, "On Atmospheric Movements" (*Gesammelte Abhandlungen*, iii, p. 309), and believes that the phenomenon he witnessed is exactly such as would result from Helmholtz's theoretical deductions.—*Wied. Ann.*, No. 10, 1897, pp. 374–378.

J. T.

10. *Light, visible and invisible*: A series of lectures delivered at the Royal Institution of Great Britain at Christmas, 1896; by SILVANUS P. THOMPSON. 294 pp. New York and London, 1897 (The Macmillan Company).—The special conditions under which the lectures here presented to the general public were delivered has determined the form and method of this volume by Professor Thompson. The general reader is the gainer, because of the simplicity and directness of the style adopted and the liberality in the introduction of illustrations. The volume occupies a somewhat new field, since it not only reviews the phenomena of light in the narrow sense, with a discussion of the invisible spectrum, but treats also of the long electric waves discovered by Hertz and further of the discoveries of Röntgen. An interesting chapter is devoted to the work of Hertz and his followers and an appendix follows on the electrical theory of light. The last lecture is devoted to the production and phenomena of the X-rays of Röntgen, which the author ventures to call "Röntgen light." This subject is clearly presented with numerous illustrations of a familiar kind. The appendix contains a summary of other kinds of "invisible light."

In the strictly optical part of the work the author develops the subjects of reflection, refraction, etc. from the wave theory, and in the appendix following shows how the essential formulas for lenses can be deduced by this method (see *Phil. Mag.*, Oct., 1889).

11. *Bibliography of X-ray Literature and Research* (1896–1897). Being a ready reference index to the literature on the subject of Röntgen or X-rays. Edited by CHARLES E. S. PHILLIPS. With an Historical Retrospect and a chapter, "Practical Hints," by the editor. Pp. xxxii and 68. New York, 1897. (The Electrician Company, London; D. Van Nostrand, New York.)—The literature of the X-rays has increased so rapidly since the publication

of Röntgen's paper, nearly two years since, that it is impossible for many of those now interested in the subject to keep themselves fully informed as to what other workers have done. Hence this carefully prepared and conveniently arranged bibliography will be found widely useful. It is intended to include references to all important papers that have appeared up to March, 1897. The editor has given in the introduction a brief summary of the historical development of the subject; he also adds a chapter giving suggestions as to the best method of overcoming some of the mechanical difficulties involved.

12. *Tafeln und Tabellen zur Darstellung der Ergebnisse Spectroskopischer und Spectrophotometrischer Beobachtungen.* Herausgegeben von TH. W. ENGELMANN, Professor in Utrecht. Leipzig, 1897 (Wm. Engelmann).—This publication includes ten copies of each of two accurate and well executed plates and two sets of tables. The first of the plates gives at the top the solar spectrum with the Fraunhofer lines and in line with this below five copies of the spectrum of white light with scale divisions arranged according to wave length (from 80 to 40). This plate is designed as a foundation to be used in recording the various absorption spectra under examination. The second plate gives at the top the usual colored spectrum with a similar scale, the position of the Fraunhofer lines are also indicated; below are a system of ruled horizontal lines, the vertical lines corresponding to the wave lengths and the horizontal lines arranged from 100 to 0. This plate is intended for use in the photometric measurements connected with the observations of absorption spectra; detailed suggestions are added in regard to the proper method of recording to be employed.

Of the two tables, the first gives the numerical values of the coefficients of extinction (e) for variations of light intensity (i) from 99.5 to 0.1. The second gives the relative intensities of the light transmitted through layers of thicknesses 1.0 to 0.1, relating to the amount of coloring material present.

II. GEOLOGY AND NATURAL HISTORY.

1. *Paleozoic faunas of the Argentine*; Professor E. KAYSER of Marburg, in an article entitled "Beiträge zur Kenntniss einiger palaeozoischer Faunen süd-Amerikas," (Zeitschr. d. deutsch. Geol. Ges., 1897,) has brought together a valuable description of the paleontological faunas of Argentine accessible to study in Germany. Five separate lots of fossils from different sources and collected by different hands were studied and results reached. These may be summarized as follows:

I. A Cambrian fauna from Iruya and Ojo de Agua in the province of Salta, Northern Argentina, in a grey, fine-grained quartzite sandstone, contains the following species, viz: *Liostracus Steinmanni* n. sp., *L. Ulrichi* n. sp., *Agnostus iruyensis* n. sp., *Orthis saltensis* Kays.?, *Lingulella* cf. *ferruginea* Salt., and *Lingulella* cf. *Davisii* Salt.

II. A Lower Silurian (Ordovician) fauna came from Portezuelo near Salta, in the province of the same name, and from Mudana in the province of Jujuy. The first was in a firm yellow quartz sandstone; and the second from a fine-grained, micaceous, somewhat slaty, yellowish grey sandstone. The fossils noted are *Megalaspis* sp., *Bellerophon* sp. and *Didymograptus* sp.

III. Another Lower Silurian fauna was obtained from a limestone in Cerro del Fuerte, east from Jachal in the province of San Juan. This fauna contains the species *Iliaenus Argentinus* n. sp., *Machurea Avellaneda* Kays., *Leptaena sericea* Sow., and *Orthis calligramma* Dalm.?

IV. The Devonian fauna occurs at several horizons in a series of rocks lying apparently conformably upon the Lower Silurian limestones, in the neighborhood of Jachal. The chief locality is at Cerro del Fuerte, east of the Jachal River. The rocks are described by Bodenbender as about 400 meters thick. The lower 200 m. consists of barren clay slates. In the upper 200 m. of slates and grauwacke there are three fossiliferous horizons. The lower zone contains *Leiorhynchus Bodenbenderi* and *Leptocoelia acutiplicata*; the middle zone contains besides the same *Leptocoelia*, also, *Chonetes fuertensis*, *Phacops*, *Homalonotus*, *Tentaculites*, *Bellerophon*, etc.; the upper zone contains *Spirifer antarcticus* (= *chuquisaca*), *Chonetes folklandica*, *Vitulina pustulosa* and several bivalves.

The second locality is west of the Jachal River, at Cerro del Agua Negra and at Cerro Blanco. The formation here is 2000-3000 m. thick, and is composed of grauwacke, sandstones, quartzites, slates and very subordinate beds of limestones. At the Cerro del Agua Negra locality only the first fauna appears with *Leior. Bodenbenderi*, *Leptoc. acutiplicata* and *Tropidoleptus fascifer*. At Cerro Blanco two higher faunas appear, the lower marked by numerous remains of *Lingula subalveata* and *Pholadella radiata*, and the upper by numerous conularia, starfish, crinoids, *Spirophyton*, etc.

The list of species of the Devonian fauna is as follows, viz: *Cryphaeus* sp., *Phacops* cf. *rana* Green, *Homalonotus* sp., *Orthoceras* sp., *Naticopsis*? sp., *Bellerophon* sp., *Bellerophon* aff. *Murchisoni* d'Orb., *Conularia Quichua* A. Ulrich?, *Tentaculites* sp., *Leptodomus* sp., *Pholadella radiata* Hall., *Allerisma*? sp., *Tropidoleptus fascifer* n. sp., *Liorhynchus Bodenbenderi* n. sp., *Liorhynchus*? *Brachebuschi* n. sp., *Meristella*? sp., *Leptocoelia acutiplicata* Conr., *Vitulina pustulosa* Conr., *Spirifer antarcticus* Morr. et Sharpe, *Orthothetes* sp., *Orthothetes* cf. *arctostriatus* Hall., *Chonetes folklandica* Morr. et Sharpe?, *Chonetes fuertensis* n. sp., *Chonostrophia* sp., *Lingula (Dignomia) subalveata* n. sp., *Orbiculoidea* cf. *humilis* Hall.

V. A few fossils of Devonian age are described from Coloolo and Chililaya, two points near the shores of the Titicaca sea. The rock in the first case is a hard blackish slate, the second is a yellowish, fine, sandy clay rock. The fossils reported are *Homa-*

lonotus sp. (recalling to the author most nearly *H. Herscheli* Murch. from Capland described by Salter), *Leptocelia flabellites* Conr. and *Retzia*? sp.

The study of the above faunas has led the author to make the following correlations:—The Iruya fauna he refers to the Middle Cambrian, or Paradoxides zone of the Swedish section, and he has revised his correlation of Cambrian fossils, previously* described from the Argentine Republic, referring them now, also, to the Paradoxides zone instead of to the Upper Cambrian according to his first conclusion.

The Lower Silurian fauna (2 and 3) is correlated with the north European "Orthocerankalk."

No trace of the Silurian (Ober-silur) has been discovered in the region, and the author quotes Prof. Bodenbender as reporting the Devonian as lying, by transgression, immediately upon the Lower Silurian limestone in the neighborhood of Jachal. The Devonian faunas (4 and 5) are found to represent more closely the faunas of the Hamilton and Upper Helderberg formations of New York than any other faunas of the northern hemisphere.

A review of the various known Devonian faunas of South America has led the author to the conclusion, that several faunas very closely related to each other extend over an immense extent of surface of that region of the earth. Also that the Devonian fauna of Capland is intimately associated with them. These faunas correspond closely to those of the Upper Helderberg and Hamilton formations of North America. All belong alike with them either to the younger Eodevonian or to the older Mesodevonian age, while the older Eodevonian and the younger Mesodevonian and the Neodevonian are not represented, paleontologically, at any point in the whole region, so far as at present known.

The fossils referred to in this interesting report were collected by Professors Bodenbender and Brackenbusch, and Drs. Berg, Valentin and Hettner.

H. S. W.

2. *Volcanoes of North America; a reading lesson for students of geography and geology*; by ISRAEL C. RUSSELL, pp. 1-346, plates 1-16, figures 1-71. 1897. (The Macmillan Co.)—Professor Russell introduces the general reader for the first time to a particular knowledge of the volcanoes of the North American continent, and to the peculiar phenomena and physical features traced directly to volcanic action. In the first chapter (pp. 1-126), the characteristics of volcanoes are explained by reference to those of sundry types found in all parts of the world. The selection of these examples is wisely chosen, because of the fuller knowledge we possess of volcanoes situated in the midst of the older civilized countries than of the American volcanoes, equally good as illustrations, but the very existence of many of which has been learned within the last half century. A brief chapter on the

* Kayser: Ueber primordiale u. untersil. Foss. aus der Argentinischen Republik. Palaeontographica, Suppl. 1878.

general distribution of volcanoes follows, and then in the third, fourth and fifth chapters descriptions are given of the several volcanoes, in the order of their distribution, found in Central America, Mexico and along the Cordilleran region of the United States to its most northern province Alaska, and in the Aleutian belt of islands, where the greater number are of volcanic origin. In these descriptions typical examples of volcanic mountains and of lava flows are selected for presentation, and they make a series of the author's characteristic portraits of nature, the more truly artistic and impressive because of their severely accurate and realistic nature. We are made to see these from the point of view of a scientific observer who has done not a little, himself, to explore and bring to light the American wonders of both fire and ice.

The theory of volcanoes is left for the seventh chapter, after the reader has learned what volcanoes are, and it is not till the facts and theories are both before us that the author gives free leash to the imagination and vividly depicts the life history of a volcanic mountain. The book is thoroughly readable and instructive, and the reader is referred all along the way to the original literature where fuller scientific elaboration of the facts may be found.

H. S. W.

3. *British Museum Catalogues: (Catalogue of Tertiary Mollusca in the Department of Geology, British Museum of Natural History. Part I. The Australasian Tertiary Mollusca; by GEORGE F. HARRIS, pp. i-xxvi, 1-407, plates I-VIII. London, 1897.)*

Catalogue of the fossil Cephalopoda. Part III, containing the Bactritidæ and part of the suborder Ammonoidea, by ARTHUR H. FOORD and GEORGE C. CRICK, pp. i-xxxiv, 1-303, figures in the text 1-145. London, 1897.

The two new numbers of the increasingly valuable series of British Museum Catalogues, whose titles are here given, have been recently received.

Mr. Harris, in the Catalogue of Australasian Tertiary Mollusca, has done a particular service to paleontology in bringing to notice the phylogenetic characters of the Gasteropoda, and in using the characters expressed in ontogenetic development of individuals for the close discrimination of the geological age of the faunas to which they belong. The plates contain a large number of illustrations of the protoconchs of Gasteropoda, beautifully drawn by Miss G. M. Woodward.

The Catalogue of the Cephalopoda is augmented by a volume on the Goniatices. The authors have brought the classification and nomenclature of Goniatices up to date, given a brief synopsis of the chief steps in the historical modifications in nomenclature. The figures are particularly valuable in bringing together representations of the suture lines for a large number of the species described.

H. S. W.

4. *Coral Boring at Funafuti.*—It is stated in *Nature* of Dec. 9, that the coral boring carried on in the atoll of Funafuti under

the supervision of Prof. David has reached a depth of 643 feet. In regard to the deposits passed through, three zones have been recognized. The *first* extended to a depth of 200 feet; of this 40 feet were made up of coral reef rock and below the material was also largely derived from corals with brief interludes of true reef. The *second* zone, from 200 to 373 feet, consisted largely of sandy material, sometimes a calcareous mud, with occasional coral fragments. These deposits are not reef but were doubtless formed in the neighborhood of a reef. The *third*, or lowest, zone corresponds apparently to the first; the character of the material suggested that it was formed near a reef which occasionally extended out laterally, building up layers of true reef upon detrital coral. Much of the rock pierced at this depth was a hard and compact coral limestone.

Prof. David, though not attempting as yet to discuss the theoretical bearing of the facts obtained, remarks that they prove that true reef has been pierced to a depth of more than 600 feet. Further, for the whole time represented coral must have been growing in great abundance in some part of the locality now represented by Funafuti, the atoll being completely isolated from all other coraliferous localities.

5. *Origin of the Diamonds of South Africa.*—In an article in recent numbers of the *Geological Magazine*, describing some rock specimens from Kimberley, South Africa, T. G. BONNEY presents his conclusions in regard to the origin of the diamonds and the volcanic phenomena of the region as follows:

I believe, as I have already stated, that the diamonds were not produced where they are now discovered, but, like the conspicuous olivine, pyroxenes, mica, garnets, and iron-oxides, had their origin at a much greater depth in the earth's crust. Thus I think it improbable that the carbon was obtained from the Karoo Shales. In other words, I consider the diamonds, whatever may have been their past history, to have come from the crystalline floor on which these shales were deposited, or to be at any rate Pre-Triassic in age. I see no reason why carbon should not be present in the earth's magma, whether it afterwards crystallized in a peridotite or in native iron.

Volcanic action probably began before the end of the Karoo epoch, as the great sheet of so-called melaphyre seems to be intercalated with its higher deposits, and some of the dykes may be approximately coeval with it. Afterwards (was it because of this impenetrable cover of lava?) the pipes were formed, probably in a short time, by a series of great explosions, caused by gases accumulated at considerable depth. These sent the outer part of the crystalline floor, including the diamonds, as well as the overlying Karoo shales, flying shattered into the air. Cones and craters may have been built up above these pipes, but I expect that, like some of those in the Eifel, they were never high, and that the shattered material mostly fell back, after a few explosions, into the pipes and filled them like the "necks" in Scotland.

Then the volcano, after some more lava had struggled to reach the surface (forming, at any rate, the dykes in the necks), passed into a solfatara stage, during which the numerous secondary changes mentioned above were produced, the carbonates were deposited, and the minor structure of the mass was obscured. Afterwards ordinary meteoric agencies began to work; water percolating from above still further affected the mass, more especially in its upper parts, producing the "yellow ground" and the "soft blue" and depositing tufa.

The result of this examination is to confirm me in my opinion that the diamantiferous rock—the so-called Kimberlite—is a volcanic breccia rather than a peculiar form of peridotite. While it is difficult, owing to secondary changes, to demonstrate the fragmental character of the matrix, I have failed to identify it with any form of peridotite (or serpentine) known to me, and I cannot understand how masses of that rock, the smallest of which is about 370 yards in diameter, masses of which one has been traced to a depth of 500 yards, could remain throughout in a practically uniform glassy condition.

6. *Les Diamants du Cap*; par L. DE LAUNAY. 226 pp., with many illustrations. Paris, 1897 (Baudry et Cie.)—The subject of the diamond production of South Africa is one which never fails to be of interest, and this recent contribution to it by Professor L. De Launay deserves the attention it will have from many readers. The author is well-known from his earlier volumes, the first an exhaustive treatise on mineral veins in general (this Journal, vol. xlvi, 309, 1893), and the second on the gold mines of the Transvaal (*ibid.*, ii, 88, 1896).

The present volume does not attempt to be a complete treatment on the diamond—such an one, for example, as was published some years ago by M. Boutan,—but is limited to the occurrence in South Africa with only a brief allusion to other regions. A recent visit to Africa has given the author opportunity to make original observations for himself. An account is given of the early discoveries here in 1867, and the gradual development of the industry from the time when a multitude of individual claims were worked at the various localities to the present condition of affairs, where the whole output is practically controlled by one syndicate. It is interesting to note that according to the table given by the author, the African mines in Griqualand have yielded since 1867 about 12,000,000 kilograms of diamonds, valued at \$360,000,000; this does not include the production of the Jagersfontein mine in the Orange Free State. A figure is given of the largest diamond which has been found—the Excelsior diamond of Jagersfontein; this is a mass of a rather irregular triangular form, three inches in its longest dimension and weighed as found 971 carats.

An interesting account is given of the geology of the deposits, with numerous illustrations, and then the author goes on to discuss the method of exploitation and the treatment of the various materials brought up in the mining. In regard to the method of

formation of diamonds in general, the author refers to the interesting and remarkably successful synthetic experiments by M. Moissan and concludes that the conditions of formation in South Africa must have been very similar.

7. *The Building Materials of Pennsylvania. I. Brownstones*; by THOMAS C. HOPKINS. 122 pp. Appendix to the Annual Report of Pennsylvania State College for 1896.—This is an interesting account of the Mesozoic brown and red sandstones used as building material in Pennsylvania. It discusses their general features with respect to chemical and mineral composition, microscopic structure, behavior under physical tests, and similar points, and further gives detailed descriptions of the various portions of the brownstone area in which quarries have been located. A brief summary of the brownstones from other localities in the United States closes the work. Some twenty-six full-page plates give illustrations of the quarries, prominent buildings and bridges in which the material has been used, and other points.

8. *A Catalogue of Minerals, alphabetically arranged, with their Chemical Composition and Synonyms*; by ALBERT H. CHESTER. Third edition; 56 pp. 8vo. New York and London, 1897 (John Wiley & Sons).—We have here an alphabetical list of mineral names now in use, including names of species, their synonyms, and prominent varieties. With the first is given a brief statement of the chemical composition. Collectors will find this useful as a check list.

9. *Synopsis Mineralogica; Systematische Uebersicht des Mineral-reiches*; by Dr. ALBIN WEISBACH. Dritte Auflage. 97 pp. Freiberg, 1897 (J. G. Engelhardt).—After an interval of thirteen years, Prof. Weisbach has given us a new third edition of his "Synopsis of Mineral Species." Its scope is too well known to require any special explanation. The many who have found it useful in the past will be glad to have it thus brought fully up to date.

10. *Eighth Annual Report of the Missouri Botanical Garden*.—Professor TRELEASE incorporates with his specific report as Director, three papers of high value. The report itself possesses much interest as indicating the great scientific activity of the establishment under charge of the director, and showing how symmetrically the work in different lines is being developed.

M. J. Cardot contributes a memoir entitled, *The Mosses of the Azores*, and a second paper, *On some mosses collected in Madeira by William Trelease, in June, 1896*. Professor Trelease presents a memoir, *Botanical Observations on the Azores*, in which he gives the results of his studies in these islands, during part of 1894 and 1896. It is needless to speak of this valuable communication in detail, but attention must be called to the thoroughness of the treatment, and the excellence of the illustrations.

The volume concludes with a list of the publications of the Garden, and of those issued by the instructors in the Shaw School of Botany, attached to it.

11. *Catalogus Mammalium tam viventium quam fossilium*, a Doctore E. L. TROUËSSART, Parisiis. Nova Editio (Prima completa). Fasciculus III. 664 pp., Berlin, 1897 (R. Friedländer & Sohn).

The last published part of this valuable work embraces pp. 453-664, and includes the Myomorpha, Hystrichomorpha, Lagomorpha of the Rodentia, II.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Institute of France, Cuvier Prize*.—At the session of the *Académie des Sciences* held at Paris, December 13, 1897, the Cuvier Prize of 1,500 francs was awarded to Professor O. C. Marsh, of Yale University. This prize is "awarded every three years for the most remarkable work either on the Animal Kingdom or on Geology."

2. *Mazama: A Record of Mountaineering in the Pacific Northwest. Crater Lake number*, vol. i, No. 2, 298 pp. Portland, Oregon, 1897. (Published by the Mazamas.)—The society, named the Mazamas, has as its main object the exploration of the snow peaks and other mountains of the Pacific Northwest, and the collection and dissemination of scientific knowledge in regard to this region. The first number of their publications was issued in May, 1896, and contained some twenty-two articles chiefly relating to the snow peaks, Mount Hood and Mount Adams. The second number, recently issued, is given to Crater Lake. It presents to the reader a series of articles by different writers, describing the scenic features of the lake, its discovery and early history, its geology, fauna and flora. A large amount of interesting and valuable information is thus brought together in regard to this remarkable spot. The numerous excellent plates which accompany the number give an excellent impression of the beauty of the scenery. It will be remembered that an article on the Geology of Crater Lake was published in this Journal for March, 1896, by Mr. J. S. Diller.

3. *Kleinasiens Naturschätze, seine wichtigsten Tiere, Kulturpflanzen und Mineralschätze, vom wirtschaftlichen und kulturgeschichtlichen Standpunkt* von KARL KANNENBERG. Mit Beiträgen von Prem.-Lieut. Schäffer. Mit xxxi, Vollbildern und II Plänen, pp. 274. Berlin, 1897. (Gebrüder Borntraeger.)—This is a concise and interesting summary of the prominent animals, the plants and trees, also the mineral resources of Asia Minor. To each section is added a summary of the literature of the subject and also a list of the Turkish and local names for the different objects.

The book is profusely illustrated by half-tone reproductions of photographs, which give a very satisfactory impression of the natural features and life of the region. Of the plates, two the most noteworthy are those showing the basaltic columns of Kurû Serâi near Boyabâd, which are remarkable for their height and regularity.

4. *Applied Mechanics*; by JOHN PERRY, F.R.S., pp 678, with 371 illustrations and 25 tables. London, 1897 (Cassell & Co.).—This book embodies the course of instruction in Applied Mechanics at the Finsbury Technical College, which is based on the laboratory method, each student being furnished with tools for measuring the quantities used in every discussion. It is described in the title as “a treatise for those students who have time to work Experimental, Numerical and Graphical Exercises illustrating the Subject,” and contains a wealth of material sufficient to equip a student in engineering with as ample and practical a store of knowledge as most would have time to appropriate. The style and arrangement are, like the subject-matter, excellent.

W. B.

5. *Fifty-second Annual Report of the Director of the Astronomical Observatory of Harvard College for the year ending September 30, 1897*; by EDWARD C. PICKERING.—The Report of Professor Pickering just issued gives a summary of the work done at Cambridge with the various observatory instruments; also of the photographs taken under the Henry Draper memorial, which have led, for example, to the discovery of 17 new variable stars; of the work at the station at Arequipa, Peru, and that at the Blue Hill Observatory.

6. *Ostwald's Klassiker der exakten Wissenschaften*, Leipzig, 1897 (Wilhelm Engelmann). Recent publications of this valuable series include the following:

Nos. 88, 89. *Krystallogometrie oder Krystallogonomie und Krystallographie*. Von Johann Friedrich Christian Hessell. (1830.) Erstes Bändchen. 192 pp. Zweites Bändchen, 165 pp.

No. 90. *Abhandlung über die Systeme von regelmässig auf einer Ebene oder im Raum vertheilten Punkten*. Von A. Bravais (1848). 1897. 142 pp.

No. 91. *Untersuchungen über verschiedene Anwendungen der Infinitesimalanalysis auf die Zahlentheorie*. Von G. Lejeune Dirichlet. (1839-1840.) 1897. 128 pp.

No. 92. *Ueber den natürlichen Zusammenhang der organischen mit den unorganischen Verbindungen, etc.* Von H. Kolbe (1859.) 1897. 42 pp.

Science Readers, by Vincent T. Musché. Revised and adapted for use in schools, with a preface by Mrs. L. L. W. Wilson, Ph.D., Philadelphia Normal School. Book I, 127 pp. Book II, 128 pp. Book III, 176 pp. Book IV, 216 pp. New York, 1897 (The Macmillan Company).

La Vie, mode de mouvement, Essai d'une théorie physique des phénomènes vitaux, par E. Préaubert, professeur au Lycée d'Angers. Paris, 1897 (Félix Alcan).

OBITUARY.

PROFESSOR WINNECKE, the distinguished astronomer, died at Bonn, on Dec. 3, 1897.

REV. SAMUEL HAUGHTON, D.D. of Dublin died on October 31, 1897. He was a man of keen, original mind and his scientific writings include a wide range of topics in Mathematics, Geology, Physical Geography as well as in his own department of medicine.

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ART. XII. — *The 27-Day Auroral Period and the Moon;*
by H. HELM CLAYTON.

SEVERAL years ago my attention was called to a tendency of auroral displays to recur at intervals of 27 days. This is illustrated by the following cases taken from the records of the Blue Hill Meteorological Observatory :

TABLE I.

	Interval.		Interval.		Interval.	
		Other Auroras.		Other Auroras.		Other Auroras.
1892			1893		1895	
Dec. 23	28		Dec. 29	29	Jan. 19	
1893			1894		Feb. 14, 15, 16	27
Jan. 20	26		Jan. 27	26	Jan. 2	
Feb. 15	55	Feb. 4	Feb. 22, 23		" 3	0
Apr. 11	26	" 5			" 4	
May 7					Mar. 14	27
					Apr. 10	27

This table gives all the auroras observed between the first and last dates in each of the series. In these instances the recurrence of auroras at intervals of approximately 27 days seems too well marked to arise merely from chance coincidence. For example, in the last series there are four auroral displays at exact intervals of 27 days and no intermediate displays. The probability of a casual arrangement of the auroral displays in this manner is inversely as the cube of 27, or as 1 to 19,683. That is, out of 19,683 auroral displays one chance arrangement of this kind might be picked out. But during three successive winters, as shown by the above table, there were auroral displays in series with an interval of 27 days plus or minus one day in each case, and with an average interval very slightly exceeding 27 days. The chance of this being merely an acci-

dental arrangement is calculable but is complicated by the fact that there were auroral displays on other days than those in the series. It is sufficient for my purpose to show that the probability of chance occurrence in series of this kind is so small that the more reasonable conclusion is that there is some natural cause for this grouping, and this, I think, is in evidence.

These sequences of auroras at intervals of about 27 days have been noticed before, and have heretofore been attributed to a connection of the aurora with the rotation period of the sun. Fritz in Europe, and Dr. Veeder and Professor Bigelow in this country have each maintained the existence of such a connection, though they differ somewhat in regard to the length of the period. The length of the lunar period formed by the oscillations of the moon to the north and to the south of the earth's equator is also about 27 days, and I was led to investigate the connection of this period with that of the auroras, especially as there seems a physical reason for such a connection. Dr. Nils Ekholm and Svante Arrhenius have shown (*Ueber den Einfluss des Mondes auf den electrischen Zustand der Erde*, Stockholm, 1894) that the difference of electrical potential between earth and air at the stations in northern Europe is greatest when the moon is south of the equator and least when the moon is north of the equator, while the reverse is true at Cape Horn. Their explanation is that the moon is an electrified body, charged negatively like the earth, and that when it is north of the equator it acts more directly by induction on the parts of the earth beneath, diminishing the electrical potential in the northern hemisphere between the earth and the air, while the potential increases in the southern hemisphere. The reverse takes place when the moon is south of the equator. For the purpose of comparing the positions of the moon north and south of the equator with the occurrence of auroras, I selected from the *Nautical Almanac* (for the data from which I am indebted to Professor E. C. Pickering) all the dates when the moon reached its greatest northern declination. Taking these as the first day of each period, I classified the numbers of auroras observed in the United States into periods of 27 days. The auroral data was taken from the *American Meteorological Journal*, vol. ii, p. 227, from the *Monthly Weather Review*, and from the *Proceedings of the Rochester Academy of Science*. Table II shows the number of stations in the United States reporting auroras on each day of the lunar period. Columns 1 to 6 show the totals in groups of fifty periods; column 7 shows the totals on each day of the lunar period for the entire interval of 23 years from 1870 to 1892; column 8 gives the departures of the totals of each day from the mean of the column. The results show a very

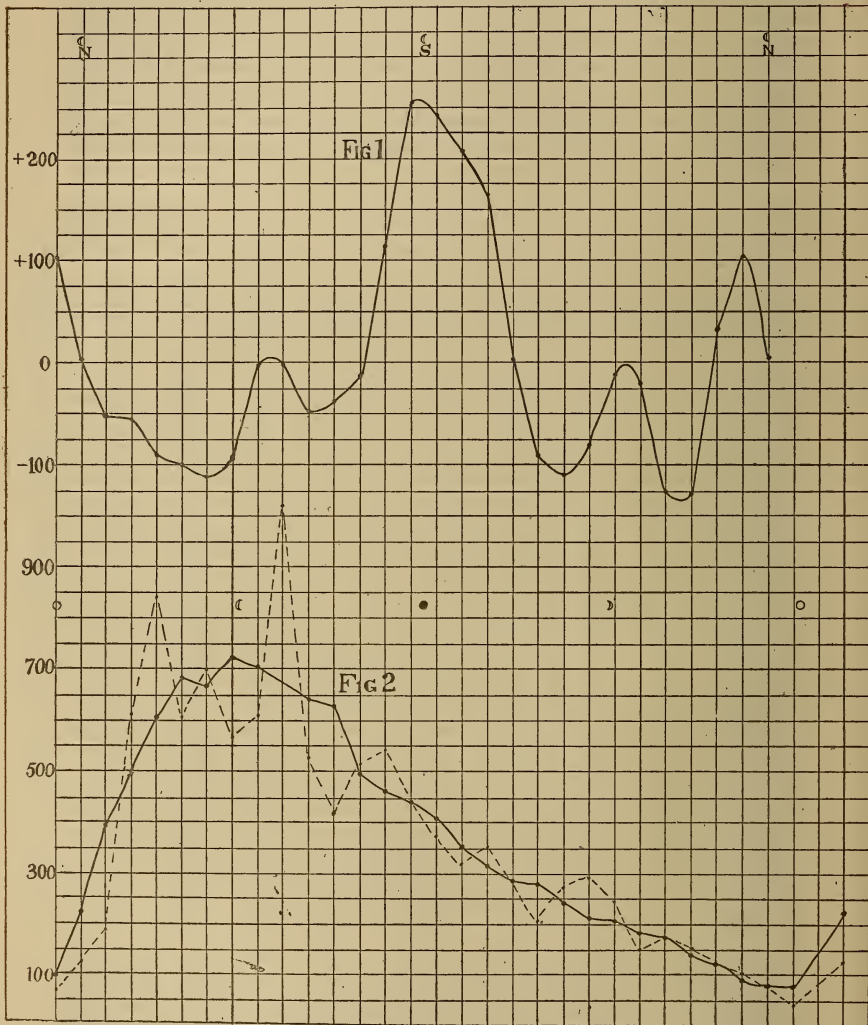
decided excess of the frequency of auroras at the time of the moon's greatest southern declination, and thus agree well with the results of Dr. Ekholm which show the greatest difference in potential between the earth and air in the northern hemisphere at this time. However, the residuals in column 8 show also an excess of auroras about the time of the moon's greatest northern declination and about the time of the moon's passage across the plane of the earth's equator. These excesses, unless accidental, are not easily explained by the theory of differences of potential produced by the induction of the moon. To see

TABLE II.

Day of Period.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	1870 to 1873	1874 to 1877	1878 to 1881	1881 to 1884	1885 to 1888	1889 to 1892	1870 to 1892	Dept from mean.	Mean of five.	Second order means.	1885 to 1888 Winter half-year.	1893 to 1896 Winter half-year.	1885 to 1888 Summer half-year.	1894 to 1896 Summer half-year.
⊙ N 1	75	77	117	188	229	75	761	+217	-10	+105	25	28	234	84
2	105	46	97	74	105	49	476	-68	+24	+5	17	39	78	116
3	77	60	45	91	113	98	484	-60	-10	-53	11	66	113	107
4	93	132	77	86	50	81	519	-25	-75	-55	8	45	54	147
5	74	65	105	86	26	76	432	-112	-73	-90	31	280	13	215
6	74	89	74	54	71	70	432	-112	-104	-98	27	407	35	150
7	50	77	74	80	111	97	489	-55	-77	-110	51	310	17	168
8	47	46	56	65	42	72	328	-218	-57	-94	24	171	68	126
9	139	149	100	107	93	68	656	+112	-51	-2	56	665	23	35
10	121	161	57	91	64	35	529	-15	-41	-1	62	635	14	31
11	88	69	71	112	69	52	461	-83	-9	-46	96	248	11	51
12	115	73	101	89	108	55	541	-3	-19	-36	57	391	34	99
13	89	76	85	44	124	69	487	-57	+62	-13	66	95	21	33
14	91	210	88	54	118	48	609	+65	+116	+115	154	257	35	56
15	168	294	59	77	240	93	931	+387	+159	+256	146	164	69	98
⊙ S 16	221	115	39	103	124	128	730	+186	+220	+243	110	85	76	95
17	151	251	77	74	143	61	757	+213	+196	+215	82	80	49	139
18	87	266	72	233	93	43	794	+250	+101	+165	57	690	39	84
19	71	99	32	93	132	63	490	-54	+38	+3	62	140	21	69
20	59	69	49	97	94	86	454	-90	-23	-90	47	173	16	78
21	44	64	51	80	65	115	419	-125	-73	-109	42	159	34	87
22	127	46	56	90	54	76	449	-95	-51	-79	28	133	106	112
23	71	53	79	166	107	68	544	0	-69	-11	38	102	98	173
24	114	57	85	70	139	133	598	+54	-83	-18	8	48	68	106
25	60	39	52	88	86	40	365	-179	-53	-125	29	48	37	49
26	50	43	27	112	57	60	349	-195	-9	-128	20	43	52	80
27	69	186	107	85	103	60	600	+56	-30	+33	11	39	94	95

what effect smoothing would have on the somewhat irregular numbers in column 8, the mean of each consecutive five was taken and the results are given in column 9. In this column the slight maxima found in column 8 at the time of the moon's equatorial passage are smoothed out, but the maximum at the time of the moon's greatest northern declination is still prominent. However, if instead of taking the mean of five, the

smoothing is done by taking the second order of means, that is, by taking the mean of each two and then the mean of each two of these means, the results when plotted give a



smooth curve without destroying any of the features of the original residuals. The results of this second smoothing are given in column 10 and plotted in the accompanying diagram, fig. 1. The numbering of the days of the period in the table is made to begin one day before the time of greatest

northern declination of the moon. As shown in column 12 the excess of auroras on the fifteenth day, that is at the time of greatest southern declination of the moon, is 46 per cent greater than the mean; while at the times of minima on the seventh and twenty-first days the frequency of auroras is 20 per cent less than the mean. This range of 66 per cent in the frequency of auroras in the totals of three hundred successive periods is entirely too large to be considered accidental.

Each group of auroras of 50 periods given in columns 1 to 6 shows the same general distribution of auroras as the totals. In order to see whether the period remains the same through the different seasons of the year, two groups of data were classified into periods, as described before, and summed for the winter and summer half-year separately. The data for the two groups were taken from tables found arranged conveniently for the purpose, the first by Dr. Veeder in the Proceedings of the Rochester Academy of Science, vol. ii, Plate II, and the other by the editor of the U. S. Monthly Weather Review in that publication. The first covers the four years 1885 to 1888, and the other the three years from October, 1893 to October, 1896. The results are given in columns 11 to 14, Table II. These columns show that there is a strong indication of the reversal of the period between the winter and summer half-years. In the winter half-year the maximum is found near the time of the greatest southern declination of the moon, while in the summer half-year the maximum is found near the time of greatest northern declination of the moon. In attempting to discover the cause of this phenomenon, I noticed that in my table of auroras arranged in periods of 27 days there was a strong drift of the larger numbers to the right, and of such an amount as to indicate a period of about 29 days between them. This period I at once inferred to be the same length as the synodic revolution of the moon, and its cause to lie in the fact that more auroras were seen in the dark of the moon than in the opposite phase. In order to determine to what extent the frequency of reports of auroras was thus affected, the intervals from 1885 to 1888 and from 1894 to 1896 were divided into periods of 30 days, beginning each period with the date of full moon as taken from the Nautical Almanac. The number of stations in the United States reporting auroras on each date was entered in a table in its proper place beginning with the date of full moon, and the totals were obtained for each day of the period during the two intervals mentioned. The results are given in Table III. In column 1 are given the totals for each day of the period from 1885 to 1888, and in column 2 are given the totals for each day of the period from 1894 to 1896. In column 3 are given the totals of

TABLE III.

	1	2	3	4	5
	1885 to 1888.	1894 to 1895.	Totals.	Mean of 5 Days.	Second order Means.
☾ 1	18	50	68	96	74
2	8	116	124	226	128
3	31	157	188	398	302
4	42	667	709	494	611
5	39	802	841	609	749
6	85	521	606	684	688
7	241	459	700	664	642
☽ 8	160	405	565	720	610
9	131	477	608	704	726
10	118	1004	1122	648	845
11	175	353	528	641	649
12	251	167	418	628	473
13	175	354	529	492	504
14	160	383	543	461	514
15	187	255	442	442	450
● 16	200	175	375	406	378
17	140	180	320	355	342
18	193	158	351	308	327
19	142	146	288	287	283
20	119	86	205	282	243
21	110	162	272	242	261
22	80	216	296	214	252
☾ 23	90	57	147	208	185
24	48	102	150	184	156
25	68	109	177	150	163
26	83	69	152	141	150
27	55	67	122	122	125
28	45	58	103	95	98
29	15	43	58	78	65
☽ 30	11	29	40	78	50

the two intervals. The totals in column 3 are smoothed by taking the mean of each consecutive five which appear in column 4, and by taking the second order of means which appear in column 5. The results in every column show the very marked excess in the number of auroras reported between last quarter and new moon. This is the part of the lunation when no moonlight occurs between sunset and midnight, the part of the day when most records of auroras are made, because the observers are then awake. But why there should be a greater number of auroras near the last quarter than near new moon is not very evident. In the column of totals, the frequency of auroras is almost twice as great near last quarter as

near new moon, and in the mean of each consecutive five the maximum number of auroras occurs exactly at the time of last quarter. The irregularities in the totals are almost entirely smoothed out in the column giving the mean of five, and even after they are thus smoothed the number of auroras near the last quarter of the moon is about ten times as great as the number reported near full moon. The results in columns 3 and 4 are shown in the diagram, fig. 2, the lighter broken line representing the unsmoothed totals and the heavy line the mean of five. This great variation in the number of auroras according to the age of the moon furnishes a clue to the reversal of the time of maximum frequency of auroras in the 27-day period, as a result of which the maximum occurs near the time of the moon's greatest northern declination in summer and near the time of the moon's greatest southern declination in winter. In the summer the greatest southern declination of the moon occurs near full moon, so that the chief maximum of auroras occurring at that time is obscured. In the winter the greatest northern declination occurs near full moon, so that the secondary maximum at that time is obscured, and the chief maximum at the time of greatest southern declination is well marked. But as yet there appears no reason why there should be a secondary maximum of auroras at the time of the moon's greatest northern declination, for according to Ekholm's theory of the moon's induction of electricity on the earth, the difference in potential between the earth and the air ought to be at a minimum at the time of the moon's greatest northern declination.

It is well known that when the sun crosses the plane of the earth's equator there is a marked maximum in the number of auroras. This is well shown for the United States by the following table, prepared by Professor Hazen, showing the number of stations reporting auroras during each of the twelve months of the year for an interval of 23 years :

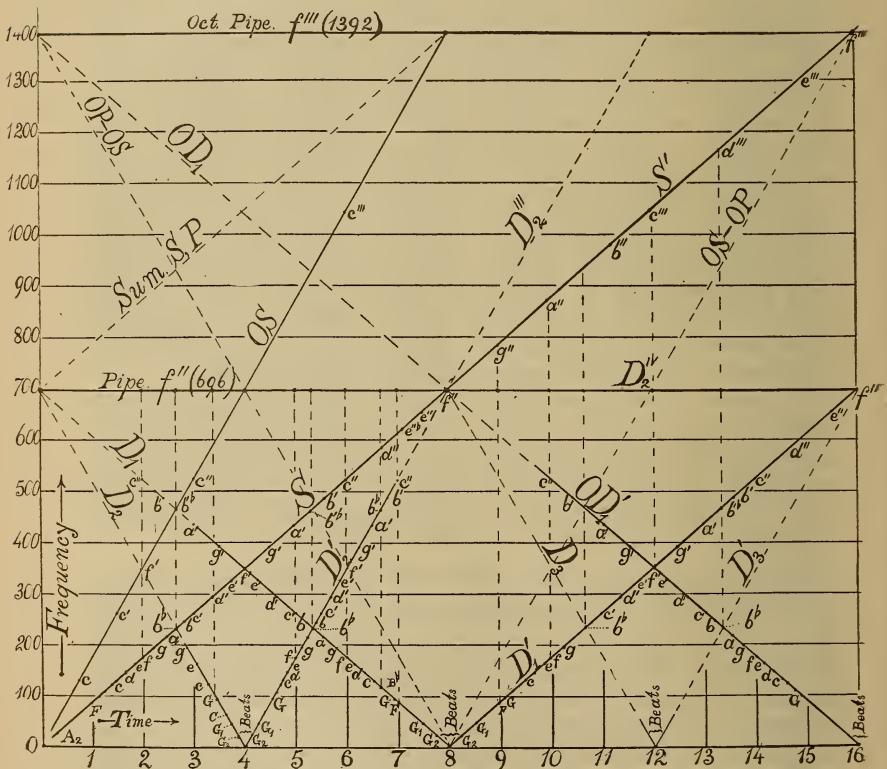
Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1005	1455	1396	1724	1270	1061	1223	1210	1735	1630	1240	912

The explanation of this, according to the theory of Mr. E. B. Elliot (Bull. Phil. Soc., vol. i, p. 45), is that the number of auroras depends on the rate at which the earth, in its annual orbit, cuts through cosmic lines of electric force.

Since Dr. Ekholm's theory fails to explain the secondary maximum shown by the curves at the time of the moon's greatest northern declination and the tertiary maxima at the time the moon crosses the plane of the earth's equator, I am led to believe that some magnetic effect must be involved, probably engendered by the unequal cutting of the lines of magnetic force by the moon in its motion around the earth.

ART. XIII.—*The Combination Tones of the Siren and an Organ Pipe*; by CARL BARUS.

IN view of the brilliant development of experimental acoustics, I can hardly suppose that the present simple but efficient method of studying combination tones (difference tones in particular) is new. Be this as it may, the subject on its own merits is well worthy of close inspection, and the chart which I submit will, I think, be of much assistance. Without it, the disentanglement of the interpenetrating trains of harmony which reach the listener, is extremely difficult even to a musical ear. I will therefore venture to describe my work.



Helmholtz in his classical experiments obtained his most pronounced combination tones by the aid of his many-voiced siren. Few, however, possess this apparatus. Moreover, in the case given, the difference tones must change from low to high pitch,

and vice versa, at the same time with the siren, supposing that the same musical interval is retained. In order to exhibit the continuity of these phenomena perspicuously (see chart), I have modified this experiment by replacing one siren by an ordinary open organ pipe of fixed and sufficiently high pitch. This is mounted on the same bellows with a simple siren rising continuously from low to high pitch. The advantage gained in this way is best exhibited in the accompanying diagram, but consists essentially in producing difference tones whose frequency-changes vary at first in opposite direction to the pitch of the continually rising siren. Thereafter with a passage through zero, the difference tones change in the same direction as the pitch of the siren. This contrast between ascending and descending cadences, of which there are several successive groups, facilitates recognition, while the apparent scattering of the difference tones into beats beyond the lower limits of audition, and their subsequent emergence and coalescence from beats, is of special acoustic interest. The method is thus peculiarly adapted for demonstrating the whole scope of these complex phenomena even to an indifferently musical ear. It is not so useful in fixing the pitch of a single group of notes, though this also succeeds after a little practice, for an ear accustomed to recognize chords and musical intervals.

2. To work out the diagram, I used an ordinary open pipe, f'' , (frequency $n = 696$) which happened to be available and which was high enough in pitch to admit of difference tones of a wide range below it. The siren was an ordinary small single-voiced König instrument. By supposing the angular velocity of the disc to increase at a small constant rate in the lapse of time—a condition of things nearly enough reached in the experiment—the diagram is constructed by representing the frequencies (n) of the different notes as ordinates, and times, t , in arbitrary units ($0 \dots 16$) as abscissas. In such a diagram the notes (chords) heard simultaneously will lie on the same vertical. A number of these have been accentuated by drawing the vertical lines in question from note to note, because of their value in orientation. (See chart.)

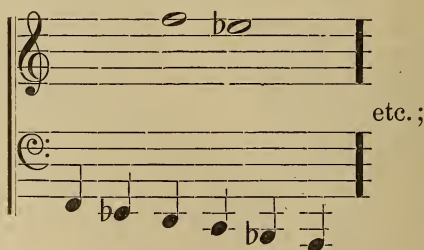
In the chart the continuous note of the organ pipe (P) is given by the broad horizontal lines at the level $n = 696$, extending quite across the diagram while its first overtone, the octave, is shown by a similar line (OP) at $n = 1392$. The continuity of notes given out by the siren is shown by the broad diagonal (S below f'' , S' above f'') extending from the origin at an angle of 45° as far as the height $n = 1392$ or f''' . Beyond this the notes were difficult to produce and their succession too slow. The first overtone of the siren is shown by the line (OS) having double the slope of (S). The successive notes of

the diatonic scale along any of these diagonals are indicated by dots and lettered in the usual way, and these are obviously much more crowded in the lower regions ($n < 696$), where the pitch of the siren changes with proportionate rapidity, than in the upper regions ($n > 696$).

Thus, the first order of difference tones ($D_1 = P - S$)* is shown by the diagonal descending from $n = 696$ and $t = 0$ at an angle of 45° below the horizontal to the abscissa $n = 0$ in the left half of the diagram, and rising from the abscissa $n = 0$, at an angle of 45° to the original level $n = 696$ in the right half of the diagram as shown at D'_1 . These are the chief difference tones in question. Where they were heard either directly or indirectly (including beats) the line is drawn in full and the notes indicated. Otherwise the line is broken. Of course it is almost impossible to recognize the precise pitch at which the difference tone is first heard, since the ear is obliged to depend on musical intervals for orientation. With more practice the limits could doubtless be extended.

The interesting feature of this order of difference tones (D_1, D'_1), which are quite sweeping and easily heard, is the transition (at abscissa $t = 8$) of the descending into the ascending cadence.

The difference tone here passes beyond the limits of audition, thereafter to emerge again. With his many-voiced siren Helmholtz used an analogous phenomenon to test these limits. In the present experiment the vanishing of the difference tone is approached by a marked chord of the seventh, $Fc''e''b''f''$, followed by the effective musical sequence in the key of B^b , which is nearly



finally while the treble is sharpened descending from $F'_1(n=43)$ to (I think I could say in my case) A_2 , where $n = 27$. The last sensations however are much as though the head were being profoundly shaken and the pitch recognized probably imagi-

* The frequency of D_1 is obtained, in other words, by deducting the frequency of the note of the siren from that of the organ pipe, all referred to the same vertical.

nary. Without wishing to enter into the memorable Helmholtz-König controversy, it is certain that the difference tones vanish with the failure of the ear completely, before any beats are heard as such. These introduce an entirely different sensation (by contrast a very commonplace sensation), the sibilant rattling being at first rapid, then slowing up into complete unison, finally to reappear again with excess of frequency in the pitch of the siren over that of the organ pipe. The beats gradually gain in rapidity, finally to vanish in the profound difference tones of the ascending cadence of the first order D_1' . So far as I can make out, the only discontinuity here is physiological and due to the failure of the ear.

The next train of sounds of marked prominence, though not quite so clear and deliberate as the preceding, are the difference tones of the second order ($D_2 = D_1 - S$, or $= OS - P$), due to the combination of the first order of difference tones D_1 with the notes of the ascending siren S_1 as well as to the first overtone of the siren (OS) combining with the organ pipe (P). On the same time-scale, these notes must appear in a descending cadence D_2 , vanish through beats, and reappear in an ascending cadence D_2' and D_2'' just twice as rapidly as the difference tones of the first order, as is shown by the greater steepness of the lines converging above $t = 4$ of the abscissa. Beyond this what has been said in general about D_1 in passing through unison applies to D_2 . They are strong enough to mask some of the first order of difference tones. They intersect the siren notes (S) and the first order of difference tones (D_1) about in b^{\flat} . The latter, coinciding with the b^{\flat} of the lines D_1 and OS and the f'' of the organ pipe, is easily found. More marked however is the b^{\flat} of D_2' at its intersection with D_1 , coinciding with the b^{\flat} of S and f'' of the organ pipes. We have here two ascending, one descending and one stationary cadences, and the listening ear hears two orders of difference tones chromatically converge upon the common b^{\flat} and thereafter diverge again. Other coincidences are given in the diagram. Prominent intervals are apt to be in the key of B^{\flat} .

In the second half of the diagram ($t > 8$) the second order of difference tones separate into $D_2''' (= OS - P)$ and $D_2^{IV} (= S' - D_1')$ coalescing with P at f'' .

In the left half of the diagram we have furthermore the octave difference tones $OD_1 (= OP - S)$ due to the first overtone of the pipe and the ascending siren, and the summation tones, "*Sum.*" ($= S + P$). Neither of these high trains was I able to hear. Finally the octave or first overtone of both pipe

and siren give a difference tone shown by the line ($OP - OS$) of the chart. This also escaped me.

I come now to the right half of the diagram ($t > 8$), in which the ascending cadence of difference tones of the first order (D'_1) has already been recognized. Here the siren, S' , is continually above f'' and the result is a distinct descending cadence of difference tones of the first order ($OD'_1 = OP - S$), due to the combination of the first overtone, f'' , of the organ pipe and the siren. This is the continuation of the train not heard in the preceding section. OD'_1 is fainter than D_1 , but otherwise like it, finally vanishing into not very distinct beats at $t=16$ of the abscissa. These two first orders of difference tones, as a rule about equally strong, intersect above $t = 12$, in f' , which being an octave below f'' of the organ pipe and heard together with the fifth C''' of the siren, is a landmark in this region of difference tones. It is upon this note, f' , that the two ascending and descending cadences (D'_1 and OD'_1) chromatically converge, thereupon again to diverge.

But there must be another phenomenon here, namely the difference tones of the third order ($D_3 = OD'_1 - D'_1$ and $D_3' = D'_1 - OD_1$) due to the combination of the two difference tones of the first order in this region. With these the difference tone ($D_3 = P - (OS - OP)$) and ($D_3' = (OS - OP) - P$) would completely coincide. But I have only been able to recognize the third order of difference tones through faint beats at $t = 12$, at which the two steep diagonals D_3 and D_3' converge because of the unison of the component notes in f' . The train ($OS - OP$) also eluded me. Finally reference to overtones* above the first seemed in every way superfluous.

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* The relative strength of the different cadences will clearly depend on the relative strengths of the fundamental and overtones. Thus with a pipe b' the cadences of the second half of the diagram came out more clearly, etc.

ART. XIV.—*Some Products found in the Hearth of an Old Furnace upon the dismantling of the Trethellan Tin Works, Truro, Cornwall,** by WM. P. HEADDEN.

THE suite of samples forming the subject of the following notes was presented to the writer by Dr. Richard Pearce of Denver, who states that they were obtained from the hearth of an old furnace in the Trethellan Tin Works at Truro, Cornwall. The furnaces had been idle for a short period prior to the abandonment of the works, which took place about 1872, but they were not dismantled until 1892, and it was at this date that the samples were obtained. These furnaces had been in use for at least sixty, and probably for nearly a hundred years. The ores smelted in them were the usual Cornish tin-ores carrying some arsenopyrite. Dr. Pearce showed, in an article published in 1871, that this arsenopyrite is cobaltiferous, and this is probably the source of the cobalt found in the samples.

Stannous Sulphide.—This compound occurred as black, highly lustrous, monoclinic crystals covering a slag surface to the thickness of nearly a quarter of an inch. The forms made out were 111, $\bar{1}\bar{1}\bar{1}$, 110 and 010. The crystals are tabular, owing to the development of the clinopinacoid; the lustre is strongly metallic. The crystals are invested with small globules of metallic tin, invisible to the naked eye, but which appear rather abundantly when the crystals are examined under the microscope. The stannous sulphide does not rest immediately upon the slag, but upon a stratum of another crystallized compound, which also appears, but in somewhat isolated groups, through the mass of stannous sulphide crystals.

Crystals which proved to be the same in composition were observed occurring sparingly in the upper part of another mass of crystals an inch, or perhaps more, in thickness; these were much smaller and were quite free from tin. The analytical data on which the identification rests are analyses of these two specimens. In the latter case, 1.78 per cent insoluble has been deducted, and the remainder calculated to a hundred, when the analyses give the following composition for the crystals:

	Per cent.	Atomic Equivalent.	Atomic Ratio.	
Sn	71.538	60.63	70.05	1.00
Fe	4.881	8.71		
Cu	0.452	.71		
S	23.129	72.27	72.27	1.03
	<hr/>			
	100.000			

* Abstract of an article read before the Colorado Scientific Society, Nov. 6, 1897.

The crystals from the slag were contaminated with metallic tin, but I feared to continue the treatment of the mass with ferric chloride until the whole of the tin should be removed, lest the sulphide of tin should be attacked. The analysis of these crystals, soluble in hydrochloric acid, gave:—

	Per cent.
Sn	80·413
Fe	2·905
S	17·134

100·452

Basing my calculation on the percentage of sulphur found, I make the amount of free tin present 22·91 per cent; deducting this and calculating the rest to one hundred, I obtained:—

	Per cent.	Atomic Equivalent.		Atomic Ratio.	
Sn	74·006	62·80	}	69·53	1·00
Fe	3·769	6·73		69·43	1·00
S	22·225	69·43			

100·000

Both analyses lead to the formula SnS, with a small part of the tin replaced by iron. In the first analysis this replacement amounts to 3/22, in the second to 3/28 of the tin.

Iron Arsenide.—This compound was found associated with stannous sulphide in two specimens, in one of them it formed the principal part of the specimen; in the other it formed only a thin layer between the slag and the stannous sulphide, and occurred sparingly throughout the mass of crystals; it also formed the major part of a third specimen.

It was freed from the stannous sulphide by boiling with concentrated hydrochloric acid and subsequently with potassium hydrate. It has a dark steel-gray color. The specific gravity was found to be 7·6500 at 16° C, but this becomes 7·9414 when correction is made for the presence of 1·76 per cent. of sand, specific gravity 2·6. The crystal form is orthorhombic. Most of the crystals show only two forms—110 and 101—but some of them show the additional form, 100, and in one or two cases I observed the presence of a brachydome. The analysis of these crystals resulted as follows:

	Per cent.	Atomic Equivalent.		Atomic Ratio.	
Sand	1·760				
As	53·224	70·9	}	74·9	1·00
S	0·536	1·7		74·6	1·00
Sn	2·847	2·3	}		
Fe	38·304	68·4			
Co	3·640	6·2			
Ni	Trace				
Cu	Trace				

100·311

If we reject the tin and sand, and calculate the remainder to one hundred, the ratio for the arsenic and sulphur to the iron and cobalt is 1:1.03, but I do not think that the tin should be rejected.

This product resembles the mineral loellingite in form, but differs from it in having the formula $FeAs$. Leucopyrite, etc., are intermediate between these two— $FeAs_2$ and $FeAs$.

$FeAs+SnS$.—The next product is a molecular combination of the preceding two: it occurs as black, shining plates belonging to the monoclinic system. The forms recognized on these crystals are the same as those given for the stannous sulphide. The material analyzed was selected with the greatest of care and, while the amount of the substance obtained was small, it was free from crystals of other substances. The analysis resulted as follows:

	Per cent.	Atomic Equivalent.		Atomic Ratio.
Fe	17.949	32.0	} 35.5	1.06
Co	2.037	3.5		
S	10.671	33.3	33.3	1.00
As	27.166	36.2	36.2	1.08
Sn	43.106	36.5	36.5	1.09

100.929

The atomic ratio is evidently 1:1:1:1. Following the indication of the other analyses, it seems that the simplest and probably the correct way of interpreting this ratio is by assigning the formula $FeAs+SnS$ to these crystals; the iron in the iron arsenide being replaced in part, as in the preceding sample, by cobalt.

An Arsenide of Tin, Sn_6As .—One of the samples in the suite was a small mass of bright, highly lustrous crystals of a grayish tin-white color. They were quite brittle, six-sided plates, whose form I could not satisfactorily make out. The crystals have a slight bronze-yellow tarnish. Their composition was found to be:—

	Per cent.	Atomic Equivalent.	Atomic Ratio.
Sn	90.414	76.62	6.02
As	9.441	12.72	1.00

99.855

This appears to be a new alloy of tin and arsenic. It is soluble in hydrochloric acid with the evolution of hydrogen arsenide, and the separation of brown flakes, not further examined, except that they were observed to be soluble in nitric acid. Ferric chloride attacked the crystals, taking tin in solution and leaving a bluish black residue containing a nucleus of the original crystal. It was quite impossible to free the crystals from metallic tin, which could be easily recognized with the aid of a magnifier, as minute globules, occurring sparingly on the crystals.

Stannic Oxide: Artificial Wood Tin.—This consisted of an irregular mass weighing about one and a half pounds. There was a central portion of metallic tin running lengthwise through the mass: at certain points this had entirely disappeared, but its former presence was shown by the structure of the mass. The oxide has a banded structure, and the banding is at some points plainly concentric. The hardness varies greatly: some portions of the mass have a hardness quite equal to that of the natural wood tin, while others are quite soft. The oxide was reduced in hydrogen to determine the oxygen, and the resulting metal dissolved in hydric chloride for further analysis. The result was as follows:

	Per cent.	Atomic Equivalent.		Atomic Ratio.
Sn	76.969	65.2	} 65.9	1.00
Cu	0.240	0.38		
Fe	0.091	0.2		
Co	0.060	0.1		
O	22.550	140.9	140.9	2.13
As	Trace.			
	99.910			

The manner in which these products may have been formed, the length of time required to produce them, etc., as well as the conditions which obtained at the time of their production, are, unfortunately, almost wholly matters of theory. The formation of the stannic oxide was evidently by oxidation of the metallic tin, a portion of which still remains, but whether aqueous vapor and hot gases, other than the air, had part in its formation is an open question. The arsenide may have been formed in a magma of molten tin, and the tin may have subsequently been removed by a process of liquation. There are some indications that this is really what happened, but the extreme cleanness of the crystals is very remarkable if this was the case, the angles throughout the network of crystals being sharp and not filled up with tin, as one would expect. In regard to the stannous sulphide and iron arsenide, I think that their occurrence on the slag is quite suggestive that they have been deposited from an atmosphere furnishing the conditions necessary for their formation. The principal part of the arsenide was deposited first and subsequently the sulphide, but some of the arsenide was deposited both subsequently to and simultaneously with the sulphide, as the crystals of the arsenide occur implanted upon those of the sulphide, and when the atmosphere, from which the crystallization took place, furnished the compounds in molecular equivalents, they crystallized together, giving the compound $\text{FeAs} + \text{SnS}$. In the masses furnishing the arsenide, there is neither any residual tin recognizable as such, nor sign of flowing, nor yet of absorption by the bricks of the hearth.

ART. XV.—*Kant as a Natural Philosopher*; by GEO. F. BECKER.

KANT'S fame as a metaphysician has completely overshadowed his reputation as a physicist, at least outside of Germany. One occasionally sees a slight reference to the fact that he had an idea of some sort of nebular hypothesis, but usually the context conveys the impression that it was only a futile dream. Thus a well known historian of astronomy stated in 1882 that Kant had put forward "a true nebular cosmogony, though one in which the primitive reign of chaos was little likely to terminate." In 1869, however, Huxley wrote a few vigorous paragraphs on Kant's results* and shortly afterwards Lord Kelvin, referring to Huxley's abstract, remarked that Kant's paper only wanted the knowledge of thermodynamics "to lead to a thoroughly definite explanation of all that is known regarding the present actions and temperatures of the sun and other heavenly bodies."†

All of Kant's earlier papers were on physical subjects and he retained his interest in natural philosophy through life. He studied Newton: at one time he lectured on mathematics, and his course on physical geography was repeated through many years. Some of his papers are now of little interest, but others, at least from an historical point of view, are very important. The titles of those which seem to me most noteworthy are given in a footnote below.‡

The first three of these papers, which are also the most original, were all published before Kant's poverty allowed him

* Presidential Address, Geol. Soc. London, Discourses Biological and Geological, 1894, p. 320.

† Address to Geol. Soc., Glasgow, April 5, 1869.

‡ The volume and page numbers refer to Immanuel Kant's *Sämmtliche Werke*, edited by G. Hartenstein, Leipzig, Voss., 1868.

1754. Untersuchung der Frage, ob die Erde in ihrer Umdrehung um die Achse, wodurch sie die Abwechselung des Tages und der Nacht hervorbringt, einige Veränderung seit den ersten Zeiten ihres Ursprungs erlitten habe, vol. i, pp. 179-186.
1754. Die Frage; ob die Erde veralte, physikalisch erwogen, vol. i, pp. 187-206.
1755. Allgemeine Naturgeschichte und Theorie des Himmels, oder Versuch von der Verfassung und dem mechanischen Ursprunge des ganzen Weltgebäudes nach Newton'schen Grundsätzen abgehandelt, vol. i, pp. 207-345.
1756. Neue Anmerkungen zur Erläuterung der Theorie der Winde, vol. i, pp. 473-487.
1763. Der einzig mögliche Beweisgrund zu einer Demonstration des Daseins Gottes. Siebente Betrachtung, Kosmogonie, vol. ii, pp. 180-193.
1785. Ueber die Vulcane im Monde, vol. iv, pp. 193-202.
1786. Metaphysische Anfangsgründe der Naturwissenschaft, vol. iv, pp. 355-462.
1802. Physische Geographie. Auf Verlangen des Verfassers aus seiner Handschrift herausgegeben und zum Theil bearbeitet von Dr. Fr. Th. Rink, vol. viii, pp. 145-452.

to complete his studies for the degree of Doctor of Philosophy. The paper on the volcanoes of the moon gave him an opportunity of reasserting his belief in his nebular hypothesis after many years of reflection, and of making a very great addition to the cosmogonic apparatus. The discussion of the metaphysical bases of natural science contains interesting reflections and definitions. It is difficult to say how much of it was absolutely new, since all natural philosophers have dealt with the same ideas. His definitions of fluids and solids* sound extremely modern. "A material in which a motive force, however small, produces shear is a fluid, no matter how powerful the cohesion of its parts." A solid is a body "which resists shear with a certain degree of force." "The resistance to shearing is die Reibung," by which he means what is now denoted by rigidity; liquids, he says, have none of it. In his theory of the winds Kant was anticipated by Geo. Hadley,† but he supposed himself to be the first to perceive the effect of the rotation of the earth on northerly or southerly winds. He deduced from this effect the cause of the easterly trades, the westerly winds of latitude 28° to 40° and the monsoons. Kant's paper on this subject was very probably intended as a reply to D'Alembert, whose theory of the winds procured him the prize of the Berlin Academy in 1746. D'Alembert endeavored to account for atmospheric currents as an immediate result of the attraction of the sun and moon. The physical geography was edited from lecture notes by a pupil when Kant was an old and broken man. There is good reason to suppose that it would have been more valuable if Kant had written it out himself at an earlier date.

Kant was indeed no dreamer, but one of the best informed men of his time. It was the great object of his life to discourage visionary speculations, "Schwärmerei," and to reduce all subjects to the confines of reason. His theory of the heavens, however it may appear to modern readers, was conceived from this point of view. Even Newton had felt himself called upon to attribute various details of the solar system to the direct intervention of the Creator, and it was the habit of that day, as of other days, to confound the mysterious with the miraculous. Kant endeavored to offer a rational explanation of many mysteries and in large measure he was successful. He saw, as well as one can see now, that astronomy has two divisions. In spherical and gravitational astronomy mathematics reigns supreme, and certainty is attainable. In physical and historical astronomy, on the other hand, a high degree of probability is the nearest possible approach to absolute truth. Kant says of his theory of the heavens: "In general,

* Kant's Werke, vol. iv, p. 420.

† Phil. Trans., vol. xxxix, 1735, p. 58.

the highest geometrical precision and mathematical infallibility can never be demanded from a treatise of this description. If the system is founded on analogies and agreements, developed according to the rules of credibility and in a logical manner, it satisfies the conditions which its object demands." In judging of Kant's theory, allowance must be made for the faulty data at his disposal, particularly in respect to the masses of the planets, and for the undeveloped state of astronomical science. I know of no more striking way to emphasize the remoteness of the period when the theory was published than to note that in 1755 Lagrange was 19 years old, William Herschel 17, and Laplace 6. Kant was not always right, and indeed he himself threw doubt on certain of his results, but some of his great successors fell into some of the same pitfalls. That many of his theories are held to-day shows the keenness of his scientific faculty, and almost excites a regret that he did not remain loyal to Urania. It is doubtful, however, whether he could have been restrained from metaphysical inquiries. There is a small group of men, naturalists by instinct, who seem irresistibly compelled to include among the phenomena forming the object of their inquiries the mechanism of the intellect and the relations of ideas. Such are Aristotle, Bacon, Descartes, Kant and a living English philosopher.

Kant was not the first philosopher to speculate on the origin of the heavenly bodies, though he was the first Newtonian to do so. If one leaves aside some vague speculations of the ancients, there can be no doubt that the first germ of the nebular hypothesis is to be found in Descartes' *Principles of Philosophy*, published in 1644 (43 years before Newton's *Principia*). It may briefly and imperfectly be represented as follows. The content of the universe is divisible into three categories.* The first corresponds nearly to the luminiferous ether of the present day and its agitation produces light, the second answers approximately to gas, the third to solid or liquid substances. This last Descartes calls "opaque matter." In the beginning these materials were almost uniformly distributed through space and possessed motion in nearly equal amounts.† The nebulous mass was divided into patches of common rotation, or the famous Cartesian *vortices*. In each vortex there were subordinate vorticules, eddies in a whirlpool. The motion of rotation was most rapid at the center, dimin-

* *Les principes de la Philosophie*, Cousin's edition. 1824, part 3, sec. 52. The three categories are summarized as "être lumineux, être transparent, et être opaque ou obscur."

† In all, "Autant de mouvement qu'il y en a encore à présent dans le monde." (Part 3, sec. 46). Descartes supposed the momentum of the universe a fixed quantity. Leibnitz, I believe, was the first to assert the constancy of the total energy.

ished with increasing radius to a minimum, and increased again towards the edge. Nebulous material was driven from the center towards the periphery in the equatorial plane of the vortex and flowed back again along the axis of rotation. The first stage in the evolution of systems was the segregation of opaque matter in spots, such as are still to be seen on the sun. In the smaller subordinate vortices these accumulated until they formed a crust which partially or completely arrested the vertical circulation. The minor stellar bodies so consolidated were then captured by the larger vortices and were incorporated into them as passive constituents. These opaque masses sought a position of equilibrium in the rotating fluid of the vortex. At first such a body would descend towards the center. If, however, it possessed sufficient "solidity," which seems to be mass per unit of exterior surface,* it soon acquired such centrifugal velocity as to be thrown out of the periphery of the vortex, passing into the next similar vortex and so on. It thus became a comet. If the opaque mass had less solidity, it found a position of equilibrium within the vortex and became a planet moving on an orbit of small eccentricity.† The planets of smallest solidity are nearest the sun.‡

Swedenborg also published a vortical cosmogony in 1734, forty-seven years after the appearance of Newton's *Principia*. Messrs. M. Nyrén§ and E. S. Holden† have each given some

* Cf. part 3, sec. 122. Descartes regarded space as a "plenum" and does not here consider motion in a vacuum. The measure of force was solidity into velocity. The resistance of the plenum was proportional to the exterior surface of a moving mass.

† Et parceque toutes les petites parties de la matière qui compose un tourbillon ne sont pas égales ni en agitation, ni en grandeur, et que leur mouvement est plus lent selon qu'elles sont plus éloignées de la circonférence, jusques à un certain endroit au-dessous duquel elles se meuvent plus vite, et sont plus petites selon qu'elles sont plus proches du centre, ainsi qu'il a été dit ci-dessus, si cet astre est si solide que, devant que d'être descendu jusques à l'endroit où sont les parties du tourbillon que se meuvent le plus lentement de toutes, il ait acquis autant d'agitation qu'en ont celles entre lesquelles il se trouvera. il ne descendra point plus bas vers le centre de ce tourbillon, mais, au contraire il montera vers sa circonférence, puis passera de là dans un autre, et ainsi sera changé en une comete. Au lieu que s'il n'est pas assez solide pour acquérir tant d'agitation, et que pour ce sujet il descende plus bas que l'endroit ou les parties du tourbillon se meuvent le moins vite, il arrivera jusques à quelque autre endroit entre celui-ci et le centre, où étant parvenu il ne fera plus que suivre le cours de la matière qui tourne autour de ce centre, sans monter ni descendre davantage, et alors il sera changé en une planète. Part 3, sec. 119.

‡ Therefore the earth must be less dense than Mars, which has the smaller diameter (part 3, sec 147), and therefore the earth must consist of a rigid shell with a fiery interior (part 4, sec 3), Descartes concludes. This is the first assertion that the earth has a fluid interior. Descartes was driven to make it by the exigencies of a false theory. The doctrine once accepted, its origin was forgotten; and but for Lord Kelvin, it would probably have remained a misleading article of faith with geologists to the end of the 19th century.

§ Vierteljahrsschrift der astronomischen Gesellschaft, 1879, p. 80. This paper is translated in the *New Church Review*, July, 1897.

† *North American Review*, vol. cxxxi, 1880, p. 377.

account of this theory. The solar system, according to Swedenborg, was formed from a chaotic mass which rolled together to a great sphere and afterwards, by its rotation, threw off a ring. This by expansion burst, and the fragments shrank to planets. I see no important advantage in this as compared with the Cartesian cosmogony. Even if deductions from any such vortical theory were correct, they could still have no scientific standing, since they would be conclusions from false premises and their correctness therefore accidental.

In 1750 Thomas Wright (of Durham) published a book, "The Universe and the Stars," to an abstract of which Kant expresses obligations. It is so tiresome as to seem much longer than it is, and the only original conclusion which I can find is that the visible stellar system is spheroidal or cylindrical, the Milky Way marking the position of the periphery. At the center is "an intelligent principle" round which the system revolves. Wright, like Cassini, thought that Saturn's rings were composed of small satellites,* a conclusion which he draws from the eccentricity of the rings.

Turning now to Kant's cosmogony, it may be interesting to note in the briefest terms the more striking of his views in a connected way, and then to draw attention to such of them as seem anticipations of the opinions held by subsequent investigators.

In developing his nebular hypothesis Kant regards the solar system from two points of view. The first contemplates the unity of plan. Six planets and nine satellites revolve in orbits about the sun, all moving in the same sense, that namely in which the controlling central body, the sun, rotates. Their orbits vary but little from a single plane, that of the sun's equator; the more distant bodies belonging to the solar system (viz: comets), however, show divergencies standing in sufficiently close relation to the deficiency of the impressed movement. This unity of plan indicates a single pervading cause of motion. On the other hand, from the second point of view, the interplanetary space is substantially empty; it contains no matter through and by which accordant motions could have been communicated to the system.†

Hence this space must once have contained matter, and the material abstracted from interplanetary space must be that which is now gathered in the members of the solar system; for the quantity of matter in the universe is inalterable. Kant therefore assumes that the materials of the solar system were

*I have only seen the American reprint (without plates). Phila., Wetherill, 1837. This edition has amusing notes of the mystic order by C. Wetherill and C. S. Rafinesque.

† Kant's Werke, vol. i, p. 245.

originally disseminated in an elementary state, as atoms, throughout the entire space belonging to the system. The material is not supposed to be heated or in motion, the average density of the nebula is many times smaller than that of the terrestrial atmosphere, and the conditions are explicitly the simplest conceivable.*

He proceeds to develop from this hypothesis not merely the conditions of the solar system but of the star cluster bounded by the Milky Way and other star clusters which he supposes to be represented by the nebulae. As the solar system is to the cluster of which it is an insignificant member, so is this to a greater group of clusters; and infinite space is occupied by a rotating group of similar constitution but of an infinite order of magnitude and of complexity.†

For the solar system he deduces many remarkable conclusions. The shrinking nebula acquires rotary motion, he erroneously supposed, in consequence of irregular impact of the component particles and their elasticity.‡ Tendencities to motions in all directions, excepting in one resultant plane, are suppressed by mutual interferences of the free particles. Most of the material accumulates at the center, in the sun, but a wide, thin disc of heterogeneous matter remains. This disc consists of discrete particles each of which has acquired such a velocity and direction as to maintain the appropriate orbital motion. On the whole the inner zones of the disc will contain a larger proportion of denser substances than are to be found in the outer ones; while the outer rings, being of relatively large circumference, will be of greater mass than the inner ones. Mutual attraction and adhesion, beginning at relatively massive particles, cause the agglomeration of the particles in any zone or ring to single planets or to groups of planetary bodies. The direction of axial rotation is deduced from the mode of formation, the outer part of any accumulating planetary mass moving with greater velocity than the inner portion.§ (The proof offered for this last proposition is unsatisfactory.)||

* Kant's Werke, vol. i, p. 247.

† Kant's Werke, vol. i, p. 290.

‡ Though Kepler's law of areas was well known to Kant, he did not realize the more general theorem, that the moment of momentum of a system on which no external forces act is constant.

§ Kant's Werke, vol. i, pp. 267 and 258.

|| Mr. H. Faye (*L'origine du monde*, 1884, pp. 117 and 143) rejects Laplace's nebular hypothesis on the ground that the latter is in error in his deduction as to the rotation of the planets. Mr. Faye thinks that because the inner numbers of a swarm of particles tend to revolve with a higher velocity than the outer ones, retrograde rotation would ensue. This is a case where simple explanations are tempting but misleading. The problem rigorously dealt with involves the solution of the problems of three or more bodies. It does not appear to me that Mr. Faye has given any satisfactory proof of his position. The same may be said of Laplace, but it may be suspected that this great man had solved some particularly

Kant appeals to his theory of Saturn as a confirmation of the credibility of his whole hypothesis. Nevertheless he represents the rings not as a relic of a condensing nebula but as an emanation from the planet. The rings, according to his theory, are composed of discrete particles* condensed from fumes and vapors which had been thrown off from the equator of the planet by rapid rotation while the planet was still in a highly heated condition. These particles acquired their moment of momentum from the planet and revolved in obedience to the law that this moment is constant. He attempts to account for the stability of the mass by its division into many rings, pointing out that if it were continuous, friction must destroy its motion.

Kant also computed the then unknown period of rotation of Saturn on the hypothesis that centrifugal force and attraction are equal at its surface, so that the rings are practically continuous with the planet. He obtained a period of $6^{\text{h}} 23^{\text{m}} 53^{\text{s}}$. Herschel in 1794 from direct observations found its period $10^{\text{h}} 16^{\text{m}}$, which differs from Prof. A. Hall's determination by a very few minutes. Mr. Faye supposes the German astronomers to have omitted mention of Kant's prediction out of regard for the philosopher, the discrepancy between it and the observations being "overwhelming." The French astronomer, however, also remarks that the discrepancy, while calling for explanation, does not invalidate the theory. Perhaps Kant's theory of tidal retardation would have filled the gap. Kant also speculated on the flattening of Saturn and concluded that the density must increase towards the center of the planet. This conclusion he extended to Jupiter and inferred its applicability to other heavenly bodies.

In the zodiacal light he saw an analogue to the Saturnian rings, but he drew an essential distinction between the materials which reflects the zodiacal light and the rings of Saturn. The velocity of rotation of the sun being quite insufficient to maintain particles in free revolution near its surface, the heat of the sun must coöperate to keep the fame-like mass in a state of expansion even if the material came from the sun, as Kant thought probable. He also contemplated the possibility that it is a remnant of the nebula.

simple cases, applicable to the question in hand, of the problem of three bodies and generalized from the result. It seems impossible that he should not have perceived the true nature of the question, or that he should have committed himself without an inquiry which was qualitatively satisfactory.

* Kant reached this result independently, but afterwards became acquainted with an investigation of Dominico Cassini's, *Mem. de l'Acad.*, Paris, 1705, p. 14, in which the rings of Saturn are regarded as swarms of minute satellites. This is nearly but not quite Kant's view; for his rings are, so to speak, raw material of which the satellites might have been made, but were not.

The planets in agglomerating become fluid. Newton, and indeed Descartes, had previously pointed out that planets had passed through the fluid condition. Kant seemingly ascribed the fusion of planets and satellites to the impact of their component parts.*

Kant expressed in the clearest manner and with sufficient demonstration his view that the period of rotation of the moon was reduced to coincidence with that of its revolution by tidal action on the satellite while it was still liquid. He draws the conclusion that the moon is somewhat younger than the earth.† He also demonstrates that oceanic tides retard the rotation of the earth, and predicts that the earth will eventually turn one side only to the moon.

In a cooling planet, according to Kant, there is a rough and partial separation by density. Such a process is still progressing in Jupiter which Kant regards as still fluid. The planets eventually become solid throughout.‡ The obliquity of the axes of rotation to the planes of revolution may be in part due to changes in shape accompanying consolidation and in part due to irregular distribution of velocities in the gathering mass of a planet. The progressively increasing density of the planets as the sun is approached is due to the varying proportion of the heavier elements in the contracting nebula; the lighter elements being deflected into orbital paths more easily than the heavier ones. Kant in 1755 regarded the sun as a solid burning mass, attributing its small density to the fact

* Kant's Werke, vol. i, p. 302.

† Ibid., p. 183 to 186. It may be of interest to translate a few sentences literally from this paper, "Ob die Erde in ihrer Umdrehung um die Achse einige Veränderung erlitten habe." "The water of the ocean covers at least one-third (sic) of its surface and is kept in continual motion by the attraction of the above mentioned celestial bodies [the sun and moon]. Moreover this motion is in one direction, exactly opposed to the rotation. . . . Since this flow is opposed to the rotation of the earth, we have here a cause which may be counted upon to retard and diminish rotation continuously to the extent of its capacity The termination of this change of rotation will occur when the earth's surface, from the point of view of the moon, shall be relatively at rest, i. e. when it rotates in the same time as the moon revolves. If it were fluid throughout, the moon's attraction would soon bring its rotation down to this fixed remainder. This immediately reveals the cause which has compelled the moon in its journey round the earth always to exposit to it the same aspect. . . . The attraction which the earth exerts on the moon, acting on the satellite while it was still fluid, must have reduced the rotation of the moon (formerly no doubt greater than now) to this fixed residue in the manner just explained."

‡ This is distinctly stated in *Allgemeine Naturgeschichte*; and in *Ob die Erde veralte*. One of the sentences in the preceding footnote is equivalent to an argument that, were the earth not solid, internal tidal friction would long since have reduced its period of rotation to that of the moon's revolution. This ingenious mode of reasoning on the earth's rigidity has not been revived or quantitatively tested so far as I know. It is worthy of consideration. In the *Physische Geographie*, 1802, however, he asserts that while the surface irregularities of the earth show solidity of the superficial portion, it does not follow that time enough has yet elapsed to carry consolidation to the center.

that the greater part of the material of the nebula acquired by impacts only a very small tangential velocity, and thus fell directly into the central mass. This fallacious explanation arose from his incorrect view of the generation of moment of momentum.

Further light as to the origin of the heat of stellar bodies came to Kant in 1785, thirty years after the publication of his theory of the heavens. Adair Crawford, in 1779, published his experiments on the development of heat by the compression of gases. These discoveries Kant says indicate a method of making comprehensible the development of any degree of heat as an accompaniment of the formation of heavenly bodies (suns or planets) from the initial nebula. He points out that the increase of temperature depends upon the initial and final densities and upon the brevity of the time of condensation. He infers that the central body, on account of its greatest mass and attraction, must develop the greatest heat and is rendered capable of being a sun.*

Comets in Kant's system are derived from the extreme portions of the nebulous mass which gave rise to the solar system. The original position of the cometary matter being at so vast a distance from the center, gravitation acted but feebly; elastic impact of the gravitating material was therefore also feeble; the mass acquired but little tangential velocity and the resulting orbits show correspondingly great eccentricity. The feebleness of attraction and the tenuity of the mass at the exterior of the nebula may account for the independence of the elliptic manifested by comets; but Kant expresses his own dissatisfaction with this explanation. Retrograde comets Kant hardly attempts to explain; he even thinks there may be an optical illusion.† Kant supposed the eccentricity of the planets to increase with distance from the sun, and predicted that planets with greater eccentricity than Saturn and at greater distances from the sun would be discovered.‡ These in his opinion would form in a sense a transition to cometary bodies.

Kant considers the end of the solar system as well as its inception. The world itself is doomed to destruction as a habitable planet by the process of base-levelling and consequent flooding by the ocean.§ All the planetary bodies will eventually fall into the sun, the inner ones first, in consequence of the universal tendency of motion to gradual retardation. While Kant had a perfectly clear idea of the retardation of the motion

* Ueber die Vulcane im Monde 1785: Kant's Werke, vol. iv, p. 201.

† Kant's Werke, vol. i. p. 265.

‡ Ibid., p. 243.

§ The process of base-levelling is excellently described in the paper "Ob die Erde veralte?" 1754, Kant's Werke, vol. i, p. 203.

of rotation by tidal action, and inferred the former more rapid rotation of the moon, I do not find in his papers a definite statement as to the means by which the dissipation of orbital energy is achieved. He did not regard planetary space as a perfect vacuum and may have relied upon the resistance of the interplanetary medium for the predicted effect. The fall of such great and numerous masses as the planets into the sun would, he says, immeasurably increase the heat of the central body. He also seems to have regarded the planets of small density as capable of combustion. The heat thus generated he believed great enough to dissociate the material of the system and to restore it to its original nebulosity.* Then commences a fresh cycle of evolution.

Kant's doctrine of the restoration of the nebula by the dissociation attending the collapse of the solar system must certainly be pronounced false in the light of the second law of thermodynamics. It is almost impossible, however, to see how Kant could have avoided this error before Carnot's day. His attempt was to frame a theory for the universe, for all time, and some regenerative principle was a necessity to such a scheme. The second law of thermodynamics as now understood seems to divide everlasting time into two portions, the former of which is a perfect blank. In the light of present knowledge it would appear that the entire stellar system, planets and residual nebulae alike, must have been in the condition of an immensely diffused nebula not more than a few hundred million years ago and that the universe is now hastening towards eternal death. It is evident that the initial diffusion, whatever its date and its degree, can have lasted but an instant, during which the potentialized molar energy represented the maximum proportion of the total energy of the universe. By the principle of dissipation, molar energy is continually wasting away or undergoing conversion into molecular energy. Hence if the quantity of matter and the total energy of the entire system are constant, the molar energy at a period preceding that instant must have been smaller and must then have increased. The only alternative compatible with the second law seems to be to suppose that the total energy of the universe underwent an increase at that time. The universe would then not be a conservative system, the equation of energy would not apply to it, and aliquid ex nihilo fit. Such an increase of energy might or might not be due to a creation of matter. Thus if the molar energy was maximum within a finite period, either the quantity of energy in the universe is variable and has been increased or there is an undiscovered, regenerative, third law of thermodynamics

* Kant's Werke, vol. i, p. 302.

which in some circumstances supersedes the second. In either event the number of the fundamental principles of natural philosophy would be still incomplete.

It is possible, however, to imagine the date of this critical period in the universe, the epoch of initial nebulosity, infinitely remote, though little intellectual satisfaction is to be attained by this means. If a strictly finite amount of matter were distributed in a space not merely relatively large but absolutely infinite, so that every atom should be at a truly infinite distance from any other, then a strictly infinite lapse of time would be required to produce a finite degree of condensation. Known laws would therefore account for present conditions if the ratio of space to mass in the universe is not merely large, but (like time itself) absolutely infinite. Such an assumption however seems preposterous, while it is far from incredible that some natural law remains to be discovered, even one which would make a *perpetuum mobile* of the universe as a whole.

The attempt which Kant made to create moment of momentum from the impact of nebulous matter is curiously out of accord with the rest of his investigation. In treating of Saturn's rings he avoided any such mistake, and the persistency of moment of momenta follows from his own scheme of the universe. When the solar system collapses, only to be restored to a nebulous state, as he supposed, it will be in rapid rotation, according to his own theory. It is thus only for the very first of the infinite succession of developments that his exposition asserts a fallacious source for rotational movement.

Kant seems to have anticipated Laplace almost completely in the more essential portions of the nebular hypothesis. The great Frenchman was a child when Kant's theory was issued, and the *Système du Monde*, which closes with the nebular hypothesis, did not appear till 1796. Laplace, like Kant, infers unity of origin for the members of the solar system from the similarity of their movements, the small obliquity and small excentricity of the orbits of either planets or satellites.* Only a fluid extending throughout the solar system could have produced such a result. He is led to conclude that the atmosphere of the sun, in virtue of excessive heat, originally extended beyond the solar system and gradually shrank to its present limits. This nebula was endowed with the moment of momentum which Kant tried to develop by collisions. Planets formed from zones of vapor, which on breaking agglomerated. He appeals to the rings of Saturn as an illustration of nebular contraction; he also considers the Zodiacal light as due to a

* The retrograde satellites of Uranus were discovered by Herschel in 1787, but Laplace in his hypothesis does not refer to them.

nebulous remnant. In the first editions of the *Système du Monde*, Laplace, like Kant, supposed some of the nebulae to represent stellar islands outside of the Milky Way system. In 1824 the work was revised and this explanation was omitted. In the revised edition, but not in the earlier ones, Laplace refers the equality of the moon's periods of rotation and revolution to tidal action caused by the earth's attraction in the still fluid moon.* Comets were regarded by Laplace as little nebulae formed outside of the solar system, while Kant considered them as arising in the extreme portions of the solar nebula.

The main points of comparison between Kant and Laplace seem to be these. Kant begins with a cold, stationary nebula which, however, becomes hot by compression and at its first re-Genesis would be in a state of rotation. It is with a hot, rotating nebula that Laplace starts, without any attempt to account for the heat. Kant supposes annular zones of freely revolving nebulous matter to gather together by attraction during condensation of the nebula. Laplace supposes rings left behind by the cooling of the nebula to agglomerate in the same way as Kant had done. While both appeal to the rings of Saturn as an example of the hypothesis, neither explains satisfactorily why the planetary rings are not as stable as those of Saturn. Both assert that the positive rotation of the planets is a necessary consequence of agglomeration, but neither is sufficiently explicit. The genesis of satellites is for each of them a repetition on a small scale of the formation of the system. Each refers comets to nebulous matter more distant than the planets, but Kant thought it merely the superficial portion of the solar nebula. Both contemplated extragalactic systems of stars.

While Laplace assigns no cause for the heat which he ascribes to his nebula, Lord Kelvin goes further back and supposes a cold nebula consisting of separate atoms or of meteoric stones, initially possessed of a resultant moment of momentum equal or superior to that of the solar system. Collision at the center will reduce them to a vapor which then expanding far beyond Neptune's orbit will give a nebula such as Laplace postulates.† Thus Kelvin goes back to the same initial condition as Kant, excepting that Kant endeavored (of course vainly) to develop a moment of momentum for his system from collisions.

The extragalactic stellar systems imagined by Kant were

* This seems to have been overlooked. For Lord Kelvin (*Geological Time*, Geol. Soc. Glasgow, Feb. 27, 1869) ascribes the discovery to Helmholtz.

† On the Sun's heat. Lecture to Royal Inst., 1887, or Popular Lectures, vol. i, p. 421.

similar to those which the elder Herschel regarded as probable in the earlier part of his career, and in which Laplace believed prior to 1824. The subject has been under discussion ever since and is not definitely settled. Of late years the application of the spectroscope and the researches of Proctor have made it seem possible that only one stellar system is visible. If others exist they may be too far off for their light to reach the earth, or have progressed too far towards extinction to be sensibly luminous.*

After Kant's explanation of the heat of the sun as due to compression, the theory does not seem to have been revived until Helmholtz enunciated it in 1854.† It now has the adherence of Lord Kelvin, and, so far as I know, of all physicists as the main source of solar radiation.

The novelty of Kant's view of Saturn's rings was that he supposed them to be composed of fume, or minute discrete particles, instead of satellites, as Cassini and Wright had done. It is rather strange that Laplace, though, like Kant, appealing to Saturn as an illustration of the nebular hypothesis, should yet have regarded the rings as solid. The older view, practically in the Kantian form, was reviewed by Maxwell,‡ who was evidently unaware of the earlier hypothesis.

Little advance has been made in explanation of the Zodiacal light since Kant's time. It is regarded as partly gaseous and partly composed of solid matter, perhaps meteoroids. Its spectrum seems to be that of reflected light.

Kant's idea of a transition from planets to comets has not received verification, and the orbit of Neptune is at present the most nearly circular of all the planetary orbits, excepting that of Venus, instead of the most eccentric as Kant would have supposed. Hence his prediction that planets exterior to Saturn would be found cannot be placed to his credit, its truth being accidental.

Kant was not the first to notice the decrease in density of the planets Earth, Mars, Jupiter and Saturn, while the densities of Mercury and Venus were unknown in his time. Such

*The possibility that ether envelopes a stellar system like an atmosphere without extending indefinitely into space, is perhaps worth considering in reference to the hypothesis of the existence of distant star groups.

†Helmholtz's paper, *Ueber die Wechselwirkung der Naturkräfte*, was a popular lecture delivered in Königsberg and, according to Thomson and Tait, was on the occasion of a commemoration of Kant (*Nat. Phil.*, vol. ii, p. 493). In this paper appeared also his views on the tidal retardation of the earth and the moon, and the collapse of the solar system. Kant is mentioned as author of the nebular hypothesis, but not in connection with these more detailed questions. It is certainly most curious that at a Kant celebration Helmholtz should have announced the rediscovery of four of Kant's theories.

‡Proceedings R. S. Edin., vol. iv, 1858, and Adams prize essay, for 1856. Both may be found in his collected works.

merit as he possessed in the matter is consequently confined to the attempt to account for the greater frequency of relatively dense matter among the inner planetary rings. Euler supposed the densities to be proportional to the square roots of the mean motions. If a is the mean distance, this is equivalent to making the density proportional to $1/a^{3/4}$. Lagrange in 1782* assumed the density to be proportional to $1/a$. In this hypothesis Lagrange was anticipated by Buffon† in 1769.

Modern results do not indicate such simplicity. Since there is compression in the inner portions of a planetary body, mean density must be a function of mass. This is perhaps a sufficient explanation of the fact that Earth has a higher average density than Mercury, Venus and Mars. The planetary densities are divisible into two groups. Those planets just named do not differ very greatly in this respect. The outer group from Jupiter to Neptune are vastly less dense, but it is not certain that the diameters of these bodies represent anything except the exterior of their atmospheres. They are probably still highly heated, and their average density is not very different from that of the sun. Now the sun is certainly vastly hotter and more expanded than the outer planets, and it must therefore be composed of material which would be denser than the mass of Jupiter at the same temperature. It is conceivable that this difference is due solely to the greater pressure within the sun's mass.

Kant's opinion (1755) that Jupiter is still fluid seems to be the earliest expression of that view. Buffon in 1778 announced his opinion that both Jupiter and Saturn are fluid.‡

The theory of base-levelling has been so generally accepted by geologists and physical geographers throughout the century that it is scarcely worth while to mention individuals, but some of those who do not happen to be familiar with Kant may be glad to read a few of his vigorous sentences on the subject. "In respect to change of the earth's shape there remains to be discussed a single cause which can be reckoned upon with certainty; it consists in the fact that the rain and the streams continually attack the land and sluice it down from the highlands to the lowlands, gradually making the elevations into plains and, so far as in them lies, strive to rob the globe of its inequalities. The action is certain and no matter of opinion. The land is also subject to this action so long as there is material on the

* *Nouveaux Mém. Acad. Berlin*, 1782, p. 158.

† *Oeuvres comp. Paris*, 1827, vol. i, p. 215.

‡ *Époques de la Nature. Oeuvres complètes de Buffon*, Paris, 1827, vol. v, p. 84. Miss A. M. Clerke in her *History of Astr.* in the 19th Century, 2d edition, errs as to the date of Kant's publication on this subject and assigns the priority to Buffon.

declivities which can be attacked and transported by rain water.”*

In 1754, according to Kant, the Berlin Academy offered a prize for a solution of the question “Whether the rotation of the earth which produces the alternation of day and night, has undergone any change since the time of its origin? What is the cause and how can the fact be established?”† Kant’s paper printed in the same year dealt with both the tidal retardation of the moon while still in a fluid state, and the retardation of the earth’s rotation by the marine tides. The subject seems then to have fallen into complete oblivion for nearly seventy years. The retardation of the moon’s rotation was rediscovered by Laplace in 1824. The earth’s retardation was maintained by Prof. James Thomson in conversation about 1840, as Lord Kelvin mentions.‡ J. R. Mayer expressed the same opinion in print in 1848.§ Helmholtz in 1854 discussed the tidal retardation both of the moon and of the earth.|| William Ferrel and C. Delaunay afterwards again suggested tidal retardation of the earth. It was only at a later date that Kant’s paper was brought to light.

So far as I know, J. J. von Littrow, in 1830, was the first to revive the Kantian idea of a final collapse of the solar system.¶ In 1854 Helmholtz again recurred to it. He explains the future annihilation of the rotation of the planets by tidal friction, and relies on a certain inevitable amount of resistance in interplanetary space to destroy orbital motion. Thomson and Tait, in 1867, showed that after the earth has come to expose to the moon a constant aspect, the effect of the solar tides will be to reduce the distance between earth and moon until they come together. By a similar argument it is said to follow that loss of energy (irrespective of a resisting medium) will not cease until all the bodies of the solar system “subside into a state of motion in circles round an axis passing through their center of inertia, like parts of one rigid body.”** It does

* Kant’s Werke, vol. i, p. 203.

† I find in the memoirs of the Academy no mention of this prize, and Kant’s paper printed in 1754 does not seem to have been offered in the competition. Peschel and Leipoldt, however, refer to it as having taken the prize. (*Physische Erdkunde*, vol. i, 1884, p. 54.)

‡ *Geological Time*, Address Geol. Soc. Glasgow, Feb. 27, 1868.

§ *Beiträge zur Dynamik des Himmels*, Heilbronn, 1848. Translated in *Phil. Mag.*, vol. xxv, 1863, p. 403.

¶ *Populärwissenschaftliche Vorträge*, 2d Fascicle, p. 130.

‡ In *Vorlesungen über Astronomie*, second part 1830, p. 146, he announces this approaching catastrophe and ascribes it to external influences acting on the system. Later he indicated friction in a resisting medium as the external influence. This explanation probably appeared in the first edition of his work, *Die Wunder des Himmels*, 1834.

** *Nat. Phil.*, 2d ed., sec. 276. The text of this section is the same as in the first edition of 1867.

not seem certain that Kepler's laws are sufficiently rigorous for application to ensuing conditions, but if they are so, the number of bodies would seemingly reduce to two. By the third law, if T is the time of revolution and a the mean distance, T^2/a^3 is the same constant for all the planets. Hence if the solar system reaches a condition in which T is the same for all the planets, a must also be the same, and all the planets must revolve on the same circle. In view of Lagrange's investigations on the stability of the solar system, it hardly seems possible that all the planets should acquire and permanently pursue the same exactly circular orbit unless they were to coalesce to a single mass.

In his preface to his *Theory of the Heavens*, Kant says: "I seek to evolve the present state of the universe from the simplest condition of nature by means of mechanical laws alone." After more than one hundred and forty years of rapid progress in science, it cannot be denied that his attempt was astonishingly successful.

Washington, D. C., December, 1897.

ART. XVI.—*The Islands and Coral Reefs of the Fiji Group*; by ALEXANDER AGASSIZ.*

. . . . On our arrival at Suva we found the "Yaralla," a twin-screw steamer of about 500 tons, chartered from the Australasian United Steam Navigation Company, awaiting us. We have now been about six weeks cruising among the islands, and have found the boat admirably suited for our purpose. During the past summer I had shipped to Australia our outfit for dredging, sounding and for deep-sea towing as well as all the materials necessary for preserving our collections. This equipment we found safely stored in the "Yaralla." I had also brought with me deep-sea tow-nets of the various patterns used by the Prince of Monaco, by Dr. Giesbrecht of the Naples Zoölogical Station, and by Hensen on the "National" Expedition, in order to compare their efficiency with the Tanner deep-sea self-closing net in use on the "Albatross" and which I had adopted on my various expeditions. Unfortunately our time here is so limited and the conditions for towing at great depths among so many intercepting islands are such that the results likely to be obtained seemed to make it unadvisable to devote the time necessary for such a comparison. Although nothing was done to test the different deep-sea self-closing towing nets, yet we have made at various points along our course a number of deep hauls, from 150 fathoms to the surface, with the open net. A large number of hauls were made off Suva which gave us an excellent collection of pelagic forms, the collections of Crustacea and of Aculephs being specially noteworthy. Mr. Mayer will prepare a report on the Aculephs. When practicable we have also made collections on the reef-flats of various islands and atolls.†

I also brought to Suva a complete diamond-drill boring apparatus and a competent man to superintend the work: Mr. W. Eyers, recommended to us by the Sullivan Machine Co., of Chicago, from whom the apparatus was obtained.‡ To provide against contingencies, a comparatively small hand machine was sent, capable of drilling to a depth of from four to five

* Extracts from a letter of Alexander Agassiz, dated Suva, Fiji Islands, December 15th, 1897, addressed to E. S. Dana.

† Dr. Wm. McM. Woolworth and A. G. Mayer accompanied me as assistants. Dr. Woolworth and my son Maximilian have taken a large number of photographs illustrating the physiognomy of the islands and their reefs. A selection from these I shall use in my final report.

‡ I have to thank the Trustees of the Bache Fund of the National Academy of Sciences at Washington for an appropriation of \$1200 towards defraying a part of the expenses of boring.

hundred feet. An oil motor was also provided to expedite the work with increasing depth.

This machinery had already been shipped when information reached the United States that Professor David of the University of Sydney had left for the Atoll of Funafuti in charge of an expedition to take up the unfinished work of boring of the party in charge of Professor Sollas, sent out by the Council of the Royal Society of London. The day before leaving Cambridge for the Pacific, news arrived that Professor David's party had succeeded in reaching a depth of nearly 600 feet, the bottom still being in coral. This information seemed to settle the coral question, and all I hoped to accomplish was merely to confirm the work of Professor David by boring in some other district. Subsequent information received from Professor David leads me to think that the matter is not so simple as was represented by the newspapers. From what we have seen thus far of the Fiji islands reef I can only conclude that the boring at Funafuti has settled nothing and that we are still as far as ever from having a general theory of the formation of coral reefs. In fact with the present information obtained here I should never have thought of boring in the atolls of this group, for reasons which will be given presently.

The track which we followed was so arranged as to include in our first trip one or two of each type of island and of the different types of atolls, barrier and fringing reefs in the group. Starting from Suva, after visiting Mbenga we went to Ovalau, Wakaya, Makongai, Koro, skirted along the western shore of Taviuni, examined the northeastern coast of the same island, passed through the Matangi passage to Motua Levu and Motua Lailai, skirted along the western extremity of the Nanuku reefs. From there we steamed to Wailangalala, where we landed our boring apparatus and the crew needed for working the same. We then turned north, passing close to Nuku Mbesanga and Adolphus reef and entered Ngele Levu Lagoon. We next examined the Ringgold islands, paying special attention to Thombia, an extinct crater in Budd reef. From there we returned to our former anchorage off Thurston Point in Taviuni and followed our old track back to Wailangalala, where we found our boring party settled and at work. We then steamed south, examining Williamson reef, the Kimbombo islets, Bell reef and entered the Vanua Mbalavu Lagoon through the Ngillangillah passage, leaving the lagoon by the Tonga pass. We touched at Mango, Tavutha, Naiau and Lakemba, passed Aiwa, entered the Oneata Lagoon, visited Thakau Lekaleka, touched at Motha, entered the Komo Lagoon, the Yangasa cluster and the Ongea Lagoon. We passed Fulanga, close to the entrance, which was too shallow to allow

our vessel to enter, but near enough to give an excellent idea of its characteristic structure. We next touched at Kambara, anchored in the crater of Totoya, stopped at Moala: from there we made Solo Light House, examined the North Astrolabe reef, steamed through the Great Astrolabe reef, coming out west of Ono. We next examined a part of the shore of Kandavu and returned to Suva by way of Vatu Leile. On our second trip we visited Ngau, Nairai, the Horseshoe reef, Mbatiki and entering the Moturiki channel south of Ovalau, examined the barrier reef between it and Suva as far as Mbau. After our return to Suva we made a third trip along the southern coast of Viti Levu as far as Naudronga; skirting the reef as closely as was prudent, we were able to follow the changes in the Great Barrier reef of Viti Levu west of Suva as it gradually passes into a fringing reef and disappears off the Singatoka River, to appear again first as a fringing reef and then as a barrier reef extending beyond the Nandi waters to the west of Naudronga. We then paid a second visit to Vatu Leile and returned to Suva, having steamed a little over 1300 miles.

I came to Fiji under the impression that we were to visit a characteristic area of subsidence; for according to Dana and Darwin there is no coral reef region in which it is a simpler matter to follow the various steps of the subsidence which has taken place here. Dana, in his last discussion of the coral reef question, states that it is impossible to find a better series of islands than those of the Fiji to illustrate the gradual changes brought about by subsidence, which transform a volcanic island with a fringing reef to one with a barrier, and next to one with a circular reef ring and finally to one in which the interior island has disappeared and has left only a more or less circular reefing. For these reasons one of the Fiji atolls promised to be an admirable location for boring and settling the question of the thickness of the coral reef of an atoll. My surprise was great, therefore, to find within a mile from Suva an elevated reef about 50 feet thick and 120 feet above the level of the sea, the base of the reef being underlaid by what is locally called soapstone, probably a kind of stratified volcanic mud. The western extension of this reef can be traced at several points along the north shore of the harbor of Suva; the island of Lambeka and Vua and Dra-ni-mbotu, which are from sixty to ninety feet in elevation, being part of an elevated reef extending to low-water mark. It was this elevated reef or its extension westward which we traced from the Singatoka river to the Nandi waters. A short distance inland from the mouth of the Singatoka there is a bluff of about 250 feet in height, composed of a coral-reef limestone which is the inner exten-

sion of the elevated reef patches and bluffs visible on the shore of Viti Levu. I am informed by Dr. Corney that the islands of Viwa and Asawailau to the northward of the Nandi waters are also remnants of this elevated reef.

But the traces of extensive elevation are not limited to the larger island of Viti Levu. I found the islands on the rim of the atoll of Ngele Levu to consist entirely of coral rock elevated to a height of over sixty feet on the larger island. The surface of the island where we crossed it was a mass of hummocks of honeycombed, potted and eroded coral-masses resembling in every way the elevated reefs with which I had become familiar in the Bahamas, Cuba and Florida. The northern sides of the island of Ngele Levu are on the very outer edge of the rim of the lagoon, deep water running up to the shore line. We next found that at Vanua Mbalavu the northern line of islands were parts of an elevated reef forming vertical bluffs of coral-rock which had been raised by the central volcanic mass of the main island to a height of over 500 feet at Ngillangillah, at Avea to 600 feet, at the Savu Islands to 230 feet and on the main island to a height of nearly 600 feet. On the south of the main island the elevated coral bluffs are very much lower, those of Malatta and Susni reaching a height of a little over 400 feet. Going farther west and south we find at Mango the vertical bluffs of an elevated coral reef of over 600 feet and underlaid by volcanic rocks which crop out at the sea level.

At Tavutha the coral limestone bluffs are probably 800 feet high. At Naiau they are over 500 feet, at Lakemba they reach a height of about 250 feet on the southwest side of the island; the rest of the island is volcanic. On the island of Aiwa the elevated reef is fully 200 feet thick. In the Oneata group the highest point of the elevated reef bluffs is about 160 feet. South of the volcanic island of Motha and enclosed within the same barrier reef, on the island of Karoni the elevated reef is about 120 feet thick. On the three islands of the Yangasa group it attains a thickness varying between 240 and 390 feet, and finally on Ongea, the most southeasterly cluster we visited, the elevated reef attains a thickness of nearly 300 feet. At Fulanga the elevated reef attains a thickness of 360 feet, at Kambara it is about 200 feet thick, and at Wangawa it is perhaps over 300 feet: these islands are in part volcanic. Finally at Vatu Leile, the most westerly island we examined, the elevated reef forming the island is 110 feet thick at its northern extremity.

All this plainly shows that the southern part of Viti Levu and as far south as Vatu Leile, and the whole length of the windward islands of the Fiji group from Ngele Levu on the

north to Ongea on the south, have been subject to an elevation of at least 800 feet; as there is abundant proof that a great part of the thickness of the elevated reef has been eroded to reduce it in certain localities to the level of the sea or to leave at others bluffs and islands or islets, the occurrence of which we have traced at so many points.

But the evidence of a very considerable elevation is not limited to that furnished by the remains of the elevated reefs just mentioned: it is natural to assume that the elevation we have just traced was but a part of a more general elevation which perhaps took place in late Tertiary times and in which the whole group was involved. It is plain that there must have been most extensive denudation and erosion going on throughout the group for a very considerable period of time, geologically speaking. The outlines of the islands deeply furrowed by gorges and valleys, the sharp and serrated ridges separating them, the fantastic outlines of the peaks of Viti Levu, Vanua Levu and Ovalau, all attest to the great work of atmospheric agencies which has been going on for so long. The separation of islands, islets or isolated rocks from the points or spurs of the larger islands also bears witness to the great length of time during which action of the sea necessary to bring about their separation has been at work: adding to this the fact that we are in a region of a former powerful and extensive volcanic activity, the traces of which can still be seen in all directions, forces which have undoubtedly played a great part in the lifting of the island masses and their subsequent shaping to their present outlines.

From this evidence I am inclined to think that the corals of to-day have actually played no part in the shaping of the circular or irregular atolls scattered among the Fiji islands; furthermore that they have had nothing to do in our time with the building up of the barrier reefs surrounding either wholly or in part some of the islands; I also believe that their modifying influence has been entirely limited in the present epoch to the formation of fringing reefs, and that the recent corals living upon the reefs either of the atolls or of the barriers form only a crust of very moderate thickness upon the underlying base. This base may be either a flat of an eroded elevated reef or of a similar substructure of volcanic rocks, the nature of that base depending absolutely upon its character when elevated in a former period to a greater height than it now occupies.

Denudation and erosion act of course more rapidly upon the elevated reef rocks than upon those of a volcanic character. It is therefore natural to find that the larger islands like Kandavu, Taviuni and Ovalau are of volcanic origin, while the

islands which once occupied the area of the lagoons of Ngele Levu, of the Nanuku reef, of Vanua Mbalavu, of the Argo reefs, of the Oneata, Yangasa, Aiwa, Ongea and Vatu Leile clusters being elevated coral reefs, they have disappeared almost entirely, leaving only here and there a small island to attest to the former existence of the more extensive elevated reef once covering the whole area of what is now an atoll. Smaller volcanic islands like Matuku, Moala, Ngau, Nairai and Koro also show the extent to which each island has been eroded after its elevation. The erosion being least in Koro and Matuku, somewhat greater in Moala and Ngau and still greater in Nairai. In such atolls enclosing volcanic islands like Mbenga, Wakaya, Makongai, the erosion and denudation have been still greater, these islands covering but a comparatively small part of the area once occupied by the island originally covering the area of the lagoon. Denudation and erosion have been still more active in the Ringgold islands, in the Kimbobo cluster and in Komo, and it may have gone so far as to leave no trace in an atoll to indicate either its volcanic or coral (elevated reef) origin: the shape of the atoll being entirely due to mechanical action and not being connected in any way with the growth of the corals which have been found afooting upon reef-flats formed by atmospheric agencies or by the action of the sea.

So that as far as we can judge from the case of the Fiji islands, the shape of the atolls and of the barrier reefs is due to causes which have acted during a period preceding our own. The islands of the whole group have been elevated, and since their elevation have, like the northern part of Queensland, remained nearly stationary and exposed to great and prolonged denudation and erosion, which has reduced the islands to their present height; the platforms upon which the barrier-reef corals have grown being merely the flats left by the denudation and erosion of a central island of greater size than that now left; while the atolls are similar flats from the interior of which the islands have been eroded and the lagoons of which have been continually scoured by the action of the sea, the incessant rollers pouring a huge mass of water into the lagoon, which finds its way out through the passages leading into it.

In the Fiji islands the atolls and islands, or islets, surrounded in part or wholly by barrier reefs, have not been formed by the subsidence and disappearance of this central island, as is claimed by Dana and Darwin. The Fiji islands are not situated, as was supposed, in an area of subsidence, but on the contrary they are in an area of elevation, so that the theory of Darwin and of Dana is not applicable to the islands and atolls of the Fiji group.

What the age of the elevated reef of the Fiji is, I am unable to state; its aspect and position show it to be of considerable age, probably antecedent to the present period. In many ways it resembles some of the late Tertiary elevated limestones which I have seen on the northern and southern coasts of Cuba. The great thickness which the elevated coral reefs attain in this group, at least 800 feet, also shows that they may have been deposited originally during a period of subsidence, but not a period of subsidence taking place in our epoch or which could have had any effect in shaping the outline of the islands of the Fiji group and their accompanying reefs.

Whether the elevation of the Fiji group corresponds in time with that of northern Queensland, I am unable to state. I can only suggest that it is not improbable that the elevation of Queensland and of the Pacific islands to the east, New Caledonia, the Loyalty Islands, the Solomon, New Hebrides including Fiji and Samoa, may have been synchronous. It may be that these islands have, like northern Queensland, been subject to an immense erosion and denudation which have reduced them to their present proportions.

The elevation may have been preceded, as in Queensland, in still earlier geological times by a great period of depression, during which the thick beds of coral reef limestone may have been formed. How far east this elevation extended is not known; its area probably included the Cook islands and Tahiti, and judging from some photographs I should feel inclined to consider atolls of the Paumotu as having been formed by causes similar to those which shaped those of the Fijis.

The evidence thus far collected on the Fijis shows the futility of boring in this group. Any result obtained would merely at some point indicate the thickness of a former elevated reef; a reef formed in a period preceding our own. We should obtain information which could have no bearing on the main question, if I am correct in the interpretation of what I have observed, information in fact which may be obtained as one steams along without the trouble or cost of boring. Should I be correct, it would be natural to look upon the results of the boring at Funafuti much in the same light and to assume that the island, as well as others in the Ellice group, is also in this area of elevation and that the great thickness of coral obtained was reached by boring in the base of an ancient reef. So that the results obtained by Professor David from the boring at Funafuti do not assist us in any way in corroborating the theory of subsidence as essential to the formation of atolls.

However that may be, it only emphasizes what has been said so often, that there is no general theory of the formation of

coral reefs, either barrier, or atolls, of universal application. Each district must be examined by itself,—at least such has been my experience in Florida, in the Bermudas, the Bahamas, in Cuba and the West India Islands and the Sandwich Islands. The results of this trip show plainly that the theory of Darwin and Dana, of the formation of atolls and of barrier reefs by subsidence, is not applicable to the Fiji islands, notwithstanding the boring at Funafuti. In all the localities I have visited the coral reefs form but a thin crust upon the underlying base (it is not more than 50 to 60 feet thick in Florida), and the shape and slope of this base is in no way due to the growth of the corals living upon it.

This still leaves open the question of the formation of such thick masses of coral-reef rock, which though they may originally have been formed by subsidence, as other massive deposits have been, yet may also have been formed by the gradual pushing out to seaward of the outer edge of a reef; the reef increasing both in height (depth) and in width by the constant pushing out of the mass of débris and of blocks detached from the outer edge, forming a talus upon which corals may grow whenever the talus has reached the depth at which they thrive. I am inclined to think that the careful study of such a shore reef will alone give us a correct idea of the manner in which such thick masses of coralline limestone may have been formed.

There is still another phase in the formation of atolls which has received but little attention. I refer to the formation of atolls as the result of the denudation and erosion of volcanic summits or of extinct craters. There are in the Fiji two extinct craters which are most interesting: one of these is the small extinct crater of Thombia on the Ringgold islands. The highest point of its rim, the exterior circumference of which is about two miles, is nearly 600 feet, and it is continuous with the exception of a small part of its eastern edge, about a fifth of a mile, across which reaches a fringing reef, the extension of the fringing reef surrounding the island. This reef closes the entrance into the crater, which is about half a mile across at the level of the sea and has a depth of 24 fathoms. The other extinct crater is that of the island of Totoya, an isolated peak in the southern part of the group. It is about six miles in outer diameter with an inner basin of three miles and a depth of 34 fathoms. The highest point of the rim is 1200 feet and at two points it is low, forming in one case a narrow isthmus separating the crater from the outer lagoon. The horns of the open rim are connected by a fringing reef-flat on which thunders the Pacific swell, piling up the water into the great basin of the crater. This water finds its way out through an opening called the "Gullet," which though narrow forms an excellent passage to the anchorage inside of the crater. Totoya

has not only a fringing reef but also a barrier reef somewhat triangular in shape, surrounding the island. It is evident that the barrier reef has been formed upon the denuded and eroded spurs of the island which once extended seaward from the outer rim of the volcano.

Supposing now that the erosion of both Thombia and Totoya had continued long enough to reduce the rim of these volcanoes to the level of the sea or to form a chain of small islands, we should have, as soon as corals had covered the flats thus formed, which indicate the former existence of the rim, atolls of nearly circular form. The one, that of Thombia, being quite small with a circumference of 2 miles and a depth of 24 fathoms without patches in the central lagoon; the other being much larger, more than 25 miles in circumference, having a depth of 34 fathoms inside the lagoon. The lagoon of the Totoya atoll would be dotted with patches some of which formed parts of the rim, others being the remains of eroded spurs extending towards the center of the extinct crater.

There are in Fiji a number of small atolls from one to three or more miles in circumference the formation of which, it seems to me, can only be satisfactorily explained on the theory that they have been formed upon the eroded summits or rims of extinct craters, the rim of the volcano having been eroded either to a continuous flat or to flats separated by deeper passages (as in the case of the low parts of the rim of Totoya) forming entrances into the enclosed lagoons. Such atolls are Motua Levu, Motua Lilai, the Adolphus reef, Bell reef, Williamson, Pitman and the Horseshoe reefs and Thakau Lakaleka. Of course it is possible that some of these atolls may have been formed from the erosion and denudation of isolated peaks or ridges. It is also possible that some of the larger atolls in which are enclosed volcanic islands, like Vanua Mbalavu, Komo, Motha, Lakemba, Mbenga, the Ringgold islands and others, may represent parts of the rim or ridges and spurs of volcanic peaks and extinct craters which have disappeared by erosion and have left the outer flats upon which the barrier-reef corals have grown; while the deeper valleys and gorges of these now eroded volcanic islands represent the undulations in depths of the lagoons. The depths inside the lagoons vary greatly: in the case of Vanua Mbalavu we find 72 fathoms on parts of the eastern slope of the lagoon. These great depths, far beyond any at which corals can grow, represent the elevated gorges and slopes of the volcanic peaks which probably once extended over the whole area enclosed by the outer reef, during the elevation of which the reef which covered a part of the same area was lifted to its present or even to a greater height.

Such large volcanic centers with extensive craters of considerable depth are not unknown. We can reconstruct conditions from Totoya which would give us an atoll open to the west, with a few islands on the outer rim and a greatest depth of 250 fathoms inside the lagoon. Again Haleakala in the Sandwich islands has a crater with a depth of nearly 250 fathoms, while many small volcanic peaks, some fully 1200 feet in height, rise from its bottom. The diameter of Haleakala is fully as great as that of any of the atolls in Fiji. So that the great depth of the lagoons of some of the atolls can no longer be considered as a proof of the theory of subsidence.

Fulanga is also interesting as illustrating the formation of an atoll by the same causes which have produced the Sounds in the Bermudas. In the case of Fulanga we have a volcanic summit which has raised the elevated coral reef forming its rim to a height of probably 200 feet. This coral rim has been broken through and the action of the sea has gradually hollowed out in the interior a circular sound resembling a crater, which is due solely to the disintegration of the inner parts of the elevated reef. In the interior and outer edge of the Sound of Fulanga many parts of this reef still exist as small mushroom-shaped islands or small rounded or conical hills. It is also probable that some of the elevated reef-flats forming the rims of atolls owe their origin to causes similar to those which have shaped the crater-like Sound of Fulanga. This has perhaps been the case with such atolls as Ngele Levu, the Oneata, Ongea and Yangasa clusters and others.

The great variety of causes which have been active in shaping the present physiognomy of the reefs and atolls of Fiji shows the impossibility of assigning any one factor, like subsidence for instance, as is done by Dana and Darwin, as the single cause for the formation of the many different kinds of atolls and barrier-reef islands to be found in the Fiji group. The formation of the great barrier reef of the southern shores of Viti Levu is due to causes very similar to those which have given to the northern coast of Cuba between Nuevitas and Matanzas its present physiognomy. Along those parts of the island where denudation and erosion proceed rapidly owing to the soft character of the shore rocks, very extensive flats have been formed as those south of Ovalau. When the reef-barrier flats have been eroded from a harder base, like volcanic rocks, the flats are less prominent and somewhat more extensive when the old elevated coral reef formed the shore hills; or the reef-flats may disappear altogether when the harder volcanic rocks have been only little affected by erosion or denudation. From the nature of the negro-heads scattered upon the reef-flats it is generally a simple matter to ascertain the character of the base of the reef-flats of an atoll or of a barrier reef.

We were fortunate in being at Levuka at the time of the appearance of the "Bololo." On the morning of the 17th of November we left the ship at 3 o'clock bound for a spot named "Bololo" Point, about 3 miles south of Levuka. We had scarcely reached the spot when our guide fished up a few of the worms and in a few minutes the water was full of them. Canoes put off from the shore; men, women and children were wading on the reef with nets and all kinds of utensils to catch "Bololo." With the increase of daylight the "Bololo" became more abundant and at one time they were so plentiful that the water surrounding the boat was filled with them to such an extent as to resemble thick vermicelli soup. We made an excellent collection of the worms, preserving a large number by different methods. We found, as we had expected, that their sudden appearance was connected with spawning. There were males and females full of sperm and eggs. When in captivity the discharged spermatozoa rendered the water milky and the masses of eggs were left as patches of dark green granules on the bottom of the dish. The discharge of the eggs and spermatozoa was followed by the collapse of the worms, of which nothing was left but an empty skin scarcely visible. The "Bololo" seems thus suddenly to disappear. The males are light brown or greenish, while the females are colored dark green. Their activity while swimming about is something wonderful and the bursting of the animal when it discharges its eggs or spermatozoa is quite a peculiar phenomenon. Dr. Woodworth has made it an object to collect all the material possible in regard to the "Bololo," and on our return he will prepare a paper on this interesting annelid.

I have to thank the State Department at Washington for their kind offices in obtaining for us letters from the Foreign Office to the Government of Fiji. Sir George O'Brien, the High Commissioner for the western Pacific, gave us all possible facilities for visiting the different islands of the group. I am also indebted to the Hon. Charles Stuart, the Colonial Secretary, and to the Hon. W. L. Allardyce, assistant native Commissioner, for assistance and advice. To Dr. Corney and the Hon. John Berry I owe information regarding the presence of elevated reefs at various points I had not examined. To Captain D. Calder I am greatly indebted for his interest in our behalf. We were fortunate in retaining the services of Captain Robert Cocks as pilot during our expedition. His knowledge of the reefs is accurate and extensive. Finally I have to thank Captain Thomson as well as the officers and crew of the "Yarralla," who have been indefatigable in our interest.

I hope during the coming summer to prepare a fully illustrated report of this interesting cruise.

ART. XVII.—*Simple Compensated Shunt Box*; by WILBUR M. STINE.

THE usual method to compensate for the shunting of a galvanometer that the resistance of the circuit may remain unaffected by the introduction of the shunt, is to insert in series with the galvanometer in succession certain auxiliary or compensating resistances.

If the resistances of the various shunts to the galvanometer be denoted by S_1, S_2, S_3, \dots , the multiplying factors by n_1, n_2, n_3, \dots , taken in the order of their descending values, and the compensating resistance by r_1, r_2, r_3, \dots : a set of defining equations may be given to the usual method for compensation. These equations are, for a galvanometer of resistance, g ,

$$S_1 = \frac{g}{n_1 - 1} \quad (1)$$

$$S_2 = g \frac{n_2(n_1 - 1)}{n_1(n_2 - 1)^2} \quad (2)$$

$$S_3 = g \frac{n_3(n_1 - 1)}{n_1(n_3 - 1)^2} \quad (3)$$

$$r_1 = g \frac{(n_1 - n_2)}{n_1(n_2 - 1)} \quad (4)$$

$$r_1 + r_2 = g \frac{(n_1 - n_2)}{n_1(n_3 - 1)} \quad (5)$$

and

$$r_1 + r_2 + r_3 = g \frac{n_1 - 1}{n_1} \quad (6)$$

According to the usual practice, n_1, n_2, n_3 have the respective values, 1000, 100 and 10, and the preceding equations readily reduce to constant relations, thus—

$$S_1 = g \times 0.001001$$

$$S_2 = g \times 0.010193$$

$$S_3 = g \times 0.1233$$

and

$$r_1 = g \times 0.00909$$

$$r_2 = g \times 0.100909$$

$$r_3 = g \times 0.889$$

The foregoing equations are obtained only by long and tedious algebraic processes, and it is readily apparent that their final values are such as to throw doubt on the accuracy of the adjustment of a box.

On inspection it is seen that both the structural and analytical difficulties inherent in the usual form of compensated shunts arise from the fact that the compensating resistances are introduced into the circuit to be shunted.

By re-arranging the connections and attaching them to three part sockets, a marked simplicity is introduced into the calculations for a given set of shunts.

Proceeding to investigate the new arrangement of the resistances and shunts clearly shown in the accompanying figure,—the resistance of the galvanometer circuit through shunting becomes successively R_{c_1} , R_{c_2} , R_{c_3} , and in general

$$R_c = \frac{g}{n_x} \quad (7)$$

Now write

$$\left. \begin{aligned} Q_1 &= r_1 + r_2 + r_3 \\ Q_2 &= r_2 + r_3 \\ Q_3 &= r_3 \end{aligned} \right\} \quad (8)$$

For the shunt at C, the compensating resistance Q_1 is

$$Q_1 = g - \frac{g}{n_1} = g \frac{n_1 - 1}{n_1} \quad (9)$$

Similarly

$$Q_2 = g \frac{n_2 - 1}{n_2} \quad (10)$$

and

$$Q_3 = g \frac{n_3 - 1}{n_3} \quad (11)$$

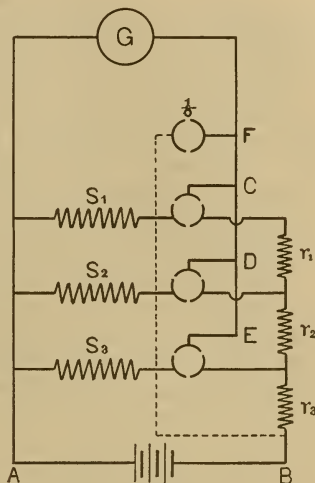
If n^x has the values given above,

$$\left. \begin{aligned} Q_1 &= 0.999 g \\ Q_2 &= 0.99 g \\ Q_3 &= 0.9 g \end{aligned} \right\} \quad (12)$$

The values of r are found by subtraction between the equations of (12) as is readily indicated in equation (8); and are

$$\left. \begin{aligned} r_1 &= 0.009 g \\ r_2 &= 0.09 g \\ r_3 &= 0.9 g \end{aligned} \right\} \quad (13)$$

Since only the galvanometer is shunted, the values of S_1 , S_2 , and S_3 are easily found.



ART. XVIII.—*Mineralogical Notes on Cyanite, Zircon, and Anorthite from North Carolina; by J. H. PRATT.*

1. *Cyanite*.—The mineral to be described occurs on the farm of Tiel Young, near North Toe River, Yancey Co., North Carolina, a few miles from Spruce Pine, Mitchell Co.

Some exceptionally large crystals of a grass-green color were obtained by the author during the summer of 1896 from Mr. M. Alexander, a jeweler in Asheville. After some difficulty the occurrence was located, during the past summer, and the locality has been thoroughly worked by Geo. L. English & Co. of New York, with the result that many good crystals of the cyanite have been obtained.

The mineral occurs in a decomposed mica schist from which the single crystals are easily separated. The crystals are often intergrown and masses of these were obtained as large as one's two fists. All of the crystals found were of a rich grass-green color and many were quite transparent. A few of the crystals showed a deep blue center with the grass-green margins. The crystals vary in size from $1 \times .7$ cm to 3.2×6 cm; a few coarser ones were observed that were considerably larger. The faces are generally smooth, giving fair reflections of the signal on the reflecting goniometer.

The forms observed on these crystals are as follows:

c , 001	a , 100	M , $\bar{1}\bar{1}0$	
b , 010	m , 110	Q , 120	t , 520

The face 520 is apparently a new one for cyanite. The three pinacoids were the only faces observed on the majority of the crystals, some of which were doubly terminated. After a very careful examination of the terminations, they were decided to be real basal planes and not cleavage surfaces. On one of the crystals, all of the faces observed were developed.

The following table shows the identification of the forms by calculated and measured angles. In obtaining the calculated angles the elements given in Dana's *Mineralogy* (1892), deduced from Rath's measurements* on Greiner crystals, have been used.

$$a : b : c = 0.89938 : 1 : 0.70896 ; \alpha = 90^\circ 5\frac{1}{2}' ; \beta = 101^\circ 2\frac{1}{4}' ; \gamma = 105^\circ 44\frac{1}{2}'$$

	Calculated.	Measured.
$a \wedge m$, 100 \wedge 110	34° 17'	34° 17'; 34° 20';
$a \wedge M$, 100 \wedge $\bar{1}\bar{1}0$	48 18	48 43; 48 41; 48° 45'
$a \wedge Q$, 100 \wedge 120	48 43	48 50
$a \wedge t$, 100 \wedge 520	17 9	17 13
$a \wedge b$, 100 \wedge 010	73 56	73 40; 73 38; 73 42
$b \wedge M$, 010 \wedge $\bar{1}\bar{1}0$	57 46	57 41

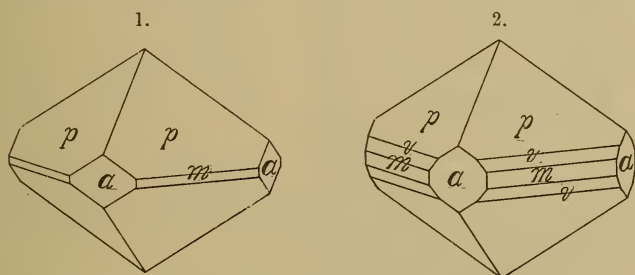
* Zs. Kr., v, 17, 1880.

The specific gravity is 3.64 and was determined upon several different samples. Iron and chromium were very carefully tested for, but no trace of either was observed in the analysis, which showed only the presence of alumina and silica.

Pale green cyanite has been obtained from a number of localities and it has also been found in the vicinity of the green cyanite locality on the farm of Isaac English of Spruce Pine, Mitchell Co., imbedded in an undecomposed mica schist. Another occurrence that is worthy of note is that of Graves Mt., Georgia. At this locality thin small plates of the pale green cyanite are associated with well crystallized rutile.

Zircon.—Some specimens of zircon crystals were obtained of Messrs. Geo. L. English & Co., from New Stirling, Iredell Co., North Carolina, and on account of their size and development it has been thought a description of them would be of interest.

The crystals are all very similar in their habit, in which the unit pyramid is strongly developed while the prism faces are short, figs. 1 and 2. Fig. 1 represents the majority of the



crystals, where the prism of the first order is only slightly developed, at times being hardly perceptible. Those represented by fig. 2 are similar in their habit to some zircon crystals described by the author from the townships of Dungannon and Faraday, Ontario.*

The following forms were observed on these crystals :

a , 100; m , 110; p , 111; v , 221; x , 311.

The face x , 311 was only observed on a very few of the crystals and was but slightly developed. The crystals are all well developed with smooth faces, making them well adapted for measurement on the reflecting goniometer. Although the author had no reflecting goniometer at hand, the faces were readily identified by means of the contact goniometer.

The crystals vary in size from 1^{cm} to 2.5^{cm} in diameter and are of a reddish-brown color.

* This Journal, vol. xlviii, p. 215, September, 1894.

Anorthite.—The occurrence of this feldspar at Buck Creek, Clay Co., N. C., has been mentioned by J. V. Lewis.* The mineral forms with olivine a mass of forellenstein (troctolite) rock, outcropping over an area of about two acres. The particles of feldspar vary in size from that of a pea to some nodules that were an inch and a half long by three-quarters of an inch broad and are separated from the olivine by a zone of fibrous silicates, composed partly of enstatite.

The feldspar has suffered some kaolinization but the interior of the larger nodules is free from all decomposition. By means of the heavy solution a product was obtained for analysis that varied in specific gravity from 2.6995 to 2.7440.

The results of the analysis made by C. H. Baskerville† are as follows:

		Ratio.	
SiO ₂	44.05	.754	2.23
Al ₂ O ₃	30.87	.302	.92
FeO .....	.84	.011	} .328 1.00
CaO	17.30	.308	
MgO .....	.36	.30	
Na ₂ O	3.65	.057	
K ₂ O .....	.83	.009	
Moisture .....	.35		
Loss on ignition ...	1.60		
	99.85		

The ratio of SiO₂ : Al₂O₃ : CaO, is near to 2 : 1 : 1, which identifies the feldspar as an anorthite.

Mineralogical Department,
North Carolina Geological Survey, December, 1897.

* Bulletin No. 11, N. C. Geological Survey.

† Of the chemical department of the N. C. Geological Survey.

ART. XIX.—*The Source of the X-rays*; by JOHN TROWBRIDGE and JOHN E. BURBANK.

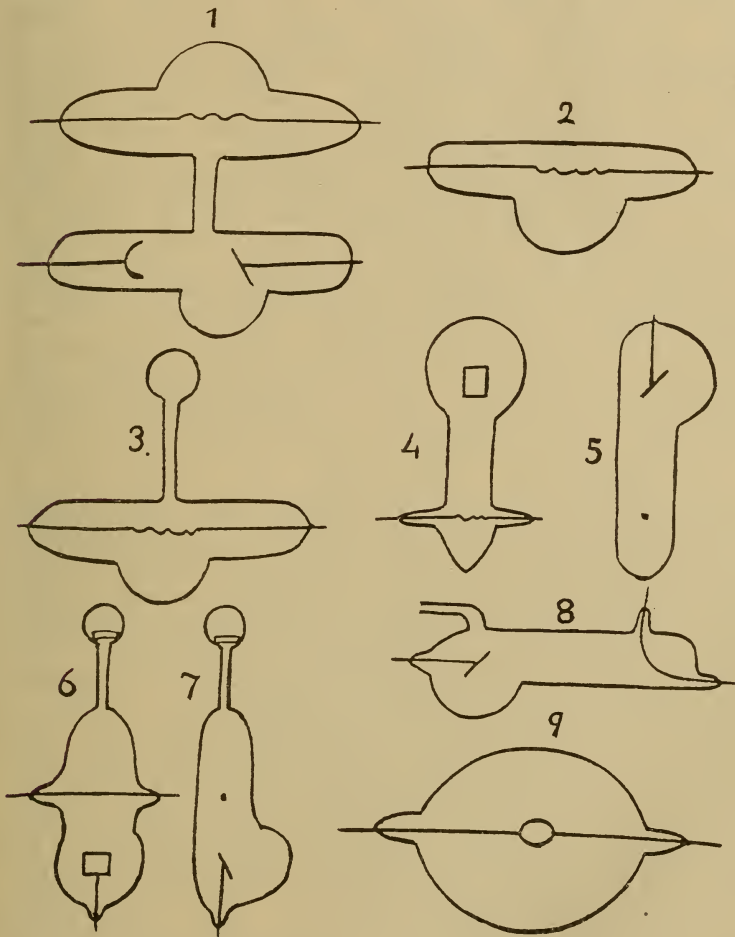
THE experiments described in this paper were conducted with Crookes tubes containing no interval between the anode and the cathode: and no discharge therefore in the usual sense occurred in the tubes. A continuous conductor was led through the rarified tube, and it was discovered that the X-rays were given off from every element of this conductor at right angles to its surface when a disruptive discharge occurred in the circuit of which the tube formed a part. This remarkable result was obtained by means of the very high electromotive force obtained by a Planté rheostatic machine which was charged by ten thousand storage cells. We shall describe our experiments with the various tubes we employed and in conclusion state our results.

The first tube is shown in fig. 1 (p. 131). It consisted of a straight wire tube joined to an ordinary Crookes tube of the focus pattern. This latter tube was joined to the straight wire tube in order to test the vacuum in the latter and to be sure that the necessary conditions existed for the production of the X-rays. When the terminals of the straight wire tube were connected to the Planté machine, and the latter was excited, the entire tube fluoresced brilliantly. This fluorescence was especially bright in the connecting tube between the straight wire tube and the Crookes tube, and a beam of light passed across the Crookes tube and formed a fluorescent spot on its bulb.

Photographic plates were exposed opposite to the thin bulb on the straight wire tube. These plates were carefully insulated from the ground and were covered in one case with a sheet of hard rubber $\frac{1}{8}$ of an inch in thickness, and in another case by a sheet of glass about $\frac{1}{2}$ inch in thickness. A powerful brush discharge was seen in the dark room to pass from the thin bulb of the tube to the insulator which covered the plates, and on developing the plates they were found to be covered with star-like clusters surrounded by nebulous patches. It was evident that the brush discharge had produced discharges at the surface of the dry plate, even through plates of glass $\frac{1}{2}$ an inch in thickness. Moreover there was a general darkening of the surface of the plate which indicated the action of the X-rays. No metallic objects could be placed upon the dry plates, for a powerful spark immediately passed to them and punctured the tubes. The darkening, however, was apparently diminished under strips of glass, although the effect of the brush discharge masked the effect of the X-rays.

Before the straight tube was exhausted powerful brush discharges were given off at the ends of the tube. When the tube was exhausted these brushes were much diminished and were replaced by a powerful brush which came off from the straight wire through the bulb of the tube and speedily punctured the latter when any object, even an insulator, was brought within six inches of the bulb. The most interesting results obtained with this form of tube was the production of the so-called X-ray burn by means of the brush discharge from its bulb. When the back of the hand was exposed to this brush discharge, which assumed a peculiar forked nature in the dark-room, a peculiar prickling sensation was experienced and all the symptoms of the well-known X-ray burn developed. The skin when examined under a microscope exhibited an appearance similar to that shown by the photographic plate. There were centers of inflammation surrounded by regions of lesser degrees of burn. It seems evident that the so-called X-ray burn is due to an electrification—a discharge at the surface of the skin—and this electrification may or may not be accompanied by the X-rays. This first form of tube was then abandoned, and a straight wire tube alone (fig. 2) was employed. Similar results were obtained with this tube. It was significant that the whole interior of this tube fluoresced brilliantly when it formed part of a circuit through which a disruptive discharge passed. This latter form of tube was replaced by that represented in fig. 3. A side ending in a thin bulb was added to the straight wire tube. The same phenomenon was exhibited by this tube: in addition a brilliant fluorescence filled the side tube, which appeared to flow in or flow out of the narrow tube which ended in the small bulb. We were reminded by this phenomena of Poynting's hypothesis of the flow of energy into a wire. This form of tube was replaced by a straight wire tube which is represented in fig. 4 and fig. 5 (side view). A straight wire passed completely through the tube and was in circuit with a line on which there was a rapid change of potential. At one end of this tube opposite a thin bulb blown on the tube is a piece of platinum foil inclined like the ordinary focus plane in a focus tube. At first we connected this focus plane with the ground, and having ascertained that X-rays were given off very strongly from this foil, we removed the ground connection and substituted for it a sheet of zinc. The tube still gave off X-rays. We then removed the sheet of zinc and found that X-rays were given off with undiminished strength. This tube was then modified into the form represented in fig. 6 and fig. 7 (side view). The straight wire occupied the middle of a tube: in one end of this tube was placed a focus plane of platinum and at the other end

there was a long, narrow tube which ended in a thin bulb. In this bulb was a crystal of calcite which was confined in the bulb by the narrowness of the bore of the connecting tube. This tube showed that X-rays were given off at right angles to the straight wire, for the calcite fluoresced a brilliant red and the fluoroscope showed X-rays proceeding from the inclined



piece of platinum. This form of tube, moreover, showed that the X-rays are reflected, so to speak, from the interior surface of the glass, for there were multiple shadows of the wire on the sides of the tube which were produced by the X-rays of varying intensity which were developed on the surface of the glass, and which in turn, proceeding from this surface at

different angles, produced elongated shadows. In the next form of tube, the wire passing through the tube was no longer straight, but was bent in the manner represented in fig. 8. In this form of tube there was a brilliant caustic formed on the sides of the tube opposite the concave side of the wire, and this brilliant caustic threw distorted shadows of the bent wire on the opposite side of the tube. It was evident that the X-rays were given off at right angles to the surface of this wire, and therefore coincided in direction with the lines of electrostatic force. We next experimented with the form of tube represented in fig. 9. This consisted of a large thin bulb five inches in diameter, enclosing a continuous conductor, the center of which consisted of an aluminum mirror. When this tube was exhausted to a very high degree, the mirror formed a bright fluorescent spot on the bulb, the position of which could be readily changed by means of a magnet. When the exhaustion was carried to a very high degree, reversing the current from a Ruhmkorf coil through the tube caused no marked difference in the appearances in the tube: at a lower degree, however, a marked difference resulted. With the employment of a powerful Ruhmkorf coil giving sparks of at least eight inches, X-rays could be detected in this tube, and when the tube was connected to the Planté machine, the X-rays gave strong effects in the fluoroscope.

In order to test the question whether the so-called cathode rays and X-rays are generated primarily only at the cathode, a very large resistance of distilled water was interposed in the circuit with the continuous wire tube (fig. 9) in order to damp any oscillations which might arise. The circuit thus consisted of the tube, the water resistance, a spark gap and the secondary coil of a large Ruhmkorf. The tube was connected at first permanently to the air pump. As the exhaustion proceeded a beam of rays proceeded from the mirror on the continuous conductor which was focused on the wall of the tube. This beam was more brilliant and produced a stronger fluorescence on the tube when the wire was negative than when it was positive. At a higher stage of the vacuum, however, very little if any difference could be detected in the appearance of the tube, and X-rays could be detected outside the tube opposite the fluorescent spot caused by the mirror. That is, the X-rays were given off both when the wire constituted the cathode of the circuit and also the anode. It seems therefore that the term cathode rays is not a general one. It would seem that electric rays might be a more comprehensive one for both cathode rays and X-rays.

Furthermore the phenomenon of electrostatic induction plays an important part in the phenomena of the so-called

X-rays. When the tube represented in fig. 9 had reached a certain stage of exhaustion, a bit of tin-foil connected to a zinc plate 10×16 cm and 1 mm thick, was stuck upon the outside of the tube where the mirror formed the fluorescent spot. This zinc plate was carefully insulated from the ground. It was seen that a bundle of rays was reflected by the tin-foil to the opposite wall of the tube, showing a well-defined shadow of the mirror and the continuous conductor on this wall. The direction of this shadow could be changed at will by changing the position of the tin-foil. This phenomenon was produced both when the wire was the cathode and when it was the anode. It can be explained on the hypothesis that a layer of electrified particles is held by a condenser action on the wall of the tube and that the fresh coming particles are strongly repelled by those that have accumulated at the spot.

The behavior of aluminum toward the X-rays is so remarkable that it merits especial investigation. Can it be that it manifests a remarkable condenser action toward the high electromotive forces which produce the X-rays, similar to the action which has been observed at lower voltages?*

We connected to the air pump, at the same time, two exactly similar tubes, one of which had two pointed terminals of platinum, the other two pointed terminals also; but one consisted of aluminum and the other of platinum. The discharge from a Ruhmkorf coil was sent through these tubes which were in multiple circuit. At a certain stage of the exhaustion it was seen that the discharge passed more easily when the aluminum wire was made a cathode than when it constituted the anode. When the wire terminals in both tubes were made of thin discs, the difference was less marked. This might have been surmised, from previous investigations on the effect of form of electrodes on resulting polarization.† It may be that the anomalous action of aluminum in respect to X-rays is due to a species of dielectric polarization on the surface of the platinum and that thus the surface becomes a new source of electrostatic stress, similar to that which was observed by connecting a bit of tin-foil and a capacity to the tube. Since we are dealing with very high differences of potential and with high charges on the ions, the instantaneous exhibition of electrical energy is very great and might probably explain the diffusion of this energy through the air. According to this hypothesis the light manifestations of the X-rays arise only at the fluorescent screens, or at other suitable surfaces.

* L. Graetz, Wied. Ann., No. 10, 1897, p. 323.

† Karl Robert Klein, Wied. Ann., No. 10, 1897, p. 259.

Conclusions.

1. A Crookes tube enclosing a continuous conductor is well suited, with the employment of high electromotive force, for the study of electric lines of induction.

2. The direction of the so-called X-rays and cathode rays can be changed by electric induction.

3. The so-called X-ray burn can be produced by an intense state of electrification.

4. The so-called cathode rays and X-rays are given off from every element of a continuous conductor at a high stage of the vacuum in a Crookes tube, both when this conductor constitutes the cathode and when it forms the anode of the electrical circuit. The term electric rays, possibly rays of polarization, would appear to be more comprehensive than the terms cathode rays and X-rays.

Jefferson Physical Laboratory, Harvard University.

ART. XX.—*Four New Australian Meteorites*; by HENRY A. WARD, Rochester, N. Y.

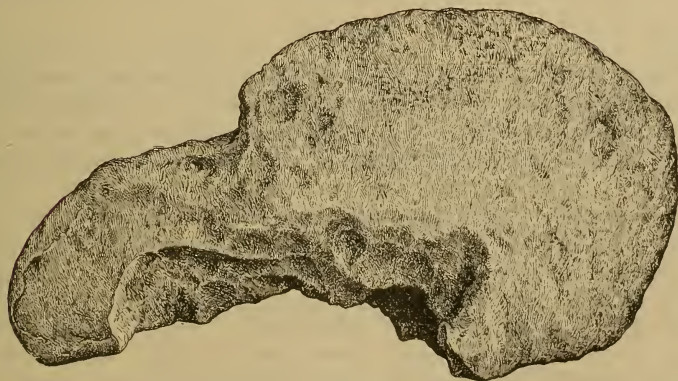
[Read before the Rochester Academy of Sciences, Jan. 11th, 1898.]

THREE of the meteorites below described were obtained by me during a trip through Australia in 1896. The fourth was sent to me during the following summer.

Roebourne.

This iron meteorite was discovered in 1894 by Mr. H. Reginald Hester on an alluvial plain 200 miles southeast of Roebourne (the nearest town) and 8 miles from the Hammersley Range of hills, in northwest Australia. The old aborigines say that it was always there! The specimen was taken by Mr. Hester to Perth, the capitol of West Australia, where it was deposited in the Public Museum and lay for several years. Casts of it had been made in the meantime and distributed to various Australian and European Museums. In June, 1896, I obtained the whole mass from Mr. Bernhard H. Woodward, the curator of Perth Museum, who also gave me the above facts as to the finding.

The mass is shaped a little like the skull of an eagle. Its length is 57^{cm}; its width 34^{cm} and its greatest thickness 7^{cm}. It weighed when entire 191½ lbs. or 86·8 kilos.



Roebourne meteorite, 1 ft. 10½ in. long.

The entire surface is comparatively smooth, with the exception of the lower edge, which is characterized by large and deep pittings, and further has the appearance of a portion having been separated at this point either before or shortly after

its reaching our atmosphere. A most interesting feature of the iron is noticed on the small end (see cut), where there is a prominent ridge or selvedge, having the semblance of being formed by the metal fusing and then being turned over the edge. The length of this ridge, following around the curve, is 27^{cm}, and it extends from 1 to 3^{cm} inwards from the edge. Nothing but a deep surface melting can have caused this. The entire surface is of a lustrous reddish-brown hue, with the metal showing prominently through it in some places.

The Widmanstätten figures are quite regular in size, but very dim on account of the great number of small flakes, probably of schreibersite, scattered through the mass. As far as sectioned, the troilite nodules have been few in number and very small in size, the largest being only 12^{mm} in diameter.

This iron is octahedral.

Analysis of the Roebourne Meteorite by Mariner and Hoskins, Chicago, Ill.

Fe	90·914
Ni	8·330
Co	·590
P	·156
S	trace
Mn	trace (?)
Si	·010
C	trace
	<hr/>
	100·000
Specific gravity	7·78

Ballinoo.

This siderite was found early in 1893 by George Demmack, a shepherd, on the water-wash of a tributary of the Murchison River, about ten miles south of Ballinoo, West Australia. It was taken to the Public Museum of Perth, where I obtained it in June, 1896, together with its history as here given.

The length of the mass was 34^{cm}; its width 27^{cm}; and its greatest thickness 11^{cm}. It weighed 93 lbs. or 42·9 kilos. In appearance it suggests a huge flattened potato.

Its pittings are comparatively few; on face showing in cut, there are but five that are prominent. All of these, however, are of special interest from the fact that they show a pitting within a pitting, the inner one having been formed in each case by the troilite having been worn away to a greater depth than the iron surrounding it. That this is the cause is shown clearly on a cut surface parallel to the pitted face (shown in cut) and 5^{cm} from it. Here a troilite 3^{cm} in diameter corresponds with the large pitting in lower left-hand corner of

the cut. The original coating of the mass has entirely disappeared, except in the larger and more prominent pittings and a few small blotches on the smooth parts, where it has a graphitic black, granulated appearance. The oxidized surface is very thin, the metal showing clearly through it on all prominent ridges.



Ballinoo meteorite, $\frac{1}{4}$ natural size.

The Widmanstätten figures, though well developed on etching, are very minute and are scarcely visible to the naked eye. This iron is octahedral. The etched surface also shows numerous sections of troilite not more than 1^{mm} thick and up to $2\frac{1}{2}^{\text{cm}}$ long, surrounded by schreibersite. On one section there is a troilite nodule 1^{cm} thick entirely surrounded by a layer of what seems to be graphite, averaging 1^{mm} in thickness. On the same section there are also thin patches of this graphite (?) from 2 to 3^{mm} in diameter.

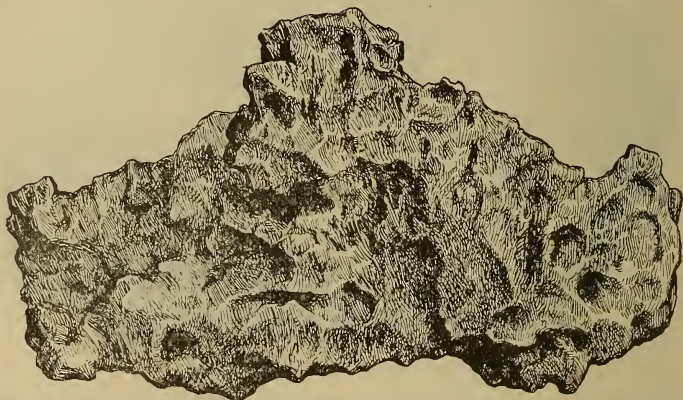
The markings on this iron are more nearly identical with those of Cowra than any other iron with which I am acquainted.

Analysis of the Ballinoo Meteorite by Mariner and Hoskins, Chicago, Ill.

Fe	89.909
Ni	8.850
Co .....	.740
P .....	.501
C	trace
Cu	trace
S	trace
Si	trace?
	100.000
Specific gravity	7.8

Mungindi.

A siderite found early in 1897 in Queensland, three miles north of Mungindi P. O., New South Wales. Its length is 39^{cm}; width, 24½^{cm}; greatest thickness, 17^{cm}. Its weight is 62 lbs. or 28·1 kilos. The exterior surface shows in some places the original crust, which is of a dense black, graphitic appearance. But the larger portion of the crust is of a dark yellowish-brown color, while on the prominent ridges it is worn entirely away, thus allowing the edges to show the silver color of the iron within.



Mungindi meteorite, $\frac{1}{4}$ natural size.

The whole surface on all sides is completely covered with pittings, rather uniform in size, but varying much as to general shape. Some few of the deeper and smaller circular ones, as seen in cut, are undoubtedly formed by the disappearance of the troilite nodules that once filled these cavities. The prominent ridges all have the same general trend, which is in the line of the main axis of the mass.

A cross-section when etched with weak acid brings out, very quickly, Widmanstätten figures of great clearness and beauty: the markings are strongly octahedral. The sectional face as shown in the cut displays several troilite nodules of various sizes and shapes, some of which are long thread-like masses from 3 to 4^{cm} in length, while others are round or oblong in shape. Patches of schreibersite, small in size, are also plainly visible throughout the section, while the Laphamite lines of Smith show distinctly here and there.

As to etching, it is attacked more readily and quickly by weak acid than is any other iron with which I am acquainted.

Another mass of Mungindi weighing 51 lbs. was found at the same time with the one just described. Both masses were discovered by a half-breed and were lying together nearly covered with the red soil.



Mungindi meteorite, section $\frac{1}{2}$ natural size.

Both of these masses are mentioned, without description or analysis, in the Records of the Geological Survey of New South Wales, vol. v, by Mr. George W. Card. Both pieces were subsequently sent to me by Mr. E. F. Pittman, the Director of the Survey, for cutting and distribution.

Analysis of the Mungindi Meteorite by Mariner and Hoskins, Chicago, Ill.

Fe	90.307
Ni	8.230
Co	1.360
P .....	.093
C .....	.010
S	trace
Si	trace?
	<hr/>
	100.000
Specific gravity	7.4

Mooranoppin.

This octahedral iron was found in or before 1893 by an aboriginal on the sand-plains near Mooranoppin, 160 miles east of York, Western Australia. Its general shape was that of an oblong bar 10^{cm} in length, 8^{cm} wide and 4^{cm} thick. Its weight was 2½ lbs. The original crust is shown on exterior surface of a brownish black color.

The blades of kamasite are so broad that the Widmanstätten figures are not prominently clear on an etched surface. The sections are penetrated by numerous fissures, the largest of which are 1^{mm} wide and 3^{mm} long. These fissures are filled with a black graphitic mineral. A nodule of the same material 1½^{cm} in diameter occurs at one end of the section and is surrounded by a band of troilite. A few small nodules of troilite, ranging from 1 to 3^{mm} in diameter, occur also sparingly in the section.

This entire mass was obtained by me from the Perth Museum in 1896. I have since cut it into slices.

ART. XXI.—*Measurement of Self-Inductance by Alternating Current and Electrodynamometer*; by K. E. GUTHE.

IN a recent article in this Journal (December, 1897), Professor H. A. Rowland publishes a number of methods for the measurement of inductances and obtains results of far greater accuracy than is possible with the methods commonly used. The principle on which he bases his experiments may here be stated in a more general form:

If alternating currents of the same period but of different phase, traverse the coils of an electrodynamometer, the deflection is proportional to the product of the maximum intensities of the currents, multiplied by the cosine of their difference of phase, or

$$d = a I I' \cos \theta$$

It is apparent that we have no deflection, if the difference of phase is 90° , and it is this special case which we employ in practice. The above rule has first been formulated by A. Overbeck,* and was also applied by him to measurements of capacities and inductances which he arranged in various ways, especially in the form of a Wheatstone's bridge. Since the number of resistance boxes to be used in that arrangement decrease the accuracy of the method appreciably on account of their self-inductance and capacity, I was led last summer to try the three simplest arrangements possible, two of which have been given in Rowland's list (3 and 6). Before describing the third method, which I consider the simplest of all, I will give some of the practical details of my work with the first two.

As the source of the alternating current we use a small laboratory-alternator, which makes about 1850 revolutions per minute.

The electrodynamometer is of the Edelmann type and its movable system is replaced by a few turns of fine copper-wire wound on a light wooden frame, having a resistance of 156 ohms. Currents of .00001 ampere can easily be detected but the self-inductance of the coils is quite appreciable, for the stationary coil .116 henry and for the movable a little less than .1 henry. Therefore the correction for self-induction in series with the condenser must be applied. It may be mentioned that the correction as given in Rowland's paper for method 3, in which the self-inductance is put in parallel with the capacity, is wrong; the correct formula is

$$\frac{L'}{c} = rR' \left(\frac{1}{1 - b^2lc} \right)$$

* Wied. Ann., xvii, p. 816, 1882.

For great sensitiveness we need a rather large condenser. The absorption, as was also mentioned in Rowland's paper, has a very disturbing influence. In a former paper* I pointed out also the variation of the apparent resistance. The Stanley condensers are remarkably free from these faults.

The work with the two methods referred to showed indeed that they are superior to others and especially Rowland's method \S gave good satisfaction. In this the capacity and the movable coil (r) in parallel with a non-inductive resistance (R'') are placed in series with a parallel arrangement of the self-induction and stationary coil (R) with another non-inductive resistance (R').

$$\frac{L}{c} = (R + R')(R'' + r).$$

On account of the large self-induction of the coils of the electro-dynamometer, which is always measured in addition to \times , difficulties arose, when we attempted to measure coils with small self-inductance. The third method I devised enables us to measure these very accurately. It is a simple application of the above mentioned rule.

I use a two-phase generator, consisting of a stationary Gramme-ring, inside of which a two-pole field-magnet rotates. This generator has been designed by Professor Carhart and is described by Carhart and Patterson.† It gives two currents differing in phase by 90° . The E. M. F. of the generator can easily be adjusted to any desired value up to 60 volts by varying the current through the movable field magnets. One of the currents we send through the stationary, the other one through the movable coil of the electro-dynamometer. By inserting resistance in series with the stationary coil, a balance is easily obtained. We connect then the coil, whose inductance we wish to measure, in series with one of the branches and add resistance, until the balance is again obtained. By using a standard induction we can determine the increase in resistance necessary to balance a given increase of self-inductance. For any given frequency, slight variations of which do not appreciably affect the result, the formula is

$$L_1 : L_2 :: R_1 : R_2$$

To show the delicacy of the method I add two sets of observations, taken on different days.

* *Electrical Engineer*, Sept. 16th, 1897.

† *Electrical Measurements*, p. 114, or *Phys. Rev.*, iii, p. 141, 1895.

Let R' be the resistance necessary to balance the electro-dynamometer,
 L the known self-inductance added,
 R'' the resistance, to produce the new balance,
 R_1 the increase in resistance,
 R the resistance corresponding to $\cdot 01$ henry,
 R''_{\times} and R_{\times} the values for the resistances obtained with \times in series.

R'	L	R''	R_1	R	R''_{\times}	R_{\times}	\times
180.8	.02	212.1	31.3	15.65	198.45	17.7	.0113
179.97	.035	234.92	54.95	15.7	197.62	17.65	.01121

Experiments made by students using other methods (see Carhart and Patterson's measurements) gave for the same coil values lying between $\cdot 0107$ and $\cdot 0117$ henry as the extreme limits, but mostly nearer to the average, which exactly agrees with the second value given above.

The capacity and the self-inductance of the ordinary resistance coils exclude a still greater accuracy, but I feel sure that this can be obtained by employing resistance free from those faults. A preliminary experiment with a fine wire gave as the length that had to be added, when the self-inductance of the standard was increased from $\cdot 005$ to $\cdot 015$, from $\cdot 015$ to $\cdot 025$ and from $\cdot 025$ to $\cdot 035$ henry, 810, 812, 814 divisions respectively.

I believe this method to be of some advantage, when we have an electro-dynamometer of large self-inductance. The possible errors are small, since only one resistance-box is used for the adjustment, and the experiment can easily be performed by even inexperienced students.

Physical Laboratory of the University of Michigan.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the Influence of Proximity on Voltaic Action.*—Some time ago GORE showed that when an electrolyte was used in the form of a vertical column about three meters in height, the electrodes being as far as possible perfectly similar, the difference of pressure at its upper and lower ends, due to the action of gravity, produced an electromotive force giving a feeble current on closed circuit. Reasoning that if by producing pressure, gravity exerts an influence on chemical and voltaic action, even an excessively minute one, similar effects should be produced when a large mass, either of metal or other substance, acts by gravity on a voltaic electrode placed at the end of a horizontal column of electrolyte, the author has made a series of experiments to test the question and gives in his paper results which go to establish the correctness of his conclusion. — *Phil. Mag.*, V, xliii, 440-457, June, 1897.

G. F. B.

2. *On the Action of Light on Chlorine and Hydrogen.*—It has been shown by GAUTIER and HÉLIER that when equal volumes of hydrogen and chlorine, both carefully dried, are submitted to diffused daylight for ten or twelve hours, the quantity of hydrogen chloride formed corresponds to only about 2.55 per cent of the mixture employed; while if the gases be moist, the amount of hydrogen chloride produced under precisely similar conditions may rise even to 60 per cent. Exposed to diffused sunlight for an hour, 6.7 per cent of the mixed gases entered into combination when they were dry and 92.5 per cent when moist. Hence it appears that when the vapor of water is present, the combination is materially facilitated; a result which the authors regard as due to the formation of intermediate products, for instance, hydrochloric acid. In subsequent experiments, the dry mixture of gases was exposed to artificial light. Using an albo-carbon flame at the distance of a meter, the light emitted being equivalent to 14.5 carrels, it was observed that after 237 hours 92.5 per cent of the hydrogen and chlorine had combined to form hydrogen chloride. The rate of this formation increased at first, reaching a maximum, after three hours exposure, of 2.8 per cent per hour. Then it decreased somewhat rapidly. In no case, however, was any limit to the combination indicated; thus showing a marked difference between the action of light and heat. The maximum rate of formation is attained much sooner with sunlight than with artificial light. The authors also observed, that the rate of combination, after the maximum is passed, is not proportional to the uncombined hydrogen and chlorine, since the hydrogen chloride already formed, while it does not limit the action, exerts a decided retarding influence upon the union. Moreover, when the chlorine is in excess, the combination is more rapid. Thus if the

mixture contained 54.8 volumes of chlorine, 42.3 volumes of hydrogen and 2.6 volumes of air, the union was complete after an exposure of 31 hours to the albo-carbon light; while if the gases were mixed in equal volumes 250 or more hours were required under similar conditions. If the hydrogen be in excess the effect is similar though less strongly marked.

BERTHELOT expresses the opinion that it is necessary to take into the account in all experiments made on the combination of mixed gases, the possible reactions which may take place between the gases themselves or the products of their reaction, and the walls of the containing vessel. This action in some cases may be simultaneous and not successive, chemical stresses between the gases and the material of the walls, which together constitute a heterogeneous system, determining the occurrence of any change at all. This local action on the walls will occasion local thermal disturbances which may alter the nature or the rate of the change at the point, and which may even lower the initial temperature at which these changes will take place. Moreover, the reaction may be influenced by the condensation of a gas film on the surface of the walls of the tubes. In fact, the action of surfaces more than the action of masses is here to be taken into the account, these surface actions determining the equilibrium of the system.

GAUTIER, in reply, calls attention to the fact, that Berthelot's criticisms refer rather to his early experiments on the combination of heated gases than to the action of light on gases, now under discussion. The function performed by the walls of the vessel, which in his investigations were kept constant in temperature and were not permitted to become heated by the reaction, is, as he believes, to regulate the speed of the combination and not to limit it. Again, carbon monoxide and oxygen show similar phenomena to those given by hydrogen and oxygen; but in the former case there can be no hydrate formed. The same results are obtained with vessels of glass, silvered glass, porcelain or quartz, and they are independent of the mode of cleaning the surfaces to which the gas is exposed.—*C. R.*, cxxiv, 1267-1273; 1273-1276; 1276-1278, June, 1897.

G. F. B.

3. *On the Series Spectra of Oxygen, Sulphur and Selenium.*—In continuing their researches, RUNGE and PASCHEN have now examined the oxygen compound line spectrum and have given in tabular form the wave-lengths of the observed lines. Besides the six triplets which were noticed by Piazzzi-Smyth, the authors have found seven other triplets in the spectrum, similar in character, the whole thirteen taken together forming two distinct series. As far as can be determined, the differences between the rates of vibration of the three component lines of each triplet, are the same. All the triplets are distributed regularly over the spectrum, the two series which they form being similar to those which have been already observed in the case of magnesium, calcium, strontium, zinc, cadmium and mercury. Moreover, there are in the oxygen spectrum two other series of lines in addition to the triple

AM. JOUR. SCI.—FOURTH SERIES, VOL. V, NO. 26.—FEBRUARY, 1898.

series. It is probable that they represent pairs, since in four of the brightest of them their double character has been observed distinctly. The compound spectrum of sulphur is similar to that of oxygen. Like this, it contains two series of triplets, the first of which consists of six triple lines, the second of four. As before, the differences in the vibration-ratios of the three components are about the same, but these differences are nearly five times greater than is the case in the oxygen triplets. Selenium also gives a compound spectrum in which triplets occur, quite similar to those seen in the case of oxygen and sulphur.—*Ann. Phys. Chem.*, II, lxi, 641–686, July, 1897. G. F. B.

4. *On the Production of Electricity by Chemical Means.*—The cuprous chloride carbon monoxide cell of Borchers' has been experimented with by ANDREAS. He used carbon electrodes which were immersed respectively in solutions of cupric chloride in water and of cuprous chloride in hydrochloric acid, the two being separated by a porous jar. To put the cell in action chlorine was passed into the cupric solution and carbon monoxide into the cuprous. The current at first produced diminished rapidly after a time, when it was found that the cuprous salt had been completely oxidized, the carbon monoxide having taken no part in the action. Of the 1950^{cc} used in one case, only 10^{cc} were oxidized to carbon dioxide. The results were similar with platinum, palladium or nickel electrodes, used at various temperatures. The author then made a gas battery by placing two pieces of platinum gauze together, having a piece of filter paper between them moistened with an electrolytic solution. The resistance was low and it gave promising results with coal gas and air, with oxygen and hydrogen, and with chlorine and hydrogen. With the gases under a pressure of 3 atmospheres, the last combination gave an electromotive force of 1.5 volts and a current of about one ampere. Of course, the cost of the platinum would prevent its commercial use economically. Fairly good results, however, were obtained with carbon, sulphurous oxide being passed on the one side and chlorine on the other, both under pressure, into carbon tubes immersed in sulphuric acid. With one ohm resistance in circuit, this battery gave an electromotive force of 0.5 volts, the resulting products being sulphuric and hydrochloric acids. If the electrodes were made very large probably good results could be obtained with air and sulphurous oxide, the products now being only sulphuric acid.—*Zeitschr. Elektrochem.*, iii, 188–192, November, 1896. G. F. B.

5. *On Graphite, Graphitite and Graphitoid.*—From a careful consideration of the evidence put forward for the existence of graphitite and graphitoid as distinct modifications or varieties of graphite, as well as from his own observations made on natural and artificial material, WEINSCHENK concludes that there is no essential difference between these and graphite and that they must be taken, therefore, as being identical with the latter. The property of not swelling up when moistened with nitric acid and

ignited, on which the name graphitite was based, is explained by the fact that the crystals of "graphitite" are smaller and more compact and hence freer from cleavage cracks into which the acid could penetrate. The so-called graphitic acid has been obtained in crystals having the outlines of the original graphitite and with the same optical characters as graphitic acid. Moreover graphitic acid has also been prepared from graphitoid. There is no difference between the readiness with which graphite and graphitite burn, the rate of burning depending on the size, on the scales and on the purity of the material.—*Zeitschr. Kryst. Min.*, xxviii, 291–304; *J. Chem. Soc.*, lxxii, ii, 447, October, 1897. G. F. B.

6. *Manuel d'Analyse Chimique appliquée à l'Examen des Produits Industriels et Commerciaux*; par ÉMILE FLEURENT, Docteur des Sciences, Professeur remplaçant du Cours de Chimie Industrielle au Conservatoire des Arts et Métiers. 8vo, pp. iv, 582. Paris, 1898 (G. Carré et C. Naud. 12 francs).—As he says in his preface, Dr. Fleurent does not offer this manual as a complete treatise on chemical analysis. His object has been (1) to give the best general methods of qualitative and quantitative mineral analysis and of elementary organic analysis, free from unnecessary detail, (2) to avoid long and tedious processes and to furnish only one, or at most only two methods, giving rapidly the most accurate results, and (3) to furnish the industrial chemist engaged in commercial analysis with the necessary methods for rapidly examining fertilizers, vegetable and animal products, fermented beverages and the like. After twenty pages of preliminary observations on the organization of the laboratory, on reagents and their preparation, on taking samples and on the interpretation of the analytical results, the book is divided into two parts, one treating of mineral, the other of organic matter. The former after giving the principles of qualitative and quantitative analysis, considers the analysis of alloys, mineral colors and fertilizers, and cements. The latter takes up first organic analysis and then treats of soils, fertilizers, vegetable and animal products, including starch, fat, sugar, etc., and finally of fermented drinks. Short chapters are also given on the examination of fibers and the testing of petroleum. The book appears to be carefully written, is well illustrated, and will without doubt be of excellent service to the commercial chemist, for whom it was prepared. G. F. B.

7. *Organic Chemistry for the Laboratory*; by W. A. NOYES, Ph.D., Professor of Chemistry in Rose Polytechnic Institute, Terre Haute, Ind. 12mo, pp. xii, 257. Easton, 1897 (Chemical Publishing Co. \$1.50).—The publication of handbooks for the organic laboratory in this country is a gratifying evidence of the rapid development of the science of organic chemistry in instruction. The book before us must be regarded as a most valuable addition to existing manuals and is altogether worthy of Dr. Noyes' high reputation. The style is succinct and clear, the classification of subjects admirable, the methods described are the best possible and the illustrations numerous. G. F. B.

8. *Deductive Physics*; by FREDERICK J. ROGERS, M.S. Large 8vo, pp. vi, 260. Ithaca, 1897 (Andrus & Church).—"The object of this volume," the author tells us in the preface, "is to present in compact, though logically complete form, the principal facts, laws, definitions and formulas of the science of physics." Unquestionably the two errors to which text-books are most liable are bulkiness with corresponding diffuseness, on the one hand, and compactness with more or less unintelligibility, on the other. To select the right mean between these undesirable extremes is often a difficult matter. The book before us is certainly compact; but as a text-book it seems to us dry. Supplemented, however, as it is intended to be, with experimental lectures, it will, no doubt, serve a good purpose as a compendium of facts and principles for ready reference. It is provided with numerous problems and is well illustrated with diagrams.

G. F. B.

9. *Modes of Motion; or Mechanical Conceptions of Physical Phenomena*; by A. E. DOLBEAR, Professor of Physics, Tufts College. 16mo, pp. iv, 119. Boston, 1897 (Lee & Shepard).—A series of discussions to show the close relationships of physical quantities and their nature as modes of motion.

10. *Electrical Wind*.—It is still an open question whether it is possible to electrify air which is entirely free from dust particles. Late investigations by Lord Kelvin tend to prove that air can be electrified. S. ARRHENIUS describes experiments which support the view that the so-called electrical wind or electrical point, working, is due to an electrification of the surrounding medium by means of which the molecules are separated into ions which then manifest their electrical charges and repel one another. An arrangement with fine points which could be electrified was suspended by a torsion wire in a suitable vessel which could be filled with dry air, hydrogen, oxygen and marsh gas. The reaction of the suspended apparatus was found to be proportional to the gas density, and the experiments therefore support the electrical ion theory rather than the dust theory.—*Wied. Ann.*, lxiii, 1897, pp. 305-313.

The results of Arrhenius appear to be contrary to those obtained by E. Warburg,* who finds by the use of an electrometer that dry air freed from dust cannot be electrified and that the bearers of electrical charges in moist air are drops of water.

J. T.

11. *Heat produced by the Röntgen rays*.—E. DORN believes that he has detected an effect of heat produced by the Röntgen rays. The method employed to detect the heating was that described by Toepler for the measurement of very small pressures (*Wied. Ann.*, lvi, p. 609, 1895). Two connecting vessels are in communication with a tube containing a column of light, easily moving fluid-like toluol. One vessel is screened from the effect of the X-rays, while the other, which contains a strip of metal, is exposed to their action. A change in the pressure-level was detected and

* *Wied. Ann.*, lxiii, 1897, pp. 411-418.

was measured in heat equivalents by means of an electrical current which was passed through a suitable conductor in the tube which was exposed to the X-rays. The author attributes the movement of the pressure level to heat, and does not refer to a probable electrification of the air in the tube.—*Wied. Ann.*, lxiii, pp. 160-176. J. T.

12. *Effect of Cathode rays on air.*—P. LENARD shows that the cathode rays in air form regions of mist condensation. A jet of steam at a short distance from an aluminum window of a Crookes tube becomes of a bright whiteness and of a cloudy nature. Cathode rays work in this respect far more powerfully than X-rays. A. Paulsen has formed a cathode-ray theory of the Northern lights and he had anticipated a condensation working of the cathode rays. He has also assumed that the rays of the Northern light form clouds.—*Wied. Ann.*, lxiii, 1897, pp. 253-260. J. T.

13. *Electric arc between aluminum electrodes.*—V. v. LANG, in the course of an investigation of the polarization of electrodes between which the electric arc is formed, finds that a steady current can be obtained by means of an alternating current which feeds an electric arc between an aluminum terminal and a carbon terminal. The direct current amounts to about six per cent of the alternating current and flows from the positive aluminum to the negative carbon. This action is the reverse of that noted when an alternating current flows in an electrolytic cell in which an aluminum electrode and an electrode of another metal are placed.—*Wied. Ann.*, lxiii, 1897, pp. 191-194. J. T.

14. *Stratified discharges of electricity in free air.*—MAX TOEPLER shows that the phenomena of stratification are not confined to discharges in rarified media, but can be produced in atmospheric air at ordinary pressures. The discharges were photographed, thin layers of poorly-conducting substances being interposed between the spark terminals.—*Wied. Ann.*, lxiii, pp. 109-116. J. T.

II. GEOLOGY AND NATURAL HISTORY.

1. *On the Geology of Johnson County, Iowa.*—Professor SAMUEL CALVIN has developed some facts of more than ordinary interest in the chapter on Johnson County in the Annual Report of the Iowa Geological Survey (vol. vii, pp. 33-116, 1897).

The classification of the formations, which is particularly remarkable for the intervals not represented, is as follows, viz:

Group.	System.	Series.	Stage.
Cenozoic	{ Pleistocene or Quaternary	{ Recent	{ Alluvian Loess
		{ Glacial	{ Iowan till Kausan till
Paleozoic	{ Carboniferous	{ Pennsylvanian	{ — Des Moines
		{ Mississippian	{ — Kinderhook
	{ Devonian	{ Upper Devonian	{ — State Quarry
		{ Middle Devonian (Hamilton?)	{ Cedar Valley Wapsipinicon
{ Silurian	{ Niagara	{ Anamosa Le Claire	

In the Devonian system an unconformity is recognized as separating the Devonian from the Silurian formation, and the lowest member of the Devonian in this county is the peculiar "Fayette breccia" described by Norton from the Lime county exposure (Iowa Geol. Surv., vol. iv, p. 157). This is shown, both by its fossils and by the presence of the Otis and Independence beds below it in other regions, to be Devonian and near to the horizon of the Hamilton of New York.

Another unconformity is recognized higher up in the Devonian, separating the Cedar Valley formation from the State Quarry. The characters of this latter formation are so peculiar that special attention may be called to them by a few quotations:

"At the state quarries, or North Bend quarries, in sections 5 and 8 of Penn township, there is a body of limestone of Devonian age, possessing marked characteristics which set it off sharply from the rest of the Devonian in Iowa. The formation has a thickness of about forty feet. At present there is some uncertainty as to its exact taxonomic relations.

"On fresh fracture the state quarry rock is light gray in color. In texture it varies somewhat in different beds, but near the middle of the formation it is composed of coarse, imperfectly comminuted fragments of brachiopod shells cemented together, the spaces being filled with interstitial calcite. Among the recognizable species of shells *Atrypa reticularis* is the most common, but some beds contain very large numbers of *Dielasma* (*Cranæna*) *iowensis*. At some horizons shells of an *Orthothetes* are common. *Orthis impressa* is not rare and *Rynchonella pugnus* (*Pugnax pugnus*) occurs occasionally. The shells, or fragments of shells, making up the limestone are not embedded in a matrix. They are simply piled on each other and cemented together in a manner illustrated by the formation of the modern coquina along the east coast of Florida. The rocks near the middle of the state quarry beds are a brachiopod coquina having the interstices completely filled with crystalline calcite. * * *

"The anomalous relations of this formation, the limited areas to which it is confined, the abrupt manner in which it appears and disappears, sometimes at the level of one member of the Cedar Valley section and sometimes at the level of another, all lead to the conclusion that it was deposited unconformably on the Cedar Valley limestone after the lapse of a considerable erosion interval. The same view is even more strongly suggested by the fact that in certain respects the fauna of the state quarry beds is unique. The deposit near Solon furnishes *Pugnax pugnus* Martin, *Melocrinus calvini* Wachsmuth, and a very peculiar stromatoporeid, none of which is found in the other Devonian formations. Of other species that have a greater vertical range, as for example *Atrypa reticularis*, there is sufficient variation to distinguish them from individuals of the same species found at other horizons. The *Orthothetes*, so common in the beds in section 5 of Penn township, is associated with *Pugnax*, and like it is

limited to the state quarry stage. The great mass of cemented crinoidal debris comprising the beds in Graham township and the upper ten or fifteen feet of the formation at the state quarries, has no parallel in any other stage of the Iowa Devonian. The presence of *Dipterus*, which elsewhere occurs only in the upper Devonian, tends likewise to separate this from the underlying Cedar Valley formation. In this connection it may be noted that the Rhynchonelloid shell *Pugnax pugnax* is a Carboniferous rather than a Devonian type. It is true that this species is found in the upper Devonian of New York, and at the same horizon in Europe; but it is in the Carboniferous, particularly in Europe, that it attains its fullest development. Faunally, therefore, the relations of the state quarry limestone are with the upper, and not with the middle Devonian, as is the case with the Cedar Valley beds; and so all the phenomena relating to this limestone and its interesting fauna seem to require for their interpretation a number of crustal movements and a period of erosion in the Iowa Devonian heretofore unsuspected."

To the reviewer of this report the phenomena of this quarry are recognized as a confirmation of the theory advanced several years ago* that the *Cuboides* fauna of the Tully limestone in New York, when studied in comparison with the faunas occurring below it in the New York series of Devonian, must have had an origin from the west and north, by the migration of faunas, rather than in any modification of faunas existing in the immediate region previous to the time of the Tully limestone.

The writer has for several years been expecting to find evidence of a barrier having existed in early Devonian time, extending from the Archæan tongue of Wisconsin toward the ancient island of southeastern Missouri. According to my interpretation of the several Devonian faunas of America, a continuity of the faunas, after the *Cuboides* zone appeared in the New York area, is noticed in the whole extent of the northern Devonian from New York to Iowa, through the Mackenzie river, across to China and on to the European formations as far as Devonshire in England.

This continuity of faunas does not appear in the Middle Devonian formations, but the brake seems to separate the well known New York faunas from those of Iowa and the Mackenzie valley, and Nevada. The barrier, therefore, was supposed to exist somewhere between Iowa and New York. The State Quarry limestone of Iowa has furnished Prof. Calvin with the very evidence I have been looking for. This evidence points to the occurrence of violent disturbance of the preëxisting quiet sea, the removal in places of channels through the deposits, the sudden local and wholesale destruction of life—with the introduction of a fauna new to that region, but which, like the *Cuboides* fauna proper, is characteristic of the stages following, and not preceding the *Cuboides* zone in the North American region.

H. S. W.

* The *Cuboides* zone and its fauna, Bull. Geol. Soc. Am., vol. i, pp. 481-500, 1890.

2. *Iowa Geological Survey: Vol. VII, Annual Report, 1896*, with accompanying papers; pp. 1-555, plates i-xi, figs. 1-81, and six folded maps. SAMUEL CALVIN, State Geologist, 1897.—The volume contains the ordinary administration reports with special papers on the detailed geology of the counties of Johnson, Cerro Gordo, Marshall, Polk, Guthrie and Madison. There is also an elaborate report on the Artesian Wells of Iowa, by W. H. NORTON, representing pp. 113-428 of the volume but bound separately. As the records of the wells have been preserved and carefully correlated, they furnish evidence of the underground structure and variation in thickness of the several beds penetrated not previously published.

H. S. W.

3. *La face de la Terre (Das Antlitz der Erde) par ED. SUESS, traduit . . . et annoté sous la direction de EM. DE MARGERIE, avec une préface par MARCEL BERTRAND.* Tome 1, pp. i-xv, 1-835; 2 colored charts, figs. 1-122. (Armand Colin & Cie.) Paris, 1897.—This translation into French of Suess's classical work opens to many English readers, as well as French, a rich storehouse of structural geology. The French translation has been made by M. Em. de Margerie and eight distinguished specialists. Many notes, especially in the way of bringing the bibliographic references up to date, have been made by the editors, and 76 of the 122 figures are new to this edition.

The book is divided into four parts, two of which appear in the present volume. The first treats of the movements of the outer crust of the globe, including an exhaustive study of the evidences of the traditional deluge in the region of the lower Euphrates; the causes (earthquakes), and the nature of the earth movements resulting are discussed. Dislocations, volcanoes, and a discussion of the relations between the movements affecting our senses and the phenomena of dislocation close this part. The second part treats of mountains and the structure and plan of mountains, more fully those of southern Europe, but, also, clearly those of the chief mountain regions of the globe are described and well illustrated. The two remaining parts on ocean and land surfaces are reserved for a second volume.

American geologists will find here brought together a vast amount of accurate details regarding, particularly, European structural geology, the original sources for which are scattered widely through geological literature and thus out of reach of any but the professional geologist.

H. S. W.

4. *Boletín del Instituto Geológico de México.* Nums. 7, 8 y 9. *El Minera de Pachuca.* 183 pp. Mexico, 1897.—The latest publication of the Geological Institute of Mexico, under the able directorship of Dr. JOSÉ G. AGUILERA, is a quarto volume of 183 pages, with numerous plates and other illustrations, devoted to a discussion of the mineral deposits of the Sierra de Pachuca. The description of the region, together with an excellent half-tone plate, gives a very clear idea of the general physiographical and geological relations. The various systems of mineral veins

are described in detail and a full account given of the augite-andesites and other igneous rocks. The system of exploitation is then discussed and the various metallurgical processes by which the metals are obtained from the ores. In the preparation of this volume the Director, J. G. Aguilera, has been ably seconded by E. Ordoñez, I. O. González, P. C. Sánchez and others.

5. *Zirkelite*: A question of Priority; by Dr. M. E. WADSWORTH. (Communicated.)—In the *Mineralogical Magazine*, Vol. xi, pp. 86–88 (read June 18, 1895) is described a mineral containing zirconium, titanium, lime, iron, etc., under the name of *zirkelite*. This paper was prepared by my friend, Dr. E. Hussak, and by Mr. G. T. Prior. Later Mr. Prior (l. c. pp. 180–183, read Nov. 17, 1896) published an analysis of the same mineral.

I wish to protest against the use of the name *zirkelite* for this mineral on the ground of the prior use of it to designate a commonly-occurring rock belonging to the basaltic family. When two subjects are so intimately connected as mineralogy and petrography it does not seem to be for the interest of science that names should be duplicated in them. So true is this that I abandoned the name *rosenbuschite*, which I had given to a class of rocks in honor of Professor Rosenbusch, because only a few weeks previously it had been employed to designate a new mineral.

The term *zirkelite* was used by me in 1887, or seven years before it was taken by Messrs. Hussak and Prior. (See Preliminary Description of the Peridotites, Gabbros, Diabases and Andesites of Minnesota. Bulletin No. 2. Geological Survey of Minnesota, 1887, pp. 30–32.) It was used to designate the commonly-occurring altered conditions of basaltic glassy lavas which are often called diabase glass, etc. *Zirkelite* occurs forming the entire mass of thin dikes, and the exterior parts of many dikes of diabase and melaphyr, as well as the surface of old lava flows like the melaphyrs and diabases of Lake Superior, Newfoundland and elsewhere. *Zirkelite* holds the same relation to tachylite that diabase and melaphyr do to basalt, *i. e.* an older and altered type. The macroscopic and microscopic characters of this rock were given in the place cited above.

The term *zirkelite* was again used in the same way in my Report of the Geological Survey of Michigan for 1891–1892; (1893, pp. 90, 97, 138, etc.) It was also published in my classification of rocks given in the Catalogue of the Michigan College of Mines (Michigan Mining School), 1891–1892, p. 104; 1892–1894, Table XI; 1894–1896, Table XI. Further the term *zirkelite* is defined in accordance with my usage in Löwinson-Lessing's *Petrographisches Lexikon*, 1893, p. 252; and accounts of it are given in the *Neues Jahrbuch für Mineralogie*, 1893, II, p. 292, and in Kemp's *Handbook of Rocks*, 1896, p. 170.

Michigan College of Mines, Houghton, Mich., Dec. 17, 1897.

6. *Krystallographische Winkeltabellen*; by VICTOR GOLDSCHMIDT, large 8°, 432 pp. Berlin, 1897 (Julius Springer).—In this work is presented for the first time a complete table of

angles for all the crystal forms of all crystallized mineral species. Such a table is eminently useful to the crystallographer to determine without laborious calculation whether the forms observed on a crystal are already known or are new. But the construction of a complete table, based on the accepted method of interfacial measurements between crystal faces, was impracticable, since it required the presentation of an enormous number of angles for each form, and would thus be too bulky to be useful. Monographs on various mineral species contained approximations to such tables, but they were not complete even for those species and were widely scattered through the literature. The invention of the goniometer with two circles* by means of which each face on a crystal may be measured independently of all the others, and its position determined with reference to a fixed pole and meridian by two angular coördinates, first made possible the formation of a complete table of angles. For such a table need now contain for each form only these two angular values, ϕ and ρ (corresponding to geographical longitude and latitude for a point on the earth's surface), which fully characterize the form and which may be directly and rapidly compared with the results of measurements. The tables before us contain these values for each well-established form of each mineral, calculated from the axial elements of the substance and the symbol of the form; there are also given for each form several angles which facilitate the comparison of these angular coördinates with the results of the ordinary interfacial measurement; and lastly a set of linear coördinates which enable the rapid plotting of the form in a gnomonic projection. In an introduction of 29 pages necessary explanations of the values contained in the tables are given, and the schemes employed in each system for the calculation of the values are shown. Some idea of the enormous labor represented by this volume may be given by the statement that it contains upwards of 70,000 values; of this number about half are values recurring more or less often, such as angles of 45° and 60° , but the remainder required each a separate calculation. An appendix contains notes on the various minerals, indicating the particular orientation adopted in each case. The volume forms a logical conclusion to the elegant system of crystal measurement and description which the author has developed, and will be a welcome aid to the increasing number of those who are pursuing their crystallographic studies in the fruitful fields he has discovered.

C. P.

7. *Tabellarische Uebersicht der Mineralien nach ihrer kystallographisch-chemischen Beziehungen geordnet*; von PAUL GROTH. Vierte vollständig neubearbeitete Auflage, 184 pp. Braunschweig, 1898 (Fr. Vieweg und Sohn).—The fourth edition of Groth's Mineralogical Tables has just appeared and will be

* For a brief description of this instrument and the method of using it, as well as for references to the original papers concerning it by Goldschmidt and others, see this Journal, vol. ii, 1896, p. 279.

warmly welcomed by all mineralogists. It would be difficult to find in the literature of the science a publication of like scope, which could be compared with it in the extent to which it has contributed to the advancement of the science. Whether we consider the excellence of the classification presented as a whole, or the arrangement and discussion of the characters of the individual groups, or still further, the suggestions made in regard to the probable chemical constitution of many of the individual species, the work has been from its first appearance of the highest value to all interested in the subject. In its present form, it is brought down to the present time, with the introduction of the new species described since the appearance of the last edition in 1889, also the changes among the old species made necessary by recent investigations, and further the new system of crystallographic nomenclature which the author has developed in his valuable *Physikalische Mineralogie*.

8. *Minéralogie de la France et de ses Colonies*. Description physique et chimique des Minéraux; Étude des Conditions géologiques de leurs Gisements. Tome Deuxième; par A. LACROIX, pp. 353-804. Paris, 1897 (Librairie Polytechnique, Baudry et Cie, Éditeurs).—The author is to be congratulated upon the completion of the second volume of his admirable Mineralogy of France. Earlier parts have already been noticed in this Journal and attention has been called to the very large amount of new material which has been brought together here, in regard to the occurrence of mineral species in France and her colonies. The part now issued includes pages 353 to 804, embracing the native elements, the sulphur compounds, and the chlorides and fluorides. Wherever the reader opens the volume, he is sure to find something of peculiar interest, either in the description of the methods of occurrence or in the characters of the minerals themselves. Many excellent illustrations are introduced, a considerable number of them by the photographic process, which is here used to good advantage.

9. *A Description of Minerals of Commercial Value*; by D. M. BARRINGER. 168 pp. New York, 1897 (John Wiley & Sons).—This novel work is intended as a reference book for those practically interested in minerals, especially miners, prospectors, or students in the field. In addition to some preliminary matter of a general nature, it consists for the most part of a series of tables giving the prominent metals in alphabetical order, with the names of the important ores, and for each the prominent physical and chemical characters, arranged very clearly in tabular form.

10. *A Complete Catalogue of Minerals*, compiled by WARREN M. FOOTE. 187 pp. Philadelphia, 1898.—Collectors will find this well edited catalogue of much convenience in their work. Besides various other lists, the most extended one of which is in accordance with the generally accepted system of classification and gives a brief summary of the characters of each species, there is also one including the minerals classified according to composi-

tion under the prominent metal which they contain. Numerous half-tone plates from photographs give satisfactory reproductions of the actual appearance of the specimens.

11. *Synoptical view of the various divisions of Embryophyta siphonogama*; by A. ENGLER, bearing date October, 1898.—In the 165th installment of *Pflanzenfamilien*, Professor Engler presents a detailed account of his reasons for suggesting the classification which he gave in his Syllabus, in 1892 (and in fact earlier), and introduces his statements by a synoptical view of his system. The strictly technical character of the whole memoir renders it unwise for us to transfer any part of it to our pages, but we must call attention to the importance of the communication. All of our readers who are interested in Systematic Botany should undertake an early and thorough study of the synopsis, explanations, and charts. Those who examine this paper by Professor Engler will be impressed by his fairness towards those with whom he cannot agree, and with his singular fairness in pointing out defects in his own system. In view of Professor van Tieghem's important papers already examined in this Journal, the present installment of the *Pflanzenfamilien* will be particularly welcome to all students of Botany at this time.

G. L. G.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Scientific Collections presented to Yale University*.—Professor O. C. MARSH has recently presented to Yale University, for the benefit of all departments of the University, the extensive and valuable collections belonging to him and now deposited in the Peabody Museum, New Haven. The deed of gift is dated January 1st, 1898. The conditions attached to the gift are only such as appear necessary to insure the permanent care and preservation of the collections themselves. The main collections, six in number, include the following:—

(1) *The Collection of Vertebrate Fossils*. This is the most important and valuable of all, as it is very extensive, contains a large number of type specimens, many of them unique, and is widely known from the descriptions already published, mainly in this Journal. In extinct Mammals, Birds, and Reptiles, of western North America, this series stands preëminent. It represents the main results of nearly thirty years explorations in the Rocky Mountain region.

Among the prominent features of this collection may be mentioned: (1) the series of fossils illustrating the genealogy of the horse, as made out by Professor Marsh; (2) the Birds with teeth, nearly two hundred individuals, described in his monograph "Odontornithes"; (3) the gigantic Dinocerata, several hundred in number, Eocene mammals described in his monograph on this group; (4) the Brontotheridæ, huge Miocene mammals, some two hundred in all; (5) Pterodactyles, over six hundred in number; (6) Mosasaurs, represented by more than fifteen hundred individuals; (7) a large number of Dinosaurian reptiles, some of

gigantic size. Besides these are various other groups of Mammals, Birds, and Reptiles.

(2) *The Collection of Fossil Footprints.* These specimens are mainly from the Connecticut Valley, and thus have a special local interest. They form one of the most extensive and complete collections of the kind in this country.

(3) *The Collection of Invertebrate Fossils.* This includes a large number of interesting specimens from many formations and localities, both in this country and in Europe. Among the series of specimens especially valuable may be mentioned several thousand from the Mazon Creek locality in Illinois; a very extensive collection of Crinoids from Crawfordsville in Indiana; the largest collection of nearly entire Trilobites yet discovered; and one of the rarest series of Silurian Sponges known.

(4) *The Collection of Recent Osteology.* This is believed to be the most complete collection in this country for purposes of study, particularly of Mammals, Birds, and Reptiles. The collection is rich in Anthropoid Apes, the Gorillas being represented by no less than thirteen individuals, and the other genera by rare characteristic specimens.

(5) *The Collection of American Archeology and Ethnology.* This collection is noteworthy for its Central American antiquities, several thousand specimens in number and many of them unique. Among them is the famous de Zeltner collection, containing many gold ornaments. The specimens from Mexico are also of great interest, and the series is a representative one. It includes the well-known Skilton collection.

(6) *The Collection of Minerals.* This is a limited collection, but contains many valuable specimens, among them an interesting series of Nova Scotian Zeolites. These were mainly collected by Professor Marsh, before he graduated at Yale, during numerous visits to Nova Scotia.

Besides the six main collections named, are several others of less value, which include fossil plants, casts of fossils, geological specimens, and recent zoölogical material. These, also, are covered by the present deed of gift.

The conditions on which Professor Marsh has given his collections to Yale University, for the benefit of all departments of the University, are few in number, the more important being the following:—

(1) The scientific collections I now give to Yale University shall be kept in the present Peabody Museum building or in additions thereto equally safe from fire.

(2) During my life, these collections shall remain, as now, under my supervision and control, available for my own investigation and description, or for the work of others designated by me.

(3) At my decease, and forever after, these collections shall be under the charge of the Trustees of the Peabody Museum and their successors, and in the special custody of Curators recommended by them and appointed by the Corporation of Yale University.

(4) The type specimens and others of special importance in these collections shall not be removed from the Museum building. Less valuable specimens, however, especially duplicates, may be so removed by vote of the Trustees of the Museum.

2. *The Smithsonian Institution, 1846-1896. The History of its First Half Century.* Edited by GEORGE BROWN GOODE, 856 pp. City of Washington, 1897.—The Secretary of the Smithsonian Institution has chosen wisely in the method he has adopted for commemorating the completion of the first fifty years of its active work. A public meeting, gathering representatives from other scientific institutions, might perhaps have given a greater publicity to the event at the time, but it would have failed to have the permanent character which is gained by the distribution of this most interesting volume. It is well that the public at large should be fully informed in regard to the founding of this trust, the admirable way in which it is administered, and the widely different methods in which it is accomplishing the purpose designed by Mr. Smithson—as stated in his will—“of founding an establishment for the increase and diffusion of knowledge among men.” Whether we consider the wise-minded and far-sighted generosity of the donor, the exceptionally successful way in which his plans have been carried out, or the high character and ability of the three Secretaries and others in charge of the work, the institution must be regarded as one entirely unique and without parallel.

The preparation of this volume has been unfortunately twice interrupted by the death of those specially occupied upon it. Dr. James C. Welling, one of the regents, undertook the editorial supervision on the plan drawn up by Dr. G. Brown Goode, but he died in September, 1894. The task was then assumed by Dr. Goode himself in addition to his other arduous duties, but in 1896 his life of remarkable activity was prematurely closed. Fortunately, however, at this time the manuscript was so far advanced that it was possible to carry it through to completion and to publish it without delay on the lines he had laid down.

To Mr. Goode we owe several of the most interesting chapters in the work. First, the description of the founding of the Institution (1835-1846); then that of the Establishment and the Board of Regents, with brief sketches of each of them; and, again, a most interesting and appreciative account of the three Secretaries, Joseph Henry, who was appointed in September, 1846, soon after the Act of Congress establishing the Smithsonian Institution was signed by President Polk, and who served until his death in 1878; then following him, Prof. Spencer F. Baird, who served from 1878 to 1888; and finally the gifted gentleman who now occupies the position, Prof. S. P. Langley. The extent, high character and value of the scientific work accomplished by Henry and Baird in their active lives, as well as that which has been and is still being carried forward by Langley, are too well known and appreciated to require special notice here. Another chapter by Dr. Goode describes the Smithsonian building and grounds.

The account of the generous and high-minded Englishman, James Smithson, who founded this trust, is given by Prof. Langley and appropriately forms the opening chapter of the volume.

It would be interesting here, were it possible, to quote from it, and further to follow out the successive steps in the establishment of the Institution as traced by Dr. Goode, from the death of Smithson in Genoa, in 1829, and the announcement of the Smithson bequest in September, 1835, to the final Act of Congress by which the Institution was established in 1846. But those interested must turn for these facts to the volume itself.

Probably few people not immediately connected with the Institution appreciate how actively its work is carried on, and through what a wide range of departments its influence is felt. The reader who will study Chapters VII to XIV will gain a new insight into the subject, and appreciate in how remarkable a manner Smithson's bequest has borne fruit. We have described here the founding and development of the Library; again the growth of the Scientific Collections from the earliest years, expanded, as they are now, into the United States National Museum; the work in the study of American Ethnology; the remarkable system of International Exchanges for scientific publications; the Astro-Physical Observatory; the National Zoölogical Park, founded within recent years; the work of the Institution in exploration in many fields; and, finally, its various series of publications, by means of which it puts in the hands of the public many papers and volumes which would otherwise be inaccessible or perhaps not brought to light at all.

The latter portion of the volume is devoted to chapters which summarize the work which has been accomplished by the Institution in the various departments of science, each written by a specialist in that line; also other chapters, as one by President D. C. Gilman, showing what the Smithsonian has done in coöperation with other institutions of learning, and another by Dr. J. S. Billings describing its influence in the development of libraries, the organization of societies, and the publication of scientific literature in the country.

A striking proof that the value of the work of the Institution has been thoroughly appreciated by those who have had the opportunity to be near it, is seen by the numerous gifts that have been made to it by private individuals for particular ends, usually in the form of bequests, but also by living donors, as the gift of \$5000 by Alexander Graham Bell for astro-physical research. The most important of all the bequests received was that establishing the Hodgkins fund of \$200,000, subsequently increased by \$50,000 more.

It is obviously impossible within the limits of the present notice to do full justice to this beautiful volume, with the large number of interesting facts which it contains, and the numerous fine portraits of those gentlemen who have been most closely connected with its history. It must suffice if this summary of its contents shall have accomplished the object of leading those interested in science to inform themselves of the great work which the munificence of Smithson has made possible.

3. *Wiedemann's Annalen, Jubelband.* 436 pp. with index, 1897.—Following an earlier precedent, the fiftieth anniversary of the doctorate of Gustav Wiedemann is now commemorated by the publication of a special volume of the *Annalen der Physik und Chemie*; this forms vol. lxxiii of the regular series.

Like all the publications of this honored Journal it is crowded with original matter of importance to physicists; fifty-seven articles are here included. The labors of Dr. Wiedemann, both as author and editor, are well known, but it may be noted that a few years since, on the publication of the fiftieth volume of Wiedemann's *Annalen*, a summary of his work was given by Hermann von Helmholtz.

4. *Untersuchung über die Bahn des Cometen, 1822, IV*; von Dr. ALBERT STICHENOTH, pp. 64, quarto. Leipzig, 1897 (W. Engelmann).—This comet, which was discovered by Pons and observed for nearly four months at sixteen observatories, was investigated by Bessel with Besselian thoroughness. The present treatise, which is among the most laboriously complete to be found in comet literature, and admirably planned, introduces the small effect of perturbations and is of interest as settling the question of the eccentricity. Bessel's eccentricity of 0.9963021 (period 5449 years) is wisely made the independent variable of the normal differential equations and the effect on the normal equations of 9 values of ϵ from 1.0 to 0.9943 determined.

It is thus shown that the normal equations are satisfied within reasonable limits of error by any period from 4504 to 8748 years, but not by a parabola. W. B.

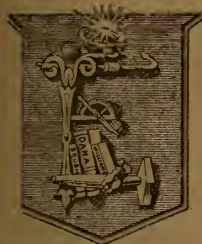
5. *Problems of Nature, researches and discoveries of Gustav Jaeger, M.D., selected from his published writings*; ed. and transl. by HENRY G. SCHLICHTER, pp. 1-261. (Williams & Norgate, London), 1897.—The book contains thirty-two chapters on various topics, illustrating the views of a thoughtful, educated physician on matters suggested by the investigations of Darwin and others during the last fifty years.

6. *Verzeichniss sämtlicher Präparate, Drogen und Mineralien mit Erläuterungen*, 1897.—A new edition of the well-known Merck catalogue of chemical preparations, drugs and minerals.

OBITUARY.

DR. ALBRECHT SCHRAUF, Professor of Mineralogy at the University of Vienna and for many years Custos in the Imperial Museum, died in December last at the age of sixty years. He was an active worker and profound thinker, the author of many mineralogical memoirs and of several books, the most important, his *Lehrbuch der physikalischen Mineralogie* (1868) and his *Atlas der Krystallformen* (1865-1877); the last was never completed.

RARE MINERALS.



So comparatively few collectors are interested in ugly, rare minerals, that we doubtless fail to make due mention in these columns of the large number of rare species which come and go in our store. It is, therefore, always a surprise to scientific collectors who favor us with a visit, to find how many rare minerals we can furnish, and how many minerals once regarded as rare have been deprived of that distinction through our active efforts to secure them in quantity. For example, we have a large drawer full of good specimens of Melanophlogite, one of Fergusonite, another of Chondrodite, one of Bertrandite, and six drawers full of fine crystallized Descloizites, and as many of yellow Wulfenites and of crystallized Orpiments. We also have a large stock of specimens of Beryllonite, Hiddenite, Thorogummite, Aguilarite, Minium, Calaverite, crystallized Nagyagite, Pollucite, and indeed of many other rare minerals. Of course there are very many species which we cannot supply, and many of which we have but one or two specimens, but it is a satisfaction to remember that our World's Fair Collection embraced about 650 distinct species, 338 of which were in specimens superior to any others exhibited. Such being the case it must be evident that any descriptive advertisement of our wonderful stock of rare minerals would be too lengthy for journalistic advertisements, and that even a mere list of rare species now in stock would fill many pages of fine print. Look over the following *greatly abbreviated* list, and if you do not see what you want, write to us, and very likely you will find that we have it.

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Obituary—DR. ALBRECHT SCHRAUF.

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T H E

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. XXII.—*Geothermal Data from Deep Artesian Wells in the Dakotas*; by N. H. DARTON, U. S. Geological Survey.*

THIS paper is intended to set forth new facts as to the underground temperature of a portion of eastern South Dakota and North Dakota, derived from records of temperatures of waters flowing in large volume from nearly level strata lying from 500 to 1500 feet below the surface. These temperatures are found to be exceptionally high over a wide area, but present regular regional variations. The salient features are shown in figure 1, p. 163.

Nearly all the waters in the great artesian basin of the Dakotas are perceptibly warm,—some are notably so,—but as they are derived from a considerable depth, no attention has been paid heretofore to the geothermal rates which the high temperatures indicate. In the course of several investigations which have been made in the artesian basin, temperatures of many of the flows have been observed, some with great care. The highest temperature recorded is at Harold, in Hughes County, where the flow is stated to be 94.9° F. At Pierre the water has a temperature of 92° F. and supplies a fine swimming pool at the sanitarium. At some other localities in the Missouri valley the temperatures of flows are as follows:

Cheyenne Agency	79° F.
Crow Creek Agency	72° F.
Chamberlain	70° to 71.6° F.
Fort Randall	80° F.
Greenwood	70° F.
Yankton	60° to 64° F.

* Published by permission of the Director of the U. S. Geological Survey. Read at Montreal meeting of the Geological Society of America, December, 1897.

AM. JOUR. SCI.—FOURTH SERIES, VOL. V, NO. 27.—MARCH, 1898.

In James River valley the greater number of flows range in temperature from 65° F. to 70° F., and the principal wells vary in depth from 550 to 1500 feet. The flows are usually several hundred gallons per minute, in many cases from 1000 to 2000 gallons and in a few instances from 3000 to 4000 gallons per minute.

The water-bearing horizon is the Dakota sandstone, which lies upon crystalline rocks and beneath a thick mass of Upper Cretaceous shales and chalk. The beds lie nearly horizontal or in an irregular, very flat-bottomed synclinal.*

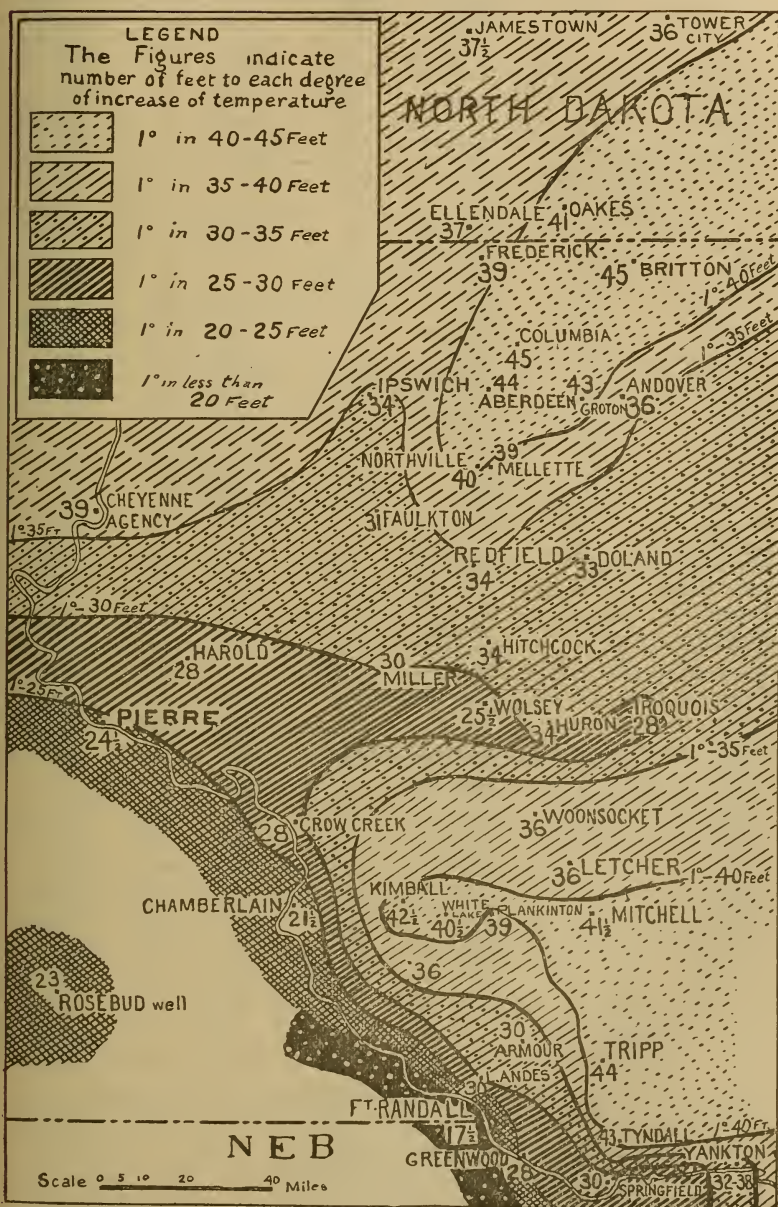
As the waters from the wells selected flow in large volume and have been flowing for some time, their temperature at the surface is practically the same as that of the underground stratum from which they rise. As the depth of the water-bearing stratum is known in every case, it has been a simple matter to calculate the rate of temperature-increase. In many parts of the world it has been found that the rate of increase of temperature averages about one degree for each 50 feet, below the first 40 feet, in which the temperature is usually regarded as that of the mean annual temperature of the region. In the greater part of the artesian basin of the Dakotas the rate of increase is found to be greatly more than this, attaining at Fort Randall a rate of one degree for each 17½ feet. At this well the temperature of the water is 80° F., or possibly slightly more, but the depth from which it is derived is only 576 feet, which indicates the abnormally high rate of increase. At Chamberlain, a rate of one degree for 21½ feet is indicated, and at Pierre one degree for 24½ feet. To the north and east these amounts diminish, but over a wide area the amount of increase is one degree for every 25 to 35 feet. The records of temperatures, which I have been able to obtain, are scattered widely over the artesian basin, so as to afford a very definite idea as to the areal distribution of the underground temperatures. They are principally derived from two observers: Prof. J. H. Shepard of the U. S. Experiment Station at Brookings, South Dakota,† and Col. E. S. Nettleton's report‡ on "Artesian and Underflow Investigation" for the Department of Agriculture. The data are given in the table on page 164.

* A description of the geology and resources of the basin may be found in the paper entitled "Preliminary Report of Artesian Waters in a portion of the Dakotas," by N. H. Darton, 17th Annual Rep. U. S. Geol. Survey, 1895-96, Part II, pp. 1-92, Pl. LXIX-CVII, Washington, 1896.

† South Dakota Agricultural College, etc.; Bull., xli, November, 1894, 35 pp.

‡ Sen. Ex. Doc., No. 41, 52d Congress, 1st Sess., Part IV, Washington, 1893.

1.



Map showing rates of increase of underground temperatures in deep wells in Eastern South Dakota and North Dakota, by N. H. Darton.

Table of Data bearing on Artesian Well Temperatures in the Dakotas.

Locality.	Depth of bed	Temperature	Flow	Mean	Rate of
	yielding the	of	per	annual	temperature
	water.	flow.	minute.	temp.	increase
	Feet.	F.	Gallons.	F.	for 1° F.
					Feet.
Aberdeen, City well No. 1	1077-1100	66·9° <i>s</i>	400	42°	44
Andover	1070-1075	71·6° <i>s</i>	300	42	36
Armour	696- 757	68·3° <i>s</i>	1500	44	30
Britton	976-1000	64° <i>n</i>	60C	42	45
Chamberlain, Mill	585- 600	71·6° <i>s</i>	4000	45	21½
“ 25 miles S.E.	851- 937	70°	1098	45	36
Cheyenne Agency	1337	79°	500	45	39
Crow Creek	760- 780	72°	Many	45	28
Columbia	927- 964	63° <i>n</i>	940	42	45
Doland	880- 855	69·05° <i>s</i>	370	42	33
Ellendale	1042-1087	69° <i>n</i>	700	40	37
Fort Randall	576	80° <i>n</i>	600	47	17½
Frederick	1045-1139	69° <i>n</i>	135	41	39
Faulkton	1032 ?	74·5° <i>s</i>	100	42	30½
Greenwood	641- 651	70°	3000	47	28
Groton, 4 miles north	840- 942	63° <i>n</i>	150	42	43
Harold	1435-1451	94·9° <i>s</i>	84	43	28
Hitchcock	950- 953	70·1° <i>s</i>	1260	42	34
Huron	960	70°	2250	42	34
	836	65°	360	42	36
Ipswich	1000 ?	71·6° <i>s</i>	Many	42	34
Iroquois	850- 855	71·4° <i>s</i>	1000	42	29
Jamestown	1458-1476	76° <i>n</i>	460	37	37½
Kimball	988-1068	66·9° <i>s</i>	185	43	42½
Lake Andes	725- 773	70°	1500	45	30
Letcher	570- 577	58° <i>n</i>	80	42	36
Mellette	884- 920	65° <i>n</i>	1320	42	39
Miller	1115-1139	79·8° <i>s</i>	363	42	30
Mitchell	530- 548	56° <i>n</i>	56° <i>n</i>	43	41½
Northville	958- 980	66·1° <i>s</i>	1900	42	40
Oakes	937	62° <i>n</i>	817	39	41
Pierre	1150-1170	91·8° <i>s</i>	900	45	24½
Plankinton	740- 745	62° <i>n</i>	225	43	39
Redfield	944- 964	70·1° <i>s</i>	1260	42	34
Rosebud Reservation	2500	153½°	No.	46	23½
Springfield	530- 592	65° <i>n</i>	3292	46	29
Tripp	? - 815	63°	700	45	44
Tyndall	700- 735	62·6° <i>s</i>	1000	46	43
White Lake	842- 850	64° <i>n</i>	150	43	40½
Wolsey	858- 878	76° <i>n</i>	330	42	25½
Woonsocket	684- 725	61·5° <i>s</i>	1150	42	36
	489- 595	62° <i>n</i>	1450	46	34
Yankton	432- 455	60° <i>n</i>	330	46	32
	610- 615	62° <i>n</i>	880	46	38
	600- 672	64° <i>n</i>	165	46	35
“ Cement works, 4 miles west	450- 500	64° <i>n</i>	1300	46	26½

In this table the observations given by Prof. Shepard are marked *s*, and they are, I believe, very accurate. The temperatures marked *n* are by Col. Nettleton. They are approximate but appear to accord very satisfactorily. The figures for the Huron wells were given by the well owners; the Cheyenne Agency, Crow Creek and Greenwood wells were reported by

the United States Indian Agents at these points; the well 25 miles southeast of Chamberlain is on the authority of the well driller, Mr. Kaufman, and the well at Tripp is stated by the chairman, Mr. Hassett, of the Town Board as "about 63° F." A 2500-foot boring on the Rosebud Reservation, 65 miles southwest of Pierre, was tested by a pair of self-registering maximum thermometers, sent to its bottom by my assistant, Mr. F. H. Ainsworth. The mean annual temperatures which have been used for the comparisons are based on observations which have been made by the U. S. Signal Service as follows :*

Jamestown, North Dakota	37° F.
Huron, South Dakota	42°
Kimball "	43°
Fort Meade "	45°
Fort Randall, South Dakota	47°
Fort Sisseton, "	48°
Fort Sully, "	45°
Webster, "	43°
Valentine, Nebraska	46°
Yankton, South Dakota	46°

For the wells not very near these places I have assumed the most probable mean temperature in comparison with the nearest localities at which observations were made. It is realized that there is of course some chance for error in this procedure, but the small difference does not greatly affect the final product of calculation. It would of course have been much safer to have observed the temperature of the earth at a moderate depth at all the localities to determine the differences of temperature, but this was not practicable. In most cases it has been possible to take for the depth the middle of the water-bearing bed as far as pierced by the well. The rate of temperature-increase has been calculated from the surface down to this depth and without deducting the usual 40 feet at the surface, as has been done sometimes in making such calculations. In considering the data I have selected only wells over 400 feet in depth and yielding large flows. They are all cased from the top to the bottom. The deep well at Highmore was excluded on account of its small flow, for in this instance the water loses much of its heat before reaching the surface. The temperature of the Highmore water, however, is 72° F., according to Nettleton, the flow is 9 gallons and the source is about 1550 feet below the surface. At Aberdeen one of the earlier city wells was reported by Nettleton to yield water at a temperature of 66° F., from a depth of from 905 to 918 feet,

* "Certain Climatic Features of the two Dakotas," by J. P. Finlay (Weather Bureau), page 119, Washington, 1893.

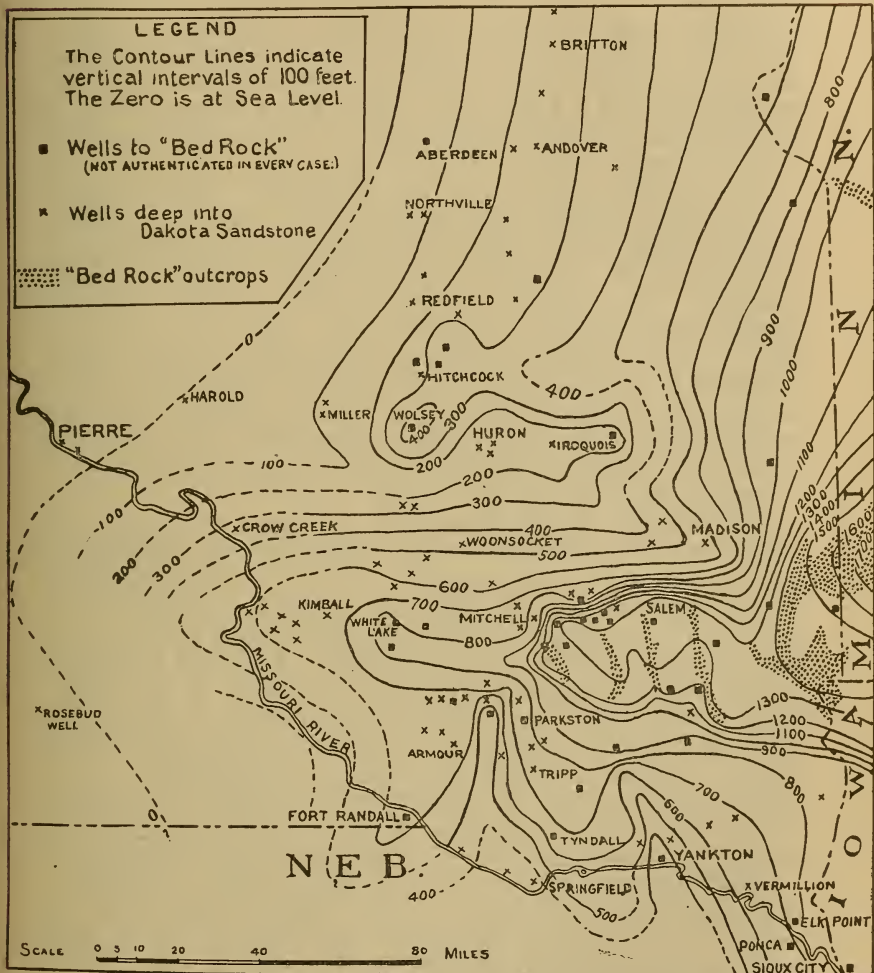
which is at the rate of 1° for each 38 feet, somewhat less than in the deeper well recorded in the table. I prefer, however, to take the figures of Professor Shepard for this deeper well, for here the conditions appear to be more definitely determined.

It will of course be obvious that where underground water is circulating rapidly in horizontal beds, it would retain the same temperature over quite a wide area under high land and low land alike, consequently, if a well were sunk on high land the rate of increase in feet to every degree would be a very much larger figure than in the adjoining low lands, where the water would be reached at much less depth. I have weighed this suggestion in the region in question, and excepting, possibly, about Tyndall, Yankton and Springfield, believe that its influence is practically nothing. It must be borne in mind in this connection that underground waters move at an extremely low rate of speed, which is probably not over a mile or two a year in the sands of the Dakota formation, and under these conditions the water of a flowing well represents very nearly the local underground temperature at the bottom of the casing of the well. The altitudes of the wells have been found to have practically nothing to do with the differences of temperatures, excepting probably where wells are quite near together. It is not fair to assume that the isogeothermal *planes*, even for moderate depths, are closely parallel to minor undulations of the surface of the ground. Consequently in a deep well on a high hill the rate of temperature-increase would be lower than in a correspondingly less deep well at the foot of the hill. The ratios in a case of this sort have not as yet been ascertained and they probably vary locally.

The difference of rate in the increase of temperature in the wells at Chamberlin is thought to be due to the relative positions of these wells. The city well with the smaller rate is some distance east of the mill well, which may account for the difference, as it is in line with the diminution eastward to 1° in 41 feet at Kimball. In the wells at Yankton the difference of actual temperatures of the waters is not great, but as the depths of the wells vary considerably the ratio of temperature-increase varies from 32 to 38 feet for each degree. It is probable that in this case the water may all come from one stratum, and if the minimum depth of this be taken, the rate of 1° for each 32 feet is obtained. In the cement works 4 miles west of Yankton an increased rate is indicated. The areal relations of the data are shown in fig. 1. As the observations are distributed at short intervals over a wide district, and the geothermal ratios vary gradually and uniformly, it has been possible to introduce isogeothermal lines in this figure. Without a knowl-

edge of the vertical gradients of temperature-increase in the individual wells, it would not be safe to attempt to calculate the temperature to a uniform depth beneath the surface, so I

2.



Contour map of "Bed Rock" surface in a portion of the Dakota Artesian Basin, by N. H. Darton.

have employed the "feet per degree" product for the "isotherms."

The most notable features in figure 1 are, the strip of high temperature along the Missouri River valley beginning near

Pierre and extending far to the southwest, south and southeast, and culminating at Fort Randall; the long area of moderately thermal district extending eastward along the latitude of Pierre, from Miller, Wolsey, Huron and Iroquois; the area of relatively cool underground conditions extending westward as a tongue through Mitchell, Plankinton, White Lake and Kimball, and southward towards Tyndall, and the similar oblong area extending through Britton towards Aberdeen. In considering the data it was at once observed that these features of areal distribution were closely similar to the configuration of the "bed rock" surface. Accordingly I have given, in fig. 2, a contour map of this surface for comparison. The long area of the cooler underground conditions from Mitchell to Kimball will be seen to be almost coincident with the underground ridge shown in the figure. This ridge is mainly of Sioux quartzite. The area of higher temperatures just north is approximately along the bottom of the valley in the "bed rock," which extends from Madison through Huron and south of Wolsey. Beyond these very striking features the resemblances are not noteworthy, but those above pointed out strongly suggest that the cooler area extending from Kimball to Salem is in some way related to the presence of the ridge of crystalline rock beneath the surface.

This brings us to the question of the cause of the thermal conditions in the Dakota artesian basin, but no satisfactory solution has as yet been suggested. So far as we know there are no metamorphic processes nor orogenic movements in progress in this region which would give unusual underground heat. The suggestion of the oxidation of pyrites by underground waters is probably untenable on account of the depth. Several ideas have been considered, comprising one that possibly some glacial chilling still remains in the ridge of "bed rock"; another of different ratios of conductivity, and a third, that the process of induration now probably in progress in the sediments is giving rise to heat; but many difficulties preclude their acceptance in our present state of knowledge.

This investigation is to be extended as widely as possible, and preliminary to this end I am now making a canvass of all available underground temperature observations in the United States so far as noted. I shall be very glad to receive data from geologists and others.

ART. XXIII.—*On a Series of Transition Beds from the Comanche to the Dakota Cretaceous in Southwest Kansas;*
by CHARLES NEWTON GOULD.

DURING the last decade the geology of Southwest Kansas has received considerable attention. Such earnest investigators as St. John, Hay, Cragin, Williston, Hill, Haworth, Prosser, Vaughan and Ward, by their published articles have made this region familiar to American geologists. Probably the most exhaustive report is that of Professor Prosser.* To his excellent review of the literature the reader is referred.†

The Cretaceous of the region is conformable throughout and everywhere rests unconformably on the eroded surface of the subjacent Triassic (?) Red Beds and is covered by the Tertiary or by the Pleistocene. It begins near Sun City in north-western Barber county, and gradually thickens westerly, attaining its maximum on the upper Medicine river west of Belvidere. It thins out to a mere line at Coldwater, again thickens on Bluff, Bear and Sand creeks in Clark county and finally disappears at the Big Basin in the western part of the county. As stated by Professor Prosser,‡ the lower part of the Cretaceous—consisting of two formations, the Cheyenne sandstone and the Kiowa shales,§—undoubtedly belongs to the Comanche Series.

The Cheyenne sandstone is composed mainly of coarse-grained, friable, false-bedded sandstone. Its color is normally yellowish or gray with streaks and blotches of red, pink, brown or black. The lower part contains many smooth, water-worn pebbles and occasional lenticular masses of bluish clay, while the upper part consists of alternating layers of sandy shale and more or less argillaceous sandstone, containing much lignite and a most interesting flora, consisting of ferns, conifers, dicotyledons, etc. No animal fossils have been found. The maximum thickness is probably between 50 and 60 feet.

The Kiowa shales, which lie on the Cheyenne, consist of bluish-black to yellowish papyraceous shales with numerous layers of limestone, containing great numbers of marine invertebrates. In the lower part of the shales are found vertebrates and insect remains. The maximum thickness reported by Prosser is 140 feet.

The presence of Dakota-like sandstone in both the Belvi-

* University Geological Survey of Kansas, vol. ii, 1896, pp. 55-194.

† Ibid., pp. 96-111.

‡ Ibid., p. 111.

§ These names were first used by Professor Cragin. See Bulletin Washburn College Laboratory of Natural History, vol. ii, December, 1889, p. 65, and Colorado College Studies, vol. v, April, 1893, p. 49.

dere and Clark county regions has been noticed by nearly every geologist who has visited the localities. Professor Cragin says :* "The actual contact of the Dakota series upon the Fredericksburg division" (Comanche) "is well shown in the heads of Bear creek and Little Sandy in Clark county. . . . At the Blue Cut hill S.S.W. of Belvidere in Kiowa county and on many high points in this and neighboring counties bowlder-remnants of the Dakota sandstone overlie the Fredericksburg shales." In the upper West Bear creek section he mentions 40 feet of "dark brown to yellow Dakota sandstone containing meager fragments of dicotyledonous leaves."† Professor Cragin afterwards refers to the "leaf-bearing *Reeder* (Dakota?) sandstone which surmounts the Kiowa shales in the upper valley of the Medicine Lodge river near the post-office at Reeder."‡ And again, in speaking of the Tucumcari shales (the upper member of the Kiowa) says :§ "At their summit they frequently contain bands and concretions of clay-ironstone, in the succession of which, premonitory of the immense aggregation of concretions that constitute certain parts of the Reeder sandstone of Kiowa and Clark counties, the Gryphæa, now in its maximum size, is lost sight of, becoming scarcer and more poorly preserved before wholly disappearing."

Professor Hill describes the Dakota on Blue Cut Hill.||

Professor Prosser mentions the occurrence of "Dakota" sandstone in various localities¶ and describes apparent contact with the underlying Kiowa on upper West Bear creek (Cragin's locality) and assigns to the Dakota at this place a thickness of 75 feet.**

The writer has spent a good part of four summers in the region, having worked with Dr. Williston and Professor Hill in 1894, in the employ of Johns Hopkins University in 1895, with Professor Prosser in 1896, and with Dr. Williston and Dr. Ward in 1897. It was while acting as a member of Dr. Ward's party that the Transition Beds, which form the title of this article, were discovered.††

Of the following sections Nos. I, II and III were made on Greenleaf's and Kirby's ranches on the upper Medicine river some ten or twelve miles west of Belvidere, and twelve miles south of Greensburg, Kiowa county, Kansas, while Nos. IV and V were taken on Little Sand and Chatman creeks twelve miles northwest of Ashland, Clark county, Kansas.

* Bulletin Washburn College Laboratory Natural History, vol. ii, March, 1890, p. 74.

† Ibid., p. 77.

‡ American Geologist, vol. xvi, December, 1895, p. 381.

§ Ibid., p. 382.

¶ This Journal, vol. I, September, 1895, p. 210.

‡ Loc. cit., p. 118.

** Ibid., pp. 162-164.

†† Science, N. S., vol. vi, Nov. 26, 1897, pp. 814, 815.

SECTION I.

$\frac{1}{2}$ mile south of Greenleaf's ranch.

No.	Feet.
3. Small Tertiary knob resting unconformably on No. 2	15-95
2. Bluish clay shales, weathering white, containing numerous clay-ironstone, geodic, concretions, breaking with a conchoidal fracture into small fragments with sharp edges. One stratum of brown sandstone 4 inches thick contains marine bivalves and shows ripple marks on its surface. The clays contain layers of sandy shales in the upper part. The Spring Creek clays	50-80
1. Typical upper Kiowa bluish-black to yellowish shales with selenite crystals and numerous Gryphaea, grading insensibly into No. 2	30-30

SECTION II.

$\frac{1}{2}$ mile west of Greenleaf's ranch.

4. Tertiary sandstone on top of bluff	10-90
3. Yellowish brown sandstone, usually distinctly stratified, but occasionally massive and cross-bedded, containing bands and concretionary pockets of dark brown or black clay-ironstone, breaking with a conchoidal fracture; eroded in upper part. The Greenleaf sandstone	40-80
2. Bluish-white clay with clay-ironstone concretions. Slope mostly covered. The Spring Creek clays	20-70
1. Black to bluish Kiowa shale to bed of river, with occasional Gryphaea. Slope usually covered	20-20

SECTION III.

On Spring Creek, 1 mile south of the Kirby (or C. W.) ranch.

No.	Feet.
6. Tertiary slope to top of divide	50-200
5. Dark brown massive sandstone, often cross-bedded, with many white pebbles and large nodular concretions, which sometimes attain the size of 2x3 feet. No fossils noticed. The Reeder sandstone	20-150
4. Yellowish clays, arenaceous below, becoming reddish above and containing several strata of light yellow sandstone. The characteristic fragments of clay-ironstone color the slopes. The Kirby clays	20-130
3. Light gray to yellowish sandstone often distinctly stratified but sometimes cross-bedded and massive with bands and pockets of the characteristic dark brown or black clay-ironstones. The Greenleaf sandstone	55-110
2. (c) Yellowish to bluish clays, weathering white, containing, in lower part, bands of spongy clay-ironstone like (b), which weather into small, irregular, pinkish lumps and give a red tint to the slopes	20

No.	Feet.
(b) Dark brown to yellow, rough, spongy clay-ironstone with bands and pockets of clay, weathering into conspicuous buttresses. It is occasionally concretionary or undulatingly stratified, and in places disappears.....	5
(a) Shales and clays, greenish to yellow, containing many strata of gray shaly sandstone 1 to 8 inches thick. The clay contains many reddish-brown clay-ironstone concretions often geodic and containing clay. On weathering these break with a conchoidal fracture, often forming round or angular, cup-shaped fragments with sharp edges.....	15
(a), (b) and (c) form the Spring Creek clays.....	40-55
1. Blue-black papyraceous shales with selenite crystals, not distinguishable from the Kiowa, and grading insensibly into No. 2	15-15

SECTION IV.

On the second butte north of the mouth of Chatman creek 12 miles northwest of Ashland, Clark county, Kansas.

No.	Feet.
6. Thin blanket of Tertiary on top of hill	2-277
5. Black and brown sandstone often concretionary, weathering into round boulders	5-275
4. Yellowish gray sandstone and arenaceous shales usually quite soft, distinctly stratified, containing fossil leaves and twigs, probably conifers.....	10-270
3. Dark brown sandstone, often cross-bedded, and more or less conglomeratic, containing numerous white clay or limestone pebbles. Numerous fragments of fossil wood are imbedded in the sandstone. About two hundred yards north are fragments of what appears to have been a silicified log.....	15-260
2. Kiowa shales with typical fossils	145-245
1. Red Beds from the level of the mouth of Chatman creek*	100-100

SECTION V.

On Chatman creek where the road from Ashland to Day's ranch crosses, 12 miles northwest of Ashland and 2 miles northeast of Section IV.

No.	Feet.
6. Tertiary to top of hill.....	20-112
5. Dark brown or almost black, hard, fine-grained sandstone, mostly weathered out in blocks, containing a typical Dakota flora. The Dakota sandstone.....	25-92

* Thickness of Nos. 1 and 2 from Prosser's section at Butte $\frac{1}{2}$ mile south. Loc. cit., pp. 166-167.

No.	Feet.
4. Light brown to black sandstone, usually massive with pebbles and large concretions; sometimes cross-bedded and containing clay-ironstone. The Reeder sandstone	15-67
3. Massive sandstone, yellowish to dark brown with occasional small concretions of clay-ironstone. It is usually distinctly stratified, but sometimes cross-bedded. The Greenleaf sandstone	25-52
2. Yellowish to blue clay shale with characteristic clay-ironstone fragments covering the slopes. The Spring Creek clays	12-27
1. Kiowa shales grading into next above	15-15

A study of these sections, together with the already well-known Comanche series, has led to the following classification of the Cretaceous rocks of Southwest Kansas :

III. Dakota Group.

7. Dakota leaf-bearing sandstone.

II. Medicine Beds.

- 6. Reeder sandstone.
- 5. Kirby clays.
- 4. Greenleaf sandstone.
- 3. Spring Creek clays.

I. Comanche Series.

- 2. Kiowa shales.
- 1. Cheyenne sandstone.

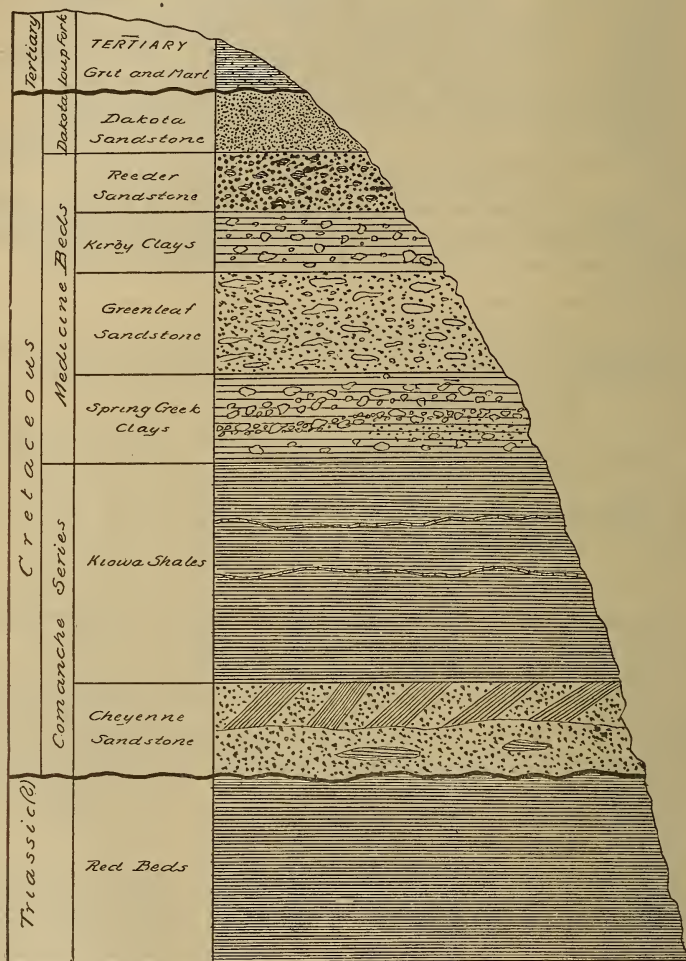
A section of the rocks of the region would be represented as shown in the accompanying figure (p. 174).

The terms Cheyenne sandstone and Kiowa shales are understood in the sense as used by Prosser.* The Spring Creek clays are named for Spring creek, a southern tributary to the Medicine river 12 miles west of Belvidere, on which the clays are well exposed. The Greenleaf sandstone is named from the Greenleaf ranch on which the sandstone was first studied, and the Kirby clays from the Kirby (also known as the C. W. or Fullington) ranch on which the clays have a typical exposure. Professor Cragin's term, Reeder sandstone, is used to include all the sandstone between the Kirby clays and the true leaf-bearing Dakota. The entire series of transition beds is included under the term Medicine beds, named from the river near the head of which the beds are best studied. The term Dakota sandstone refers to the true leaf-bearing sandstone.

The typical exposure of the Medicine beds is on Spring creek, at which point Section III was made, this being the

* Loc. cit., pp. 112-114.

only locality found where post-Cretaceous erosion has not carried away more or less of the series. Even in this locality, near the mouth of the creek the Reeder, Kirby and all but 15 feet of the Greenleaf are wanting. At this point may be seen a good example of the unconformity of the Greenleaf and Ter-



tiary, the latter containing in its lower part small, lenticular masses of the eroded Greenleaf. At Section I nothing but the Spring Creek remains and at Section II the upper part of the Greenleaf is gone.

As would naturally be expected in a series of deposits varying from deep sea to fresh water, representing several elevations and depressions, and occupying a period of apparently

rapid sedimentation, the lithology changes rapidly. Shale beds change to sandstone sometimes in a few rods. Evenly stratified sandstone suddenly becomes distinctly cross-bedded. Masses of nodular concretions, or soft, spongy, clay masses appear and disappear with no apparent regularity.

The only distinguishing characteristic of the entire series is the great number of clay-ironstone concretions which are found from the lower Spring Creek to the upper Reeder. These concretions are of all sizes and shapes; round, oblong or angular, often nearly cubical. On exposure to the air they usually break with a conchoidal fracture, exposing cutting edges, and form fragments sometimes box- or cup-shaped covering the slopes and often rendering them conspicuously brown for miles.

Dr. Lester F. Ward first found the fossil leaves on Chatman Creek. An hour's search among the broken fragments of rock lying on the surface revealed over 100 specimens. Dr. Ward identified the leaves and under the date December 6th, 1897, kindly wrote me, in part, as follows:

"The most common species is *Proteooides daphnogenoides* Heer, an original Dakota group species, described by Heer in the earliest paper on the plants of that formation, his *Phyllites crétacées du Nebraska*, 1866, and since found to be a very common species, but our forms are rather smaller than the average.

"We also seem to have *Embothrites daphneoides* Lx.; then there are a number of leaves that I refer to *Eucalyptus*. I think *E. Geinitzi*, Heer, is among them, and there is certainly one new species.* It is just possible that we also have *Laurus Plutonia*, Heer."

It may be of interest to observe that the Chatman creek locality where these leaves were found is not more than a mile from the place on upper West Bear creek from which Cragin reports "meager fragments of dicotyledonous leaves."

The "discovery of the true base of the Dakota group"† cannot but be of interest to geologists. It is to be hoped that the subject may soon be worked out in greater detail.

The writer would here make grateful acknowledgment to Dr. Lester F. Ward not only for assistance and encouragement in the field, but also for interest taken in the identification of fossils and correction of this manuscript, and to Mr. Jesse Greenleaf of Greensburg, Kansas, who kindly conducted Dr. Ward and myself to the typical localities.

Southwest Kansas College,
Winfield, Kansas, December 27th, 1897.

* Since writing this article Dr. Ward has named this species *Eucalyptus Gouldii*. See Bulletin of the Torrey Botanical Club, vol. xxiv, December, 1897, pp. 576-577.

† Lester F. Ward, Science, N. S., vol. vi, Nov. 26, 1897, p. 815.

ART. XXIV.—*Examination of some Triclinic Minerals by means of Etching Figures*; by T. L. WALKER, Geological Survey of India.

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WHEN crystals are acted upon by corroding reagents the crystal surfaces are seldom dissolved at a uniform rate. Frequently they become pitted with small corrosion or etching figures which are bounded by plane surfaces and which indicate the symmetry of the crystal surface upon which they occur. If a holohedral hexagonal crystal bounded by the prism $(10\bar{1}0)$ and the basal pinacoid (0001) be etched, then there should be two kinds of etching figures. As the basal plane has six lines of symmetry, the corrosion figures on it must exhibit six lines of symmetry which must coincide with those of the basal plane. Hexagonal figures whose sides are parallel to the edges $(0001) \wedge (10\bar{1}0)$ would satisfy the requirements of symmetry (fig. 1, p. 184). The figures on the prismatic faces must be different from those on the basal plane. Since each prismatic face is symmetrical in two directions, the corrosion pits must also conform to these requirements and must have two lines of symmetry which must be identical in direction with the symmetry lines of the prismatic face on which they occur (fig. 2). If these conditions are not fulfilled, then we are compelled to conclude that the crystal in question is not physically and geometrically holohedral hexagonal but only apparently such.

As an illustration of this use of etching figures in crystallographic studies we may refer to the case of muscovite, which was supposed to be rhombic until Baumhauer* discovered that the figures produced on (001) by treating with fused caustic potash, did not show rhombic symmetry. As there appeared to be only one plane of symmetry in the figures while a rhombic basal pinacoid should possess two lines of symmetry, it was concluded that muscovite is only pseudo-rhombic but really monoclinic (fig. 3).

By employing this method the conclusions arrived at by purely geometrical studies have frequently been corrected.

Since etching figures reveal the crystal symmetry, faces which are crystallographically equivalent, such as the eight faces of a holohedral octahedron, the four prismatic faces of tetragonal, rhombic and monoclinic holohedral forms or the two basal planes of holohedral hexagonal crystals, must give similar figures. Parallel faces are generally equivalent but not always. In the case of parallel faces at opposite ends of

* Sitzber. Akad. München, 1874, p. 245, and 1879, p. 99.

a hemimorphic axis there can be no equivalence—the basal planes 0001 and $000\bar{1}$ in the hemimorphic tourmaline being crystallographically different ought to give different etching figures. This mineral is a representative of a large class of substances whose crystals have no crystallographic center and whose parallel planes are equivalent only when this is required by other elements of symmetry—lines or planes. Thus in the case of calamine, or hemimorphite, which is devoid of a center of symmetry, we should expect the basal planes 001 and $00\bar{1}$ to give different corrosion pits, but pairs of parallel prismatic faces should give similar etching figures. This is required by the presence of two planes of symmetry (100) and (010) and may be proved as follows: the prismatic faces $1\bar{1}0$ and 110 are symmetrical about the symmetry plane (010) , therefore these faces are equivalent and the etching figures on them must also be similar; but the faces 110 and $1\bar{1}0$ are symmetrical with regard to the symmetry plane (100) , therefore the faces are equivalent and the etching figures must be similar. But since the faces $1\bar{1}0$ and $1\bar{1}0$ are both equivalent to the face 110 , therefore they are equivalent to one another and will give similar etching figures, though the crystal possesses no centre of symmetry. In the same way it may be shown that all four prismatic faces are equivalent.

Very few experiments have been made with etching figures to determine the equivalence of pairs of parallel faces. I first made a few experiments to prove that parallel faces give similar figures when they belong to the same crystal form and different figures when they belong to different crystal forms, and then proceeded to examine some of the triclinic minerals with a view to determine which of them have equivalent parallel faces and which different. There are two recognized divisions in the triclinic system: first, crystals having surfaces in pairs which are crystallographically equivalent and give similar etching figures, and second, crystals whose surfaces are not always present in parallel pairs, and when they are, do not give similar corrosion figures and are not crystallographically equivalent. The first group are holohedral triclinic, and since they possess a centre of symmetry, Zirkel and others refer to them as *centro-symmetric*. The second group is often referred to as hemihedral triclinic or tetartohedral monoclinic, but as the crystals possess no element of symmetry, whether of line, plane or point, they are appropriately spoken of as *asymmetric*. Up to the present time no mineral representative of this latter group is known. A small number of complete artificial chemical salts crystallize in asymmetric forms.

Etching Figures on Tourmaline.—I selected a transparent greenish yellow crystal of tourmaline about a quarter of an inch in diameter. The prismatic zone was composed of the trigonal prism $\frac{\infty R}{2}$ ($10\bar{1}0$) and the prism of the second order ($11\bar{2}0$). One end was terminated by a single plane, the basis 0001, while the other end was not crystallographically terminated, a part of the crystal being broken off. The crystal was sent to R. Fues of Berlin with the request to prepare two thin polished plates parallel to the base. After several fruitless attempts, I finally succeeded in obtaining good etching figures, by bringing the already slightly warmed tourmaline plate into a red-hot mixture of potassium bisulphate and coarsely powdered fluor spar. Below red heat no corrosion took place. After ten minutes the crystal was withdrawn from the red-hot fusion and allowed to cool slowly so as to prevent cracking. By treating with hot dilute hydrochloric acid it was easily cleansed from the coating of the corroding mixture. On examination with the microscope the face corresponding to the natural basis, 0001, was seen to be well covered with small figures which may be described as sharply angular equilateral triangles, with their sides parallel to the edges of the trigonal prism and basal plane and the angles pointing toward the above mentioned edge (fig. 4). The figures on the parallel face—the artificial basis $000\bar{1}$ —are also equilateral triangles, but the sides are curved and the angles blunt. A closer examination showed that the little figures are probably nine-sided and closely resemble sections through many tourmaline crystals whose prismatic zone is composed of the forms ($10\bar{1}0$) and ($11\bar{2}0$), the former predominating so as to give a trigonal habit to the crystal, with the latter forming narrow faces bevelling the edges of the trigonal prism. The chief sides of the corrosion figures are parallel to the edges of the trigonal prism and the base, but the angles of the triangle are turned away from the edge of the trigonal prism. This is shown in a more or less idealized form in fig. 5. Thinking this difference between sharp and blunt triangles might be due to the position or temperature of the crystal during the reaction, I etched the second polished plate, taking the precaution to hold it in such a position, by means of platinum pointed forceps, that both should be subject to exactly the same conditions. The resulting figures were quite like those on the first plate. The high temperature caused the greenish yellow crystal plates to become water-clear.

These figures are different, but as the basal planes of tourmaline contain three lines of symmetry the figures on *both* planes must also contain three lines of symmetry and these

must coincide with the lines of symmetry of the basal planes. A glance at figures 4 and 5 will show that this is the case. Although the trigonal axis of symmetry of tourmaline compels the figures to be built on the plan of the equilateral triangle, yet while conforming to this requirement the difference in the faces 0001 and 000 $\bar{1}$ is very clearly indicated by the difference of the etching figures.

Acid Dextro-Tartrate of Strontium.—This is one of the best known and most easily prepared of all the substances crystallizing in the asymmetric or hemihedral division of the triclinic system. Dr. Steeg & Co. of Homburg v. d. Höhe supplied me with a few very fine crystals for examination. These crystals possess one very perfect cleavage direction, which, according to the orientation proposed by A. Scacchi* and adopted by Liebisch,† is taken to be the basal pinacoid (001) and (00 $\bar{1}$). Very thin cleavage plates are easily prepared which serve very well for etching. As the substance is readily soluble in water, good figures were prepared by placing the cleavage fragment between folds of a piece of *very* slightly moistened calico and pressing between the finger and thumb for twenty seconds. A microscopic examination showed that the figures on 001 were four-sided with their sides parallel to the edges of the cleavage plate. The four sides of the corrosion pits are nearly equal (fig. 6). On the parallel face 00 $\bar{1}$ the figures are also four-sided but very slender, almost reduced to mere lines at times (fig. 7). After etching and examining a large number of cleavage plates, I satisfied myself that these figures are unmistakably different and eminently characteristic for the two faces upon which they occur. It would be impossible to confuse them. So much is this so, that if a crystal were split into half a dozen cleavage plates and these etched, then by means of the difference of the figures the upper and lower surfaces could be distinguished and the crystal reconstructed with all the fragments properly oriented.

So far as I know, the only previous experiments made with etching figures with a view to determining the crystallographic equivalence of pairs of parallel faces, are those made by Miers on spangolite. This hemimorphic hexagonal mineral had been described by Penfield from a single specimen from Arizona, when Miers found it on some specimens of Cornish copper minerals. In his description in the *Mineralogical Magazine* he says: "In order to obtain independent evidence of the hemimorphic character of this mineral, experiments were next made upon etched figures, it being thought that possibly some

* A. Scacchi, *Atti. Accad. delle Sc. Fis. e Mat.*, Napoli, 1, 1863.

† *Grundriss der Krystallographie*, p. 176, Leipzig, 1896.

difference might be found between the etching upon the upper and under surface of a cleavage plate. This was found to be the case; cleavage plates exposed to the action of dilute hydrochloric acid showed upon both sides the characteristic etched triangles figured by Penfield. These were identical in form, but very different in dimensions; the plates were invariably attacked with much greater rapidity upon the lower or attached end than upon the surface directed toward the unattached end of the crystal.”*

I was not aware of Miers' experiments till after those on tourmaline and acid dextro-tartrate of strontium were completed and this paper written in almost its present form.

From the experiments above described I think the desired confirmation has been given to the statement:—*Crystal faces belonging to the same crystal form give identical or similar etching figures, while faces belonging to different crystal forms give different etching figures even if the faces be parallel to each other; or conversely, if parallel faces give different etching figures, the faces do not belong to the same crystal form.*

Taking the above statement as a basis, I proceeded to examine some of the common triclinic minerals with a view to determining which of them are centrosymmetric and which asymmetric.

Axinite.—I was fortunate enough to obtain a few of the beautiful crystals from Bourg d'Oisans in Dauphiné. This mineral has been crystallographically described by many authors, so that several different ways of orienting the crystals are in common use. The references in this note are to Naumann's orientation, which is probably the one most generally used by English and American mineralogists.

By acting upon the crystals for five minutes with a hot mixture of equal volumes of concentrated sulphuric and hydrofluoric acids, very sharp figures were obtained. The most easily examined and at the same time most striking are those on $\bar{1}\bar{1}1$, which is the face designated by the letter *r* by Naumann and Schrauf. The figures contain no line of symmetry. Those on $1\bar{1}1$ and $\bar{1}1\bar{1}$ are illustrated in figures 8 and 9 and are related to one another in the same way as the right hand is to the left. This, however, is in accord with crystallographic characteristics of the system, the faces being related to each other in the same way, so far as outline is concerned. This dissimilarity is well seen in the case of the pyramidal faces in the rhombic system. The eight faces of a simple rhombic unit pyramid are all scalene triangles; the triangular faces 111 ,

* *Min. Magazine*, vol. x, p. 276, 1894.

$\bar{1}\bar{1}1$, $1\bar{1}\bar{1}$ and $\bar{1}\bar{1}\bar{1}$ are equal to one another and are identical in form—these triangles can be placed upon one another so as to coincide *without being turned over*. The faces $1\bar{1}1$, $11\bar{1}$, $\bar{1}\bar{1}\bar{1}$ and $\bar{1}11$ bear to each the same relationship and may be made to coincide by superposition *without being turned over*. The triangles of the first group cannot be made to coincide except by turning over. The triangles of these two distinct groups are related to one another as right and left. Suppose that on such faces we have etching figures, triangular in outline and with their edges parallel to those of the triangular face upon which they occur. They too must be related to one another as right and left, but with this difference, that the corrosion pits have three dimensions, and by turning over the triangular outlines may coincide, but the pits will then project in opposite directions and will form a closed space which will be symmetrical about the plane of contact. This is quite like the relation that the valves of a clam shell bear to one another—they can never be so turned as to fit into one another. So also the cast of a corrosion pit on a pyramid face of one of the above groups cannot be fitted into a pit on a face of the other group. The one is the mirror image of the other turned about 180° . The figures accompanying this paper have generally been turned in this way so that the image relationship may be plainly seen.

For clearness it would be well to refer to figures which agree in all respects as identical—those on all the faces of either of the above groups are *identical*; figures which have the right and left relationship may be referred to as *similar*, while all corrosion pits not belonging to either of these classes may be designated as *different*.

The dagger-shaped figures on the faces $1\bar{1}1$ and $\bar{1}\bar{1}\bar{1}$ of axinite crystals being *similar*, we must conclude that the mineral is centro-symmetric.

Cyanite.—Pale blue crystals from St. Gothard were used. They are well developed in the zone of the vertical axis showing the forms (100) (010) and (110). The crystals are contained in paragonite schist and are elongated in the direction of the vertical axis. As the mineral is very cleavable along (100), good material is easily obtained for etching. Their cleavage fragments, which had been previously carefully warmed, to avoid decrepitation or unnecessary shattering from suddenly heating, were plunged into a red-hot mixture of potassium bisulphate and coarsely powdered fluorspar. After one or two minutes they were taken out, allowed to cool slowly and then cleansed by boiling with hydrochloric acid. Very satisfactory figures were obtained. Those on 100 are shown in fig. 10

and are similar to those on $\bar{1}00$ (fig. 11), thus indicating that the mineral is centro-symmetric triclinic.

Chalcanthite, or Copper Vitriol.—This triclinic mineral rarely occurs in well developed crystals, so that the crystals etched were artificial and grown from a saturated solution of copper sulphate. About twenty grams of ordinary "blue stone" was dissolved in hot water to concentration, acidified with a few drops of sulphuric acid, filtered and allowed to cool, when the larger portion crystallized out. The solution was poured into a second dish and after twenty-four hours half a dozen well-formed crystals had separated. These were used for examination. The corrosion figures were obtained by increasing the temperature of the saturated solution, from which the crystals had grown, about two degrees. When the warm (comparatively) mother liquor had reacted for sixty seconds the crystals were removed and quickly dried with filter paper. The figures resulting in fig. 12 are those formed on the front face of the left hemiprism $1\bar{1}0$. Those on the parallel face $\bar{1}10$ are seen in fig. 13. As the corrosion figures on the parallel faces are similar, we conclude that chalcanthite is centro-symmetric triclinic.

Rhodonite.—Fragments of rose-colored crystals from Långbangshytta, Wermland, Sweden, were treated for one minute with a warm mixture of equal volumes of concentrated sulphuric and hydrofluoric acids. As this mineral is very rich in crystal forms and exhibits many different types, accordingly having only fragmentary crystals to work upon, it was difficult to determine with certainty the symbols for the faces. The corrosion figures from two parallel faces are represented in figs. 14 and 15. The faces in question were largely developed, striated and were cut obliquely by the two principal cleavages, presumably (110) and $(\bar{1}\bar{1}0)$. Though not certain, I have assigned the figures to the basal pinacoids 001 and $00\bar{1}$ according to Dana's crystallographic orientation of the mineral. The striation referred to is parallel to the longer direction of the etching figures. The corrosion pits are such as to warrant the conclusion that the mineral is centro-symmetric triclinic.

Albite.—The material employed for this examination consisted in two or three small water-clear crystals from the Alps. Cleavage fragments parallel to (001) were easily prepared, on which the angle of optical extinction was measured under the microscope and found to be $+4^{\circ} 54'$, thus proving the crystals to be a plagioclase free from lime, that is albite. By treating

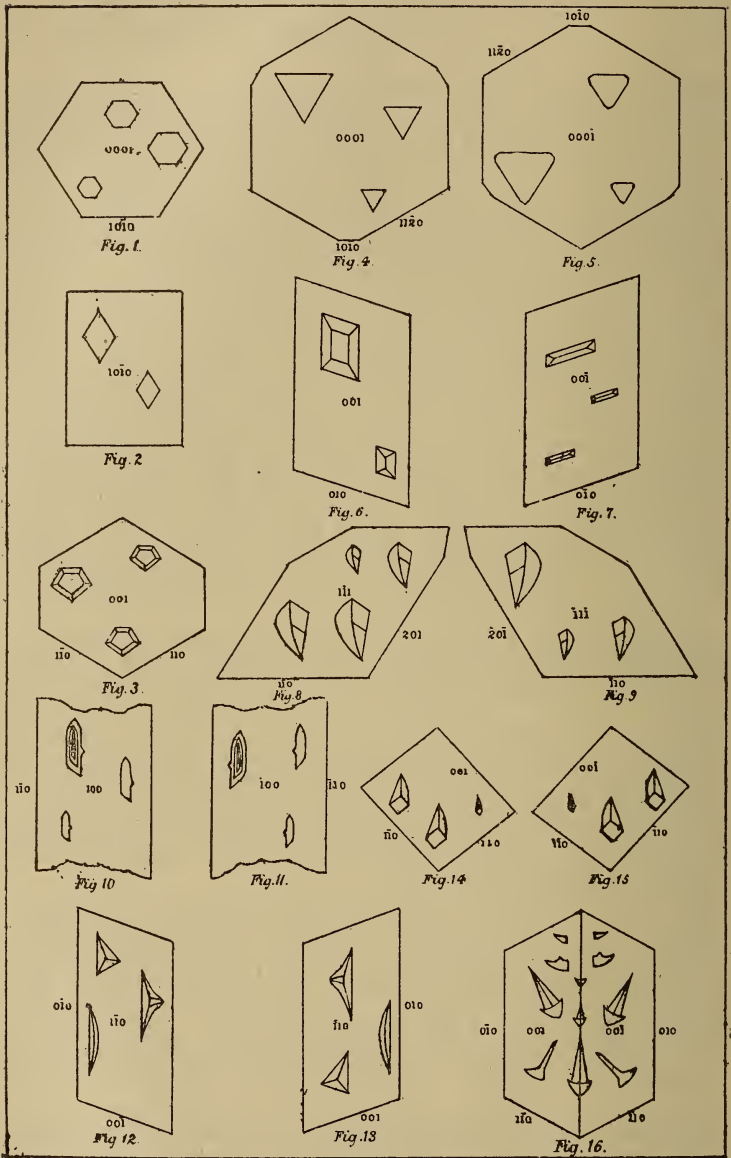
for thirty seconds with a half-and-half mixture of sulphuric and hydrofluoric acids, very interesting figures were obtained. At first sight there seems to be no regularity about them, but it is soon seen that all the figures can be referred to a very simple primitive corrosion pit which resembles in outline a right-angled triangle whose sides are 3, 4 and 5, the shortest side being parallel to the brachypinacoidal edge and the smallest angle directed towards the left. The figure on $00\bar{1}$ is similar and has its smallest angle pointing in the opposite direction. Figure 16 represents a basal cleavage fragment from an albite crystal simply twinned according to the albite law. On the left are the figures on 001 and on the right those on $00\bar{1}$. The primitive figures are seen to give, on further development, such pits as those shown immediately below them. The arrow-headed corrosion figures are the commonest and appear to be the adult or final form. All intermediate stages in development between these are plainly seen under the microscope. The offshoot from the primitive form may take place from one of the angles and produce nail-shaped figures. This can take place from any of the three angles and can be traced through all the intermediate stages. It is commonest from the right angle of the triangle, as is the case in the instance figured.

Since the primitive form gives rise to four different final forms or types and a large number of intermediate stages, it is not surprising that at first sight one should not see any definite order. The first, third and fourth types are the commonest.

This development from simplicity and uniformity to variety and complexity appears to be almost as common in crystal life as biologists have shown it to be for organic life. Minute crystals and tiny etching figures give promise of a heterogeneity and variety which they do not actually possess in their earlier stages of development.

But there is another form of etching figure to be noted. Suppose a figure should begin exactly on the line of contact between twinning lamellæ, the figures would develop symmetrically on both sides of the line of contact. This is illustrated in figure 16. These figures possess a plane of symmetry and are such as we might expect on the basal plane of a monoclinic crystal. If the albite twinning lamellæ were very, very thin, then all the figures would be like these, because every figure would be large enough to extend across several lamellæ. This only proves by means of etching figures what has been long known from geometrical crystallographic studies—viz, that twinning increases the symmetry of a crystal.

Some of the pits above described are represented in the



See next page for Explanation of Plate.

drawings as if some of their surfaces were curved. This only means that there are a large number of faces present, so that the figures *appear* to have curved surfaces, just as prisms of tourmaline often appear to be rounded. There does not seem to be any reason to depart from the opinion of Baumhauer and Becke, who hold that the surfaces of etching figures are never curved but always plane.

The small number of minerals dealt with in this paper were selected generally because they were most easily obtained in suitable specimens, at other times because they gave definite results. I hope to describe more of the triclinic minerals at a future time.

My thanks are due to Babu Nrependra Nath Bose, who has redrawn the figures from sketches made by myself.

Indian Museum, Calcutta, Nov. 1st, 1897.

EXPLANATIONS OF PLATE.

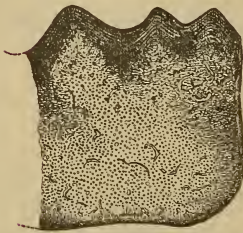
- FIGURE 1.—Corrosion figures such as might be formed on the basal plane of a holohedral hexagonal crystal.
- FIGURE 2.—Corrosion figures showing the symmetry of the prismatic face of a holohedral hexagonal crystal.
- FIGURE 3.—Figures on basal plane of muscovite showing monoclinic symmetry—produced by fused KOH.
- FIGURES 4 and 5.—Figures on 0001 and $000\bar{1}$ of tourmaline showing the physical difference between the two parallel planes—produced by red hot fusion of KHSO_4 and CaF_2 —time 2 minutes.
- FIGURES 6 and 7.—Figures on 001 and $00\bar{1}$ of acid dextro-tartrate of strontium. Produced by pressing between very slightly moistened folds of calico for 20 seconds.
- FIGURES 8 and 9.—Figures on $1\bar{1}1$ and $\bar{1}1\bar{1}$ of axinite—produced by a hot mixture of equal volumes of strong H_2SO_4 and HF acting for 5 minutes.
- FIGURES 10 and 11.—Cyanite, 100 and $\bar{1}00$ — KHSO_4 and CaF_2 at red heat for 1 to 2 minutes.
- FIGURES 12 and 13.—Copper vitriol, $1\bar{1}0$ and $\bar{1}10$. Produced by raising the temperature of the mother liquor in which the crystals had grown 2°C . and allowing the slightly warmed solution to corrode for sixty seconds.
- FIGURES 14 and 15.—Rhodonite, 001 and $00\bar{1}$, hot mixture of equal volumes of strong H_2SO_4 and HF—time 60 seconds.
- FIGURE 16.—Albite simply twinned—shows figures on 001 and $00\bar{1}$ —same reagent as in 14 and 15—time 30 seconds.

ART. XXV.—*Some new Jurassic Vertebrates from Wyoming.*
First Paper; by WILBUR C. KNIGHT.

FOR the last three years the University of Wyoming has had parties in the field collecting vertebrate remains from the Jurassic rocks. Much of the material collected is new to science and will be described as soon as it is possible to study it properly. Among the lower forms are two new species of *Ceratodus*, a genus not well represented in the American terranes.

Ceratodus robustus, sp. nov. (Fig. 1.)

1.

*Ceratodus robustus*, natural size.

The description of this species is based upon the greater portion of a supposed right mandibular tooth, the anterior margin and first horn having been broken off. The known portion of the tooth is quadrangular in form. The anterior and posterior margins are nearly straight and are at right angles to each other. Posterior inner corner of tooth rounded. Exterior margin divided into four short, broad rounded horns, separated by three broad, shallow, rounded depressions. Surface of the tooth very large, and not cut by the angular depressions as in most of the *Ceratodi*. The tooth is fastened to a piece of the dentary bone that measures 33^{mm} long, 31^{mm} wide and 10^{mm} thick. The fragmentary tooth measures 29^{mm} long, 31^{mm} wide and 10^{mm} thick. So far as known there are no closely allied forms. This species was discovered by the writer in Albany county, and was associated with the bones of a crocodile and a supposed new *Dinosaur*.

Ceratodus americanus, sp. nov. (Fig. 2.)

2.

*Ceratodus americanus*, natural size.

All that is known of this species is a left mandibular tooth.* It is triangular in shape. The interior and posterior margins merge into one, and form a well-rounded outline. Anterior margin nearly straight. The junction of the anterior and interior margins truncated. The exterior margin is divided into four angular horns, separated by three angular depressions. The first and largest horn is separated from the second by a right angular depression. The greatest length of the tooth is 21^{mm}, greatest width 17^{mm}. This species is probably closely related to *C. guntheri*† Marsh. It was found by the writer in Carbon county, and was associated with the bones of a *Megalosaur*.

University of Wyoming, Laramie, Nov. 30th, 1897.

* I am not absolutely certain that this is a mandibular tooth. It is possible that one horn has been broken off, in which case it would belong to the right palate.

† This Journal, III, vol. xv, page 76.

ART. XXVI.—*On the Accessory Elements of Itacolumite, and the Secondary Enlargement of Tourmaline*; by ORVILLE A. DERBY.

THE peculiar type of granular quartz-rock characteristic of the gold and diamond regions of the Serra do Espinhaço in the state of Minas Geraes, Brazil, which has come to be generally known by the name of itacolumite, proposed in 1822 by Eschwege,* has given rise to much discussion. Eschwege and the majority of subsequent writers on the geology of the region (Helmreichen, Claussen, Pissis, Heusser and Claraz) regarded it as a member of the primitive group of rocks having a special mode of formation, an idea that has found expression in some recent text-books of geology (Lapparent, *Traité de Géologie*, 2d ed., Paris, 1885). Later writers (Hartt, Liais, Gorceix, Derby) have regarded it as a metamorphosed sandstone. The view that it is only a special phase of an ordinary sandstone has also been presented, though not, so far as known, by any geologist who has seen it in place. The most definite evidence thus far presented by the advocates of any one of these discordant views is that of the very pronounced and characteristic schistose structure by those who maintain the metamorphic hypothesis, but the force of this argument, which was long considered as conclusive in favor of a clastic origin, has been greatly weakened by recent studies on the crystalline schists.

On the hypothesis that, if clastic as presumed, some internal evidence of the mode of origin might be found in the mineral elements of the rocks themselves, a microscopic examination has recently been made of the isolated grains separated by washing from hand specimens of the rock, from several of the typical localities in Minas Geraes as well as from other points in the same state and from those of Goyaz and Bahia. As the original itacolumite of Eschwege was divided by him into a schistose and massive group, which, by later writers (Derby, Gorceix), have been considered to be independent formations, it may be stated that the material examined was for the most part known, or presumed, to represent the schistose and older group, and that in several instances the specimens presented the property of flexibility which was for a long time, but erroneously, supposed to be characteristic of the rock as a whole.

The quartz grains of these rocks present no unequivocal

* *Geognostisches Gemälde von Brasilien, und wahrscheinliches Muttergestein der Diamanten*, Weimar, 1822.

evidence of clastic origin. They are sharp and angular with jagged outlines and perfectly fresh surfaces, as in the crystalline schists generally and in many eruptive rocks as well. The clearest indication of a clastic nature, that of a difference in the size of the grains in some specimens, is of doubtful value, since metamorphosed eruptives of original porphyritic structure might present it as well. No cases of the secondary enlargement of worn grains such as have been described by Törnebohm, Irving and others, could be detected in typical samples of the rock, as those showing such enlargements present macroscopically the aspect of sandstone rather than of itacolumite. These are from the diamond district of Lençoes in the state of Bahia, where both types of rock occur (the itacolumite very abundantly as rolled pebbles in the sandstone or conglomerate), and one of the specimens is highly charged with tourmaline in a manner suggestive of contact metamorphism.

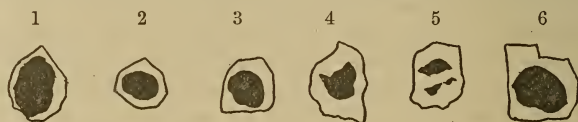
The mica (or mica-like) mineral which is almost invariably present in greater or less abundance is also perfectly fresh and is undoubtedly authogenic. Formerly referred to talc or chlorite, it proves in most places to belong to some of the varieties of muscovite. The predominant type is white with a pearly luster, but a green variety suggestive of fuchsite is quite common. That of a specimen representing the diamond-bearing bed of Grão Mogol (massive itacolumite of Eschwege and Helmreichen) is a green brittle mica of high specific gravity and apparently a member of the clintonite group. A specimen of sandstone with a small stringer of vein quartz from the Lençoes region in Bahia shows green mica in the vein and in the microscopic fissures of the rock for a centimeter or so in its immediate vicinity, but not in the general mass of the rock, which is a typical clastic sandstone. From this case it appears that the production of mica in these rocks does not necessarily indicate an advanced degree of metamorphism.

Among the rarer accessories zircon is the most constant and the only one that, in most cases, presents unequivocal evidence of an allothogenic origin in the rounded angles and dulled luster of the faces due to wear in transportation. (As the angles of zircon are often rounded in eruptive rocks in which it is undoubtedly an authogenic element, this character alone cannot be taken as an evidence of wear.) In a few cases the mineral is rare and extremely minute and in these the signs of wear are indistinct. In the most of the specimens examined, however, the zircons are more abundant than would be expected in a corresponding volume of a zirconiferous eruptive, showing an apparent concentration which of itself is an indication, though not an unequivocal one, of clastic origin. When of

fair size and abundant, the signs of wear are generally so distinct as to be unmistakable. The predominant type is that of short, stout, rounded prisms, frequently of a rose color and sometimes partially whitened (by incipient malaconization in the parent rock?), which is suggestive of granite or granitic gneiss as the original rock from which they were derived.

The iron ores, magnetite and hematite are usually present, though often in very minute quantities. The two oxides sometimes occur together, though in general hematite is the most abundant and characteristic. Both are sharp-angled with lustrous faces and are evidently authogenic. Pyrite is frequently present and often in octahedral forms which on becoming altered to limonite (or hematite?) afford martite-like forms difficultly distinguishable from those derived from magnetite. Ilmenite has not been observed, though titanium oxide in the form of isolated crystals or aggregates of rutile or anatase, or both, is frequent and always with the perfectly fresh appearance of an authogenic element. Considering these rocks, on the evidence of the zircons, as original sandstones derived from granites or gneisses and with a certain concentration of the heavy accessories of the parent rock, the presumption is that the iron ores would be equally or more abundant than the zircons and be represented by magnetite, titaniferous magnetite or ilmenite. On this hypothesis, there has been in the metamorphism of the rock a notable reduction in the quantity of the free iron oxides, a recrystallization of the remaining portion as hematite and more rarely as magnetite, and an isolation of the titanium oxide when present as rutile or anatase. The iron oxide that has disappeared as such has perhaps gone to the green mica, or the pyrite, or possibly has been leached out. In connection with the supposed isolation of the titanium from ilmenite, an iron sand from the diamond region of Lençoes in Bahia is interesting. Agglomerated nodules of worn, or etched, grains of iron oxide giving the characteristic streak of hematite show perfectly fresh microscopic rutile in the interspaces between the grains. They are presumed to come from the sandstone formation of the region and to represent an ancient natural concentrate of black sand (magnetite, perhaps titaniferous, and ilmenite) in the original sediments. As is well known, the transformation of magnetite to hematite and the formation of rutile and anatase from titanium-bearing minerals (sphenes or ilmenite) may take place in the process of atmospheric weathering, and are not therefore necessarily indicative of metamorphism. When, however, as in the case of the rocks in question, the hematite takes the form of a well-crystallized specular iron, it may be presumed that true metamorphic changes are involved.

A frequent, though not constant, accessory is tourmaline in minute prisms, or prismatic fragments, with lustrous faces. The appearance of the grains is that of an authogenic element even when, as in two cases, there is evidence of a new formation about allothogenic grains. These two cases are in the residue from the rocks of the Jurumerim cutting on the Minas e Rio Railroad in southern Minas Geraes, where the observations on the flexibility of itacolumite recorded in this Journal (vol. xxviii, 1884, p. 103) were made, and from a decomposed rock of a cutting on the Mogyana Railroad close to the station of Rifaina, near the Rio Grande bridge on the boundary between São Paulo and Minas Geraes. In these residues a considerable number of the larger grains of tourmaline show a dark, sometimes completely opaque, nucleal portion enclosed in lighter colored transparent material having the same optical orientation. At first sight the appearance might be taken for zonal structure, but with proper illumination, the dark nucleus is seen to be either well rounded with a fretted surface indicative of wear, or angular with outlines that do not correspond with those of the completed individual, as would be the case with zonal structure. The accompanying figures, kindly drawn by Dr. E. Hussak, show some of the most interesting cases observed. Figs. 1 to 5 are from Jurumerim, fig. 6



from Rifaina. Basal sections (1 and 2) are nonpleochroitic. In sections parallel to the c -axis the nucleus is black when this axis is perpendicular to that of the polarizer, and dark brownish red when parallel to it, though it is often necessary to concentrate a very strong light on the dark center for it to appear translucent. The rounded nuclei represented by figs. 1, 2, 3 and 6, show a roughened surface indicative of wear which is less distinct, or imperceptible, in the angular fragments like fig. 4. In one case the light-colored tourmaline substance of the outer shell was seen filling a deep V-shaped embayment in the rounded surface of the dark nucleus. The lower dark grain in fig. 5 is an iron ore, probably magnetite.

The whole appearance of these dark-centered tourmalines is that of clastic grains, either well rolled or recently broken, that have been enlarged by a new formation of the same substance which, as in the well-known case of enlarged quartz grains, takes on the same optical orientation as in the fragment that serves as a nucleus. The amount of tourmaline in the

rocks in which the phenomenon has been noted is not so great that the newly-formed additions, and the grains that do not exhibit secondary enlargements, may not reasonably be attributed to a readjustment of material already existing in the rock as clastic elements, rather than to the introduction of new material. On this hypothesis the frequent and wide-spread occurrence of minute quantities of tourmaline in rocks where its presence cannot be attributed to contact metamorphism, may perhaps be satisfactorily explained. The secondary enlargement of tourmaline seems to have been already observed in similar rocks (see Van Hise, 16th Ann. Rpt. Geol. Sur., p. 685), but I have been unable to find any account of it.

Considering the itacolumites as original sandy sediments derived for the most part from granites and granitic gneisses, other frequent accessories of these latter rocks, and more especially the phosphates, monazite, xenotime and apatite, might be expected to occur, at least sporadically, in them. A careful search failed to reveal unequivocal evidence of their presence, though dubious grains were noted that are suggestive of worn and partially corroded monazite and xenotime. The hypothesis that they may have disappeared, giving rise to new combinations, is favored by the somewhat frequent occurrence of the aluminium phosphate, lazulite, in these rocks, and of amorphous phosphatic masses (*favas* of the diamond miners) in the detritus derived from them or their associates. To test this hypothesis, a small fragment of itacolumite containing lazulite, evidently authogenic, was examined in the hope that some trace of an original clastic phosphate might still be found. In fact, along with some dubious grains suggestive of altered and corroded xenotime, an undoubted intergrowth of this mineral was detected. There is therefore direct evidence of the association of newly-formed and clastic phosphates in the same rock, which, taken in connection with the strong antecedent probability of the occurrence of allothogenic phosphates in these rocks and their apparent disappearance, and with the fact that monazite and xenotime are frequently partially altered and corroded in the decay of eruptive rocks, gives a reasonable degree of plausibility to the hypothesis. Further observations on this point are however desirable.

The observations here recorded and others less complete on the argillaceous rocks associated with them, show that with the degree of metamorphism that this series exhibits, all of the original clastic elements except zircon are subject to changes that may obliterate or render dubious their evidence of such origin. In addition to the well-known processes of fragmentation, recrystallization and secondary enlargement by which such evidence may be obliterated, by the renovation of worn

surfaces, etching has in several cases been noted. In the cases of quartz and of staurolite in which it is most pronounced, the etching seems to have taken place during the decay of the rocks. In the few cases in which it has been rather indistinctly observed on zircons, it appears to be attributable to magnetic absorption, to which also the rounding of the angles, when found in eruptive rocks, is probably due. Whether in more completely metamorphosed rocks these changes may render zircon also useless as an evidence of clastic origin, is a question to be investigated for which material is unfortunately not at hand. The observations thus far made on siliceous and argillaceous rocks, both eruptive and clastic, give a hope that it may prove to be a reliable witness in the great majority of cases. The occurrence of macroscopic zircons in calcareous rocks, however, indicates either an introduction of new material or a migration and concentration of the material of microscopic clastic grains that occur in most limestones when not absolutely pure. An investigation of this point in some of the well-known zircon localities would be of interest.

ART. XXVII.—*Auriferous Conglomerate of the Transvaal* ;*
by GEORGE F. BECKER.

THE auriferous conglomerate of the Witwatersrand gold-field, South African Republic, constitutes the most important gold deposit ever known. Without counting imperfectly explored extensions, the workable area is a strip of country a couple of miles in width and about 30 miles in length. This little district has yielded since 1887 about 240 million dollars worth of gold, and careful estimates indicate that only about one-fifteenth of the accessible gold has been extracted. The production is increasing rapidly. The output in 1897 was one-third greater than that in 1896, and reached 3,034,674 ounces, worth about \$51,675,550. During 1897 the other gold fields of the Transvaal (which equals Arizona in area) produced enough to bring the total product up to \$58,434,000. The total product of the United States in 1896 was in round numbers 53 million dollars, but that for 1897 is estimated at 61½ millions.† It is evident that the banket is a very notable factor in the financial policy of all commercial nations, and even in the party politics of the United States.

The nature of this wonderful deposit is a subject of manifest interest to geologists and mining engineers, who, however, have arrived at various conclusions. No considerable doubt exists that the puddingstone is a marine littoral deposit, but some observers have held that the gold is detrital, being part and parcel of the conglomerate; others that it is a chemical precipitate from the ocean in which the pebbly beds were laid down; and still others that the precious metal reached the uplifted but uncemented gravel in solution, so that the ore-bearing strata are allied to ordinary veins. Two authorities regard the deposits as in part detrital and in part venous impregnations.

The banket skirts the southerly edge of a large area dotted over with proclaimed gold-fields in which ordinary veins are associated for the most part with crystalline schists. This area

* This paper, which has been prepared at the request of the editor of this Journal, is essentially an abstract of a longer one, "The Witwatersrand Banket with notes on other Gold-Bearing Puddingstones," U. S. Geol. Survey, Ann. Rep. 1896-97, Part V. It contains, however, references to opinions by Messrs. Stelzner and Zirkel, which I had overlooked; and to a paper by Mr. John Hays Hammond which has just appeared. For permission to publish this material I am obliged to Mr. R. H. Benson.

† The South African mining companies turn in statistics of their production with admirable promptitude, but unfortunately in terms of ounces of crude bullion and in spot values. The returns of the English mint show that the average fineness is 0.8475 or \$17.52 per ounce, coining value.

includes the northern part of the Transvaal and portions of Mashonaland and Matabeleland. Its extent is approximately 130,000 square miles and the remnants in it of prehistoric workings are so extensive as to lead to the belief that gold to the value of millions of pounds sterling has been extracted. The ancients, however, appear to have been unaware of the auriferous character of the banket. The age of the rocks in the northerly area is uncertain but it is supposed to be Silurian or older. They are known as the Swasi schists. They are certainly older than the banket beds, the more important of which occur in the Lower Cape formation. This, by imperfect correlation with occurrences near Cape Town, is thought Devonian or Lower Carboniferous. A less important banket, the Black Reef, occurs in the Upper Cape which rests unconformably on the lower series. The Triassic coal-bearing series is separated from that containing the Black Reef by another unconformability and shows only traces of gold.

The uplift of the Lower Cape was of moderate violence and took place under no great load. The northerly edge of the series was sharply bent upwards and the outcrops are now found at angles of southerly dip usually included between 45° and 70° . To the southward, underground, the strata rapidly flatten; so that in the lower workings dips of 20° to 30° are common. The bending of the beds was achieved to a smaller extent by plastic flexure than by multiple systematic fractures, and many of the faults are marked by dikes of subsilicic pyroxenic rocks. The main period of uplift and dike injection occurred before the Upper Cape. In such cases of what may be called *comminute flexure*, the fractures though simultaneous dislocate one another at the instant of formation. When filled with dikes or veins they often give the erroneous impression of successive disturbances. There appear, however, to have been along the Witwatersrand some relatively unimportant injections of later date than the main uplift.

Associated with the dikes, and manifestly connected with them genetically, are numerous quartz seams. These cut the country as irregularly as the dikes. As a rule they show neither gold nor sulphurets, but sometimes masses of pyrrhotite and a little pyrite are found in them, and in a few cases pockets of gold have been encountered, particularly, it is said, at their intersection with the reefs. It is possible that this last conclusion is an erroneous one, for the white veins nowhere contain gold so distributed as to form workable ore in considerable quantities, and it is only where they cross drifts or stopes that they are broken down. There is no way of ascertaining just how much gold has come from the pockets in the white quartz, but opinions among the managers seem agreed that it does not

exceed a few thousand pounds in value. With this exception all of the gold of the Witwatersrand occurs in the basket reefs, of which by no means all carry gold in remunerative quantities.

The basket is a highly siliceous mass, consisting of quartz pebbles embedded in a matrix composed of sand, pyrite, and other minerals, all cemented by secondary silica. The cement has the same character as in ordinary quartzite. The large quartz pebbles have all the characteristics of vein quartz, but show under the microscope undulous extinctions and other evidences of the dynamic action to which they have been subjected. They are frequently cracked, and then sometimes show veinlets along the fractures. The quartz pebbles often carry pyrite and other sulphurets, as zinc blende and galena. This was recognized by Dr. A. Koch,* who states that pyrite occurs as inclusions in the quartz pebbles of almost all the conglomerates. So, too, Mr. A. Pelikan† states that in the suite of specimens which he has examined pyrite is found as inclusions in the quartz pebbles. Mr. De Launay denies this occurrence. Gold and pyrite, he says, exist exclusively in the cement, never in the pebbles. In the Crown Reef mine I found more than a dozen instances of the inclusion of sulphurets in the course of a brief search, and I observed a great number of such cases in other mines on subsequent occasions. These were cases in which the sulphurets were disseminated through the quartz of the pebbles, not arranged on surfaces which might be interpreted as recemented cracks. Under the microscope I find many cases of the inclusion of disseminated pyrite in pebbles of what is plainly vein quartz. Some of the sulphuret-bearing pebbles are auriferous. One such which I collected in the Crown Reef was large enough to bear trimming, so that the outer surface could be entirely removed. The residual kernel was assayed by Mr. A. F. Crosse and found to contain gold in appreciable quantities. Prof. Le Neve Foster‡ states that assays by Mr. Richard Smith show some of the pebbles to be auriferous. The question whether free gold exists in the pebbles has been much discussed, and has been treated as if it were a matter of the first importance in deter-

* Vorkommen und Gewinnung der nutz. Min. in der Südafr. Republik, by Carl Schmeisser, 1895, p. 48.

† Verhandl. k. k. geol. Reichsanstalt, 1894, p. 421. Dr. Koch examined basket from the Simmer and Jack, Robinson, Village Main Reef, Meyer and Charlton, and Langlaagte Estate. Mr. Pelikan's specimens came from the Robinson, Crown Reef, and Meyer and Charlton. I have slides from the Ferreira, Village Main Reef, Crown Reef, Simmer and Jack, Robinson, City and Suburban, and the Crown Deep. I have also examined a series from the Ferreira owned by the general manager, Mr. Harry Johns.

‡ Text Book of Mining, 1894, p. 42.

mining the nature of the gold deposits. This is quite a mistake, as I shall explain somewhat later. I was assured that free gold has repeatedly been observed in the pebbles with the naked eye, but I did not succeed in getting a sight of any such specimen. Mr. Pelikan, however, has found moss gold embedded in the quartz of his specimens, and has photographed under the microscope the occurrence of gold embedded in quartz. These photographs are published in Mr. Goldmann's work,* with different tints for pyrite and gold. I possess a slide of Ferreira ore which shows free gold solidly embedded in a quartz pebble.

The matrix of the banket contains most of the gold and pyrite. Some of the pyrite in the matrix is said to be in well-defined, sharp crystals, but much more of it is in the form of rolled pebbles. In some of the ores of the district it is evident to the naked eye that pyrite pebbles exist, but in most cases a thin section is needed to display them. Dr. Koch says that the grains of pyrite are generally shaped by attrition, or at least display rounding of the edges and corners. This is confirmed by Mr. Pelikan. Mr. De Launay also calls especial attention to the fact that the pyrite often occurs in grains which are rolled, or at least broken, blunted, or rounded. He finds such pyrite pebbles extremely prevalent both in the Main Reef series and elsewhere. He considers the pyrite pebbles as auriferous, and mentions having observed under the microscope gold embedded in the pyrite, without stating whether in these particular instances the pyrite was rounded or not.† In some of the specimens which I have examined the pyrite is substantially all in the form of well-rounded pebbles, isolated from one another by sand and secondary minerals. No one who has seen such specimens would admit for a moment either that the pyrite was not rolled or that it was fractured by movement in the rocks during upheaval. The pebbles have been worn round, and the detritus has been removed. In several cases they are externally converted into a brownish-black mineral, which is probably hematite, and the conversion must have taken place before the upheaval of the banket, for the specimens are blue and fresh. The pyrite pebbles measure on the average one-tenth of a millimeter in diameter. In some specimens the pyrites are densely crowded into layers and the pebbly character is less apparent. Some recrystallization may have gone on in these cases, but I did not succeed in finding the well-defined crystal outlines usual in embedded sulphurets. The pyrite pebbles in many cases contain numerous scattered

* *South African Mines*, by C. S. Goldman, 3 vols., 1895-96, vol. 3, plate 6.

† *Les Mines d'or du Transvaal*, 1896, pp. 306, 347.

particles of gold, which may be seen by very strong incident light. I have observed this both in my own slides and in Mr. Johns's suite.

The free gold in the matrix, like the pyrite, seems to be in two different conditions. Dr. Koch found the metal in minute crystals, or in irregular sharp-cornered, hackly aggregates. Mr. Pelikan observed it in irregular lumps, grains, and scales, which, in his opinion, correspond beyond a question to alluvial occurrences. According to Mr. De Launay, the gold almost always occurs as extremely minute scales, often so thin as to be translucent, very rare exceptions being aggregates of gold on the white quartz veins, small masses of free gold crystallized by secondary solution in the banket, and coatings on joint planes. Mr. Crosse also has found evidence of the existence of gold in a crystalline condition. In my slides the gold in the matrix corresponds most closely to Mr. De Launay's description. It appears in irregular flakes and scales, which often conform to the accompanying sand grains, as if pressure had molded the metal. The grains are not smooth, but neither have they either the crystalline appearance or the hackly surface of gold in vein quartz. The scales are often excessively thin, and pass over into mere yellowish-brown stains in which, by the help of direct sunlight, shining yellow points can be observed. The smaller scales of gold found on beaches are not ordinarily smooth, but they are smoother than those of the banket. I believe that pressure and the roughness of the surrounding detritus have determined their outlines to a large extent in the puddingstone.

Besides the more important minerals of the banket, Dr. Koch found in the matrix magnetite (also noted by Mr. Curtis), zircon, rutile, tourmaline, muscovite, chlorite, and a colorless highly refracting mineral not determined. Mr. Pelikan found biotite and a greenish mineral, perhaps identical with Dr. Koch's, which he suspects of being pyroxenic. Dr. Hatch notes marcasite, copper pyrites, blende, galena, ilmenite, and magnetite; he also records that Mr. Crosse has detected corundum by chemical means. I have repeatedly found pyrrhotite in the mines (for example, in the Crown Deep), but only in association with the white quartz veins referred to above. There is either magnetite or hematite among the pebbles of my slides, and zircons were observed. The main mass of the matrix consists, besides gold and pyrite, of sand grains, chlorite and sericite, and secondary quartz. It is interesting and important to compare this matrix with slides of the quartzite adjoining the banket, because many grains which might be interpreted as secondary in the matrix are there seen to be mere sand. In both quartzite and matrix it is apparent that

the sand grains have been largely attacked by sericite and that a portion of the irregularity of outline is due to this cause. The matrix also contains prisms, often grouped in fan-shaped aggregates, of a colorless secondary mineral, possibly an amphibole. The same or a similar mineral was noted by Koch and by Pelikan. Its determination is not essential for the purposes of this paper.

It is worth while to observe that the cement of the conglomerate is distinguishable from ordinary vein quartz as seen under the microscope. The crystallization of the cement has been accompanied by corrosion of arenaceous minerals, and the matrix is mingled with the products of this action as vein quartz seldom or never is. On the other hand, the cementing material of the conglomerate and that of the quartzite at a distance from the banket reefs appears to be indistinguishable under the microscope. In other words, the banket is a coarse heterogeneous quartzite.

It is well recognized on the Rand that, other things being equal, the coarser pebble carries the greatest quantity of gold. Usually the rich ore is heavily sulphureted, but this is not invariable. As a rule, the thinner portions of reefs are richer than thicker portions. It is usually the under portion of a coarse streak which is richest, but such a coarse streak is sometimes met with in the lower portion of a reef and sometimes in the upper portion. There is in this respect no general rule. It is said that the sandstone near the banket in rare instances carries gold. It is known, however, that in some alleged instances of this kind the gold was really confined to the parting between the sandstone and the banket. The banket is patchy. There are rich patches and poor ones, rich patches in poor ones, and poor patches in rich ones. Sometimes these patches have an elongated form, and then are often called "chutes." Opinions differ among managers as to whether there are on the Rand any real continuous chutes or channels, such as are almost invariably found in gold-bearing quartz veins. I could learn of no case which was an indubitable chute as distinguished from an elongated patch. Much less does any rule hold, as in most gold quartz districts, concerning the pitch of ore bodies on the surface of deposition. For the most part the bodies are certainly patches, and, if there are true chutes as well, two distinct types of deposit are present. The general uniformity of appearance and conditions militate against this view.

It has already been mentioned that the Lower Cape is intersected by numerous dikes, mostly of diabase or closely allied rocks, these dikes being connected in the most evident and

intimate manner with the formation of the white quartz seams which carry pyrrhotite and rarely pockets of gold. I made a special effort to ascertain whether the dikes are in any way connected with the tenor of the banket, and consulted many of the most experienced managers on the subject. There is, I believe, substantially no connection.* The ore at and near a dike is sometimes rich and sometimes poor; a single dike will intersect one stope, or one reef, at a point where the assays are high, and will cut another working or another stratum of puddingstone in a poor patch. The conditions are such as they would be if, after ore deposition were complete, the country had been disrupted and injected with dikes having no connection with the deposition of gold in the banket. Mr. De Launay came to precisely the same conclusion, and emphasizes it by an "assay plan" with the dikes drawn into it, and this diagram fully justifies his position.† Mr. John Hays Hammond, however, has very recently expressed his opinion that although it is generally true that there is no ascertained connection between the richness of the banket and these dikes, there are nevertheless notable examples of local enrichment due to the proximity of dikes.‡ Such exceptions seem to me hard to prove, for I think it would not be difficult to find other cases in which banket close to dikes is locally almost barren. Indeed I have heard of such occurrences, but cannot believe the local impoverishment due to the presence of the intrusive rock.

In the foregoing pages an attempt has been made to gather all the more striking facts which it is necessary to consider in testing the theories propounded to account for the deposition of gold on the Rand. One of them must be right.

The theory that the banket reefs are of alluvial origin, representing metamorphosed placers, was probably the earliest to be suggested, and was held as long ago as 1887, when gold production first began. Who first advocated this solution I am unable to state. It has been supported in 1891 by Mr. De Launay, who has since adopted another view, by Mr. Pelikan in 1894, and by Prof. F. Zirkel.

In 1888 Mr. W. H. Penning§ was led, mainly by the character of the gold (which he describes as occurring in sharp grains, not waterworn), to state: "I am convinced that it was deposited—at the same time the gravels were being accumulated—from water holding gold in solution." This is the opinion ex-

* Messrs. Hatch and Chalmers find no reliable evidence that dikes have acted beneficially on the tenor of the reefs. *The Gold Mines of the Rand*, 1895, p. 72.

† *Op. cit.* p. 324.

‡ *Engineering Mag.*, Feb. 1898, p. 746.

§ *Jour. Soc. Arts*, London, vol. 36, 1888, p. 437.

pressed by Mr. De Launay in his latest work, 1896. Stelzner also inclined to a similar opinion.*

In discussing Mr. Penning's paper, Mr. W. Topley suggested that the water, which percolating through the already formed conglomerates deposited the gold, may have been at a high temperature. In 1890 my friend, Mr. J. S. Curtis, published a paper† on the banket, in which he states that Mr. Gardner F. Williams, now manager of the Kimberley diamond mines, considered the gold in the conglomerate as not alluvial but quartz gold, deposited after the upheaval of the strata. Mr. Curtis accepted this view, considered the deposits as closely resembling lodes, and referred the impregnation of the conglomerates to the action of the dikes. This opinion is based on the angular character of the gold and on the presence of pyrite both in the banket and in the dikes. Had the iron sulphide of the banket been alluvial, Mr. Curtis says, "there would have been pebbles of pyrites." Of course the large proportion of rounded pebbles of pyrite in the banket was then unknown. Mr. Curtis explained the fact that gold is not found in the sandstone by the relative porosity and openness of the conglomerate. The view of the deposits first distinctly expressed by Mr. Curtis is that to which Dr. Koch leans, and which is adopted by Messrs. Hatch and Chalmers, and by almost all the engineers on the Witwatersrand. Messrs. Hamilton Smith and John Hays Hammond consider a portion of the gold detrital and a portion as a deposition from solution after the uplift of the rocks.

None of the theories are free from objections, real or specious. The impregnation theory implies that there must be deep fissures through which the auriferous solutions obtained access to the once-barren banket beds, and that the solutions permeated the coarse beds to the practical exclusion of the finer sandstone strata. A system of fissures such as would be needed to convey metalliferous solutions certainly exists in the dikes and faults so abundant on the Rand. There are also less-pronounced partings or joints, often nearly parallel to the conglomerate beds. These last are very important in stopping the ore, and they are well known to all managers. All of these dislocations were produced during the upheaval of the beds from a nearly horizontal position into that which they now

* In 1894 Messrs. Schmisser, Stelzner, Suess and Zirkel testified before the Silver Commission in Berlin. The first two regarded it as an open question whether the gold of the banket is detrital or a chemical precipitate contemporaneous with the formation of the beds of puddingstone. The others were convinced that it is detrital, Zirkel adding that the deposits had undergone subsequent chemical metamorphism. (Kommission behufs Erörterung . . . des Silberwerths. Berlin, 1894, pp. 594-95, et passim.)

† Eng. and Min. Jour, vol. 49, 1890, p. 200.

occupy. The gold in the basket is not distributed in any apparent relation to the dislocations. Not only do the dikes cut the reefs in poor and rich patches indiscriminately, as was pointed out above, but such of the dislocations as are in sandstone or in quartzite are, as a rule, absolutely barren. The fissures are also almost altogether wanting in some localities where the ore is nevertheless of good grade. This is the case in portions of the Geldenhuis Deep and of the Simmer and Jack. In these mines there is often an inconvenient absence of any partings to which stoping can be carried, and this "freezing" is not attended by any falling off in the assays. On the other hand, the white quartz veins are manifestly related to the dikes, often starting from them or accompanying them, and themselves not dislocated by the fissure system to any greater extent than is easily accounted for by slight renewals of movement postdating the main upheaval. The white veins, however, cut and fault the basket, but without enriching or impoverishing it. The only natural conclusion is that the dikes and white veins postdate not merely the formation of the conglomerate, but the deposition of gold in the basket. The deep fissures which afforded channels for the ore-bearing solutions might be narrow, as a rule; but it is hardly possible that all of them should be so, and it is most improbable that the ore which they contained should not be rich, as rich as the basket would be if all the pebbles were removed from it. Now, no such "rake veins," as they would be called, have been met with on the Rand.

If the solutions rose through "rake veins," they would permeate all accessible permeable strata and partings. Now, it seems to be generally assumed that a conglomerate without matrix would be much more permeable to fluids than a sandstone. This is true if only rapid currents, such as might be impeded by fluid friction, are to be considered. There is no probability, however, that ores are deposited from rapid currents. For slow currents fluid friction is a vanishing quantity, and then the permeability of a given rock may be considered as measured by the interstitial space. Now, the interstitial space in a conglomerate composed of pebbles of various sizes is really less per cubic foot than that of a fine but even-grained sandstone. If the material is of absolutely uniform grain, the interstitial space is wholly independent of the size of the component particles, and cannot fall below 26 per cent. It is a fact well known to mill men that a cubic foot of sized tailings weighs less than a cubic foot of unsized tailings. Sandstones used for building in some cases contain over 20 per cent. of voids, and highly indurated sandstones contain 4 or 5 per cent.

Even if the ore-bearing currents were so rapid as to permeate the pebbly beds more freely than sandstones possessing the same interstitial space, the smaller resistance of the former would not confine ore deposition to the coarser mass. Permeation would take place in any direction in inverse proportion to the resistance in that direction, and the auriferous fluid would escape from the pebble-layer as sewage does from porous underground distributing pipes. It follows, then, that the sandstones as well as the conglomerates should have been impregnated when soaked in an auriferous solution, and to approximately an equal extent, while as a fact the sandstone does not contain one one-thousandth part of the gold. The impregnation theory would, furthermore, seem to involve the presence and the prevalence of chutes in the banket. There is no doubt that most of the gold occurs in patches which are distinctly different from chutes, and many engineers are confident that real chutes are absent. Much of the pyrite is in the form of minute waterworn pebbles, and much of the gold is inclosed in the pyrite, indicating a common origin for the two minerals. This fact is regarded by De Launay as fatal to the impregnation theory, and, indeed, it seems impossible to reconcile this mode of occurrence with the hypothesis.

Had the gold been deposited from solution one or another of the characteristics of various deposits might well have been absent or obscure. It is difficult to believe that all should have been obscure if not totally absent. The evidence in such a case must be considered cumulatively.

The strength of the impregnation theory lies in the fact that some of the gold and of the pyrite appears to be crystallized, as if deposited in place. A portion of the observed phenomena seem certainly secondary. Below water level, or "in the blue," visible gold is very rare* on the Rand. In the oxidized upper levels it was much more frequent, and free gold was often found in the cavities from which pyrite had disappeared by oxidation. This is, of course, a very common phenomenon at the croppings of auriferous deposits, and can be accounted for only by the recrystallization of gold attending the oxidation of pyrite. The *modus operandi* is also pretty clear. Ferric sulphate is a weak solvent for gold, and iron sulphate is one of

* "Very rare" is a relative term. Mr. Hammond takes exception to my statement, which he probably interprets in a more superlative sense than I intended it. Hatch and Chalmers, who were certainly thoroughly familiar with the ore, assert that, as a rule, the gold "is disseminated through the ore in finely divided particles which are rarely of sufficient size to be visible to the eye" unless the ore is first panned. I am quite aware that in most of the mines a speck of gold is seen from time to time and that there are some specimens in which it is abundant. The point of the statement in the text is that *more* visible gold occurred in the oxidized zone than beneath it.

the products of decomposition of pyrite. Recrystallization is a process which goes on in the presence of weak solvents. Recrystallization of rock components is a very common thing, and the ordinary phenomenon called metamorphism is substantially recrystallization. The quartzite walls of the Main Reef are in part recrystallized sandstones, and recrystallization of silica has certainly taken place in the banket. Some recrystallization of gold and pyrite in the blue may very probably have occurred as an incident to general metamorphism or to the formation of the white veins. Hence the impregnation theory is not the only one which will account for the state of one portion of the gold and pyrite, and the fact that it could explain this state is insufficient to outweigh the many objections to the theory.

On the whole, then, it appears to me that this theory is untenable. It is popular with engineers accustomed to quartz veins, partly because it involves a close analogy between the Rand deposits and the more familiar type of gold deposit.

The theory maintained by Mr. De Launay in his latest work is that the sea in which the banket was deposited was a saturated solution of gold and pyrite. These minerals were precipitated as the banket accumulated, a part of the pyrite being at the same time waterworn. This theory is an elaboration of Mr. Penning's. It avoids some of the objections to the impregnation hypothesis. The absence of rake veins and well-marked chutes is consistent with the scheme of Messrs. Penning and De Launay, and it would account fairly well for the patchiness of the reefs. Mr. Penning was driven to it by the angularity of the gold; Mr. De Launay, by the supposed importance of the rarity of gold in the pebbles.

The precipitation theory, however, is by no means free from objections, chief of which is that it gives no account of the most important feature of the deposits, namely, the association of gold in largest quantity with the coarsest banket. One would expect to find the sands at least as much mingled with the auriferous precipitate as the banket. Precipitates are usually thrown down in a fine state of division. How is it, then, that the currents which swept away all mud and fine sand did not also carry off the crystals of gold and pyrite before they had time to reach considerable dimensions? To meet this evident objection Mr. De Launay makes the following statement:

Pour tenir compte de ce fait caractéristique que l'or est presque-exclusivement dans les conglomérats et non dans les grès intermédiaires, on admettrait l'influence d'une préparation mécanique ayant concentré l'or et la pyrite, en leur qualité d'éléments

lourds, avec les galets les plus gros, comme cela s'est passé pour tous les dépôts d'alluvions aurifères.

Thus this geologist supposes a relatively quiet deposition of gold and pyrite from sea water in unsorted material, followed by a natural concentration. Now, sorting begins the moment that detritus from the land reaches the sea. I perceive no opportunity for the supposed quiet precipitation of gold and pyrite; nor do I understand why precipitation, if it takes place at all, does not continue during the sorting process, so that the sands eliminated from the pebbly material would continue to be enriched by precipitation.

The fundamental hypothesis of a sea highly charged with gold and pyrite seems to me extremely improbable. Had the ocean at any time been so charged, the mineral would, as Mr. De Launay says, be precipitated with extreme ease. How then could the ocean become highly charged? It would seem that the gold and pyrite going into solution, say at the mouth of some submarine solfataric vent, must be thrown down almost immediately and close to the point at which solution took place. An almost uniform distribution of gold along a coast known to be at least 30 miles in length would then be impossible. Again, if the ocean ever was so powerful a solvent for gold, why are there not many and indubitable cases of deposits formed by this method?

The advantages of the precipitation theory over the simple detrital theory are, as I understand Mr. DeLaunay, that the former hypothesis explains why there is no gold or pyrite in the pebbles and why the gold is not substantially all on the foot wall of the reefs. These advantages are by no means substantial ones, as will presently appear.

As has been noted above, pebbles which carry crystallized pyrite and other sulphurets disseminated through the quartz, and not on fissures of any sort, are fairly abundant on the Rand. Gold is also known in the pebbles. Some writers consider it very strange that if the pebbles came from auriferous quartz veins, gold-bearing pebbles are not more abundant.* As a matter of fact, in the auriferous river gravels of California and Venezuela, pebbles showing visible gold are extremely rare. Even in the vast exposures of the hydraulic washings one might spend weeks in the vain search for a specimen. In the sluices, however, small pieces of auriferous quartz may be found with the gold, separated by the concentration process from thousands of tons of barren pebble. On the auriferous beaches of California, Oregon, and Alaska, such pebbles seem

* Mr. Curtis did not adduce the rarity of gold-bearing pebbles in favor of the impregnation theory, no doubt because of his familiarity with California gravels.

to be still rarer than in the river gravels. Thus the rarity of gold-bearing pebbles on the Rand is such as should be expected from analogy if the deposits belong to the class of placers.

The presence of crystallized gold and pyrite is by no means unaccountable on the same theory. Even in the Tertiary gravels of California recrystallization of sulphurets is now in progress, and it is probable that recrystallization of gold also has taken place to some extent. On the Rand it is certain that solutions capable of dissolving gold to some extent have been present below water level at some time since the original deposition. These accompanied the formation of the white quartz veins which cut the blanket beds and which occasionally carry a little gold. The same solutions must have been capable of dissolving pyrite. The solvent fluids were probably hot waters containing sulphides of the alkalis and carbonates. Such waters dissolve gold and sulphurets, and they almost invariably accompany eruptive activity such as is manifested in the dikes of the Rand. Now, recrystallization being due to the action of fluids which exercise a feeble solvent power, it would be extremely remarkable (taking the existence of the white veins into consideration) if the gold and pyrite of the blanket showed no evidences of recrystallization. It is quite as easy to account for recrystallization of the gold and the pyrite as for the conversion of the sandstone into quartzite.

The objection to the theory under consideration, that the gold is not uniformly found on the foot wall of the reef, is entirely without weight. In auriferous *river* gravels, indeed, most of the gold is found either on bed rock or on layers of pipeclay; but the blanket is not a river deposit. As has been explained already, river gravels are distinguishable both by the form of the pebbles and by their imbrication or "shingling" from marine gravels, to which class those of the Rand belong. The deposits are therefore comparable with the auriferous beach deposits of the Pacific Coast or of New Zealand, and not with the river gravels of the Sierra Nevada. In the beach gravels the gold is found at the bottom of the layer of material set in motion by the last wave or current by which the mass has been agitated. Hence the beach deposits consist of stratified masses of gravel and sand in which the gold is for the most part confined to those layers which are composed of heavy particles, but not necessarily to the bottom of such layers, for if these have any considerable thickness, the upper part may be disturbed without movement in the lower portion. Thus thin layers of rich gravel, underlain and overlain by substantially barren layers, are very characteristic of gold-bearing beach deposits.

On the Pacific Coast the gold is commonly associated with

black sands, consisting largely of magnetic iron oxide or titanite iron ore. On the Rand, magnetite, though not absent, is relatively rare. It does not follow that the deposits of the two regions are not similar. The magnetite on the Pacific beaches does not originate to any extent in the gold-quartz veins, but in country rock. If the country rock happened to be poor in magnetite the sands would not be black. Such seems to have been the case in the Jurassic gold-bearing marine conglomerate of Placer County, California. Again, the magnetite may have been in part converted into pyrite by the sulphur-bearing solutions accompanying the intrusion of the dikes.

The beach sands of the Pacific Coast of North America and those of New Zealand form along the shores of extensive gold-bearing regions. It is natural that they should so form; it would be difficult to comprehend their entire absence, and it is hard enough to understand why they are not more abundant. What has become of the immense quantity of gold swept away by erosion from the western slope of the Sierra Nevada and the auriferous territory of northern California? It has certainly been carried to the sea, and, as a heavy metal, some of it has been left along the coast in the beach sands. The aggregate quantity of gold in the sand is very great, but I see no probability that it represents more than a small fraction of the gold which has been scattered by Nature's hydraulic process. The only answer is that the metal has been so trituated, so "floured," that it has been swept away into the abyss of the Pacific and perhaps partly dissolved in the waters of the ocean. Just as very fine gold can not be saved in a sluice, so still more finely comminuted gold must remain suspended almost indefinitely in ocean currents.

Now, at the time of the formation of the conglomerate the Witwatersrand lay along the shore of an extensive auriferous area, presenting belt after belt of quartz veins striking in a direction nearly parallel to the coast. The drainage probably cut across this area, bringing down auriferous detritus. The streams certainly brought down vein quartz from a gold-bearing country. This supply was more abundant at some times than at others, the variation probably representing fluctuations in the gradual upheaval of the land area. It is clear that vigorous currents swept the shore, for otherwise such accumulations of conglomerate could not have been formed. Here, then, there were all the conditions for the formation of beach placers. It might have been predicted *a priori* that, if littoral deposits could be found within a moderate distance to the southward of the area of Mashonaland, Matabeleland, and the northern Transvaal, they would be nearly certain to show some alluvial gold.

It has been argued that if the deposits of the Witwatersrand are ancient beaches they are substantially unique. It is certainly true that they are the richest of such deposits ever known, but geologically and qualitatively they by no means stand alone. Europe, America, Australia, and New Zealand all possess auriferous, marine gravels of pre-Tertiary age. Ancient river gravels would be preserved only under exceptional circumstances, and it is doubtful whether a single case of pre-Tertiary gold-bearing river gravels is yet known. It is interesting to compare other old gold placers with the deposits of the Witwatersrand, and for that reason notes on some of them were added to my other paper. They certainly reënforce the argument for the alluvial origin of the gold in the banket, and it may be noted that nearly all of these deposits lie in the regions known to contain gold-quartz veins older than the marine strata.

Let it be assumed for the sake of argument that the banket really represents a marine placer of early Paleozoic age, formed off the shore of an extensive gold-bearing region, and since injected with dikes. One would then expect to find the gold in the coarser streaks of the resulting conglomerate and on the lower side of such streaks. The reef would extend for many miles and perhaps for many hundreds of miles. The tenor would depend in part on the strength of the currents sweeping along the coast, and in part on the quality of the material fed into the sea at the different points, or at the same point during different seasons. Hence, conglomerate of a given coarseness would be richer at some points than at others, and there might be almost barren portions or beds, but the distribution would be in patches, not in chutes. The gold would almost all be finely divided, for nuggets would commonly remain in the rivers. Pyrite would almost certainly appear in the sands, but experience shows that gold-bearing pebbles would be rare. When the conglomerate was upheaved, injected with dikes, and metamorphosed, it would be found that the dikes sometimes cut poor patches and sometimes rich ones, their disposition having nothing to do with the original distribution of the gold. The sandstones would be converted into quartzites, and recrystallization of gold and pyrite would occur to some extent. In short, it seems to me that deposits exactly analogous to those of the Rand must form in this way, while in some details the composition of the banket would doubtless depend on the lithological character of the back country.

Thus, it seems to me that there are no valid objections to the theory of marine placer origin and no noteworthy features left unexplained by this theory, while so much can not be said

of either the impregnation or the precipitation theory. The beach deposits of the Pacific form an excellent instance of such marine placers, although they are not so rich as those of the Rand. On the other hand, no case is known of an extensive gold deposit which is certainly an impregnation in sand or gravel, nor is there an established case of marine precipitation.

There seem to be no other possible theories besides those discussed, but Messrs. Smith and Hammond are of the opinion that the gold is partly detrital and partly in place in the banket. Speaking with exactness, I agree with them, for, as has been mentioned, the white quartz veins are not absolutely barren. To my mind, however, it seems conclusively proved that only a minute fraction of 1 per cent. of the gold has this origin, for I see no reasonable evidence that any portion of the gold excepting that to be found in the white quartz seams is untransported.

On the theory which I have adopted the auriferous banket should be found to stretch along a line of ancient coast bounding an area in which gold-bearing quartz veins were rich and numerous. How large this area may have been, and therefore how long its ancient coast was, it is as yet impossible to say; but the indications are that the area was extensive and the coast long. Doubtless some portions of the coast will furnish only banket too poor to work, but until the Lower Cape formation has been traced across the continent of Africa other spots as rich as the Rand may be hoped for.

Washington, D. C., February, 1898.

ART. XXVIII.—*The Estimation of Manganese as the Sulphate and as the Oxide*; by F. A. GOOCH and MARTHA AUSTIN.

[Contributions from the Kent Chemical Laboratory of Yale University—LXVII.]

THE estimation of manganese by the conversion of salts of that element with volatile acids to the form of the anhydrous sulphate by the action of an excess of sulphuric acid, evaporation, and gentle heating was formerly a recognized procedure. On the authority of Rose,* however, this method was set aside on account of the supposed difficulty of removing the excess of acid without disturbing the composition of the normal salt. Thus, Oesten, working under Rose's direction, obtained, upon submitting the crystalline hydrous sulphate $\text{MnSO}_4 \cdot 5\text{H}_2\text{O}$ to heat, results which may be summarized and compared with the results obtained by Rose's sulphide method (the ignition of the residue with sulphur in hydrogen) as follows :

$\text{MnSO}_4 \cdot 5\text{H}_2\text{O}$ taken. gram.	MnSO_4 found. gram.	Theory. gram.	Error. gram.	MnS found. gram.	Theory. gram.	Error. gram.
1.659	1.043†	1.037	0.006 +	0.597	0.595	0.002 +
	1.023‡		0.014—			
1.481	0.934†	0.926	0.008 +			
	0.905‡		0.021—			
	0.725§		0.201—			
1.430	0.880†	0.893	0.013—	0.509	0.512	0.003—

† Ignited gently. ‡ Ignited at low red heat. § Ignited at strong red heat.

The residues remaining after the gentle ignition of the sulphate weighed apparently several milligrams more than should have been the case if the salt had been reduced to the normal anhydrous sulphate. At higher temperatures the sulphate turned brown and lost altogether too much weight. A comparison of the errors of the process in which the ignition was at low temperature with those of the sulphide process would seem to justify Rose's rejection of the former method for the latter. Upon recalculating these results, however, using atomic weight in use at present—viz : Mn = 55, S = 32.06, O = 16—it becomes plain that the errors of the two processes, as shown in Oesten's work, are not very different numerically, though with opposite signs.

$\text{MnSO}_4 \cdot 5\text{H}_2\text{O}$ taken. gram.	MnSO_4 found. gram.	Theory. gram.	Error. gram.	MnS found. gram.	Theory. gram.	Error. gram.
1.659	1.043	1.039	0.004 +	0.597	0.599	0.002—
1.481	0.934	0.928	0.006 +			
1.430				0.509	0.516	0.007—

* Ann. d. Phys. u. Chem, cx, 125.

The most uncertain element in these experiments is the difficulty, well-recognized at present, of getting the hydrous manganous sulphate, upon which the experiments were made, in a perfectly definite condition of hydration.

Volhard* subsequently studied the sulphate process, and showed that manganous sulphate may be dehydrated, separated from an excess of sulphuric acid, and brought into definite condition for weighing as the anhydrous salt by careful and protracted heating over a special device of his own—a ring burner enclosed in a sheet-iron casing. Thus, on evaporating and dehydrating a solution of pure neutral manganous sulphate, Volhard obtained the results recorded in the following statement:

Residue of MnSO_4 left by evaporation and dehydration ..	0.1635
“ after treatment with 3 drops of H_2SO_4 and heating 3 hours	0.1635
“ after heating 2 hours	0.1638
“ after treatment with 4 drops of H_2SO_4 and heating 2½ hours	0.1635
“ after heating 3 hours	0.1635

Similar results were obtained on evaporating with sulphuric acid and igniting in like manner an aqueous solution of manganous chloride. Volhard's recommendation of the method has not secured for it the acceptance which its simplicity and exactness would seem to demand—possibly because the periods of ignition appear to be considerable and the manner of heating special.

In our own experiments with the sulphate process we have found that special apparatus is unnecessary, that the time of treatment may be short, and that the process is in every respect simple as well as very exact. We took for a starting point manganous chloride prepared in the manner to be detailed. An aqueous solution of the so-called pure manganous chloride of commerce was boiled with pure manganous carbonate (to throw out aluminum, iron and chromium), filtered, and precipitated with ammonium sulphide. The precipitate thus obtained was dissolved in a very slight excess of hydrochloric acid (to leave behind possible traces of nickel, cobalt, and copper), the solution was boiled to expel hydrogen sulphide and precipitated with sodium carbonate. The manganous carbonate thus thrown down was boiled repeatedly with successive portions of water, and washed until the washings were free from chloride. The greater part of this purified carbonate was dissolved in the least possible amount of pure hydrochloric acid, the reserved portion of the carbonate was added, the mix-

* Ann. d. Chem., cxviii, 328.

ture was boiled, and the solution of the purified and neutral manganous chloride was filtered from the excess of undissolved carbonate. Definite portions of this solution were precipitated with silver nitrate, and from the weight of the silver chloride thus obtained the amount of manganous chloride present was calculated. Portions of the solution thus standardized were drawn, for our experiments, from a burette into a weighed platinum crucible, sulphuric was added in amount more than equivalent to the manganese, the solution was evaporated on the water-bath until the water was removed, and then, supported by means of a porcelain ring, or triangle, within a larger porcelain crucible used as a radiator so that the bottom and walls of the one were distant from the bottom and walls of the other by an interval of about 1^{cm}, the crucible was heated more strongly. The outer porcelain crucible may be heated over a good Bunsen flame to a red heat without risk of overheating the manganese sulphate within the inner crucible, and the ignition may proceed as rapidly as is consistent with the avoidance of mechanical loss by spattering. The results obtained by treatment of equal portions (50^{cm}³) of the same solution are given, together with the results of standardizing the solution by precipitation with silver nitrate, in columns A of the following table. In the other columns are given comparative results got in the treatment of equal portions of several other solutions employed subsequently in other work.

MnSO ₄ calc'd from AgCl found in 50 ^{cm} ³ of solution A.	MnSO ₄ found by treatment of 50 ^{cm} ³ of solution A with H ₂ SO ₄ .	MnSO ₄ found by treatment of 50 ^{cm} ³ of various solutions with H ₂ SO ₄ .					
gram.	gram.	B	C	D	E	F	G
(1) 0.3518	(1) 0.3513	(1) 0.3100	(1) 0.3256	(1) 0.3534	(1) 0.3524	(1) 0.3355	(1) 0.5475
(2) 0.3512	(2) 0.3514	(2) 0.3104	(2) 0.3254	(2) 0.3543	(2) 0.3520	(2) 0.3357	(2) 0.5476
	(3) 0.3518	(3) 0.3096					

These results show plainly that the process of estimating manganese in the form of the anhydrous sulphate is both simple and accurate.

The estimation of manganese as the manganoso-manganic oxide Mn₂O₄, has been so frequently criticized unfavorably that the method may be said to have passed from very general use excepting in certain cases in which the directness of the process is a temptation to incur the risk of some uncertainty. The production of the other oxides of manganese in definite condition is thought to be even more uncertain. Manganese dioxide,

MnO_2 , begins, as Wright and Menke have shown* to lose oxygen at a temperature (about 210°C.) to which the hydrated oxide must be heated to free it from water, or very nearly that at which the nitrate is converted into the dioxide; so that the chance of producing an undecomposed dioxide by the ignition of the hydrated dioxide (the form in which the dioxide generally appears in analytical processes), or of the nitrate, is small. Manganic oxide, Mn_2O_3 , is produced, it is said, from the other oxides by ignition at a low red heat under the ordinary conditions. The manganoso-manganic oxide, Mn_3O_4 , forms, presumably, when an oxide of manganese is submitted, under ordinary atmospheric conditions, to the high heat of the blast-lamp. If the proportion of oxygen in the surrounding atmosphere is reduced below the normal, the conversion of Mn_2O_3 to Mn_3O_4 goes on very easily, as Dittmar has shown,† at a temperature between the melting points of silver and aluminum, while if the proportion of oxygen in the surrounding atmosphere falls much below the normal, the reverse change, from Mn_3O_4 to Mn_2O_3 , tends to take place at the same temperature. It is not surprising, in view of these phenomena, that the estimation of manganese as the oxide Mn_3O_4 should have fallen into disrepute; and yet, if the condition most favorable to the production of that oxide—a low proportion of oxygen in the surrounding air—can be maintained during the ignition, it is not impossible that the indications of the process might prove to be, under the conditions, reasonably accurate. Now, this may be exactly the condition of affairs when the ignition takes place ordinarily; for, if the products of combustion displace the ordinary air about the crucible, the proportion of oxygen about the oxide falls to a low limit. We have made the experiment of enclosing the ignited crucible within an inverted crucible, so that the products of combustion should be held immediately about and above the ignited oxide, but our experience has shown that the object in view is attained, apparently, quite as well when the ignition is so arranged that the crucible simply rests well within the upper part of the flame of a strong Bunsen burner, or blast-lamp, in such manner that an oxidizing flame covers nearly the entire wall of the crucible.

In the following experiments we have put to the test this matter of getting definitely the different oxides of manganese. We started with a known amount of pure anhydrous sulphate, prepared from the pure chloride in the manner previously described. This sulphate was converted by ignition into the oxide—presumably the oxide Mn_3O_4 —the containing crucible being well within the upper flame of a powerful burner.

* Jour. Chem. Soc., xxx, 775.

† Jour. Chem. Soc., xvii, 294.

In the next step, this oxide was further oxidized by moistening it with nitric acid and heating the residue gently until the evolution of fumes ceased, the containing crucible being placed well above a porcelain crucible used as a radiator and heated so that only the bottom showed a faint red heat. In this process the attempt was made to arrest the ignition at the point where the anhydrous dioxide was produced. As the table shows, and as would be expected, this attempt was only occasionally and partly successful.

The residue of the last process was then submitted to a higher heat. The platinum crucible containing the oxide was placed within and touching the bottom of a larger porcelain crucible which was heated to redness. Under these conditions the temperature should not be too hot, and the products of combustion should naturally be thrown so far away from the oxide undergoing ignition that circumstances should be favorable for the formation of the oxide Mn_2O_3 . The event proved that the attainment of the exact condition corresponding to the symbol Mn_2O_3 is a matter of some uncertainty.

Next, the oxide was subjected to the highest heat of a strong Bunsen burner (or in some cases, the broad flame of a blast lamp), the crucible being well surrounded by the products of combustion. The results of this treatment, it will be seen, agree, with a single exception out of ten experiments, reasonably well with the theory for Mn_3O_4 .

By treating the final oxide with nitric acid and repeating the cycle of operations described, the observations of the phenomena were multiplied, until finally, the oxide formed last was treated with sulphuric acid, ignited in the manner previously detailed, and weighed as the anhydrous sulphate, thus showing that no significant loss of material had taken place in the series of manipulations. The table comprises the results of these experiments. The Roman numerals indicate the order of treatment.

The inference is plain that the estimation of the manganese in the form of the manganoso-manganic oxide, Mn_3O_4 , is by no means to be considered utterly untrustworthy when the process is conducted in the manner described, though it must be recognized that an irregular result may occur occasionally. The danger of accepting such an irregularity as a correct indication may be eliminated to a very considerable extent if the precaution is taken invariably to moisten the ignited oxide with nitric acid, and ignite again. The indications of harmonious results thus got may be taken with a fair degree of confidence. However, it is, in our judgment, by far the wiser and simpler plan to convert an oxide of manganese obtained in course of analysis into the sulphate and to weigh the manganese in that form.

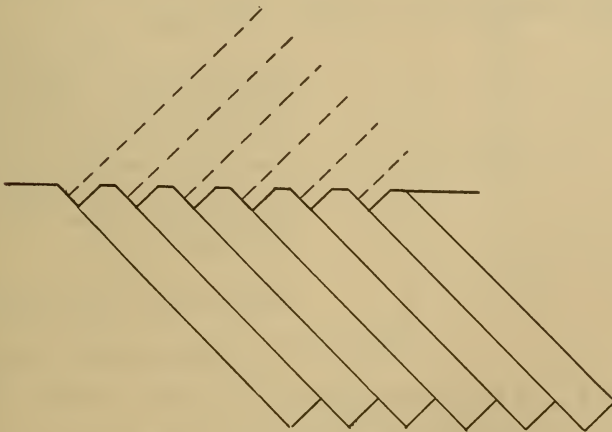
ART. XXIX.—A Spectroscope without Prisms or Gratings;
by A. A. MICHELSON.

THE resolving power of a diffraction grating is proportional to the product of the total number of lines by the order of the spectrum observed. But little effort seems to have been made to make a decided step in the direction of increasing the *order* of the spectrum observed, and this is doubtless because for a grating acting by *opacity* the brightness of the spectrum diminishes very rapidly as the order increases. This difficulty has been successfully overcome by ruling the lines in such a way as to concentrate the greater proportion of light in one spectrum, but so far as I am aware such attempts have been limited to the first, second or third spectrum and the results even here are somewhat fortuitous.

It seems nevertheless quite possible to construct gratings which shall throw a quite large proportion of the light in very high orders of spectra—say the hundredth—in which case the grating space must be of the order of a hundred waves or say twenty to the millimeter, instead of a thousand. The lines would have to be drawn with no more accuracy than before, and the grating could be completed in a very short time and temperature changes would have a much smaller effect than at present.

It may be that there are more serious practical difficulties in the way of such a ruling as is represented in fig. 1 than would

1.

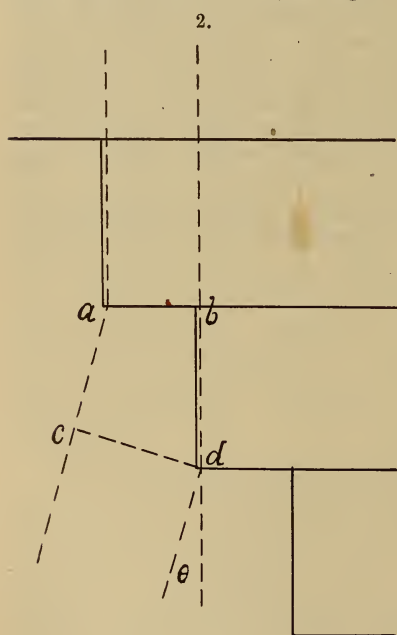


be anticipated. Especially may this be true if the greater part of the light is to be returned in the direction from which it

came; for that the grooves must be correspondingly deep, and the grating space would vary with the depth. Fig. 1 at once suggests a possible method of effecting the same result; by building up the steps by equal thicknesses of optical glass. Here the difficulty, even supposing the optical work to be practically perfect, would be the joining of the separate plates in such a way as to have always the same distance between them.

By using the same arrangement for transmission instead of reflection this difficulty is avoided—and there remains absolutely nothing but the difficulty of making a considerable number of plane-parallel plates of the same thickness—to an order of accuracy only one-fourth that required in the former arrangement, or even one-tenth of this if the other medium be water or oil instead of air.

Probably the surprising thing is the smallness of the number of plates required to give results which are comparable with those of the best gratings.



This can be shown as follows: let abd (fig. 2) be one step in the series of plates and let $ab = s$ and $bd = t$. If m is the order of the spectrum observed, $m\lambda = \mu \cdot bd - ac$ or

$$m\lambda = \mu t - t \cos \theta + \delta \sin \theta.$$

$$\frac{d\theta}{d\lambda} = \frac{m-t \frac{d\mu}{d\lambda}}{t \sin \theta + \delta \cos \theta}$$

$$\frac{d\theta}{dm} = \frac{\lambda}{t \sin \theta + \delta \cos \theta}$$

and if $\delta\theta$ is the displacement corresponding to $\delta\lambda$ and $\delta\theta_1$, that corresponding to $\delta m = 1$, assuming Cauchy's formula $\mu = a + b/\lambda^2$ and taking the approximate value of $m = (\mu - 1)t/\lambda$, we have

$$\delta\theta/\delta\theta_1 = [(\mu - 1) + 2(\mu - a)] \frac{t}{\lambda} \cdot \frac{\delta\lambda}{\lambda}$$

For ordinary glass the coefficient of t/λ is approximately equal to unity; so that if $\frac{\delta\lambda}{\lambda} = .001$ as in the case of the two sodium lines, and $t = 5^{\text{mm}} = 10000 \lambda$, then $d\theta = 10 d\theta_1$, that is, the sodium lines would be separated by ten times the distance between the spectra.

The resolving power of such a combination is mn , exactly as in the case of gratings; so that with but *twenty* elements 5^{mm} thick and hence $m = 5000$ the resolving power would be 100000, which is about that of the best gratings.

The experiment was actually tried with but *seven* elements, placed between a collimator and an observing telescope and the collimator slit illuminated with light from a sodium flame. The images were so distinct that the broadening of the lines could be very easily detected, and the Zeeman effect was readily observed when the sodium flame was placed in a magnetic field.

It is important to note that the resolving power is independent of the number of plates but depends only on the total thickness, and the only advantage in a large number of elements is the greater separation of the spectra. The overlapping of spectra is doubtless a disadvantage, which however could be overcome by a preliminary analysis; and for the examination of single lines and especially in the investigation of effects of broadening, shifting or doubling of lines, the method seems especially well adapted. A battery of twenty plates has been ordered and it is hoped that further results will be obtained within a few weeks.

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SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On an Electrochemical method for changing an Alternating into a Direct Current.*—It has long been known that when an aluminum plate is made the anode in an electrolytic cell, the oxygen set free upon this plate produces there a coating of oxide which greatly increases the resistance of the cell. Hence a cell having such an electrode acts like a trap, the current being permitted to flow freely when the aluminum plate is made the cathode, while when it is the anode the current is very feeble. GRAETZ has now proposed to utilize such cells for the purpose of changing alternating currents into direct ones. For this purpose a number of such cells are arranged in series, the number being so chosen that the polarization at the anode is either equal to or is greater than the current-pressure. Under these circumstances the current in that direction for which the aluminum plate would act as the anode is greatly diminished, while the opposite current passes freely. The issuing current therefore is practically a current in one direction.—*Ann. Phys. Chem.*, II, lxii, 323-327, September, 1897. G. F. B.

2. *On the Electrochemical Equivalent of Carbon.*—It has been noticed that in electrolyzing liquids evolving oxygen, using carbon as the anode, this carbon is acted upon chemically, the character and extent of this action depending upon the electrolyte employed. Thus COEHN has determined that when a current of 0.12 ampere is sent through six electrolytic cells having pure carbon anodes and platinum cathodes, the electrolyte being sulphuric acid diluted with 1, 10, 20, 50, 100 and 500 volumes of water, for ten hours, the most concentrated acid remains colorless, the most dilute becomes dark brown, while the intermediate solutions have intermediate shades; at the same time there being considerable mechanical disintegration. At higher temperatures this disintegration becomes less, while the electrolyte is still more deeply colored. Thus at 100°, in a solution made up of equal volumes of sulphuric acid and water, the mechanical disintegration becomes inconsiderable. The author determined the loss of weight of a carefully purified carbon anode under these circumstances, and obtained the value 3.5 as the electrochemical equivalent of carbon; but this number is probably too high, as some mechanical loss had taken place. He then made a number of experiments at the ordinary temperature, using sulphuric acid diluted variously with from 10 to 500 volumes of water, the fragments of carbon mechanically separated being collected and weighed, and their weight subtracted from the total loss of the anode. The value of the electrochemical equivalent of carbon thus obtained varied from 2.7 to 3.0. It thus appears that this number is independent both of the concentration of the acid and

of its temperature, although the action at first appears to be materially influenced by these conditions.—*Zeitschr. Electrochem.*, iii, 424–5, April, 1897.

G. F. B.

3. *On the Use of the Copper Voltmeter.*—Additional experiments have been made by FOERSTER upon the copper voltmeter and the best means of avoiding the errors to which it is liable. While the copper sulphate solution should be concentrated in order to avoid the deposition of the metal in the pulverulent form, yet it increases the concentration of the cuprous ions; although, owing to their oxidation by the air, the solution never becomes saturated with these ions. Hence when the solution is exposed to the air the quantity of copper deposited is too small, particularly when the current density is small. The fact that a copper plate in an acid solution of copper sulphate is most strongly attacked at the surface of the liquid, is thus explained. If sulphuric acid be added to the copper sulphate solution, while it diminishes to some extent the concentration of the cuprous ions, its presence is of much more importance in preventing the separation of cuprous oxide, which, owing to the hydrolysis of cuprous sulphate, takes place in neutral solutions. If this cuprous oxide be deposited on the cathode, it not only increases the weight of the deposit but it causes inequalities in conductivity and hence gives rise to the production of cuprous ions where the current density is smallest. Again, a saturated sulphate of copper solution cannot be used because the solubility of this salt is diminished by the presence of the acid and hence causes the deposition upon the anode of the salt itself, producing an increase in resistance. He recommends as a suitable solution, one containing 125 grams of $\text{CuSO}_4(\text{H}_2\text{O})_5$ and 50 grams of H_2SO_4 to the liter. When air is present no more copper is dissolved by the strongly acid solution than by the weaker one; a normal solution of copper sulphate, normal also as to the sulphuric acid, dissolving 17 milligrams of copper, while a solution containing only one thousandth of an equivalent of acid, under the same conditions, dissolved 15 milligrams. For very weak currents the author uses a closed voltmeter containing a solution of copper sulphate, one-tenth or even one-twentieth of a gram-equivalent, and one gram-equivalent of sulphuric acid; a slow current of pure hydrogen being continuously passed through it. This reduces to a minimum the formation of cuprous ions, while their conversion at the anode into cupric ions is prevented by enclosing this anode in parchment paper. The author states that the maximum current density for obtaining an adherent copper deposit is higher the greater the concentration of the solution and the more completely local dilution is prevented by stirring. In the case of a normal solution of copper sulphate and sulphuric acid, a current of 2 amperes per square decimeter is not too great. No advantage results from measuring the loss of the anode to determine current.—*Zeitschr. Electrochem.*, iii, 479–482, 493–497, May, 1897. G. F. B.

4. *On the Commencement of the Combination of Hydrogen with Oxygen.*—An investigation has been made by BERTHELOT to determine the precise character of the influence which is exerted upon the combination of oxygen and hydrogen by the walls of the vessel containing the gaseous mixture. The two gases were always mixed in the proportion of two volumes of hydrogen and one of oxygen. It was noted that in presence of dry barium oxide, no combination took place at ordinary temperatures, nor even at 100° or 182° . At 250° , however, 77 per cent of the gaseous mixture disappeared in five hours, and at 280° the whole of it disappeared in 26 hours. At first, as subsequent experiments showed, the oxygen disappeared more rapidly than the hydrogen, a portion of it uniting with the barium oxide to form peroxide which the hydrogen afterward reduced. Thus, for example, at 280° all the oxygen disappeared after five hours, while 16 per cent of the hydrogen remained; the latter however being slowly absorbed. The action of the barium oxide appears analogous to that of platinum. A similar action was observed with potassium hydroxide, the gases combining slowly at 250° and quite rapidly at 280 – 300° . In this case the glass is attacked, the manganese which it contains forming alkali manganates. Here also the oxygen disappears more rapidly than the hydrogen, peroxides and manganate being formed. In presence of moisture glass was found to absorb considerable oxygen; but if the water be in larger proportion, no such absorption was observed. The author regards this intermediate formation of alkali peroxides as taking an important part in the combination of hydrogen and oxygen when heated in glass vessels.—*C. R.*, cxxv, 271–275, August, 1897.

G. F. B.

5. *On the Different Varieties of Carbon (Amorphous, Graphite, Diamond).*—An elaborate investigation has been made by MOISSAN upon the production, modes of occurrence and general properties of the various forms of carbon. The first of his three papers is devoted to amorphous carbon. Eleven different products were examined, made as follows: (1) by the imperfect combustion of petroleum, (2) by the imperfect combustion of acetylene, (3) by the detonation of acetylene with mercuric fulminate, (4), by the action of sulphuric acid on starch, (5) by the action of ferric chloride on anthracene at 180° , (6) by the decomposition of carbon tetr iodide at 200° , (7) by the action of light on carbon tetr iodide, (8) by the action of a Smithsonian couple on a solution of carbon protoiodide in carbon disulphide, (9) by the action of zinc filings on carbon tetr iodide, (10) by the action of magnesium on a solution of the tetr iodide and (11) by the action of boron at a red heat on carbon dioxide. All the specimens of carbon thus produced were amorphous and more or less impure, the complete purification in many cases being very difficult if not impossible, the carbon holding traces of moisture, hydrocarbons and the previously associated elements, iodine, lead, zinc, etc., with great avidity. The most impure samples were those given by methods

(4) and (5). By whatever method produced, the density of the amorphous carbon was always less than two, that of the purest non-ignited lampblack being 1.76. Amorphous carbon polymerizes on heating, thus raising its ignition point in oxygen and its resistance to chromic acid solution.

The second paper treats of graphite, the samples considered being from Ceylon, Borrowdale, Ticonderoga, Greenville, Omeansk, Mugrau, Scharzbach and Karsok; and also from an American pegmatite, and the Blue Earth from the Cape. The carbon in meteorites is considered, and also that separated from iron. The densities, the ignition-points and the rates of oxidation of artificially prepared samples are discussed and the displacement of carbon in fused cast-iron by boron and silicon is considered. The preparation and properties of intumescent graphite are also described.

In the third paper, the diamond is taken up, and its properties are given and the composition of the ash left on combustion. The occurrence of diamonds in the Blue Earth from the Cape, in sand from Brazil and in the Cañon Diablo meteorite is discussed; and then the author passes to consider the solubility of carbon in various metals at ordinary pressures, and the formation of definite carbides, as well as the effect of high temperatures on different forms and the properties of carbon vapor. Numerous experiments are described on the artificial production of diamonds and a description is given of the method used for the combustion of artificial diamonds.—*Ann. Chim. Phys.*, VII, viii, 289–305, 306–347, 466–558, July, Aug., 1897.

G. F. B.

6. *Die Wissenschaftlichen Grundlagen der Analytischen Chemie.*; Elementar dargestellt von W. OSTWALD. Zweite vermehrte Auflage, 12mo, pp. x, 200, Leipzig, 1897 (Engelmann), 5 marks.—This book, like all of Ostwald's writings, has been remarkably well received by chemists; so much so that a new edition has been called for in less than three years. It treats of the scientific basis of analytical chemistry in the light of the more modern views of physical chemistry of which its author is so distinguished an exponent. It is divided into two parts, the first being theoretical and the second practical. The subjects treated in the first part are the detection of substances, the separation of substances in the solid, liquid and gaseous states, physical separation-methods, chemical methods of separation, and the measurement of substances. The second part treats of the application of these principles to the detection and estimation of substances, the first chapter considering acids and bases, the second the alkali metals, and so on, ending up with chapters on the non-metals and on the calculation of analyses. The most important chapter in the book seems to us to be that on chemical separation methods, in which is considered the modern theory of solution, including Van't Hoff's theory of osmotic pressure and Arrhenius' theory of electrolytic dissociation, according to which "salts do not exist as such in aqueous solution but are more or

less completely split up into their constituents or ions." The substances detectible by reagents therefore are these free ions only. Thus the chlorine in metallic chlorides is an ion when in solution and hence reacts with silver nitrate; while chlorates, chlor-acetates and chloroform do not so react, since these substances contain no chlorine ions. The ions of potassium chlorate are K and ClO_3 and it is these ions which react with suitable reagents. In short all the reactions of analytical chemistry when they occur in solution are ionic reactions. Thus the author defines an acid to be a compound which contains hydrogen as an ion when in aqueous solution and a base to be one which under like circumstances contains the ion hydroxyl. The reading of such a book as this by the student cannot fail to be of the greatest advantage to him, since it leads him to consider the philosophy underlying his analytical processes and thus broadens out his horizon. The book is worthily dedicated to Wislicenus. G. F. B.

7. *Lehrbuch der Allgemeinen Chemie*; von Dr. WILH. OSTWALD, Professor an der Universität zu Leipzig. In zwei Bänden. Zweiten Bandes, zweiter Teil. *Verwandtschaftslehre*. Zweite Lieferung, Bogen 14-26. Zweite umgearbeitete Auflage. Leipzig, 1897 (W. Engelmann).—This is the part last issued of the remarkable Treatise on General Chemistry by Ostwald, now appearing in its second edition. It is not too much to say that it appears destined to exert upon the science of chemistry a more important influence than any other similar treatise now extant.

G. F. B.

8. *Inorganic Chemical Preparations*; by FRANK H. THORP, Ph.D., Instructor in Industrial Chemistry in the Mass. Inst. of Technology. 8vo, pp. iv, 238, Boston, 1896 (Ginn & Co.).—The author has sought in this manual to provide the student with such simple directions in manipulation and experimentation as shall enable him to prepare the 100 substances mentioned in it with accuracy and success. The matters it treats of are well considered and the book will no doubt serve a useful purpose in instruction.

G. F. B.

9. *Experimental Physics*; by WILLIAM A. STONE, A.B., Instructor in Physics at the Phillips Exeter Academy, 12mo, pp. vi, 378. Boston, 1897 (Ginn & Co.).—An elementary laboratory manual for students in preparatory schools and academies. The subjects seem well selected, the descriptions accurate, the directions plain, the illustrations good, and the questions upon the work suggestive.

G. F. B.

10. *Physical Experiments*; A Manual and Note Book. By ALFRED P. GAGE, Ph.D., 8vo, pp. ix, 97, Boston, 1897 (Ginn & Co.).—A laboratory note book containing, among other exercises, those required for admission to Harvard University. G. F. B.

11. *Transmission of Radiant Heat by Gases at Varying Pressures*.—CHARLES L. BRUSH shows that Dulong and Petit's sixth law: "The cooling power of a fluid diminishes in a geometrical progression when its tension itself diminishes in a geometrical pro-

gression. If the ratio of this second progression is 2, the ratio of the first for air is 1.366; 1.301 for hydrogen; 1.431 for carbonic acid; and 1.415 for olefiant gas," is only approximately true in the case of a large balloon and at pressures from a few millimeters upward. It is not true when a small balloon is used, and at small pressures it is not true of large or small balloons. In small balloons the cooling effect of the last millimeter of air is nearly ten times as great as that of all the rest up to atmospheric pressure combined."

The author finds that Professor Crookes's statement: "That each additional diminution of a millionth would produce a still greater retardation of cooling, so that in such high vacuo as exist in planetary space the loss of heat—which in that case would only take place by radiation—would be exceedingly slow," is not true, for the curves representing the rate of cooling do not break down materially at pressures as low as a twentieth of a millionth. The enormous heat-conducting capacity of gases at very small pressures is shown by the curves. In the large bulb used, hydrogen at a pressure of only twenty-six millionths of an atmosphere transmits heat as rapidly as the ether. At seventy-six millionths it equals air at atmospheric pressure, that is to say it does the work of nearly two hundred thousand times its weight of air.—*Phil. Mag.*, Jan., 1898, pp. 31-42. J. T.

12. *Conductivity of Carbon for Heat and Electricity.*—L. CELLIER has determined the heat and electrical conductivity of carbon and finds that Professor Weber's law connecting heat conductivity and electrical conductivity does not hold in the case of carbon, and that carbon cannot be at all compared with metals.—*Wied. Ann.*, No. 7, 1897. J. T.

13. *Determination of Relative Heat Conductivity by the Isothermal Method.*—W. VOIGT describes a modification of Senarmont's method of determining relative conductivity by means of the melting of a substance on the surface of the bodies. Voigt uses a mixture of wax and turpentine, with *Elaidinsäure* in definite proportions, and obtains melting curves of extraordinary sharpness. Double plates were employed, cut in the form of right-angled triangles, with acute angles of 45°. These plates were put together so as to form a right-angled parallelogram, and having been cooled with the above substances were exposed to a source of heat, and the angles between the melting curves on the two plates were measured. The correspondance between the observed and calculated values was very good.—*Wied. Ann.*, No. 1, 1898, pp. 95-100. J. T.

14. *Röntgen's Original Papers on the Röntgen Rays.*—The original papers of RÖNTGEN, first published in the proceedings of Der Würzburger Physik. Medic. Gessellsch., have been republished in the current number of Wiedemann's *Annalen der Physik und Chemie*, as leading articles. There is a quiet irony in this, as if to show that Röntgen had anticipated the labors of the army of investigators who have endeavored to extend his work.—*Wied. Ann.*, No. 1, pp. 1-37. J. T.

15. *Johanniskäfer Light*.—In an earlier paper, H. MURUOKA stated that the light from this species of fire insect, when filtered through paper or cardboard, could affect photographic plates. In connection with M. Kasuya the author has re-examined the phenomenon and finds that it was due to a moisture in the cardboard which brought out a peculiar property of the latter. This moisture was communicated doubtless by the fire insects. Aqueous vapor alone did not produce photographic effects. When bits of the cardboard, however, were placed in water, a photographic plate exposed to the vapor of water was sensibly blackened. Various organic substances were then tried, and photographic effects were produced by a large range of such substances, among which were resin, coffee, camphor, tea, also oil of turpentine, mercury and alcohol. It was found that zinc, cadmium and magnesium act upon photographic plates, and it was noteworthy that cadmium and magnesium blacken photographic plates only around the boundaries of the pieces of metal. Cadmium oxide exhibited an effect which cannot be ascribed to radiation or to vaporization. For instance, two thick pieces of cardboard A and B of the size of the to-be-covered photographic plate were perforated—A with a little square hole, B with a large one, both in the middle of the plates. A was laid upon a glass plate and the perforation was filled with oxide of cadmium powder. B was then laid on A and on B was placed a photographic plate. It was expected that the blackening would extend over the entire surface of the perforation in B, for the vapor of the powder could reach all points of this perforation. The darkening, however, was confined to a surface equal to the little square opening.

If A and B were placed 1^{cm} apart and a copper rod was placed between the openings without resting on either cardboard, there was no blackening under the copper rod. This seemed like a phenomenon of radiation, but radiation apparently cannot explain the limitation of the blackening in the first case.—*Wied. Ann.*, No. 1, 1898, pp. 186–191.

J. T.

16. *On the Occlusion of Hydrogen and Oxygen by Palladium*; by LUDWIG MOND, WILLIAM RAMSAY, and JOHN SHIELDS. (Abstract of a paper read December 16, 1897, before the Royal Society.)—During their investigations on the nature of the occlusion of gases by finely divided metals, and in particular on the occlusion of hydrogen and oxygen by platinum black, the authors have had occasion to examine the behavior of palladium to these gases.

The palladium was employed in three states of aggregation, viz: in the form of (a) black, (b) sponge, and (c) foil. Palladium black, prepared in the same way as platinum black, contains 1.65 per cent of oxygen, or, taking the density of palladium black as 12.0, 138 volumes of oxygen. It differs from platinum black, however, inasmuch as the oxygen cannot be removed in vacuo at a dull red heat, and consequently had to be determined in the ignited substance by passing hydrogen over it and weighing the

water produced. Palladium black dried at 100° contains 0.72 per cent of water, and hence, on the assumption that the oxygen exists as PdO, we have for the analysis of palladium black—

Pd	86.59 per cent	
PdO	12.69 “	= 1.65 per cent O ₂
H ₂ O	0.72 “	

On heating in an atmosphere of oxygen, palladium black goes on absorbing oxygen at least up to a red heat, with the formation of a brownish-black substance, which does not again lose its oxygen at a dull red heat in vacuo. The amount of oxygen absorbed (nearly 1000 volumes) was about one and a half times as much as corresponds with the formula Pd₂O, and if the ignition had been sufficiently prolonged, the whole of the palladium would probably have been converted into the oxide PdO.

Palladium black, when exposed to hydrogen gas, absorbed over 1100 volumes, but of this only 873 volumes were really occluded, the remainder having formed water with 139 volumes of oxygen originally contained in the black, which is in good agreement with the direct gravimetric estimation.

Of the hydrogen occluded, about 92 per cent was pumped off slowly at the ordinary temperature, and almost the whole of the remainder at 444° . Increase of pressure of the hydrogen from one atmosphere up to 4.6 atmospheres had no influence on the quantity occluded at the ordinary temperature.

The pure palladium sponge remaining in the experimental tube after the above experiment was over occluded 852 volumes of hydrogen, and about 98 per cent of this was extracted in vacuo at the ordinary temperature.

New palladium foil behaved in a very peculiar fashion. At first it scarcely occluded any hydrogen even after ignition in the gas and subsequently cooling down. It was therefore charged and discharged several times electrolytically with hydrogen, but still it persistently refused to occlude any appreciable quantity when replaced in an atmosphere of hydrogen.

After powerful ignition in the blowpipe flame, when it was probably oxidized and then again reduced at a still higher temperature, it was introduced once more into the experimental tube. It immediately occluded a considerable quantity of hydrogen, and by maintaining the temperature between 100° and 130° , a large additional quantity was slowly absorbed. On cooling down to the ordinary temperature, hydrogen was again occluded, and it was finally found to have taken up 846 volumes, i. e. approximately the same quantity as the black or sponge.

The hydrogen occluded by palladium foil is given off again very slowly at the ordinary temperature in vacuo, but rapidly and almost completely at 100° .

The paper contains some attempts to explain the extraordinary behavior of palladium foil.

The heat evolved on the occlusion of hydrogen by palladium black was measured in an ice calorimeter (temperature of the room 20–24°) in nearly the same way as the corresponding heat of occlusion of hydrogen by platinum black, thereby avoiding errors due to the preëxistence of oxygen in the substance.

Favre's statement that the heat of occlusion remains constant for the different fractions of hydrogen occluded was confirmed, and it was found that +46.4 K (4640 g. cal.) were evolved per gram of hydrogen occluded.

The authors consider that this number may be taken as correct within 1 per cent, and compare it with the different values found by Favre and those calculated by Moutier and Dewar.

If the external work done by the atmosphere be eliminated, the heat evolved per gram of hydrogen occluded becomes +43.7 K.

The heat evolved per gram of oxygen absorbed was also determined in an indirect manner, and found to be +11.2 K (1120 g. cal.).

This number, referred to 16 grams of oxygen, lies intermediate between the values given by Thomsen for the heat of formation of palladious and palladic hydroxides, and may be consistent, considering the accuracy of such measurements, with the formation of either of these hydroxides or with a mixture of both. In any case it is of the same order of magnitude, and taken in conjunction with the behavior of palladium black when heated in an atmosphere of oxygen, is undoubtedly in harmony with the view that the absorption of oxygen by palladium black (and probably also by platinum black) is a true phenomenon of oxidation.

The authors have also investigated the atomic ratio—palladium : hydrogen for fully charged palladium black, sponge, and foil, and give in tabular form the corresponding ratios deduced from experiments by Graham and Dewar in which wire and block palladium were charged with hydrogen electrolytically. They have arrived at the conclusion that no matter whether the palladium exists as black, sponge, foil, wire, or compact metal, or whether it is charged by direct exposure to hydrogen gas (the proper conditions being observed), or charged electrolytically, the amount of hydrogen occluded in each case is approximately the same, the atomic ratio varying between 1.37 and 1.47.

Hoitsema has shown that Troost and Hautefeuille's deduction that a compound exists having the formula Pd_2H is not warranted. The constancy of the heat of occlusion over the whole range of absorption is also opposed to the view that such a compound is formed.

The composition of fully charged palladium hydrogen corresponds closely with the formula Pd_3H_2 first suggested by Dewar. The principal and almost only evidence, up to the present, in favor of the formation of such a definite chemical compound is to be found in the approximation of the above atomic ratios to the

theoretical value 1.5, required by the formula Pd_3H_2 . Although Hoitsema's arguments may be equally well directed against the existence of this compound, the authors consider that additional and independent evidence is desirable, and hope to be able to provide it.

It is also shown that the heats of occlusion of hydrogen in platinum and palladium black are not in favor of the view which has sometimes been put forward, that the heat of occlusion of a gas represents the heat of condensation or liquefaction of the gas in the capillary pores of the absorbing substance, or the heat of solidification or fusion.

17. *Refractivities of Air, Oxygen, Nitrogen, Argon, Hydrogen and Helium.*—The results obtained by RAMSEY and TRAVERS in an investigation of the refractivities of a series of gases are given in the following table:

Refractivities of Gases, Air equal to Unity.

	Directly compared.	Through			
		Oxygen.	Nitrogen.	Hydrogen.	Argon.
Hydrogen	0.4733	0.4737	0.4727	-----	-----
Oxygen	0.9243	-----	0.9247	0.9237	0.9261
Nitrogen	1.0163	0.0155	-----	1.0170	1.0191
Argon	0.9596	0.9577	0.9572	-----	-----
Carbon dioxide	-----	1.5316	-----	-----	-----

The values are compared here directly and also through the other gases mentioned. The greatest care was taken to obtain pure material in each case. The special method of experiment is stated to have been the same as that described by Lord Rayleigh (*Proc. Roy. Soc.*, lix, 203):

The authors have also calculated the refractive index of air from the determinations obtained with the individual gases present, viz.

Oxygen	0.9243
Nitrogen	1.0163
Argon	0.9596

and the densities of the constituent gases, and obtained the following numbers:

$$(1.0163 \times 78.15) + (0.9243 \times 20.91) + (0.9596 \times 0.94) = 99.653$$

They hence conclude that the refractivity of the mixture, air, is somewhat less than that of the sum of the refractivities of its constituents taken in the proportion in which they occur. This discrepancy is not sensibly altered by such minor changes in the data given as seem to be admissible.

To test the same point similar calculations were made with a mixture of hydrogen and helium, selected as being particularly favorable since their critical points are so low and they hence approximate closely to the ideal gas. The result was to obtain a

value of the refractivity of the mixture which was about 3 per cent *higher* than the observed value, the difference being of an inverse character to that of a mixture of oxygen and nitrogen, as was to have been anticipated.

A third experiment made with "artificial air" consisting of a mixture of 19.13 per cent carbon dioxide and 19.29 per cent of oxygen, gave a result which was less than that calculated. The difference was not great, but was believed to considerably exceed the error of the several determinations.

In regard to the theoretical point involved, the authors make the following remarks:

"The coefficient of compressibility of hydrogen is too small, while that of other gases, such as oxygen and nitrogen, is too great. The effect of mixing equal volumes of hydrogen and helium, each of which has too large a coefficient of elasticity, is to cause each to occupy twice the volume that they previously occupied, and to halve approximately the pressure for each. The pressure is therefore lower than it would be for an absolutely ideal gas, for each gas, hydrogen and helium. The sum of these pressures will accordingly be too low, or transposing, the sum of the volumes will be too great. The opposite argument holds for air.

Now, in considering volumes we deal not merely with the co-volume, i. e., the space occupied by the molecules, but also with the interstitial space inhabited by the molecules. But the refractive power, if Clausius's deduction from the formula of Lorentz and Lorentz is correct, is a function of the dielectric constant, and hence of the co-volumes of the gases. And here the discrepancy is more easily detected than by any determination of density. It must therefore be concluded that gases are not, as postulated by Dalton, indifferent to one another's presence, but that they modify one another's properties in the same manner as do liquids, though to a different extent. This mutual action at high pressures and small volumes modifies even the volume relations, as recently shown by Dr. Kuenen. And it must persist at low pressures and large volumes, though it may not always be possible to make measurements of pressure and volume accurate enough to lead to its detection. The refractivity, however, seems to be a means delicate enough to be used for this purpose."—*Proc. Roy. Soc.*, lxii, 225.

18. *Experiments with some Electro-Chemical Actinometers.*—M. H. RIGOLLOT has recently published in the *Annales de l'Université de Lyon* the results of an interesting series of experiments, having as their object the investigation of the electromotive force developed by the action of light upon one of two metallic plates immersed in an electrolyte, the other being kept in darkness. The experiments were carried on with plates of copper, covered respectively with the oxide, fluoride, chloride, bromide, iodide; also with plates of tin having a surface of oxide, and of sulphide, and finally of silver sulphide. The investigation

includes the effect of white light in general, then that of different portions of the spectrum on the plates specified, and finally the effect of sensitizing the plates with various coloring matters. As sources of illumination, gas, the electric arc, and solar light were employed, the two last exclusively where the spectrum was needed. The special arrangement of the apparatus is described in detail, and then the results obtained with each of the substances under examination, for the three cases mentioned. In the cases when the spectrum was employed, a series of plotted curves show the variation of the electromotive force for waves of different length and particularly the point at which the maximum was reached. As coloring matters, various substances were employed; thus with plates of copper oxidized, eosine, safranin, erythrosine, etc., were used. These had a remarkable effect in changing the position of the maximum in the spectrum.

As an example of the results obtained the following table is quoted: it gives the electromotive force (E.M.F.) developed with plates of copper oxidized, the effect varying widely with the degree of oxidation.

Degree of oxidation.	E.M.F. developed.
Straw-yellow	5×10^{-5} volt.
First violet	7
Second "	118
Third "	194
Oxid. more advanced	194
Blackish	7

The author concludes that by employing the substances mentioned, actinometers highly sensitive to light can be formed, the electromotive force of which, other conditions being equal, depends upon the electrolyte used. The maximum of sensibility in the spectrum for a given wave-length depends on the nature of the sensitive layer, and is independent of the electrolyte. The use of the coloring matters employed serves to increase the electromotive force for radiation, but gives a maximum for a certain wave-length dependent upon the choice of the material. This maximum always takes place for waves of greater length than those which correspond for the maximum absorption of light by the same coloring matter.

In discussing various applications of such actinometers, the author gives, for example, the actinic degree, defined as $\frac{e_2}{e_1}$, for various forms of light, including gas, Drummond light, the magnesium lamp, and the electric arc. Here e_1 is the deviation of the luminous point when a Carcel lamp illuminates the actinometer, and e_2 the same when the various light sources mentioned below are employed. The results are as follows:

	e_2	e_1	Actinic degree. $\frac{e_2}{e_1}$
Gas burner	39	39	1.0
Auer " No. 0	42	"	1.08
" " No. 1	43	"	1.10
" " No. 2	43.5	"	1.12
Drummond light	48	40	1.20
" "	60	"	1.50
" "	60	"	1.50
Magnesium "	107	39	2.72
Electric arc., 8 amp.	106	40	2.70
" 15	120	39	3.08
" 17	125	"	3.2
" 18	130	"	3.3

II. GEOLOGY AND NATURAL HISTORY.

1. *Earth Movement*; by CHARLES R. VAN HISE, Trans. Wisconsin Acad. Sci., Art, and Letters, vol. xl, pp. 465-516, Jan., 1898.—The "gravitation theory" suggested by Prevost in 1840 is presented in this paper with great force and clearness in the light of the science of to-day as the explanation of the various phenomena of earth movement. Epeirogenetic, orogenic and epigene movements are all alike shown to be gravitative. Vulcanism, too, is referred to the same cause. The dominant force which is behind the great regional extrusions of igneous material is gravity. Further it has been noted that these extrusions are contemporaneous with great crustal movements. The phenomena may be considered under the headings of, vulcanism in connection with regional compressive movements, vulcanism in connection with regional tensile movements, and local vulcanism" (p. 497). "I would not underestimate the power of steam in vulcanism, but that its expansive power is the chief force in the transfers of liquid material within the earth seems to me to be wholly unproved. The dominating force as explained is believed to be that of gravity" (p. 502).

The author explains the deep-seated flowage of material from the oceanic basins landward in continental growth as follows:

"It has been supposed that the regions below the sea have a higher conductivity than the continents and their downward extensions. If this be so, the former regions would ever continue to cool more rapidly than the latter, and would contract more. Both of these contractions would result in concentration of the rocks of the sea bed and in bringing them nearer to the center of the earth than the continental masses. Hence gravity would be more effective on the mass below the sea than elsewhere, and differential stresses would result. The quantitative value of the increased effectiveness of gravity on the mass of the sea beds should be estimated upon various numerical suppositions, but the

amount of contraction in cooling, solidification, and crystallization is so great that it can hardly be doubted that its effectiveness would be considerably increased. As a result of the unequal contraction the continental ship would be no longer in isostatic equilibrium. Differential vertical movement would be set up, and material below the sea areas would tend to flow toward the land areas, and thus tend to elevate the continents, but the average of the movements would be downward. Whether the continents absolutely or relatively rise under these stresses would depend upon the average amount of contraction of the earth. It is probable that this contraction would more than counteract the tendency to uplift, and therefore that relative elevation, and not absolute elevation would occur. The process above outlined might continue until approximate isostatic equilibrium has again been reached. We thus have a real cause for a very long continued growth. When the hypogene forces causing more rapid subsidence of the sea beds than of the continents, and consequently relative upheaval of the continental masses, shall have finally exhausted themselves, it cannot be doubted that the epigene forces will win, and that the continental masses will be reduced to an even platform slightly below the level of the sea.

. . . . Summarizing, we have seen that differential subsidence slowly but surely causes the continental masses to rise or fall with reference to the surface of the sea. As a result of the subsidence of great areas, smaller areas, such as the plateaus and mountain ranges and systems, may be elevated. The horizontal stresses, thickening the strata along the zones of plication and producing the mountain systems and plateaus, are but incident to the larger movements of subsidence. By vulcanism vast masses of magma are introduced into the outer part of the crust of the earth, or spread over its surface. The continental areas, wherever they are above the sea, are being degraded by the wasting forces of water, ice, and wind. Concurrent with these movements is deep-seated flowage. As a result of these movements it is possible that the continents may grow. The remote cause to which continent-making, differential subsidence, mountain-making and attendant phenomena, epigene transfer, vulcanism, and deep-seated compensatory flow, are due, is the force of gravity persistently working upon a plastic contracting mass: and therefore the center of gravity of the various masses moved, is nearer the center of the earth as a result of the movements." H. S. W.

2. *The Geology of Massanutten Mountain in Virginia*; by ARTHUR COE SPENCER, pp. 1-54, 1 map and 3 diagrams, 1896. (A thesis for degree of doctor of philosophy, Johns Hopkins University.)—The selection of an isolated synclinal area such as the Massanutten Mountain for careful study has resulted, as might be expected, in the testing of a large number of speculations regarding mountain-building and the formation of the original series of sediments. The present study was suggested and guided by Mr. Bailey Willis, whose extended studies of the Appalachians well fit him to

propose nuts to crack, and it is not unexpected to find very little new light thrown upon these problems by one entering upon their study for the first time, nevertheless Mr. Spencer has given a very vivid analysis of the facts in the case. The stratigraphy, structure, topography and geological history are each wrought out with distinctness and fullness. The chapter on structure is particularly interesting, showing the secondary folding of the beds in the course of the principal synclorium, and calling attention to the still finer puckerings and the cleavage planes developed in the finer sediments, illustrating the high degree of complexity of movements suffered by the rocks of a much plicated region. The author has attempted to give, in detail, the hypothetical conditions of the region for each period of change in deposition. This part of the paper, it seems to the writer, is less satisfactory and chiefly because of the need of an immense body of facts before any satisfactory solution of such problems is possible.

H. S. W.

3. *Geological Survey of Canada*. G. M. DAWSON, Director.—The following part of the Annual Report, vol. ix, for 1896 has been received, viz:

Part S. Mineral Statistics and Mines (No. 625). ELFRIC DUER INGALL and Assistants, pp. 15-172s, 1897. The following interesting facts regarding the mineral production and its rate of increase is given in the introduction. In 1886 the value of the mineral production of Canada is estimated at a little over ten million dollars. The production had increased in 1896 to over twenty-two and a half million dollars, or 125 per cent. In comparison with the value of production in the United States, Canada's production in 1896 amounts to $3\frac{1}{2}$ per cent of that of the United States for the same year. The relative per capita production of minerals for the two countries is as follows, viz: for Canada about \$4.50 and for the United States about \$8.00. H. S. W.

4. *Geological sections from Moscow to Siberia and return*; by PERSIFOR FRAZER, Ex. Proc. Acad. Nat. Sci., Phil., October, 1897, pp. 405-457.—The author has given in this paper a summary account of the Oural excursion of the last Congress of Geologists, adding to the particulars given in the carefully prepared (in French) *libret guides* of the excursions, account of his own experiences and views.

H. S. W.

5. *Note on the "Florencia Formation"*; by HENRY A. PILSBRY. (Communicated.)—Upon reading the valuable paper by Mr. O. H. Hershey upon the "Florencia Formation," in the August number of this Journal, my attention was particularly directed to the position assigned to the formation, in the Pleistocene series, *below* the Iowan loess. It seems to me possible that this one point requires further investigation either to establish or disprove the conclusion reached by Mr. Hershey, as the result evidently of much careful observation.

The principal reason for doubting the assigned age of the Florencia deposit is that its fauna is apparently much more

modern than that of the Iowan loess. The list of Florencia fossils consists exclusively of species still living in the same region. Every one is doubtless to be found to-day in the flood débris of any creek of moderate size in northwestern Illinois.

On the other hand, the Iowan loess, as developed at such a typical locality as Iowa City, Iowa, for example, contains an assemblage of species nowhere occurring recent, including some species and varieties now extinct. For comparison with Mr. Hershey's Florencia list of fossils, the following characteristic Iowan loess forms may be mentioned:

<i>Zonitoides shimeki</i> Pils.	<i>Polygyra multilineata</i> Say.
<i>Comulus fulvus</i> Drap.	<i>Helicina occulta</i> Say.
<i>Pyramidula strigosa iowensis</i> Pils.	<i>Succinea avara</i> Say (variety). " <i>lineata</i> W.G.B. "
<i>Pyramidula striatella</i> Anth.	" between <i>lineata</i> and <i>obliqua</i> .
<i>Pupa muscorum</i> L.	<i>Limnæa humilis</i> Say.
" <i>blandi</i> Morse.	" <i>desidiosa</i> (?).
<i>Sphyradium simplex</i> Gld. (variety).	

Many others might be enumerated; but it will be observed that in this brief list of the forms found abundantly at Iowa City, *Zonitoides shimeki* and the strongly marked variety of *Pyramidula strigosa* are extinct; the Succineas, while probably referable to recent species, are still very unlike the living shells; the *Helicina* is approaching extinction, being now excessively local and discontinuous in distribution, while several other species do not now occur in the Iowa or Illinois fauna.

These considerations render it very likely that the Iowan loess fauna is an older one than that of the Florencia formation; for it is inconceivable that we should have sandwiched between the modern fauna and a prior one in all respects identical with it, a fauna containing extinct species and recognizably differentiated varieties, such as that of the loess.

It seems likely therefore that the Florencia is a very recent formation in comparison with the Iowan loess.

The discrepancy observed by Mr. Hershey between his list of Florencia fossils and the published lists of Iowan loess fossils is, so far as generic differences are concerned, merely a matter of nomenclature; the loess lists giving the older generic names, while Mr. Hershey's Florencia list is expressed in the modern generic arrangement. There is therefore no such wide faunal divergence between the two deposits as would appear from Mr. Hershey's remark.

Academy of Natural Sciences, Philadelphia.

6. *Geology of Franz Joseph Land*.—A recent number (Dec. 15) of the Quarterly Journal of the Geological Society contains an interesting article by E. T. Newton and J. J. H. Teall, descriptive of rocks and fossils from Franz Joseph Land, collected by the Jackson-Harmsworth Expedition. The general results arrived at, which throw much light upon the hitherto almost unknown

geology of this region in the far north, are given in the following paragraphs.

“In conclusion, we may perhaps be allowed to sketch out briefly the salient features in the geological history of Franz Josef Land, so far as this can be done in the light of our present knowledge. Passing over the plant-bed at Cape Stephen, the age of which is uncertain, the first event of which we have any record is the deposition of a series of shales and sandstones containing plant-remains, beds of lignite, and other evidences of littoral or estuarine conditions. Intimately associated with these shallow-water deposits are some purely marine beds, the age of which is placed beyond all doubt by the occurrence of such well-characterized zonal fossils as *Ammonites macrocephalus* and *A. modiolaris*.

Owing mainly to the brilliant researches of Neumayr, it is now generally recognized that the Jurassic sea reached its greatest extension in the present land-areas during the Callovian and Oxfordian periods. Hydrocratic and geocratic movements alternated during Jurassic times, with a decided balance in favour of the former, and a recession of the coast-line towards the north. Even in the North of Scotland we find no decided evidence of the proximity of land during the Oxfordian period, although the lower portions of the Jurassic formation are represented by littoral and estuarine deposits.

Under these circumstances the discovery of *A. macrocephalus*-beds in Franz Josef Land in association with plant-bearing strata is of special interest. It extends the range of this ammonite several degrees towards the north, and shows, in all probability, that during the period of its existence a coast-line lay somewhere in this direction. Marine deposits of Callovian and Oxfordian age are now known to range from Sutherland to Cutch and from Franz Josef Land to the North of Africa; and *A. macrocephalus* is one of the most widely distributed of all Jurassic ammonites. The soft Jurassic sediments were subsequently covered up and preserved from destruction by vast flows of basaltic lava; and it is not a little remarkable that rocks of the same general period have been preserved in the same way in districts so far removed from Franz Josef Land as the Northwest of Scotland and Abyssinia. We have already pointed out that Dr. Nansen refers the basalt in part to the Jurassic period; but in view of the fact that the basalts of the West of Scotland were at one time supposed to be of the same age, for reasons similar to those relied upon by him, this conclusion cannot be regarded as definitely established. At the same time it is important to notice that, if we except the North of Ireland, the Upper Cretaceous period is unrepresented, or but feebly represented, by sedimentary deposits in regions like the Deccan of India and the high plateaux of Abyssinia, where basalts are extensively developed. It is therefore quite possible that the vast outpourings of basic lavas which have given a special character to extensive areas of the earth's surface may have commenced in pre-Tertiary times.

The present configuration of the archipelago of Franz Josef Land conclusively proves that it is formed of the fragments of an old plateau. The land frequently ends off in high cliffs, capped with sheets of basalt which must have extended far beyond their present limits. When one compares the topography of this district with that of the Fæøes and the West of Scotland, one is inclined, notwithstanding the immense tracts of water which now separate these localities, to ask whether they may not at one time have been continuous, and whether the northern portion of the North Atlantic, as suggested by Suess, may not be of comparatively recent origin.

But whatever answer may be given to this question, it is clear that at the close of the volcanic period the various islands of Franz Josef Land were united and formed part of an extensive tract of land. This land was subsequently broken up, partly, in all probability, by the sinking of certain areas along lines of fault, and partly by denudation.

The final stages in the history of the district are represented by the raised beaches, which prove that this region, like so many other portions of the extreme north, has quite recently been under the influence of a geocratic movement."

7. *On a remarkable occurrence of xenotime*; by G. CHRISTIAN HOFFMANN. (Communicated.)—A mineral not previously identified as occurring in Canada, has somewhat recently been observed in the township of Calvin, province of Ontario. Here, in one part of a coarse granite vein—composed of quartz, microcline, albite or oligoclase, muscovite and biotite, Mr. C. W. Willimott found, embedded in the microcline, a mass weighing not less than 312 grams which on examination by Mr. R. A. A. Johnston proved to be xenotime. The mass is made up of a closely compacted aggregation of more or less divergent long slender prisms, among which, however, a few stout individuals are observable, one of which measures 7^{mm} in diameter. It has a prismatic cleavage; an uneven fracture; a dark reddish-brown color; a resinous luster, and a light flesh-red streak. The hardness is about 5, and the specific gravity, at 15.5° C., 4.395. Small quantities of an altered magnetite and very small crystals of a reddish-brown garnet, most probably spessartite, are found accompanying the mineral; and a fine specimen of a yellow beryl has been received which was also said to have come from this vein.

8. *On the Crystalline Structure of Gold and Platinum Nuggets and Gold Ingots*.—A paper by Professor A. LIVERSIDGE, in the Proceedings of the Royal Society of New South Wales, gives the results of an investigation of a series of nuggets of gold and platinum and also of gold ingots. Sections of these were prepared and etched by means of chlorine water as well as investigated in other ways. A series of sixteen excellent plates show the effects of the action, and the main conclusions are stated as follows:

"As far as it [the investigation] goes, it proves that gold nug-

gets do not show that they have been built up of concentric coatings round a nucleus, but that they possess a well marked internal crystalline structure and that they usually enclose foreign substances, also that a similar crystalline structure is shown by gold which has been fused; I do not, however, think that native gold has necessarily been in a fused condition, on the contrary I think it has been deposited from solution and usually within veins or pockets in rocks, although if it had been deposited round nuclei, it might still have possessed the crystalline structure which has been described and figured in this paper."

9. *Flora of Franz Josef Archipelago*; by HARRY FISHER.—In the Geographical Journal for December, 1896, pp. 560-563, I made some remarks on the above. Since the publication of that account I have had opportunities of studying this flora, and of comparing the results with those of almost every other known arctic region. A full account will shortly be presented to the Linnean Society. Mr. Armitage has told you that southwesterly winds are almost unknown in Franz Josef Land. I believe this will account, to some extent, for the flora being more scanty and stunted on the whole than that of almost all the other arctic regions. The summer temperatures are lower than elsewhere. There is no doubt that the presence of the Gulf Stream on the west and northwest coasts of Spitsbergen will account for the luxuriance of the flora up to Brandewjne bay, whereas the east coast of North-East Land resembles Franz Josef Land. The Gulf Stream, however, will not account for the comparative richness of the flora of Melville Island, of Grinnell Land, and of Port Foulke, the last named being on the Greenland side of Smith Sound; these are separated by channels of inconsiderable width from the mainland. To the north of Port Foulke is the Great Humboldt glacier, which has been considered to form a barrier to the northward progress of the flora on the west side of Greenland. We know next to nothing of the plant-life on the lands to the north of Peary Channel; but I expect an extension of the Grinnell Land flora will be found there, and probably an arctic Siberian type also. The most northern land in Asia, Cape Chelyuskin, has a smaller flora even than Franz Josef Archipelago (and most of the plants are as dwarf), notwithstanding that it is on the mainland of a vast continent. This can only be accounted for by supposing it to have been submerged until comparatively recent times; but the flora of arctic Siberia is generally poor in species.

There is one zoological fact of interest to the botanist. Young snowy owls visit Franz Josef Archipelago every summer; two of these handsome birds were killed on Cape Flora, and I found pellets and feathers of this species on all the capes which we visited. Several birds were seen besides the two which we killed. Does not their presence indicate the existence of the lemming, and therefore the willow, in recent times?

It is difficult to understand why some of the plants maintain an existence under such unfavorable conditions as the present,

unless they are, as they appear to be, dying-out remnants of a typical arctic flora. I am thinking of the starved colony of *Graphephorum Fisheri* Asa Gray (a grass), composed of about twenty lifeless-looking individuals on Mabel Island, and not seen elsewhere; and also of *Stellaria longipes* and Goldie, which presents a similarly lifeless appearance. Of this two flowers only were seen; they were on Cape Neale. Even flower-buds were not found elsewhere. The bald-leaved *Cerastium* makes no attempt at flowering. A few other plants merely exist. Unless the conditions improve, most of these plants will disappear; not, as in warmer climes, to be replaced by others, I fear, there being already abundance of spare ground untenanted by any plant. It is very remarkable that I should have found seedlings of the poppy (*P. nudicaule* L.), the scurvy grass (*Cochlearia fenestrata* Br.), and *Draba leptopetala* Fr. This was quite unexpected, for I know of nothing of the kind from similar latitudes. The anthers and stigmas of the poppy, so far as I had time for observation, were ripe at the same time. There are no insects which are likely to have assisted in fertilization in this case; but, as regards the scurvy grass, my observations lead me to the conclusion that diptera may occasionally assist, but at the same time they are more certainly foes than friends, inasmuch as their larvæ feed ravenously on the floral organs of this species. Seedlings of the scurvy grass were found on Gully rocks and on Cape Flora, sparingly. Those of the poppy were seen in one place on the latter cape. Seedlings of the *Draba* were found on Cape Flora, but in such limited quantity that they only occupied half a square inch. I look upon this last rather as an accidental result. The case of the poppy is a little stronger, and *Cochlearia* (scurvy grass) probably increases to some extent by seed in most summers. All attempts at solving the problem of the derivation of this flora are purely theoretical. The depth of the sea between Novaya Zemlia, Spitsbergen, and Franz Josef Archipelago only throws a little light on the subject. Geology and ocean currents render little service; possibly the working out of the driftwoods may throw some light on this obscure subject.

A large number of specimens of driftwoods were collected, and have been entrusted to Prof. Carr, M.A., F.G.S., F.L.S., of the University College, Nottingham, for examination. Of all of these numerous microscopical sections have been made, which will be compared with similar sections of known woods from Siberia, arctic Europe, and North America (prepared from specimens kindly supplied by the director of Kew gardens, supplemented by some in the Fisher collection in Nottingham Natural History Museum from the Russian Empire, all of which are authenticated by Dr. Regel and Herder). These driftwoods are mainly coniferous, but a few are non-coniferous, and it is hoped that the exhaustive examination to which they will be subjected will prove their identity and probable place of origin. The labor of collecting and sledging these woods, many of which were huge trunks,

was borne by Messrs. Jackson and Armitage and Dr. Koettlitz; some few were collected by Mr. Child and myself, my own task being a light one, consisting of cutting suitable pieces for examination and for specimens, etc., chiefly from the heaps which three of us made on Capes Gertrude and Flora. On Cape Mary Harmsworth Dr. Koettlitz collected woods, and Mr. E. Else brought a fine piece also. These are now in Prof. Carr's hands. A fine section was made on ("Tween") Cook's rocks by Mr. Child; this is with the others.

There are certain plants in Franz Josef Archipelago which give a color to the landscape, occurring as they do in patches or carpets up to an altitude of 500 feet. The poppy is the most showy, but several mosses rival this flower in brilliancy. I have previously mentioned in this Journal the bright color of these plants, but I did not specify them. There are four species which I ought to particularize: *Splachnum Wormskiöldii* Hornem., brilliant green; *Aulacomnium turgidum* Schwgr., pale yellow-green; *Bryum obtusifolium* Lindb., red to crimson and purple; *Orthothecium chryseum* Lorenz, golden yellow. It is interesting to find that these mosses flourish in the neighborhood of loomerics, and that in their absence they become quite scarce. This is particularly the case as regards *Splachnum*. "The *Splachnum* family are remarkable among mosses for the preference they exhibit for growing in bogs, on the droppings of animals such as sheep, cattle, or foxes, sometimes occurring also on the bones of dead animals."—*Geographical Journal*, February, 1898.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *International Congress of Zoology, 1898.*—The Fourth Congress of Zoologists is to be held at Cambridge, England, on the 23d of August, 1898. Sir John Lubbock has been appointed President, in the place of Sir W. Flower, who was elected to this position at Leyden, but was compelled to resign in consequence of ill-health. The Secretaries are F. Jeffrey Bell (3 Hanover Square, London, W.), G. C. Bourne and A. Sedgwick.

Circulars have been widely distributed making preliminary announcements in regard to the meeting and extending to British, Foreign and Colonial zoologists an invitation to be present. For the benefit, particularly, of those who may have failed to receive these documents, the following paragraphs are quoted from the circular issued by the Reception Committee:

"The seat of an ancient University, which counts among its *alumni* distinguished Zoologists, from the days of Ray and Willughby to those of Charles Darwin and Francis Balfour, seems to offer a peculiarly fit meeting-place for the Congress on its first visit to the British Islands, and the Reception Committee, including the present representatives of Zoological Science in Cambridge, hereby offer a cordial welcome to their brethren at home and abroad who may accept this invitation.

The Reception Committee hope to avail themselves largely of the facilities offered by the several Colleges of Cambridge for the accommodation and enter-

tainment of their visitors, while there is assurance that the more suitable of the public buildings of the University will also be placed at their disposal for the same purposes.

The International Congress of Physiology is to meet in Cambridge concurrently with that of Zoology, and certain arrangements will be made in common, though there is no intention of uniting the two Congresses—each of which will retain its distinct organization.

The general arrangements of the Zoological Congress will be made, and from time to time communicated, by the General Committee established at the House of the Zoological Society in London (3, Hanover Square), but the duties of the Reception Committee at Cambridge will be greatly facilitated by the receipt of a reply to this invitation, which they hope may be accepted.

On the receipt of such an acceptance on the accompanying form, further details with regard to local arrangements will be duly forwarded. It is hoped that it will be possible to find rooms in the several Colleges for many of the visitors; but it is necessary to point out that the accommodation afforded within College walls is not suitable for ladies. The Reception Committee will use their best endeavors to find accommodation in lodgings for members who are accompanied by ladies, and it is proposed in due course of time to issue a statement relating to the cost of apartments, railway fares, and other information which will be useful to visitors. Reception Committee: Alex Hill, M.D., Master of Downing College and Vice-Chancellor of the University; Alexander Peckover, Esq., LL.D., F.L.S., St. John's College, Lord Lieutenant of the County; Ernest T. Hooley, Esq., High Sheriff of the County; S. R. Ginn, Esq., Mayor of Cambridge, and others."

2. *Report of S. P. Langley, Secretary of the Smithsonian Institution, for the year ending June 30, 1897*, pp. 80. Washington, 1898 (Government Printing Office).—The Report of the Secretary of the Smithsonian just issued gives the usual statement in regard to the year's work of the Institution. In this the description of the National Zoological Park is particularly to be noted. Further, the account of work done in the Astrophysical Observatory. In regard to the latter the following paragraphs are quoted from the report of Mr. C. G. Abbot.

"The work of the observatory during the past year has consisted largely in preparing for publication an account of the research on the positions of absorption bands in the infra-red solar spectrum.

In this report, which was completed in May, 1897, but which, owing to unavoidable delay, has not yet appeared in type, the positions of about 225 absorption lines and bands are determined in deviation and refractive index for a 60° rock-salt prism at the temperature of 20° centigrade. These lines are distributed in the salt spectrum between deviations of 40° 25' and 38° 45', corresponding to wave lengths 0.76 μ and 5.20 μ , respectively. The average error probable in the absolute angular deviations of these lines is about 4 seconds of arc, but in their relative deviations measured from the A line in the visible spectrum the probable error averages only about 0.5 seconds of arc, a degree of accuracy even exceeding the anticipations held forth in last year's report. The bolographs from which these results were obtained were taken on exceptionally favorable occasions between October 26, 1896, and January 9, 1897. These bolographs, 13 in number, were selected from among many more, of all degrees of excellence, taken during the same interval.

The forthcoming report contains, in addition to the results above mentioned, an account of the investigations leading up to this research on the infra-red absorption lines; a description of the successive improvements in the instrumental conditions which have rendered possible the present results; a description of the present apparatus and its adjustment; and a discussion of present sources of error and the possibility of future progress. The results of several subsidiary investigations are given, among others being the change of deviation of rock salt with change of temperature, the heat conductivity of rock salt, the effect of diffraction in decreasing the intensity of energy in the spectrum with narrowing slit widths. The report is illustrated with reproductions of photographs and drawings of apparatus, platted curves explanatory of various matters, bolographic curves, and line spectra similar to that here given. With the illustrations, the report is expected to cover about 175 quarto pages."

3. *Studies from the Yale Psychological Laboratory.* Edited by EDWARD W. SCRIPTURE, Ph.D. Volume iv, pp. 141, New Haven, Conn.—This volume contains the results of the excellent research work carried on at the Yale Psychological Laboratory under the charge of Dr. E. W. Scripture. It includes the following articles by Dr. Scripture: Researches on reaction time; Researches on voluntary effort; New apparatus and methods; Elementary course in physiological measurements. Also by C. E. Seashore, Ph.D., the following articles: Influence of the rate of change upon the perception of differences in pressure and weight; Weber's law of illusions. Finally by Alfred G. Nadler, M.D.: On reaction-time in abnormal conditions of the nervous system. Various notes conclude the number.

4. *The Sylvester Medal.*—It is announced that the movement among mathematicians to found some memorial to perpetuate the memory of Professor J. J. Sylvester has finally taken shape in a Sylvester medal for the encouragement of mathematical research. A general international committee has been appointed and the work of collecting subscriptions has gone so far that it is stated that the sum of six hundred pounds is already assured; this does not include American contributions. Those desiring to participate in the movement may send contributions to the treasurer, Lord Rothschild, New Court, St. Swithin's Lane, London, E. C.

5. *Floods of the Mississippi River.*—Bulletin E of the Weather Bureau, United States Department of Agriculture, contains a highly interesting discussion by Park Morrill of the floods of the Mississippi in their various relations to precipitation, drainage, and the special phenomena involved. The great spring flood of 1897 is particularly described. To the 77 pages of text are added 58 large plates. Mr. Morrill is the forecast official in charge of the river and flood service.

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T H E

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. XXX.—*The Bolometer*; by S. P. LANGLEY.

IN the number of this Journal for March, 1881, there appeared an article descriptive of the actinic balance (since called the Bolometer), an instrument which has gained acceptance among physicists as a useful aid in the study of radiant heat. It was, it may be remembered, originally devised by the writer to discriminate the heat in any small portion of the grating spectrum, but it has since found wider applications.

As at first constructed, the strips, representing arms of the Wheatstone bridge, were made of iron from 0.001 to 0.0001 of an inch in thickness. The instrument was even under these initial conditions, very many times as sensitive as the best thermopile the writer then possessed, but there does not appear to be any definite statement as to the exact sensitiveness in its early form.

In the article referred to, however, the instrument is represented as giving a deflection of about 40 scale divisions (millimeters) from the lunar heat, concentrated by a thirteen-inch lens, and it was sufficiently accurate to give a probable error of rather less than one per cent for a single observation on a constant source of heat, so that the accuracy of the bolometer (quite a distinct consideration from its sensitiveness) was even then as great as that of the best photometric process. The galvanometer in use at that time was one of the early Thomson pattern made by Elliott.

The first bolometers were made by the writer's own hands. Subsequently the strips were usually cut out from sheets of thin platinum, and in one or two instances made from flattened wire, the strip of the linear bolometer at that time (about 1883)

being usually about 10 millimeters long; anywhere from 0.001 to 0.01 of a millimeter thick, and, according to its special purpose, being made from 1 millimeter to 0.1 millimeter wide.

About 1886 the mounting of the instrument had been improved by the writer, so that the strip appeared like the vertical "wire" of a reticule in the focus of a positive eye-piece. It was also movable in some cases by a micrometer screw, and was, in fact, a micrometer thread controlled in the usual way, but endowed with the special power of feeling the radiations from any object on which it was directed.

In the earliest spectrum work the bolometer developed another important quality, its "precision." This quality is quite independent of the accuracy with which it repeats measures of radiation or any constant source of heat, and concerns the precision of setting, as a micrometer thread. It could even twelve years ago, be pointed, not only like the thermopile, within a fraction of a degree of the place of the source of radiation, as for instance on a bright line in the spectrum, but within a fraction of a minute of arc.

The instrument of course depends for its general efficiency on the galvanometer with which it is connected. That used in 1886* had several improvements due to the suggestions of Sir William Thomson and Professor Rowland, and was, perhaps, at that time, the most effective instrument of its kind in use for such a purpose, the mirror and needles having been specially constructed at the Allegheny Observatory. The mirrors were platinized by the kindness of Professor Wright, and were at that time nearly a centimeter in diameter. The needles were hollow magnets made by Mr. Very of the Allegheny Observatory. For the damping mechanism of the older galvanometer, I had substituted a dragon-fly (*Libellula*) wing, in which nature offers a model of lightness and rigidity quite inimitable by art. At that time, when making a single vibration in 20 seconds, a deflection of one millimeter division of the scale at one meter distance was given by a current of 0.000,000,0005 amperes, the instrument as described being capable of recording a change of temperature in the bolometer strips of less than 0.00001 of a degree centigrade. So much less than this could be observed by special precaution, that it might be said that this one one-hundred-thousandth of a degree was not only indicable but measurable by the apparatus, which was employed as described, in the determinations of the relations of n to λ for the rock salt prism, and by which the infra-red spectrum was at that time followed by actual measurement, to a wave-length of rather over five one-thousandths of a millimeter.

*This Journal, 3d series, vol. xxxii, page 90, 1886.

Since then the bolometer has been used in various researches, of which some occasional account has been given in this Journal. (See numbers for November, 1888, and August, 1890.) During recent years it has been specially employed in making a bolographic map of the lower spectrum, the publication of which has been greatly delayed by conditions incidental to the relations of the Smithsonian Observatory with the Government, but which it is hoped will not be deferred much longer.

Without here entering into an account of the work done by it, I have thought that it might be of interest to give very briefly a statement of the present condition and form of the instrument itself, considered under three aspects:

1. Its precision, or the degree of exactitude with which it can be set on a special point, as, for instance, on a line of the invisible spectrum, recognized by its heat radiation alone.
2. Its accuracy, or its capacity for repeating the same measure of radiation under like conditions.
3. Its sensitiveness, or capacity for detecting minute radiations.

The instrument which I will take as the subject of comparison with the earlier one as described in this Journal (August, 1886), is now in use in a chamber automatically kept at a temperature, constant within one-tenth of a degree centigrade.

The strips, the essential part of the instrument, are in the present case made by Mr. C. G. Abbot, and are of platinum, the central one being rather less than 0.1 of a millimeter wide. (The case is now made of metal instead of ebonite, and is surrounded by a current of water.)

It is quite possible to make bolometer strips much narrower, but this is less necessary with the employment of the long-focus, image-forming mirror, so that in the present case the strip is at such a distance that it subtends an angle of 3.4 seconds. Its angular aperture is in practice adapted to that of the slit, which, with the use of the long collimator employed by the writer, gives a capacity of pointing (pointing, that is, *in the dark*), with a probable error of little over a second of arc. Quite recently, owing to the use of a novel collimating system of two cylindrical mirrors proposed by Mr. Abbot, the slit, though at a moderate distance, can have an opening sufficient to avoid prejudicial diffraction effects, while subtending an angle of considerably less than one second of arc.

In the galvanometer, the use of the fine quartz threads and specially small mirrors, originally due to Mr. Boys, has lately been carried to what seems near the practicable extreme, the quite invisible thread being made some 30 centimeters long, the mirror 2 millimeters in diameter, and weighing but 2 milli-

grams, and its six needles, of proportionate weight and dimensions.

This system is now made to serve with a much shorter swing than that formerly employed. If we reduce it to a time of single vibration of 20 seconds, only for the purpose of comparing it with the values already given in the earlier form, we obtain the results submitted below.

Before giving them, however, it is to be mentioned that the apparatus at Washington is most unfavorably situated, owing to its being subject to tremor from the traffic of neighboring streets and to other causes, which it has been the object of years of struggle to conquer. This has been so far done that the values presently to be given (which, it will be remembered, are only attainable in a chamber of constant temperature, with special precaution against disturbance from external tremor), can be counted on as real values, always obtainable under proper conditions, and, in fact, rather within than without the average working capacity of the instrument.

I here consider the bolometer as at present employed.

(1) With regard to its precision, or exactness of pointing. The old thermopile could be set on a portion of the spectrum only with an error of a considerable fraction of a degree. The linear bolometer as employed in 1886 could be set with a probable error of a fraction of a minute of arc. The bolometer as employed to-day, and moved through the spectrum by clock-work, can be automatically set with a probable error of a single observation of little over a second of arc, can be set, that is, in the dark with a precision little inferior to the capacity of the eye in setting a micrometer thread in the light.

(2) As to its accuracy. I have had occasion recently to take a series of measures of successive throws of the galvanometer, using as a source of heat an Argand petroleum flame in a common student's lamp. I had no photometer at hand, but taking the usual statements of the text books as to the accuracy of vision, it might be expected that such measures with the eye would give a probable error of about one per cent. (This is where sources of light of similar quality are compared.) The probable error of a single galvanometer reading was between 0.03 and 0.04 of one per cent., and this included the fluctuation of the intensity of the source of radiation, and the error of estimating tenths by the reader on the scale, both quantities of nearly the same order as the error in question. It seems safe to say, then, that *no* error attributable to inaccuracy of the bolometer could be detected by the means employed.

(3) As to sensitiveness. In the early work, for a time of single swing of 20 seconds, a deflection of one millimeter with

the scale at a meter's distance was obtainable with a current of 0.000,000,000,5 of an ampere. At present, under such circumstances, a similar deflection would be obtained with 0.000,000,000,0012 ampere, that is to say, the apparatus is about 400 times as sensitive as it was when first described.

At present, the bolometric apparatus under the conditions already cited, will indicate a change of temperature in its strips of at any rate much less than one-ten-millionth of one degree centigrade.

Smithsonian Institution, Washington, Feb. 1898.

ART. XXXI.—*On the Temperature Coefficients of Certain Seasoned Hard Steel Magnets*; by ARTHUR DURWARD.

IN a paper* published last year, Prof. B. O. Peirce gave the induction coefficients of a large number of glass-hard magnets made of different kinds of steel and carefully seasoned in the manner described† by Messrs. Barus and Strouhal. These magnets being at my disposal, it seemed to me that a series of measurements of their temperature coefficients might yield interesting results, since it is often desirable to know the comparative effects of slight changes of temperature upon the moments of magnets of different shapes used in determining the strengths of magnetic fields. I had not been able to discover that any one else had experimented upon so large a variety‡ of stout seasoned magnets, and I hoped that the results might be sufficiently uniform to indicate some relation connecting the temperature coefficients of such magnets, made of a given kind of steel, with their dimensions. Some of the tables printed below show very approximately what this relation is for certain brands of steel. The temperature coefficients of two magnets of the same dimensions and material, however, sometimes differed so widely that the results did not seem capable of any very definite interpretation. This was especially true in the case of a large set of magnets made of twice

* This Journal, November, 1896.

† Bulletin of the U. S. Geological Survey, No. 14. 1885.

‡ L. Dufour, Pogg. Ann., xcix, 1855; Holmgren, Acta Soc. Scient. Upsala. 3, i, 1856; Gore, Phil. Mag. (4), xl, 1870; Unverdorben, Inauguralschrift, 1866; Gordon and Newhall, Phil. Mag. (4), xlii, 1871; Marshall, Proc. Edin. Soc., vii, 1873; Jamin, Mondes, 2, xxxiii, 1873; Wild, Carl's Repert., ix, 1873; Favé, Comptes Rendus. lxxxii, 1876; Gaugain, Comptes Rendus, lxxxii; Poloni, Naturforscher. xiii, 1880; Trowbridge, this Journal, 1881; Poloni, Beiblätter, v, 1881; Poloni, Journ. de Physique, 2, ii, 1883; F. Kohlrausch, Wied. Ann., xxii, 1884; Berson, Journ. de Physique, 2, v, 1886; Ledebøer, Journ. de Physique, 2, vii; Chistoni, Mem. Modena, 2, ix, 1893; Cancani, Atti. Acc. Lincei, 1887.

hardened steel, where some abnormally large temperature coefficients were explained by the fact that the steel proved to be soft in places. Local softness is very difficult to avoid in re-hardening steel rods which have once been made glass-hard, and one must expect to find that an occasional specimen of once hardened steel is soft in places.*

If great accuracy is required it is of course necessary to determine the coefficients of a given magnet by direct experiment, but the average of determinations made on a number of magnets of a certain size seems to show very approximately what may be expected of normal specimens.

The straight bar magnets experimented on were of several kinds of steel, and varied in length from 3^{cm} to 20^{cm}. Most of them were circular cylinders, though there were about 40 of rectangular cross section and a few were what are commonly called "hollow cylinders." All had been heated to a cherry red in a special gas heater, then immersed in a large tank of rapidly stirred, acidulated or salted, ice water, and finally exposed for a long time to a temperature of 100° C. After the rods, which were still glass-hard, had been magnetized to saturation between the poles of a soft iron yoke in a long solenoid, they were again exposed for hours to the temperature of boiling water. After standing for several months, most of the magnets were reboiled, re-magnetized in the same direction as before, and then boiled again. In some cases this process was repeated several times.

Besides a number of twice hardened magnets, and a few bar magnets of rectangular cross section, I tested nearly 120 round, straight magnets made of once hardened tool steel, from 0.32^{cm} to 1.11^{cm} in diameter. I am indebted to Prof. B. O. Peirce, and also to Mr. C. G. Persons of the staff of the Jefferson Physical Laboratory, for additional tests made on about 200 magnets.

It was desirable first to find out how nearly constant the temperature coefficients of such magnets are between ordinary room temperatures and 100° C. To test this the magnet to be experimented on was mounted horizontally in a non-magnetic holder, fixed in a wooden tank, so as to be in Gauss's A position with reference to a mirror magnetometer which rested on a stable support of its own. The tank could be moved eastward or westward on a track and could be clamped to the track if desired. Its distance from the magnetometer could be accurately adjusted by the help of a slow motion screw. By means

* The permanent magnetic moment of one of two hollow magnets made by a well known firm of instrument makers for use in the Jefferson Physical Laboratory, and supposed to be as nearly alike as possible, proved to be nearly twice as great as that of the other, and this difference was due to difference in hardness.

of non-magnetic steam and cold water pipes, furnished with suitable valves and connections, the tank, which had a good stirring apparatus, could be filled with about 15 liters of water at any required temperature from about 15° C. to 100° C.

On the opposite side of the magnetometer was a seasoned compensating magnet in Gauss's A position, held, and protected completely from rapid temperature changes, within a wooden carriage sliding on a horizontal scale. This compensating magnet having been placed with its center at a convenient distance (d_0) from the center of the magnetometer needle, the tank, filled with water at nearly the temperature of the room, was fixed at such a distance from the magnetometer as to bring the needle back into the meridian. If M_0 is the magnetic moment of the compensating magnet and $2l_0$ its magnetic length, and if M_1 is the moment of the magnet to be tested and M_1' its moment when, having been heated to a higher temperature, the needle is deflected so as to cause a scale reading n with a scale distance a ,

$$\frac{M_1 - M_1'}{M_1} = \frac{Hn}{M_0} \cdot \frac{(d_0^2 - l_0^2)^2}{4ad_0}.$$

If α_0 is the angle through which M_0 would deflect the needle if M_1 were absent,

$$\frac{M_1 - M_1'}{M_1} = \frac{n}{2a \tan \alpha_0}.$$

The method of procedure was then as follows: The compensating magnet was placed at a given fixed distance from the magnetometer, the magnet to be tested clamped in the non-magnetic holder in the tank, and cold water turned in. The position of the wooden tank was then adjusted until the needle showed its original zero reading. Steam was then passed in at intervals and deflections taken at various desired temperatures up to 100°, the positions of both magnets remaining unchanged throughout the process. The dimensions and the magnetic moment of the compensating magnet being known, the fractional loss of moment of the magnet to be tested could be easily calculated from the formula given above. With this apparatus I tested about 25 magnets; additional magnets were tested for me in a similar manner by other observers. The total number tested was sufficient to determine with some degree of certainty how much the curve of variation of magnetism differed from a straight line.

It appeared in the first place that among the magnets which had not been heated above room temperature for a long time, some did not regain their original strengths immediately after being heated to 100° C. and then cooled to room temperature again. There was in several instances a temporary loss of moment

of 4 per cent or 5 per cent, but this loss seemed to disappear entirely after the magnet had been allowed to stand for about 24 hours. The numbers in the second column of Table I show the difference between the moments of a certain cylindrical magnet, 0.5^{cm} in diameter and 15^{cm} long, at 17° and at the temperature indicated by the corresponding numbers in the first column. These differences are expressed in terms of the original moment at the room temperature of 17°.

TABLE I.

Temperature.	Loss of moment in terms of the original moment at 17°.
17°	0.0000
43	0.0043
64	0.0091
81	0.0131
100	0.0180
81	0.0134
60	0.0094
19.5	0.0012

Effects of a similar nature might have been looked for if observations had been taken without allowing ample time for the magnet to attain a uniform temperature at each stage, but it is certain that no sensible error from this source enters into the results here given.

Many seasoned magnets show no measurable time lag in attaining their original moments after they have been heated to 100° C., and none show any such lag if they have been heated to only about 20° above the room temperature and then cooled, or if they have been heated to 100° shortly before the experiment has begun. In other words, a second heating immediately after the first does not add to the temporary loss of moment brought about by the first heating. When a seasoned magnet is exposed to constantly higher and higher temperatures it attains at each stage, in a fraction of a minute, a state which it would keep sensibly unchanged if exposed for hours to that temperature.

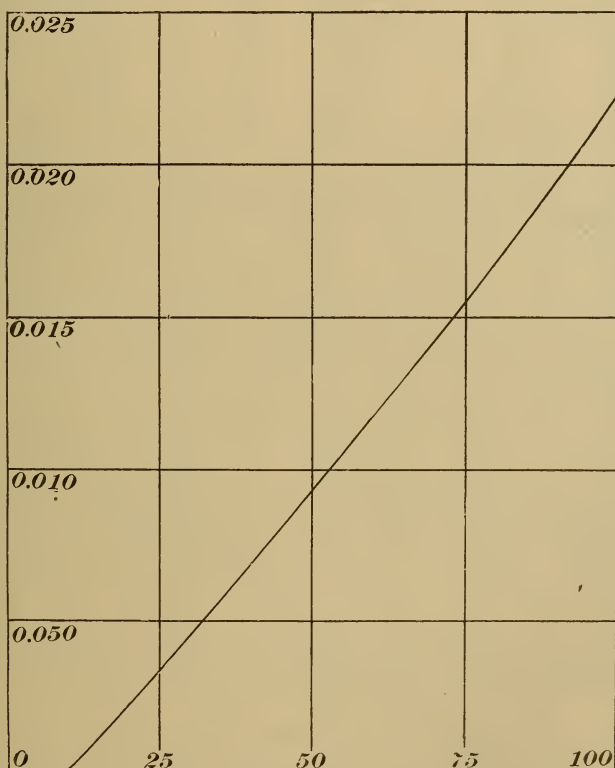
With very few exceptions all the magnets tested had distinctly greater temperature coefficients at higher temperatures than at lower temperatures, so that if the losses of moment in terms of the moment of the original low temperature be used as ordinates and the temperatures as abscissas, the curve is concave upwards. In the case of magnets made of a single specimen of tool steel 1.11^{cm} in diameter, the concavity was extremely small and in a solitary instance there was a distinct convexity, but other magnets made of the same bar as this

abnormal one gave curves like those of the hundreds of other magnets experimented on.

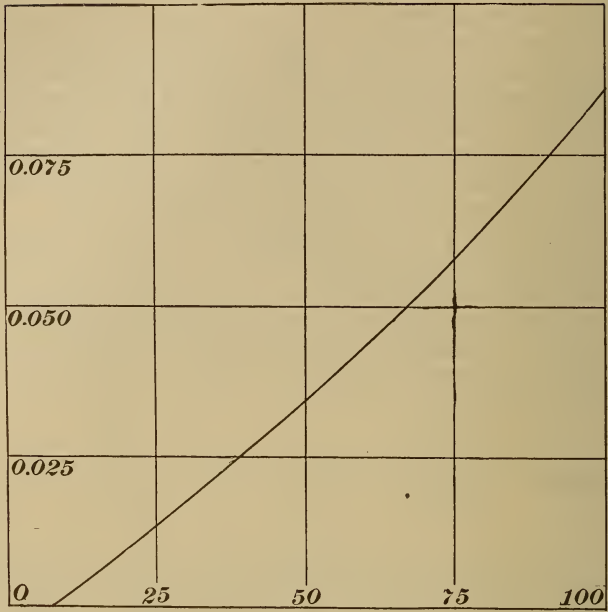
Many curves were obtained with rising temperatures, but as has been said these sometimes differ slightly from those made with falling temperatures, unless the magnet has been recently boiled when no such difference appears. In some instances the curve is almost straight from room temperatures up to 40° C., and is again nearly straight between 80° and 100°, so that most of the curvature falls between 40° and 80°.

As fair examples I give (in Tables II, III and IV) the results of observations made for me with great care on three magnets. If the temperatures are used as abscissas and the fractional loss of magnetic moment as ordinates, Tables II and III yield curves which are concave upwards, while the curve obtained from Table IV is nearly straight. These curves are shown in figures 1, 2, and 3.

1.



2.



3.

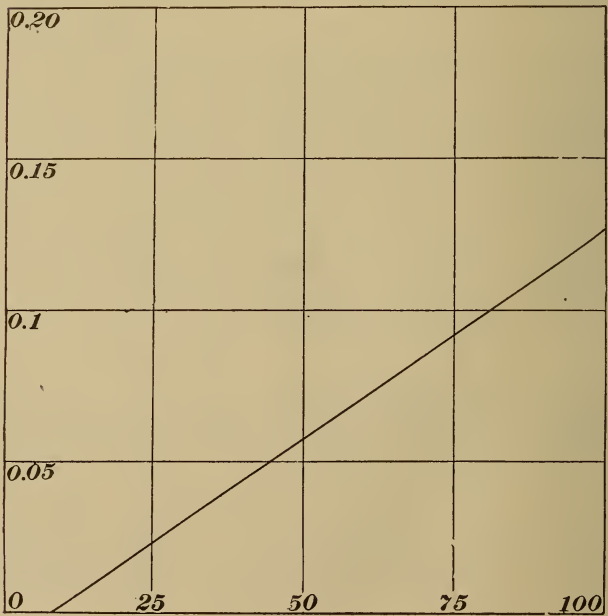


TABLE II.

Results of 25 observations on a seasoned magnet 20^{cm} long made of Crescent Drill Rod 0·81^{cm} in diameter.

TABLE III.

Results of 33 observations on a seasoned magnet 8^{cm} long made of Crescent Drill Rod 0·94^{cm} in diameter. (Last decimal place in doubt.)

TABLE IV.

Results of 42 observations on a seasoned magnet 6^{cm} long made of Crescent Drill Rod 1·11^{cm} in diameter. (Last decimal place in doubt.)

Temperature.	Loss of magnetic moment in terms of the moment at 10° C.	Temperature.	Loss of magnetic moment in terms of the moment at 7·6° C.	Temperature.	Loss of magnetic moment in terms of the moment at 8·1° C.
10	0·0000	7·6	0·0000	8·1	0·0000
20	0·0022	12·0	0·0033	12·0	0·0052
30	0·0045	20·0	0·0097	20·0	0·0160
40	0·0068	30·0	0·0178	30·0	0·0298
50	0·0092	40·0	0·0262	40·0	0·0434
60	0·0117	50·0	0·0347	50·0	0·0570
70	0·0142	60·0	0·0435	60·0	0·0707
80	0·0167	70·0	0·0532	70·0	0·0845
90	0·0194	80·0	0·0639	80·0	0·0982
100	0·0223	90·0	0·0751	90·0	0·1122
		100·0	0·0872	100·0	0·1265

After I had determined the characteristic form of the temperature curves of such bar magnets as made up my collection, it remained to find out how the temperature coefficients at ordinary temperatures and the average loss of magnetic moment when the magnets were heated from room temperature to 100° C. vary with the dimensions of the magnets. Of course the temperature coefficients of magnets made of different kinds of steel may differ widely in absolute value, but my experiments seem to show that for most common kinds of fine steel their values change relatively in much the same way with the dimensions of the magnets. I had a number of brands of steel made by several makers, but the results given here were mostly obtained with Crescent Drill Rod and Jessops Square Tool Steel. Crescent Drill Rod is usually magnetically indistinguishable from Jessops Round Tool Steel. Stubs Drill Rod makes somewhat weaker magnets, but the difference is slight. Some brands of special steel, intended for telephone magnets and the like, make stronger magnets than the polished drill rod, but are not so advantageous as the latter for such purposes as deflector magnets, the moments of inertia of which must be computed. The measurements were made in a similar manner to those mentioned in the preceding pages, but the magnet was fixed in a holder in a non-magnetic tube, through which steam, tap water, or water at any convenient tempera-

ture might be sent in a constant flow. The magnetic field about the magnetometer needle was in some cases weakened to make the apparatus more sensitive.

In measuring many seasoned magnets of a given size I have often found, as has been already said, one or two magnetically much weaker than the average, and these generally had very large temperature coefficients. I have rejected all such as being imperfectly hardened, and have assumed that magnets having high moments and low temperature coefficients are representative. Results obtained with such magnets give smooth curves.

TABLE V.

Crescent Polished Drill Rod.
Diameter, 0.64^{cm}.

Weight per cm. of length, 2.4 grams.

Length in centimeters.	Approximate magnetic moment, per gram of the seasoned magnet at 15° C., expressed in c. g. s. units.	Mean loss per degree of the magnetic moment when the magnet is heated from about 15° C. to 100° C., expressed in terms of the moment at the lower temperature.	Temperature coefficient of the seasoned magnet at 15° C.
3	5.0	0.00114	0.00057
4	7.0	0.00091	0.00049
5	9.0	0.00073	0.00044
6	11.0	0.00060	0.00039
8	15.0	0.00043	0.00030
10	19.0	0.00035	0.00026
12	23.0	0.00030	0.00023
15	31.0	0.00026	0.00021
20	43.0	0.00024	0.00020

TABLE VI.

Crescent Polished Drill Rod.
Diameter, 0.81^{cm}.

Weight per cm. of length, 3.9 grams.

Length in centimeters.	Approximate magnetic moment, per gram of the seasoned magnet at 15° C., expressed in c. g. s. units.	Mean loss per degree of the magnetic moment when the magnet is heated from about 15° C. to 100° C., expressed in terms of the moment at the lower temperature.	Temperature coefficient of the seasoned magnet at 15° C.
6	13.0	0.00087	0.00077
8	17.0	0.00080	0.00070
10	20.0	0.00073	0.00064
12	24.0	0.00066	0.00058
15	29.5	0.00057	0.00050
20	41.0	0.00040	0.00037

TABLE VII.

Crescent Polished Drill Rod.
Diameter, 0.95^{cm}.
Weight per cm. of length, 5.5 grams.

Length in centimeters.	Approximate magnetic moment, per gram of the seasoned magnet at 15° C., expressed in c. g. s. units.	Mean loss per degree of the magnetic moment when the magnet is heated from about 15° C. to 100° C., expressed in terms of the moment at the lower temperature.	Temperature coefficient of the seasoned magnet at 15° C.
6	10.0	0.00086	0.00078
8	14.0	0.00078	0.00070
10	17.0	0.00071	0.00063
12	20.5	0.00063	0.00056
15	26.0	0.00055	0.00049
20	36.5	0.00040	0.00036

TABLE VIII.

Crescent Polished Drill Rod.
Diameter, 1.11^{cm}.
Weight per cm. of length, 7.6 grams.

Length in centimeter.	Approximate magnetic moment, per gram of the seasoned magnet at 15° C., expressed in c. g. s. units.	Mean loss per degree of the magnetic moment when the magnet is heated from about 15° C. to 100° C., expressed in terms of the moment at the lower temperature.	Temperature coefficient of the seasoned magnet at 15° C.
4	5.5	0.00110	0.00109
6	8.5	0.00088	0.00087
8	10.0	0.00070	0.00070
10	12.0	0.00062	0.00062
15	19.5	0.00052	0.00051
20	30.5	0.00048	0.00047

TABLE IX.

Twice hardened Crescent and Jessops Drill Rod.
Diameter, 0.95^{cm}.
Wt. per cm. of length, 5.5 grams.

Length in centimeters.	Approximate magnetic moment, per gram of the seasoned magnet at 15° C., expressed in c. g. s. units.	Mean loss per degree of the magnetic moment when the magnet is heated from about 15° C. to 100° C., expressed in terms of the moment at the lower temperature.
4	5.0	0.00158
6	7.5	0.00133
8	10.0	0.00115
10	13.0	0.00106
12	16.0	0.00094
15	20.5	0.00088
18	26.0	0.00082

TABLE X.

Jessops Square Tool Steel.
Dimensions of cross section 0.81 × 0.81^{cm}.
Wt. per cm. of length, 5.3 grams.

Length in centimeters.	Approximate magnetic moment, per gram of the seasoned magnet at 15° C., expressed in c. g. s. units.	Mean loss per degree of the magnetic moment when the magnet is heated from about 15° C. to 100° C., expressed in terms of the moment at the lower temperature.	Temperature coefficient of the seasoned magnet at 15° C.
4	4.5	0.00163	0.00139
5	6.0	0.00145	0.00116
6	8.0	0.00125	0.00102
8	11.5	0.00103	0.00087
10	16.0	0.00094	0.00078
14	24.5	0.00080	0.00065
20	38.0	0.00065	0.00051

TABLE XI.

Jessops Flat Tool Steel.
 Dimensions of cross section,
 $1.6\text{cm} \times 0.32\text{cm}$.
 Wt. per cm. of length, 3.9 grams.

Length in centimeters.	Approximate magnetic moment, per gram of the specimen magnet at 15°C ., expressed in c. g. s. units.	Mean loss per degree of magnetic moment when the magnet is heated from about 15°C . to 100°C ., expressed in terms of the moment at the lower temperature.
6	11.0	0.00089
8	15.0	0.00071
10	18.5	0.00058
15	27.5	0.00034
20	36.5	0.00028

TABLE XII.

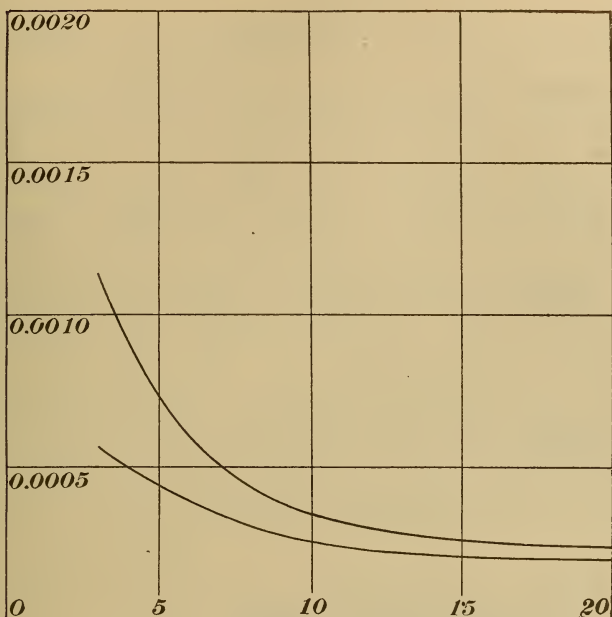
Tubular magnets of Crescent
 Polished Drill Rod.

Length in centimeters.	Outside diameter in centimeters.	Inside diameter in centimeters.	Mean loss per degree of the magnetic moment when the magnet is heated from about 15°C . to 100°C ., expressed in terms of the moment at the lower temperature.
6	0.95	0.70	0.00087
7	0.95	0.70	0.00075
7.5	1.28	0.94	0.00063
10.	1.28	0.94	0.00061

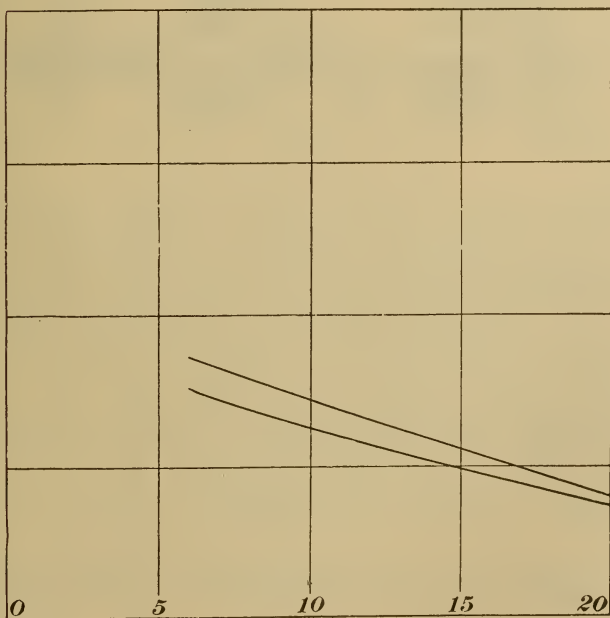
Tables V to XII show how the temperature coefficients of magnets made of different specimens of steel and their losses of magnetic moment between room temperatures and 100°C . varied with their lengths. It is evident that in the case of magnets made of a given kind of steel, the temperature coefficients are functions of both the diameters of the magnets and of the ratios of their lengths to their diameters. Very long slender magnets have in general relatively small temperature coefficients, but it does not seem possible to reduce indefinitely the coefficient of a magnet made of a stout rod of tool steel by increasing the length. Figures 4, 5, 6, 7, and 8, in which the lengths of the magnets are used as abscissas, show graphically the results given in Tables V, VI, VII, VIII, and X, and recall Cancani's experiments upon magnets made of fine steel wire.

The Jefferson Physical Laboratory,
 Cambridge, December, 1897.

4.



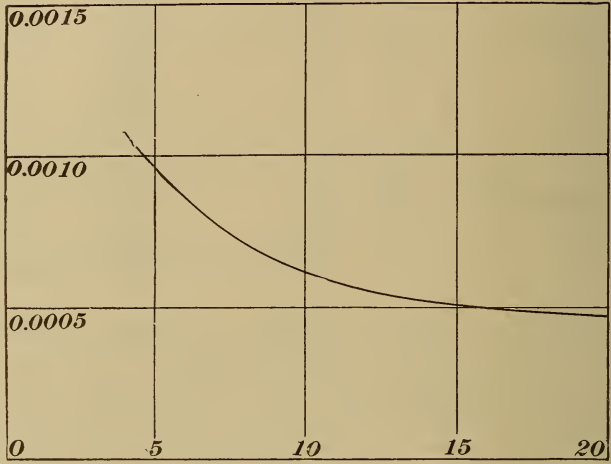
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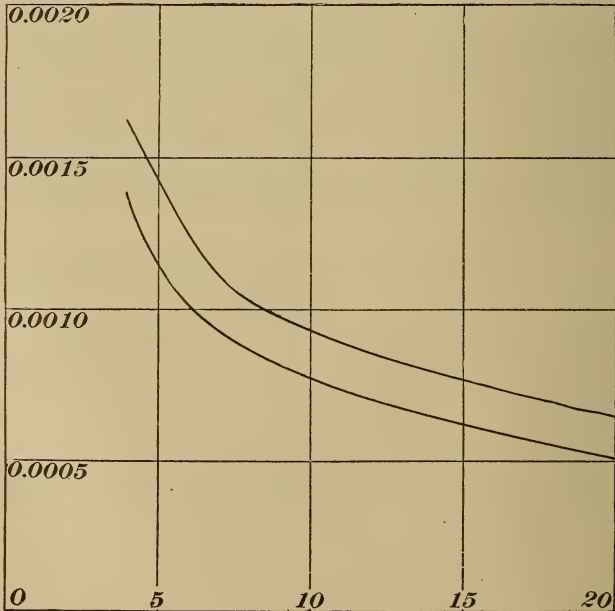
6.



7.



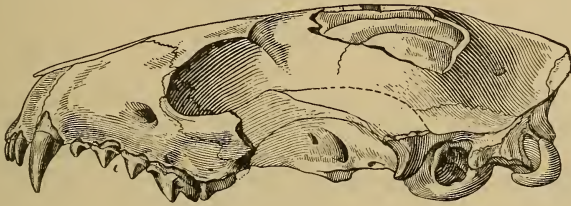
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ART. XXXII.—On the Skull of *Amphictis*; by E. S. RIGGS.

THE genus *Amphictis* has so far been made to include three species: *A. antiquus** from Saint-Gerard-le-Puy, and *A. leptorhynchus** and *A. ambiguus*† from the Quercy phosphorites. All of these forms are based upon mandibular characters, and so far only a single upper tooth has been described.‡ The genus is characterized by Schlosser as follows:§ “Diese Gattung zeichnet sich vor Allem aus durch den einfachen Bau der *Pr* und durch die Länge des unteren zweiwurzligen M_2 . Die Vorderpartie dieses Zahnes besteht aus einem Aussen- und einem Innenzacken, der Vorderzacken ist schon sehr undeutlich geworden. Der Talon ist sowohl am M_1 , als auch am M_2 als Schneide entwickelt, wenigstens der Hauptsache nach.”

An almost complete skull (No. 11455) in the Princeton collection from the Phosphorites probably belongs to this genus, although it is decidedly smaller than the specimens hitherto referred to it, and the means of positively determining it as such are not at hand.

Lateral view of the skull $\times 1$.

The upper dentition is, I3, C1 P4, M2. The incisors have conical crowns slightly compressed antero-posteriorly. The third is much larger than the first and second. The canines are somewhat recurved and are oval in cross section. The first premolar is still functional, but has lost the anterior root. The second is larger, two-rooted, concave on both borders and retains a slight basal cingulum posteriorly. The third premolar is only a little larger than the second but has a basal cingulum on the anterior as well as on the posterior side. The sectorial is similar to that of *Putorius*, but has a stronger internal tubercle and a less prominent anterior cingulum. There is no fissure between the median cusp and the heel as in the civets.

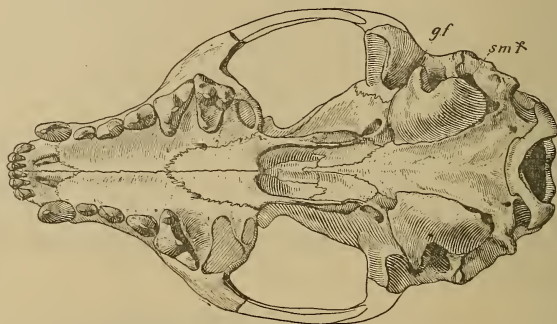
* Pomel, Catalogue méthodique, p. 63.

† Gervais, Zoologie et Paleontologie, gen. ii, p. 51.

‡ Schlosser, Die Lemuren, Chiropteren, etc., des europäischen Tertiars, p. 121.

§ Idem, p. 118.

The first molar bears three small but well-marked tubercles. Of these the inner one is the largest; it is flanked by a prominent internal cingulum which may be regarded as an incipient fourth cusp. The outer tubercles are shifted mesially, leaving a broad external surface which is elevated to form a marked prominence at the acute antero-external angle. In outline the anterior border is convex, the posterior concave. The second molar has been lost from both sides of the specimen, but the alveolas show that it was reduced to a single-rooted tooth.



Base of the skull $\times 1$.

The characters of the base of the skull show affinities with both the mustelines and the Viveridæ. The alisphenoid canal is present as in the viverines and the older fossil cats. The otic bullæ are well inflated and there is no inferior lip to the auditory meatus, as is true of the viverines; but the tympanic walls are much thickened and inclose but a single cavity, into which the meatus externus enters at the middle much as in the mustelines. The paroccipital processes are free from the bullæ and are directed backward, downward and outward as in the early Carnivora and Creodonts. The mastoid processes are blunt and inconspicuous, but lie close to the meatus and form part of its posterior wall as in certain mustelines. The posterior nares open on a line with the last molars; the pterygoids are grooved infra-laterally.

The posterior lacerate foramen opens at the posterior border of the bulla near the stylo-mastoid as in *Bassaris*,* and the carotid foramen lies just in front of it as in that form. The foramen ovale and the posterior opening of the alisphenoid canal lead into a common fossa, as in the civets and the early cats. The post-glenoid foramen opens at the extremity of the anterior rim of the auditory meatus and is partially concealed

* Flower, Proceedings of the Zoölogical Society of London, 1869, p. 10.

by it. The posterior palatine foramina appear just back of the maxillo-palatine suture.

The occiput is nearly perpendicular. The lambeloidal ridges are prominent only at the inion. There is no sagittal crest; the *linea semicircularis* are only slightly marked and do not unite until they reach the occiput, enclosing a narrow sagittal area. The cranium is expanded, showing a large and well-convoluted brain.

The frontal region is concave along the median suture; the nasals are narrow and slender as in the civets. The post-orbital processes are only slight, but back of them there is a marked notch-like constriction.

The measurements are as follows :

	M.
Length of skull from incisors to condyles . . . . .	.074
Breadth across mastoid processes . . . . .	.031
Height of occiput above condyles . . . . .	.021
Glenoid cavity to incisors . . . . .	.054
Breadth across post-orbital processes . . . . .	.019
Occiput to incisors . . . . .	.076
Incisors to last molar . . . . .	.085
Length of molar dentition . . . . .	.026
Breadth of incisor dentition . . . . .	.008
Breadth across first molars . . . . .	.027
Length of base of sectorial . . . . .	.008
Breadth " " . . . . .	.0055
Length of base of first molar . . . . .	.006
Breadth " " . . . . .	.0085
Greatest breadth of nasals anteriorly . . . . .	.007
Breadth of nasals at middle . . . . .	.004

It will be seen that *Amphictis*, though by no means a primitive form, has many characters in common with both *Mustelidæ* and the *Viveridæ*. The general proportions of the skull are musteline. The structure of the inner ear, and of the par-occipital and mastoid processes are essentially characteristic of that group, as are also the presence of the glenoid, and the distinct condylar foramina. But on the other hand the short and expanded auditory meatus, the inter-sagittal space, the character of the molars, and the presence of the alisphenoid canal ally it to the *viverines*. Thus the genus forms a connecting link between the two families and furnishes further evidence in support of Schlosser's theory that they are of common origin.*

* Die Lemuren, Chiropteren, etc., de europäischen Tertiars, p. 107.

ART. XXXIII.—*On the Condition of Oxidation of Manganese precipitated by the Chlorate Process*; by F. A. GOOCH and MARTHA AUSTIN.

[Contribution from the Kent Chemical Laboratory of Yale University—LXVIII.]

HANNAY,* who was the first to propose the precipitation of manganese from its solution in nitric acid by the use of potassium chlorate, states that precipitation is complete, but that the oxide produced is not of constant composition. While, therefore, precipitation by this method serves an excellent purpose in separating manganese from other substances, it was Hannay's opinion that reliance cannot be placed upon the determination of the oxygen value of the oxide to estimate the manganese. Beilstein and Jawein,† who proposed the same method, subsequently, regarded the precipitate as the oxide MnO_2 . Hannay's reaction was developed, independently, by Hampe‡ and Ford§ into the method which is now known as the "chlorate process" for the estimation of manganese. The discussion of the exact condition of the precipitated oxide was very active ten years ago, and occasional echoes of it are heard at the present day; and yet, in all this discussion we find no account of an adequate test of the process upon an exact amount of a salt of manganese known to be pure. The discussion for the most part has centered about the degree of oxidation of the precipitate, but there is obviously another condition to be taken into account, viz: the possibility of the mechanical inclusion of the comparatively insoluble chlorate in the precipitated oxide. As to the existence of the latter source of error we have had in the course of our work very strong affirmative evidence, the apparent condition of oxidation of the precipitate being sometimes so high as to be otherwise inexplicable. This difficulty does not occur, however, when a more soluble chlorate is chosen to do the work of oxidation, and we have found quite as convenient and much safer the substitution of sodium chlorate for the comparatively insoluble potassium chlorate. Besides, the rapidity with which the sodium chlorate is decomposed makes its use an advantage.

With regard to the completeness of the precipitation our experience has shown that with due precaution the method is practically perfect. Thus, after boiling manganous nitrate (free from chlorides and sulphates) with strong nitric acid (85^{cm^3}) and sodium chlorate (5 grms.) for five minutes, adding, subsequently, 15^{cm^3} of the nitric acid and a few crystals more of

* Jour. Chem. Soc., vol. xxxiii, 269.

† Ber. d. d. Chem. Gesell., xii, 1528.

‡ Chem. Central-Blatt., 1885, 714. § Trans. Inst. Am. Min. Engineers, ix, 347.

the sodium chlorate, and discontinuing the heating as soon as the liquid again boils, the insolubility of the manganese is so great that no more than insignificant traces may be recovered from the filtrate after cooling, filtering upon asbestos and washing with water. The test for manganese in the filtrate and washings was made after evaporation and solution of the residue in distilled water by treating the hot solution with bromine and ammonia. In the first division of the table below are results obtained by treating the manganese precipitated from the filtrate with potassium iodide and sulphuric acid, the iodine set free being determined by sodium thiosulphate. In the second series the precipitated manganese dioxide was reduced by a known amount of decinormal arsenious acid and the amount remaining unoxidized was estimated by titration with iodine in the presence of acid potassium carbonate.

TABLE I.

MnSO ₄ taken. gram.	Mn found by KI treatment in filtrate. gram.	Mn found by As ₂ O ₃ treat- ment in filtrate. gram.
0.3361	none	----
0.3361	none	----
0.3361	0.00006	----
0.3361	0.00005	----
0.3361	0.00002	----
0.3361	0.00008	----
0.3361	none	----
0.4128	----	0.00003
0.4128	----	0.00003
0.4128	----	Trace
0.4128	----	Trace

It will be seen that in no case did the manganese which escaped precipitation—that which corresponded to the iodine freed or the arsenious acid oxidized—exceed 0.0001 gram. Plainly this modified method of handling the chlorate process may be trusted to precipitate the manganese with gratifying rapidity and approximation to completeness. Our experience has shown plainly that prolonged boiling results in a considerable loss of manganese (from 0.0010—0.0030 gram.). This we think is due to the solvent effect of the lower oxides of nitrogen naturally produced (as is always the case in boiling nitric acid) after the chlorine dioxide has been thoroughly expelled. An excess of the chlorate at the end of the boiling seems to be essential and a slight yellow color in the solution, due to chlorine dioxide, is a favorable indication rather than the reverse. We find it best to filter the undiluted nitric acid, under pressure,

upon asbestos on a perforated cone with a filtering surface of about 40^{sq} cm. The dilution of the nitric acid before filtration tends to produce some solubility of the manganese, and the loss then introduced, though trifling if the filtration is rapid, may be considerable if the process of filtration is prolonged, as is the case in the method approved by the "Verein der deutschen Eisenhütteleute."*

Our experiments upon the chlorate process have been made with manganous chloride prepared as detailed in a former paper, viz: by boiling manganous chloride with manganous carbonate, precipitating the filtered solution with ammonium sulphide, dissolving the washed manganous sulphide in dilute hydrochloric acid, precipitating the solution thus obtained with sodium carbonate (after boiling out hydrogen sulphide), dissolving the greater part of the manganous carbonate (thoroughly washed by repeatedly boiling it in successive portions of water) in the least amount of hydrochloric acid, and boiling the solution thus obtained with the remainder of the pure carbonate and filtering. The standard of the solution thus prepared, neutral and probably very pure, was fixed by evaporating definite portions with sulphuric acid and weighing the residue as the normal sulphate in accordance with the procedure outlined in a former paper.†

Any method, by means of which the oxidizing power of the higher oxygen compounds of manganese is discoverable, may, obviously, be employed to determine the condition of the manganese precipitated in this chlorate process. Convenient processes for the determination of the available oxygen in the higher oxides of manganese are the iodometric methods of Bunsen and Pickering. Bunsen's method is applicable to any of the higher oxygen compounds of manganese—though somewhat inconvenient because it involves the distillation of the chlorine liberated by the action of strong hydrochloric acid upon the substance and its collection in potassium iodide, the iodine thus set free being estimated by standard thiosulphate. According to Pickering's‡ method the higher oxide is treated immediately with potassium iodide and hydrochloric acid and the iodine liberated is estimated by sodium thiosulphate. Plainly, the latter method is limited to the treatment of the less refractory or more finely comminuted oxides, and it fails in the presence of ferric salts and all other substances capable of liberating iodine from the acidified iodide.

Still another general iodometric method for determining the oxygen value of the higher oxides of manganese is suggested

* Von Reis, Zs. f. angewandte Chem., 1891, 376.

† This Journal, IV, v. 209.

‡ Jour. Chem. Soc., xxxvii, 128.

by Deshayes's titration of permanganic acid in nitric acid by means of standard arsenious acid.* Our experience in following out this idea shows that the precipitated oxides of manganese, as well as the soluble permanganate, may be easily reduced with the aid of gentle heating by arsenious acid in the presence of sulphuric acid, and that the determination of the excess of arsenious acid by titration with iodine after neutralization of the free sulphuric acid by an alkaline carbonate gives exact data for estimating the oxidizing power of the manganese compound. We found, however, that if the iodine is allowed to come into contact with the manganous carbonate thrown down by the alkaline carbonate, as is inevitable for at least short intervals during the titration of the arsenious acid in presence of the floating carbonate, the danger arises of more or less reoxidation of the manganous carbonate by the iodine and the consequent introduction of error. Fortunately the difficulty may be obviated by adding to the solution while still acid enough tartaric acid, or alkaline tartrate, to prevent the precipitation of the manganese in the subsequent neutralization by the bicarbonate.

Confining our attention to the last two simpler iodometric methods—the reduction of the higher oxide by an acidified iodide on the one hand and by arsenious acid on the other—we made, first, some experiments to determine the accuracy with which manganese may be thus estimated. We used for the manganese compound of known oxidizing power a solution of potassium permanganate filtered carefully through asbestos and standardized against ammonium oxalate which had been found to be the exact equivalent of a specially prepared lead oxalate. For each experiment a definite portion of this solution was drawn from a burette and treated with a solution of pure manganous sulphate until the color of the permanganate had vanished, thus precipitating a hydrous oxide approximating quite closely probably to the condition of oxidation of the dioxide, but containing at all events, whatever its actual composition might be, the exact amount of available oxygen originally in the permanganate. In the experiments of the following table this precipitate was treated with a solution of potassium iodide (6 grn.) and tartaric acid (10 grn.), by which the freshly prepared hydrate is dissolved quite as well as by the iodide and hydrochloric acid of Pickering's original method and with less risk of evolution of iodine outside the main reaction. From the iodine found by titration with this sulphate we have calculated the weight of manganese dioxide which would liberate it; and a comparison of this value with the amount of the dioxide theoretically precipitated by the interaction of the

* Bull. Soc. Chim., xxix, 541.

known permanganate and the sulphate, upon the assumption that two molecules of the former throw down five molecules of the hydrated dioxide, should disclose the error of the analytical process when applied to the estimation of manganese dioxide. In all probability the assumption that it is the dioxide that is precipitated, and which afterwards acts upon the iodide, is not quite true under the conditions, since the precipitation takes place in presence of an excess of a manganoous salt; but for our purpose it does not matter, since we are in effect simply dealing with the oxidizing power of a known amount of permanganate.

TABLE II.

Mn theoretically precipitated by KMnO_4 as MnO_2 . gram.	Mn in MnO_2 corresponding to iodine found. gram.	Error of the analytical process (applied to MnO_2) in terms of Mn. gram.
0.1351	0.1347	0.0004—
0.1351	0.1347	0.0004—
0.1351	0.1350	0.0001—
0.1351	0.1353	0.0002+
0.1351	0.1358	0.0007+
0.1351	0.1353	0.0002+.

Thus, it is obvious that the mean error of the results is practically inconsiderable, varying between extremes of -0.0004 gram. and $+0.0007$ on 0.1351 gram. of manganese dioxide.

In the experiments of Table III the precipitated oxide was treated with an excess of a standard arsenious acid solution and 5^{cm} of sulphuric acid of half strength, and the whole was heated until the manganese dioxide was dissolved. To this liquid was added tartaric acid (10 gram.) to prevent the precipitation of the manganese and the oxidation by iodine in the subsequent titration, the acid was neutralized by acid potassium carbonate, and the arsenic still remaining in the arsenious condition titrated by standard iodine.

TABLE III.

Mn precipitated by action of KMnO_4 on MnSO_4 as MnO_2 . gram.	Mn in MnO_2 corresponding to As_2O_3 oxidized. gram.	Error of the process in terms of Mn. gram.
0.1392	0.1396	0.0004—
0.1109	0.1117	0.0008—
0.1112	0.1117	0.0005—
0.1109	0.1117	0.0008—
0.1109	0.1117	0.0008—
0.1117	0.1125	0.0008—

It is clear that either of these methods of reduction, the action of an acidified iodide or that of arsenious acid, is capable of yielding fairly accurate indications when we have to deal with a pure salt of manganese. When, however, the manganese is associated with a considerable amount of iron, as is frequently the case, it becomes a matter of necessity to separate the manganese before attempting its estimation. For this purpose the "chlorate process" is by far the simplest of those generally used, and though it has been the subject of much discussion, it is at present the method of separation most widely used by the practical chemists, whether the final estimation of the manganese is made gravimetrically, as in Ford's process, or volumetrically, as in the methods of Volhard, Williams, or Pattinson.

Definite portions of the solution of pure manganous chloride were drawn from a burette into an Erlenmeyer flask of 300^{cc} capacity, evaporated to dryness, precipitated by the "chlorate process" with the modifications given in detail above. The oxide, after careful washing, was returned with the asbestos to the flask and treated by one or other of the methods to be described. It was either treated with potassium iodide (5 grms.) and sulphuric acid (10^{cc}) of half strength, the iodine set free being estimated by thiosulphate; or, it was heated with an excess of standard arsenious acid and 10^{cc} of sulphuric acid of half strength, and after cooling, adding 5 gm. of the Rochelle salt and neutralizing with acid potassium carbonate, the arsenious acid remaining unoxidized was estimated with standard iodine. In Table IV are given the results obtained from this work.

TABLE IV.

Mn taken in the form of manganous chloride. gm.	Mn found upon the hypothesis that MnO ₂ is precipitated. gm.	Error. gm.	Mn found in the filtrate after evaporation and treatment with bromine and ammonia. gm.
<i>By reduction with potassium iodide.</i>			
0·1225	0·1183	0·0042—	0·00006
0·1225	0·1177	0·0048—	Trace
0·1225	0·1180	0·0045—	0·00008
0·1225	0·1169	0·0056—	Trace
<i>By reduction with arsenious acid.</i>			
0·1222	0·1189	0·0033—	Not determined.
0·1222	0·1191	0·0031—	" "
0·1222	0·1199	0·0023—	" "
0·1222	0·1200	0·0022—	" "
0·1222	0·1186	0·0036—	none
0·1222	0·1187	0·0035—	0·0001
0·1222	0·1189	0·0033—	0·0002
0·1222	0·1194	0·0028—	Trace
0·1222	0·1205	0·0017—	0·0001

The results show plainly that, while the manganese is so completely precipitated in the chlorate process of oxidation when properly conducted that only insignificant traces may escape, the condition of oxidation cannot be taken to be that of the dioxide. The average error thus put upon the determination of the manganese known to be present is more than two per cent. It follows, as a matter of course, that the indications of any process which rests upon the assumption that the oxygen value of the manganese compound precipitated in the chlorate process corresponds to that of the dioxide must of necessity be erroneous. If, therefore, the chlorate method is to be employed for the separation of the manganese, it is obvious that precautions must be taken to secure a definite condition of oxidation of the manganese before processes which depend upon the oxygen value of the higher oxide may be applied for the estimation of that element. The process which in our hands seems to give the oxide in definite condition is based upon the observations of Wright and Menke* that a dilute solution of potassium permanganate acting in excess, at 80° C., in the presence of zinc sulphate, and in thorough mixture upon manganous sulphate, yields an oxide which, though combined with alkali, holds the oxygen exactly in the proportion corresponding to the dioxide. Three-fifths of the manganese in such a precipitate represents the amount of that element originally present in the manganous salt. In the following table are given the results of experiments in which manganese was determined iodometrically after the interpolation of the permanganate treatment.

In these experiments a solution of manganous chloride of known strength was drawn from a burette, evaporated to dryness in a small beaker, heated with nitric acid until there was no evidence of the presence of nitrogen oxides. Strong nitric acid was poured in until the volume was 85^{cm³}, sodium chlorate (5 gm.) was added carefully, the liquid was boiled five minutes, more nitric acid (15^{cm³}) and a few crystals of the chlorate were introduced, and the solution brought to boiling temperature again. After cooling, the liquid was filtered on asbestos and washed with water, and the oxide upon the asbestos and walls of the beaker was dissolved in 2^{cm³} of hydrochloric acid. After diluting a little the solution was evaporated with 5^{cm³} of strong sulphuric acid until no more hydrochloric acid remained. The solution of manganous sulphate (not exceeding 0.5 gm. of the salt), very nearly neutralized by potassium carbonate, was mixed with a solution of zinc sulphate (2 gm.) and a freshly and carefully filtered dilute solution of potassium permanganate (1.5 gm. of the salt), the liquid, amounting now to about

* Jour. Chem. Soc., xxxvii, 36.

500^{cm}³, was heated to 80° C., and acid potassium carbonate added, in quantity a little more than enough to neutralize the remnant of the acid present. The precipitate was collected upon asbestos, and after careful washing was returned to the flask in which the precipitation had been made. The oxygen value of the oxide was determined by one or other of the methods described. In the one case the flask was fitted with a paraffined stopper having two bores, one holding a Will and Varrentrap absorption apparatus (in which a solution of potassium iodide dissolved any escaping iodine), the other a small separating funnel. Sulphuric acid and potassium iodide in solution were run in through the funnel, the iodine set free was titrated with thiosulphate—the amount of manganese being reckoned from the iodine set free. The results of this work follow in the first part of Table V. In the second case the dioxide obtained in the manner described above was reduced by warming gently with a decinormal solution of arsenious acid. After cooling, and neutralizing with acid potassium carbonate in the presence of Rochelle salt, the excess of the arsenious acid was estimated with iodine in the presence of starch. The estimation by this method gave the results recorded in the second part of Table V.

TABLE V.

Mn taken in the form of chloride. grm.	Mn found upon the hypothesis that MnO ₂ is the oxide finally obtained. grm.	Error. grm.
<i>By reduction with potassium iodide.</i>		
0·0643	0·0637	0·0006—
0·0643	0·0642	0·0001—
0·0643	0·0642	0·0001—
0·0651	0·0651	0·0000
0·1125	0·1121	0·0004—
0·1125	0·1121	0·0004—
0·1125	0·1120	0·0005—
0·1214	0·1206	0·0008—
0·1214	0·1207	0·0007—
0·1214	0·1223	0·0009+
0·1214	0·1214	0·0000
<i>By reduction with arsenious oxide.</i>		
0·1213	0·1212	0·0001—
0·1213	0·1201	0·0012—
0·1213	0·1203	0·0010—
0·1213	0·1208	0·0005—

These results show plainly, that if the precautions to which attention has been directed are taken, viz: dilution of the solution and heating to 80° C., presence of zinc sulphate, and (most essential of all) the almost complete neutralization of free acid before the addition of the potassium permanganate, the manganese dioxide precipitated by the chlorate process from pure manganous nitrate may subsequently, after reduction, be brought by the permanganate treatment so nearly to the full degree of oxidation represented by the symbol MnO_2 , that the amount of manganese originally treated may be calculated with a very fair degree of accuracy from the oxygen value of three-fifths of the oxide found. We do not recommend this procedure as a rapid analytical method; our purpose is accomplished when the fact is brought plainly to view that the oxide precipitated by the chlorate process is not the dioxide, but that it may be made such by subsequent treatment.

ART. XXXIV.—*San Angelo Meteorite*; by H. L. PRESTON,
Rochester, N. Y.

[Read before the Rochester Academy of Science, March 8th, 1898.]

THE San Angelo siderite is oblong in shape and was, previous to cutting, 51^{cm} long by 29^{cm} wide and 14^{cm} thick. Its weight was 194 pounds or 88 kilos. A considerable portion of this siderite was obtained by Prof. H. A. Ward, Chief of Ward's Natural Science establishment, through the courtesy of Prof. Geo. P. Garrison of the University of Texas, Austin, Texas, and he is indebted to Mr. James Abe March of San Angelo, Texas, for the facts in reference to its locality, and the manner in which it was found.



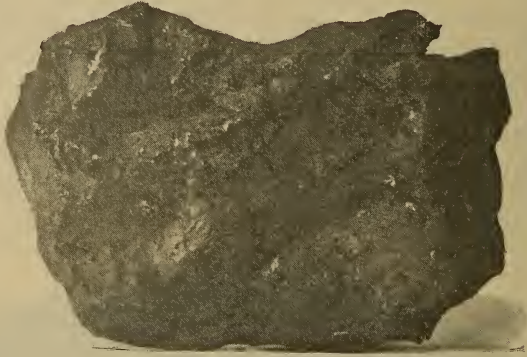
San Angelo meteorite; about $\frac{1}{6}$ natural size.

It was discovered by Mr. John Johnson on the prairie seven miles south of San Angelo, Tom Green County, Texas, about July 1st, 1897. The prairie on which the meteorite was found is called "Lipan Flats," a body of land entirely devoid of vegetation, without even mesquite trees. The meteorite was partially buried in the soil, and Mr. Johnson discovered it while riding horseback in search of cattle, and states that unless one rode over it, it would not have been seen, as the color of the soil and the meteorite were nearly the same.

The exterior surface of the mass is of a dark reddish brown color, considerably spotted with large yellow patches. None of the original crust is perceptible. The surface is very much oxidized and some places can be seen where scales a quarter of an inch or more in thickness have flaked off, thus intimating that the mass had lain for many years in its original position

where discovered. The surface of the iron is marked on all sides by large and characteristic pittings, some of them as much as 12^{cm} in diameter.

At one end of the meteorite several ounces had been forced from the main mass, which has left a rough, jagged surface five by six inches.



San Angelo meteorite showing octahedral structure; $\frac{1}{3}$ natural size.

This is of unusual interest, as the octahedral structure of the iron is beautifully shown by numerous octahedral faces, the largest of which is one and a quarter inch in diameter and is very sharp and clear. So also are many of the smaller octahedral faces shown over this surface where the separation of the mass was made.



San Angelo meteorite, etched section; about $\frac{1}{3}$ natural size.

A portion of this part taken off has been forged in a blacksmith shop: this piece when polished and etched has the same

general appearance as have all forged meteoric irons we have seen.

On slicing the mass we find the troilite nodules very scarce, the largest and only prominent one we have come across being 26^{mm} in its greatest diameter and continuing of this size only through three thin slices. The Widmanstätten figures are brought out sharp and distinct on the etched surfaces, and are much more regular both in form and size, than in any other iron with which I am familiar. The rhombic figures are from an inch to an inch and a half in diameter, and vary but little throughout the mass. The so-called Laphamite lines are prominently present, extending across the large patches of plessite.

There are two exceedingly interesting veins which appear on either end of most of the slices, that are filled with a black, lustrous graphitic-looking mineral; the longest of these veins following the curve is 11^{cm} and varies from 1 to 4^{mm} in width; the other is 6^{cm} long with a like variation of from 1 to 4^{mm} in width.

Another distinguishing feature of this iron are the numerous small fissures or cracks, usually extending from the exterior surface inwards, and following in a zigzag course along the edges of the kamacite plates, and in some instances the rhombic form of



San Angelo meteorite sketch showing fissures; about $\frac{1}{3}$ natural size.

the Widmanstätten figures as seen on the cut showing etched surface, is strongly outlined by these fissures as seen in sketch. These show clearly that with a little more heat the expansion of these cracks or fissures, would have caused masses to separate from the iron, which would tend to cause the large pittings, as suggested by me in an article in the January number of this year, of this Journal. In one case, as seen in left-hand edge of cut,

if a separation had taken place along these fissures, it would have created a cavity or pitting four inches in diameter and one inch or more in depth, while numerous smaller pittings could have been created in the same way as suggested by following the outline of the fissures on cut.

The following is an analysis of the San Angelo meteorite by Mariner & Hoskins of Chicago, Ills.

Fe.....	91.958
Ni.....	7.860
Co.....	<i>trace</i>
Cu.....	0.040
P.....	0.099
S.....	0.032
Mn.....	<i>trace?</i>
Si.....	0.011
C.....	<i>trace</i>
	100.000
Specific gravity	7.7

ART. XXXV.—*The Pre-Glacial Decay of Rocks in Eastern Canada*,* by ROBERT CHALMERS, of the Geological Survey of Canada.

THE pre-glacial decay of rocks in glaciated countries is a subject which has not hitherto received much attention from geologists. In North America the chief investigations regarding subaerial rock decay have been made in regions to the south of the glaciated zone, and but little has been attempted in those portions once occupied by Pleistocene glaciers. The prominence given to the action of these glaciers may have been one of the causes of this neglect or inattention to the products of rock-decomposition. The boulder-clay and certain gravels and sands overlying it being of considerable thickness, and their origin having apparently been found readily explicable from the action of these glaciers, the sedentary beds beneath, which occur usually in thin and detached sheets in glaciated regions, have thus, to a large extent, been overlooked. That they form a very important member of the superficial deposits, nevertheless, in the glaciated areas of Eastern Canada at least, and one from which the boulder-clay and all the other overlying stratified deposits have been mainly derived, no geologist will now attempt to deny.

In the regions of North America to the south of the glaciated belt the beds formed from rock decomposition have been studied, together with the stratified deposits resulting from their modification, by a number of leading geologists. Chamberlin and Salisbury, McGee, Hilgard and others have investigated their character and relation to the later superficial deposits; while near the limits of the glaciated area, T. Sterry Hunt† and Pumpelly‡ have shown the depths to which this process of decay penetrated and the manner in which the different kinds of rocks have been attacked by it. Russell has treated the question in its wider bearings and given detailed notes and descriptions regarding the chemical and mechanical agencies by which these changes in the rocks are effected; but his work also appertains to non-glaciated portions only of the United States.§ Prof. Kerr has shown how frost affects the decayed rock materials on slopes and declivities, an action which must be of more potent effect in Canada than in the Southern Appalachians.||

* Paper read in Section C (Geology) British Association for the Advancement of Science, Toronto, August, 1897.

† This Journal, vol. xxvi, 1883, pp. 190–213, etc.

‡ Ibid., 3d series, vol. xvii, 1879, pp. 133–144.

§ Bulletin U. S. Geological Survey, vol. viii, 1888–89.

|| This Journal, 3d series, vol. xxi, 1881, pp. 345–358.

An ample field for the study of rock-decay and of the different agencies by which it is effected exists in Canada, in which few workers have yet been found. In the eastern portion, previous to 1882, when the writer began investigations in the surface geology of the Maritime provinces, only two geologists were known to have observed phenomena of this kind. Sir J. W. Dawson had noted decomposed slates at Les Eboulements on the north side of the St. Lawrence below Quebec;* and Dr. T. Sterry Hunt observed the products of rock-decay on the south side of Mount Royal, at Montreal, and also at Rigaud Mountain in Vaudrenil.† In these and other places, e. g., Ste. Anne de Beaupre, Charlesbourg near Quebec, Portneuf, Lachute, etc., the materials in question lie at the southern base of ridges or hills and have escaped the eroding action of the Pleistocene ice. Since the date above mentioned the writer has collected a considerable body of facts relating to this subject in the eastern portion of Canada to which reference has been made in reports on the surface geology of New Brunswick, Nova Scotia and Prince Edward Island in the volumes since published by the Geological Survey of Canada. In the present paper an attempt is made to collect together the results of the scattered observations of these years and draw the attention of geologists to these ancient and very interesting products of rock-decay which seem to be the only remnants now in existence here representing the long ages which elapsed between the Carboniferous, or rather the Triassic, and the Pleistocene.

The question of rock-decay in the geological ages which preceded the Tertiary, however, is not here considered. No remnants of such, as distinct from those of later ages, have been recognized in the region under discussion. But it is possible they do exist, though indistinguishable from those of Tertiary age. Fossil evidence is, so far, entirely wanting in the pre-glacial decayed rock materials of Eastern Canada.

Definition of Terms.

Preliminary to a discussion of the pre-glacial decayed rock materials, it is, perhaps, desirable to explain and define certain terms employed in this paper regarding them. The materials in question have been found to be principally of two classes—*sedentary* and *modified*. The term *sedentary* is used to designate all those portions of the rock surface of the region which have decomposed *in situ* whether to greater or less depths, and which, although now in the form of loose gravel, sand, etc.

* Notes on the Post-Pliocene Geology of Canada, Can. Naturalist, 1872.

† This Journal, vol. xxvi, 1883, pp. 208–209.

have not been removed from their original situation. These have sometimes been called residuary or indigenous, or simply rotten rock *in situ*.

The *modified* pre-glacial beds consist really of the sedentary material removed from their original position, and worn and changed by the agency of rivers, streams, and, perhaps, to some extent by that of the atmosphere before they were deposited in stratified beds. They are best developed in protected valleys, although oftentimes greatly eroded and in places almost wholly swept away by glacial denudation and river action. In some valleys, owing to the heavy filling of boulder-clay thrown down upon them during the glacial period, or to the dislocation of portions of the valleys from local differential movements, they have been partially preserved and form thick stratified deposits.

Physiographic Features of the Region.

Topographically the region embraced in these observations exhibits highly diversified features and its geological formations include a great variety of rocks of different ages and character. It has also been the theater of a remarkable system of mountain-building action, and has undergone great and repeated oscillations of level. The subærial erosion and base-leveling to which it has, from time to time, been subjected, have doubtless largely obliterated the original features, except within a few limited areas,—the only plane surfaces of any extent now existing, properly attributable to these causes, being the St. Lawrence valley and the Carboniferous area of New Brunswick. The northeast Appalachian Mountain system constitutes the principal topographical feature, extending throughout the entire length of the region and terminating at Gaspé. This system has subsidiary and parallel ranges or spurs with intervening valleys. As a rule these valleys are floored with the latest rocks, and thick deposits of Pleistocene age usually occupy them. Although the existing mountain ranges and valleys were originally due to orogenic movements, the minor topographical features are largely the result of the processes of disintegration referred to slowly and unceasingly in progress. The slates and sandstones seem to have been more deeply decomposed than the crystalline rocks. In the valleys and especially beneath the boulder-clay, the decomposed products under consideration are found in the thickest beds, although usually occurring also upon the slopes and ridges. Thus while glacial erosion and other forms of denudation have been active and long-continued, these sedentary and other pre-glacial stratified beds have been preserved in sheets of greater or less extent and thickness in every part of the country.

Distribution of the Decayed Rock Materials.

Pre-glacial beds of decomposed rock, sedentary and stratified, have been observed by the writer in Quebec, New Brunswick, Nova Scotia, Prince Edward Island and the Magdalen Islands. In some localities the sedentary or indigenous materials occur apparently in extensive sheets; in others they are detached and local. For the most part they were met with in fragmentary masses, however, having evidently been much denuded before the boulder-clay was laid down upon them. In a few places in Quebec and in Prince Edward Island, also in the Magdalen Islands, these decomposition products have been partially assorted, and now form thick stratified deposits in river valleys. It is in the bottom of these that gold is found in the Chaudière valley, and other places in the "Eastern Townships" of Quebec. Similar assorted and re-assorted fluvatile deposits, though of greatly reduced thickness, occur in certain parts of Nova Scotia, having been observed along the northern slope and base of the Cobequid Mountains, also in several parts of Prince Edward Island. The Magdalen Islands are non-glaciated, and hence the decayed rock materials there are nearly in the same condition yet as they were in other parts of Eastern Canada previous to the glacial period, forming thick beds which have been slightly assorted by marine action during the Pleistocene submergence. It is in the river valleys of southeastern Quebec as referred to above, that the decomposed materials underwent the greatest transportation and assortment, as will appear by the sections of these beds given on the following pages.

Wherever these decomposition products occur in sedentary beds, though mantled by boulder-clay, the rock surface beneath is without striation from ice. And from the occurrence of these in so many localities it is evident that a considerable extent of rock surface in Eastern Canada has not been scored nor abraded during the glacial period, the ice apparently having slid over the beds which covered it with a sluggish motion, impinging only against the more prominent parts of the solid rock beneath and striating these.

In the province of Quebec these beds appear, as stated above, to have been least denuded in the hilly broken country lying between the St. Lawrence River and the International boundary, the ridges serving as barriers to protect them in many places from denudation by the Pleistocene ice. The comparatively light erosion of the first glaciation of the Appalachian system, and the mantling of these beds by the boulder-clay produced by it, preserved them also, to some extent, from the more powerful erosion of the Laurentide ice which followed.

Hence the occurrence of these sedentary beds, locally, in greater thickness here than in most other parts of the region under review. It is, however, chiefly in the form of deposits which have been assorted and re-assorted from the original sedentary material that they are found in the ancient river bottoms. Sections of these have been exposed in the banks of the Chaudière, Du Loup, Ditton and other rivers from which a knowledge of their character and relation to the other deposits, as well as to the solid rocks beneath, has been obtained.

At St. George, on the east bank of the Chaudière River, a tunnel was run in 800 or 900 feet in search of the pre-glacial channel of Slate Creek—a small tributary—passing through boulder-clay and other beds beneath to the rock surface. The beds inferior to the boulder-clay, which is here about 60 feet in thickness, were found to be in descending order,—(1) stratified sand and clay (locally called by the miners quicksands and pipe-clay); (2) coarse stratified gravel with pebbles and a few bowlders; (3) a local deposit of coarse slaty materials, apparently decomposed quartzose slate, thrown down probably as talus at the foot of a slope or bank, though at present forming a compact bed; (4) fine-grained, yellow sand with ochreous streaks. The stratification of this is obscure, but it is evidently parallel to that of the next bed beneath wherever it is seen. (5) The last graduates into rotten rock *in situ*, the stratification of which is quite distinct, dipping southeastward at a high angle; (6) slates and sandstones, decaying, fissile, and non-glaciated.

This section it will be seen, exhibits in descending order three different kinds of deposits beneath the boulder-clay, viz: (1) transported and water-worn material, (2) talus, and (3) sedentary beds passing into the solid rocks below.

Another section of the pre-glacial deposits is shown in an old hydraulic pit in the valley of Rivière du Loup, about a quarter of a mile from its junction with the Chaudière. The succession here is as follows, in descending order: (1) boulder-clay, with an intercalated, stratified band,—thickness of the whole 75 feet; (2) tough, dark gray, stratified clay, 1 to 3 feet; (3) gray, ochreous sand, stratified, (quicksands of the gold miners.) 12 to 14 feet; (4) compact unstratified clay, (pipe-clay of the miners,) 6 feet; (5) gray stratified gravel, with numerous pebbles and a few water-worn bowlders, 5 feet; (6) hard, yellow, oxidized gravel, stratified, with an abundance of worn bowlders from two feet in diameter downwards, containing alluvial gold in the bottom, 28 to 30 feet. None of the materials are glaciated and all are of local origin. The foot of the bank was covered with tailings, but near by the

sedentary materials and non-glaciated rock surfaces were observed.

Beneath the boulder-clay in this section we have, therefore, a thickness of about 45 feet of assorted, water-worn, stratified deposits, apparently all derived from sedentary, decayed rock material. The lower portions are coarse and oxidized throughout, the upper mostly finer and showing less oxidation, having evidently been laid down in deeper and quieter waters. These appear to rest upon denuded beds of rotten rock and non-glaciated rock surfaces. No fossil remains have yet been detected in them; but they are probably of Tertiary age. It is not unlikely that they are the equivalents of certain beds discovered many years ago at the western base of the Green Mountains at Brandon, Vermont. These were said to form a deposit lying beneath the boulder-clay and resting upon the solid rocks, which showed gravel and sand with kaolin or porcelain clay, and lignite or fossil wood, as well as several other oxidized materials. Fossil fruits were also discovered there, from which Mr. Lesquereux was led to refer the beds to the Miocene.*

In the valley of the Little Ditton River, oxidized pre-glacial materials, carrying gold, were also noted. Like those of Rivière Du Loup, they are chiefly of alluvial origin, but the portions resting immediately upon the rough, broken, jagged surfaces of the non-glaciated slates were sedentary.

Beyond the limits of the "Eastern Townships" so called, these materials were observed in a great number of places in southeastern Quebec not only in valleys, but on the hillsides and at the base of declivities, where they have been, in some way, protected from denudation. They were noted on Orleans Island, in Montmagny county, also near Rivière du Loup, Intercolonial railway, and at Little Metis. Indeed, many parts of the Notre Dame Range, on the St. Lawrence slope, exhibit more or less pre-glacial rock debris *in situ* with talus at the base, the glaciation here having been produced chiefly by northward moving ice which failed to remove it.

In the Gaspé peninsula similar decomposition products occur in some localities, and certain non-glaciated marginal areas were seen along the coast. The most remarkable example of this kind met with is on the point of land terminating in Cape Gaspé. This point has never been glaciated, and is covered with decayed rock material and devoid of boulder-clay. We have here a remnant of the land surface in the same condition as it was in the Tertiary period.

Local sheets of these decayed rock materials were first noted

* Geology of Canada, 1863, p. 929.

in the maritime provinces of New Brunswick, Nova Scotia and Prince Edward Island upon areas occupied by Carboniferous rocks, and have subsequently been observed in almost every part both of the higher and lower grounds. In the numerous localities where they were seen the superposition of the boulder-clay was a constant feature, except in the Magdalen Islands, where the products of glacier action seemed to be absent. In the great Carboniferous plain the general character and condition of these beds are closely similar throughout and are such as to indicate that, in pre-Pleistocene time, a thick continuous sheet existed. They are much thicker and of greater bulk in Prince Edward Island, however, than on the mainland, in many places exceeding the boulder-clay beds in volume. In the central part of the island along the railway line, where they seem to have suffered less denudation than on the coast, beds of sedentary material, five, ten and even twenty feet in thickness were observed. In many places they are capped only by stratified or partially stratified gravel, sand, and clay of variable thickness, due to fluvial, marine, or perhaps ordinary atmospheric action, though usually boulder-clay overlies them throughout the island. On the mainland of New Brunswick and Nova Scotia, especially near the coast, the decomposed materials were seldom seen *in situ* of greater thickness than about five feet, and often not exceeding a foot or two. A section at one of the numerous localities in which these products occur in the Carboniferous area of New Brunswick, seen along the highway between Chatham and Richibucto near the Black River bridge, is as follows: (1) Gravel and sand, unstratified, containing flat, angular fragments of rock apparently *in situ* imbedded therein, thickness, eighteen inches; (2) rotten rock, with loose pieces of the underlying sandstones also in place, but with a little gravel and sand in the interstices, four to five feet; (3) gray sandstone showing still less decomposition, and evidently passing into the solid rocks (millstone grit) beneath, which here lie nearly horizontal.

Wherever the unabraded or non-glaciated rock surface beneath the decayed rock is exposed, it usually presents a mammillated appearance, showing that the corroding action has penetrated more deeply in some spots than in others. No foreign boulders or other drift materials occur in these beds, though they are not uncommon in the overlying boulder-clay and upon the surface.

In southern New Brunswick and in some parts of northwestern Nova Scotia the character of the decomposed beds is different from that of those met with upon the Carboniferous areas, being dependent upon, and of course closely related to, the underlying rocks there. On the pre-Cambrian the materials

are coarser and often contain pebbles and boulders of considerable size, the finer matter having evidently been carried away by post-glacial denudation. In the hilly districts bordering the Bay of Fundy, talus was observed at the base of the slopes in a few places. On the Cambrian and Cambro-Silurian this debris is finer and where slates prevail the materials are in loose, fissile beds, i. e. they occur in the form of thin laminæ or scaly fragments of all sizes lying in the same position as the original strata. Materials of this kind were observed in the southern counties of New Brunswick, also on the south side of the St. Lawrence near Quebec. The decayed rock upon these and the older formations is less gravelly and sandy than upon the Carboniferous sandstone areas, as might naturally be supposed.

In many parts of the Maritime provinces these decomposition products were observed to have been only partially or slightly acted upon by the Pleistocene ice. In this condition they seemed to contain the same angular pebbles or gravel as the rotten rock *in situ* beneath, but were shifted greater or less distances from their original position by glacier-ice, and the interstices filled with a bluish or gray clay, or sandy clay, as the case might be, which baked hard on exposure. Beds of this kind usually graduate upwards into true boulder-clay.

The occurrence of such extensive sheets of decomposed sedentary rock in the region under consideration, much denuded as they seem to be, points to the former existence of a universal mantle of this material overspreading the country everywhere in Tertiary and preceding ages, probably from the first appearance of dry land. It was, however, partly modified by the same agencies as are in operation around us at the present day, namely by rivers, lakes, rain, snow, etc., and in the valleys, especially, was changed into deposits of stratified clay, sand and gravel. During the glacial period this decayed rock furnished the principal portion of the material constituting the boulder-clay, and also that of the overlying, modified, post-glacial beds.

Agencies which produced Decomposition of the Rocks.

The indigenous materials under discussion appear to be the result mainly of two different agencies—mechanical and chemical. Although it is not the purpose of the writer to enter into details regarding these in the present paper, it may be stated, that under the climatic conditions of this country, the most important seem to be (1) the precipitation, and (2) the carbonic acid of the atmosphere and of decaying vegetable matter, the latter usually resulting in what is called oxidation. The changes of temperature which have such a wide range in these latitudes must also have exerted a direct influence in pro-

ducing expansion and contraction of the rocks, thus causing numerous superficial cracks, crevices and joints which open them to the disintegrating agents referred to. Exfoliation, which is often seen in granite districts, and sometimes on diorite bosses, is chiefly due to this expansion and contraction. Although at first glance decomposition would seem not to have been as deep in this country as to the south of the glaciated zone, yet such an inference may not be correct, owing principally to the fact that denudation has been so much greater; and the existing remnants of these pre-glacial beds do not by any means show the amount of rock-decay which took place. The removal of so much of the decayed materials by atmospheric and glacial action must have exposed some portions of the rock surfaces at least to a renewed attack of the disintegrating processes time after time—a condition of things which would not occur so generally in regions upon which ice never gathered. It is true that the mantle of snow which envelopes the earth's surface here for five or six months every year and the freezing of the superficial beds during the same period have a conservative effect, and tend to check and practically arrest decomposition for a certain time; but rock-decay, nevertheless, may have been more effective and rapid at other seasons than in those parts of the earth where the decayed materials lie and accumulate as residuary beds to a great thickness. Thus while the process referred to does not exhibit the accumulated beds here that are found in southern latitudes, it does not necessarily follow that the depth of such action may not have been as great. The fact just stated has to be borne in mind, namely, that the decayed materials have undergone great denudation, thus giving the disintegrating forces renewed power at intervals to act directly upon the rocks.

The principal oxidation and decay of the rocks would seem to be from chemical agencies, whether on the surface as the rotten rock was denuded, or deep-seated beneath a load of sedentary material, or along joints, cracks, etc. These processes have been in incessant operation since the region became dry land. At present the great mantle of boulder-clay acts as a preserver of the rocks from the decaying processes in many districts, though even under this impervious capping the agents of decomposition, doubtless, to some extent, carry on their work.

It thus appears that if the climate and the seasons of Eastern Canada in past ages were at all similar to those prevailing at the present day, the conditions of rock-decay would necessarily be somewhat unlike those of tropical and non-glaciated regions, though probably the results may not have been very far different. The general character of the beds might possibly be nearly

the same in both regions, but for the reasons stated they may never have been as deep in the glaciated zone. The facts would seem to point to the conclusion, however, that rock-decay has been in progress in this country for long ages, probably as long as in southern climates, although somewhat irregular and intermittent in its operations.

From the extent and depth of the sedentary and assorted beds found beneath the boulder-clay it may be inferred that the Pleistocene glaciers were not as heavy, or of such erosive power, as many geologists have supposed. This has been the case especially in the flat districts of the Maritime provinces occupied with Carboniferous rocks. In these districts the ice has been of a less vigorous and sweeping character than in the more elevated parts of the country, and was apparently sluggish in movement, passing over the loose deposits and rock surfaces without eroding them deeply. Only from certain low ridges, or from the brows of hills exposed to the full force of the grinding ice masses, have the decomposition products been wholly removed and the surfaces of the solid rocks beneath scored and laid bare.

The general aspect of the dry land in Eastern Canada before the advent of the glacial period must have been closely similar to that of the country to the south of the glaciated area. The greater denudation it has suffered since from subærial and glacial agencies and the filling up of the valleys, partially or wholly with the boulder-clay, thus levelling and reducing the inequalities of the surface, have largely modified, in some places entirely changed, the appearance. But amid all the vicissitudes of climate and oscillations of level which the region underwent, and the denudation to which the surface has been subjected, these products of rock-decay, representing the subærial action of long ages, have thus been preserved in remnants and detached sheets, the recognition of which unfolds another episode in the geological history of Eastern Canada hitherto overlooked, and adds new interest to the study of its superficial deposits.

ART. XXXVI.—A New Form of Make and Break; by CHARLES T. KNIPP.

A MAKE and break to operate a sounder so as to tick seconds is indispensable in a well-equipped physical laboratory. The method of allowing a tip of platinum wire, fastened to the lower end of the second's pendulum, brush through a drop of mercury on an amalgamated brass or copper support, is vexing in the extreme and not in the least reliable. It requires constant attention, as the mercury is readily oxidized by the making and breaking of the current.

The following device is easily made and can be readily attached to any second's pendulum. The general arrangement is at once seen by aid of the figures.

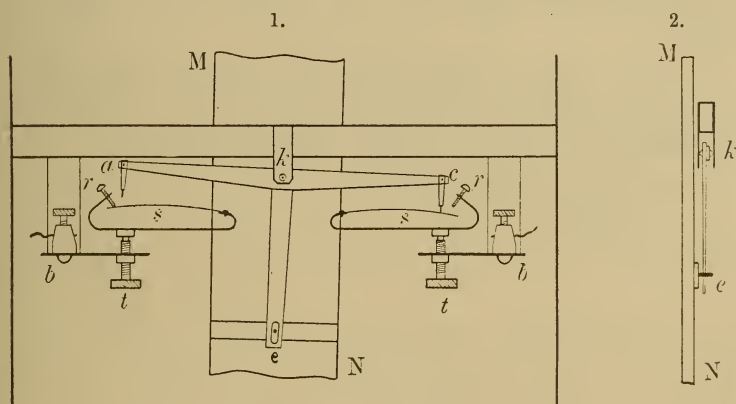


FIG. 1. The T, *a c e* is pivoted at *k*; *s, s* are delicate springs made of sheet steel. Adjustments are made by means of the thumb screws *t, t* and the set screws *r, r*. The current is connected through the binding posts *b, b*. The pendulum *MN* carries a stud which engages the lower end of the T, *a c e*.

FIG. 2. Shows a side elevation and manner of pivoting at *k*.

The T-shaped frame is made of thin sheet brass. It is pivoted at the center. At the lower end of the stem of the T is a slot which engages a stud on the pendulum. Fastened to the ends of the arms are short arms which project downward. At the lower end of each small arm is soldered a platinum tip. Clamped at one end of a brass frame, supported by a thumb screw, is a delicate spring of sheet steel. The spring is held in the desired position by a set-screw at the other end of the frame, as shown in the left hand side of fig. 1. The adjustment should be such that when the pendulum is in its lowest position the platinum tips just touch the springs. The adjust-

ment is readily effected by means of the thumb and the set-screws. Two binding posts are conveniently placed to which the circuit from the battery and sounder is connected. Obviously the circuit is closed only when the pendulum passes through its lowest point—when the platinum tips are in contact with the two springs. Fig. 1 shows the pendulum at the extreme end of its path. The right-hand spring is depressed while the left-hand platinum tip is a considerable distance above its spring. A small piece of platinum foil is soldered to the spring just below the platinum tips to insure good electrical contact. The friction is very slight. The pendulum, as a consequence, will have a smaller amplitude, causing the clock to run some faster. The friction at the points of contact of the platinum tips can be greatly reduced by shortening the arms of the T, thus making the springs and arms of equal length and approximately radii of the same circle. Fig. 2 is a side view showing the stud on the pendulum, the pivot, and support.

The writer made this device and placed it in position March, '97. After being once adjusted it gave no trouble. Wires were run to the various laboratory rooms. The device is always ready and responds promptly when the sounder is attached.

Physical Laboratory, Indiana University,
Bloomington, Ind.

ART. XXXVII.—*Datolite from Guanajuato*; by OLIVER C. FARRINGTON.

WHILE examining, about two years ago, the mineral collection of Sr. Ponciano Aguilar, the well-known mining engineer of Guanajuato, Mexico, my attention was attracted to some small transparent crystals accompanying a specimen of calcite from the San Carlos mine of Guanajuato.

As I could not at the time identify the crystals, Señor Aguilar kindly presented me with the specimen that I might give them further study. A subsequent determination of the blowpipe characters showed the mineral to be datolite, a species which has not so far as I know been previously reported from this locality. Examination of the crystal form showed the habit and development of the crystals to be unique and apparently peculiar to the locality. They were accordingly made the subject of the following study.

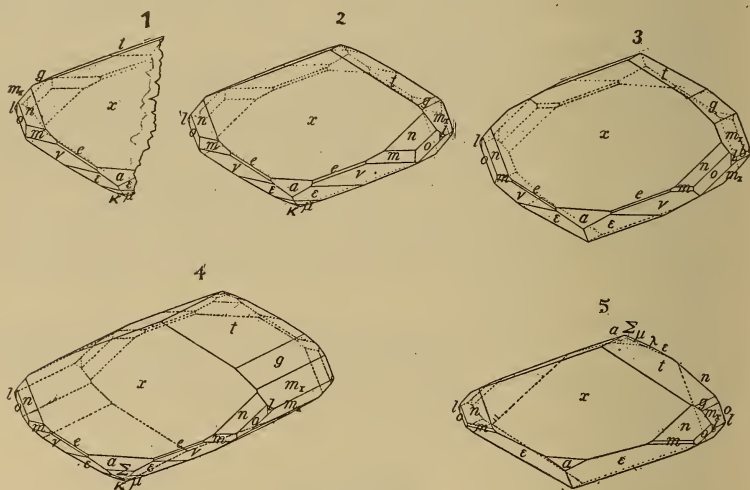
The calcite crystals with which the datolite is associated have the form of $-\frac{5}{4}$ rhombohedrons which are coated with drusy calcite. Small quartz crystals about 5^{mm} in length and made up of the usual prism terminated by the + and - rhombohedron also accompany them. Regarding the nature of the occurrence of the specimen, Señor Aguilar was unable to give any further information than that it was from the mine already mentioned. The rocks of the region are, however, well known to be altered andesites.

The datolite crystals are transparent, colorless, of vitreous luster and small size, the largest being not over 4^{mm} in length by 1^{mm} in thickness. Upon them a total number of 17 forms was identified, as follows, the symbols being in accordance with those chosen by Dana:

$a(100, i-\bar{i})$	$x(102, -\frac{1}{2}-\bar{i})$	$\kappa(\bar{1}15, \frac{1}{5})$
$b(010, i-\bar{i})$	$\Sigma(\bar{3}02, (\frac{3}{2}-i))$	$\mu(\bar{1}14, \frac{1}{4})$
$e(320, i-\frac{2}{3})$	$t(013, \frac{1}{3}-\bar{i})$	$\lambda(\bar{1}13, \frac{1}{3})$
$m(110, I)$	$g(012, \frac{1}{2}-\bar{i})$	$\epsilon(\bar{1}12, \frac{1}{2})$
$o(120, i-\bar{2})$	$m_x(011, 1-\bar{i})$	$\nu(\bar{1}11, 1)$
$l(130, i-\bar{3})$	$n(111, -1)$	

The faces are fairly sharp and bright but in the zones of prisms and hemi-pyramids merge into one another so that it is difficult to distinguish them. The crystals all have about the same number of faces, but differ in the faces developed. The prisms have about the same development on all the crystals. Thus e , 320, is scarcely more than a line; m , 110, and o , 120,

appear as well-defined faces, while l , 130, is always a minute triangular face at the edge of e . The negative hemi-pyramid n , 111, is always well-defined, and the positive hemi-pyramids, v , $\bar{1}11$, and ϵ , $\bar{1}12$, are usually prominent. The succeeding faces of this zone round off in a manner which has been noted on datolite from other localities. The clinodomes can usually be distinguished by being duller in luster than the other faces and by their showing minute striations diagonal to their edges. The habit of the crystals is determined by the predominance of the orthodome x , 102, the crystals being tabular with respect to this face, and of the clinodomes t , g and m_x . To these faces the prisms and pyramids are quite subordinate and, as mentioned later, may become very minute. The habit produced by predominance of the faces mentioned may perhaps best be described as an arrow-point habit. It is illustrated by fig. 1. As here indicated,



only half the crystal is present in nature and that the left half, the point of attachment being near the symmetry plane. This development is very constant and by being familiar with it one can recognize the prominent faces at a glance.

Crystals approaching these in habit, in that they are tabular with respect to x , have been described by E. S. Dana from Bergen Hill, N. J.,* and by Franzenau from the Swiss Alps in Tyrol.† The Guanajuato crystals differ, however, from those described by Dana in that they only rarely have a rhombo-

* This Journal, III, vol. iv, p. 17, and fig. 14, pl. 1.

† Handbuch der Mineralogie, C. Hintze, p. 173.

hedral aspect and from those of both authors in the predominance of the clinodome t , 013. Through the kindness of Prof. Dana, I have had an opportunity to examine some undescribed crystals from Bergen Hill which resemble the Guanajuato forms more closely. In these the clinodomes t and g are still lacking, their place being supplied by the pyramid G , but the habit, mode of attachment and relative development of the faces is such as to make the crystals in other respects very similar to the Guanajuato forms. They differ from the Bergen Hill type already referred to, chiefly in the subordinacy of ϵ , $\bar{1}12$. They may therefore be considered as a simple modification of this type.

In order to illustrate the different types observed on the Guanajuato datolites, four crystals, which are represented in the accompanying figures, were chosen. Crystal No. 1 is shown in completed form in fig. 2, fig. 1 showing the left half of the same crystal. This crystal illustrates what is perhaps the commonest type, the crystal being thin by reason of the shortness of the clinodiagonal axis, and rather acutely terminated on account of the predominance of the clinodome t . From the series of positive hemi-pyramids it will be noticed by the figure that the pyramid λ , $\bar{1}13$, is wanting and this was usually true, the face being found on only one crystal.

Measurements in the zones of prisms, pyramids and domes showed in all cases close approximation of measured to calculated values. A zone well brought out on this crystal is that of x over n to x . Measured and calculated angular values in this zone compared as follows :

	Measured.	Calculated.
$102 \wedge 1\bar{1}1$	$34^{\circ} 20'$	$34^{\circ} 21'$
$1\bar{1}1 \wedge 1\bar{2}0$	29 42	29 50
$1\bar{2}0 \wedge 0\bar{1}\bar{1}$	52 1	51 53
$0\bar{1}\bar{1} \wedge \bar{1}0\bar{2}$	63 57	63 56

Fig. 3 illustrates the second crystal chosen. Here the clinodomes have a more nearly equal development than in the previous forms and the crystal has, therefore, a more blunt termination. The clinopinacoid is present, but only two of the series of positive hemi-pyramids occur, these being, as may be noted on the figure, ν , $\bar{1}11$, and ϵ , $\bar{1}12$. Measurement of the zone x over n on this crystal gave the following results :

	Measured.	Calculated.
$102 \wedge 1\bar{1}1$	$34^{\circ} 21'$	$34^{\circ} 21'$
$1\bar{1}1 \wedge 1\bar{2}0$	29 51	29 50
$1\bar{2}0 \wedge 0\bar{1}\bar{1}$	51 54	51 53
$0\bar{1}\bar{1} \wedge \bar{1}0\bar{2}$	63 49	63 56

Another interesting zone well developed on this crystal is that of x over t to w . In this zone the measured and calculated angles compared as follows:

	Measured.	Calculated.
$102 \wedge 3\bar{2}0$	$49^{\circ} 20'$	$49^{\circ} 21'$
$3\bar{2}0 \wedge 1\bar{1}\bar{1}$	24 46	24 46
$1\bar{1}\bar{1} \wedge 0\bar{1}\bar{3}$	56 45	56 40
$0\bar{1}\bar{3} \wedge \bar{1}0\bar{2}$	49 15	49 13

In crystal No. 3, shown in fig. 4, the forms are much extended in the direction of the clinodiagonal axis, making a thicker crystal and one which displays more than the others the rhombohedral appearance noted by Dana. Here the pyramids and prisms appear only as a slight truncation of the edge formed by the meeting of the orthodome and the clinodomes, and might therefore easily be overlooked. The crystal shows no new faces except the positive hemi-orthodome Σ , $\bar{3}02$, which here appears for the first time.

The crystal shown in fig. 5 is peculiar for displaying a merohedrism worthy of note. The series of fundamental positive hemi-pyramids is here represented in the upper rear octants by ϵ , $\bar{1}12$, λ , $\bar{1}13$, (this face not being wanting from the series as in the other crystals) and κ , $\bar{1}14$. These faces are all small, and only slightly truncate the edge formed by the junction of the orthodome x and clinodome t . In the lower front octants, however, λ and κ are wanting and only ϵ appears, so greatly enlarged that it is equal to t in size. The crystal shows, therefore, inclined-faced hemihedrism with respect to λ and κ , and were ϵ not present could properly be termed hemihedral. As this face is present, however, the absence of the other faces should more properly perhaps be regarded as accidental and the occurrence be considered due to merohedrism.

It may be worthy of note that in measuring the smaller faces I found direct sunlight reflected by a movable mirror a more satisfactory source of light than any artificial light. Signals could be obtained from faces by this means which gave none whatever with artificial light. With a darkening attachment on the goniometer work in a dark room with its heat and bad ventilation is thus avoided and in most cases good readings could be made from sunlight even without the darkening attachment.

Field Columbian Museum, Chicago, Feb. 1, 1898.

ART. XXXIX.—*On Clinohedrite, a new mineral from Franklin, N. J.*; by S. L. PENFIELD and H. W. FOOTE.

THE mineral that is to be described in the present paper was first brought to our notice in the autumn of 1896 by Mr. Frank L. Nason of West Haven, Conn., who sent a few specimens of it to the Mineralogical Laboratory of the Sheffield Scientific School for identification. When informed that the mineral was a new species Mr. Nason visited the locality for the special purpose of obtaining more material, but so little was found that it seemed best to postpone the investigation until more could be secured. About a year later Mr. E. P. Hancock of Burlington, N. J., sent some Franklin minerals to our laboratory for identification, among them specimens of the new mineral, and on learning the nature of the material he took a keen interest in having it investigated, generously placing at our disposal for that purpose the few specimens he had collected. A short time later Mr. W. F. Ferrier of Ottawa, Canada, also called our attention to an exceptionally fine specimen of the mineral, which he had had the good fortune to find at the locality.

The specimens were all obtained from the dump of one of the new shafts of the Trotter mine, and are supposed to have come from a depth of about one thousand feet. The mineral is associated with transparent prisms of green willemite, a massive variety of brown garnet, phlogopite mica, small yellow crystals of axinite, dull crystals of datolite, and a reddish-brown mineral, occurring in slender prismatic crystals, which is now being investigated, and proves to be a new silicate containing lead, iron and calcium as essential constituents.

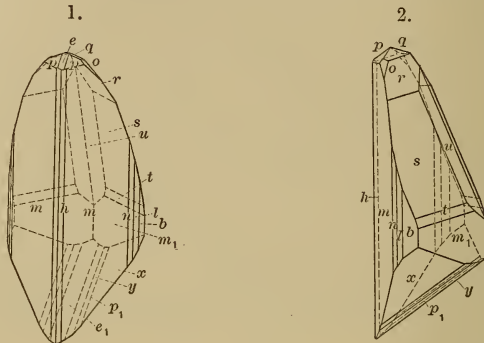
The crystallization is *monoclinic*, and the crystals are especially interesting as they belong to that division of the monoclinic system characterized by a plane of symmetry, but not an axis of symmetry, or to the class of crystals called by Groth* the "*domatische Klasse*." No form in this class consists of more than two faces, and the pinacoid $b, 010$, is the only one where the faces are parallel. The prevalence of forms without parallel faces gives to the crystals a peculiar *inclined faced* character or appearance, which has suggested the name of the mineral, *clinohedrite* ($\kappa\lambda\acute{\iota}\nu\epsilon\upsilon\upsilon$, incline, and $\epsilon\delta\rho\alpha$, face). Very few examples of this kind of symmetry have been observed among mineral substances, the best being some crystals of pyroxene described by Williams,† but pyroxene generally

* *Physikalische Krystallographie*, 3 Auflage, p. 356, 1895.

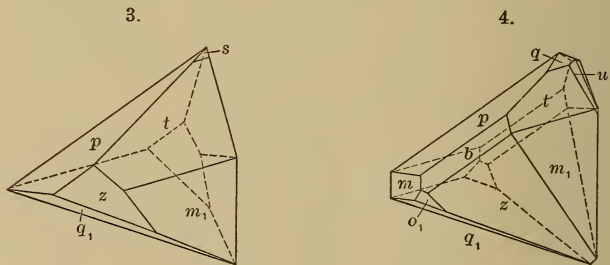
† *This Journal*, xxxviii, p. 115, 1889.

exhibits the normal or most highly developed type of monoclinic symmetry, and specimens which show the lower degree of symmetry are so rarely met with that it seems probable that they are only the result of an accidental development of a part of the crystal faces.

The crystals of clinohedrite on a specimen sent to us by Mr. Hancock were exceptionally fine and well adapted for crystallographic study. They were about 4^{mm} long, and from 2 to 3^{mm} in diameter, and had the habit represented in figs. 1 and 2, the



latter being drawn with the pinacoid $b, 010$, in front. They were generally attached at the end represented as the lower one in the figures, and the forms at that end, when they could be observed, were rounded and graded into one another so that



it was difficult to decide what ones were present and how they should be represented in the figure. At the upper, or free ends of the crystals, however, the faces were exceptionally perfect, and gave beautiful reflections. The crystals on the specimens sent by Mr. Nason were not so well suited for crystallographic study, several of the forms being striated and rounded, and it was so difficult to obtain satisfactory measurements that

the relations of the forms did not become wholly clear until the crystals from Mr. Hancock's specimen had been studied. Some of the crystals were 3^{mm} in diameter, and figs. 3 and 4, drawn in the same position as fig. 2, will serve to exhibit the curious habit which they present.

The position which has been adopted seems well suited for representing the forms of the crystals which are given in the following table:

$b, 010$	$n, 120$	$p, 111$	$r, \bar{3}31$	$o, \bar{1}31$
$h, 320$	$l, 130$	$p_1, \bar{1}1\bar{1}$	$s, \bar{5}51$	$o_1, 1\bar{3}\bar{1}$
$m, 110$	$e, 101$	$q, \bar{1}11$	$t, \bar{7}71$	$x, \bar{1}3\bar{1}$
$m_1, \bar{1}10$	$e_1, \bar{1}0\bar{1}$	$q_1, 11\bar{1}$	$u, \bar{5}31$	$y, \bar{1}2\bar{1}$

The form z , figs. 3 and 4, is probably $\bar{1}6\bar{1}$, but no measurements could be obtained from it.

The axial ratio was derived from the measurements marked by an asterisk in the accompanying table, and is as follows:

$$a : b : c = 0.6826 : 1 : 0.3226, \beta = 100 \wedge 001 = 76^\circ 4'$$

Following is a list of measurements with the calculated angles:

	Calculated.	Measured.	Calculated angle on $b, 010.$	Measured angle on $b, 010.$
$m \wedge m, 110 \wedge \bar{1}\bar{1}0 =$	67° 2'	66° 57'	56° 29'	56° 29'*
$h \wedge h, 320 \wedge 3\bar{2}0 =$	47 38	----	66 11	65 5
$n \wedge n, 120 \wedge 1\bar{2}0 =$	105 54	----	37 3	37 12
$l \wedge l, 130 \wedge 1\bar{3}0 =$	126 34	----	26 43	26 55
$p \wedge p, 111 \wedge 1\bar{1}\bar{1} =$	29 8	29 8*	75 26	----
$q \wedge q, \bar{1}11 \wedge \bar{1}\bar{1}1 =$	34 52	34 49	72 34	72 36
$r \wedge r, \bar{3}31 \wedge \bar{3}\bar{3}1 =$	63 15	62 56	58 22½	----
$s \wedge s, \bar{5}51 \wedge \bar{5}\bar{5}1 =$	67 43	67 43	56 8½	56 20
$t \wedge t, \bar{7}71 \wedge \bar{7}\bar{7}1 =$	68 32	----	55 44	----
$u \wedge u, \bar{5}31 \wedge \bar{5}\bar{3}1 =$	43 52	44 6	68 4	68 0
$x \wedge x, \bar{1}3\bar{1} \wedge \bar{1}\bar{3}\bar{1} =$	75 52	----	52 4	51 56
$y \wedge y, \bar{1}2\bar{1} \wedge \bar{1}\bar{2}\bar{1} =$	54 56	----	62 32	----
$p \wedge e, 111 \wedge 101 =$	14 34	14 36		
$m \wedge p, 110 \wedge 111 =$	51 54	51 54*		
$p \wedge q, 111 \wedge \bar{1}\bar{1}1 =$	58 37	58 29		
$q \wedge r, \bar{1}11 \wedge \bar{3}31 =$	36 21	36 20		
$r \wedge s, \bar{3}31 \wedge \bar{5}51 =$	12 45	12 44		
$s \wedge t, \bar{5}51 \wedge \bar{7}71 =$	5 50	5 47		
$y \wedge e_1, \bar{1}2\bar{1} \wedge \bar{1}0\bar{1} =$	27 28	27 42		
$b \wedge o, 010 \wedge \bar{1}31 =$	46 43	46 43		

The cleavage is perfect parallel to the pinacoid $b, 010$, but is not often observed. The hardness is 5.5 and the specific gravity 3.33. Many of the crystals are transparent, and the color varies from amethystine to nearly colorless or white.

The crystals exhibit very distinctly the phenomenon of pyroelectricity when tested with the red oxide of lead and sulphur method described by Kundt.* On cooling a crystal of the type represented by figs. 1 and 2 the p , e , and the upper extremities of the m faces in front became positively electrified and attracted the particles of sulphur, while the diagonally opposite faces x , y , p_1 , e_1 , and the lower extremities of m_1 became negatively electrified and attracted the red oxide of lead.

A section parallel to the pinacoid 010 when examined in polarized light showed an extinction of about 28° from the vertical axis in the obtuse angle β , and this direction corresponds to b . The plane of the optical axes is at right angles to 010. The crystallographic axis b is the obtuse bisectrix, and corresponds to c . The double refraction is not very strong, and is negative.

Material for the chemical analysis was first carefully selected by hand picking, and was then further purified by pulverizing and separating by means of the barium mercuric iodide solution. That portion which was used for the analysis varied in specific gravity between 3.344 and 3.327.

The method of analysis was as follows: Water was determined as loss on ignition, and the residue, after fusion with sodium carbonate, was dissolved in hydrochloric acid. The solution was evaporated twice to separate the silica, and in the filtrate from the silica the acid was neutralized with a slight excess of ammonia, formic acid of specific gravity 1.12 was added so as to make about one-fourth of the final volume, and hydrogen sulphide was passed into the hot solution until the zinc was precipitated. After filtering, the zinc sulphide was dissolved in hydrochloric acid, and the zinc reprecipitated as carbonate and weighed as oxide. In the filtrate from the zinc the small quantities of iron and alumina were precipitated twice with ammonia. To the filtrates acidified with hydrochloric acid bromine was added, and on making alkaline and heating to boiling all of the manganese was precipitated, but as it carried a little calcium it was redissolved, precipitated from an acetic acid solution with bromine, and finally determined as pyrophosphate. Calcium and the trace of magnesium were separated and determined in the usual manner.

The results of the analysis by Foote are as follows:

* Ann. d. Phys. u. Chem., xx, p. 592, 1883.

	I.	II.	Average.	Ratio.		Theory for H ₂ CaZnSiO ₅ .
SiO ₂	27·14	27·29	27·22	·454	0·97	27·92
ZnO	37·43	37·46	37·44	·462	} ·469	1·00
MnO	·49	·50	·50	·007		
CaO	26·31	26·19	26·25	·469	} ·471	1·00
MgO	·07	·08	·07	·002		
H ₂ O	8·53	8·59	8·56	·476	1·01	8·37
(Fe. Al) ₂ O ₃	·26	·31	·28			
			100·32			100·00

The ratio of SiO₂ : (Zn + Mn)O : (Ca + Mg)O : H₂O is very nearly 1 : 1 : 1 : 1, from which the formula H₂ZnCaSiO₅ is derived, in which the zinc and calcium are replaced to a slight extent by manganese and magnesium respectively. The formula may also be written (ZnOH)(CaOH)SiO₅, and that hydroxyl is present is proved by the fact that water is not expelled much below a faint redness. The formula is analogous to that of calamine H₂Zn₂SiO₅ or (ZnOH)₂SiO₅.

The pyrognostic properties are as follows: In the closed tube at a gentle heat the mineral is unchanged, but at a temperature approaching faint redness it exfoliates, whitens and gives off water. Heated before the blowpipe the mineral exfoliates at first, and then fuses at about 4 to a yellowish enamel. A coating of zinc oxide is obtained when the mineral is heated alone or with a little sodium carbonate on charcoal. The powdered material dissolves readily in hydrochloric acid, and gelatinous silica is obtained when the solution is evaporated.

In conclusion we take great pleasure in expressing our sincere thanks to Messrs. F. L. Nason and E. P. Hancock, who have generously placed at our disposal all of the specimens of this rare mineral which they have been able to collect.

Mineralogical-Petrographical Laboratory,
Sheffield Scientific School, March, 1898.

ART. XL.—*On Rhodolite, a new variety of garnet*; by
W. E. HIDDEN and J. H. PRATT.

DURING the past fifteen years there has been found from time to time, over a very limited area of western North Carolina, a variety of garnet which is strikingly beautiful and quite novel in several respects. It has been called "rose-garnet," almandine and has also received other strictly local names; among mineralogists it has excited unusual interest and admiration.

The peculiarities which distinguish this garnet from the ordinary occurrences of the species are: its variety of shades and tints, for the most part similar to those belonging to the rhododendrons and roses; its surprisingly small amount of coloring matter; its gem-like transparency; its freedom from internal imperfections, microscopic inclusions and striæ, all so universally characteristic of common garnets; also its remarkable brilliancy when cut as a gem. There is but one variety of garnet now known, which approaches it in this last respect, when in the gem form, and that is the *green* demantoid of Siberia, which often vies with the diamond in its luster and dispersive effect upon light. Most garnets are beautiful only by *transmitted* light and then exhibit only dark shades of color, while these new garnets give most beautiful effects of brilliant and varied coloring by *reflected* light alone; thus proving the uncommon purity and great clearness of this new material.

These garnets occur as one of the pebbly constituents of the gravel-beds and they are found much after the manner of mining for "placer" gold, where hydraulic processes are used. The exact place or ledge from which they have been derived has not, as yet, been discovered, but similar material of an inferior grade has been found *in situ* at one place accompanied by much pyrite and biotite.

The locality is situated in Macon County, North Carolina, upon a brook known as Mason's Branch. This brook flows southwestward from Lyle Knob (a spur of the Cowee Mountains). Franklin, the county seat, is about six miles distant. The associated minerals, in the gravels, are: Quartz, rarely as isometric pseudomorphous dodecahedrons; small rough garnets of a dark pyrope nature; small corundum crystals, of pale blue, amethystine and pink shades, sometimes with a distinct ruby tendency; spinel, the pleonaste and gahnite varieties; bronzite (transparent); iolite (colorless); cyanite; fibrolite; hornblende; staurolite (often clear and glassy); rutile; menacanite; chromite (rare); monazite (rarely green); zircon; gold

and sperrylite in minute quantities, and also several as yet unidentified species. It is our intention to publish a description of some of these accompanying minerals in the near future.

As yet no crystals of the new garnet have been found, all the material occurring as rolled pebbles, fragmentary masses or as highly etched (naturally corroded) pieces. The predominant color is a pale rosy tint inclining to purple, and some carefully selected pieces of this character, which showed no inclusions under the magnifying glass, were used for the chemical analysis.

In the analyses, silica and the bases were determined by the well known methods. Ferrous and ferric oxides were determined by the method described by one of us.* The results of the analyses are given below together with the specific gravity which was determined upon two separate samples.

Specific gravity = 3.837—3.838.

	I.	II.	III.	Average.	Ratio.	
SiO ₂	41.54	41.65		41.59	.693	= 3.
Al ₂ O ₃		23.26	23.10	23.13	.226	} .237 = 1.02
Fe ₂ O ₃	1.88	1.92		1.90	.011	
FeO	15.48	15.63		15.55	.216	
MgO		16.90	17.48	17.23	.437	} .669 = 2.89
CaO	1.02	.86		.92	.016	
				100.32		

The ratio of R''O : R'''₂O₃ : SiO₂ is nearly 3 : 1 : 3, which would give the general formula 3R''O . R'''₂O₃ . 3SiO₂ or R''₃R'''₂(SiO₄)₃ which classifies this mineral as one of the garnets. The ratio of MgO to FeO (.437 : .216) is almost exactly 2 : 1, which would indicate that the mineral is composed of two molecules of a magnesium-aluminum garnet (pyrope) and one molecule of a ferrous iron-aluminum garnet (almandite). The theoretical composition calculated for this ratio is given below, together with the analysis after substituting for Fe₂O₃ its equivalent of Al₂O₃ and for CaO its equivalent of MgO and then recalculating to 100 per cent :

	Analysis recalculated.	Theory for 2Mg ₃ Al ₂ (SiO ₄) ₃ . Fe ₃ Al ₂ (SiO ₄) ₃ .
SiO ₂	41.76	41.48
Al ₂ O ₃	24.41	23.50
FeO	15.62	16.59
MgO	18.21	18.43
	100.00	100.00

* J. H. Pratt in this Journal, vol. xlviii, 1894, p. 149.

Although the agreement of the analysis, as deduced, and the theory is not absolutely close, it must still be regarded as on the whole satisfactory and the formula $2\text{Mg}_3\text{Al}_2(\text{SiO}_4)_3 \cdot \text{Fe}_3\text{Al}_2(\text{SiO}_4)_3$ may be accepted as expressing the composition of this mineral.

The analysis proves that this garnet is not almandine nor wholly pyrope and is distinctive enough in color alone to merit a varietal name. We, therefore, propose the name of *Rhodolite*, from the two Greek words *ῥόδον*, a rose, *λίθος*, a stone, as an appropriate name for this new gem. This name has been selected as describing its most prominent character, namely, its delicate rose-like color. It will be seen that these new gems are very unlike all kinds of garnets hitherto described.

Cowee Valley, N. C., March 14, 1898.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the Solubilities of Liquids.*—Several years ago Alexéeff called attention to the solubility of liquids in each other and showed that in the case of mixtures of aniline, phenol and water, it is often difficult to distinguish between the solvent and the dissolved substance. The same condition has now been observed by AIGNAN and DUGAS in the case of mixtures of acetic acid and benzene, which in various proportions become homogeneous at different temperatures. Thus for example :

Acetic acid	30 ^{cc}	40 ^{cc}	50 ^{cc}	60 ^{cc}	70 ^{cc}
Benzene	70 ^{cc}	60 ^{cc}	50 ^{cc}	40 ^{cc}	30 ^{cc}
Temperature of } homogeneity }	102°	75°	50°	30°	2·5°

The authors show that if V_a and V_b represent the respective volumes of two liquids A and B, which are introduced into the sealed glass tube, if α and β be their reciprocal solubility coefficients, and if V_1 and V_2 be the volumes of the two layers of liquid respectively, A saturated with B and B saturated with A, then

$$\frac{V_1}{V_2} = \frac{1 + \beta}{1 + \alpha} \cdot \frac{V_a - \alpha V_b}{V_b - \beta V_a}$$

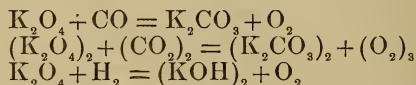
They also point out that a similar relation holds if masses be taken in place of volumes. It follows therefore that when the temperature varies, if α tends towards the value V_a/V_b , the numerator of the first member, V_1 should tend towards zero; while if β tends towards the value V_a/V_b , then V_2 should tend towards zero. Hence it is necessary to notice toward which extremity of the tube the surface of separation of the liquid disappears on heating. With the mixtures named above, when the per cent of acetic acid is 30, 40 or 50, the surface of separation tends towards the bottom of the tube; so that saturated solutions of acetic acid in benzene occur at 75° and 50°; while with 60 and 70 per cent of acetic acid, the disappearance of the surface of separation tends towards the top of the tube; so that at 30° and 2·5°, the solutions are saturated solutions of benzene in acetic acid.—*C. R.*, cxxv, 498–500, October 1897. G. F. B.

2. *On the Thermodynamics of the Swelling of Starch and the Determination thereby of its Molecular Mass.*—An investigation upon the thermodynamics of the phenomenon of the swelling of starch has been made by RODEWALD. He defines the term "swelling" to be the absorption of water or other liquid by a solid substance which does not show either visible or microscopic pores. The expression which he has deduced from thermodynamical considerations, for the heat set free, in terms of the

change of specific volume, is $r = T [dp/dt(s' - s) - y]$. The experimental work was done mostly upon starch. This substance, when air dried, was found to contain about 16.33 per cent of water. By means of an ice calorimeter, the heat which is produced by soaking in water starches having originally different amounts of moisture was determined, the results being tabulated and plotted as a curve. The contraction in volume as a function of the percentage of water, was also noted and plotted; the curve being similar to the heat curve. From the values of the heat change and the volume change for the dry and moist starch, dp/dt and y in the equation given above are obtained; thus giving the numerical equation $r = 273(s' - s)1.75 - 0.00507$. Next, the author deduces a relation between the heat of swelling (and hence the volume change) and the water content and thus derives the equation $\log(s' - s)w = 0.8 - 2 - 0.0423w$. Consequently when $w = 31.63$, $\gamma = 0$. An expression given by Kirchhoff for the vapor pressure of sulphuric acid solutions is used to calculate that of the starch; the result being 4.5594 for a content of 31.63 per cent of water. The author deduces from this calculated value of the vapor pressure, the number 4370 as the molecular mass of starch; corresponding to the formula $C_{162}H_{270}O_{136}$. Moreover, he finds the expansion-coefficient to be a linear function of the content of water. And he calculates the attractive force between dry starch and moisture as 2073 kilograms per square centimeter.—*Zeitschr. Phys. Chem.*, xxiv, 193–218, October 1897.

G. F. B.

3. *On the Evolution of Oxygen during Reduction.*—When rubidium dioxide is reduced by hydrogen, oxygen is evolved; a fact which Erdmann attempted to explain by supposing the intermediate formation of hydrogen peroxide. FRENZEL, FRITZ, and VICTOR MEYER have now made experiments to test this explanation, in some of which the formation of hydrogen peroxide was not possible. Thus on heating potassium peroxide to the softening point of glass (the vessel being of silver) in a current of air, no oxygen is evolved. But when heated in carbon monoxide, carbon dioxide, or hydrogen, to the boiling point of sulphur, a considerable amount of oxygen is set free. Now in the case of carbon monoxide, as well as in that of the dioxide, the formation of hydrogen peroxide as an intermediate product is impossible. So that the three reactions appear to be analogous:



Again, silver oxide decomposes when heated to 250° in a current of air; but in hydrogen it yields free oxygen even when heated only to the boiling point of water. Indeed, it evolves oxygen in carbon monoxide even at the ordinary temperature; the fact being that a portion of the oxide in reduction evolves sufficient heat to raise the temperature of the rest above the decomposing

point. Potassium permanganate acted similarly. This salt decomposes at 218° in air; but in hydrogen it begins to evolve oxygen at 155° and gives it off freely at 182° . Barium peroxide does not give off oxygen during reduction.—*Ber. Berl. Chem. Ges.*, xxx, 2515–2519, November 1897.

G. F. B.

4. *On Chromium Tetroxide and Perchromates.*—It has been observed by WIEDE that on cautiously treating with ammonia the blue solution obtained by extracting a mixture of hydrogen peroxide and chromium trioxide with ether, the color gradually disappears, and on sufficient cooling the underlying aqueous layer takes a deep brown color and deposits a greenish-brown precipitate on standing. On dissolving this in warm 10 per cent solution of ammonia, and allowing it to cool, pale brown needles separate having the composition $(\text{NH}_3)_3\text{CrO}_4$. The new compound dissolves in water, suffering partial decomposition, evolves oxygen when treated with strong acids and explodes when heated. If treated with alkalis or if the ethereal solution itself is treated with a concentrated solution of potassium or sodium hydrate instead of ammonia only alkali chromates are formed. On using substituted ammonias, corresponding perchromates are formed. When for example the ethereal solution is treated with pyridine and the ether is evaporated in a rapid current of air, blue scales are produced. And if one of these be placed in the ethereal solution after the pyridine has been added, long dark blue glistening prisms gradually form having the composition $\text{H} \cdot \text{C}_5\text{NH}_5\text{CrO}_6$. These crystals are so unstable that they explode violently even at the summer temperature. But if dry, they can be kept for weeks in the cold; though when moist they decompose rapidly. It is soluble in most of the neutral organic solvents, and is acted upon only gradually by potassium permanganate in acid solution. Aniline, when added to the ethereal solution of perchromic acid, gives, on diluting the solution with an equal volume of light petroleum naphtha, dark red crystals, $\text{H} \cdot \text{NH}_2\text{Ph} \cdot \text{CrO}_6$ resembling potassium permanganate. It is even more explosive than the pyridine compound.—*Ber. Berl. Chem. Ges.*, xxx, 2178–2189, October 1897.

G. F. B.

5. *On Potassium Percarbonate.*—It has been shown by Constan and von Hansen that in very concentrated solutions, the alkali carbonates will dissociate into the ions $\overset{+}{\text{M}}$ and MCO_3^- , the latter uniting, on being set free by electrolysis at the anode, to form percarbonates $\text{M}_2\text{C}_2\text{O}_6$. If a solution of potassium carbonate be electrolyzed the evolution of oxygen decreases as the temperature falls, becoming almost nil at -10° . At the same time in place of the hydrogen-potassium carbonate which at first forms at the anode, there is produced a bluish amorphous powder consisting of potassium percarbonate. VON HANSEN has further studied this reaction and finds that if the density of the solution of potassium carbonate surrounding the anode is not allowed to fall below 1.52, small temperature variations do not markedly affect the yield, even when it rises to 0° . When the concentration falls,

even a very little below saturation, the yield falls off greatly. High current density at the anode is also essential. When this is only 0.5 to 2 amperes per square decimeter, the product contains only from 25 to 55 per cent of percarbonate; while with a density of from 30 to 60 amperes per square decimeter, it may contain as much as 85 to 95 per cent. By allowing the saturated solution of potassium carbonate to flow slowly in at the bottom of the anode compartment of the electrolytic cell, the best results are obtained. The solution which has already undergone electrolysis floats on this, the solid percarbonate remaining suspended in it slowly flows away; and the percarbonate is collected and dried on a porous plate. From 2.2 to 2.4 grams of percarbonate, containing 87 to 93 per cent, is obtained per ampere hour. When dry the percarbonate is only slowly decomposed at 100°, its rapid decomposition requiring 200° to 300°. In aqueous solution, it decomposes slowly at the ordinary temperature, rapidly at 45°. When perfectly dry, it may be preserved almost without change. It is very little soluble in alcohol, but extremely soluble in water. It may be purified by digestion at -5° to -10° with concentrated potash solution which dissolves the bicarbonate. The remaining solid after washing with alcohol contains 95 to 99 per cent of percarbonate.—*Zeitschr. Elektrochem.*, iii, 137144, 445-448, Oct. 1896, April 1897. G. F. B.

6. *On the Formation of Natural Petroleum and the Spontaneous Polymerization of Hydrocarbons.*—While the hypothesis that natural petroleum has for the most part been produced by the distillation under pressure of animal fats, and hence accounts for their small content of nitrogen, it fails to account for the high molecular mass, boiling point and density of certain of its constituents; it being well known that the product of the artificial distillation of such fats are mainly low boiling light hydrocarbons. ENGLER now proposes to ascribe this high molecular mass, boiling point and density to the gradual polymerization of the light hydrocarbons first formed, and has obtained considerable evidence of such changes. Thus samples of Galician petroleum increased in density by 0.0011-0.0015 in about three weeks, while a Javanese petroleum increased by 0.01 in a few days. Distillates from coal tar showed similar results. The fractions obtained by the distillation of fats under pressure were then examined and proved to undergo a similar condensation. In one case the density increased by about 0.002 in a month; while in five other cases, there was an increase of density in nine years of 0.016. Since the time which has elapsed since the production of petroleum is very great, it appears probable that its present high density may have been acquired in this way.—*Ber. Berl. Chem. Ges.*, xxx, 2358-2365, October 1897. G. F. B.

7. *The Sun's Place in Nature*; by SIR NORMAN LOCKYER, K.C.B., F.R.S., etc., 8vo, pp. xvi, 360. London, 1897 (The Macmillan Co., Limited).—This book is a summary of the evidence which its industrious author has been for many years collecting as to

the exact position which our sun, judged by spectroscopic evidence, should occupy among its fellows. In his previous volume, "The Meteoritic Hypothesis," he has brought forward the arguments for believing that the primordial matter was not, as the Nebular Theory assumes, an intensely heated glowing gas, but was a meteoric swarm or a congeries of such swarms, which by condensation and consequently closer and more frequent impact, produced an increasing heat and continued to rise in temperature until the loss became equal to the gain. Hence he says: "The idea which one arrives at by a discussion of all the spectroscopic facts is that we begin with a condition in which meteorites in swarms and streams are very far apart, and from the collisions of these a spectrum results which gives us bright flutings and lines, in other words the spectrum of the nebulae; when they become a little more dense, we get the bright line stars; and as they become denser still we find the stars with a mixture of bright and dark flutings. Then still more condensation and dark lines and at length the highest temperature of all; after which begins a descent on the other side till at last we end in cool dark bodies like the earth and moon." Of his five groups, the author selects the Orion nebula as the type of the first, α Herculis as the type of the second, α Cygni as that of the third, Sirius as that of the fourth and Arcturus as that of the fifth. The maximum temperature being reached in the fourth group, those stars in previous groups are rising and those in succeeding groups are falling in temperature, our own sun belonging to the fifth. While broadly speaking the hypothesis before us is a real advance over its predecessor, yet as to matters of detail it has not received, we believe, the general assent of astronomical spectroscopists. Thus, for example, it is extremely difficult if not in many cases impossible to distinguish a star of the third group from one of the fifth; i. e., a star which is supposed to be rising in temperature from one which is falling. Still the book places the arguments in a clear light and cannot fail to be of use in helping us to reach a final conclusion.

G. F. B.

8. *Nature of Röntgen Rays.*—Professor G. G. Stokes states his belief that these rays are transverse vibrations of the ether, and that the cathode rays are streams of rapidly-moving particles. He conceives of the apparent transparency of thin aluminum plates to the cathode rays as the result of a process similar to that which happens to a copper plate immersed in a sulphate of copper solution which is undergoing electrolysis. On one side copper is separated, on the other is dissolved. The deflection of the cathode rays by magnetic and electrostatic force, Stokes regards as a great objection to their being considered light rays. According to his views the Röntgen rays are impulses, and not vibrations.—*Manchester Memoirs*, 41, Part iv, 1896–97. J. T.

9. *Impulse theory of X-rays.*—Following Professor Stokes, Professor J. J. Thomson has elaborated the impulse theory of X-rays from the point of view of the electro-magnetic theory of light. When a rapidly-moving electrified particle is stopped,

its electro-magnetic energy may be transformed into waves which are identical with light waves. Professor Thomson gives the equations of condition for such a moving particle, and shows that they lead to the conclusion that in the X-ray phenomena two waves result from the electric impulses, one of which is a spherical wave and the other a plane wave. The dimensions of the plane waves are extremely small. The X-ray effects are therefore produced at the surfaces where the electrified moving particles are stopped.—*Phil. Mag.*, February, 1898. J. T.

10. *Acoustic phenomena in the Electric Arc.*—The initial resistance of the voltaic arc is largely determined by the density of the surrounding air. If a sound wave travels through the gaseous layer of the voltaic arc, there arise periodic changes in the transitional resistance, and consequently similar periodic changes result in the current strength. These changes can be studied in neighboring telephone circuits. H. Th. Simon has made a careful study of these phenomena, and makes a calculation of the change of temperature produced by a sound wave passing through the heated gas of the arc; and also of the change of pressure which might result in the gas. Lord Rayleigh has estimated that the least change of pressure which can produce an appreciable tone in ordinary air has the value $\Delta p = 6 \cdot 10^{-9}$ atmosphere. Simon finds $\Delta p = 9 \cdot 10^{-5}$ atmosphere, and states that the discrepancy probably arises from the presence of harmonics. Recent experiments in the Jefferson Physical Laboratory with a large storage battery show that the discharge of this battery through vacuum tubes is accompanied by a high note which rises in pitch as the resistance external to the tube is increased.—*Wied. Ann.*, No. 2, 1898, pp. 233-239. J. T.

11. *Time of vibration of very high notes.*—It is well recognized that the measurement of high notes is very difficult and Ant. Appunn discusses the conditions for the investigation of such high periods, and describes a series of pipes constructed by him which gave vibrations extending from 2500 vibrations a second to 50,000 per second. The length of the pipe which gave 50,000 per second is 1.28 millimeters.—*Wied. Ann.*, No. 2, 1898, pp. 409-416. J. T.

12. *Electrical excitation.*—Many attempts have been made to explain contact electricity by the laws of electrolysis, and thus to connect it with the chemical and physical nature of the substances. Alfred Coehn discusses the various theories of ions and ion concentration, and formulates the law that matter of higher dielectric constants charge themselves positively by contact with matter of lower dielectric constants. There are notable exceptions to this law.—*Wied. Ann.*, No. 2, 1898, pp. 217-232. J. T.

13. *A Manual of Experiments in Physics; Laboratory Instruction for college classes;* by JOSEPH S. AMES and WILLIAM J. A. BLISS.—This volume is a companion to the Theory of Physics, by Professor Ames, which was noticed in the number of this *Journal* for June, 1897. The long experience of the author as a teacher of

physics, which enabled him in this first volume to develop with unusual clearness and method the principles involved in physical phenomena, has now aided him in the description of a series of laboratory experiments for college classes. This work, in the preparation of which he has been associated with Dr. Bliss, is on a decidedly higher level than most of those which have been published hitherto. The experiments are selected with judgment and the method of presentation has much to be recommended, not only in the fullness and accuracy of statement but still more as regards the prominence given to the statement of the general theory involved in each and the object for which it is performed. In developing these points, reference is constantly made to the companion volume, and the student who uses the two works conscientiously cannot make the mistake so common of performing an experiment blindly, without understanding why it has been done or what physical principles it illustrates. Each experiment is accompanied by a practical illustration, drawn out numerically in full, and a series of questions and problems follow; these last bear particularly upon the sources of error involved and the degree of accuracy possible in each case.

II. GEOLOGY AND MINERALOGY.

1. *Recent Publications of the U. S. Geological Survey*.*—The Eighteenth Annual Report for 1896-7 has five parts, of which Part i, *Report of the Director*; Part v, *Mineral Resources*, and two papers of Part iii, *Economic Geology*, have already been issued. The remaining papers of Part iii, and Part iv, *Hydrography*, will soon appear. Those of Part ii are of a theoretical nature and will appear last. The report of the Director with an appendix on Triangulation and Spirit leveling contains 440 pages with two maps showing the condition and progress of astronomic location, primary triangulation, traverse and precise leveling, topographic surveys, and gauging stations. The total appropriation for the work of the Survey during the year was \$568,690, of which \$184,200 was for topography, \$118,700 for geology, \$14,000 for paleontology, \$10,000 for chemistry, \$50,000 for hydrography, and \$30,000 for preparation of report on mineral resources. There were thirty geological field parties in as many States and Territories. Most of the geologists continued the areal and structural work of former years. N. S. Shaler completed his investigations on Cape Cod and took up the Mesozoic coal basin near Richmond, Va.; B. K. Emerson extended his work in Mass.; T. Nelson Dale in eastern New York and Vt.; J. F. Kemp in the Adirondack region; W. H. Hobbs in western Mass. and Conn.; J. E. Wolff, assisted by A. H. Brooks, coöperating with the State Survey in New Jersey; M. R. Campbell, assisted by J. A. Taff and W. C. Mendenhall, in Kentucky and

* Issued since May, 1897. See lists in this Journal for Aug. 1897, page 155, and for Nov. 1897, page 392.

Tenn.; C. W. Hayes in Ga. and Ala.; Arthur Keith in Va., Md. and N. C.; W. B. Clark in N. J., Md. and Del.; N. H. Darton in the District of Columbia, Md. and Va., besides a large amount of hydrographic work in S. Dak. and Nebraska; C. R. Van Hise, assisted by W. S. Bayley, J. M. Clements and S. Weidman, in the Menominee iron region of Lake Superior; R. T. Hill and T. W. Vaughan in Texas and Indian Territory; W. H. Weed assisted by L. V. Pirsson in Montana and Arkansas; R. C. Hills in Colo.; C. W. Cross, assisted by A. C. Spencer and C. W. Purington, in Colo.; W. Lindgren in Idaho; H. W. Turner, A. C. Lawson and J. C. Branner in California; J. S. Diller, assisted by A. J. Collier, in Oregon; Bailey Willis, assisted by I. C. Russell and G. O. Smith, in Washington. Special surveys were made in the Yukon gold region of Alaska by J. E. Spurr, H. B. Goodrich and F. C. Schrader; S. F. Emmons, assisted by G. W. Tower, made a special study of the mining district of Butte, Montana; G. H. Eldridge surveyed the phosphate rocks of Florida; C. D. White extended his studies of the coal floras of the Carboniferous in Ky., Tenn., Penn. and Ohio; T. C. Chamberlin, in general charge, assisted by Frank Leverett, H. B. Kummell, W. C. Alden and J. E. Todd, extended their glacial investigations in Iowa, Mo., Ind., Ills., Ky. and N. Y.; G. K. Gilbert made a special study of the region of the Great Lakes; the Director (C. D. Walcott), assisted by F. B. Weeks, studied the Cambrian in southwest Nevada and California. Of the paleontologists: G. H. Girty studied the Paleozoic in Ohio; T. W. Stanton the animals, and F. H. Knowlton the plants of the Cretaceous in Colorado, Wyoming and Montana; W. H. Dall the Tertiary among the large collections in the Smithsonian Institution; L. F. Ward the Cretaceous Paleobotany in Maryland and Virginia. Thirteen pages of the report are devoted to the hydrographic work at 109 stations in 22 States. The total value of the mineral resources for 1896 was \$623,717,288, with only about one-twentieth of the normal annual increase over that of 1895.

The two economic papers of Part iii which have already appeared are:—

Reconnaissance of the Gold Fields of Southern Alaska, with some notes on the General Geology by G. F. Becker, pp. 1-86, 23 plates including 2 maps.

Geology of the Yukon Gold District, Alaska, by J. E. Spurr, with chapter on the History and Conditions of the District to 1897 by H. B. Goodrich, pp. 1-392, and 20 plates including 12 maps, of which 5 in colors are geological.

To meet the great demand for information concerning the gold region of Alaska, a pamphlet of 44 pages with 1 map showing routes of travel and distribution of gold-bearing rocks in Alaska has been issued by the Geological Survey.* It was prepared by S. F. Emmons chiefly from the papers of Spurr and Becker, using the Coast Survey chart T as topographic base.

* See p. 305 of this number.

Bulletin No. 149, *Bibliography and Index of North American Geology, Paleontology and Mineralogy for 1896*, by F. B. Weeks, contains 152 pages. The bibliography consists of papers and references classified by authors. In the index the classification is by subject and thus rendered especially useful.

The following folios have been issued :

- No. 31. Pyramid Peak, Colorado, by W. Lindgren.
 33. Briceville, Tennessee, by Arthur Keith.
 34. Buchanan, West Virginia, by J. A. Taff and A. H. Brooks.
 35. Gadsden, Alabama, by C. W. Hayes.
 36. Pueblo, Colorado, by G. K. Gilbert.
 37. Downieville, California, by H. W. Turner.

The Pueblo Folio of Colorado was prepared for laymen as well as geologists, and is an excellent model of its kind. The structure of the western edge of the great plains is well shown and its geological development described. Among the novel features are tepee buttes, whose form suggests the name and whose origin is ascribed to limestones standing vertically in the Pierre shales. A special sheet illustrates the deformation of the Dakota sandstone. Being very porous, this sandstone is the chief reservoir for underground water. The water resources are shown by a map upon which the areas yielding flowing wells and pumping wells are distinguished, and by contours the depth is indicated at which the water will be found.

Recognizing the important bearing of the hydrographic investigations in charge of N. H. Newell upon the agricultural resources of much of the western country, the work and publications in that line have been greatly extended. Besides the forthcoming Part iv of the Eighteenth Annual, which is devoted exclusively to hydrography, a series of twelve water-supply papers have been issued discussing the probabilities and methods of using to greatest advantage the water-supply of certain districts.

J. S. D.

2. *The Gold fields of Alaska*.—Three important contributions to the knowledge of the mineral resources of Alaska have been recently prepared by the United States Geological Survey.* Using these as his chief sources of information, Mr. S. F. Emmons has now prepared a pamphlet† to accompany a map of Alaska showing the known gold-bearing rocks.

* 1. Coal and Lignite of Alaska, by W. H. Dall. 17th Ann. Rept. U. S. Geol. Survey, Pt. 1. Washington, 1896.

2. Reconnaissance of the Gold fields of Southern Alaska by Geo. F. Becker. 18th Ann. Rept. U. S. Geol. Survey, Part iii, pp. 1-86. Washington, 1898.

3. Geology of the Yukon Gold District, Alaska, by J. E. Spurr with introductory chapter by H. B. Goodrich. *Ibid.*, pp. 101-391.

† Map of Alaska showing known gold-bearing rocks, with descriptive text containing sketches of the geography, geology, and gold deposits and routes to the gold fields, by S. F. Emmons, pp. 1-44. U. S. Geological Survey, Washington, 1898. The base used for the geological map is a part of chart T of the U. S. Coast and Geodetic Survey. Edition of June, 1897.

From this pamphlet we quote at some length below. It contains a brief historical introduction and reference to available literature; a geographical sketch describing the region, the rivers, climatic conditions and routes to the Klondike. Then follow some twenty pages sketching the geological features. The latter are more elaborately described in the second and third reports named, by Messrs. G. F. Becker and J. E. Spurr, and the coal deposits are described in Mr. Wm. H. Dall's report.

The original deposits of gold, or quartz veins have been noted in the coastal region as well as in the interior.

"At present, so far as known, it is only in the coastal region that deep mining is being carried on in gold-bearing veins. Here it has become a well-established industry, and many large quartz mills are running on the ore extracted from these veins. The principal deposits are found in a belt somewhat over 100 miles in length on the seaward slope of the mainland, reaching from Sumdum on the southeast past Juneau to Berners Bay near Seward on the northwest. This belt may be also considered to include the deposits on Admiralty and other islands. A second belt, further west, is represented by the deposits on the western side of Baranof Island, not far from Sitka. The ores, though not always exceptionally rich, are worked at a good profit because of the natural facilities of the region for cheap reduction. The most notable instance of this is the great Alaska-Treadwell mine, which has extracted over seven million dollars' worth of gold from an ore carrying \$3.20 a ton, which is worked at an average cost of \$1.35.

The deposits occur in metamorphic slates, diabases, and granites, all similar to the rocks of the auriferous belt of California, and probably, like those, they are of post-Jurassic age.

At Uyak Bay, on Kadiak Island, gold deposits in slates are being worked, and the gold-bearing beach sands of the western end of that island and at Portage Bay and the Ayakulik River on the neighboring mainland are apparently derived from metamorphic slates associated with granite, so that it is possible that these more recent gold-bearing rocks extend that far westward. On Unga Island, of the Shumagin group, still further west, gold occurs in eruptive andesites of Tertiary age, and several mines have been opened on these deposits, the most important of which is the Appollo, one of the most successful in the province. . . .

In the Yukon Basin the gold, so far as known at present, is derived from a much older series of rocks, for the gold-bearing slates of the coastal region have not yet been recognized there. While the exact age of these gold-bearing rocks has not yet been determined, they are known to be older than the limestones supposed to represent the Carboniferous and Devonian formations of the Cordilleran system; hence they are probably pre-Paleozoic, and in part are possibly as old as the Archean.

These rocks have been classified by Spurr as follows:

Later Tertiary beds	}	Tertiary.
Kenai series		
Mission Creek series		—Cretaceous.
Tahkandit series		—Carboniferous and Devonian.
Rampart series	}	? pre-Paleozoic.
Fortymile series		
Birch Creek series		
Basal granite-schist.		

Birch Creek series.—Resting upon the fundamental granite is a series of rocks, roughly estimated as possibly 25,000 feet in thickness, named the Birch Creek series, from the place of their typical occurrence. They consist mainly of quartzitic rocks, generally thin-bedded or schistose, so that they pass into mica-schist; in some places they contain carbonaceous matter and develop graphitic schists. There are also bands which probably originated as intrusive rocks, but which by compression have become schistose like the other members. These rocks have abundant quartz veins; they are generally parallel to the schistosity or bedding, small, and not persistent, but some cross the bedding and are then wider. They carry gold with abundant pyrites, and sometimes galena. They are often broken and faulted.

Fortymile series.—Younger than the Birch Creek series, but in general closely associated therewith, is another thick series of rocks, called the Fortymile series because of their development on Fortymile Creek. They are characterized by alternations of beds of marble, from a few inches up to 50 feet in thickness, with quartzites, which pass into micaceous, hornblendic, or garnetiferous, and sometimes graphitic schists. They are traversed by abundant dikes of eruptive rock, mostly granites and diorites. Two sets of quartz veins are developed in these rocks: (1) an older set, which are generally parallel to the schistosity or lamination, like those in the Birch Creek series, and like them are broken by later movements and carry pyrite and occasionally galena; (2) a set of larger veins, which form an apparent transition from dikes of aplite. They cut across the bedding and are not disturbed by later rock movements, hence are younger in age.

Rampart series.—This still later series is primarily distinguished from the preceding by the darker color of its rocks, which are dark-green when fresh and become a dark-red by weathering. They consist largely of basic eruptive materials, beds of diabase and tuffaceous sediments, with hard green shales and some limestones containing glauconite. They also contain novaculites and jasperoids, or secondary quartzose rocks which are at times glauconitic. Serpentine and chlorite are frequent alteration products. These rocks also contain a few quartz and calcite veins, which are generally developed along shear zones. The basic character of these rocks and their large content of pyrite seem favorable to the concentration of ore deposits; but the observed veins are younger than the joints and shear planes,

which were probably produced by the rock movements that crushed the veins of the older series, and assays of their ores have as yet shown but insignificant amounts of gold and silver. These veins, like those in the granite, are much less abundant than those in the Birch Creek and Fortymile series; hence it is thought that the latter are probably the principal source of gold in the placers.

The younger rock series noted are, briefly, the following:

Tahkandit series.—This is a temporary division made for purposes of mapping and consists of limestones, sometimes white and crystalline, generally green or black, alternating with shales. In certain localities, notably on the Tahkandit River, it has conglomerates carrying greenish pebbles supposed to be derived from the rocks of the Rampart series; thus an unconformity or erosion interval is suspected. In the beds of this series have been found fossils of Carboniferous age and plants of Devonian aspect.

Mission Creek series.—Later than the Tahkandit series, but, like it, not very well defined, is the Mission Creek series, consisting of shales and thin-bedded limestones with gray sandstones. Locally there are thin beds of impure lignite and at the base a conglomerate containing pebbles not completely rounded derived from older rocks in the neighborhood, which sometimes carries gold. The beds of this series are sometimes altered and sharply upturned and folded, but generally have a rather fresh appearance. In the neighborhood of shear zones they are impregnated with pyrite and carry small quartz veins. The limited exploration of these rocks has developed no important deposits of mineral. The age of the beds is as yet uncertain, but they are in part as late as Cretaceous. They sometimes overtop the Tahkandit beds and rest directly on rocks of the Rampart series.

Kenai series.—Next above the Mission Creek rocks, and not always readily distinguishable from them, is a great thickness of rather loosely consolidated conglomerates, shales, and sandstones, generally greenish in color, which are the coal-bearing rocks of the region; they everywhere contain plant remains, and rest unconformably upon the older rocks. They have, however, been folded to a certain extent, and stand upturned at angles of 20° to 60° . They are supposed to be of Eocene Tertiary age.

Later Tertiary beds.—Other and more recent Tertiary beds have been observed, generally in the more open country of the Lower Yukon, which have little economic importance, though they sometimes contain thin lignitic seams. They are variously known from the localities where they have been observed, as the Nulato sandstones and Twelvemile and Porcupine beds, the two last named being assumed to belong to the same series. . . .

As regards the occurrence of the gold-bearing formations, the Birch Creek, Fortymile, and Rampart series described above, they constitute a belt which extends about 500 miles in a general northwest-southeast direction, but there are indications that the actual extent of these exposures may be twice as great.

The best-known exposures of these rocks occur along the north-eastern flanks of a broad belt of fundamental granites and crystalline schists which apparently form the central nucleus or backbone upon which they rest. This belt is known in a general way to extend up the Tanana River from near its mouth southeastward across the White River below the Donjek. In the latter region C. W. Hayes reports quartzites and limestones resembling the Birch Creek and Fortymile series on the southern flanks of the granite, but the width of the belt, and whether there is any considerable extent of the gold-bearing formations along its southern flanks, is as yet unknown. It may not improbably extend into the high range of the Tanana, of which Mount McKinley is the culminating point and in which the Kuskokwim and Sushitna Rivers of western Alaska take their rise, for from the reports of Moravian missionaries and of the traveler Dickey it appears that gold occurs in the sands of each of these streams. To the westward the granite backbone appears to pitch gently downward, as its surface area narrows, and no exposures are known west of the Yukon River. It is probably not a continuous mass of granite on the surface, but contains smaller areas of the later rocks folded in with it. East of the international boundary the area in which the granite occurs apparently widens, but its exposures are less continuous, the overlying rocks not yet having been worn away. One granitic axis appears to extend eastward from the Fortymile district through the Klondike region in a nearly east-west direction, which is that of the prevailing strike of the sedimentary rocks. The Canadian geologists report a second granite axis on the Dease River just below Dease Lake, which may belong to the older granites, though they do not make the same distinction that Spurr does between the older granites and the later intrusive rocks.

Rocks of the various gold-bearing series above the granite are reported at the following localities: Their first appearance, to one ascending the Yukon from the sea, is near the mouth of the Nowikakat. From here up to the Tanana River, rocks of the Birch Creek series outcrop frequently along the river, when not concealed by Tertiary sandstones and conglomerates, and the range of low mountains on the north side and parallel to the river is probably formed of these and Fortymile rocks. About 3 miles above the mouth of the Tanana, granite is exposed on an island in the Yukon, and 12 miles higher calcareous quartzitic schists of the Fortymile series appear under the Tertiary conglomerates. From the mouth of the Tanana up to Fort Hamlin, at the lower end of the Yukon Flats, the river runs in a canyon-like channel, known as the Lower Ramparts, cut through a low range of mountains which consist principally of the dark greenish and reddish rocks of the Rampart series, except where these are buried under Tertiary conglomerates. The latter rocks occur immediately above the exposures of Fortymile rocks, and again from Mynook Creek up beyond the mouth of Hess Creek. Higher

up on these streams the Rampart rocks come to the surface, and the Fortymile rocks are supposed to be uncovered at their very heads. Between the two areas of Tertiary rocks the Rampart rocks occupy a belt 15 to 20 miles wide along the river, and are cut by great dikes of intrusive granite.

From Fort Hamlin up to near Circle City, a distance, neglecting curves, of about 200 miles, the river flows through a perfectly flat region covered by fine silts and gravels, known as the Yukon Flats, in which no outcrops of solid rock have been observed. In the Birch Creek district, around the headwaters of Birch Creek and southwest of Circle City, the Birch Creek series occupy a broad area; their general strike is east and west, curving at either end to the northward, and the prevailing dip is between 5° and 30° to the south. There is, however, evidence of a northern dip as well, and the Fortymile schists and marbles rest upon them along the trail to Circle City. Marbles, probably belonging to the Fortymile series, are also reported in the hills between Birch Creek and the Tanana to the southward.

At the crossing of Birch Creek by the trail from Circle City, and along the Yukon River for 30 or 40 miles above the Yukon Flats, rocks with the characteristic dark coloring of the Rampart series are exposed. From these up to the mouth of Mission Creek rocks of the Tahkandit, Mission Creek, and Kenai series occupy the banks of the river. On Mission Creek itself only these later formations are found, but the gold in the gravels is supposed to come from the conglomerates of the Mission Creek series, which contain pebbles of the older rocks. On American Creek, the main branch of Mission Creek which comes in from the south, the dark rocks, shales, limestones, and tuffaceous beds which form the bed-rock are supposed to belong to the Rampart series, which also occur along the Yukon River from 5 to 10 miles above Mission Creek to within 25 miles of the mouth of Fortymile Creek. Above this to some distance above Fortymile Creek the river runs in beds of the Mission Creek series.

It is in the Fortymile district and the adjoining mining district on tributaries of Sixtymile Creek that the relations of the different gold-bearing series are best seen. Here there is an east-west axis or backbone running parallel to the upper part of Fortymile Creek and along the divide between it and Sixtymile Creek, with quartzite-schists of the Birch Creek series resting immediately on it both to the north and to the south. Above these on either side are the marbles and alternating schists of the Fortymile series. Fortymile Creek below the forks runs for a considerable part of its course along the junction between these two series, on the northern flank of the anticline. Dikes of various eruptive rocks, including intrusive granite, are very abundant, especially on the South Fork. On the upper part of this fork are green tuffs and slates of the Rampart series, overlain unconformably by conglomerates, sandstones, and coaly shales of the Mission Creek series. Both the South Fork and Sixtymile Creek are supposed

to head in a backbone of granite around Sixtymile Butte, which is surrounded by quartzite-schists of the Birch Creek series. These regions lie partly in American, partly in Canadian territory.

The Canadian area has not been studied by American geologists, except in wayside observation along such routes of travel as necessarily lay through it. The Canadian geologists, on the other hand, did not in their earlier and published observations recognize any subdivisions in the older rocks such as have been made by Spurr. Hence it is not possible to attempt even a proximate outline of the Canadian gold-bearing rock formations. General geological data and local discoveries of gold-bearing gravels indicate that the gold-bearing area is very large, and may be roughly defined as reaching from Dease River to the boundary, with a width of 200 to 300 miles or more. The recent enormously rich discoveries have, however, been confined to a more limited area around the Klondike and Stewart Rivers. It is assumed that the east-west uplift of fundamental granite and overlying rocks extends eastward into the Klondike district, and that a second uplift in a southeasterly direction extends from upper Fortymile Creek toward the valley of Stewart River.

Spurr noted outcrops of the schistose quartzites of the Birch Creek series for a large part of the distance from the mouth of Fortymile Creek up to the junction of the Pelly and the Lewes at Fort Selkirk; also granites at various points, in some cases schistose like the fundamental granite, in others fresh and massive-like intrusive granite. There were also occasional belts of marble belonging to the Fortymile series, notably one 5 or 6 miles above the mouth of Sixtymile Creek, not far from that of Stewart River. These observations afford a rough section across the belt of crystalline schists mentioned by the Canadian geologists as stretching eastward and southeastward along the upper Pelly and adjoining streams and across to the Frances River. Along the eastern edge of the crystalline belt they also recognized rocks of a general greenish color, made up largely of altered volcanic rocks, which would answer to the description of the Rampart series. Similar rocks were also noted at various points on the Lewes above its junction with the Pelly, notably in the Seminow Hills near the Big Salmon River, which may represent the development of the Rampart series on the south flanks of the crystalline belt. . . .

The hills surrounding the gulches of the Little Mynook and Hunter Creeks, on the Lower Yukon, are formed of rocks of the Rampart series. The bed-rocks are of diabase, tuffs, impure shales, and quartzites, and in the bottoms of the gulches there is from 10 to 20 feet of gravel. The gravel consists in part of angular fragments of rocks that form the walls of the gulch, in part of waterworn pebbles of Birch Creek schist, schistose granite, and other rocks. The gold is generally in rounded, bean-shaped grains and nuggets, and less frequently in unworn par-

ticles. This points to a two-fold origin of the gold, as derived in part from the rocks immediately about and in part from distant and older rocks, which may have been worn down, possibly along an old seashore, into terrace gravels, and then by subsequent erosion brought into the present stream beds. Further exploration in the hills to the south may disclose the true source of these pebbles and of the gold that accompanies them. On American Creek, in the Mission Creek district, the gold-bearing placers are also derived from rocks of the Rampart series—quartzitic schists, serpentines, and chloritic rocks—and the gold is said by Spurr to have been derived mainly from the schistose zones in the bed-rock.

The richest gravels have been found in the Birch Creek and Fortymile districts. In the entire Birch Creek district, which lies south of Circle City, and on Miller, Glacier, Poker, and Davis creeks of the Fortymile district, near the international boundary, the bed-rocks are always the quartzite-schists of the Birch Creek series, containing veins of quartz. The gravels rest, as a rule, directly on the schist, though in some cases, as on Harrison and Eagle creeks in the Birch Creek district, there is clay beneath the gravels, and the gold as a rule does not extend into the bed-rock but occurs chiefly at the top of the clay. Generally, however, the schist is rotted and reddened from oxidation for a few inches to several feet below the surface, and in this part the gold has settled into the cracks and joints. The pay gravels lie mostly next the bed-rock, in an average thickness of perhaps 2 feet, though sometimes up to 10 feet, while the overlying gravels average 8 or 10 feet, with a maximum of 25 feet. In the gravels the schist is in quite large, flat fragments, and the quartz is in boulders of varying size. The schist fragments lie flat, and are mixed with sand, showing that the sorting action of running water has not been carried far. In the concentrates from the sluice boxes the heavier minerals associated with the gold—galena, magnetite, limonite, hornblende, and garnet—are in each case such as are found in the neighboring schists, and the nuggets of gold often have pieces of quartz still adhering to them. All these facts are evidence that the gold is derived from rocks in the vicinity, and is not brought from a great distance, perhaps by glaciers, as some erroneously suppose.

The rocks of the Fortymile series in the Fortymile district, as already stated, form the west bank of Fortymile Creek, and south of the South Fork cross the divide between Franklin Gulch and Napoleon Creek, where they are overlain by green slates of the Rampart series, which in turn are overlain by conglomerates of the Mission Creek series. In Franklin Creek the bed-rocks are marbles interbedded with mica- and hornblende-schists; the gravel contains fragments of marble, quartzite, mica-schists, and vein quartz. At one point a quartz vein is found in the bed-rock, and below it native silver has been found in the gravels, which apparently came from this vein. It is the schistose rocks that

mostly carry the gold, as the marbles do not show much evidence of veins. In this gulch are two levels; the higher one, at the head of the gulch, had not been worked, while the pay gold had been found mainly at the lower level, near the mouth of the gulch.

Chicken Creek, so-called because its gold occurs in grains the size of chicken feed, drains a wide area toward the Ketchumstock Hills to the southwest, and the actual source of the gold is less readily defined. The gravel contains fragments of granite, quartzite, schist, and marble.

On Napoleon Creek conglomerate forms the bed-rock near the mouth. The gravels contain fragments of quartzite, vein quartz, hornblende-granite, and various eruptive rocks, and the source of the gold is assumed to be the conglomerate, which is made up of fragments of the older rocks, for the rocks higher up the gulch above the conglomerates have not been found to carry much gold.

The most trustworthy reports from the Klondike region indicate that the exceptionally rich placer gravels thus far found occur in side valleys entering the main Klondike Valley from the south, such as Bonanza, Eldorado, and Hunker creeks, and in some gulches across the divide tributary to Indian or Stewart rivers. No gold in paying quantities had been found on the Klondike itself. The placer deposit generally consists of 10 to 15 feet of frozen muck and decayed vegetation at the surface, then a gravel bed that rarely pays; below that a clay selvage, under which is pay dirt from 1 to 5 feet in thickness resting on the upturned edges of the schist, from which it is separated by a clay selvage. The pay streak or bottom of the old channel is usually very regular and straight, not following the bends of the present stream."

3. *Geological nomenclature.*—The general secretaries of the International Geological Congress have made a report of the action of the congress relative to geological nomenclature, of which the following is a translation:

The seventh Geological Congress, which convened at St. Petersburg on the 17th to the 24th of August 1897, considered, according to the announcement of the circulars of the committee of organization, the questions of stratigraphical classification and nomenclature.

After discussing the question in the session of August 18 (30) the Congress passed the following votes:

"The Congress is of the opinion that the historic method should be adopted in seeking to make the nomenclature more natural."

"The council is charged with naming a committee for the study of the principles of classification in the spirit of the first clause."

The council thereupon decided to compose the committee of a number as restricted as possible, but, in order not to deprive it of the coöperation of geologists capable of rendering assistance in the work, added certain consulting members. The following committee was appointed.

Members effectifs: M. M. Barrois, Ch., Capellini, G., Hughes, Thomas, Renevier, E., Tietze, E., Tschernyschew, Th., Williams, H. S., v. Zittel, K.

Members consultatifs: Choffat, P., Clark, W., de Cortazar, D., Davis, W. M., Dawson, G., Déperet, Ch., Frech, Fr. Griesbach, C., Karpinsky, A., Kayser, E., de Lapperent, A., Martin, K., Mayer-Eymar, Ch., Nathorst, A., Nikitin, S., Stephensen, G., De Stefani, G., Taramelli, T., Uhlig, V., Van deu Broeck, E., Walcott, Ch., Woodward, Hor.

In the session of August 20 (Sept. 1), which was devoted to the question of the stratigraphic nomenclature, the Congress, after the discussion of the propositions of Messrs Bittner, Frech, Karpinsky and Tschernyschew, accepted the following propositions:

I. The introduction of a new stratigraphic term in the international nomenclature ought to be based upon well established scientific need, justified by some particular reasons. Every new appellation ought to be associated with some distinct characteristic—both stratigraphical (batrologique) and paleontological—of the deposits to which it is applied; at the same time it ought to be founded upon facts observed not in a single section only, but over a more or less extended area.

II. The appellations applied to a terrain in a particular sense cannot be employed in another sense.

III. The date of publication decides the priority of stratigraphic names applied to the same beds.

IV. For small stratigraphic subdivisions sufficiently well characterized paleontologically, in case of the creation of new names, it is preferable to take the most important paleontological peculiarities as a basis. Geographic or other names should not be employed except for sections of some importance including several paleontological horizons, or where the terrain cannot be characterized paleontologically.

VII. Names badly formed, from an etymological point of view, are to be corrected without excluding them, on that account, from use in the science.

As to the following two propositions:

V. "It is preferable, in the case of various stratigraphic terms already existing in the literature, to substitute the words superior, median and inferior for those applied to sections and series.

VI. "When a term given to a whole series of beds is to be restricted in meaning to a part only of the beds, it should not be applied except to the beds which are paleontologically the more characteristic,"—it was decided to refer them for consideration to the stratigraphic committee elected at the session of August 18th (30).

Concerning the place of re-unions of the stratigraphic committee, the Congress decided that the committee should itself determine place of meeting, taking consideration of the re-unions of the various geological societies.

The committee elected Professor Renevier president, and Mr. Lugrom secretary of the committee.

The report is signed by the general secretaries, MM. Th. Tschernyschew and C. de Vogdt. H. S. W.

4. *The Development of Glyphioceras and the Phylogeny of the Glyphioceratidæ*; by JAMES PERRIN SMITH. (Proc. Cal. Acad. Sci., Series III, vol. i, No. 3, pp. 105-129. With three plates. 1897.)—The author has traced out and illustrated the stages of growth of this early goniatite from actual specimens of *Glyphioceras incisum* Hyatt from the Lower Carboniferous formation in northern Arkansas. The following summary is given of the ontogeny of the genus *Glyphioceras*.

“*Glyphioceras* in its ontogeny goes through the following stages: phylembryonic, protoconch, representing the primitive cephalopod; ananepionic, Silurian nautiloid; metanepionic, Anarcestes of Lower Devonian; paranepionic, Tornoceras of Middle Devonian; neanic, Prionoceras of Upper Devonian and Carboniferous, showing gradual transition through ana-, meta-, and paranepionic, and a gradual change from Prionoceras to *Glyphioceras* in the late adolescent and early adult stages. Prionoceras is undoubtedly the family radicle, and Brancoceras is a side-branch, since *Glyphioceras* does not go through any stage corresponding to the latter genus. *Gastrioceras* comes from Prionoceras (through Münsteroceras) by somewhat narrowing the whorl and division of the ventral lobe. *Glyphioceras* comes directly from Prionoceras by narrowing the umbilicus so as to conceal most of the inner whorls and by division of the ventral lobe.

The division of the subfamily *Glyphioceratidæ* into Brancoceras, Prionoceras, Pericyclus, *Glyphioceras* (subgenus Münsteroceras), *Gastrioceras*, *Paralegoceras*, is quite proper for phylogenetic reasons.

According to Steinmann the *Ceratitidæ* of the Trias are descended from *Gastrioceras*, and the *Tropitidæ* from Pericyclus, but neither of these groups goes through stages of growth corresponding to these genera. *Tropites* does, however, go through a Prionoceras stage, and later it resembles closely *Gastrioceras*, but it already has the *Tropites* keel before the ventral lobe is divided. It then descends from the *Glyphioceratidæ*, but directly from the radicle and not through any modified form. But it is quite likely that some of the genera assigned to the *Tropitidæ* do descend directly from other members of the *Glyphioceratidæ*. H. S. W.

5. *Brief notices of some recently described minerals*.—RASPITE. A new tungstate of lead, $PbWO_4$, from the Broken Hill mines in New South Wales, described by C. Hlawatsch. It occurs in small brownish yellow transparent crystals of tabular habit; these belong to the monoclinic system. The hardness is 2.5 and the luster adamantine; an approximate determination of the refractive index gave the unusual value 2.6. An analysis by F. P. Treadwell yielded:

WO ₃	PbO	Fe ₂ O ₃ , MnO	
49.06	48.32	1.43	= 98.81

Raspite, associated with stolzite, occurs with decomposed galena

in limonite. It is named after Rasp, the discoverer of the Broken Hill mines.—*Ann. Mus. Wien.*, xii, 1897.

LEONITE. A mineral closely related to blödite, obtained from the Prussian salt mines of Westeregeln and Leopoldshall. It is characterized by its containing potassium in place of sodium, its formula being $\text{MgSO}_4 \cdot \text{K}_2\text{SO}_4 + 4\text{H}_2\text{O}$. It occurs in monoclinic crystals which are now described by C. A. Tenne, the existence of the mineral having been earlier recognized.—*Zs. Geol. Ges.*, xlviii, 632.

TRIPUHYITE. A new antimonate of iron from Tripuhy, Brazil, described by E. Hussak and G. T. Prior. It occurs in microcrystalline aggregates of a dull greenish yellow color. The streak is canary-yellow; the specific gravity 5.82. An analysis gave the following results:

Sb_2O_5	FeO	CaO	SiO_2	Al_2O_3	TiO_2	<i>undet.</i>
66.68	27.70	0.82	1.35	1.40	0.86	1.19=100

The above corresponds to the formula, $2\text{FeO} \cdot \text{Sb}_2\text{O}_5$.—*Min. Mag.*, xi, Dec., 1897.

GERSBYITE. A hydrous aluminum phosphate near lazulite in composition, and resembling it in its fine blue or bluish green color. It occurs in grains and small crystals imbedded in the cyanite of a schistose damourite-quartzite. Five analyses give amounts of water varying from 7.19 to 15.40 per cent. It is named by Igelström from the village Gersby, near which it is found in the Ransäter parish, Wermland, Sweden. The same region has afforded an imperfectly investigated mineral called by Igelström **MUNKRUDITE**. It seems to be near *svanbergite* in composition.—*Zeitschr. f. Kryst.*, xxviii, 310, 1897.

LANGBEINITE. An anhydrous potassium-magnesium sulphate, $\text{K}_2\text{Mg}_2(\text{SO}_4)_3$, described by Luedecke from Westeregeln and other points in the Prussian salt mines. It is remarkable as crystallizing in the tetartohedral class of the isometric system, the crystals being highly modified and characteristic in form. The specific gravity is 2.83. The fresh salt is colorless and without taste. The analyses made agree closely with the above formula.—*Zs. Kryst.*, xxix, 255.

6. *Handbuch der Mineralogie*, von Dr. CARL HINTZE. Erster Band, 160 pp. Elemente, Sulfide, Oxyde, Haloide, Carbonate, Sulfate, Borate, Phosphate. pp. 1-140. Leipzig (Veit & Comp. 1898). The appearance of the first part of Volume I of Hintze's Mineralogy is encouraging, as showing that notwithstanding the labor which the author has put upon the nearly two thousand crowded pages of the second volume already completed, his energy is not exhausted, and at no very distant date we may hope to see the entire work completed. The present part is devoted to the native elements, beginning with carbon and extending nearly through the discussion of iron.

7. *Ueber Alter, Lagerungsform und Entstehungsart der Periadriatischen granitkörnigen Massen.* Habilitationsschrift, Dr. WILHELM SALOMEN.—This paper contains a general review of the

facts connected with the intrusion and method of occurrence of a number of areas of igneous rocks, well known from the large amount of geological literature bearing on them, such as the Adamello and Riesenferner groups and Predazzo and Monzoni. It contains a number of new facts and will prove of interest and value to those whose studies lead them to look up the literature dealing with the geology of these regions.—*Tschermak's Min. Petr. Mitth.*, xvii, 1897.

L. V. P.

8. *Petrology for Students, an introduction to the study of rocks under the microscope*; by ALFRED HARKER. Second ed., 12mo, pp. 334 (University Press, Camb.).—We have had occasion to notice previously the appearance of this excellent little manual. The fact that it has now run into a second edition shows that it was needed. The new edition, in addition to a thorough revision, contains some new matter, especially references to American localities and rock types, which will render it more useful in this country.

L. V. P.

III. BOTANY AND ZOOLOGY.

1. *Pflanzenphysiologie. Ein Handbuch der Lehre vom Stoffwechsel und Kraftwechsel in der Pflanze*; von DR. W. PFEFFER, Professor an der Universität Leipzig. Erster Band. Stoffwechsel. Leipzig, 1897.—This is the first volume of the revised edition of a work which was issued in 1880, when its author was a professor in Tübingen. During the period of almost twenty years which have elapsed since the first date, Professor Pfeffer has continued to enrich every department of vegetable physiology. His communications have touched some fields which lie on the border between physiology and other sciences, while in the domain of physiology itself the contributions have been important and, in at least one part, revolutionary in their effects. The peculiar relations of motile protoplasm to chemical agents and to tinctorial reagents, have been made so clear that the work of further experimenting in this field promises substantial results. In other branches of experimental morphology, also, Professor Pfeffer has opened up new paths.

For this revision students have been waiting with impatience. Under the condition of extreme specialization which now prevails, and which is likely hereafter to characterize all scientific research, an occasional presentation of a balance sheet by a critical master is an absolute necessity. It was expected that in this complete revision would be given such a balance sheet, contrasting the real contributions, however trivial, with the untrustworthy and unverified results which clamor for publication. This hope has not been disappointed. All questions have been discussed impartially and decisions have been made without prejudice. Therefore, as might be looked for, this treatise is a distinct contribution in itself to the department of vegetable physiology. Professor Pfeffer has always paid much attention to the dynamics of vegeta-

ble life, and this is shown even in this part, which is devoted to the appropriation and distribution of matters by plants. The remaining volume, to be devoted to the relations of plants to the forces, will possess even a higher degree of interest than the present. We trust that Professor Pfeffer will give his consent to the translation into English of this second edition of his valuable handbook, in order that it may reach a wider circle of thoughtful men in many departments of thought.

G. L. G.

2. *Permeability of the bark of tree-trunks to atmospheric gases.*—M. HENRI DEVAUX, *Comptes Rend.*, Dec. 6, 1897, has made use of a simple apparatus for determining some of the relations of the living peripheral layer in the trunks of large trees to the gases of the atmosphere. He cements, by means of wax, a small funnel to the bark of the tree to be examined, fills the funnel with water, and then diminishing the pressure, observes the bubbles which escape into the water. Apertures on large trunks are virtually lenticels like those of small branches, and from these trunk lenticels air escapes abundantly under the conditions noted. In some cases there is a marked difference between the two sorts of lenticels, those of the trunk being less permeable than those of the twigs.

Not only do respiratory exchanges take place through these apertures but through accidental wounds, however small. In two instances the impermeability of the lenticels was practically complete, namely, in *Picea excelsa* and *Populus alba*. Even under great exhaust no bubbles were withdrawn from the bark of these. The experiments were conducted in October. Perhaps a different condition of affairs as to permeability prevails at other seasons of the year.

One of the most interesting observations made by the investigator was in regard to the influence exerted by lichens in occluding the lenticels. Even when the lichen on the trunk is crustaceous, and closely appressed, it does not close the pathway of the gases to and fro. No report is yet given as to the character of the gases thus withdrawn from the plants.

Two gaps appear to be unfilled in this account of the permeability of the bark of tree-trunks: the recorder does not make it clear that he eliminated errors arising from the contained air of the corky layer; and, secondly, no proof appears that the gas escaping in bubbles came wholly from the living tissues within the corky layer. Nevertheless this application of an old method is interesting and may suggest further steps in the same direction.

G. L. G.

3. *Lessons with Plants: Suggestions for Seeing and Interpreting some of the Common Forms of Vegetation*; by L. H. BAILEY. Pp. xxxi + 491, figs. 446. New York, 1898 (The Macmillan Company; \$1.10).—The purpose of Professor Bailey's book is not to teach the science of botany but to serve as a guide in the "nature-study" of plants, and it is intended for the use of beginners in the secondary schools. In each chapter some

characteristic feature of plant-structure or plant-life is described from illustrative material, special emphasis being laid on those points which can be directly observed. The facts are presented in a popular yet scientific manner and are usually supplemented by suggestive questions or directions for the pupil. The numerous figures, which were drawn from nature by Professor Holdsworth, add very much to the value of the book. A. W. E.

Garden-making. Suggestions for the utilizing of Home Grounds, by L. H. BAILEY, aided by L. R. Taft, F. A. Waugh, and Ernest Walker. New York, 1898 (The Macmillan Company).

4. *Catalogue of the Madreporarian Corals in the British Museum*. Vol. iii, *Montipora and Anacropora*; by HENRY M. BERNARD. London, 1897, 4to., 192 pages, 34 plates.—This handsome volume is devoted mostly to the genus *Montipora*, which is one of the most extensive genera of reef-corals, and also one in which the species are very hard to determine or define, owing to their great variability, as well as to their large numbers. In this work the author recognizes 135 species, of which 81 are described as new. They were represented by 450 specimens, but, as the author states, many of the species are only represented by a single specimen, sometimes only a fragment. Very likely a larger series of specimens might serve to unite some of these forms, but doubtless many more remain to be discovered.

The descriptive part of the work is preceded by a historical sketch of the knowledge of the genus, and of the various views that have prevailed, as to its affinities. Its structure is also discussed, as well as the distribution of the species. No species is known from the Atlantic Ocean, but they are everywhere abundant in the warmer parts of the Indo-Pacific region. The new species are beautifully illustrated by photographs reproduced by the colotype process, and also by greatly enlarged lithographic figures of one or more calices and the surrounding structures.

Of *Anacropora*, six species are recognized and described. The work is thoroughly well done. A. E. V.

5. *A Text-book of Zoology*; by T. JEFFREY PARKER and WILLIAM A. HASWELL. 2 vols., 8vo, 1402 pages, 1171 cuts. London: Macmillan & Co., 1897.—This is in every way an admirable text-book of zoology, and exceedingly well adapted for advanced students. Yet it is written so clearly that it can be used even by beginners. The illustrations are profuse and have been selected with excellent judgment from the most reliable sources. The subjects are taken up in accordance with their sequence in the classification adopted, each of the larger groups having a section or chapter devoted to it. At the end of the second volume there are brief sections devoted to geographical distribution, the philosophy of zoology, and the history of zoology, which add greatly to the value of the work.

In the system of classification adopted, perhaps the most unusual feature is the large number of primary groups or phyla. Of these there are twelve, viz: Protozoa, Porifera, Cœlenterata,

Platyhelminthes, Nemathelminthes, Trochelminthes, Molluscoida, Echmodermata, Annulata, Arthropoda, Mollusca, Chordata. To many zoologists this number of primary groups will undoubtedly seem unnecessarily great. But it is true that it enables one to define the groups more clearly. Perhaps the Nemathelminthes and Trochhelminthes are the least satisfactory of the vermian series. A number of groups, allied to one or the other of these, are treated as appendages of the former, with uncertain affinities. Such are the Chætosomidæ, Echinoderidæ, etc. The Nemertinea are, in the same way, appended to the Platyhelminthes. The second volume is devoted almost entirely (582 pages) to the Chordata.

The Adelochordata are included in the Chordata, somewhat doubtfully, as a sub-phylum. The objections to this view of the affinities of *Balanoglossus*, etc., are, however, pretty fully stated.

The number of orders recognized in some of the classes is unusually large. Of existing Aves, 26 orders are adopted. On the other hand, the number of mammalian orders is but 12, and of Pisces but 11, but many zoologists will be disposed to consider several of the so-called orders of birds as of less value than many of the "sub-orders" of fishes or mammals. Of Insecta, only 8 orders are recognized, the Neuroptera and Orthoptera being adopted with their early significance and extent.

But these are matters upon which there is still great differences of opinion and are of only secondary importance in a text-book of this character.

A. E. V.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *United States Coast and Geodetic Survey.*—The Report of W. W. Duffield, the Superintendent of the United States Coast and Geodetic Survey for the year ending June, 1896, has recently been issued. In addition to the usual subject-matter and charts, among which we note particularly a general one of Alaska, there are a series of twelve appendices. Of these is especially to be mentioned one on terrestrial magnetism, by C. A. Schott, Assistant. This, in continuation of earlier publications on the same subject, gives the distribution of the magnetic declination in the United States for the epoch January 1st, 1900. The text and tables are accompanied by three charts, the first and third giving the distribution of the isogonic lines for the United States and Alaska respectively, for the epoch mentioned; the second showing the annual change of magnetic declination from 1895 to 1900.

2. *Annals of the Astronomical Observatory of Harvard College.* Edward C. Pickering, Director. Volume XLII, Part I. Cambridge (John Wilson & Son, University Press), 1897.—This publication, just issued, contains a record of observations made at the Blue Hill Meteorological Observatory in 1896, under the direction of A. Lawrence Rotch. This record with Tables I to

VII occupies pages 1-27, following which are two appendices. Appendix A is devoted to a study of special cloud forms, by A. E. Sweetland, especially as regards their relations to cyclones and anti-cyclones, to precipitation, and temperature changes. Appendix B, by S. P. Fergusson, gives an interesting discussion of the results obtained by the exploration of the upper atmosphere by means of kites. The special forms of kites are described, as also the registering meteorological apparatus carried by them. The results obtained thus far show the value of this new method of meteorological research.

3. *L. Rüttimeyer-gesammelte kleine Schriften allgemeinen Inhalts aus dem Gebiete der Naturwissenschaft-nebst einer autobiographischen Skizze*, herausgegeben von H. G. STEHLIN. Band I, pp. 1-400, portrait, 1 map and 6 figs.; Band II, pp. 1-456, 1 fig. Basel (Georg et Cie), 1898.—In these two volumes are collected the addresses and smaller essays of the Swiss naturalist Rüttimeyer, who is best known for his works on vertebrates, recent and fossil, but chiefly mammals, and who died in 1895. They are mainly written in popular style, and some of them are still interesting reading, though reflecting the views of the older school of naturalists. The following are a few of the titles of the papers: On the form and history of the vertebrate skeleton; on the historic method in paleontology. The limits of the animal world, a discussion of Darwin's theory. On the nature of progress in the organic creation. From the sea to the Alps, descriptions of the structure, form and color of our continent upon a section from England to Sicily. A sketch of the history of glacier-studies in Switzerland. Sketches of the lives of Agassiz, of Charles Darwin, of Bernhardt Studer, etc.

His more important scientific works were on Ruminants (Bos, Deer, Equidae, etc.), and on the fossil turtles. H. S. W.

4. *Transactions of the American Microscopical Society*. Edited by the Secretary. Volume xix, pp. 207, Buffalo.—The volume just issued, bearing date of December, 1897, contains the proceedings of the American Microscopical Society for the twentieth annual meeting, held at Toledo, Aug. 5th, 6th and 7th, 1897. It includes an address by the President, E. W. Claypole, entitled, "Microscopical Light in Geological Darkness," which discusses some of the ways in which the recent work with the microscope, especially in petrography, has served to throw light upon obscure geological problems. A series of valuable papers follow, chiefly on biological subjects.

5. *Physikalisch-chemische Propädeutik*; von H. GRIESBACH. zweite Hälfte, 2 Lieferung, Leipsic, 1897 (Wilhelm Engelmann).—Two previous parts of this valuable text-book on physical, chemical and biological science have already been noticed in this Journal (vol. ii, p. 450). The present part, comprising pages 593-944, maintains the high standard of excellence and fullness that characterized the earlier issues. The scope of the work has been somewhat enlarged beyond the original plan,

so that another part will appear, which is promised during the course of the present year. H. L. W.

6. *Bibliography of the Metals of the Platinum Group. Platinum, Palladium, Iridium, Rhodium, Osmium, Ruthenium.* 1748-1896. By JAS. LEWIS HOWE, pp. 318, Washington, 1897, Smithsonian Miscellaneous Collections, 1084.—This exhaustive bibliography has been prepared by Prof. J. L. Howe under the auspices of the Committee of the American Association having charge of indexing chemical literature. Prof. H. Carrington Bolton is chairman of the committee.

OBITUARY.

WILLIAM A. ROGERS was born at Waterford, Conn. on the 13th of November, 1832. He entered Brown University in 1853 and graduated in 1857. In 1859 he was elected Professor of Mathematics in Alfred University, N. Y. and remained there until 1870. During this period he spent a year as a special student in the Harvard College Observatory and eighteen months in the U. S. Navy. He built and equipped the Alfred Observatory in 1865, and the subsequent year being appointed Professor of Industrial Mechanics in Alfred, he spent several months in preparation for his new duties in the Sheffield Scientific School. In 1870 he was appointed assistant, and in 1875 Assistant Professor in the Harvard Observatory, where he remained until 1886, when he accepted the Professorship of Astronomy and Physics in Colby University, Waterville, Me. In 1897 he was elected Babcock Professor of Physics in Alfred University, expecting to enter upon his new duties on April 1st, 1898. Professor Rogers was a man of remarkable powers as an observer and of exceptional acuteness as an experimenter. His work at the Harvard Observatory in the former line ranks with the best work done there; and he stood easily at the head of the metrologists of this country in the line of linear measurement. He was elected to the American Academy in Boston in 1873, a Fellow of the Royal Microscopical Society of London in 1880, President of the American Microscopical Society in 1887, Vice-President of the American Association in 1883 and a member of the National Academy of Sciences, in 1885. In 1880 Yale University gave him the degree of A.M., in 1886 he received that of Ph.D. from Alfred University and in 1892 Brown University conferred upon him the degree of LL.D. He died in Waterville, March 1st, 1898. His list of published papers includes about 70 titles. G. F. B.

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[FOURTH SERIES.]

ART. XLI.—*Some Conditions affecting Geyser Eruption*;
by T. A. JAGGAR, JR., Cambridge, Mass.

1. *Introduction: the influence of hydrostatic pressure.*

BOTH field observation and experiment have contributed to our present knowledge of the physical causes of geyser eruption. The natural history of geyser regions has been summarized by Weed,* and the experimental work by Andreae.† Weed concludes that geysers occur only in acid volcanic rocks, and along natural drainage lines where meteoric waters accumulate for discharge. The source of heat is conceived to be escaping hot vapors from slowly cooling lavas, the only known geysers occurring in regions of recent volcanic activity. New geysers originate by the opening of new waterways along fissure planes in the rock, and such new orifices of overflow are continually forming to compensate the diminution in activity of older vents. The cause of the intermittent spouting which distinguishes the typical geyser was originally stated by Bunsen‡; the boiling point of water rises with increased pressure, hence decreases from the lower end of a water-filled tube upward. If water of a lower stratum, nearly, but not quite, at the boiling point, be lifted by the entrance of steam from below to a level of less pressure and lower boiling point, "the heat which it possesses is in excess of that necessary to make it boil. This excess of heat is instantly applied to the generation of steam: the column is lifted higher and the water below is further relieved. More steam is generated, and from the middle downwards the mass suddenly bursts into ebullition. The water above, mixed with steam-clouds, is projected into the atmosphere. . . ."§

* School of Mines Quarterly, New York, 1890, vol. xi, No. 4, p. 289.

† Neues Jahrbuch für Min. Geol. und Pal., 1893, Bd. ii, p. 1.

‡ Tyndall: Heat as a Mode of Motion; Appleton, 1888, p. 168.

§ Tyndall, l. c., pp. 169-170.

The accuracy of Bunsen's theory was early confirmed by experiment and the only mechanism necessary to produce geyser eruption is a tube filled with water, open above and heated below. Many further experiments have been made, however, with a view to explaining the variations observed in the period and interval of geyser eruptions, the relative amount of steam and water, and the effect of artificial stimulants in hastening eruption. Andreæ's experiments were directed toward the imitation of Peale's* types, a classification based on the form of the basins and the relation of the periods of steam and water in the eruption. It is noteworthy that in most of these experiments, the apparatus recommended has an open basin above, which retains the water thrown out and permits it to *flow back* into the geyser tube.

In Peale's classification no mention is made of the nature of the geyser-spring during the interval of quiescence; in some cases there is continuous overflow or discharge, in others there is no overflow except during eruption. As it may be shown that this fact of the presence or absence of hydrostatic pressure at the geyser vent has an important bearing on the conditions of eruption, the writer would suggest a classification based on this very simple distinction; it is a singular fact that in the published descriptions of geysers this point has been frequently overlooked. If geyser waters represent meteoric drainage, they are affected by the laws of hydrostatic equilibrium. In such case a tube continuously overflowing is in a distinctly different class from one which throws off its waters to join the superficial drainage to the sea only during the period of its occasional or intermittent discharge. The first case is represented by such a geyser spring as "Excelsior," in the Yellowstone Park, a violently boiling cauldron in the hill slope, continually discharging vast volumes of water into the pond below, which in turn drains into the Firehole River; the Great Geyser of Iceland and the Rotomahana Geysers† of New Zealand are other types of the continually overflowing class. "Old Faithful" is the type of the second class: its waters may be seen in violent ebullition a few feet below the orifice of the vent, but overflow takes place only during eruption.

Any apparatus designed to imitate accurately either of these must be provided with a supply reservoir having subterranean connection with the geyser tube, by which water may siphon in to replace that discharged. Obviously this replacement takes place in nature: if the water, as asserted, is meteoric, and governed by the same laws that determine the loci of springs, the natural method of such replacement is by the action of gravity. In the case of Excelsior, this subterranean compensa-

* U. S. Geological Survey of the Territories, 1884, vol. xii, pt. 2.

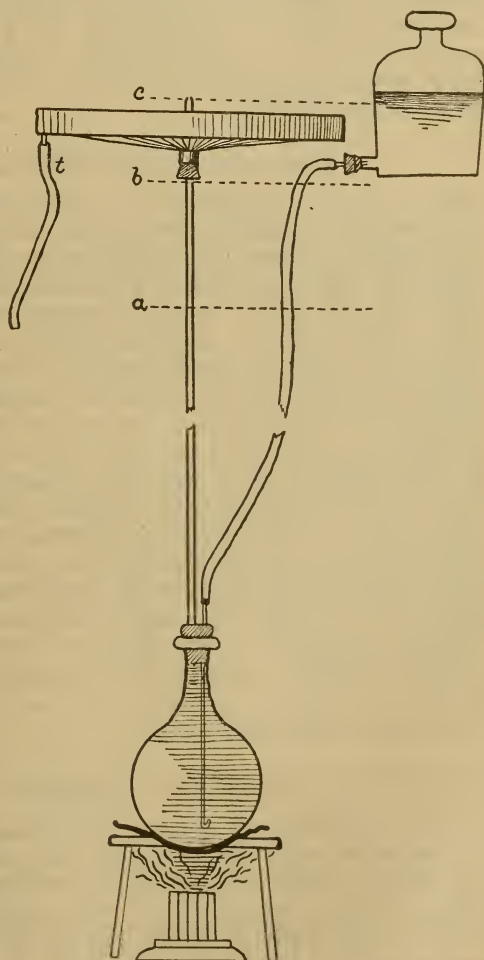
† Destroyed by the Tarawera eruption in 1886.

tion is continuous; the effective head of water at the orifice of exit is fairly constant: in the case of Old Faithful the water-column is in equilibrium, and replacement occurs only after each eruption, when this equilibrium has been disturbed by the ejection of the column.

2. Experimental Demonstration.

A simple device to illustrate this process was described by G. Wiedemann* and mentioned by Andreae.† Wiedemann made no geological comparisons, the apparatus having been constructed for class-room illustration in physics; and most of the geological experimenters have used back-flow apparatus, without supply reservoirs. The essential parts of Wiedemann's apparatus are a water-column heated below, and a supply-tube entering this column and connecting it with a reservoir of cooler, superficial waters. When the excess of steam generated has thrown out the main column, cooler water filters in through the supply tube, and fills the geyser tube to the level of the reservoir. For effective and regularly repeated geyser eruptions, the reservoir level must be maintained a little below the height of the mouth of the geyser tube.

The accompanying figure illustrates Wiedemann's apparatus, as it has been used by the writer. The dimensions are



* Wiedemann's *Annalen*, xv, 1882, p. 173.

† l. c., p. 4.

as follows: capacity of each flask, one quart; length of main geyser tube 4 feet, diameter (outside) $\frac{5}{16}$ inches: diameter of basin 2 feet; the bottom flares funnel-wise from the center slightly, and is provided with a $\frac{1}{4}$ inch outlet tube *t*. The lower flask rests on a sheet of wire-netting over the flame of a four- or six-tube Bunsen burner, and the basin and reservoir bottle are supported above on a wooden frame. The basin is of zinc and may be raised or lowered so that the mouth of the geyser tube is flush with the bottom of the basin or raised above it as shown. The supply tube is recurved slightly at the bottom of the flask, so that the cold jets which siphon in from the reservoir will not be directed against the glass wall of the flask and break it. The reservoir bottle is connected by rubber tubing with the supply tube, so that the bottle may be freely raised or lowered to various levels indicated by the dotted lines *a*, *b* and *c*.

Experiment 1. "Old Faithful" Type.

When heat is applied below, the reservoir level being at *a*, after about 14 minutes an eruption takes place, characterized by violent ebullition in the flask below, ejection of the water-column to a height of about 4 feet and of a mixture of steam and water for a few seconds longer: then the water-level in the reservoir is seen to fall suddenly, a stream is seen to be flowing into the lower flask from the curved tip of the supply-tube, the cooling of the base of the column is accompanied by condensation of steam and downward suction, the water rises to level *a* again and a period of repose follows. It should be noted that if the level of the cooler water in the reservoir is at *a*, the expanded warmer water in the geyser tube is somewhat above *a*. The process described is repeated at regular intervals of about $1\frac{1}{2}$ minutes, the duration of each eruption being about 20 seconds. If the water in the reservoir be not renewed it gradually becomes warmer and the intervals are of shorter duration. In this case, or with the reservoir level somewhat higher, as at *b*, and the geyser mouth raised above the basin as shown in the figure, we have in miniature the conditions of "Old Faithful."

Experiment 2. "Excelsior" Type.

The conditions are altered if we raise the reservoir level to the point shown in the figure, namely, just above the height of the geyser mouth (*c*). In such case there is continuous overflow of the hot water, and if the outlet tube *t* be left open, this will continually flow off: this overflow must be constantly compensated at the supply tube by cooler water from the reser-

voir, so that the water in the flask never reaches the boiling point. If the water-level of the reservoir be maintained constant, this circulation will continue indefinitely, and in such case there will be a dome-shaped mass of hot water continually boiling up and overflowing at the geyser's mouth, as in the case of the Excelsior geyser. Now at this stage, if the water-level in the reservoir be allowed to sink under the drain upon it, it may fall to a level *six inches* below *c*, without interrupting the continuous overflow; in other words, it may fall back to the *b* level, and yet the geyser will continue to act as a boiling spring, without entering into an eruptive phase. The cause of this is to be found in the differential expansion of the water noted above, and a convectional upflow which acts as a driving power even against a reversed head, after overflow has once been established.* The overflow tube *t* may at this stage be led into the reservoir at the *b* level; this establishes a permanent circulation, the only loss being by evaporation. With the diminution in pressure if the level of the reservoir sinks, there is tendency toward diminished inflow of cooler water at the supply-tube: this implies rise in temperature of the water at the base of the geyser-column, which tends to augment both volumetric expansion and convectional velocity. Hence there is here a critical point where the hydrothermal and hydrostatic forces are in very delicate equilibrium; if the reservoir is lowered an inch, the overflow decreases, ebullition takes place below, and an eruption of extraordinary violence takes place. The same effect is at once produced by placing the glass stopper in the reservoir bottle and so checking the atmospheric pressure. When the mouth of the geyser-tube is flush with the bottom of the basin, an eruption may be induced by stopping the overflow tube *t* and permitting the water-level to rise in the basin, thus augmenting the pressure on the geyser column. Eruptions once started will continue intermittently, if the hydrostatic conditions are maintained constant: if, however, the water-level of the reservoir again rises to a point where continuous overflow is possible at the geyser's mouth, the eruptions will cease and a hot-spring phase will follow.

3. Field application of the results of experiment.

The two simple experiments described, when compared with the facts of nature, account for the most essential variations observed in the phenomena of geyser eruption. Both are methods of draining the reservoir: the one continuous, the other spasmodic. In the same way the geyser-springs drain

* Such convection currents gain no momentum without overflow, hence at the *a* level convection played no essential part in the phenomena observed.

off the superficial waters that accumulate from the abundant rainfall of the Yellowstone Plateau. The "Excelsior" cauldron is stated by Hague* to discharge constantly into the Firehole River 4400 gallons of boiling water per minute, "and there is no evidence that this amount has varied within the last two or three years (1887)." Weed† has estimated, on the moderate assumption that one-third of the eruption-column of Old Faithful is water, that 3000 barrels are thrown off at each eruption. Here we have examples of continuous and spasmodic drainage methods, both sending their waters eventually to the Madison River, and resupplied from a local source.

The geyser basins are topographic hollows, which supply vents for the meteoric waters accumulated in fissures of the decomposed rhyolite. These waters are heated by vapors escaping from the only partially cooled deeper lavas, and are escaping in the form of springs and geysers. In the springs the overflow is occasioned by hydrostatic pressure: in the geysers it is permitted by occasional violent discharge. The transition from one phase to the other may readily be induced, as shown in Experiment 2, by very slight changes in the hydrostatic pressure, i. e. variations in the mean level of ground-water (*Grundwasserspiegel*), or in the local head for any specific case. The head may be modified at either the source (supply-reservoir) or the orifice of exit; head is diminished by lowering the reservoir through formation of new outlets or through decreased supply, or by building up a cone around the geyser tube. Conversely head may be increased by excessive supply (rainfall) at the reservoir, by clogging of outlets, or by the water finding a new vent at a lower level.

Bunsen stated that the transition from a geyser to a tranquil "Laug" like those frequently found in Iceland, would be occasioned by building up the geyser's bowl so as to raise the water-level, and thus "the water in the depths below, owing to the increased pressure, cannot attain its boiling point, and the eruptions of necessity cease."‡ While this may be true in special cases, we are inclined to believe that the efficient cause of cessation of eruption is generally to be found in an increase in the amount of continuous overflow, due either to new outlets (which may in many cases be subterranean), or increase in the local head. Probably many of the geysers whose eruption intervals are irregular, are in a condition of equilibrium near the critical point described in Experiment 2, so that very slight changes in the local pressure bring about eruption or cessation.

* Arnold Hague: *Geol. History of the Yellowstone Nat'l Park*, Trans. Am. Inst. of Min. Eng., vol. xvi, 1888.

† l. c.

‡ Tyndall, l. c.

It should be noted that exactly the reverse of Bunsen's prediction takes place in our apparatus; an overflowing spring, when confined by building up a basin about it (see page 327), finally ceases to overflow: convectional currents are thus checked, the boiling point is reached below and eruption begins.

On this hypothesis it will be seen that the source of heat is conceived to be fairly constant in the geyser region for like depths, while the variations in the springs are dependent wholly on delicately-balanced hydrostatic conditions; this seems consistent with the facts. A glance at the published atlas sheets (U. S. Geological Survey) of the Yellowstone Park will show that the three principal geyser basins are on drainage lines, and represent the sources of the Gibbon and Firehole Rivers, which unite to form the Madison. These basins are slight depressions in the rhyolite plateau, in a region of maximal rainfall "quite unlike that found in the adjacent country, as is shown by the meteorological records."* On the opposite side of the Continental Divide to the south, and of the Central Plateau on the east, the headwaters of the Snake and Yellowstone Rivers are represented by large lakes. No such lakes exist on the Madison side, the fissured rhyolite there holding its waters in hundreds of subterranean conduits, like a huge hot sponge, and this water overflows in the depressed areas in the form of sinter-building springs and geysers. The Norris and Upper Geyser Basins are about 7400 feet, the Lower Basin about 7200 feet above mean sea level; while the higher points on the divide rise to 8500 feet, affording drainage into these basins of 1100 feet fall. It is further significant that the highest of the geyser-basins is more than three hundred feet below the level of that enormous water-surface, the Yellowstone Lake, where hot springs still abound, and only a few miles of uninterrupted rhyolite sheets stretch between the geyser-basins and the lake.

With a fairly constant source of heat, and springs variously overflowing or confined according to the height of their orifices relative to the local source in each case, it would follow from the experiments that continuously overflowing geysers should exhibit greater irregularity in their eruptive periods and intervals than those so confined within their tubes that no discharge is possible except by incessant eruption. This is borne out in the types mentioned: Excelsior, the Great Geyser of Iceland, and Rotomahana are all known to have been quite irregular: while Old Faithful, the Constant, the Minute-man and the little Model, in the Yellowstone district, are all of the confined type and erupt with great regularity. Excelsior, now recognized as the greatest geyser in the world, was formerly called

* Hague, l. c.

the "Cliff cauldron" and was not known to be a geyser until 1878, when it was first seen in action: it continued to play at irregular intervals for four years and then ceased, resuming its eruptions in 1888. These were continued for only a short season, and since that time the vent has continuously discharged vast volumes of hot water, without explosive eruptions. There is evidently a delicate balance of adjustments between the hydrostatic and thermal forces which govern the actions of this torrent in the depths; it is possible that the level of the source is affected by exceptional variations in the mean annual rainfall. We should thus expect a period of eruption to follow within a year of a season of exceptional dryness, and consequent diminution of head.* In the case of Old Faithful regular eruptions have taken place about once an hour ever since its discovery in 1870: it is a very old vent, as indicated by the seventy feet of sinter which have been built into the walls of its conduit. It is probable that the water-column became confined by reason of the gradual erection of this enclosing shaft; where there may have been formerly continuous overflow, the column is now in equilibrium with its source, and is ejected only under accumulated steam pressure with rhythmic regularity. The tube fills to within a few feet of the orifice soon after each eruption; this implies percolation into the tube of cooler waters through lateral ducts: as it takes practically a uniform period, some sixty-five minutes, to heat this new column to a state of ebullition at the base, and has done so for twenty-eight years of human record, it is fair to conclude that the heat supply is constant.

While this coincidence of overflow with irregularity of eruption, and confinement with regularity, is in general accord with the facts of observation, it is not essential to the theory that every irregular geyser should visibly overflow at the surface or that every regular one should be enclosed. A non-eruptive spring may have subterranean outlets, and an overflowing one may play at quite regular intervals; in such a case ebullition in the depths will depend on the ratio of the amount of inflowing cooler water to the amount of heat supplied: in some cases, too, the overflow may be from a separate superficial source. Complications in the conduit system, such as steam-filled chambers, curved ducts and connections with other geysers, will readily account for the composite eruptions observed at some of the vents: a long steam period following the first eruption may be induced in our apparatus by partially reducing the

* It is noteworthy, though hardly relevant to this case, that in Virginia City, Montana, northwest of the Yellowstone Park, the mean annual rainfall for 1877, the year preceding the first observed eruptions of Excelsior, was much less than the average of the mean annual records for the next four years.

atmospheric pressure at the reservoir-bottle with the stopper: the same effect is produced by clamping the rubber supply tube and thus checking the inflow of cooler water. When a powerful geyser-spring passes from an eruptive phase to quiescence, or the reverse, there is probably a reflex effect on the level of the source, for the total volumetric discharge is probably usually less for the same period under thermal action alone, than when hydrostatic pressure is combined with convection. In other words, geyser eruption is probably not so effective a method of drainage as continuous overflow in certain cases; thus the eruptive phases of Excelsior may have induced a rise of level in the source, an increase of head, and a consequent return to a condition of violent overflow without eruption.

4. Soaping Geysers.

It has long been known that by artificially confining the steam in small-mouthed geysers of high surface temperature, eruption may be brought about prematurely. In Iceland the Strokr is thus stimulated by dumping into the neck of the funnel large pieces of turf. In the Yellowstone district, it has been found that a small amount of soap or lye added to the geyser water will frequently hasten eruption. This is explained by Hague* as due to the increased viscosity of the liquid. "Viscosity must tend to the retention of steam within the basin and . . . explosive liberation must follow . . . Viscosity in these hot springs must also tend to the formation of bubbles and foam when the steam rises to the surface, and this in turn aids to bring about the explosive action, followed by a relief of pressure, and thus to hasten the final and more powerful display." Graham,† as a result of experiments with an artificial geyser, agrees that viscosity has much to do with the confinement of the steam, but questions the influence of bubbles and foam.

Experiment 3. The effect of soap.

The apparatus was arranged to give regular eruptions as in Experiment 1, with the geyser-tube flush with the bottom of the basin and the water maintained about an inch deep in the basin without overflow. A small quantity of fine shavings of Ivory soap was thrown into the basin: these gradually dissolved and the milky solution was, after several eruptions, sucked into the flask below. The occasional steam-bubbles, which, in pure water, rise rapidly through the geyser-tube and

* Arnold Hague: Soaping Geysers, Trans. Amer. Inst. Min. Eng., vol. xvii, 1889, p. 546.

† This Journal, January, 1893, p. 54.

escape at the surface during the intervals between eruptions, were less numerous, very small, and slower in their upward movement through the soapy solution; after five or six eruptions it became evident that the intervals were somewhat shorter (averaging 1 min. 20–30 seconds instead of 1 min. 30–40 seconds) and the periods very noticeably longer (40–45 seconds instead of 20 seconds). The ebullition in the flask was more violent than in the case of pure water, and columns of fine bubbles accumulated in the geyser-tube, only to be ejected with a violent sputter and give place to a new accumulation. It was evident that these accumulated myriads of tiny steam bubbles, confined within the tube and adhering to the walls of the tube, formed a cushion opposing considerable resistance to pressure from below.

After the diffusion of the soapy solution had become general, the reservoir (and consequently the geyser-column) was lowered to the level *a*; the intervals were at once shortened to an average of about one minute, in consequence of the rapid accumulation at the surface of the column and *within the tube* of the cushion of steam bubbles. So resistant is this cushion, that as it grows by the addition of new bubbles rising from below, the water column is actually depressed, down to the neck of the flask; here a point is reached where the frictional resistance of the froth cushion and the hydrostatic pressure are balanced. A further accumulation of steam forces up the column of foam, release of pressure permits the water to burst into violent ebullition and an eruption takes place. From this it would appear that in those geysers where the tube is small, the growth of a cushion of steam soap-bubbles may play a very important part in accelerating the development of eruptive conditions.

Summary.

1. Geysers and boiling springs are subject to the laws of hydrostatic pressure, in common with other springs.

2. In a geyser-spring, overflow once established may be maintained by convection even against a reversed head; this leads to a critical point in the spring's mode of discharge.

3. In this condition, with a constant source of heat, very slight changes in the local head are sufficient to induce a change in the nature of a geyser-spring's mode of action. Such change in the head may be caused by variation in rainfall, by building up a sinter cone, by forcing new outlets at lower levels, or by clogging of old conduits.

4. Geyser basins afford drainage channels for meteoric waters. The drainage takes place by either continuous over-

flow (hot springs) or spasmodic eruption (geysers). Both types, as well as transitional forms, are represented in the Yellowstone Park.

5. In general, those geysers which are irregular in their eruptions have continuously overflowing vents; and the most regular geysers have confined waters, which overflow only during eruption. This is explained by the fact that the overflowing vents are under hydrostatic pressure, cooler water from lateral ducts is continually replacing that which flows off, and the ebullition necessary to produce eruption is thus prevented; eruption can only take place in the seasons of minimal inflow of cooler water, when the heat is in excess. Where the water is confined, on the other hand, and the supply of heat constant, cooler water rushes in only after each eruption, and a definite interval is required to bring it to the boiling point at the base of the column. Overflowing and confined springs should be distinguished in any description or classification of geysers.

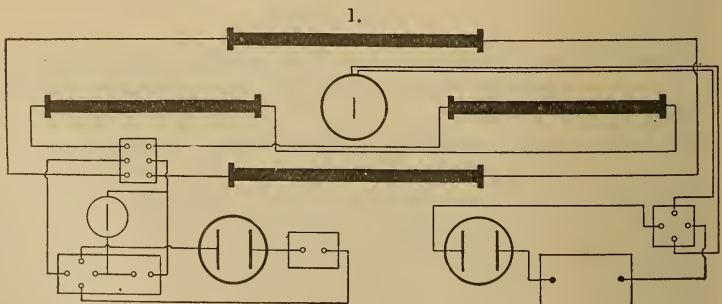
6. For the artificial stimulus of geyser eruption, an important effect of the bubble-forming alkalies, in small tubes, is the initial depression of the water-column by the growth of a confined cushion of minute steam bubbles. The release of pressure induced by the final ejection of the froth column causes eruption.

ART. XLII.—*On the Properties of Seasoned Magnets made of Self-Hardening Steel*; by B. O. PEIRCE.

IN searching for a material of which to make a set of standard measuring magnets which should be as permanent as possible and have small temperature and induction coefficients, I have tested a large number of magnets made of some of the brands of self-hardening tool steel now in common use for lathe tools. It is obvious that self-hardening steel has certain disadvantages as compared with ordinary fine tool steel: it is not generally obtainable in the form of slender, polished, accurately cylindrical rods, it is extremely difficult to work while cold, and most magnets made of it are somewhat weaker than similar magnets made of the best drill rod.

My experiments seem to show that comparatively short seasoned magnets made of self-hardening steel have decidedly smaller induction coefficients than magnets of the same dimensions made of tool steel. The difference in the case of the temperature coefficients is much less, though the advantage appears to be on the side of the self-hardening steel. It is comparatively easy to get a long uniform rod of self-hardening steel and extremely difficult to make a very long slender rod of tool steel uniformly glass-hard and at the same time straight. The temperature and induction coefficients of long magnets of the two kinds of steel seem not to be very different.

Most of the experiments here recorded were made on pieces cut from cold rods of self-hardening steel by the help of a very thin elastic emery wheel, which did not unduly heat the material. Large rods of glass-hard tool steel cut under water



by the same wheel showed no disturbance of temper at the ends of the pieces. The susceptibilities of many of these specimens of self-hardening steel were then determined in an

induction bench (figure 1) before and after they had been exposed to steam at 100° C. for hours in the manner suggested by Messrs. Barus and Strouhal. The results given in Tables III and IV show that the long-continued heating did produce a slight "relaxation" of the metal.

The pieces of steel were then magnetized between the poles of a soft iron yoke in a large solenoid carrying a current of 25–35 amperes. The semi-permanent moments which they acquired in this way were, however, much reduced (as may be seen by comparing the figures given in columns 2 and 3 of Table V) by boiling them for a long time in water and thus seasoning them. I expected that a number of long, seasoned magnets of given dimensions made in this way would be more nearly alike than a set of similar magnets made of tool steel, in the case of which the difficulties of uniform hardening are so great; but in this I was disappointed. Occasional very abnormal specimens occurred. A magnet seemingly like its neighbors would show a very low moment and at the same time temperature and induction coefficients 30 per cent or more above the others, which would prove to be nearly alike. An attempt to remedy these defects by remagnetizing the steel failed. I have assumed that a normal magnet is characterized by a high magnetic moment and low temperature and induction coefficients, and, although I could not prove, as in the case of tool steel, that all abnormal magnets were either soft in places or cracked, I rejected all such without question.

The temperature coefficients* were determined in a piece of apparatus described by Mr. Arthur Durward in his paper "On the Temperature Coefficients of Certain Seasoned Hard-Steel Magnets." The magnet to be experimented upon was fixed firmly in a non-magnetic holder inside a non-magnetic tube so as to be in Gauss's A Position east of a mirror magnetometer. By the help of an elaborate system of pipes constructed by Mr. J. Connors of the staff of the Jefferson Laboratory, tap water, steam, or a stream of water from a bath-water heater at almost any desired constant temperature between 15° and 100°, could be sent through the tube surrounding the magnet. On the west of the magnetometer, so placed in Gauss's A Position as to bring the needle back into the meridian, was a short, seasoned, compensating magnet fixed within a wooden holder and completely shielded from sudden temperature changes. If M' is the moment of the compensating magnet; α_0 , the needle deflection which it would cause if the magnet to be

* G. Wiedemann, *Pogg. Ann.*, 1852, 1858, 1864; Dufour, *Arch. de Genève*, 1857; Lamont, *Handbuch d. Magnetismus*, 1867; Barus and Strouhal, *Bulletin of the U. S. Geological Survey*, No. 14, 1885; F. Kohlrausch, *Wied. Ann.*, 1884; Cancani, *Atti Acc. Linc.*, 1887.

tested were away: M_0 , the moment of the last named magnet at the temperature t_0 , at which the adjustments have been made; and M , the moment of this magnet when, its temperature having become t , the needle is deflected through the

$$\text{angle } \alpha, \quad \frac{M_0 - M}{M_0} = \frac{\tan \alpha}{\tan \alpha_0}.$$

The strength of the field around the magnetometer needle could be modified at pleasure, and in this way great sensitiveness obtained. The change of moment caused by a change of temperature of a small fraction of a degree, even in the case of the shortest magnets used, could be easily measured when the center of the magnet was many times the length of the magnet away from the magnetometer.

If any one of my magnets which had not been heated above room temperatures for some time, was heated to 100° and then brought back to the room temperature, it did not immediately regain its original moment, and in the case of some magnets this temporary loss seemed to be greater than any which Mr. Durward noticed in the case of tool steel magnets. Upon reheating the magnet to 100° , there seemed to be little if any addition to this temporary loss, and the moment passed through a cycle when the temperature returned to its old value after going through any succession of changes. Whatever the previous history of a magnet had been, a sudden increase in temperature was accompanied by a sudden, not a gradually

TABLE I.

Results of observations on a seasoned magnet 8^{cm} long made of Jessops Square Self-Hardening Tool Steel.

Dimensions of cross section, 0.96^{cm} × 0.96^{cm}.

Temperature.	Loss of magnetic moment in terms of the moment, M_0 , at 7.7° C.
7.7	0.0000
12.0	0.0028
20.0	0.0087
30.0	0.0171
40.0	0.0259
50.0	0.0353
60.0	0.0448
70.0	0.0559
80.0	0.0683
90.0	0.0825
100.0	0.1016

TABLE II.

Results of observations on a seasoned magnet 6^{cm} long made of Mushet Square Self-Hardening Tool Steel.

Dimensions of cross section, 0.96^{cm} × 0.96^{cm}.

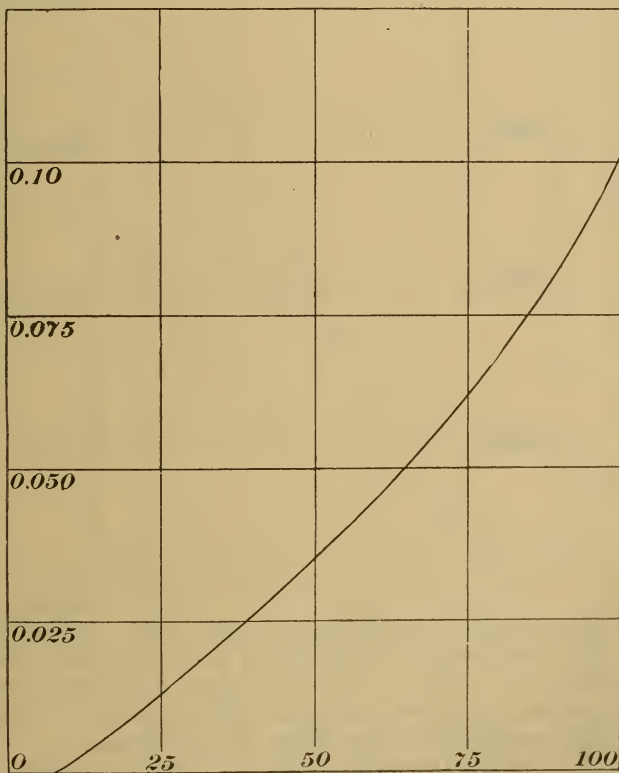
Temperature.	Loss of magnetic moment in terms of the moment, M_0 , at 7.2° C.
7.2	0.0000
12.0	0.0048
20.0	0.0140
30.0	0.0275
40.0	0.0420
50.0	0.0580
60.0	0.0805

increasing, fall of moment and the rate of the fall per

degree increased with the temperature. If, therefore, a curve be plotted the abscissas of which give the temperatures and the ordinates the differences between the moment (M_0) of any magnet at some given lower temperature (t_0) and the moments (M) of the same magnet at these temperatures, this curve will be concave upward.

Tables I and II give the results of a series of observations made by Mr. C. G. Persons on two short, stout, magnets made of self-hardening steel, which are fairly representative. In figures 2 and 3, where these results are shown graphically, the temperatures are used as abscissas and the corresponding values of the ratio of $M_0 - M$ to M_0 as ordinates. It is worthy of

2.

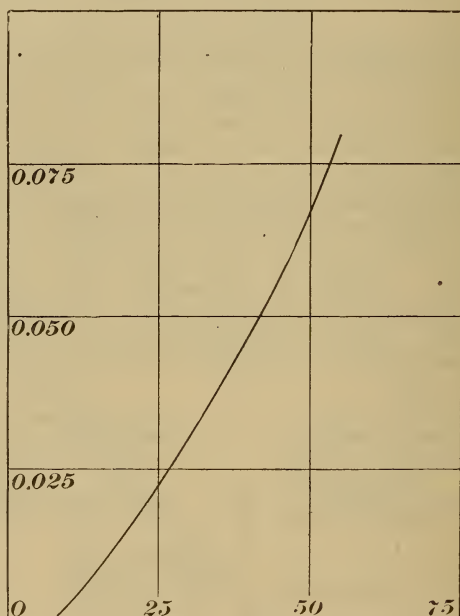


notice that these curves depart so widely from straight lines that the temperature coefficient, $-\frac{1}{M} \cdot \frac{dM}{dt}$, is in each case

about three times as great at 100° C. as at the temperature of the tap water.

Tables III, IV, and V show the results of a large number of measurements on magnets made of two well known brands of self-hardening steel. If the lengths of the magnets are used as abscissas and the corresponding numbers in the last two columns of each of these tables as ordinates, we get the curves represented in figures 4, 5, and 6. In the case of magnets made of ordinary fine tool steel, the differences between the temperature coefficients at low temperatures and at the temperature of boiling water, which are large when the magnets are

3.



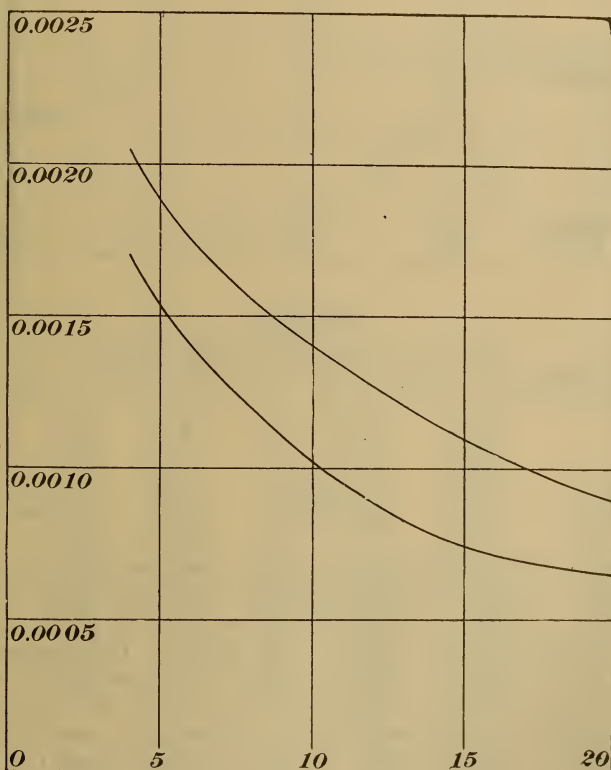
short, often become insignificant when they are relatively long. No such tendency is shown in the curves here printed. A portion of the upper curve in figure 6 which seems too nearly vertical, was drawn through points obtained by measuring a large number of magnets less than 4^{cm} long.

The work of Mr. Durward appears to show that whereas relatively long magnets made of fine tool steel generally have smaller temperature coefficients than relatively short ones, we cannot hope to reduce to zero the temperature coefficient of a magnet made of stout rod by lengthening it indefinitely. It

does not seem likely that a very long magnet made of the Jessops self-hardening steel, which I experimented on, would have a much lower temperature coefficient than the longest specimens I used.

The only very stout magnets with negative temperature coefficients that I have seen described are the comparatively weak ones made by Lamont of a kind of laminated steel and iron used in Russia. One of the advantages of very slender magnets, like those used so skillfully by Professor T. Gray, is that their temperature coefficients are comparatively small, as Cancani and others have shown. The relative loss of moment, when heated from the room temperature of 10° C. to 100° C.,

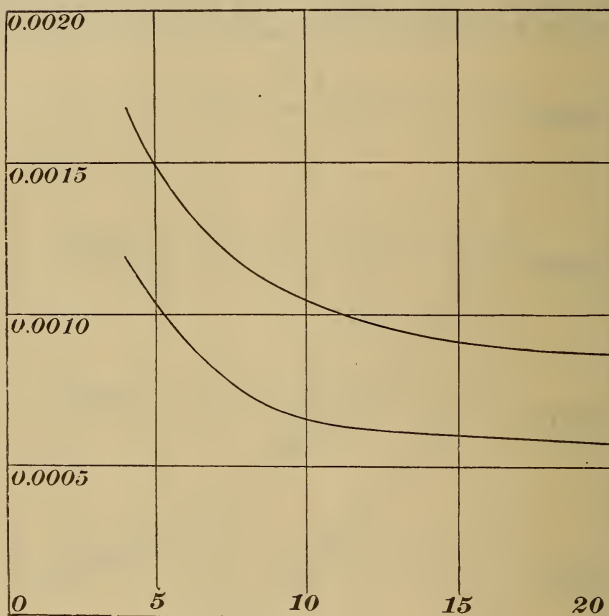
4.



of a number of very strong, seasoned magnets 10^{cm} long made of "Crescent Drill Rod" are shown in the following table. These results seem to point to small if not to negative coefficients in the case of very thin wire.

Diameter in centimeters.	$\frac{M_{10} - M_{100}}{M_{10}}$
0.33	0.00024
0.33	0.00022
0.33	0.00022
0.26	0.00015
0.23	0.00012
0.18	0.00010
0.18	0.00010

5.



Much smaller coefficients than those here indicated are often obtained. I have a seasoned magnet 10^{cm} long made of Crescent Drill Rod 2.0^{mm} in diameter the moment of which appears to be constant between 10° C. and 100° C. The moment per gram of this magnet is 29.3 c. g. s. units. A somewhat stronger magnet made from a piece of the same rod has a small but unmistakably positive coefficient. I have been unable to procure any very slender pieces of self-hardening steel, but if we may judge by the trend of observations made on thick specimens, a thin wire of this steel would yield magnets with very small temperature coefficients.

6.

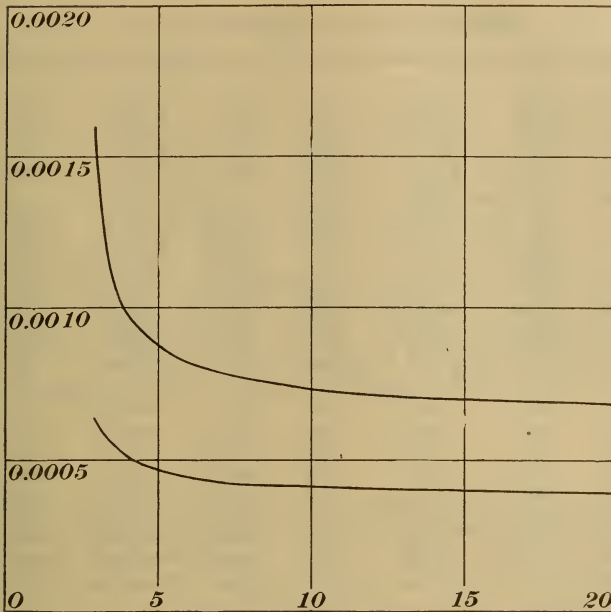


TABLE III.

Musket's Square Self-Hardening Tool Steel.

Dimensions of cross section 0.96×0.96 cm. Wt. per centimeter of length, 7.9 grams

Length in centimeters.	Moment per gram of the magnetism induced in the specimen in the condition in which it was purchased, when placed lengthwise in a unit field.	Moment per gram of magnetism induced in the specimen after it had been long boiled when placed lengthwise in a unit field.	Approximate magnetic moment per gram of the seasoned magnet at 15° C., expressed in c. g. s. units.	Approximate ratio of the induced moment caused by unit field to the permanent moment in the case of the seasoned magnet.	Mean loss per degree of the magnetic moment when the magnet is heated from about 15° C. to 100° C. expressed in terms of the moment at the lower temperature.	Temperature coefficient of the seasoned magnet at 15° C.
4.0	0.08	0.08	5.0	0.016	0.00205	0.00170
6.0	0.11	0.11	8.0	0.014	0.00175	0.00140
8.0	0.12	0.13	10.5	0.012	0.00155	0.00119
10.0	0.13	0.14	13.0	0.011	0.00140	0.00101
12.0	0.14	0.15	15.5	0.010	0.00127	0.00087
14.0	0.15	0.16	18.0	0.009	0.00115	0.00077
16.0	0.16	0.17	21.0	0.008	0.00105	0.00071
18.0	0.16	0.17	23.5	0.007	0.00097	0.00067
20.0	0.17	0.18	26.0	0.007	0.00090	0.00065

TABLE IV.

Jessops Square, Self-Hardening Tool Steel.

Dimensions of cross section $0.96\text{cm} \times 0.96\text{cm}$. Wt. per centimeter of length, 7.9 grams.

Length in centimeters.	Moment per gram of the magnetism induced in the specimen, in the condition in which it was purchased, when placed in a unit field.	Moment per gram of magnetism induced in the specimen after it had been long boiled, when placed lengthwise in a unit field.	Approximate magnetic moment per gram of the seasoned magnet at 15°C ., expressed in c. g. s. units.	Approximate ratio of the induced moment caused by unit field to the permanent moment in the case of the seasoned magnet.	Mean loss per degree of the magnetic moment when the magnet was heated from about 15°C . to 100°C ., expressed in terms of the moment at the lower temperature.	Temperature coefficient of the seasoned magnet at 15°C .
4.0	0.05	0.05	4.5	0.011	0.00170	0.00119
6.0	0.07	0.08	7.0	0.011	0.00135	0.00092
8.0	0.08	0.09	9.0	0.010	0.00116	0.00074
10.0	0.09	0.10	11.5	0.009	0.00107	0.00066
12.0	0.10	0.11	14.0	0.008	0.00098	0.00063
14.0	0.11	0.12	16.0	0.007	0.00093	0.00061
16.0	0.11	0.12	18.5	0.006	0.00091	0.00060
18.0	0.12	0.13	21.0	0.006	0.00089	0.00059
20.0	0.13	0.14	23.0	0.006	0.00088	0.00058

TABLE V.

Jessops Square Self-Hardening Tool Steel.

Dimensions of cross section, $0.64\text{cm} \times 0.64\text{cm}$. Wt. per centimeter of length, 3.5 grams.

Length in centimeters.	Approximate magnetic moment per gram at 15°C . of the relaxed steel when in tight fit, after saturation before the final boiling.	Approximate magnetic moment per gram of the seasoned magnet at 15°C ., expressed in c. g. s. units.	Mean loss per degree of the magnetic moment when the magnet is heated from about 15°C . to 100°C ., expressed in terms of the moment at the lower temperature.	Temperature coefficient of the seasoned magnet at 15°C .
3.0	8.2	6.0	0.00160	0.00064
4.0	11.5	8.0	0.00099	0.00052
6.0	16.6	12.5	0.00082	0.00045
8.0	23.5	16.6	0.00077	0.00042
10.0	28.0	21.0	0.00074	0.00041
12.0	33.5	25.6	0.00072	0.00040
14.0	38.5	31.0	0.00071	0.00040
16.0	44.6	36.0	0.00070	0.00039
18.0	50.3	41.0	0.00069	0.00039
20.0	55.7	47.0	0.00069	0.00039

The Jefferson Physical Laboratory, Cambridge, Mass.

ART. XLIII.—*A Curious Inversion in the Wave Mechanism of the Electromagnetic Theory of Light*; by C. BARUS.

1. THE account given by the equations of the electromagnetic theory of light as to the motion, is without ambiguity; but when one endeavors to reconstruct such a wave graphically one is apt to fall into a trap such as will make the wave run backwards. To briefly summarize the formulæ relevant to the present paper, I will refer to the mode of derivation in which the conception of a displacement current conditioned by the time variation of electric force is first clearly put. Then the fundamental equation for electric flux in the direction of an axis (Y) in terms of the line integral of magnetic force (α, γ) around that axis is in the usual notation

$$\frac{K}{V} \frac{\delta Y}{\delta t} = \frac{\delta \alpha}{\delta z} - \frac{\delta \gamma}{\delta x} \quad (1)$$

provided the Hertzian device of measuring electric quantities electrostatically and magnetic quantities electromagnetically is introduced for symmetry. Here V is the normal velocity of light, K the specific inductive capacity of the medium. A clockwise curl of magnetic force around the electric axis is therefore in question.

On the other hand, the fundamental surface integral of magnetic flux in the direction of an axis (z), is expressed in terms of the line integral of electric forces around that axis by

$$-\frac{\mu}{V} \frac{\delta \gamma}{\delta t} = \frac{\delta Y}{\delta X} - \frac{\delta X}{\delta y} \quad (2)$$

where Hertz's method has again been used and where μ is the magnetic permeability of the medium. The curl of electric force around the magnetic axis is here counter-clockwise. Further equations need not be adduced since the electric forces X and Y in directions x and y and magnetic forces α, γ in directions x and z at the point x, y, z and at the time t , suffice for the present purposes.

From these equations to the differential equations of wave motion, known in form and treated with success even in D'Alembert's time, is not an arduous span. Making it one obtains in the usual way

$$\frac{\delta^2 Y}{\delta t^2} = \frac{V^2}{\mu K} \nabla^2 Y,$$

and

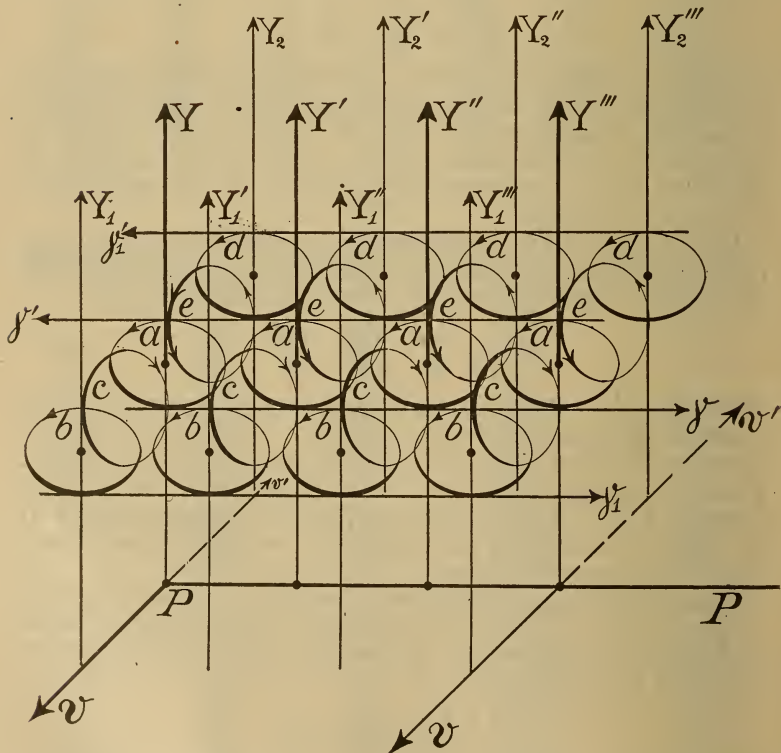
$$\frac{\delta^2 \gamma}{\delta t^2} = \frac{V^2}{\mu K} \nabla^2 \gamma,$$

two equations precisely alike except as to the variables Y and γ . The clockwise and counter-clockwise contrast of (1) and (2) has vanished. $V/\sqrt{\mu K}$ is seen to be the common velocity of the two waves, if waves there be. Applied to plane wave fronts parallel to yz one obtains

$$Y = A \sin 2\pi \left(\frac{t}{T} - \frac{x}{\lambda} \right)$$

$$\gamma = NA \sin 2\pi \left(\frac{t}{T} - \frac{x}{\lambda} \right)$$

where N is the index of refraction, T the period and λ the wave length in the given medium of permeability μ and specific inductive capacity K . The two waves differ merely and naturally in amplitude. They are alike in phase. Nothing is left to recall the opposite signs of (1) and (2). The direction



of common advance is $+x$, when the direction of positive electric force is $+y$ and of magnetic force $+z$, in english or clockwise coördinates. The wave follows the motor rule which,

given in Fleming's lucid way, points the first finger of the *left* hand in the direction of magnetic force, the second finger in the direction of electric current, leaving the thumb in the direction of advance of the wave.

2. Suppose now one endeavors to make a straight-forward step-for-step construction of the electric wave, as is done in the annexed diagram, where full arrows denote magnetic circuits and forces, open arrows the corresponding electric quantities.

Let $Y, Y' \dots$ in the original plane PP of the wave front, denote the direction of increasing electric force, and therefore of electric polarization and of electric displacement currents. Each current is accompanied by a clockwise whirl, a, a, \dots , of magnetic force encircling it. These forces neutralize each other in the regions between the electric forces, but they have a common direction γ and γ' on either side of the wave front PP . Now let the resulting magnetic forces γ and γ' in their turn be treated individually and each provided with a counter clockwise whirl of electric force, polarization and current, as shown by e, e, \dots around γ and e, e, \dots around γ' respectively. The curls so obtained both tend to neutralize the original electric forces Y, Y', \dots , and to replace them by two new planes of electric force or wave fronts $Y_1, Y_1' \dots$ and $Y_2, Y_2' \dots$ etc. Clearly electric forces above and below the plane γ, γ' would also tend to neutralize each other.

Each of the new electric forces Y_1, Y_1' and Y_2, Y_2', \dots is however again to be provided with a clockwise magnetic whirl $b, b \dots$ and $d, d \dots$ respectively, which together would tend to neutralize γ and γ' and evoke the new magnetic forces γ_1 and γ_1' . Hence by a construction quite recalling Huyghens's principle a new set of electric and magnetic forces Y_1 and γ_1 , and Y_2 and γ_2' respectively, have been obtained from the original Y and γ, γ' . The process may be indefinitely repeated, provoking an advance of the wave front in both directions, v and v' , from the original wave front PP and at right angle to this plane. In other words, the advance in the figure is to and from the reader.

But unfortunately both waves, if the forces Y and γ are correctly drawn, run in the wrong direction! This may easily be tested by using the left hand as above stated. If the direction of advance v and the electric forces are correct, the magnetic force is in the wrong direction; or finally for correct advance and magnetic force, the electric forces turn out negative. True, since we have two waves moving from each other, the discrepancy could be reconciled by coupling the forces of either wave front with the direction of the other, though such counsel is hardly compatible with sobriety. The very predic-

tion of two waves might be an uncomfortable consideration. In fact only if we accompany the electric current with a counter-clockwise magnetic whirl, and the magnetic flux with a clockwise electric whirl—only by reversing the relations of electric and magnetic field, which everybody is in the habit of associating with electromagnetic phenomena, can we make the wayward wave run right.

3. To arrive at an insight into the conditions here presented one may note that if the Y forces were constant, there would be no magnetic field in the dielectric due to the occurrence of the electric excitation. Since the magnetic forces a, β, γ , are in this case partial differential coefficients of a potential function, there may be a magnetic field due to extraneous causes. This however has nothing to do with the immediate problem. In the diagram Y, Y', \dots would alone occur unaccompanied by magnetic whirls. In the second place if $\delta Y/\delta t$ is constant a magnetic field must be evoked in the dielectric; but this field, apart from the manner of its origin, will during the period of constant $\delta Y/\delta t$ be invariable in intensity and position. It will be a stationary magnetic field, the lines of which are fixed both as to their geometry and their number. As such it is entirely unable to evoke displacement currents. In the above diagram this would mean that, although the forces Y, Y', \dots the whirls a, a, \dots and in consequence the forces γ, γ' exist, the electric whirls $e, e \dots$ and $c, c \dots$ do not exist.

Finally let $\delta^2 Y/\delta t^2$ have a significant value, positive or negative. The values $\delta Y/\delta t$ will then be variable. Displacement currents will therefore be evoked in the dielectric, and the electric whirls $c, c \dots$ and $e, e \dots$, the resultant electric forces Y_1, Y'_1, \dots and Y_2, Y'_2, \dots , the magnetic whirls $b, b \dots$ and d, d, \dots etc., will in general all have to be entered in the diagram. One may conceive the disturbance to be transferred from PP in both directions indefinitely. It need not however be a harmonic disturbance.

If however the time variation of Y, Y', \dots is simple harmonic, then $\delta^2 Y/\delta t^2$, etc., are essentially negative and negatively increasing of the Y 's themselves are essentially positive and increasing; and vice versa. Hence γ is essentially decreasing if Y is essentially increasing in the lapse of time. The magnetic polarization is therefore falling off. The effect of an increasing Y is thus virtually to superpose on any existing magnetic field, new forces γ and γ' which have directions respectively *opposite* to those given in the diagram. These new forces γ and γ' then constitute a *counter-clockwise* whirl of magnetic forces $a, a \dots$, around the electric forces Y, Y', \dots , thus wholly reversing the directions of the parts $a, a \dots$, γ and γ' of the diagram.

The same result may be reached somewhat differently: constant $\delta Y/\delta t$ is equivalent to a fixed magnetic polarization in circuit a , the value of which may be either large or small but which is clockwise around Y . Retarded variation of $\delta Y/\delta t$, such for instance as occurs in simple harmonic motion, is thus equivalent to a waning of the clockwise magnetic polarization; or from another point of view, it is equivalent to an increase of counter-clockwise magnetic polarization around Y , hence to a series of counter-clockwise whirls of magnetic force around $Y, Y' \dots$ yielding γ and γ' reversed as resultants.

4. Turning now to the values of γ and γ' which by the present inferences are *opposite* in direction to those given in the diagram, and are increasing in value in this reversed direction at the retarded rate demanded by the simple harmonic equation, it will be expedient to carry forward the argument in the step for step fashion of the preceding paragraph. If γ were constant it would be unaccompanied by an electrical effect, if we except the case that X, Y, Z , may in such a case have a potential due to extraneous causes of no relevant interest. If γ is variable but $\delta\gamma/\delta t$ constant, the result would be an electromotive force curled counter-clockwise around γ . There would be a curled electric polarization of the dielectric but no displacement current around the axis of magnetic force. Finally if $\delta^2\gamma/\delta t^2$ is significant displacement currents must occur and be maintained.

But for the case of an inherent simple harmonic law originating in Y and transferred to γ , the time variation of γ is always retarded from an absolute point of view. Hence the counter-clockwise electric polarization around γ , reversed, is falling off; in other words, clockwise electric polarization around γ reversed is increasing. Virtually therefore a clockwise displacement current is running around γ reversed, i. e. a counter-clockwise current must encircle the γ as drawn in the diagram. Hence both the whirls $c, c \dots$ and $e, e \dots$, are correctly drawn in the diagram for positive increasing $Y, Y' \dots$ and the new electric excitations (c, e) tend both to weaken Y , and to evoke the new wave front Y_1 and Y_2 as shown.

These forces Y_1 and Y_2 are then to be treated each in its turn in the same way as Y , reproducing the same results indefinitely. Thus the following paradoxical rule relative to the construction of the mechanism of a simple plane electric wave would seem to follow: Provide the original electric flux (Y) with a counter-clockwise magnetic curl (a); provide the resulting magnetic fluxes (γ, γ') each with a clockwise electric curl (c and e); and so forth indefinitely. For such a wave the electric and magnetic forces and the advance of the wave will be in correct directional relations (§ 1, end). The wave would

advance in one direction only if for Y we insert the corresponding gradient $\delta Y/\delta x$ in the direction of advance.

Mathematically stated, if Y is simple harmonic and positive, $\delta^2 Y/\delta t^2$ will be negative and $\delta^4 Y/\delta t^4$ positive again. If therefore clockwise curls are associated with positive fluxes, the magnetic curl around Y conditioned by $\delta^2 Y/\delta t^2$ must be counterclockwise, whereas the electric curl around γ or γ' conditioned by $\delta^4 Y/\delta t^4$ must be clockwise.

5. With the wave disposed of, the question nevertheless remains as to what will happen if the original impulses Y , Y' . . . are not simple harmonic but of a character to make $\delta^2 Y/\delta t^2$ positive. If then $\delta^4 Y/\delta t^4$ is also positive, $\delta^2 \gamma/\delta t^2$ is positive and increasing and the above diagram is a correct representation of the case. Energy would be transferred from the original plane PP in both directions v , v' , not however as a wave but as simple flux in the direction of the energy paths v , v' , until the original stress Y breaks down or follows some other law. It seems to me that the case is not without subtlety and that this nonharmonic rush of electric energy in a direction opposite to the usual energy path cannot be excluded. Its duration would be short since Y , Y' . . . are to remain finite.

Suppose now that such a rush and breakdown occurs irregularly: the irregularity would be accentuated since the energy paths in the rush and the breakdown would in a measure be in opposite directions. Energy so transferred could neither be easily reflected nor refracted and it certainly could not be brought to interference or polarization. In proportion as the rush and breakdown became more and more rhythmic or wave-train-like, reflection, etc., would eventually manifest themselves. One is tempted therefore to associate these occurrences with the recent advances in electro-optics, particularly since the deflecting effect of a magnet on the transient electric whirls or their resultants Y , and therefore on the energy path, is not out of the question. During the rush, in other words, the direction of electric current in the whirls or the fluxes Y remains unchanged for relatively long periods, whereas in an ordinary wave these directions are regularly and rapidly reversed in the lapse of time.

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ART. XLIV.—*On the Determination of Plagioclase Feldspars in Rock Sections*; by GEORGE F. BECKER. (With Plate III.)

IN examining the rocks described in a recent report* pains were taken to determine the species of the lime-soda feldspars by modern methods. The difference of refraction between a mineral and the balsam or between two minerals in contact, according to the method of Prof. F. Becke, is often useful, and Prof. J. E. Wolff was good enough to determine for me the index of refraction (1.5393) of the Canada balsam used in the final mounting of the slides of the U. S. Geological Survey. Much more useful still is the method which Prof. A. Michel-Lévy has developed in two memoirs which should be in the hands of all petrographers.† The method of Mr. Michel-Lévy does not necessitate the use of the Fédoroff table, at least in rocks which show an abundance of well-developed feldspars.

In such rocks it is usually sufficient to deal with the feldspars, which are cut nearly perpendicular to the brachypinacoid (010), g' or $\infty P \infty$. When a crystal is cut in this zone, of course the albite twin lamellæ extinguish at equal angles on opposite sides of the cross-hair of the microscope. When a crystal is twinned both according to the albite law and the Carlsbad law, this fact can be detected by placing the trace of the twinning plane at an angle of 45° to the principal sections of the nicols. The associated albite twins are then equally illuminated and cease to be apparent. On the other hand, the Carlsbad twins are not then equally illuminated, so that a crystal twinned according to both laws seems to resolve itself into a mere Carlsbad twin. The Carlsbad junction commonly shows signs of interpenetration, and is broken or irregular, while the albite junctions are straight. Supposing such a section in the zone under discussion, one has in general two sets of albite lamellæ, each extinguishing at an equal angle to the cross-hairs, but each pair at a different angle; and furthermore, the orientation of the two pairs of albite lamellæ bear a definite relation to each other, because the difference of orientation is due to Carlsbad twinning. If angles in the zone are counted from the front edge of the prism, and if one pair of albite lamellæ is cut by a plane making an angle ϕ with the front edge, then the other pair of lamellæ is cut at an angle of $180^\circ - \phi$ to the same edge. Mr. Michel-Lévy's beautiful stereographic projections (first fascicle) show how the extinctions in

* This note is an extract from a paper on the Gold fields of Southern Alaska, in the Ann. Rep. U. S. Geol. Surv., 1896-97, part III.

† Étude sur la détermination des feldspaths, 1894. Same, second fascicle, 1896.

such cases will arrange themselves. He has also plotted the extinctions for this particular zone, and shows that when a compound albite-Carlsbad twin is cut in this zone it can in almost all cases at once be referred to its proper species and its proper orientation.

By some mischance errors have crept into this diagram of the extinctions of the feldspars in the zone of symmetry, and I have taken the liberty of replotting it (on Plate III) from the stereographic projections. I have also added plots of the extinctions at 10° from the zone of symmetry in either direction. In a thin section of a rock the chances are infinitely against any feldspar being cut with mathematical precision in the zone of symmetry. Hence the question at once arises how the extinctions will vary in case the plane of symmetry is slightly inclined. These supplementary diagrams give this information at a glance and assure the observer whether or no the variation of the orientation from the position of exact symmetry precludes precise determination.

In a very great number of cases feldspars exhibit traces of zonal structure due to gradual variation in the composition of the successively deposited layers of the crystal. Mr. Michel-Lévy has shown in his second fascicle that if one regards the several plagioclases as mere mixtures of albite and anorthite, instead of as independent species, the position of equal zonal illumination is absolutely characteristic of the orientation of a feldspar in the zone of symmetry. There is only one angle in each quadrant at which equal zonal illumination occurs. This method can be used, for example, in determining when a crystal is cut so nearly perpendicular to the prismatic axis that the extinction of Carlsbad lamellæ should be taken upon opposite sides of the cross-hair. In that case the angle of equal zonal illumination cannot exceed 11° . The angle of equal illumination as a rule is less sharply determinable than, for example, that of equal illumination of albite lamellæ.

In his second fascicle Mr. Michel-Lévy regards all the plagioclases as mere mixtures of albite and anorthite, and defines the special occurrences in percentages. There is, of course, a very great amount of evidence for this position, and, so far as the needs of the working lithologist are concerned, it is probably without sensible error. At the same time it may be remarked that were there no dissipation of energy accompanying the union of the albite and anorthite they would not tend to unite. The liberation of energy corresponding to their actual tendency to union must, one would think, be accompanied by some modification in physical qualities; but this change, so far as known, is negligibly small.

Mr. Michel-Lévy's new attitude toward the feldspars involves

some slight changes in the diagrams. He has given a new diagram for the extinctions in the zone of symmetry, showing the zero angle for the same orientation in all varieties. He does not give a new set of stereographic projections for the several species, and the means are therefore not at hand for plotting the extinctions at 10° from the zone of symmetry. For this reason I have not redrawn the diagram given above of the extinctions. The changes which would be involved appear inconsiderable, and I have found the diagrams for what may be called latitude $\pm 10^\circ$ too useful to be willing to abandon them. It should be noted that Mr. Michel-Lévy's new fascicle gives stereographic diagrams for microcline.*

While the zone of symmetry is the most useful one, and is usually sufficient where material is abundant, cases also arise in which other parts of the stereographic projections are indispensable. When needful, a skillful use of the stereographic projections will suffice to determine almost any doubly twinned phenocrysts, however cut, and sometimes mere albite twins. With the aid of the Fédoroff or Klein stages any phenocrystic albite twin can be determined, but the use of such a table involves the application of low powers only.

While Mr. Michel-Lévy's method of Carlsbad twins, referred to above, is usually sufficient to determine the species of the feldspars of primary generation in porphyritic rocks, it is not easily applicable to the microlitic feldspar of secondary consolidation. Such microlites are twinned according to both the albite and Carlsbad laws, less frequently than are the phenocrysts; they are also often entirely embedded in groundmass which obscures the extinctions, and relatively high powers must be employed in examining them. Nevertheless, with patience and good eyesight, determinations can often be made. Such determinations have been used as a check upon another method which presents no difficulties, and which will now be described.

In studying the groundmass of lavas from Alaska and California, I have observed many minute, nearly square, sections of plagioclase microlites.† These sometimes show albite twin-

* Taking albite as $\text{NaAlSi}_3\text{O}_8$, molecular weight 263.36, and anorthite as $\text{CaAl}_2\text{Si}_2\text{O}_8$, molecular weight 279.09, I find the following percentages of anorthite in the several feldspars. Michel-Lévy gives somewhat different values in his second fascicle, page 107.

Feldspar.	Symbol.	Percentage of anorthite.
Albite	Ab	0
Sodium Oligoclase	Ab_4An_1	20.95
Calcium Oligoclase	Ab_2An_1	26.11
Andesine	Ab_6An_3	38.88
Sodium Labradorite	Ab_1An_1	51.45
Calcium Labradorite	Ab_3An_4	58.55
Anorthite	$\text{Ab}_{11}\text{An}_{200}$	95.06

† The length of a side is usually less than two one-hundredths of a millimeter. Sometimes there are two generations of microlites.

ning parallel to one pair of sides, while in more numerous cases no twinning is visible. They also in some cases exhibit a truncated corner. It appears probable that these microlites are elongated in the direction of the edge between the base and the brachypinacoid, and that they are cut nearly at right angles to this edge, being occasionally truncated by a hemidomal face. This suspicion is confirmed by comparison between the extinctions of such square sections and those of microlites in the same slides which show both albite and Carlsbad twinings. An elongation in the direction of this edge is also to be expected from Bravais's theory of crystallization; the two faces, base and brachypinacoid, being those of perfect cleavage. Where such microlites present themselves it is easy to see whether they are cut perpendicularly to their axes by following the microlite through the slide; for if the little prism is inclined, the image in focus will shift laterally as the objective moves.

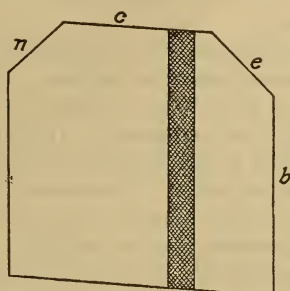
Now it happens that prisms bounded by these faces, and in a vertical position, are very favorably situated for discrimination. This will appear by examining Mr. Michel-Lévy's stereographic projections of the various feldspars at 90° to the pole p . In this neighborhood there is a saddle in the extinction surfaces of the feldspars (the central point of the saddle answering to Mr. Michel-Lévy's "most frequent extinction"), and the consequence is that an inclination of even 10° affects the extinction of a square microlite section very little. Furthermore, the difference between the behavior of different feldspars is great, so that a confusion between the different species is almost impossible, as may be seen from the little table below.*

In favorable cases the sign of the extinction can be made useful in the determination of these microlites, which are not really square. In albite the faces c (001) and b (010) make an angle of $86^\circ 24'$, while in anorthite this angle becomes $85^\circ 50'$. The divergence from rectangularity is thus sensible, and the proper position of the crystal is then with an acute angle in the upper left-hand quadrant (fig. 1). When the hemidomal faces appear, n (021) truncates the acute angle, making sensibly equal angles of between 46° and 47° with the adjoining faces. The other corresponding hemidome, e (021), truncates the obtuse angle and makes angles of from 42° to 43° with the adjoining faces. Andesine and albite can thus be discriminated when orientation is practicable. This discrimination can be confirmed by testing the index of refraction. Andesine has about the

* In this table the percentages of anorthite are given as they appear in Michel-Lévy's work. As is mentioned above, these do not answer precisely to the molecular formulas, but whether the formulas or the percentages need correction I am not certain.

same index of refraction as quartz, and a higher index than balsam, while albite has a lower index than either.

1.



Orthoclase microlites would be exactly square; they would not show polysynthetic twinning, and the index of refraction is much lower than that of oligoclase, which, like orthoclase, extinguishes at 0°.

Extinction of nearly square sections of feldspar microlites cut within 10° of the perpendicular to the edge (001) (010).

Feldspar.	Composition.	Extinction.
Anorthite	Ab ₁₁ An ₂₀₀ = 96% An	+ 42½ ± 3½
Calcium Labradorite	Ab ₃ An ₄ = 60% An	+ 38 ± 3
Sodium Labradorite	Ab ₁ An ₁ = 47% An	+ 26½ ± 2½
Andesine	Ab ₅ An ₃ = 34% An	+ 16 ± 2
Calcium Oligoclase	Ab ₃ An ₁ = 28% An	+ 4 ± 1½
Sodium Oligoclase	Ab ₄ An ₁ = 18% An	+ 0 ± 1½
Albite	Ab = 0% An	- 13 ± 2½

It need not be said that in many rocks the determination of the microlites is quite as important as that of the phenocrysts, their united volume often equaling or exceeding that of the larger crystals. It is also extremely interesting to compare the character of the two generations. It is usually stated or assumed that the microlites are all of one species. The examination of the square sections, of which a dozen or two are often visible in a single slide, leads me to a different conclusion. As a rule the majority do belong to a single species, but it is seldom that two or three out of ten do not belong to a different species; in short, the microlites in the slides I have examined show an irregularity of species of the same order as, and often greater than, that of the phenocrysts. The square sections often show zonal structure, and nearly always the exterior portion is more alkaline than the inner portion; but in a couple of cases this order was found to be reversed. Occasional reversals of this sort are to be found among phenocrysts also.

These facts clearly show that even the residual mother liquor of a consolidating lava is far from homogeneous, even over the area of a square centimeter, and therefore, also, that diffusion in such a liquid must be extremely slow, since diffusion would bring about homogeneity. The bearing of this observation on the theory of "differentiation" of rock magmas is manifest.

The existence of rod-shaped microlites, in connection with the fact that some of them show Carlsbad twinning, throws some light on the origin of twinning. If Carlsbad lamellæ of bacillar shape developed in contiguity but independently, they would form X-shaped crystals. These are said to occur, but are not common in my experience.* In the bacillar microlites under discussion one lamella has controlled the development of the rod, and the other lamella has accommodated itself. It is difficult to see how this could happen in mere crystallization, for why should one part resign its tendency to elongation in the direction of the cleavage edge? On the other hand, it is well known, from the investigations of Messrs. Max Bauer, O. Mügge, L. van Werweke, J. W. Judd, and others, that there is much reason to ascribe polysynthetic structure largely to stresses called in play by the cooling process. This theory would fully explain the bacillar microlites as well as some beautiful cases of bent phenocrysts where twinning by various laws stands in manifest relation to flexure. It would also afford an explanation of the fact, of which comparison has convinced me, that twinning is less frequent in the microlites than in the phenocrysts, for the smaller the crystal the less is the chance that external stresses upon it would reach the intensity needful to produce mechanical twinning.

In the same connection it may be noted that stresses such as would lead to the mechanical twinning of plagioclases would also set up a mechanical æolotropy in glass. As a matter of experience, I have found it extremely difficult to detect any absolutely isotropic base in some lavas which I had reason to believe contained a small amount of glass. The faint variation of tints observed with the gypsum plate between crossed nicols in such cases may, perhaps, have been due to strain and not to crystalline symmetry of structure.

* That phenocrysts often take the form of fully developed Carlsbad twins is well known.

ART. XLV.—*Some Lava Flows of the Western Slope of the Sierra Nevada, California* ;* by F. LESLIE RANSOME.

Introduction.—The field relationships of the rocks described in this paper were studied during the summers of 1895 and 1896, while engaged in geologically mapping portions of the Sonora and Big Trees quadrangles, under the direction of Mr. H. W. Turner. It was found that in addition to the andesitic tuffs and breccias which are so widely and monotonously developed over the broad western slope of the Sierra Nevada, there occurs within the district studied another series of lavas in the form of massive flows, covering much less extensive areas than the clastic andesites. Taken as a whole they form a set of superimposed flows, extending in a southwest direction from some as yet unknown source near the crest of the range, down to the village of Knight's Ferry, near the edge of the Great Valley—a distance of more than 60 miles. Only one of the flows is known to have extended the whole distance, and they have all suffered considerable dissection through the very incisive gashing of the present streams; but in a general way the line of flow may be said to follow the present course of the Stanislaus River. These lava-streams were poured out within the period of eruptive activity during which the andesitic breccias and tuffs were spread for hundreds of square miles over the western flanks of the Sierra. But their eruption was immediately preceded by an interval of sharp erosion, which cut out the channel down which they flowed toward the valley. Subsequently they were again partly covered by fresh deposits of andesitic breccia, especially in the higher portions of the range.

The distinctive chemical feature of these rocks is a rather high percentage of total alkalis, with the potash somewhat in excess of the soda. Chemically they stand between typical andesites and typical trachytes, and belong to a group which it seems necessary to classify under a new name. Without anticipation of a discussion which has its proper place after the rocks themselves have been described, the name *latite* (derived from the Italian province of Latium or Latia, where rocks closely related to those described in the present paper occur extensively) may be considered, for the present, merely as a convenient designation for the group of lavas which form the subject of the present paper, for the purpose of avoiding con-

* Published by permission of the Director of the U. S. Geological Survey; being an abstract of Bulletin No. 89 of the Survey.

fusion with the ordinary clastic andesites abundant in the same field.

The laboratory work embodied in the preparation of the following pages was carried on in the petrographical laboratory of Harvard University, and my thanks are due to Professor Wolff for the excellent facilities there enjoyed. I am also indebted to Mr. Turner, not only for the original permission to undertake the work, but for generously aiding it in many ways.



FIG. 1. Index-map showing position of area embraced in Sketch-map, fig. 2.

Physiography of the region.—The accompanying map on page 357 embraces a rectangular strip of country 63 miles in length and 14.5 miles in width, with its longer dimension lying very nearly northeast and southwest. It includes portions of the Oakdale, Sonora, Jackson, Big Trees, Dardanelles, and Pyramid Peak atlas sheets. Considerably more than half the area, however, lies within the Big Trees sheet. The extreme southwestern portion, lying west of longitude $120^{\circ} 30'$ and south of latitude 38° , is taken from the northeast corner of the unfinished Oakdale sheet. The topography is here only partly

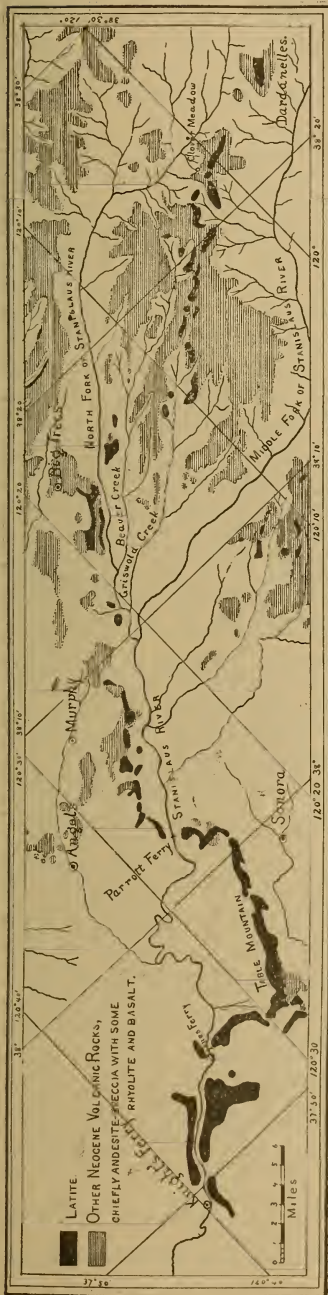


FIG. 2. Sketch-map of a portion of the drainage area of the Stanislaus River, California, showing the distribution of the latites and other Neocene lavas, by F. L. Ransome.

indicated, and the areas of latite are drawn with approximate outlines, subject to future revision. A similar explanation should also be made in regard to the corner of the map lying east of longitude 120°, which is a part of the Dardanelles sheet. The work in this portion of the area was limited to a rapid reconnoissance before the completion of the topographic map.

The elevations, in the region studied, range from a general altitude of about 500 feet, near Knight's Ferry, to 9529 feet on the culminating summit of the group of peaks, in the eastern corner of the area, known as the Dardanelles, corresponding to an average grade of 150 feet per mile. As a whole, this area is practically destitute of alluvial valley-bottoms, and is drained by streams of torrential character. It is traversed from end to end by the young, consequent Stanislaus River, including its two principal branches the North and Middle Forks, and may be regarded as a thoroughly typical transverse strip of the great tilted and dissected peneplain which forms the western slope of the Sierra Nevada. The rocks upon which this rather uneven peneplain has been carved are those of the so-called "Bed-rock Series" of the Gold Belt folios, comprising rocks of Jurassic and pre-Jurassic age, with later intrusive masses, and consisting in

the foot-hill region of closely compressed clay-slates, schists, limestones, quartzites, and various igneous rocks, with a prevailing northwest and southeast strike, and nearly vertical northeast dip, and in the higher portions of the range of gneissoidal and granitic rocks.

Toward the end of the baselevelling process, which, as shown by Diller* and Lindgren† for other portions of the Sierra, lasted at least into the Miocene, the series of volcanic eruptions began which continued through the Pliocene, and ended by covering the old surface far and wide with a blanket of clastic andesitic material in the form of breccias, rolled gravels, and fine tuffs. At the same time began the tilting which has given the peneplain its present slope of about two degrees to the southwest. The old surface revealed to-day by the stripping off of a great part of its andesitic cover, is by no means a perfectly even one. If the sharp V-shaped cañons of post-Tertiary date were all filled up, and the remnants of the Tertiary volcanic cover quite removed, there would still remain a surface of gentle relief surmounted by occasional monadnocks. On the whole though, it would be a topography of greatly subdued relief when contrasted with the possibilities for alpine types of form suggested by the nearly vertical schistose rocks and batholithic plutonic masses out of which it had been carved.

The old peneplain character is not everywhere equally well preserved. In the foot-hill region, embracing roughly the southwestern third of the map, the existence of long belts of highly inclined rocks of varying resistance to erosion, has led to the rapid development of subsequent streams and a general degradation of the surface of the country. The least defacement of the Neocene peneplain is found in the region lying between Murphy and Clover Meadow. Here the homogeneity of the underlying rocks has tended toward the perpetuation of a general consequent character of drainage, the dominant type of topography being that impressed upon the region by the prevalence of long, narrow, and often flat-topped ridges, separated by sharp V-shaped cañons. In the shelter of the latter flourish some of the noblest of forest trees, including the *Sequoia gigantea*, and the beautiful sugar pine, *Pinus lambertiana*. From Clover Meadow northeastward, the Neocene accumulations have been more thoroughly eroded away, leaving a bare hummocky granitic slope, deeply trenched by the gorges of the larger streams, and surmounted by residual

* Topographic revolutions on the Pacific Coast, 14th Ann. Rept. U. S. G. S., pp. 419-421.

† Age of Auriferous Gravels of the Sierra Nevada, Jour. of Geol., vol. iv, pp. 893 and 898.

buttes, or clusters of peaks, such as the Dardanelles, composed of remnants of the former volcanic cover.

The Table Mountain Flow.—The first and longest of the latite flows has been so designated from the fact that it forms the conspicuous topographic feature west of Sonora known as Table Mountain. Starting from Knight's Ferry, this flow can be followed up the Stanislaus River for a distance of about 8 miles to a point near Byrnes Ferry. Along this distance the latite forms broad, flat tables, with black rugged surfaces. The river has cut through the lava, and flows in a picturesque gorge cut deep into the slaty rocks of the Bed-rock series. At the brink of the gorge the edges of the Table Mountain flow form vertical cliffs, usually showing columnar structure. Near Byrnes Ferry the line of the old channel turns eastward for about 4 miles, then again resuming its northeast trend to form the long and imposing rampart of Table Mountain. Owing to the general degradation of the country immediately surrounding it, this portion of the flow, with its strikingly even crest-line and bounding columnar cliffs, is a very prominent feature in the landscape, and has been quite fully described by Trask,* Whitney,† and others, all of whom refer to it as a basaltic flow. Many tunnels have been run beneath the lava of Table Mountain for the purpose of exploiting the auriferous stream-gravels which were buried by its eruption, and subsequently protected by its resistant mass. Near Parrott Ferry the course of the lava-flow again swings northwestward and crosses the present Stanislaus River, here flowing in a deep gorge, 1000 feet below the dissected remnants of the latite that rest upon the brows of the precipitous cañon walls. From Parrott Ferry the formerly continuous lava-stream is now traceable as a series of dissevered patches, lying along the right bank of the main Stanislaus River, and of its North Fork, to a point southeast of Big Trees. Along this portion of its course the Table Mountain flow rests indifferently upon a great variety of rocks, including slates, schists, limestones, quartzites, and gneisses of the Bed-rock series, and gravels, rhyolitic tuff, and andesitic breccia of the Neocene member of the Superjacent series. As a general rule the fragments of the flow hang upon the steep slopes of the cañon rim, forming flat benches which break off abruptly on the river side in columnar cliffs.

Southeast of Big Trees the line of flow crosses the North Fork and can thence be followed as a line of dissevered frag-

* Report on the Geology of Northern and Southern California. Sacramento, 1856. State Senate Doc. 14, p. 20.

† Geol. Survey of California, vol. i, Geology, pp. 243-246. Also Auriferous Gravels of the Sierra Nevada, Mem. Mus. Comp. Zool. Harvard Coll., vol. vi, 1880, pp. 131-137.

ments up to the group of peaks known as the Dardanelles. These elevations, consisting of masses of nearly horizontal volcanic material, with a total thickness of from 1200 to 1900 feet, resting upon the worn granitic basement, exhibit an interesting variety of lavas. The westernmost peak of the group was the only one actually visited, and the sequence of the lavas there exposed is as follows: Resting immediately upon the granite on the southwest side of the west Dardanelle is a comparatively thin bed of rhyolitic tuff. This is in turn covered by several flows of olivine basalt aggregating at least 300 feet in thickness. Above the olivine basalt lies the Table Mountain flow, which here attains a thickness of about 500 feet. Its exposed edges break away in imposing columnar cliffs which give the peak its striking outline. At the base of the cliff there is usually a heavy talus of fallen columns, concealing the contact with the underlying olivine basalt. Above the Table Mountain flow, and forming the extreme summit of the west Dardanelle, are portions of the second and third latite flows whose general occurrences are next to be described.

The Biotite-augite-latite.—The rock of the second flow is readily distinguished from that of the flows that followed and preceded it by the presence of abundant megascopic crystals of biotite, and by other characteristic lithological features. It occurs in relatively thin masses, rarely exceeding 50 feet in thickness, usually resting upon the Table Mountain flow, but frequently occurring alone as the only local representative of the latitic series. Like the earlier flow, it followed the old channel already described, but is not known to have extended farther than a point about 4 miles south of Big Trees. In marked distinction from what is known of the earlier and later latite eruptions, the lava of this outburst found its way into other channels besides the main one previously outlined. Thus small patches of the biotite-augite-latite are found north of Big Trees, and south of the Middle Fork of the Stanislaus. On the summit of the west Dardanelle this flow is about 50 feet in thickness, and lies between the Table Mountain flow and the one next to be described.

The Dardanelle Flow.—This, the last product which has been preserved of the activity of the latite vents, has received its designation from the fact that a remnant of the flow forms the extreme summit of the west Dardanelle, and is there typically developed, with a thickness of about 150 feet. Like the first flow, its occurrence is limited, as far as known, to the main Neocene channel, and its remnants have not been detected below the point, about 4 miles south of Big Trees,

already indicated as the lower limit of the biotite-augite-latite.

Microscopic Petrography.—The rock making up the Table Mountain flow is dark in color, and in large masses usually exhibits columnar structure. Near Clover Meadow, however, a portion of the flow has a pronounced spheroidal structure, recalling forms which have been described in the altered Mesozoic basalts of Point Bonita.* In hand-specimens the rock is dark grey, and shows numerous tabular phenocrysts of plagioclase up to 10^{mm} in length, and a few anhedral of augite, lying in a compact aphanitic base. Most specimens show a few small amygdules, and where the bottom of the flow is actually exposed, the large plagioclase phenocrysts are often found scattered through a highly frothy and glassy matrix. Under the microscope it is seen that the phenocrysts, in the order of their abundance, are large well-formed *labradorites*, often spongy with glass inclusions, pale green *augite*, in more or less rounded forms, and *olivine*, usually in small idiomorphic crystals. These lie in a hyalopilitic groundmass consisting of *labradorite* laths, grains of *augite* and a turbid *globulitic glass*. *Magnetite* and *apatite* are present as accessory minerals. The composition of the labradorite phenocrysts, as determined by the method of Michel-Lévy, varies from Ab₁An₁ to Ab₂An₁, and an examination of numbers of the larger laths in the groundmass showed that they possessed approximately the same composition as the accompanying phenocrysts. The rock of this flow has been called an augite-latite.

The *biotite-augite-latite* of the second flow differs considerably from that just described. It varies from dark to light gray in color, and contains abundant sparkling crystals of biotite, and a few small labradorite phenocrysts, lying in a somewhat porous groundmass. A noticeable feature in most hand-specimens is the presence of irregular and frequently elongated patches of dark glass, and of small pebble-like inclusions, giving the rock at times an almost tuffaceous aspect. Under the microscope, typical facies present a pronounced eutaxitic structure. Phenocrysts of *labradorite*, *biotite*, and *augite* lie in a groundmass in which streaks, patches, and flamboyant tongues, of comparatively clear *glass*, alternate with more turbid areas in which incipient crystallization had already made some progress at the time when the lava solidified. The small inclusions appear in the majority of cases to be more fully crystalline portions of the same magma, which, having solidified, were broken up and involved in the flow by the forward movement of the viscous mass. Other larger inclusions

* University of California, Bull. of Geol., vol. i, pp. 75-80.

are plainly of foreign origin, having been caught up by the lava as it flowed over the underlying andesitic breccias. The accessory minerals are *apatite*, *magnetite*, green *hornblende*, and in one or two cases a few crystals of *hypersthene*.

The *Dardanelle flow* is composed of augite-latite almost identical in character with that of the Table Mountain flow. It is, however, more compact in texture, and the phenocrysts are smaller. Although characterized by columnar structure, the columns are neither so large nor so regular as those of the earlier flow. Microscopically it differs from the latter in containing somewhat less olivine, and in having a slightly larger proportion of glass. An occasional *zircon* can be noted among the accessory minerals.

In view of the amount of potash shown in all of the chemical analyses of the latite, and the absence of what are commonly regarded as potash-bearing minerals, considerable interest attaches to the residual glass of these rocks. Even in the *Dardanelle flow* the proportion of glass is not large, and it is difficult to find parts of the section where the glass can be studied without any overlapping of the numerous laths of labradorite. It is moreover rendered turbid by abundant globulites, which were proved to be in large part magnetite, in a very fine state of subdivision. A portion of the powdered groundmass was passed through a number 120 sieve, the dust taken out through a piece of linen, and the remaining powder well washed. After being thoroughly shaken up in Thoulet solution, about half the powder still floated upon dilution to sp. gr. 2.626. Upon subsequent dilution to sp. gr. 2.485, this powder fell, and was readily separable with a weak magnet into two portions, the non-magnetic portion consisting of fragments of more or less impure feldspar, while the darker magnetic powder consisted of globulitic glass with included fragments of labradorite laths. The glass itself has thus a specific gravity much below 2.626. Its index of refraction is lower than that of the balsam (1.540). Grains as pure as possible, picked out under the microscope, afforded abundant crystals of potassium fluosilicate when treated with hydrofluosilicic acid.

Chemical composition of the Sierra Nevada latites.—In the accompanying table on page 363, the chemical analyses of the latites from all three flows are brought together for comparison. In spite of a certain range in the silica percentages, they are clearly closely related members of a series, not far from the andesites in general composition, but slightly higher in silica, and distinctly so in alkalis, the potash, when reckoned in percentages, being always slightly in excess of the soda. When, however, molecular proportions are considered, it is more accurate to say that potash and soda are present in nearly equal amounts. As would be expected from the study

of the thin-sections, the rock of the Table Mountain flow is more basic than the biotite-augite-latitude, while that of the Dardanelle flow occupies an intermediate position. Titanic acid is present in all of the analyses, and usually in notable

TABLE OF CHEMICAL ANALYSES OF SIERRA NEVADA LATITES.

	I.	II.	III.	IV.	V.	VI.	VII.
SiO ₂ -----	56.19	59.88	56.78	59.43	61.09	62.33	65.81
	'036	'998	'946	'900	1'018	1'039	1'096
TiO ₂ -----	'69		1.15	1.38		1.05	'54
Al ₂ O ₃ -----	16.76		16.86	16.68		17.35	15.11
	'162		'163	'161		'168	'146
Fe ₂ O ₃ -----	3.05		3.56	2.54		2.98	1.85
	'019		'022	'015		'018	'011
FeO-----	4.18		2.93	3.48		1.63	1.40
	'058		'040	'048		'022	'019
MnO-----	'10			tr.		'08	
MgO-----	3.79		3.41	1.84		1.05	'37
	'094		'085	'046		'026	'009
CaO-----	6.53	5.08	6.57	4.09	4.94	3.23	1.98
	'116	'090	'117	'073	'088	'057	'035
BaO-----	'19			'14		'24	'10
SrO-----	tr.			tr.		'05	
Na ₂ O-----	2.53	3.90	3.19	3.72	3.69	4.21	2.59
	'040	'062	'051	'059	'059	'067	'041
K ₂ O-----	4.46	5.06	3.48	5.04	5.27	4.46	5.24
	'047	'053	'036	'053	'055	'047	'055
Li ₂ O-----	tr.			none.		tr.	
H ₂ O above 110°	'66		1.21	'72		'75	
H ₂ O below 110°	'34		'15	'27		'44	
P ₂ O ₅ -----	'55		'42	'58		'29	'23
			CO ₂ .18	ZrO ₂ .08		FeS ₂ .08	
				Cl .05		C .11	
Sp. gr.-----	100.02		99.89	100.04		100.33	
			2.67	2.61		2.49	2.38

- I. Augite-latitude. Table Mountain Flow. Tuolumne Table Mt., W. of Sonora. (36 S. N.) W. F. Hillebrand, analyst. H. W. Turner, 14th Ann. Rept. U. S. Geol. Survey, p. 491.
- II. Augite-latitude. Table Mountain Flow. 3 mi. E. of Big Trees. (86 S. N.) P. Fireman, analyst. H. W. Turner, 17th Ann. Rept. U. S. Geol. Survey, p. 727.
- III. Augite-latitude. Table Mountain Flow. Near Clover Meadow. (1422 S. N.) G. Steiger, analyst.
- IV. Augite-latitude. Dardanelle Flow. 4 mi. S. W. of Clover Meadow. (1419 S. N.) H. N. Stokes, analyst.
- V. Biotite-augite-latitude. 3 mi. E. of Big Trees. (85 S. N.) P. Fireman, analyst. H. W. Turner, 17th Ann. Rept. U. S. Geol. Survey, p. 727.
- VI. Biotite-augite-latitude. 4 mi. S. W. of Clover Meadow. (1420 S. N.) W. F. Hillebrand, analyst. H. W. Turner, 17th Ann. Rept. U. S. Geol. Survey, p. 727.
- VII. Biotite-augite-latitude (?). Near mouth of Griswold Creek. (1866 S. N.) G. Steiger, analyst.

amount, indicating that the magnetite is probably titaniferous. Analysis number VII, in addition to being unusually high in silica, is low in lime and magnesia, thus approaching more nearly the chemical character of a trachyte. This is a glassy,

pitchstone-like facies, which on petrographical grounds was correlated with the biotite-augite-latitude of the second flow. There are certain relations which suggest, however, that it may really have preceded the Table Mountain flow instead of following it. The chemical analysis lends additional color to this suggestion, and it is possible that in the two small masses, which alone are known of this rock, there may survive the remnants of an earlier flow than any of the three typical latite considered in this paper.

The most noticeable feature of the analyses as a whole, taken in connection with the mineralogical composition of the rocks, is the amount of potash present. By far the greater number of the thin-sections (excepting of course the biotitic facies, which however are no richer in potash than the others) contain no recognizable potash-bearing mineral. Several of the analyses contain as much as 5 per cent of potash, which, if it were present in the form of orthoclase, would make up nearly 30 per cent of the rock. This amount is entirely too large to be accounted for on the supposition that it is present in the form of orthoclase microlites which have escaped detection among the plagioclases of the groundmass, and it is fairly certain that nearly all this potash, in those facies which do not contain biotite, is present in the residual glass of the groundmass.

It is frequently observed* that in rocks of intermediate composition, like the latites, orthoclase forms a thin envelope around the basic plagioclases, while in the plutonic monzonites the orthoclase was the last to crystallize, forming a mesostasis for the earlier minerals. In the Sierra Nevada latites the conditions under which orthoclase (or some other potash alumina silicate) could separate out were never reached. This would indicate that the method, not infrequently resorted to, of assuming the presence of orthoclase in the groundmass of an effusive rock from the chemical composition of the latter, requires caution in its use.

Classification of the Sierra Nevada latites.—With the advance made in methods of petrographical research during recent years, there has come inevitably greater difficulty in the proper classification of the rocks themselves. The increased refinement in chemical analyses, and their more critical interpretation, together with the strides made in the optical investigation of the feldspars by Becke, Federow, Michel-Lévy, and others, is leading to the gradual splitting up of some of the older, more comprehensive groups. A notable example of this tendency was Brögger's differentiation of the monzonite family from the syenites, while a similar process has long been reducing the once large family of the trachytes to a size more commensu-

* See Washington, Jour. Geol., vol. iv, p. 551, for several references.

rate with the minor importance of their plutonic equivalents. Together with the establishment of new families there has come into the literature an enormous number of new rock names. In many cases these names are local, being based on mineralogical combinations and distinctions that may not be repeated in another region, or given the same values by another observer. The common custom of providing such facies with a name, derived from the locality in which they occur, is a useful one, but the local, and to a certain extent provisional, nature of such names should be borne in mind, and they should not be allowed to bury under their accumulating mass broader and more rational schemes of classification.

COMPARATIVE TABLE OF CHEMICAL ANALYSES.

	I.	II.	III.*	IV.	V.*	VI.	VII.	VIII.	IX*	X.*	XI.	XII.
SiO ₂ -----	55.44	55.69	56.19	56.76	56.78	57.97	58.67	59.41	59.43	59.88	60.03	60.88
TiO ₂ -----	.16	tr.	.69		1.15			.01	1.38			
Al ₂ O ₃ -----	18.60	19.08	16.76	16.79	16.86	17.65	15.07	17.92	16.68		17.05	16.19
Fe ₂ O ₃ -----	2.09	4.07	3.05	2.07	3.56	.63		1.71	2.54		1.83	5.37
FeO -----	4.48	3.26	4.18	6.95	2.93	7.50	8.35	2.40	3.48		4.15	1.58
MnO -----		tr.	.10			.09			tr.		.09	
MgO -----	4.75	3.41	3.79	1.63	3.41	1.71	2.97	2.99	1.84		1.12	2.96
CaO -----	6.75	6.87	6.53	6.01	6.57	5.53	8.07	4.65	4.09	5.09	6.58	5.88
BaO -----			.19						.14			
SrO -----			tr.						tr.			
Na ₂ O -----	1.79	2.89	2.53	2.43	3.19	1.50	3.36	2.63	3.72	3.90	2.31	3.11
K ₂ O -----	6.63	4.41	4.46	4.67	3.48	5.31	3.50	5.60	5.04	5.06	5.12	3.95
Li ₂ O -----			tr.									
P ₂ O ₅ -----	tr.		.55	.47	.42	.42		.87	.58		.42	
H ₂ O above 110°			.66		1.21				.72			
H ₂ O below 110°			.34		.15				.27			
Ig. or total H ₂ O	.25	.17		2.44		1.82	.82	1.30			1.42	.98
					CO ₂ .18							
									ZrO ₂ .08			
									Cl .05			
Totals -----	100.75	99.85	100.02	100.22	99.89	100.13	100.81	99.49	100.04		100.12	100.70

	XIII.*	XIV.	XV.	XVI.*	XVII.	XVIII.	XIX.*	XX.	XXI.	XXII.	XXIII.
SiO ₂ -----	61.09	61.44	61.93	62.33	63.17	63.49	65.81	58.47	60.97	57.29	60.89
TiO ₂ -----				1.05		tr.	.54	.51	.72	.49	
Al ₂ O ₃ -----		17.08	18.47	17.35	17.15	18.40	15.11	18.80	20.92	18.45	17.14
Fe ₂ O ₃ -----		3.67	1.93	2.98	2.84	2.44	1.85	3.34	3.81	4.38	3.32
FeO -----		2.42	2.23	1.63	1.31	1.09	1.40	2.64		1.20	.95
MnO -----				.08		.16		.13		tr.	.09
MgO -----		1.14	2.66	1.05	2.17	.66	.37	2.69	.29	2.08	1.16
CaO -----	4.94	6.21	4.31	3.23	4.17	2.30	1.98	6.60	.14	3.57	3.58
BaO -----				.24			.10	.09			
SrO -----				.44				.05			
Na ₂ O -----	3.69	4.06	2.92	4.21	3.08	5.70	2.59	3.58	5.03	4.43	4.54
K ₂ O -----	5.27	3.86	3.92	4.46	4.19	4.62	5.24	2.01	8.88	5.43	5.71
Li ₂ O -----				tr.				tr.			
P ₂ O ₅ -----				.29		tr.	.23	.22		.46	.27
H ₂ O above 110°				.75				.92			
H ₂ O below 110°				.44				.14			
Ig. or total H ₂ O		2.04	2.28		2.51	1.04			.83	2.18	1.61
				FeS ₂ .08		CO ₂ tr.				NiO .12	NiO .19
				C .11							
Total -----		101.92	100.65	100.33	100.59	99.90		100.19	100.42	100.31	99.94

* Sierra Nevada latites.

	XXIV.	XXV.	XXVI.	XXVII.	XXVIII.	XXIX.	XXX.	XXXI.	XXXII.	XXXIII.				
SiO ₂	52·16	52·53	52·81	54·20	54·42	57·66	58·05	58·98	61·72	61·7				
TiO ₂			·71	·40	·80									
Al ₂ O ₃	22·11	19·48	15·66	15·73	14·28	17·23	17·71	17·34	13·57	17·4				
Fe ₂ O ₃	} 8·58	11·07	{ 3·06	3·67	3·32	} 7·28	8·29	3·44	7·60	5·9				
FeO											{ 4·76	5·40	4·13	
MnO											tr.	·70	·10	
MgO	2·64	1·53	4·99	3·40	6·12	2·20	2·07	1·63	3·33	2·2				
CaO	8·61	6·61	7·57	8·50	7·72	5·32	5·81	8·64	5·88	4·5				
BaO			·24		·32									
SrO			·09		·13									
Na ₂ O	3·35	2·71	3·60	3·07	3·44	3·41	2·98	3·41	3·12	3·1				
K ₂ O	2·00	3·17	4·84	4·42	4·22	4·61	3·24	5·34	3·37	3·8				
Li ₂ O			tr.		tr.									
P ₂ O ₅			·75	·50	·59									
H ₂ O above 110°			·93		·38									
H ₂ O below 110°			·16		·22									
Ig. or total H ₂ O	·80	2·34		·50		·70	1·34	1·06	·95	1·1				
			Cl ·07			CO ₂ ·76								
			Fl tr.											
			SO ₃ tr.											
Total	100·25	99·44	100·24	100·50	100·19	99·17	99·49	99·85	99·43	100·0				
			·02											
			100·22											

- I. Ciminite, Fontana Fiescoli, Viterbo, Italy. Jour. Geol., vol. iv, p. 849. H. H. Washington, analyst.
- II. Biotite-vulsinite, Monte Santa Croce, Rocca Monfino Region, Italy. Jour. Geol., vol. v, p. 252. H. S. Washington, analyst.
- III. Augite-latite, Table Mountain, Tuolumne Co., Cal. (36 S. N.)
- IV. Olivine-bearing andesitic trachyte, Sassara, Italy. Klein, Neues Jahrbuch für Min., etc., B.B. vi, p. 8. Ricciardi, analyst.
- V. Augite-latite, Table Mountain flow, 1½ mi. E. of Clover Meadow. (1422 S. N.)
- VI. Trachyte (Klein) or Vulsinite (Washington), Bolsena, Italy. Klein, loc. cit. Ricciardi, analyst.
- VII. Ciminite, Monte Cimino, Italy. Jour. Geol., vol. iv, p. 849. Vom Rath, analyst.
- VIII. Andesite, Cabezo Felipe, Cabo de Gata, Spain. Zeitschr. Deutsch. geol. Gesell., vol. xliii, 1891, p. 719. Osann, analyst.
- IX. Augite-latite, 4 mi. S.W. of Clover Meadow. (1419 S. N.)
- X. Augite-latite, 3 mi. S.E. of Big Trees. (86 S. N.)
- XI. Trachyte (Klein) or Vulsinite (Washington), San Magno, Italy. Klein, Neues Jahrbuch für Min., etc., B.B. vi, p. 10. Ricciardi, analyst.
- XII. Augite-andesite, Mt. Pagos, Asia Minor. This Journal, IV, vol. iii, p. 43. Washington, analyst.
- XIII. Biotite-augite-latite, 3 mi. S.E. of Big Trees. (85 S. N.)
- XIV. Trachyte, Gleichenberg. Tschermak's Mineral. Mittheil., 1877, p. 277. Smita, analyst.
- XV. Augite-andesite, Kara Tash, Asia Minor. This Journal, IV, vol. iii, p. 45. Washington, analyst.
- XVI. Biotite-augite-latite, 4 mi. S.W. of Clover Meadow. (1420 S. N.)
- XVII. Biotite-dacite, Pergamon, Asia Minor. This Journal, IV, vol. iii, p. 49. Washington, analyst.
- XVIII. Sanidine-bearing andesite, Rosita Hills, Col. Cross, Proc. Colo. Sci. Soc., 1887, p. 250. Eakins, analyst.
- XIX. Biotite-augite-latite (?), near mouth of Griswold Creek. (1866 S. N.)

- XX. Hornblende-pyroxene andesite, Downieville Quadrangle, Cal. Turner, 17th Ann. Rept. U. S. Geol. Survey, p. 731. Hillebrand, analyst.
- XXI. Trachyte (Domite), Puy de Dôme, France. Zirkel, Lehrbuch der Petrographie, ii, p. 378. Lewinstein, analyst.
- XXII. Quartz-banakite, dyke near head of Stinkingwater River, Yellowstone Park region. Iddings, Jour. Geol., vol. iii, p. 947. Melville, analyst.
- XXIII. Quartz-banakite, dyke, locality and reference as above.
- XXIV. Monzonite, Predazzo. Brögger, Die Eruptionsfolge der triadischen Eruptivgesteine bei Predazzo in Südtirol, Kristiania, 1895, p. 25.
- XXV. Monzonite, Sasinathal, Predazzo. Brögger, loc. cit.
- XXVI. Monzonite, Beaver Creek, Mont. Weed and Pirsson, this Journal, IV, vol. i, p. 357. Stokes, analyst.
- XXVII. Monzonite, Monzoni, South Tyrol. Brögger, op. cit., p. 24. Schmelck, analyst.
- XXVIII. Monzonite, Yogo Peak, Mont. Weed and Pirsson, loc. cit. Hillebrand, analyst.
- XXIX. Monzonite, Mulatto, Predazzo. Brögger, op. cit., p. 25.
- XXX. Monzonite, Malgola, Predazzo. Brögger, loc. cit.
- XXXI. Monzonite, Predazzo. Brögger, loc. cit.
- XXXII. Monzonite, Blansko, Mälvren. Brögger, op. cit., p. 50.
- XXXIII. Monzonite, Hodritsch, Hungary. Brögger, loc. cit.

On the other hand, it is no part of pure petrographical science to aim directly at ease and simplicity in classification, however desirable that end may appear to the general geologist. Petrography in its present stage is occupied rightly with critical distinctions, and it is only by the recognition of such slight points of difference that they can ever be transcended, and assigned their true value in a really rational scheme of rock classification.

Recognizing the fact that igneous rocks are chemically mixtures, of practically infinite variability within certain limits, the refining tendency of modern methods tends more and more toward precision of definition, and a consequent subdivision of the older groups. This gain in precision by no means makes the classification of a given rock an easier matter, for it is evident that the greater the number of families, the more numerous will be the intermediate or transition rocks, since sharp lines of demarcation apparently nowhere prevail between closely related types. It is a question of course how far, for purposes of practical description, such subdivision of large groups should go, but it is a question that may be very well answered by the facts of geological occurrence. If a magma of a certain intermediate type with reference to two or more well established families is found to possess geological unity, and particularly if it is found to be represented by both plutonic and effusive forms, there can be little doubt of the advisability of giving it a distinctive name. Brögger's monzonite magma is an example of such a case, and he has shown very conclusively that the plutonic monzonites, being orthoclase-plagioclase rocks, should be separated from the orthoclase

rocks, or granites and syenites, on the one hand, and the plagioclase rocks, or diorites and gabbros, on the other, the mineralogical distinction being the visible sign of difference in chemical composition. In his tabular classification* he has indicated the effusive equivalent of monzonite as *trachyte-andesite*, and it is here that the latites of the present paper belong, as will now be more fully shown.

It is plain from the descriptions of the latites in the preceding pages, that in spite of their superficial basaltic character, they are in no sense basalts, being far too high in silica and alkalis, and too low in magnesia and lime, and differing from the latter rock in microscopic structure, and in the proportion of ferromagnesian constituents to the feldspars. Their specific gravity, too, is lower than that of basalts of equally compact texture.

Their relation to the andesites is much closer, and were it advisable to crowd them into one of the well-established older groups they would be placed with little hesitation in this family. Leaving out of consideration the glassy base, the latites described in the present paper possess practically the mineralogical composition of andesites. But they differ from normal andesites in chemical composition, being generally slightly lower in lime and magnesia and always higher in alkalis. In the andesites the total alkalis are as a rule less than six per cent, with soda in excess of potash. In the latites the total alkalis range from six to ten per cent, with the potash, reckoned in percentages, equal to or slightly in excess of the soda.

Rocks of this type can hardly be classed as trachytes if the latter name is to retain any precision of meaning. Not only are they decidedly untrachytic in color and texture, but differ widely mineralogically from typical trachytes. Sanidine, instead of being the dominant feldspar, is entirely absent and the conspicuous phenocrysts are labradorite. Mr. Turner† has provisionally classed some of the latites with the trachytes on the basis of their chemical composition. The analysis upon which the comparison is based was quoted from Zirkel's Petrographie‡ and as Mr. Turner remarks "contains more lime and less silica than most of the analyses given by Zirkel." The analyses in question is one by Ricciardi§ of the so-called trachyte of Bolsena, and is quoted in column V of

* Die Eruptivgesteine des Kristianiagebietes; II Die Eruptionfolge der triadischen Eruptivgesteine bei Predazzo in Sudtyrol, Kristiania, 1895, p. 60.

† Further Contributions to the Geology of the Sierra Nevada, 17th Annual Rept. U. S. Geol. Survey, p. 729.

‡ Vol. ii, p. 378 (1893).

§ Klein, Petrographische Untersuchung einer Suite von Gesteinen aus der Umgebung des Bolsener Sees; Neues Jahrb. für Min., etc., B.B. vi, 1889, p. 8.

the table of chemical analyses. Concerning this rock Washington writes: "Vom Rath first called attention to the abnormal chemical character of the 'trachyte' of Bolsena, though he speaks of it as containing no plagioclase, probably owing to the rarity of the multiple twinning. As will be seen from Klein's descriptions and my own, and from the analyses, the peculiar 'trachytes' of the region are remarkable: mineralogically for their richness in plagioclase and the frequent occurrence of olivine as an essential constituent, and chemically for their low silica and high lime and magnesia. Therefore they are not trachytes proper, but correspond to the trachy-dolerites of Abich and Hartung, and to some of the andesitic-trachytes of Rosenbusch, and we shall see that they may be regarded as effusive representatives of Brögger's abyssal monzonites. These olivine free effusive rocks will be called by the name of *Vulsinite* from the Etruscan tribe Vulsinii, formerly inhabiting this region."* There is thus fresh confirmation of the result already stated, that the latites of the present paper belong neither with the normal trachytes nor yet with the normal andesites, but occupy a position chemically about midway between the two.

Effusive rocks with a chemical composition corresponding to this intermediate taxonomic position appear to be not uncommon, and on pages 365 and 366, the chemical analyses of a number of such rocks have been placed together in tabular form. Numbers I to XIX inclusive are analyses of latites, which in the table are given the names assigned them by the authors quoted. Numbers XX and XXI, in the middle division of the table, are a typical andesite and typical trachyte respectively, being inserted to show the intermediate character of the latites. The latter as a whole form a fairly uniform chemical series.

But when attention is directed to the names and descriptions of the various effusive rocks embraced in the table, they are found to be remarkable more for variety than uniformity. Thus, besides the latites described in the present paper, there occur such names as *ciminite*, *biotite-vulsinite*, *olivine-bearing andesitic trachyte*, *vulsinite*, *andesite*, *augite-andesite*, *trachyte*, *biotite-dacite*, and *sanidine-bearing andesite*. At first glance such an abundance of names for effusive rocks of a single chemical type seems to indicate little else than a state of hopeless confusion in rock nomenclature. But while a certain amount of confusion does undoubtedly exist, the multiplicity of names has its chief explanation suggested by two other facts—partly, as pointed out by Iddings,† that rock-series as

* Italian Petrological Sketches, Journal of Geology, vol. iv, p. 547.

† Journal of Geology, vol. iii, pp. 955-956.

they occur in nature may traverse existing schemes of classification at practically any angle, but mainly, in this case, that the name of a rock is generally determined more by its mineralogical than by its chemical composition.

In the case of most igneous rocks, and of nearly all plutonic rocks, the principal mineralogical constituents can be deduced with a fair degree of certainty from an accurate bulk-analysis, and *vice versa*, the chemical constitution can be predicted from a microscopical investigation of a thin-section with sufficient accuracy to leave little doubt of the general position of the rock in an ordinary scheme of classification. But with the effusive latites this appears to be true only in a slight degree. In effusive rock of intermediate chemical composition the circumstances which determine the crystallization of the different possible mineralogical combinations, appear to depend upon a very delicate adjustment of physical and chemical conditions. This is already noticeable in the andesites, where a given magma cooling under certain conditions may give rise to a hornblende or biotite andesite, and under other conditions, by the magmatic resorption of these two minerals, may solidify as a pyroxene andesite. The latites, being intermediate rocks *par excellence*, and containing more or less unindividualized glass in reserve, exhibit this apparent capriciousness of crystallization to an unusual degree.

Thus, the vulsinites of Washington "are characterized mineralogically by the presence of alkali feldspar with a large amount of basic plagioclase (labradorite to anorthite), together with augite and diopside. Hornblende and biotite are not abundant in the type specimens, though they may be present in large amounts in other varieties. . . . Olivine is wanting, or if present is so in only accessory amounts."*

The biotite-vulsinite from Monte Santa Croce (column II) is particularly interesting with reference to the point under discussion, and the dilemma in which one is placed in attempting to adhere to a purely mineralogical classification of these rocks is well expressed in Washington's own words. He says: "We have then a rock which is chemically a ciminite and mineralogically a biotite-vulsinite.

"In regard to the name by which they should be called there may be some doubt. From a mineralogical standpoint they are obviously not ciminite, nor chemically can they strictly be called vulsinite. Since, however, in the schemes of classification in general use at the present time, the mineralogical composition takes precedence over the chemical, and bearing in mind the unadvisability of adding new names to the already overburdened nomenclature, I shall designate these rocks as biotite-vulsinite."†

* Journal of Geology, vol. iv, p. 553.

† Journal of Geology, vol. v, pp. 250-251.

The ciminities are "characterized mineralogically by the presence of orthoclase, with basic plagioclase, augite or diopside, and olivine."*

The andesite from Carbezo Felipe contains phenocrysts of feldspar and biotite. Sanidine occurs in crystals over a centimeter in length, but the main bulk of the feldspar is labradorite and andesine. Both monoclinic and orthorhombic pyroxene are present, and the rock is rich in zircon and apatite.

Concerning the classificatory position of this rock Osann writes: "Das Verhältniss der Alkalien lässt das Gestein als der Gruppe der andesitischen Trachyte nahestehend erkennen, worauf auch die vereinzelt grösseren Sanidin-Einsprenglinge hinweisen; der hohe Kalk- und Kaligehalt gegenüber den geringen Mengen an Natron erklären sich aus der Beobachtung, das neben dem Sanidin ein basischer Plagioklas (Labrador) als Einsprengling vorhanden ist. Vergleicht man die Analyse mit derjenigen anderen andesitischer, theilweise Olivin führender Trachyte (Mte. Amiata, Arsostrom, Mte. Alfina) so fällt ihr hoher MgO-Gehalt auf (im Arsogestein trotz des Olivingehaltes nur 1.77 p. ct.), derselbe findet nur in der gleichzeitigen reichlichen Anwesenheit von Biotit und rhombischem Pyroxen seine Erklärung."†

The augite-andesite from Mt. Pagos is "composed of plagioclase, diopside, and biotite, with accessory magnetite, apatite, and zircon, lying in a glass base."‡ The plagioclases are labradorite, but there are possibly a few orthoclase microlites in the groundmass.

The Gleichenberg trachyte contains, according to Hussak, large sanidine phenocrysts, fewer and smaller ones of oligoclase, biotite, and dark augite, in a globulitic base.§

The augite-andesite from Kara Tash has numerous phenocrysts of labradorite (a little more basic than Ab₁An₁), pale green diopside, some biotite, and grains of magnetite, in an abundant trichitic, glassy base.||

The biotite-dacite from Pergamon¶ contains phenocrysts of labradorite, with fewer sanidines, biotite, and olive-green hornblende. The rock is called a dacite on the basis of its chemical composition, although containing no free quartz, thus again illustrating the difficulties attendant upon a consistent mineralogical classification of these intermediate rocks.

* Journal of Geology, vol. iv, p. 838.

† Beiträge zur Kenntniss der Eruptivgesteine des Cabo de Gata, II; Zeitschr. d. d. geol. Gesell., vol. xliii (1891), p. 720.

‡ Washington, On Igneous Rocks from Smyrna and Pergamon; this Journal, vol. cliii (1897), p. 43.

§ Zirkel, Lehrbuch der Petrographie, ii, p. 383.

|| On Igneous Rocks from Smyrna and Pergamon; this Journal, vol. cliii, p. 44.

¶ Ibid., p. 48.

The sanidine-bearing andesite of the Rosita Hills is described by Cross* as containing plagioclase, orthoclase, quartz, biotite, augite, and accessory minerals. The plagioclase is referred to oligoclase. This rock is said to have its chief development as dykes, although occurring also in effusive masses.

The foregoing citations are sufficient to show how great mineralogical variety may be presented by the effusive rocks having the peculiar intermediate chemical composition of the latites. It is possible, and perhaps desirable, to assign the more conspicuous and well-marked of these mineralogical combinations separate names, but the number of the latter is apt to be large, and they are of a distinctly lower grade of importance than those rock names that express not only a certain mineral constitution but a corresponding and characteristic chemical composition as well.

It accordingly seems advisable to attempt to bring into use some more general name to embrace all the effusive rocks standing chemically about midway between the typical trachytes and the typical andesites,—a name that can be used as the general effusive equivalent of the increasingly important group of the plutonic monzonites. I should gladly have avoided the necessity of introducing a new name into a rapidly growing nomenclature, the more so, as Washington, by his admirable petrographical studies in the Italian volcanic regions, has added so greatly to an accurate knowledge of intermediate rock types which must be necessarily embraced by such a new term. But the Sierra Nevada lavas cannot be classed with the typical toscanites, vulsinites, or ciminities, as defined by Washington, although, like the vulsinites and some of the ciminities, they are to be regarded as the effusive equivalents of the monzonites. Thus there is an imperative demand for some more comprehensive name to cover the mineralogically diverse forms which monzonitic magmas, cooling under effusive conditions, may assume. For this reason, and in recognition of the importance and interest of the Italian types described by Washington, the name *latite*, derived from the Italian province of Latium, is proposed as a broader term, comparable in its scope with *monzonite*, to designate the effusive forms of the monzonite magma. It is to be noted, that the particular facies of latite represented by the Sierra Nevada lavas might also be given varietal names of the same order of importance as vulsinite or ciminite; but this has not been done in the present instance.

Abich and Hartung have used *trachy-dolerite* for rocks which in part belong with the latites; Fouqué and Michel Lévy, *trachy-andesites*; Zirkel and Rosenbusch, *andesitic-trachyte*;

* Proc. Colorado Scientific Soc., 1887, p. 248.

and Brögger *trachyte-andesite*. But all these compounds are open to objection when a name is required for an important group, standing midway between the trachytes and andesites. Such a name should above all consist of a single word, and should be free from the undesirable connotations adherent to compounds which have been variously employed.

Referring again to the table of chemical analyses, it will be seen that in columns XXII and XXIII are placed the analyses of two quartz-banakites, chosen as being the nearest known dike equivalents of the latites. The correspondence however is not quite perfect, as the two analyses show a slight deficiency in lime and a small excess of alkalis as compared with the mean of the latite analyses. Iddings* states that the rocks of these two analyses belong to the banakite series "both mineralogically and chemically, but are somewhat more siliceous, having 5 to 9 per cent more silica. They might properly be given specific names, but at present we prefer to class them with banakite, under the name *quartz-banakite*, the amount of quartz, however, being very small."

The banakites are intermediate rocks in a similar sense that the latite are intermediate. Chemically they have a rather close analogy with the latter rocks, although somewhat lower in silica, and thus tending through leucitic facies toward the truly alkaline groups of igneous rocks. It is interesting to note that Iddings† remarks in this series the tendency toward mineralogical diversity with nearly identical chemical composition, already emphasized in the case of the latites.

In the succeeding columns of the table are placed the analyses of some monzonites, quoted from Brögger, in order to show the close relationship between these rocks and the effusive latites. Washington, has already pointed out this chemical correspondence in the case of his vulsinites and ciminities,‡ and notes as well analogies with the absarokite-banakite series of Iddings.§

Since the paper, of which the foregoing is an abstract, was written, Washington's final contribution|| on the Italian volcanic regions has appeared, in which he divides the rocks between the trachytes and andesites into two series,—the *trachyandesites* and the *trachydolerites*, using the former term in a more restricted sense than in his earlier papers. The Sierra Nevada latites would fall most nearly within his trachydolerite series, although not strictly the equivalents of any of its

* Absarokite-Shoshonite-Banakite Series; Journal of Geology, vol. iii, pp. 949-950.

† Absarokite-Shoshonite-Banakite Series; Journal of Geology, vol. iii, p. 951.

‡ Journal of Geology, vol. iv, p. 832.

§ Ibid., p. 838.

|| Ibid., vol. v, pp. 349-377.

individual members. Whether some such single term as that here proposed shall be used to designate the rocks midway between the trachytes and andesites, or whether it will be found practicable to divide them into two series, or to revive the old term trachydolerite as Washington has done, may, as the latter suggests, in a slightly different connection be left to the winnowing action of time and usage.

Summary.

The contents of the preceding sections may be very briefly summarized as follows:

The area embraced by the map is a fairly typical transverse strip of the middle, western slope of the Sierra Nevada, having been worn down during the interval between the close of the Jurassic and the beginning of the Miocene to a rough peneplain. During the Miocene the volcanic eruptions began, which, accompanied by a tilting of the peneplain to the southwest, continued to the end of the Pliocene. The first eruptions were rhyolitic in character, followed by the laying down of a great cloaking cover of andesitic breccias and tuffs. The deposition of auriferous gravels both preceded and accompanied the deposition of volcanic material.

The accumulation of the andesitic breccias and tuffs was interrupted by at least one period of considerable erosion, during which a long, consequent stream, the predecessor of the Stanislaus River, established its channel down the slope, cutting down through the volcanic accumulations into the older, truncated "Bed-rock series" along the greater part of its course, and ultimately attaining a very regular grade. This stream was subsequently displaced by a heavy flow of augite-latite, the Table Mountain flow, which coming from an as yet unknown source near the crest of the range, ran down the stream bed to Knight's Ferry, near the edge of the Great Valley, a distance of more than 60 miles. A second and thinner flow followed, of augite-biotite-latite, attaining a greater lateral extent, but not so long as the first flow. The third or Dardanelle flow, of augite-latite, closed the series of latitic eruptions. The volcanic period as a whole was brought to an end by fresh andesitic eruptions, as shown by andesitic breccias resting upon the latites, accompanied by further tilting of the peneplain.

During Pleistocene time the present streams have dissected the Neocene lavas and tuffs, including the latitic flows, and have deeply incised the "Bed rock series" of Jurassic and older rocks.

The Sierra Nevada latites are mineralogically closely related

to ordinary andesites, but chemically they stand between the andesites and the trachytes. They are higher in alkalies than the andesites, the potash is generally in excess of the soda, and, *in the particular rocks described*, is present chiefly in the unindividualized glass, where no biotite is present.

Rocks of this intermediate chemical composition are fairly widespread, but characterized by considerable mineralogical diversity. The name latite is proposed as a convenient designation for this entire group of effusive rocks, standing chemically about midway between the andesites and trachytes, and corresponding to the plutonic monzonites of Brögger and possibly to some of the dike banakites of Iddings.

Washington, D. C., March, 1898.

ART. XLVI.—*On Krennerite, from Cripple Creek, Colorado*;
by ALBERT H. CHESTER.

THE writer recently received from Messrs. George L. English & Co. a specimen from the Independence Mine at Cripple Creek, Colorado, which shows a number of very distinct crystals of krennerite, a mineral not previously identified from this country. This species was first noticed among minerals from Nagyag in Hungary, and described by Krenner* in 1877, under the name bunsenin. In the same year vom Rath† called it Krennerite after its discoverer. It is an exceedingly rare mineral and has heretofore been found only at the original locality.

The mineral from Cripple Creek occurs in brilliant crystals of a pale yellowish-bronze color, but tin-white on cleavage faces. The largest of these crystals, of which there were originally about thirty on the specimen, are about 2^{mm} in length and the same in breadth, and they are at once recognized as belonging to the orthorhombic system, showing prismatic faces deeply striated, pinacoids and domes, and resembling some forms of arsenopyrite. Some of the crystals show a perfect basal cleavage. The crystallographic examination has been made by Prof. S. L. Penfield, and his results are given later. The mineral is very brittle and has a hardness of about 2.5. Heated on charcoal it decrepitates violently, and fuses easily, burning with the characteristic bluish-green flame of tellurium, and coating the coal with its oxide. A globule of seemingly pure gold finally results. It has therefore the characteristics

* 1877, Term. Füz, Pt. 1.

† 1877, Ak. Ber. Monat., 292.

of krennerite rather than of calaverite, the crystals of which do not decrepitate when heated, have no basal cleavage, and according to Penfield,* are probably triclinic. The crystals now described occur on a quartzite gangue, and are partially imbedded in a thin layer of soft, gray material, which may be kaolinite, but has not yet been examined. Small crystals of pyrite are scattered abundantly through the quartzite gangue.

The chemical examination has been made by my colleague, Prof. W. S. Myers. Three of the crystals were carefully detached, and when cleared as far as possible of all adhering matter, until nothing but crystalline faces could be observed under the magnifier, afforded extremely pure material, as shown by the analysis, the results of which are as follows, tellurium being estimated by difference:

Au	43.33	per cent.
Ag	0.45	"
[Te]	55.01	"
Insoluble	1.21	"
Fe ₂ O ₃	trace.	

Deducting the insoluble matter and calculating to one hundred we have,

	Per cent.	Ratio.	
Au	43.86	.223	} .227 1.00
Ag	0.46	.004	
Te	55.68	.445	1.97

The ratio of Au+Ag:Te is very nearly 1:2, which gives for the formula of the mineral AuTe₂, the same as in calaverite and sylvanite, though with less silver than has been recorded heretofore. In this group, however, variations in the amount of silver are very wide, and there is probably no fixed proportion of silver to gold. The present analysis corresponds very closely with that of calaverite from the same locality, by Hillebrand,† and it is very desirable that more crystals of calaverite should be found to settle the question positively as to its crystalline form, for if it is triclinic we have three distinct tellurides of gold and silver, orthorhombic krennerite, monoclinic sylvanite and triclinic calaverite. But it seems more probable that there are only two of these minerals and that calaverite is the silver-free form of sylvanite; for this new analysis, of undoubted krennerite, varies as widely from the earlier ones in its proportion of silver as do the analyses of

* This Journal, III, 1, 131, 1895.

† This Journal, III, 1, 128, 1895.

calaverite from those of sylvanite, and as shown by Penfield (l. c.), the calaverite crystals he examined have many characteristics in common with sylvanite. It hardly seems possible that these krennerite crystals are identical with the calaverite described by Hillebrand.

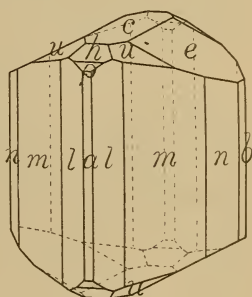
Prof. Penfield's note on the crystallography of this mineral is as follows:

"The crystals of krennerite were not very favorable for crystallographic study, as they were striated and gave generally poor reflections of the signal. Two crystals having the habit represented by the accompanying figure were measured, and gave sufficiently accurate measurements for the identification of the forms, which correspond to the prominent ones identified by vom Rath* and Schrauf.† The forms are as follows:

a , 100 l , 320 h , 101 u , 122
 b , 010 m , 110 ρ , 201
 c , 001 n , 120 e , 011

The following measurements were made:

	Measured.	Calculated.
$a \wedge l$, 100 \wedge 320	32° 25'	32° 5½'
$a \wedge m$, 100 \wedge 110	43 30	43 15
$a \wedge n$, 100 \wedge 120	61 55	62 0½
$a \wedge h$, 100 \wedge 101	61 22	61 48
$a \wedge \rho$, 100 \wedge 201	42 55	43 0
$e \wedge e$, 011 \wedge 011	54 15	53 32
$u \wedge u$, 122 \wedge 122	26 43	26 55½



The perfect basal cleavage is a prominent feature of the mineral."

Rutgers College, March 28th, 1898.

* 1877, Zeitsch. Kryst., i, 614.

† 1878, Ibid., ii, 235.

ART. XLVII.—*Some new Jurassic Vertebrates from Wyoming.* Second Paper by WILBUR C. KNIGHT.

THE University of Wyoming has in its collection of Jurassic vertebrates partial remains of four swimming saurians, that in a general way resemble plesiosaurs. The discovery of these remains is of considerable value to American Mesozoic geologists, for these data will be very valuable in correlating the American and European Jurassic. It is of equal importance in separating the term Jura-Trias, and making American Jurassic and Triassic terranes, in the place of the consolidated term that has been in use since the early surveys in the Rocky Mountains. The largest of these four species surpasses in size the European Pliosaur, and owing to the many peculiar characters it has been deemed necessary to create a new genus.

Megalneusaurus gen. nov.

Vertebra over two-thirds as long as wide; height of the centra nearly equalling the transverse diameter. Anterior cervical vertebra deeply cupped anteriorly and slightly concave posteriorly; neural arches united by suture and always found detached. Dorsal vertebra cylindrical with a forward overhanging of the upper part of the centra; anterior faces slightly concave, posterior flat; both faces with mammilla; zygapophyses spoon-shaped; neural arches firmly sutured to centra; neural spines low and nearly as long as the centra. Caudal vertebra with slightly concave faces and mammilla. Coracoids produced in front of the glenoid cavity. Joints of the digits alternate with each other. Phalanges concave proximally, convex distally. Ulna and radius short, broad, heavy bones, nearly equal in size, and separated by a small central opening. Below this opening the two bones are united by rugose surfaces; above they are united by a horn-like projection extending from the ulna and fitting into a depression in the radius. Ulna concave proximally and convex distally. Radius, inner one-fourth of the proximal end concave; outer three-fourths convex. Carpal bones six in number and all angular. Humerus a powerful bone with a prismatic shaft; distally broad and flat; proximally expanded into a spherical head. The anterior side of the head of humerus with a groove; the posterior side with a broad shallow indentation. This genus in many respects resembles Pliosaurus, but it also has characters that are common to Peloneustes and Plesiosaurus. It represents the largest known animals of the order Saurapterygia.

Megalneusaurus rex Knight.*

The type of this genus and species has been founded upon the following remains: Cervical, dorsal and caudal vertebra; one limb nearly complete; ribs and the greater portion of the pectoral girdle. The limb measures 2·209 meters in length. When found it was articulated and in the position represented in figure 1. Between the ends of the phalanges were hardened disks of siliceous matter measuring 10^{mm} in thickness. The phalanges are long cylindrical bones with rather slender shafts and expanded ends. The shape and size of these bones vary greatly when belonging to the same row. For example, the first phalange of the first digit is 87^{mm} long, and the first phalange of the fifth digit is 106^{mm} long. The first digit is coalesced with the second at the fifth joint of the second. The metacarpal of the fifth digit articulates with the ulnare and the third bone of the distal row of carpals. The radius has a groove extending two-thirds of the length of the exterior border. Radial likewise grooved. The coracoids are long, broad bones, but are not in a condition to give valuable measurements. The vertebra vary greatly in form: cervicals, truncated above, with nearly straight sides which gradually curve and form a rounded lower surface; dorsals, cylindrical, slightly compressed, with large transverse processes; neural spines low and keel shaped; caudals, flattened beneath.

Measurements.

Humerus,—Length	·991 ^m
Distal width	·365
Distal thickness	·122
Thickness of shaft	·195
Circumference of shaft	·555
Proximal width	·225
Proximal height	·266
Proximal circumference	·875
Ulna,—Width	·178 ^m
Length	·158
Distal thickness	·080
Proximal thickness	·104
Radius,—Width	·171 ^m
Length	·163
Distal thickness	·100
Proximal thickness	·100
Ulnare,—Width	·130 ^m
Length	·095
Thickness	·088
Intermedium,—Width	·100 ^m
Length	·140
Thickness	·078

* *Cimoliosaurus rex*, Science, Oct. 4, 1895, p. 449.

Radiale,—Width	·135 ^m
Length	·085
Thickness	·088
First distal carpal,—Width	·111 ^m
Length	·078
Thickness	·067
Second distal carpal,—Width	·140 ^m
Length	·100
Thickness	·067
Third distal carpal,—Width	·100 ^m
Length	·100
Thickness	·058

First row of basal phalanges.

	No. I.	No. II.	No. III.	No. IV.	No. V.
Length	87 ^{mm}	102 ^{mm}	106 ^{mm}	106 ^{mm}	106 ^{mm}
Proximal width	52	70	68	62	42
Distal width	52	60	65	50	40
Width through shaft ..	32	37	35	31	25
A cervical vertebra centrum,—Width					·080 ^m
Length					·065
Height					·078
A dorsal vertebra centrum,—Width					·152 ^m
Length					·111
Height					·150
A caudal vertebra centrum,—Width					·103 ^m
Length					·077
Height					·065

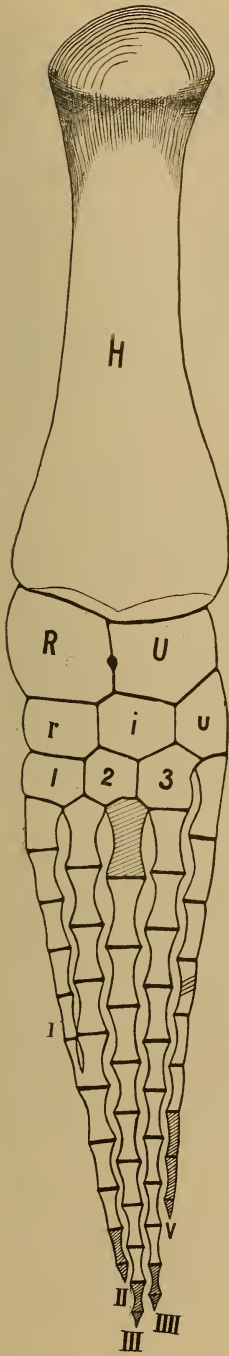
The remains of this species were found in Natrona County, by the writer. The geological position is the uppermost band of the marine beds of the Jurassic. I would suggest that hereafter these marine beds be known as the Como group. I take this opportunity to thank Dr. Baur and Dr. Williston for many suggestions in connection with this paper.

University of Wyoming, March 28th, 1898.

EXPLANATION OF FIGURES.

- FIG. 1.—Front limb of *Megalneusaurus rex*. $\times \frac{1}{8}$. H, humerus; R, radius; U, ulna; *r*, radiale; *i*, intermedium; *u*, ulnare; 1, 2, 3, distal row of carpals.
 FIG. 2.—Side view of humerus, showing the development of the head, $\times \frac{1}{8}$.
 FIG. 3.—Cross-section of the head of the humerus. $\times \frac{2}{3}$.

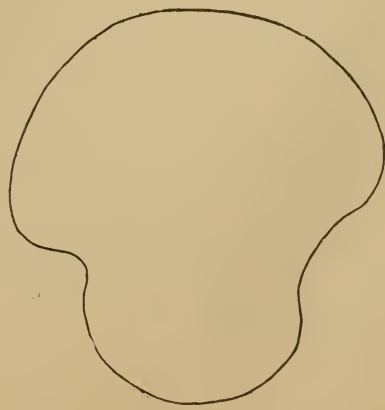
1.



2.



3.



ART. XLVIII.—*On the Estimation of Manganese separated as the Carbonate*; by MARTHA AUSTIN.

[Contribution from the Kent Chemical Laboratory of Yale University—LXIX.]

THE estimation of manganese precipitated as the manganous carbonate, when that salt is obtained by the action of sodium or potassium carbonate, has been regarded as very undesirable for the reasons that, even if the conditions of the precipitate is such that it does not run through the filter, the manganous carbonate can never be freed entirely from alkaline salt, and that the conversion of the carbonate to the manganoso-manganic oxide—the form in which it is customary to weigh—is too uncertain. It had been supposed, also, that the presence of ammoniacal salts (as well as of carbonic acid) causes solution of the manganous carbonate, until the work of Guyard (Hugo Tamm)* showed that when the precipitation is accomplished by ammonium carbonate, even in the presence of ammonium chloride, complete separation of the manganese is possible. No data are given by Guyard to show the completeness of the separation of the manganese by this process; but, Fresenius† examined the method and speaks favorably of it. In this process the main difficulty of the older method of estimation as the carbonate—viz., the inclusion of the alkaline salt—is avoided. We know now how to avoid the difficulty in the way of weighing as the oxide by converting that substance to the form of the sulphate, as shown in a former paper.‡

For a careful study of the separation of manganous carbonate by Guyard's method a solution of pure manganous chloride was prepared and standardized as the anhydrous sulphate in the manner detailed in the paper to which reference has been made above. A definite volume of the manganous chloride was carefully drawn into a platinum dish and diluted to a volume of 200^{cc}. To the solution heated to 100° C. ammonium chloride (about 10 grm.) was added and ammonium carbonate in excess. The solution was kept warm until the precipitate subsided, and then was filtered off on asbestos on a perforated crucible under pressure. The presence of ammonium chloride is necessary to insure such a condition of the precipitate that it will not run through the felt.

Inasmuch as the precipitate was collected under conditions which readily permit an attempt to weigh as the carbonate, a trial of that method was made incidentally. The event proved

* Chem. News, xxvi, 37.

‡ This Journal, IV, v, 209.

† *Zeit. f. Anal. Chemie*, 1872, 290.

as Rose* has stated previously, that when the carbonate is gently heated, evolution of carbon dioxide and oxidation of the residue begins before the water is thoroughly removed; for, though nearly all the results are above the theory, the solution of the residue in hydrochloric acid indicated plainly the presence of a small amount of a higher oxide of manganese. In the following table are found the results of a series of experiments in which the attempt was made to weigh first as carbonate and again after strong ignition—well within the oxidizing flame of a powerful burner†—as the manganoso-manganic oxide. The application of the bromine test to the hot ammoniacal filtrate showed, that in every one of these experiments, the precipitation of the manganese in the form of the carbonate had been complete.

MnCl ₂ cm ³ .	MH ₄ Cl grm.	MnCO ₃			Mn ₂ O ₄		
		Found.	Theory.	Error.	Found.	Theory.	Error.
50	10	0·2685	0·2680	0·0005 +	0·1770	0·1776	0·0006 —
50	10	0·2704		0·0024 +	0·1788		0·0012 +
50	10	0·2710		0·0030 +	0·1770		0·0006 —
50	10	0·2720		0·0040 +	0·1774		0·0002 —

As shown in this table, weighing as the carbonate is out of the question; the errors of the process when the residue is ignited in the manner described to form the manganoso-manganic oxide are much smaller though rather variable. The estimation of manganese as the anhydrous sulphate had given in the work to which reference has been made results agreeing so much more closely than could be obtained by any other method of procedure, that the attempt was made to estimate the amount of manganese precipitated as the manganese carbonate by converting it first to the oxide, then to the sulphate. A given weight of sulphate was precipitated as the manganous carbonate, after the employment of all the precautions mentioned previously in this paper, and then filtered off on ashless filter paper. After washing thoroughly with hot water, the filter was burned, the residue ignited for the condition of the manganoso-manganic oxide and weighed as such. Then the oxide was converted to the sulphate by heating with three or four drops of concentrated sulphuric acid. The agreement of the results as shown in the following table is considerably better.

* *Annal d. Phys. u. Chem.*, 1851, lxxxiv, 52.

† *This Journal*, IV, v, 209.

	MH ₄ Cl gram.	Mn ₂ O ₄			MnSO ₄		
		Found.	Theory.	Error.	Found.	Theory.	Error.
(1)	10	0·2463	0·2478	0·0015—	0·4903	0·4905	0·0002—
(2)	10	0·1110	0·1121	0·0011—	0·2225	0·2219	0·0006+
(3)	10	0·1584	0·1581	0·0003+	0·3126	0·3128	0·0002—
(4)	10	0·1672	0·1699	0·0027—	0·3355	0·3364	0·0009—

By treatment of the filtrates of (1), (2) and (3) with bromine and ammonia at boiling temperature no manganese was found. In the filtrate from number (4) by the same treatment, a small amount of manganese dioxide was precipitated, which when heated with concentrated sulphuric acid gave 0·0006 gram. of manganous sulphate; and, hence, the error in that determination is really 0·0003 gram. on the sulphate. The slightly larger deficiency recorded in the table was probably due to imperfect filtering.

It seems to be evident that Guyard's method of separation of manganese as the manganous carbonate, when handled with precautions, gives complete separation of that element. It must be recognized clearly, however, that the precipitation should be made in the presence of a considerable amount of ammonium chloride, and that great care must be used in the filtering and washing of the finely divided precipitate. It is altogether preferable to weigh in the condition of the sulphate.

In conclusion thanks are hereby expressed to Professor F. A. Gooch for kind assistance.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On New Methods for Measuring Gases.*—Several methods for measuring gases have been described by BLAIR, which seem to present important advantages. In the first, which is a new compensation method, it is the gas under examination, and not the standard gas with which it is to be compared, which is kept at constant volume or is adjusted to a known fraction of the original volume. In the apparatus used for air analysis, the whole is surrounded with a water jacket. It consists of two tubes A and B; A being filled with the gas to be tested and B with the standard volume. The tube B has a cylindrical bulb at its top of a capacity of 100^{cc}, the tube itself below this holding 1^{cc} and being graduated to 0.01^{cc}. The parallel tube A has a 79.5^{cc} cylindrical bulb at its top and just below it a second bulb of 20.5^{cc}. After filling both tubes to the 100^{cc} mark at the atmospheric pressure, their upper ends are connected by means of taps with a re-curved capillary tube having a drop of liquid in the bend. Since the pressure is the same in the two tubes, the drop will remain in the center when the taps are opened. The carbon dioxide is then absorbed, the liquid is brought to its original level in the two tubes and the taps are opened. Since the absorption has slightly decreased the pressure in A, the drop moves to that side. The liquid in B is then lowered by lowering the reservoir connected to the ends of both tubes by a rubber hose, until the drop comes back to the center. If to do this the level of the liquid in B has been lowered 0.15^{cc}, the percentage of CO₂ is $0.15 \times (100 / 100.15)$. Next the oxygen is absorbed and the process is repeated, except that the liquid in A is brought to the upper level between the two bulbs in place of the lower level. If the final level is 0.53^{cc} the percentage of oxygen is $20.5 + 0.53 \times (79.5 / 100.53)$. In this way very great accuracy is secured, all the measurements being made under nearly the same pressure, though each special gas requires specially divided tubes. Evidently this same apparatus can be used with the ordinary compensation method by placing the gas to be examined in B, which it completely fills; the standard gas volume being contained in A. Indeed a combination of the two may be employed using the second method first and then the first method. In a second method the measurements of volume are made by means of pressure readings. A pipette consisting of five bulbs is made use of, inclosed in a water jacket. Each bulb has an approximate capacity of 20^{cc} and on the connecting tubes between each pair of bulbs a mark is made, the volume of the pipette down to each mark being accurately known. Besides this pipette a graduated manometer tube is provided, connected with a movable reservoir, which tube is clamped in position and reaches to about 60^{cm} above and below the lowest mark of the pipette ;

marks being drawn on the manometer to correspond to those on the pipette. The gas is first compressed to the lowest mark and the pressure is noted on the manometer. The absorption of one constituent is then proceeded with and the pressure is again noted, the volume being adjusted to the same mark, or if this is not possible to the one above it. Finally the author describes a measuring pipette with reserve spaces. It consists of two parallel vertical branches enclosed in a water jacket. One of these branches is a cylindrical tube holding 20^{cc} and graduated. The other consists of four bulbs having a mark on the constriction below each bulb; the volume between each of these marks and the upper graduation on the first tube being accurately known. A connecting tube provided with a tap joins the two tubes at top. At bottom these tubes are connected with a movable reservoir by means of rubber hose and a three-way tap. In making a measurement the liquid is driven up to a convenient mark, the rubber tube is closed by a spring clip, and the reservoir is adjusted so as to bring the level of the liquid in it to the same point as in the graduated branch of the pipette; the volume of the gas may then be read directly. —*Ber. Berl. Chem. Ges.*, xxx, 2753-2759, 1897. G. F. B.

2. *On the Influence of the Röntgen Radiation on the Velocity and Rate of Recombination of the Ions of Gases.*—It is well known that air which has been exposed to Röntgen radiation retains the power of discharging positive and negative electrification for a short time after the rays have ceased. RUTHERFORD has investigated the duration of this after-conductivity in the case of air and other gases and from the data thus obtained has determined the velocity of the ions through various gases. These are given in the following table, in which T represents the time required for the number of ions to fall to one-half their original value.

Gas.	T in seconds.	Conductivity, Air = 1.
Hydrogen	0.65	0.5
Air	0.3	1
Hydrogen chloride	0.35	11
Carbon dioxide	0.51	1.2
Sulphurous oxide	0.45	4
Chlorine	0.18	18

Apparently there is no very close relation between the values of T and the conductivities, though in general the value of the former diminishes as the latter increases. For the same gas the value of T was observed to depend largely on the intensity of the radiation. It was also noted that the duration of the after-conductivity was affected by the presence of finely-divided matter either solid or liquid. The author found that the velocities of the ions were independent of the amount of ionization of the gas used, and were inversely as the densities with the single exception of chlorine. The velocity of the hydrogen ion through hydrogen was observed to be nearly four times as great as that of the oxy-

gen ion in oxygen. The ions of sulphurous oxide gave the slowest velocity, only one-tenth that of hydrogen.—*Phil. Mag.*, V, xlv, 422-440, November, 1897.

G. F. B.

3. *On the Connection between Fluorescence and Chemical Composition.*—According to R. E. MEYER, the fluorescence of organic compounds may be considered to be due to the presence of certain atomic groups, which undergo no change in the several fluorescent derivatives of a given substance. These groups the author proposes to call fluophores or fluophoric groups. But in order that there should be an actual fluorescence, the fluophore must be placed between two massive atomic groups, usually benzene nuclei. Thus in the derivatives of fluoran which embrace the fluoresceins, naphthofluorans, rhodamines and the like, the fluophore is the pyrone group which although not itself fluorescent becomes so in the diphenyl derivatives. The same fluophore is contained in the xanthenes, while in the xanthenes its reduction product is present; the effect of substitution being very marked. It may be said that in general the entrance of heavy atoms or groups into the benzene nuclei decreases the fluorescence, the nature and position of the substituted body influencing the result very largely. The presence of hydroxyl groups for example in any position other than that of the fluorescein hydroxyls may greatly weaken or even destroy the fluorescence of the fluoran and xanthone compounds. Only the direct derivatives of the anthracene group and not anthraquinone are fluorescent. The fluophore in the acridine compounds is $\text{CH} \begin{array}{c} \diagup \\ \text{---} \\ \diagdown \end{array} \text{N}$. In this

case the effect of the position of the substituted body is very marked, since benzoflavine, which has both its amido groups in the "fluorescein position," is far more strongly fluorescent than its isomer chrysaniline. If sulphur be substituted for oxygen in the pyrene ring, the fluorphoric character is not destroyed, the thiopyrene derivatives showing a weak fluorescence. Moreover the azine, oxazine and thioazine rings act as fluophores in the phenazines, phenazoxines and thiodiphenylamine compounds, which include many important fluorescent dyes, as mauveine, the safranines and allied naphthalene compounds, the indulins, Lauth's violet, and methylene blue; this latter showing a reddish-violet fluorescence. The influence of the solvent is also important.—*Zeitschr. physikal. Chem.*, xxv, 468-508, December, 1897. G. F. B.

4. *On a new method of preparing pure Iodine.*—Some months ago LEAN and WHATMOUGH observed that no iodine was set free when cuprous iodide was heated even to fusion in a current of carbon dioxide, while it is well known that iodine is readily evolved from this substance when it is heated in the air, even to a moderate temperature. They have based on this fact a method for preparing perfectly pure iodine. For the preparation of the cuprous iodide, a solution of a mixture of copper sulphate and ferrous sulphate was precipitated by a solution of potassium iodide; a pure product being obtained by proper dilution. This cuprous

iodide was then heated until fused in a current of dry and pure carbon dioxide in order to drive off hydrogen iodide and moisture; after which the iodide was heated in a current of dry air to between 220° and 240° . A continuous stream of violet vapor was carried forward and condensed in beautiful crystals in the cooler parts of the tube. To test the purity of the iodine so obtained 2.7529 grams was placed in a tube and heated to 75° in a slow current of dry air. After 4 hours only a slight brown residue remained, weighing 0.3 milligram; this proving afterward to have come from impurities in the air. No copper could be detected in it by the spectroscope. The fusing point of this iodine was 112.5° – 114° . It is blacker than the ordinary iodine.—*J. Chem. Soc.*, lxxiii, 148–157, March, 1898. G. F. B.

5. *On the Borides of Calcium, Barium and Strontium.*—An investigation has been made by MOISSAN and WILLIAMS on the preparation and properties of the borides of calcium, barium and strontium. Calcium boride is readily obtained by heating in a carbon crucible a mixture of 1000 parts of calcium borate, 630 parts of aluminum and 200 parts of sugar carbon, for seven minutes by means of a current of 900 amperes and 45 volts. The calcium borate is completely reduced by the aluminum, the carbon preventing the formation of aluminum oxide. The product obtained is broken up and treated first with dilute and then with concentrated boiling hydrochloric acid, water, ether, toluene and hydrofluoric acid. The resulting substance has the composition CaB_2 and forms transparent microscopic crystals, cubic or rectangular in form, which scratch rock crystal and even rubies. Their density at 15° is 2.33. Fluorine in the cold and chlorine at a red heat attack it readily, the former with incandescence. It is not decomposed by water at 250° under pressure, but the gaseous hydracids attack it at a dull red heat. Barium boride prepared similarly has analogous properties. Its crystals are small but very regular, having a density of 4.36 at 15° . They scratch rubies but not the diamond. Strontium boride is not attacked by fluorine in the cold. Its density is 3.28 at 15° .—*C. R.*, cxxv, 629–643, November, 1897. G. F. B.

6. *The Arrangement of Atoms in Space*; by J. H. VAN'T HOFF. 2d revised and enlarged edition. With a preface by Johannes Wislicenus, and an Appendix, Stereochemistry among Inorganic Substances, by Alfred Werner. Translated and edited by Arnold Eiloart. 12mo, pp. xii, 212. London, 1898. (Longmans, Green & Co.)—Perhaps no book of recent times has had a more profound influence upon structural chemistry than this little volume. It appeared first in 1877 under the title “*La Chimie dans l'Espace*,” and had for its motto a quotation from Wislicenus's paper on lactic acid, published in 1869: “The facts compel us to explain the difference between isomeric molecules possessing the same structural formulæ by the different arrangement of their atoms in space.” The new edition, of which the present work is a translation, was issued in 1894, and is to a considerable extent a

union of the original work with van't Hoff's "Dix Années dans l'Histoire d'une Théorie." The central figure in the new theory—suggested by Le Bel as well as by the present author—is the asymmetric carbon atom. To the law of the quadrivalence of carbon, announced by Kekulé, van't Hoff added the hypothesis that the four valences are directed toward the corners of a tetrahedron at the center of which is the carbon atom. The two isomers of Pasteur, of opposite rotatory power, were explained by means of this tetrahedron and its image, the isomerism disappearing when the two groups become identical, through the resulting symmetry and identity of the two tetrahedra. Thus originated the subject of stereochemistry, now so firmly fixed in the science. Even the little remaining opposition to it is directed, as Wislicenus says, against the ultimate basis—against the atomic hypothesis itself—and does not deny that the doctrine of atomic arrangement in three dimensions is a logical and necessary stage, perhaps the final stage, in the chemical theory of atoms. "It has already effected to the full all that can be effected by any theory; for it has brought into organic connection with the fundamental theories of chemistry facts which were before incomprehensible and apparently isolated and has enabled us to explain them from these theories in the simplest way. By propounding to us new problems the hypothesis has stimulated empirical investigation on all sides; it has caused a vast accumulation of facts, has led to the discovery of new methods of observation, has become amenable to the test of experiment and has at the same time started in our science a movement full of significance—in a certain sense indeed a new epoch." In the new edition a section on nitrogen derivatives has been added; in the part devoted to carbon the greatly increased number of facts has been taken into account, and special attention has been given to the amount of rotation of active bodies; thus making it a reference book at once for stereochemistry and optical activity. The translation is an excellent one, as was to be expected from the well known ability of Dr. Eiloart in this direction.

G. F. B.

7. *A College Course of Laboratory Experiments in General Physics*; by SAMUEL W. STRATTON and ROBERT H. MILLIKAN, of the University of Chicago. 8vo, pp. iv, 100. Chicago, 1898. (University of Chicago Press.)—This laboratory manual is designed for the students of the Junior College Courses in Physics in the University of Chicago. "The aim has been to select and devise a set of experiments calculated, first to give an acquaintance with the methods and a view of the field of Experimental Physics such as is requisite to a liberal education; and second to train the student to accurate observation, skilful manipulation and logical interpretation of observations." It appears to us that this aim has been realized. Within this hundred pages fifty-three experiments have been described, each excellent in character, clearly and succinctly stated, requiring the use of accurate and simple apparatus, and so performed as to lead

to the best results. The book cannot fail to be of excellent service for the class of Junior students for whom it was prepared, and so is a valuable contribution to the teaching of physics from the admirable Ryerson laboratory.

G. F. B.

8. *Text-book of Physical Chemistry*; by CLARENCE L. SPEYERS, Rutgers College. 8vo, pp. viii, 224. New York, 1897. (D. Van Nostrand Co.)—Physical chemistry is here defined as "the science which has for its object the investigation of chemical changes by physical methods." In his preface the author says: "I have adopted the view that matter is a collection of energies in space, considering the relations of the energies to be the prime object of investigation. With Ostwald, I feel confident that the materialistic interpretation has passed its prime and has no promise for the future." "The different forms of matter," he says, "we may define as different collections of activities in space, the quality and quantity of these activities changing with the different forms of matter." And again: "We need energy and a something to enable energy to collect in space before we get a material substance. This something which enables and perhaps causes the energy to collect in space we shall call matter." So that it would appear that matter has two definitions: first "a collection of energies," and second, a "something," an unknown entity which causes these energies thus to collect; the latter being not very unlike our present conception. Moreover "the belief that oxygen and hydrogen still persist as such in water, and in general the idea that the elements persist in a compound," is not justifiable. "All we may assume is that the conditions that *cause* the breaking up of a collection require the formation of those collections which went to make up the collection just destroyed. But to claim that these collections originally existed in the collection that broke up, is entirely opposed to the evidence of our senses." It will be seen from these quotations that the author follows Ostwald pretty closely even when he is most radical; sometimes even surpassing him. Thus he uses time, space and energy as his fundamental units; but he denounces the kinetic theory of gases as "a troublesome thing" which "is becoming an object of ridicule." Nevertheless the book will serve a useful purpose. It contains in compact form excellent chapters on energy, gases, heat, physical changes, equilibrium, chemical kinetics, phases, variable temperature, electrochemistry and ions. The problems are a valuable addition to the text.

G. F. B.

9. *The Tutorial Chemistry. Part II. Metals*; by G. H. BAILEY, Ph.D. Edited by William Briggs, M.A. 12mo. pp. viii, 300. London, 1898 (W. B. Clive).—This little book treats of the metallic elements in much the ordinary way, except that a more considerable space is given to chemical physics than is usual in manuals of this grade. The grouping follows the order of the periodic system and in an appendix is given a chapter on crystallography, one on spectrum analysis and a third on a series of useful experiments. The book will prove of value, we think, for second year students.

10. *The ultra red spectrum.*—Professor Langley has shown that the energy in the ultra red spectrum of sunlight falls off very rapidly and beyond $\lambda = 5\mu$ the energy is only measurable at certain points. This remarkable fall of energy in sunlight compared with that of other sources of light Langley attributes to the absorption of the earth's atmosphere. H. RUBENS and E. ASCHKINASS have studied this question of absorption by means of the method used by H. Rubens in previous researches. (H. Rubens and E. F. Nichols, *Wied. Ann.*, lx, p. 418, 1897.) This method consisted in using repeated reflections from surfaces of sylvite in order to obtain homogeneous rays of great wave length. These rays were sent through layers of carbonic acid gas and of water vapor, and it was discovered that the earth's atmosphere must be non-transparent for rays of wave length $12-20\mu$ as well as for rays of wave length 24.4μ . Langley's investigations were made with a rock salt prism of 36° . This enabled him to investigate the region up to $10-11\mu$. The authors state that the fact that beyond the region $\lambda = 12\mu$ the sun's rays are absorbed is of small importance in practical meteorology since the energy of these rays is small compared with that of the entire amount of emission of the sun.—*Wied. Ann.*, No. 3, 1898, 584-601. J. T.

11. *Transparency of fluids for heat rays of great wave length.*—By means of a method of obtaining heat rays of great wave length, H. RUBENS and E. ASCHKINASS have shown that the absorption of long heat rays by means of water is very great. The index of refraction of water for these rays is of the same order of dimension as for the visible spectrum, and the high value $\lambda = 9$ obtained for Hertz vibrations must lie beyond 24μ . It was found that benzol was more transparent for the long waves of heat than hitherto investigated substances. Bisulphide of carbon showed a comparatively small absorption, and xylol a marked transparency. The authors point out that these two substances together with chloride of silver belong to that class of substances for which, according to the extrapolated Cauchy formula applied to infinitely long wave lengths, the square of the index of refraction is approximately equal to the dielectric constant.—*Wied. Ann.*, No. 3, 1898, 602-605. J. T.

12. *Electrical resistance standards.*—W. JAEGER and K. KAHLE give a careful discussion of the results reached at the Reichsanstalt upon the tests of constancy of resistance standards. It was found that the constancy of the manganine wire standards was remarkable. Between January, 1895, and June, 1897, the change in resistance of the standards was in the hundred thousandth place.—*Wied. Ann.*, No. 3, 1898, 456-485. J. T.

13. *Electric equilibrium between uranium and an insulated metal in its neighborhood.*—Lord KELVIN with several students has shown that a sheet of metallic uranium can disturb the electric equilibrium in the neighborhood of an insulated metallic plate. An insulated metallic plate was connected to the insulated pair of quadrants of an electrometer. When the metallic uranium was

placed opposite the insulated metallic plate, the electrical equilibrium was destroyed and a deviation of 84 scale divisions was obtained from the electrometer. A plate of brass or other metal produced no effect.—*Phil. Mag.*, March, 1898, 277-278. J. T.

II. GEOLOGY AND MINERALOGY.

1. *L'échelle réduite des expériences géologiques permet-elle leur application aux phénomènes de la nature?* Par W. PRINZ. (Revue de l'université de Bruxelles, tome II, pp. 550-547, figs. 1-49. 1897.)—Professor Prinz in this paper has brought together a series of experiments to show the close similarity of the effects produced by a variety of modes of application of mechanical pressure upon various substances differing very greatly in dimensions and in physical consistency. The experiments of Daubrée and James Hall, and later of Cadell and Willis and others, with clay and wax models of geological strata, are familiar to all geologists. The folding and faulting of mountain regions are thus reproduced on a small scale. The experiments of Malloc are cited to show that the materials of the thin layer of steel, removed from the surface as the tool advances in a planing machine, behave in the same way as do the wax and clay models, and likewise the rock layers in faulting and sliding over each other.

The law that cleavage planes form at oblique angles, and schistosity planes at right angles to the direction of the compressing force, is illustrated by geological sections, by cylinders of wax and clay, by the fractures appearing in a pile of setting and setting mortar, by the cracking of walls broken by the jar of earthquake; and complex effects produced by bending an elongated cylinder of clay illustrate the same principle. The relation of the direction of the planes of fracture to the duration of the passage of the pressure is illustrated by another series of experiments bringing out the fact that the relationship between these two factors is independent of the nature of the material and of the size of the fractures.

The familiar crevasses of glaciers are first put in evidence. The same law is traced by the author through the following diverse experiments: The cracks diverging from a line made by drawing a cane through the snow, a needle drawn across a thin layer of plaster, a pencil in raggedly tearing a sheet of paper, a stick drawn through the mud of a road. Added to these are the effects produced by a steel roulette used in cutting glass, the like effect of a cart-wheel running through a muddy road. Microscopic examination of the scratch of a diamond upon a glass plate shows the same disposition of the fracture planes as in the other cases.

In these several cases it appears that the fractures produced in substances of greatly varying constitution, when pressed beyond the limit of elasticity by a hard tool either passing through it, pressing over the surface, or rolling on the surface, are alike in

diverging from the line of pressure obliquely forward. These fractures, in other words, converge toward the direction of the source of the pressure. The paper is well illustrated and is full of suggestions for structural geologists. H. S. W.

2. *Geological survey of the Witwatersrand, Southern Transvaal*; by FREDERICK H. HATCH. (Quar. Jour. Geol. Soc., liv., pp. 73-99, 1898.)—The geological structure of this South African gold region has been studied by Dr. Hatch during his occupation in the district as a mining engineer, and in the present article a résumé of what is known is clearly presented with diagrams and map. The Cape system, which rests upon the Archæan, and is followed by the Karoo system, or Coal Measures of this region, constitutes the main body of rocks illustrated. The author finds the Cape system to consist of about 50,000 feet of beds, made up as follows :

Magaliesberg and Gatsrand series.....	16,000 to 20,000 ft.	
Dolomite Formation.....	6,000 "	8,000 "
Black Reef Formation.....	20 "	50 "
Klipriversberg Amygdaloid.....	5,000 "	6,000 "
Witwatersrand Beds.....	11,000 "	15,000 "
Hospital Hill series.....	8,000 "	10,000 "

H. S. W.

3. *Revised Text-Book of Geology by James D. Dana*; edited by WM. NORTH RICE. 5th edition, revised and enlarged. pp. 1-482, figs. 1-464, 1898. (American Book Company.)—With the increased size of the Dana's "Manual," such a book as this is demanded for general classes, both in high schools and colleges when an elementary, and not a complete technical knowledge of geology is sought. The late author having completed with great pains the "Manual," was at work upon the revision of the Text-Book nearly up to the time of his death. Professor Rice, who was a pupil of the author, has finished the task, carefully revising the whole, with full appreciation of the spirit of the original, which he has preserved with a loyal devotion. A few modifications are made, bringing the nomenclature and classifications into harmony with common usage of the present date.

"In the present edition, the bearing of various events in geological history upon the theory of evolution is pointed out, in the appropriate places; and in the closing chapter, which has been entirely rewritten, the general bearing of paleontology upon evolution is discussed." Some change has been made in the treatment of the history of the Quaternary, and in the discussion of Metamorphism the editor has departed from the views held by the author. We also notice some changes in the order of discussion of the divisions of the subject. Taken as a whole, the present edition is well adapted to hold the same place of preëminence which the earlier editions, prepared by the author's own hand, have continuously occupied. H. S. W.

4. *On the genus Lepidophloios*, as illustrated by specimens from the Coal formation of Nova Scotia and New Brunswick; by

Sir J. Wm. DAWSON. (Trans. Roy. Soc., Canada. 2d ser., vol. iii., sec. iv., pp. 57-78, plates 1-xiv, 1897.)—The author brings together in the present paper a full account of what is known regarding the structure and affinities of the two species of this genus (*L. Acadianus* and *L. Cliftonensis*), already described by him, and illustrates the subject with beautiful half-tone reproductions of the remarkable specimens contained in his collection, now deposited in the Peter Redpath Museum, McGill University.

H. S. W.

5. *The Geological Survey of Georgia*; W. S. Yeates, State Geologist.—Two bulletins of the Georgia Geological Survey have recently appeared: of these bulletin No. 3-A is entitled: A Preliminary Report on a part of the Water-powers of Georgia, compiled from the notes of C. C. Anderson, late Assistant Geologist, and from other sources, by B. M. Hall, Special Assistant. 1896. (150 pp.) This report gives an account of the various water-powers of the State, most of which are at present entirely unutilized. The rapidity of the development, however, in the direction of manufacturing has directed attention to the subject, so that the information now brought together is likely soon to bear fruit.

Bulletin No. 5-A is entitled: A Preliminary Report on a part of the Phosphates and Marls of Georgia, by S. W. McCallie, Assistant Geologist. 1896. This report gives the results of investigations made in the counties lying along the Georgia-Florida State line. As the result of these, it is stated that it is improbable that there are, except perhaps in Thomas County, deposits of phosphate of sufficient extent and purity to be mined with profit. Attention, however, is called to the more or less extensive beds of marl or low grade phosphate, and the opinion is expressed that in many, if not all, of these counties deposits exist more or less extensive, which equal in many respects the green sands of New Jersey. The development and use of these deposits, it is thought, would lead to the restoration of thousands of acres of land exhausted by long cultivation, to their original fertility.

6. *Geological Survey of India—Paleontologica Indica*.—The following additions have recently been made to this important paleontological series:

Series XV. Himaláyan Fossils. Vol. I, Pt. 4.—The Permian fossils of the Productus shales of Kumaon and Gurhwal, by Carl Diener, Ph.D. Plates I to V.

Ser. XV. Vol. II, P. 1.—The Cephalopoda of the Lower Trias, by Carl Diener, Ph.D. Plates I-XXIII.

Ser. XVI. Fauna of Báluchistan. Vol. I, Pt. 2.—The Fauna of the (Neocomian) Belemnites beds, by Fritz. Noetling, Ph.D., F.G.S. Plates I, II.

Ser. XVI. Vol. I, Pt. 3.—Fauna of the Upper Cretaceous (Maëstrichtien) beds of the Mari Hills, by Fritz. Noetling. Plates I-XXIII.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Report of the National Academy of Sciences for the year 1897.*—This publication, besides the usual matter referring particularly to the Academy itself, contains the valuable report of the Commission appointed by the Academy upon a policy for the forested lands of the United States. This contains much that is new and interesting, giving the results of the observations made by the members of the Commission themselves throughout the west, as well as of their study of forestry methods in other countries. From the report we quote here the conclusions and recommendations with which it closes :

“The Secretary of the Interior, in his letter of February 15, 1896, asked the Academy whether ‘it is desirable and practicable to preserve from fire and to maintain permanently as forest lands those portions of the public domain now bearing wood growth for the supply of timber.’

Your committee is of the opinion that it is not only desirable but essential to national welfare to protect the forested lands of the public domain, for their influence on the flow of streams and to supply timber and other forest products; and that it is practicable to reduce the number and restrict the ravages of forest fires in the Western States and Territories, provided details from the Army of the United States are used for this purpose permanently, or until a body of trained forest guards or rangers can be organized. It does not believe that it is practicable or possible to protect the forests on the public domain from fire and pillage with the present methods and machinery of the Government.

In answer to the second question submitted by the Secretary of the Interior, “How far does the influence of forests upon climate, soil, and water conditions make desirable a policy of forest conservation in regions where the public domain is principally situated?” it is the opinion of your committee that, while forests probably do not increase the precipitation of moisture in any broad and general way, they are necessary to prevent destructive spring floods, and corresponding periods of low water in summer and autumn when the agriculture of a large part of western North America is dependent upon irrigation.

The answer to the third question, “What specific legislation should be enacted to remedy the evils now confessedly existing?” will be found in the series of proposed bills appended to this report. They present the following recommendations :

(1) That the Secretary of War, upon the request of the Secretary of the Interior, shall be authorized and directed to make the necessary details of troops to protect the forests, timber, and undergrowth on the public reservations, and in the national parks not otherwise protected under existing laws, until a permanent forest bureau in the Department of the Interior has been authorized and thoroughly organized.

(2) That the Secretary of the Interior shall be authorized and

directed to issue the necessary rules and regulations for the protection, growth, and improvement of the forests on the forest reserves of the United States; for the sale from them of timber, firewood, and fencing to actual settlers on and adjacent to such reserves, and to the owners of mines legally located in them for use in such mines; for allowing actual settlers who have no timber on their own claims to take from the reserves firewood, posts, poles, and fencing material necessary for their immediate personal use; for allowing the public to enter and cross the reserves; for granting to county commissioners rights of way for wagon roads in and across the reserves; for granting rights of way for irrigating ditches, flumes, and pipes, and for reservoir sites; and for permitting prospectors to enter the reserves in search of valuable minerals; for opening the reserves to the location of mining claims under the general mineral laws; and for allowing the owners of unperfected claims or patents, and the land-grant railroads with lands located in the reserves, to exchange them under equitable conditions for unreserved lands.

(3) That a bureau of public forests shall be established in the Department of the Interior, composed of officers specially selected with reference to their character and attainments, holding office during efficiency and good behavior and liberally paid and pensioned.

(4) That a board of forest lands shall be appointed by the President to determine, from actual topographical surveys to be made by the Director of the Geological Survey, what portions of the public domain should be reserved permanently as forest lands and what portions, being more valuable for agriculture or mining, should be open to sale and settlement.

(5) That all public lands of the United States more valuable for the production of timber than for agriculture or mining shall be withdrawn from sale, settlement, and other disposition and held for the growth and sale of timber.

(6) That certain portions of the Rainier Forest Reserve in Washington and of the Grand Canyon Forest Reserve in Arizona shall be set aside and governed as national parks.

Yours, respectfully, Charles S. Sargent, Henry L. Abbot, A. Agassiz, Wm. H. Brewer, Arnold Hague, Gifford Pinchot, Wolcott Gibbs.

To the President of the National Academy of Sciences.

2. *National Academy of Sciences: Washington Meeting.*—The following is a list of the papers presented at the meeting of the Academy held at Washington, April 19 to 22.

- A. AGASSIZ: The coral reefs of Fiji.
- A. AGASSIZ and W. MCM. WOODWORTH: The Fiji bololo.
- A. AGASSIZ and A. G. MAYER: The aculephs of Fiji.
- J. S. BILLINGS: The variation in virulence of the Colon bacillus.
- THEO. GILL: Biographical memoir of Edward D. Cope.
- ALPHEUS HYATT: New classification of Nautiloidea.
- A. A. MICHELSON: A new spectroscope.
- IRA REMSEN and E. E. REID: On the hydrolysis of acid amides.

IRA REMSEN and W. A. JONES: The question of the existence of active oxygen
IRA REMSEN and J. W. LAWSON: On the product formed by the action of benzenesulphonchloride on urea.

IRA REMSEN: On double halides containing organic bases.

W. K. BROOKS: McCrady's Gymnophthalmata of Charleston harbor.

CARL BARUS: Ballistic galvanometry with a countertwisted torsion system. A curious inversion in the wave mechanism of the electromagnetic theory of light.

CHARLES S. HASTINGS: A consideration of the conditions governing apparatus for astronomical photography.

T. C. MENDENHALL: The use of graphic methods in questions of disputed authorship, with an application to the Shakespeare-Bacon controversy.

A. W. WRIGHT: A method for obtaining a photographic record of absorption spectra.

H. Y. BENEDICT: Theories of latitude variation.

E. W. BROWN: Progress in the new theory of the moon's motion.

CHARLES L. DOOLITTLE: On the variation of latitude and the aberration-constant.

The next meeting of the Academy will be held at New Haven, Conn., on November 15th.

3. *American Association for the Advancement of Science.*—

The fiftieth anniversary of the Association will be celebrated at the coming meeting in Boston, August 22 to 27. A preliminary circular has been recently distributed giving the names of the officers of the meeting, of the local committee and also the plans so far as matured for giving this meeting the importance which the occasion demands. The sessions are to be held in the halls and rooms of the Massachusetts Institute of Technology and of the Boston Society of Natural History; accommodations will be thus furnished for all the Sections and for the General Sessions in three closely adjoining buildings. It is also stated that the Corporation of Harvard University has invited the Association to be its guest for a day in Cambridge; and that the Essex Institute has arranged for a day in Salem. There will also be an excursion in the harbor, and after the meeting, trips to the White Mountains and to Cape Cod. Many foreign scientists will be invited to take part, and many foreign educational and scientific institutions are expected to send delegates, thus giving to the meeting an international character. During the Association week and the days immediately preceding, a number of affiliated societies will meet in Boston including the American Geological Society, the American Chemical Society, the Society of Economic Entomologists, and others.

The President of the meeting is Prof. F. W. Putnam, who for twenty-five years has performed the laborious duties of Permanent Secretary. In retiring from this position he makes an earnest appeal to all interested in science to take hold and make this anniversary meeting thoroughly successful. This call will doubtless meet with a generous response. All correspondence should be addressed to the Local Secretary, Prof. H. W. Tyler, Massachusetts Institute of Technology, 491 Boylston st., Boston.

4. *Science Abstracts. Physical and Electrical Engineering.*—The Institution of Electrical Engineers and the Physical Society of London have recently undertaken the publication of a monthly series of abstracts in their departments of science. This appears to be an extension of the work hitherto done by the Physical Society and published in their Proceedings. The editor-in-chief is J. Swinburne and the sub-editor W. R. Cooper. The committee includes Capt. Abney, Profs. W. E. Ayrton, A. W. Rücker, S. P. Thompson, and others, and a list of about forty abstractors is given. Part 3, volume I, for March, 1898, is now in hand and gives abstracts from No. 231 to 355. It is obvious that it is a great advantage to all interested in science to have placed before them a brief, well-written digest of memoirs recently published in the many scattered journals and society transactions, and it is to be hoped that the enterprise may receive the full support it deserves.

OBITUARY.

Prof. JULES MARCOU, the veteran geologist, died at his home in Cambridge, Mass., on April 17th at the age of seventy-four years. He was born in Salins, Jura, France, April 20, 1824, and was educated at Besançon and afterward at Paris. In 1845 he became associated with Jules Thurmann, in his work on the geology of Jura Mountains; it was while engaged in this that he first met Louis Agassiz, with whom he later became intimate. Acting as traveling geologist for the Jardin des Plantes, he visited the United States and Canada in 1847 and accompanied Prof. Agassiz on his trip to the Lake Superior region in 1848. The collections of minerals he then made were forwarded to Paris in the following year. Later he studied the geology of New Jersey, Pennsylvania, Virginia and the Mammoth Cave. After a short visit to Europe, in 1850, he returned to this country and published his geological map of the United States and the British North American possessions. Entering the geological service of the United States in 1853, he made a section map of the thirty-fifth parallel from the Mississippi River to the Pacific Ocean. His impaired health compelled a return to Europe in 1855, and from that year to 1859 he held a professorship in the Polytechnic School in Zurich. In 1861 he returned to the United States and aided Prof. Agassiz in the founding of the Museum of Comparative Zoology, in which he had charge of the paleontological division. From 1864 on he devoted himself to scientific work, and in 1875 he again entered the National service for a time. Prof. Marcou was decorated with the Cross of the Legion of Honor in 1867, and was a member of many scientific societies here and abroad. He published numerous works on scientific, geological and geographical subjects, both in this country and France. His last work of note was a life of Agassiz, published in 1896. Many of his papers in recent years have been largely of a polemical nature. He was positive and vigorous in controversy and persistent in his opinions. The debatable questions on the Taconic and Jurassic furnished him with many themes for defense and attack.

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[FOURTH SERIES.]

ART. XLIX.—*A Theory to Explain the Stratification of the Electric Discharge in Geissler Tubes*; by H. V. GILL, S. J.
(With Plates IV, V.)

IN the following paper it is proposed to put forward as simply as possible certain ideas regarding the cause of the stratifications seen when a discharge of electricity takes place in a Geissler tube, and to describe some experiments which have been made to test the value of these ideas.

The stratified discharge is without doubt the most striking phenomenon presented in the case of an electric discharge through a Geissler tube, and has naturally attracted the attention of many scientists. Though, however, a vast amount of time and trouble has been expended on expensive researches as to the true cause of this curious and beautiful phenomenon, it must be said that no theory has, up to this, been accepted as satisfactory. As the question is one of great interest and importance, any contribution, however small, towards the solution of the mystery is of value, and hence it is deemed advisable to present the following paper.

In the first place, it will be useful to consider the electric spark under normal conditions, especially with reference to such of its mechanical effects as will help to throw some light on the theory we are about to develop, since those who have devoted special attention to this point are all of opinion that the discharge in a rarefied gas is in no way different from the discharge in air under ordinary conditions of pressure.*

*“The striations are only clearly marked within somewhat narrow limits of pressure. But it is in accordance with the conclusion which all who have studied the spark have arrived at—that there is complete continuity between the bright, well-defined spark which occurs at high pressures and the diffused glow which repre-

Since the most usual form of the spark in air is oscillatory, we may therefore conclude that the discharge in a Geissler tube is oscillatory likewise. These oscillations may vary in frequency from hundreds of millions per second, as in the experiments of Hertz, to some hundreds per second as in those of Dr. Lodge. That the oscillatory discharge is the more usual form of a spark appears from the most recent researches. For example, Prof. Trowbridge writes:* "The oscillatory discharge may be said to be the common occurrence in nature in the case of electrical discharges, and the one-direction discharge the uncommon. . . . In general nature avoids an unidirectional discharge."

The stratified discharge may be produced not only by an induction coil and by an electric machine, but also by a battery of elements in series. . . .

That the discharge of such a battery is in no way different from the spark discharge produced by other means, is the conclusion arrived at by physicists.

De la Rue and Müller† made use of a battery containing, when completed, some 14,000 chloride of silver cells; with this battery they performed a long series of experiments which are described at length in their various memoirs presented to the Royal Society. The discharge was found to consist of a number of distinct sparks, when examined in a rotating mirror, making 17 revolutions per second: they add,‡ "When a considerable resistance was added to the circuit, for example 4 megohms, the character of the spark was completely modified. We obtain, at a distance (between a point and a plate) a little less than in the ordinary case, a series more or less rapid of sparks analogous to those of a small Leyden jar, and which pierce the paper by small holes."

In connection with this statement it will be found useful to consult the paper of Prof. Trowbridge just cited, and in which he says: "Since the discharge from an accumulator of a large number of cells is, in general, oscillatory, I am led to the belief that the discharge from any primary battery is also oscillatory, for in all cases we have to deal with capacity and self-induction."

We insist on these facts, as they form the basis of the explanation we are about to propose. For the same reason it is necessary to recall some of the mechanical effects produced in the air by electric sparks. The most familiar of these effects is the

sents the discharge at high exhaustions—to suppose that they always exist in the spark discharge, but that at high pressures they are so close together that the bright and dark parts cease to be separable by the eye." ("Recent Researches," J. J. Thomson, p. 199.) Our investigation will show that at least the *conditions* which give rise to the strata are always present in an electric discharge.

* This Journal, Sept. 1897.

† Phil. Trans., 1878, 1880, 1883.

‡ Phil. Trans., vol. clxix, p. 55.

production of longitudinal wave disturbances, of the same nature exactly as those studied in acoustics. These disturbances have been investigated by several physicists, but with perhaps the greatest success by E. Mach.* We give briefly the results of some of his experiments.

When two sparks were made to take place simultaneously, he proved the laws of interference were fulfilled exactly as in the case of air waves studied in acoustics. The velocity of the wave is at first greater than that of a sound wave, but at some distance from the point of discharge becomes equal to it.† In order to study these interferences he employed a plate of smoked glass, and the sparks took place over its surface. The curve of interference was registered by lines on the glass where the black covering was removed by the waves at their points of interference. For example, one spark took place along a metalized string parallel to the surface of the glass and quite near to it, thus producing a line of sparks between the particles of metal on the string: a second spark passed from a terminal vertically over the plate, forming a spark at a single point. The waves due to the first spark evidently formed a cylindrical surface with the string as axis, while those due to the second formed a spherical surface around the point. The line of interference on the surface of the glass was, as theory demands, a parabola having the point for focus and the line as directrix. The surface of interference could be determined by moving the plate of glass into various positions in space. A wire containing two breaks was placed between two plates; the direct waves interfered with the reflected ones.

In all these cases the lines and surfaces of interference obeyed the laws of longitudinal waves in an elastic medium.

The velocity of the wave was found to increase with the intensity of the discharge. We call special attention to the following remark. He determined by an ingenious method the fraction expressing the density of compression to be $\sigma=0.15$. "The experiments of Toepler and Boltzmann give $\sigma=0,0035$ for the condensation of a column of air in vibration near a node (in an organ pipe); we see therefore that the condensation in the air waves produced by even feeble sparks is much greater than that observed in sounding pipes."

It follows from these results that if the oscillations of a spark could be rendered sufficiently slow, a musical note ought to be obtained. Dr. Lodge‡ has actually obtained this result, and reduced the frequency of oscillation to 500 per second.

* Vienna Academy, May-July, 1878; *Journal de Physique* [1], viii.

† It seems more probable that this falling off of the velocity is more apparent than real; we are inclined to think that the greater velocity near the spark is due to local effects such as the electrical state of the air in its vicinity, the movement of the air near the spark, etc.

‡ *Modern Views*, pp. 376-377.

Toepler* investigated these air disturbances by the ‘stroboscopic method’ of Plateau, and found that there are periodic expansions and contractions of the air along the line of discharge; these results are illustrated in his paper, which it will be useful to consult in connection with the experiments we are about to describe.

Antalik† and also Quet and Seguin‡ found that powder, such as finely divided carbon, placed on a plate between the terminals arranged itself in ridges at regular intervals along the line of discharge. Joly§ made some interesting experiments of a somewhat similar nature. These experimentalists, however, seem to have attributed the results to purely electrical causes.

The different effects produced by sparks have been imitated by means of hydraulic models, in which currents of water were made to take the place of the electric currents. We read for example:¶ “But the case in which the imitation of stratified light is striking is when one produces currents of liquids or air, interrupted at regular intervals by the vibrations of a tongue at the mouth of the tube by which the jet of water is projected on the layer of powder.”

We now pass to the consideration of the stratified discharge in vacuum, in connection with which are three facts on which our theory rests, which will be seen at once to be but logical deductions from the experiments in air just cited.

These facts may be stated as follows:

1st. The discharge which gives rise to stratification is never a continuous one, but is intermittent—and as we have seen is probably oscillatory.

2d. The gas at a stratum is not in the same physical condition as at an obscure place, but is of a quasi-resisting nature.

3d. It follows from the first that the strata are not places of continuous brightness, but are alternately bright and obscure.

That the first exists is proved by the following facts.

Spottiswoode¶¶ examined the striæ in a rapidly rotating mirror, and noticed that the image of a stratum presented, not a continuous streak of light, but a series of short bright lines separated by dark intervals. His remarks refer to the effect of a *single spark* of his great coil. He states that sometimes the striæ have a general progressive movement, usually from the positive pole. He showed that this apparent movement is

* Pogg. Ann., cxxxiv, p. 194, 1868; see “Recent Researches,” J. J. Thomson.

† Id. cliv, p. 14, 1875.

‡ Comptes Rendus, xlviii, p. 340, 1859.

§ Proc. Roy. Soc., xlvii, p. 78, 1890.

¶ C. Decharme. Ann. Chim. Phys. (5) lxxix, p. 416, etc., 1883.

¶¶ Proc. Roy. Soc., xxv, p. 73.

caused by the striæ reappearing successively at places, each a little in advance of the former position: if the striæ always reappear at the same position there is no general movement. Strata which are thus unsteady may be rendered steady by adding resistance to the circuit, which alters the period of oscillation. (See J. J. Thomson, "Discharge of a condenser.")

De la Rue and Müller,* with their battery above referred to, made many experiments on the stratified discharge. With regard to the results of their investigations they say: "... These results therefore confirm the conclusion already arrived at from other experiments, namely, that the discharge in vacuum tubes is intermittent: but we do not pretend that they make it manifest that stratification is *dependent* on intermittance."†

A passage from De la Rive's‡ paper is as follows: "In reality whether we use a coil, a battery of cells, a machine, etc., to produce stratification, we have never a continuous discharge, but a series of discharges which succeed each other so rapidly that the discontinuity cannot be detected even by a galvanometer. But this discontinuity none the less exists, as Mr. Gassiot has shown by using a battery of Grove cells at high tension, which, with the same electrodes can give rise at first to stratifications, and later on to an arc when the discharge has become continuous." Wiedemann and Rühlmann§ arrived at the same conclusion.

Many other passages|| might be cited, but we think enough has been said to show that no doubt seems to exist as to the discontinuous nature of the stratified discharge.

The second fact, concerning the physical condition of the gas at a stratum, is proved by the following passages.

De la Rue wrote some time after the memoirs referred to were published:¶ "During our experiments we were struck by the evident plasticity of the strata, whose form at times becomes modified when they meet with an obstacle or are influenced by other causes, as for example the crossing of other strata produced by a separate discharge. . . . A tube with a hydrogen residue gives evidence of this viscosity of a stratum: at right angles is a tube of small diameter; in this tube is a

* Phil. Trans., pt. 1, vol. clxiv, pp. 55-121.

† Cf. also Ann. Chim. Phys. [5], xxiv, p. 461, 1831, where de la Rue refers to the exceedingly great number of "intermissions" per second—"of millions in a second."

‡ Ann. Chim. Phys. [4], viii, 1864.

§ Pogg. Ann., cxlv, p. 235 and p. 364.

|| Cf. Phil. Trans., clxix, p. 88, in which de la Rue and Müller state that a Varley condenser of 48.8 microfarad capacity was employed with excellent results in the production of the stratified discharge. The discharge of such a condenser is evidently oscillatory.

¶ Nature, xxix, p. 350, 1884.

stopper having a loop underneath from which is suspended by two silk fibres a needle of decarbonized iron. . . . The needle was now placed at right angles to the tube and the point made positive. After a few trials at different exhausts a beautiful tongue-shaped stratification was obtained and it was then possible by altering the amount of current to make the apex of a stratum impinge on one or other end of the needle: on whichever end the stratum touched that end was pushed away by it, showing clearly that the balance of forces which held together the molecules composing a stratum are sufficient to render it viscous, and unyielding to a small resistance."

De la Rue and Müller* also came to the same conclusion from other experiments that there were vortices in the gas at a stratum.

In a more recent paper† on this subject we read: "Another effect, to which I have before alluded, is the apparent resistance which the sharply-defined edges of the strata offer to the penetration of the wire. The edge acts as if it had an elastic skin, or a sort of surface tension, bending in as the wire pushes against it, and finally snapping back to its original position, leaving the wire well within the luminous disk. Too little is known about the strata to make any discussion of these facts worth while, and I merely record them without comment."‡

Having thus enumerated the chief facts on which our theory rests, it will be seen at once that it is their natural consequence. It may be stated in general terms as follows:

* Nature, Aug., 1883, p. 383.

† R. W. Wood, Physical Review, Nov.-Dec., p. 204, 1896.

‡ It may be well to recall some of the conclusions arrived at by de la Rue and Müller (Phil. Trans., vol. clxix, p. 230)

"1°. The discharge in a vacuum tube does not differ essentially from that in air and other gases at ordinary atmospheric pressures: it cannot be considered as a current in the ordinary acceptation of the term, but must be of the nature of a disruptive discharge, the molecules of gas acting as carriers of electrification."

"2°. As the exhaustion proceeds, the potential necessary to cause a current to pass diminishes up to a certain point, whence it again increases, and the strata thicken and diminish in number till a point is reached at which, notwithstanding the high e. m. f. available, no discharge through the residual gas could be obtained."

"3°. All strata have their origin at the positive pole." . . .

"6°. If the discharge is irregular and the strata indistinct, any alteration in the amount of current makes the strata distinct and steady."

"7°. The greatest heat is in the vicinity of the strata." . . .

"11°. At the same pressure and with the same current the diameter of the tube affects the character and closeness of the strata."

In a later memoir (Phil. Trans., pt. 1, vol. clxxi, p. 108), they continue:

"1°. For all gases there is a pressure which offers the least resistance to the passage of an electric discharge. After the minimum has been reached the resistance to a discharge rapidly increases as the pressure of the medium decreases." . . .

"3°. When the discharge takes place there is a sudden dilatation of the medium in addition to and distinct from that caused by heat. This dilatation ceases instantly when the discharge ceases." . . .

"6°. The electric arc and the stratified discharge are modifications of the same phenomenon."

The electric discharge which gives rise to the stratified column being discontinuous produces periodic disturbances in the gas; these disturbances are propagated as are sound waves, studied in acoustics—exactly as in the case of Lodge's "musical sparks," if we may use the term. The stratifications are the nodes caused by these waves. In other words, the phenomenon of stratification is a form of Kundt's experiment in which the heaps of powder which accumulate at the nodes are replaced by the strata of molecules between which the discharge is taking place in a luminous form.

This idea was suggested by the similarity of the aspect of a stratified discharge and the arrangement of the powder in Kundt's experiment, together with the fact of the oscillatory nature of the electric spark. In subsequently examining the literature of this question we found that an idea somewhat similar to this had been indicated by more than one physicist,* particularly by De la Rive.

The following are some of the most striking points of resemblance between the stratified discharge and Kundt's experiments:

The appearance of the "concamerations" in Kundt's tube resembles in a striking way a stratified discharge. "In a second series of experiments M. Kundt has perfected his method by replacing the lycopodium powder by silica in very fine powder, obtained by the calcination of gelatinous silica; it forms at the nodes, no larger heaps, but "membranes" stretching across the whole section of the tube."† It is interesting to note that the nodes formed in the case of singing flames when the tube containing the flame is sounding by resonance in unison with an exterior note, have been shown by Schaffgotsh to be visible when a current of smoke ascends the tube. We may mention that de la Rue had noticed this resemblance and reproduced the figure from Tyndall's *Sound*, but he makes no mention of a similarity of cause.

Sometimes the powder in Kundt's tube takes a spiral form; the same has been at times noticed in a stratified discharge.

The diameter of the tube influences the distances between the nodes in Kundt's tube because it influences the velocity of transmission of the wave motion; the distance between the strata in Geissler's tube is similarly affected.

The general flow studied by Spottiswoode, above referred to, seems to be excellently explained by this theory—an explanation which, however, we propose with every reserve. As has

* Cf. De la Rive, *Ann. Chim. Phys.* [4], viii, p. 437, 1866. Gassoit, *Phil. Trans.*, 1858-59, etc. Stafen, *Journal de Physique*, ii, p. 190, 1873. Neyreneuf, *Comptes Rendus*, lxxviii, p. 950, 1874; lxxx, p. 1881, 1875; lxxxii, 1876.

† Cf. Tyndall's "*Sound*."

been already indicated, this movement is due to the fact that after each extinction, the stratum is renewed at a slight distance from its former position; if the stratum always reappears at the same place, there is no general movement. In Kundt's experiment, if the length of the tube is an exact multiple of the half-wave length of the note, stationary nodes are formed. But if the length is not an exact multiple of the half-wave length the nodes are not stationary, and at each vibration the node is formed a little in advance of its former position; in this case the heaps corresponding to the true nodes, when the length of the tube is a multiple of the half-wave length, are not formed with exactness, but between them are secondary smaller heaps due to this progressive form of the wave. In order to obtain the nodes well defined and without secondary heaps two means may be employed. We may either alter the length of the tube, which is the means employed by Kundt, or we might alter the note so that its half-wave length became an exact fraction of the length of the tube. If, however, we go beyond the necessary alteration a new phase of indistinctness occurs, which could be again remedied by a still further change in the length of the tube or the period of the note. Compare the following facts, bearing in mind that the oscillations are altered by the resistance of the circuit. "When the strata are in motion they preserve their respective distance apart, and their number presents neither diminution or augmentation."* "This flux can be regulated by introducing resistance into the circuit."* "Oftener we can obtain a phase of stability by introducing with care exterior resistances; if we continue to add resistance, the introduction will produce a new phase of instability, and on adding still greater resistance a phase of steadiness."† Here we see a remarkable confirmation of this theory. We must remember that in the case of strata the "note" is very high‡ and consequently a slight change in the note which would produce steadiness would not produce a change in the wave-length sufficiently great to be observed, hence the distance between the nodes will apparently remain the same in both cases. This might also be due to the "damping" effect of a wet thread, etc., especially in the case of an induction coil, for in this case the intensity, etc., of the spark is not constant during its discharge. The damping would get rid of some of the final oscillations which would render the period unsteady.

* Spottiswoode, loc cit.

† de la Rue and Müller, *Phil. Trans.*, Pt. I, vol. lxix, fin.

‡ Although the period of a note must be within certain limits in order that it may be heard as a musical note, yet vibrations having a frequency far beyond this limit can be propagated in air. "Vibrations transmitted as waves through steel or air or water cannot be more frequent than a certain number, which I cannot now put a figure to, but which I say, may be reckoned in hundreds of thousands or a few million per second." (Lord Kelvin, *Nature*, March 6th, 1884.)

Another proof is afforded by a fact which seems to have met with no explanation. Sometimes it was noticed that the interior of the tube was covered by rings of a dark deposit; these rings have been proved by several to be proper to the dark spaces. For instance, Gassiot* states: "In one of Cetti's tubes originally charged with arseniuretted hydrogen there was such a deposit." . . . "This result (i. e. of experiments which we need not dwell on), appeared to me to explain that the deposit in Geissler tubes did not arise from particles of the negative electrode, but from the gas with which it was originally charged; their being deposited exactly in the dark portions between the luminous disks may lead to a correct explanation of a phenomenon which has hitherto baffled the ingenuity of experimentalists."

Now our theory seems to supply an explanation of this fact. Let us remark that these rings have not been noticed in the case of pure gases such as hydrogen, oxygen, carbonic acid gas, etc. In the case referred to by de la Rue and Müller the nature of the gas is not stated. Probably the latter refer to the same tube as does Gassiot, for they say it was noticed in a tube which had belonged to Gassiot. To proceed, the gas is thrown into a series of stationary waves, giving rise to nodes and loops. At a node the gas is alternately in a state of compression and rarefaction. When the gas is in a state of compression the discharge takes place between the molecules. This produces a luminous ring which is a stratum. Now, although the mean temperature of a stratum as measured by any form of thermometer is but slightly higher† than that at a dark space, there is no doubt but that the heat generated between the molecules is very great. This heat decomposes the AsH_3 . Now when the compression changes into a rarefaction part of the gas thus decomposed makes a slight excursion towards the loop or dark space. The As which has been liberated at the strata is condensed on the sides of the tube in this cooler atmosphere and thus forms the rings. In the elaborate experiments of Gassiot, de la Rue, etc., the discharges were very regular, and hence the strata, as appears from several passages in their memoirs, occurred at the same place. So that there is no difficulty in conceiving how the dark rings always coincided with the obscure places. It would be, in fact, a form of Marsh's arsenic test. We do not know if the deposit in such a tube has been subjected to the arsenic test. This would be an interesting research. In Marsh's test, it will be remembered, the arsenic mirror is formed on that part of the tube just beyond the portion which has been heated.

From this last paragraph appears at once how the very

* Report Brit. Assoc. (Sect.), p. 46, 1869.

† Cf. R. W. Wood, *Physical Review*, Nov.-Dec., 1896.

nature of the discharge tends to augment the forces which cause the nodes. It is only necessary to consider that the heat generated in the discharge between the molecules forming a compression tends at once to augment the effect of rarefaction usually produced by the elastic nature of the gas. Hence the nodes are sustained in an automatic manner arising from the very nature of the discharge.

Again it is much more difficult to decompose the discharge by the rotating mirror when the strata are close together (or as we should say, when the frequency of oscillation is greater); "as the battery surface is still further increased (i. e. current working coil) these diagonal lines (image of an unsteady discharge) appear more and more crowded together, until at last they blend into unbroken flocculent striæ."* Or the mirror was not revolving sufficiently fast to decompose them.

Helmholtz showed that the surface of a wave in a tube is not plane; we have seen that in the case of the strata it is concave to the positive terminal. The dark spaces are only relatively dark.†

It has been often stated that the strata are but accidental in the discharge; and in reality they only occur for a very limited range of pressures. Geissler tubes may be lit up by rubbing them with a cloth, but in this case strata do not seem to be produced. Such tubes may also be used as detectors for Hertz waves, showing that an oscillatory discharge will light them up.

With regard to the fact stated by Trowbridge (*loc. cit.*), that the flaming discharge prevented him from observing this discontinuity of the current in a Geissler tube, (he makes no mention of the discharge being stratified,) we may refer to a paper by Sir D. Salomons‡ in which he states that a weak discharge is the most favorable for studying the strata: in this case there would be no flaming discharge.

We have tried the effect produced by using a machine in connection with a varying number of Leyden jars. While the distance between the strata does not present any regular change, which may be accounted for by the different intensities, etc., of the spark, one characteristic effect was produced. With one large jar the strata were about 0.5^{cm} apart: with four jars we were able to produce strata nearly twice as far apart by carefully regulating the charge, etc. This result is of importance as showing the effect of capacity. However, we do not insist on this fact, as it was not always produced on repeating the experiment.

* Spottiswoode, *loc. cit.*

† de la Rue and Müller, *Nature*, 1883, p. 383.

‡ *Proc. Roy. Soc.*, 1894, p. 229.

In studying the strata we must bear in mind that the tube is itself a condenser, and must therefore influence the discharge. These seem therefore good grounds for the theory we have proposed. In the experiments we are about to describe we think there will appear a striking confirmation, and proof of the truth of this explanation.

Experiments with vacuum tubes present peculiar difficulty owing to the nature of the phenomenon. Besides, there is the further disadvantage of the necessity of an expensive apparatus. For these reasons we sought for a long time some means that would be at the same time simple and adequate. The obvious way to test the truth of this theory seemed to be to endeavor to repeat Kundt's experiment with a Geissler tube. But against this was the fact that waves in so rarefied a medium would seem to be incapable of producing so marked a mechanical result. Here, again, however, is the fact that the condensations produced by the electric spark are very much more intense than those produced by ordinary sounding instruments. However we eventually adopted this method, and as will appear immediately, with excellent results. Since we argued that the effect in a rarefied gas was the same as that in air under normal conditions, it seemed logical to test the theory from the very foundation. Hence we shall at first deal with some interesting results obtained in air, and proceed gradually to the stratified discharge.

We have already seen that Mach proved electric sparks to produce disturbances in the surrounding atmosphere exactly similar to those produced by sounding bodies, and that Lodge produced musical notes by the waves produced by the oscillations of such sparks. "One sees clearly why one gets a musical note: the noise of the spark is due to the sudden heating of the air." (We might also add the sudden expansion caused by a spark which is due to electrical causes.) "And now if the heat is oscillatory the sound will be oscillatory too, but both will be an octave above the electrical oscillation, if I may so express it, because two heat pulses will accompany every complete electric vibration, the heat production being independent of the direction of the current."

Evidently if we were to replace the vibrating glass rod in Kundt's experiment by an electric spark, we ought to get nodes and consequently heaps of powder in the same manner. Since the frequency of oscillation of a spark is so exceedingly high, these heaps would be very near together.

This then was the first experiment.

A horizontal glass tube almost one meter long was sprinkled throughout its length with lycopodium powder. The two terminals of a small Voss machine were placed about 1.0^{cm} apart

near one end. After a few sparks had taken place the interior was strikingly divided throughout its whole length into little heaps quite close together. When the tube is looked at from one side, at the moment when the spark passes it is noticed that the powder rises a considerable distance at the heaps and then falls back. When the tube containing the powder is narrow, the lines of powder almost reach to the top. The result surprisingly corresponded with what we had looked for. In order to obtain a permanent record the following simple means was employed: A strip of photographic paper was placed in the tube with a small amount of powder on it. When the sparks had taken place the powder was thrown into position. The whole was then exposed to the daylight: the part occupied by the powder then appeared as white in a black background. Fig. 1, Plate IV, shows a typical example. (This way of obtaining records is very useful, and has succeeded well in the case of other phenomena, such as the magnetic lines of force, as exhibited by iron filings.)

The following are some facts about this experiment.

The greater the intensity of the spark, and the greater the capacity of the condenser, the farther apart are the lines. Thus we obtained a series of results with condensers of varying capacities. This law is well illustrated by the series of photographs.

It did not appear to matter whether the end farther from the spark was open or closed—the spark end was open in every case.

The waves could be reflected from the farther end of the tube into a second tube in which the same result was obtained.

That this result is due to air waves is clear from the researches of Mach. We confirmed it in a simple way. Some lycopodium powder on photo paper was placed in an ordinary straight lamp chimney, one end of which was 2·8^{cm} in diameter, the other 3·6^{cm}. A piece of paper was stretched tightly over one end and tapped sharply; the vibrations thus produced caused the powder to divide up into heaps a few millimeters apart. As we should expect, these heaps were farther apart when the paper was over the larger end of the tube. In order to assure ourselves that the formation of these heaps was not due to the current of air caused by the spark as distinct from the vibrations, we replaced the paper in the last experiment by a bit of cloth; on tapping the cloth no movement whatever was produced in the powder, as would have been the case had the puff of air caused by tapping the cloth been the cause of the division of the powder into lines.

We have dwelt on this experiment, as we think it has not been made before. We describe also some interesting variations which were probably suggested by the plates in Mr. J.

H. Vincent's* paper on the "Photography of Ripples," and which are striking illustrations of the laws of acoustics.

The first consisted in obtaining the circular rings which correspond to the rings on a lake when a stone is thrown in. In this case the formation of the heaps of powder presents a difficulty, as there does not seem to be any reflection of the wave. For many reasons, however, they would seem to be due to the oscillations of the spark as distinct from the sudden movement of the air caused by the explosion. We have repeated the experiments here described, substituting explosions, caused by a mixture of hydrogen and oxygen, for the spark,—in many cases more intense than those due to spark,—but in no case was the powder divided as when sparks were employed. This seems to prove, that the effect is not due to the mere current of air caused by the explosion. Another time we hope to examine this question with greater detail. A hole was cut in a piece of sensitive paper; lycopodium powder was scattered as evenly as possible all round. The two terminals were arranged so as to allow a spark about 1^{cm} long to pass vertically through the hole in the paper. The waves caused by the oscillations will of course be circles concentric with the spark. Fig. 4, Plate IV, shows the result. It will be noticed that the rings are nearer together some distance from the spark than near to it. There is an area round the spark from which the powder has entirely disappeared. This is due not only to the violence of the spark explosion, but also to the fact that a considerable portion of the powder is attracted by, and adheres to, the discharging terminal. Could not this throw some light on the 'negative dark space' in vacuum discharges? The only difficulty in obtaining this and the following results is in distributing the powder evenly over the surface at the beginning. Another point of importance is that the terminals should stand quite vertically, and not pass near the surface of the paper, as the powder in this case is attracted by them.

The effect due to reflection is well shown in Fig. 5, Plate V. In this case the "mirror" was a piece of thin metal about 1.5^{cm} high placed on the surface of the paper. The spark passed at some distance, as is evident from the photograph. The caustic appears very clearly defined, and the focus is quite distinct.

The interference of the air waves due to two simultaneous sparks was also investigated in the same way. In this case the lines of interference were well marked and formed a hyperbola with the two sparks as foci.

In all these photographs it is noticeable that the lines are farther apart near the spark than at some distance. This

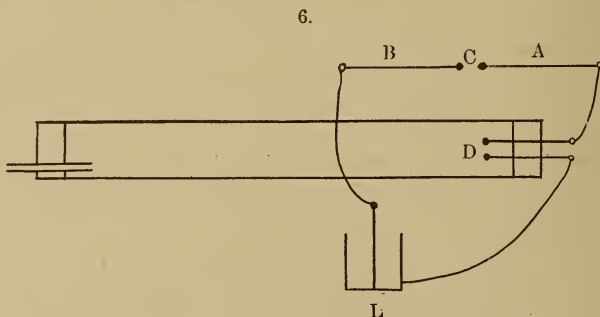
* Phil. Mag., June, 1897.

agrees with the statement by Mach that the velocity of the wave is greater near the spark than at some distance from it (see above).*

Many other interesting developments might be made, but enough has been said to show the reality of the air waves, and to give some idea of their dimensions. Whether this result could be used to determine exactly the period of oscillation of a spark is a point outside the scope of the present article. In Kundt's experiment the period of the note is calculated from the formula $v = n\lambda$ where v = the velocity of sound, and λ the wave length, i.e., twice the distance between two consecutive heaps of powder. In experiments with sparks the waves are not propagated with the velocity of ordinary sound waves; again, the intensity of the spark has so considerable an effect on the distance between the heaps that measurements derived from these distances would not be of much value. An induction coil produces similar results, but not nearly so well marked as does the Voss machine.

Having thus established that electric sparks can produce, in air under ordinary conditions of pressure, the effects among which we place the stratification in Geissler tubes, let us examine the result produced when the spark takes place in a vacuum.

As gases at low pressures—within certain limits—are good conductors of electricity, it is not quite so easy to produce intense sparks in a vacuum as in the air. This difficulty is got over by arranging the apparatus as in Fig. 6. When A and B,



the terminals of the machine, are at a suitable distance apart, sparks take place simultaneously at C and D. Of course we could simply charge a Leyden jar and then discharge it, but this operation is troublesome. The pressure of the gas was about 10^{mm} . A few sparks were passed: the powder arranged itself exactly as in our former experiments. Fig. 2, Plate IV,

* Cf. Lord Rayleigh, "Sound." The air waves (sound) produced by very violent causes, such as explosions, travel much faster than "ordinary" sound waves.

shows the result of this experiment. It will be noticed that these heaps are farther apart than when the gas was at atmospheric pressure, but the distance between them is more or less constant. This result is satisfactory in showing that the air waves even in so rare a medium possess considerable force.

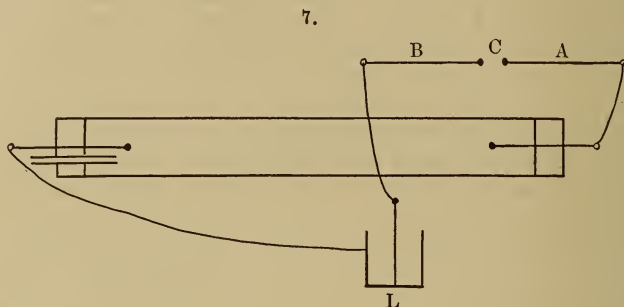
The apparatus was now arranged exactly as in the case of a Geissler tube, Fig. 7. After a few sparks the powder was as before thrown into heaps. Fig. 3, Plate IV, exhibits a result for a pressure of 5 or 6^{mm}. These heaps are far apart, which shows the violence of the spark and the great velocity of the waves. This pressure was not sufficiently low to show strata; but it was found that a Geissler tube, when substituted for the tubes used in the last two cases, showed good stratification when the spark passed through it simultaneously with the spark at C.

When an induction coil was used the discharge was not sufficiently strong to produce so marked an effect, but at each spark a slight movement in the powder was observed; and when fine powder was used rings were sometimes formed on the sides of the tube.

These experiments prove that when the pressure is not too low and when the spark is of sufficient strength (when the spark is very intense the powder is projected in a heap midway between the two poles), that there exist air waves capable of producing the Kundt's tube effect. From this we may conclude at once that in the case of a Geissler tube these waves likewise exist. It would appear to be conclusively proved that the strata and the formation of the heaps of powder are due to the same cause were we to obtain the Kundt tube effect simultaneously with the stratified discharge, but this was impossible for the following reasons. As we have seen by experiments already cited, and from our own observation, if the discharge is strong its great brightness makes it impossible to observe any stratification; while a strong discharge is essential to produce the heaps of powder. Thus though it is clear that the nature of the spark is the same in a feeble discharge as in an intense one, yet the accidental conditions are such that the discharge favorable for producing the strata is unfavorable for producing the Kundt effect, and vice versa. But if with a strong discharge in a tube containing a gas at a pressure favorable to stratification (with a feeble spark) we obtain the heaps of powder as before described, it seems sufficiently evident that the causes at work in the case of a feeble discharge are the same, and that though insufficiently strong to displace the powder they are quite marked enough to form the waves of gaseous matter, which are the strata.

In order to avoid the trouble of constantly exhausting a tube we had a Geissler tube made containing the purest and finest

lycopodium powder. This tube was 30^{cm} long. One terminal being at the extremity, the other was situated 10^{cm} from the other end. The tube was thus constructed in order to ascertain if the mechanical effects to which we attributed the stratification took place not only between the terminals but also, as our theory demands, in the space which is not between them. This tube was connected as shown in fig. 7, L being a large



Leyden jar, A and B the discharging terminals of the Voss machine. By placing A and B at a suitable distance apart sparks took place simultaneously at C and through the tube. When A and B were 1^{mm} or so apart frequent sparks took place, the space in the tube being stratified; but these sparks being very feeble, the powder, which had been arranged in a continuous line throughout the whole length of the tube, was not seen to be affected. We see at once from this experiment that the spark in the Geissler tube is oscillatory, for evidently, since the tube and the spark gap are in the same circuit, the nature of the spark is the same at both points: but it has the characteristics of an oscillatory discharge in the gap, therefore it is oscillatory in the tube also. We confirmed this by placing a card covered with lycopodium powder at a spark gap in the circuit, including a Geissler tube showing stratification. The powder was affected as in the experiments already described. Now A and B were 1.5^{cm} apart: at intervals of 10 or 20 seconds intense sparks took place between A and B, the discharge in the tube being exceedingly brilliant. After perhaps a dozen such sparks the powder was definitely arranged. As the sensitive paper was necessarily *outside* the tube the photographic record was very indistinct, but the heaps in the tube were seen to be exceedingly well defined. As some of the powder adhered to the tube the heaps were not well defined in the photograph, which is not reproduced here.

Here it was noticed that the heaps of powder took place, not only between the terminals, but also outside the line of dis-

charge, as we had anticipated. Near the negative terminal the lines became indistinct and often were not observed at all. It is not necessary to dwell on the results, as they are sufficiently explained by what has already been said regarding the nature of the spark.

Having proved that there are gas waves in the Geissler tube, we can deduce the existence of the stratified discharge. Since the gas is strongly electrified the discharge takes place between the molecules (or as some hold, between the atoms); these intermolecular discharges produce the illumination in the body of the gas. Add now the effect of waves in the gas. The gas at a condensation will be in a different condition from that at a rarefaction. When the molecules are crowded together at a condensation the number of intermolecular discharges will be very much greater than at a rarefaction. There will hence be a greater illumination at a node—this is a stratum; but as the state of condensation at a node is intermittent the illumination will be so too. Therefore, remembering that the strata are only relatively bright, and that they are not places of constant brightness, we at once deduce their existence from the presence of the waves caused by the electric discharge. And as this visible effect would only be evident under special circumstances we see how they are only observed within certain limits of pressure, the cause being always present. Thus the identity of the stratified discharge with the ordinary spark discharge seems to be established.

As has been proved by our experiments, the waves in the gas ought to exist all along the tube, even near the negative terminal; their absence as strata being due to mere local influence of the negative pole. In connection with this an experiment of De la Rive's is of interest. Referring to the effect of introducing a small amount of gas into the tube during the stratified discharge, he says:* "We begin by reducing the pressure to 2^{mm} so that the phenomenon of stratification may be as pronounced as possible. We then cause a small amount of hydrogen to enter the tube; if the gas enters at the end near the negative electrode, we see at once strata formed in the obscure space which are of a beautiful rose colour. . . . They are propagated gradually in the tube and unite with the original strata; . . . on arresting the introduction of the gas we see the luminous column slowly leave the negative electrode and take by degrees its primitive appearance." This tends to show that the dark space is due to the comparative absence of gas near the negative electrode, just as in our first experiments in air the powder is driven away near the spark. Both facts are thus probably due to the same cause.

* Loc. cit. p. 451.

It may be of interest to note an effect produced on the powder during the "sensitive discharge." As has been shown by Spottiswoode and Moulton,* in order to produce the sensitive state it is only necessary to put a small spark gap in the circuit. The tube already described was connected with an induction coil, a small spark gap being introduced at the extremity. The powder was distributed evenly all along the tube. When the spark gap was at the positive pole the discharge was sensitive; on touching the tube with the finger the powder inside the tube was observed to (if we may use the expression) boil up, little craters being produced in it at the point touched, as if there were a discharge taking place from the sides of the tube through the layer of powder. No distribution into lines was observed. Near the extremity with the gap the powder was not affected. When the spark gap was at the negative terminal the effect was hardly observable at all; but if the poles were suddenly reversed, on touching the tube the powder was affected. This effect was also noticed on touching the tube after the discharge had ceased. For some days after, the powder in the tube adhered to the side so that it could not be removed by tapping the tube; after some time, however, it became somewhat detached. This effect on the powder was *only* produced when there was a spark gap, and *never* in other cases. These results confirm the explanation which has been given, and we simply mention them in passing.

Such is the theory we propose in order to explain the stratified discharge in Geissler tubes. We have endeavored to express it as simply as possible without at the same time insisting too much on details. Our experiments seem to confirm the hypothesis on which we started, and we see that our results lead back naturally to this starting point. Again, we think any one repeating these experiments will agree that they show the oscillatory nature of the discharge in a vacuum tube.

These experiments might be confirmed by several others which would present but little difficulty to one having at his disposition sufficient apparatus. For instance, Spottiswoode's experiment might be repeated with greater care. Since any system of longitudinal waves can only be propagated by means of rarefactions and condensations, it would follow that two consecutive strata would be in opposite phases. Now we have seen that when the strata are examined in a rapidly rotating mirror, the image of each stratum presents a series of short detached lines. If two strata are in opposite phases it follows that the bright lines composing the image of one stratum should correspond to the spaces separating the bright lines of the next stratum, which spaces should correspond to the bright lines of

* Phil. Trans., 1879-80.

the third stratum, and so on. In the case of an induction coil, the whole series is that due to a *single spark*. The figure in Spottiswoode's paper does not indicate this difference of phase, but it is improbable that he looked for such a result, and, as it might not prove to be sufficiently marked to attract attention when it was not looked for, this is not surprising. Indeed, many reasons might be given to show that there would be a certain overlapping of the different images corresponding to a node.

Again, several interesting results might be obtained by comparing the number of intermissions or oscillations as determined by the mirror, with the distance between the strata, since from this theory it would follow that, *ceteris paribus*, the distance between the strata ought to increase as the frequency of oscillation decreased. However, such experiments might not be conclusive, as this distance would depend, in perhaps a greater degree, on the intensity of the discharge. We were unfortunately unable to compare the period of oscillation as calculated from the formula $v = n\lambda$, with that directly observed by means of a rapidly rotating mirror.

There are, of course, many points to be examined, but as the stratified discharge has received but little attention from the point of view proposed in the foregoing pages, it would perhaps be premature to enter into minute details. On a future occasion we hope to describe some confirmatory experiments which it is our intention to undertake.

Louvain.

ART. L.—*Orthoclase as gangue mineral in a fissure vein;*
by WALDEMAR LINDGREN.

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THE occurrence of feldspars as gangue minerals in fissure veins is not common. But on the other hand many well-authenticated instances make it certain that they may be formed during the conditions attendant upon the deposition of ordinary fissure veins, i. e. by aqueous deposition. *Lime feldspars* or *soda lime feldspars* appear to occur very rarely, the only known instance being that described by the author from Grass Valley, Cal.* Even this case could not be as completely demonstrated as would have been desirable. *Albite* is more common. While it is only rarely mentioned from European mineral deposits, it has been described as occurring in places very abundantly in Australian gold quartz mines† as well as in similar veins in the province of Minas Geraes, Brazil. In the United States, albite has been noted from several places. Genth describes it from the Steele mine, North Carolina, in the Appalachian gold belt. In California it was first noted by Genth in 1859 from Winters gold vein, Calaveras County.‡

Albite was also described by Wendell Jackson from Stanislaus mine, Calaveras County, and lately again by H. W. Turner from the Shaw mine, El Dorado County. The mineral will probably be found in many other places in the vicinity of the mother lode. It was recently noted by the author in specimens from the Gentle Annie mine, near Placerville. In spite of very careful search no albite has yet been recognized from Nevada City or Grass Valley.

Orthoclase has been described from several European ore deposits, generally having the crystallographic forms and characteristics of adularia. Thus, we find it recorded§ from Schmiedeberg and Kupferberg in Silesia, Himmelfahrt mine near Freiberg in Saxony, Schlaggenwald in Bohemia, Felsöbanya and Schemnitz in Hungary. Also from Transylvania at Botesbanya, Cseb, and Veröspatak. Most of the occurrences in the latter two countries are from gold quartz veins. Everywhere, however, the orthoclase is more of a mineralogical rarity than an abundant gangue mineral.

Breithaupt described, without detailed notes as to its occurrence, an orthoclase of adularia habit from the Valenciana

* 17th Ann. Rept., U. S. G. S., p. 87. This feldspar occurs on small stringers differing in character from the typical gold quartz veins from that locality.

† G. Ulrich, Min. Vict., 1866.

‡ G. F. Becker, 16th Ann. Rept. U. S. G. S., Part 3, p. 278.

§ Hintze, Handbuch der Mineralogie, p. 1361.

silver mine, Mexico, and gave it on account of supposed abnormal angles the name of *valencianite*. This valencianite probably occurred as gangue mineral in a vein.

From the United States orthoclase has been noted by Genth as occurring in minute crystals at the Silver Hill and Steele mines, N. C. G. F. Becker has recently recognized the presence of small grains of orthoclase in a vein quartz from Alaska. It may be added that during the examination of certain auriferous veins at Silver Crown, Wyoming, by the author, grains of microcline were sometimes found in thin sections of vein quartz.

Orthoclase is frequently mentioned from tin veins, in Saxony, Bohemia and Cornwall, and while many of these occurrences are beyond doubt, yet it may be pointed out that owing to the peculiar structure of these veins, some feldspar from the surrounding granite might in the older reports have been mistaken for true gangue mineral. While orthoclase of course is common on pegmatite veins, it has not as yet been proved that these ever are auriferous.

During the examination of Silver City mining district, in southern Idaho, undertaken last summer for the U. S. Geological Survey, a vein was encountered which from various standpoints proved to be most interesting.

The Black Jack-Trade Dollar vein outcrops on Florida mountain near Silver City and can be traced for about one mile. The strike of the vein is easterly and westerly; its dip is nearly vertical. It cuts three formations: a normal muscovite-granite forming the fundamental rock, a basalt resting on this granite and a rhyolite, capping both. As the latter two rocks are of Tertiary (Miocene) age the deposit is clearly of comparatively recent origin.

The ore minerals are pyrite, chalcopyrite and argentite; the value is chiefly in silver with a smaller amount of gold. The vein is a characteristic fissure vein, well defined and having a thickness of from a few inches to two or three feet. In the granite it is closely followed by a basaltic dike. The ordinary ore consists of typical vein *filling*, though low grade ores consisting of altered rhyolite appear along certain parts of the vein. The gangue is of an interesting and unusual character, consisting of quartz and orthoclase, in varying proportions. In general, quartz predominates, but at many places the two minerals occur in equal proportions or even with prevailing orthoclase.

The first and most common occurrence of the orthoclase is as large, irregular milkwhite grains, intergrown with vein quartz; it contains inclusions of pyrite and argentite and sometimes thin lamellæ of pyrite deposited parallel to the best cleavage plane. The grains appear under the microscope as

simple crystals. Crusts with projecting crystals of clear quartz and whitish feldspars with broken or curved faces often occur.

The second mode of occurrence is as small, more or less perfect, almost transparent crystals 1–3^{mm} in diameter, coating cracks and crevices in the altered granite adjoining the vein.

The third occurrence is as abundant small and perfect crystals coating a lamellar quartz, itself a pseudomorph after some other mineral, probably calcite.

The vein is apparently richest in orthoclase where traversing the granite. Much of it was also found where it cuts the rhyolite, but none was observed in the basalt. The vein where entering the basalt contracts and becomes very narrow.

All these occurrences demonstrate beyond doubt the aqueous origin of the mineral. The crystals have the habit of adularia, though the only strongly developed faces are 110 and $\bar{1}01$ (*m* and *x*, Dana), producing a distinctly wedge-shaped appearance. One of the larger crystals from the first described occurrence on the main vein was analyzed by Dr. W. F. Hillebrand with the following result:

SiO ₂	66.28
Al ₂ O ₃	17.93
K ₂ O	15.12
Na ₂ O .....	.25
Undetermined .....	.42

100.00

Specific gravity, 2.54.

The analysis indicates typical adularia. No orthoclase has thus far been found in the other veins near Silver City; many of them, though, possess interesting structural and mineralogical characteristics which will be described in the full report of the district.

Orthoclase has been artificially produced by the wet way by Friedel and Sarasin in 1881. In 1890, Ch. and G. Friedel obtained orthoclase in small crystals by heating pulverized muscovite with a solution of potassic silicate. It is easily seen that the interesting experiment has a direct bearing on this occurrence.

The reason why orthoclase is not more frequently found on mineral veins may possibly be found in the abundant and usual presence of carbon dioxide in thermal waters. Under such conditions the more stable compound—muscovite or sericite—would be formed, orthoclase being rapidly attacked by waters under pressure containing CO₂. Orthoclase could then only result if CO₂ were absent or present in only small quantities.

Stanford University, California, March, 1898.

ART. LI.—*Notes on Rocks and Minerals from California;*
by H. W. TURNER.

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1. *A Peculiar Quartz-amphibole-Diorite.*

IN the northwest portion of the Bidwell Bar Quadrangle on the dividing ridge between Butte and Plumas Counties, is a dike-like streak of a peculiar grayish green rock about 1.2 klm. in length. The exact locality is by the trail to North Valley about 7.3 kilometers south of Table Mountain. The surrounding rock of the district is a granodiorite (granite-diorite) having a composition intermediate between typical quartz-diorite and amphibole-granite. On account of the decomposed condition of the surface rock the exact contact between the supposed dike rock and the granodiorite was not seen, so that its dike nature was not determined with certainty. However, the chemical and mineral composition of the diorite is so different from that of the granitoid rocks surrounding it that its dike nature is regarded as probable.

Two specimens (Nos. 817 and 780 S. N.) of this rock were collected, about 400 meters apart. A microscopic investigation of thin sections of the two specimens shows them to be very similar. The rock is medium-grained and of granitic texture. It is composed principally of amphibole, plagioclase and quartz. The most abundant constituent, amphibole, is green in color and occurs chiefly in the form of short needles which show idiomorphic outlines in sections transverse to the prism. The amphibole is clearly original, and is imbedded in later feldspar and quartz, both of which are also clearly original. An analysis of No. 817 by Dr. Hillebrand (see below) shows an unusually high percentage of magnesia (11.86 per cent) for a diorite. Since the rock is composed chiefly of quartz, plagioclase and amphibole, it is evident that the magnesia is chiefly in the amphibole, and as much of the alumina (12.9 per cent) must be in the feldspar it was surmised* that the amphibole was rich in magnesia and low in alumina, possibly approximating actinolite in composition. The rather high content of lime (7.74 per cent) was also suggestive of a amphibole rich in lime, since the plagioclase appears to be andesine, a feldspar containing only a medium amount of lime. The amphibole was therefore separated from the rock by means of the Thoulet solution. An analysis made by Mr. William Valentine is given below. There is too much alumina (8.13 per cent) for actinolite. The amphibole may be considered as belonging to the aluminous series. The large extinction angle (23°) likewise places it in the aluminous series.

* Seventeenth Annual Report, U. S. Geological Survey, Part I, pp. 574-575.

Petrographic description of the diorite.—Megascopically the diorite is a grayish-green medium-grained rock showing very abundant short needle-like prisms of a green mineral. Microscopically the rock has a granolitic texture. It is composed of amphibole $>$ feldspar $\overline{>}$ quartz. The accessory minerals are rutile in irregular brownish red grains, apatite in minute prisms, occasional grains of magnetite and possibly a few zircons. Epidote, chlorite and sericite are present as secondary products.

The most abundant constituent, the amphibole, is grayish-green in color and occurs chiefly in the form of short needles which show idiomorphic outlines in sections transverse to the prism. The amphibole is clearly embedded in the feldspar and quartz and therefore earlier. The absorption is $c > b > a$. c is brownish-green, b green and a very light green. The maximum value of the extinction angle ϵ on c is 23° as determined by measurements on 55 needles. The feldspar in part shows twinning on the albite law with rather low symmetrical extinction angles on 010 in the few grains measured, suggesting oligoclase or andesine. The feldspar is partly quite fresh but some of it contains minute brightly polarizing fibers, probably sericite. The quartz is fresh and clear and like the feldspar, undoubtedly primary. The chlorite is supposed to be an alteration product of the amphibole. It is green in color and very noticeably pleochroic. The fibers are grouped in rosettes showing olive-gray interference colors. For the purpose of making a separation of the constituents of the rock 48 grams of the powdered rock were passed through a wire sieve with spaces 100th of an inch in diameter. The fine dust and the larger part of the light material (chiefly feldspar and quartz) was washed off with water in a batea. The remainder was put in a Thoulet solution of maximum specific gravity (about 3.18?) only a small amount of the material being precipitated. This was separated and found to weigh about 0.35 grams. A magnet was passed over this powder and a few grains of magnetite extracted. This heavy powder as seen under the microscope is made up chiefly of brownish-red grains presumably rutile, clear grains supposed to be zircon and grains of epidote. A portion of this heavy material was ground up in an agate mortar and treated with KHSO_4 before the blowpipe. The bead was dropped in hydrogen peroxide, giving the orange-yellow color characteristic of titanium. The brownish-red grains pretty certainly afforded the titanium, as epidote and zircon were the only other minerals in the powder. Some of the grains are striated. The brownish-red grains are therefore probably rutile. A small quantity of this heavy powder was placed in HF and H_2SO_4 mixed in a platinum dish and digested in a water-bath over night. All of the material was attacked by

the acid except the rutile and zircon-like grains. The rutile is the most abundant of the accessory constituents of the rock. The next heaviest material was of a dark green color and composed chiefly of amphibole. This was removed from the separator, washed and dried and then put into another separator and further purified. An examination of the powder under the microscope showed only an occasional grain of foreign material, so that the chemical analysis of this amphibole may be taken as being very near its actual composition.

Analysis of peculiar quartz-amphibole-diorite.

	817 S. N. Quartz diorite.	817 S. N. amphibole.
SiO ₂	54·64	50·08
TiO ₂	·61	·76
Al ₂ O ₃	12·09	8·13
Fe ₂ O ₃	1·81	2·69
FeO	5·03	6·71
MnO	0·13	0·49
NiO	0·05	
CaO	7·74	11·21
SrO	<i>trace</i>	<i>none</i>
BaO	0·05	
MgO	11·86	16·31
K ₂ O	1·01	0·46
Na ₂ O	2·35	1·22
Li ₂ O	<i>trace</i>	
H ₂ O below 110° C.	0·12	<i>none</i>
H ₂ O above 110° C.	2·44	1·40
P ₂ O ₅	<i>trace</i>	
CO ₂	<i>none</i>	
F	<i>undet.</i>	<i>undet.</i>
Total	100·01	99·46
Analyst	<i>Hillebrand.</i>	<i>Valentine.</i>

2. *A New Amphibole-pyroxene Rock from Mariposa County, California.*

The amphibole-pyroxene rock to be described occurs in small masses, pretty certainly intrusions, in the slates of the Calaveras formation in the Sonora quadrangle, California. The rocks were first collected by the writer about 1887, but they were not investigated till 1895. The first published notice of this rock may be found in the 17th Annual Report, U. S. G. S., Part I, p. 670. This consists of a note by Dr. F. L. Ransome stating the general character of the rock.

The rock consists of original augite and original amphibole in grains of nearly equal size, with a little quartz and some pyrrhotite. Scattered abundantly through the rock are large phenocrysts of brown amphibole which contain in a poikilitic

manner inclusions of augite and pyrrhotite and occasional crystals of the same primary brown amphibole that occurs in the groundmass. Both the pyroxene and the amphibole grains found in the amphibole phenocrysts are distinct inclusions, with sharp contacts and with diverse orientation and cleavage. The pyrrhotite appears to be original, as the amphibole about it is not in the least altered. Some of the pyrrhotite was separated by using a magnet on the powdered rock and tested with HCl, giving off fumes of sulphureted hydrogen. The amphibole of the groundmass in some cases shows sharp idiomorphic outlines, and there is no evidence that it results from the alteration of augite.

Prof. G. H. Williams has described a somewhat similar rock in this Journal (vol. xxxi, 1886, p. 40). Williams's rock is largely made up of diallage with a little hypersthene and olivine forming a groundmass in which are imbedded large idiomorphic poikilitic amphiboles containing abundant grains of the groundmass. The chief difference between the rock here noted and Williams's rock is the complete absence of hypersthene and olivine and the presence of primary amphibole in the groundmass and among the inclusions in the large amphiboles.

This rock is one type of a very interesting series of basic igneous rocks which are found in the foothills of Mariposa County. Typical gabbros and diabases both with and without olivine and amphibole-pierites represent different types of these igneous rocks. They have not as yet been carefully investigated.

3. *A Quartz-alunite Rock.**

Southwest of Indian Gulch in Mariposa County, California, are three sharp buttes known as the Tres Cerritos. The original material of these buttes appears to have been chiefly meta-augite-andesite tuffs (augite-porphyrite tuffs) and clay slate. The Tres Cerritos lie immediately east of a considerable area of clay slates which are pretty certainly of Jurassic age. They are supposed to belong to the Mariposa formation. Not far west of the buttes by the road to Merced these slates have been metamorphosed into typical chiastolite-schists by a granitic rock.

The rocks of the Tres Cerritos have been subjected to solfataric action and their angular outline is due to the hardness of the altered rocks. The larger portion of these metamorphosed rocks are light brown in color, highly siliceous, resembling quartzite megascopically.

The southeast butte, which was examined with the most care, is composed chiefly of a greenstone-schist which is a

* 17th Annual Report, U. S. Geological Survey, Part I, p. 685.

dynamo-metamorphic form of the meta-augite-andesite tuff. This contains layers of vein quartz, associated with which is pyrophyllite in considerable masses crystallized in beautiful stellate forms. The much decomposed and rusty schists in the creek at the west base of the butte strike about 60° west of north, and dip at an angle of 80° . At one point about due west of the butte the schists are covered with an efflorescence. Some of this was collected and examined by Dr. H. N. Stokes in the laboratory of the U. S. Geological Survey, who reported that the efflorescence is composed of hydrated sodium and magnesium sulphates with a little chloride. In the interior of this efflorescence are grains of calcium sulphate.

The quartzite-like rock under the microscope is seen to be made up chiefly of grains of quartz and a positive uniaxial mineral of greater relief than the quartz, extinguishing parallel to the cleavage and having bright interference colors. Dr. Hillebrand made a chemical examination of this rock and came to the conclusion that the unknown mineral might be alunite.

Chemical Analysis of Alunite No. 870 S. N.

SiO ₂	2·64
TiO ₂	·40
Al ₂ O ₃	38·05
Fe ₂ O ₃	·23
FeO	Not looked for
MnO	None
CaO	·55
BaO	Not looked for
MgO	trace
K ₂ O	4·48
Na ₂ O	2·78
P ₂ O ₅	trace
CO ₂	none
H ₂ O 100° -	none
H ₂ O 100° +	11·92
SO ₃	38·50

99·55

To make this more certain a quantity of the rock was powdered and the alunite-like mineral separated by means of the Thoulet solution. The specific gravity of the mineral is 2·78 as determined with the Westphal balance by grains suspended in Thoulet solution. Some of the material was heavier than this, but this greater specific gravity was undoubtedly due to inclusions of a brownish red mineral in minute grains without crystal outlines. These grains are too minute for satisfactory determination with the microscope, but a quantitative test of some that were separated from the rock, made by Mr. William Valentine, show that the mineral is rich in titanium. The mineral does not resemble titanite in color, at least such titanite

as ordinarily is found in granitic rocks. It may be brookite, but as before noted, occurs in somewhat rounded forms and not in the small tabular crystals said to be characteristic of brookite. Possibly the mineral is rutile.

On p. 425 is given an analysis of the alunite by Mr. William Valentine. It is probable that the titanite oxide in this analysis was obtained from some of the minute grains of the titanium mineral above noted. As the material was sensibly pure the analysis may be regarded as representing its composition after deducting the titanite oxide.

Alunite has not been previously found in California so far as known.

4. *Zircons from Gravels.*

Sometime since Mr. J. A. Edman of Meadow Valley, California, transmitted to the writer some heavy sands from gravel washings in California. One sample of these sands was composed largely of zircon-like crystals. The material came from a surface placer in Eagle Gulch near Edmanton about 4.5 kilometers southwest of Meadow Valley, Plumas County.

To make certain the character of these crystals some of the sand was digested on a water-bath with HF and H₂SO₄ concentrated for about two days. The residue was then washed and digested in HCl and water, again washed and digested in water alone to get rid of the dissolved material. The residue consisted chiefly of the zircon-like crystals with a few black grains, and a few specks of gold. Some of this residue was powdered and mixed with Na₂CO₃ and fused at a white heat in a little platinum crucible for five minutes. The culot was then washed in water. After the soluble material was removed there remained very abundant minute hexagonal crystals supposed to be ZrO₂.

Some of the zircon crystals and the ZrO₂? were sent to Prof. S. L. Penfield of the Sheffield Scientific School, who kindly examined them and wrote that "the zircon crystals resemble ones which I have seen associated with gold from North Carolina. The forms are not unusual, 100, 110, 111, 311, and possibly 101. The hexagonal plates (referring to the crystals obtained by fusion with Na₂CO₃) resemble those I have met in testing for zirconia. I do not consider the reaction a very delicate one. The black grains may be chromite or some spinel mineral which would resist treatment with acids."

5. *Molybdenite.*

On the southeast slope of Mt. Hoffmann in the Yosemite National Park, at an altitude of about 9500 feet, is a lens composed of garnet, epidote, quartz and calcite. This lies in a narrow strip of gneissic rock at the contact with the granitic mass that lies just east. Possibly it represents a metamor-

phosed limestone mass. In some specimens (No. 2176 S. N.) of the material bright specks of a sulphide were noted. This mineral was determined by Mr. William Valentine as molybdenite.

About three miles north of west from Tower Peak in Tuolumne County is a considerable mass of quartzite, marble and black fine-grained gneiss. At the edge of the coarsely crystallized white marble, which has a width of about 400 feet, is a white schistose pyroxenic rock. Granitic rocks and quartz veins cut both the marble and the schist. The microscope examination of the granitic dikes showed them to be quartz-diorites containing primary augite and titanite. An excavation had been made on one of the quartz veins at the contact of the marble and schist. No doubt it was regarded as a gold- or silver-bearing lode. This vein contains a large amount of green epidote, garnet and zinc blende and a bright bluish metallic sulphide. This bluish sulphide was determined by Mr. Steiger and afterwards Mr. Valentine as molybdenite.

From a quartz vein in the granite on the south side of Knight Creek, northeast of Columbia in Tuolumne County, some specimens of quartz were collected by myself some years ago. The rock containing the vein is of a type called granodiorite in the Gold Belt folios. Molybdenite was found in these specimens. The quartz prospect was called the Dorsey claim, but should not be confused with a mine of the same name which has more recently been developed on the ridge north of Knight Creek.

6. *Tellurium, Selenium and Nickel in Gold Ores.*

The presence of tellurium in gold ores, especially in Calaveras and Tuolumne Counties, California, has been known for many years. In some mines, as the Bonanza at Sonora, tellurides are very abundant. The following new localities are given on the authority of Mr. W. J. Sharwood* of the University of California.

Tellurium and selenium were found in a mine on the Mother Lode near Table Mountain in Tuolumne County. The selenium was obtained as a red sublimate by heating some five or ten grams in a glass tube. The tellurium was detected in occasional specks by the sulphuric acid test applied to the powder spread over the surface of a shallow porcelain dish. Concentrated sulphides from the same mine were found to contain 1.5 per cent of nickel. The sulphides contain so much $MgCO_3$ as to be difficult of chlorination.

Mr. Sharwood also found tellurium minerals in isolated specks with pyrite, etc., in quartz from the Keltz mine near

* Communication by letter.

the south fork of the Stanislaus River and the Ham and Birney gold mine on Five Mile Creek, which is a branch of the south fork of the Stanislaus. Mr. Sharwood also found tellurium in a cavity in a fragment of unrounded coarse gold washed from gravel. This specimen is said to have come from Big Creek, Butte County, California.

7. *Carbonaceous Material in Quartz.*

Many of the veins of the Gold Belt region of the Sierra Nevada in the older rocks that lie east of the Mother Lode, are composed of quartz which is dark in color. The coloring material is so finely disseminated that a microscopic study of the slides of this dark quartz gives no clue to the nature of the coloring material. A specimen of this quartz from the Star Gold Mine on Rose Creek, which is a branch of the Stanislaus River, in Tuolumne County, was therefore selected for a chemical examination. The quartz was examined by Dr. H. N. Stokes, who reported "that the coloring matter is carbonaceous, not graphitic. Eight grams of the quartz, after the separation of sulphides, were treated with HF. This left several milligrams of carbonaceous residue, the nature of which was confirmed by conversion into BaCO_3 ." The Star Gold Mine is in Paleozoic rocks, the Calaveras formation of the Gold Belt folios.

8. *Berthierite.*

On the southwest slope of Mt. Gibbs, which is south of Mt. Dana in Tuolumne County, in an area of schists, are some heavy ledges of dark ore which have been exploited for silver. A specimen of the ore from one of these ledges was submitted to Prof. Munroe of the Columbian University in Washington for assay. The returns gave only a trace of gold and one and one-half ounces of silver per ton. This ore is therefore of no economic value. Some blow-pipe tests made by Mr. Steiger, under the direction of Prof. F. W. Clarke, showed that the ore contains iron, antimony and silver. Prof. Clarke surmised that the mineral berthierite might be present. More of the material was examined by Dr. H. N. Stokes, who reported:

"No. 879 S. N. is possibly berthierite, as it contains a large amount of iron, which dissolves together with the sulphide of antimony in cold strong HCl. The mineral is so impure, however, that it cannot be asserted positively that this iron does not come from some other iron mineral soluble in HCl. It is full of pyrite, galena or some other sulphide containing lead, as well as quartz and other minerals too intimately mixed to admit of separation. For this reason a quantitative analysis does not seem likely to give any definite results."

U. S. Geological Survey, Washington, D. C.

ART. LII.—*Mineralogical Notes on Anthophyllite, Enstatite and Beryl (Emerald) from North Carolina*; by J. H. PRATT.

Anthophyllite.—In 1890, Prof. S. L. Penfield described a single specimen of this mineral, which was reported as having come from the Jenks corundum mine near Franklin, Macon County, N. C. During the summer of 1892, while engaged with the North Carolina Geological Survey, Prof. Penfield and the author visited an outcrop of dunite, near Bakersville, Mitchell County, and on breaking open one of the loose bowlders of decomposed rock anthophyllite was exposed, which Prof. Penfield at once recognized as identical with the specimen he had described.

As there has been no mention of the correct locality of the anthophyllite and as this name is often applied to an enstatite occurring at the Jenks corundum mine, it has been thought that a description of the occurrence of these two minerals would be of interest.

At the Woody Place, two and a half miles south of Bakersville on the Marion road, there is a large outcrop of the rock, dunite. The hillside where it occurs is quite barren and thickly scattered with loose fragments and bowlders of the altered dunite. The outcrop has been carefully examined, but the anthophyllite has only been found in the bowlders. Here it occurs in prismatic crystals imbedded in penninite. Nearly all of the anthophyllite crystals are seamed and cracked, while those near the outer part of the bowlders are somewhat decomposed and stained a dirty brown. The purest crystals are transparent and vary from a pale clove-brown to a flesh-red color.

The crystals measure from 2^{mm} to 6^{mm} in the widest diameter, and some were found that were over three centimeters in length. A great many were examined, but no terminated ones were observed. The unit prism, 110, occurring alone or in combination with the brachypinacoid, 010, were the only forms observed.

An analysis of the anthophyllite by Dr. Baskerville* is given below, together with the results obtained by Prof. Penfield.† The two analyses are very similar and confirm Prof. Penfield's conclusion that the specimen described by him was from the Bakersville locality.

Anthophyllite has been found at Corundum Hill, but it is

*Of the Chemical Laboratory, N. C. Geological Survey.

†This Journal, xl, p. 396, 1890.

more fibrous and not of such good quality as that from near Bakersville.

	I (Baskerville).	II (Penfield).
SiO ₂	56·40	57·98
Al ₂ O ₃	1·15	·63
FeO	11·40	10·39
MnO	-----	·31
MgO	28·68	28·69
CaO	·50	·20
H ₂ O	1·63	1·67
Loss at 100°	-----	·12
	99·76	99·99

Enstatite.—The enstatite from Corundum Hill, that is commonly called anthophyllite, occurs as a rock composed of a mass of interlocking bladed grayish crystals. The rock is very tough and tenacious and forms a perfectly continuous mass with the dunite, which is exposed over nearly the entire surface of the hill.

The analysis of this mineral by Dr. Baskerville* is as follows:

		Ratio.	
SiO ₂	51·64	·861	} ·943
Al ₂ O ₃	·12	·001	
FeO	9·28	·129	
MnO	·56	·008	
MgO	31·93	·798	
CaO	·45	·008	
H ₂ O	5·45	·303	
	99·43		

It is evident from the amount of H₂O found that the material analyzed was impure, and as shown by the calculations below, the ratio in the above analysis corresponds to a mixture of 44·5 per cent enstatite, 35 per cent serpentine and 20·5 per cent talc. The analysis is also given below after substituting for MnO and CaO their equivalent of MgO, deducting Al₂O₃ and recalculating to 100 per cent.

	44·5 per cent. Enstatite.	Ratio.	35 per cent. Serpentine.	Ratio.	20·5 per cent. Talc.	Ratio.	Total.	Recalculated Analysis.
SiO ₂	24·42	·407	14·87	·246	13·02	·217	52·31	52·19
FeO	7·58	·105	1·84	·025	-----	-----	9·42	9·39
MgO	12·50	·312	13·83	·346	6·51	·163	32·84	32·91
H ₂ O	-----	-----	4·46	·246	·97	·054	5·43	5·51
	44·50		35·00		20·50		100·00	100·00

* N. C. Geological Survey, Bull. 11, p. 27.

Enstatite (Bronzite).—The occurrence of a bronzite diopside rock (websterite) in the midst of an outcrop of dunite, near Webster, Jackson County, N. C., has been described by Williams* and Lewis.† Near the western border of this outcrop boulders were observed that were composed almost entirely of bronzite.

The mineral is of a resinous brown color and of a bronze-like luster even on the unaltered surfaces. No distinct crystals were observed, the specimens being a mass of interlocking crystals making a very tough rock similar to the enstatite described above. The material for analysis was carefully selected by hand picking, and showed no impurities or decomposition when examined with the magnifying glass. The analysis of this mineral by Dr. Baskerville is given below :

		Ratio.	
SiO ₂	53.62	.894	= 1.
Al ₂ O ₃ .....	.97	.009	} .012
Cr ₂ O ₃ .....	.50	.003	
FeO	9.06	.125	
CaO	1.75	.031	} .994 = 1.11
MgO	33.53	.838	
H ₂ O .....	.19	.001	
	99.62		

In the above analysis the ratio of the bivalent oxides to silica is close to 1:1 and of ferrous oxide to magnesia and lime is very near to 1:7; this would give the formula (MgFe)SiO₃ with Mg:Fe = 7:1.

Assuming that the Al₂O₃ and Cr₂O₃ belong to spinel, and deducting RO sufficient to combine with them, the analysis, after substituting for CaO its equivalent of MgO and recalculating to 100 per cent, is given below, together with the theoretical composition.

	Found.	Theory for (Mg,Fe)SiO ₃ ; Mg:Fe = 7:1.
SiO ₂	55.35	57.69
FeO	9.14	8.65
MgO	35.51	33.66
	100.00	100.00

The name bronzite is very appropriate for this Webster enstatite, as the luster is of a decided bronzite-like character throughout the entire mass, and it is undoubtedly not of secondary origin. A similar bronzite has been found at the Buck Creek, Cullakeenee, corundum mine in Clay County.

* American Geologist, vi, pp. 43-4, 1890.

† N. C. Geological Survey, Bull. 11, p. 27.

Beryl (Emerald).—Although the beryl is a very common accessory mineral in granite veins, especially those of a pegmatitic character, it is not common to find the deep emerald-green variety. The earliest report of the emerald in North Carolina is by Hidden,* who describes the occurrence in Sharpes Township, Alexander County, where it is found associated with the emerald-green hiddenite.

On the divide between Brush and Crabtree Creeks, about four miles south of Spruce Pine post office, Mitchell County, emerald has been found in a pegmatitic vein consisting chiefly of quartz and an albite feldspar, with tourmaline and garnet as accessory minerals. The country rock is gneiss and biotite schist.

The emerald has the characteristic green color of the gem, and some of the crystals are transparent. No terminated crystals were observed, but all have the prism zone well developed. The crystals vary in size from less than a millimeter up to eight millimeters in diameter.

The color of the crystals varies with their location in the vein, those nearest the schist being of the emerald variety, while those farther away are pale green or yellowish. The yellowish or cream-colored beryls are very abundant through the vein and vary in size, from those hardly 2^{mm} in diameter to one that measured 17^{cm}.

North Carolina Geological Survey, March, 1898.

* Journal Elisha Mitchell Scientific Society, 1880.

ART. LIII.—*The Bethany Limestone at Bethany, Missouri;*
H. FOSTER BAIN.

THE Coal Measures of the Iowa-Missouri coal field are made up of the well-marked series of beds known respectively as the Des Moines and the Missourian. As originally used* these terms were considered to rank as stage names, but as the work of geologic mapping has progressed in the two states it has been found that both the Des Moines and the Missourian formations are really series of quite well-marked beds. Keyes has already proposed† that the terms be considered as serial and many of the minor divisions or stages have been made out in Iowa,‡ Missouri,§ and Kansas.¶

The complete section of the Missourian series has not been published, though individual formations falling within its limits have been made out by Haworth,¶ Prosser,** Keyes and others. Among the minor division the basal member of the Missourian has been often referred to. It is a heavy bed of limestone, or really a group of limestones with their intercalated shale beds, and its outcrops have been mapped, in part in detail and in part by reconnaissance work only, in Iowa, Missouri and Kansas. The limestone is of considerable economic importance, not only because it furnishes stone for building and lime-burning but also because it marks the upper limit of the productive Coal Measures throughout most of the region. It is accordingly particularly important that there should be no mistake in its correlation. There has been some controversy as to the proper name to be applied to the bed,†† but the term Bethany or Bethany Falls seems to have priority. In the present paper it will be shown that it is not the particular limestone which forms the falls which is of significance, but a whole group of limestones, all of which are well shown within the limits of the town of Bethany, Missouri. In view of this fact the suggestion already made, that the latter portion of the name as first used be dropped, seems particularly good.

In the recent work of the Iowa Geological Survey detailed sections of the Bethany limestone have been made out at intervals from the central portion of the state, where it passes beneath the Cretaceous, to the southern border, where it is well

* Keyes: Mon. Rev. Iowa Weather Service, vol. iv, p. 3, 1893.

† Amer. Geol., vol. xviii, pp. 22-28, 1896.

‡ Iowa Geol. Surv., vol. v, pp. 378-398; *ibid*, vol. vii, 443-450, 509-520, 1897.

§ Missouri Geol. Surv., vol. x, pp. 29-71, 1896.

¶ Univ. Geol. Surv. Kansas, vol. i, pp. 145, 193, 1896.

¶¶ Loc. cit.

** Jour. Geology, vol. iii, p. 800, 1895.

†† This Journal, IV, vol. ii, pp. 221-225, 1896.

shown on Grand River. Bethany is but a few miles beyond the Iowa border and along Big Creek at this point the same beds, seen first in central Iowa, are well exposed. It was at Bethany that Broadhead* first studied the limestone. As now exposed the beds yield the following sequence, along a small tributary of Big Creek running through the town. The first exposure, which shows the top of the Bethany, is near the railway bridge north of the depot, the top of the limestone being at about 888 A. T.

6. Limestone, fragmental, loosely cemented, with many specimens of <i>Meekella striatocostata</i> , <i>Chonetes verneuiliana</i> , <i>Productus costatus</i> , <i>Athyris subtilita</i> , <i>Productus longispinus</i> , <i>Spirifer cameratus</i> and <i>Dielasma bovidens</i>	6
5. Shale, clayey, green to drab with thin bands of limestone...	2
4. Shale, clayey, drab to black	2
3. Limestone, drab blue, two ledges, 9 and 3 inches thick	1
2. Shale, black	1
1. Shale, black to drab, with irregular nodules and thin layers of impure black limestone carrying large well-formed <i>Productus cora</i> , <i>Productus nebrascensis</i> , <i>Athyris subtilita</i> , <i>Myalina subquadrata</i> (?), <i>Schizodus</i> , sp.? In the shale itself are <i>Myalina subquadrata</i> , <i>Productus nebrascensis</i> , <i>Athyris subtilita</i> , <i>Rhombopora lepidodendroides</i> and plates of <i>Eupachycrinus verrucosus</i>	6

Below this exposure for some distance there are no outcrops, but in the western part of town there are some small quarries which show the following beds :

	Feet.	Inches.
6. Shale, clayey, drab		6
5. Shale, calcareous, transition beds, with <i>Spirifer cameratus</i> , <i>Meekella striatocostata</i> , <i>Productus cora</i> , <i>Productus costatus</i> , <i>Productus nebrascensis</i> , <i>Rhombopora lepidodendroides</i> , <i>Fistulipora nodulifera</i> , <i>Myalina subquadrata</i> , <i>Athyris subquadrata</i> , and <i>Derbya crassa</i>	1	6
4. Limestone, heavy ledges, many <i>Fusulina cylindrica</i>	2	10
3. Limestone, thin-bedded with many of the fossils collected above, particularly <i>Athyris subtilita</i> , <i>Productus cora</i> , <i>Productus costatus</i> , <i>Spirifer cameratus</i> , and <i>Meekella striatocostata</i>	10	
2. Unexposed		8
1. Limestone, thin-bedded, with <i>Productus costatus</i> , <i>Productus cora</i> , <i>Productus longispinus</i> , <i>Athyris subtilita</i> , <i>Spirifer lineatus</i> , <i>Spirifer cameratus</i> , <i>Spirifera kentuckensis</i> , <i>Chonetes verneulianus</i> , <i>Hustedia mormoni</i> , <i>Dielasma bovidens</i> and <i>Fusulina cylindrica</i>	12-15	

*Trans. St. Louis Acad. Sci., vol. ii, pp. 311, 1862; Mo. Geol. Surv. Iron Ore and Coal fields, Pt. II, p. 77 et seq. 1873.

Not far from here is the mouth of the stream which is just above the falls of Big Creek. The rock forming the falls lies probably 6 to 8 feet below the base of the limestone just described. It is about 20 feet thick, the upper 18 feet being made up of a coarse but firmly cemented limestone breccia. It is marked by long dark streaks which suggest corals but which fail to show structure. The only fossil collected from it was *Productus cora*. Below the breccia is about two feet of fine-grained gray limestone, carrying large well-formed *Spirifer cameratus*, with *Productus cora*. The brecciated character of the limestone and the absence of marked sedimentation plains has given under water action rounded forms and knob and pot hole surfaces.

The general sequence found here, with the four bodies of limestone separated by shales, is the same as has already been found in central Iowa. The exposures in the latter region were first studied by White* and have been more recently reviewed by the present survey.† In many of the minuter details even, there is a close correspondence between the Bethany section and that of Madison and adjacent counties. The latter may be summarized as follows:

	Feet.
8. Limestone, thick and thin-bedded, characterized by a particular abundance of <i>Fusulina cylindrica</i> , and hence called the <i>Fusulina</i> limestone	15-30
7. Shales, predominantly dark-colored and argillaceous, containing several thin bands of bituminous limestone which are usually quite fossiliferous. About midway of the shales is a horizon which is particularly fossiliferous. The more usual forms, including <i>Athyris</i> , <i>Productus</i> and <i>Spirifer</i> , occur in great abundance and perfection. With these forms are vast numbers of <i>Derbya crassa</i> with <i>Myalina subquadrata</i> , <i>Myalina kansasensis</i> , <i>Myalina swallowi</i> , <i>Aviculopecten occidentalis</i> , <i>Productus nebrascensis</i> , etc. Not far above this horizon is usually a thin band of limestone literally made up of <i>Chonetes verneulianus</i> . The whole thickness of shale is	10-20
6. Limestone earthy, magnesian, easily disintegrating above to medium grained coarse-bedded quarry rock below ..	10-20
5. Shale, usually dark and including a black bituminous horizon	8-12
4. Limestone, well shown near Earlham and hence called the Earlham limestone. It carries an abundant fauna which will be noted later	20

* First and Second Ann. Repts. State Geol., pp. 71-72, 1868; Geol. Iowa, vol. i, pp. 245-250, 1870.

† Trans. Iowa Acad. Sci., vol. i, pt. iii, p. 144, 1895; Iowa Geol. Surv., vol. iii, p. 137, 1895; *ibid.*, vol. vii, pp. 446-451, pp. 491-539, 1897.

3. Shale, with bituminous horizon and at many points a thin black limestone 3-8
2. Shales, sandy, light-colored, very variable thickness ... 2-16
1. Limestone, fragmental, made up of irregular bits of lime rock filled in with calcareous clay. In places the rock can be picked to pieces with the fingers; elsewhere it hardens up into massive thick-bedded layers. Along a small tributary of Deer Creek in Guthrie County it is quite fossiliferous, yielding *Spirifer lineatus*, *Spirifer cameratus*, *Athyris subtilita*, *Hustedia mormoni*, *Productus longispinus*, *Naticopsis alto-nensis*, *Lopophyllum proliferum*, *Orthis pecosi*, *Bellerophum* sp., *Strapharrollus* sp., *Archæocidaris* sp. 10-15

The Earlham limestone in Madison County is one of the best developed and most easily recognized members of the section. At Robertson quarry, two miles east of Earlham, the following section was noted :

	Feet.	Inches.
11. Bed of soft, yellowish, magnesian, earthy limestone, decomposing readily when exposed to weather	4	
10. Limestone in three heavy ledges at west end of quarry	4	
9. Buff shale with <i>Chonetes verneulianus</i>		4
8. Limestone, like number 4	2	
7. Ashen shale with very few fragments of brachiopod shells		6
6. Earthy limestone, decomposing readily, yellowish, carrying large individuals of <i>Athyris subtilita</i> ..		4
5. Drab shale, with <i>Productus longispinus</i> , <i>P. costatus</i> , crinoid stems and fragments of other fossils ..		6
4. Quarry limestone, in thin layers, irregularly bedded	8	
3. Unexposed	20	
2. Sandstone, in heavy layers	7	
1. Base of sandstone to creek, unexposed	17	

At one point the quarrymen had worked down in the bottom of the quarry and exposed, below number 4, drab and black shales to the depth of three feet, and below the shales a ledge of limestone six inches in thickness.

Distributed through the limestone beds No. 4 are the following :

- Lopophyllum proliferum* McChesney.
 Stem segments and body plates of crinoids.
 Various species of Bryozoa.
Meekella striatocostata Cox.
Productus punctatus Martin.
P. costatus Sowerby.

- P. longispinus* Sowerby.
P. cora D'Orbigny = *P. prattenianus* of authors.
Athyris (*Seminula*) *subtilita* Hall.
Hustedia mormoni Marcou.
Spirifer cameratus Morton.
Spiriferina kentuckensis Shum.
Allorisma subcuneatum M. & H.

Chonetes verneulianus N. & P. is somewhat common in No. 9 but is very rare in the other members of the section. *Spirifer cameratus* and *Productus longispinus* are most abundant near the base of No. 4, while *Productus costatus* and *Athyris subtilita* are more common in the upper layers. All the species enumerated, however, with the exception of *Allorisma subcuneatum*, range through all the beds making up No. 4.

The best exposures of the Bethany limestone in southern Iowa are found along Grand River and its tributaries. From the outcrops found there a complete section can be made from the Fragmental limestone at the base up to and above the beds which farther north have been called the Fusulina limestone, but which from their excellent development in that vicinity may now perhaps be best called the De Kalb limestone.

In Union County there is an important bed of limestone which from the fact that it is well shown on Sand Creek, near Westerville, may be called the Westerville limestone. It lies some little distance above the De Kalb horizon. In Jones township section 28, and farther south along the river, the beds are exposed, showing the following section :

- | | |
|--|----|
| 5. Limestone, ash gray, fine-grained, thin-bedded, becoming almost shaly at the top, with <i>Productus cora</i> , <i>Productus costatus</i> , <i>Spirifer cameratus</i> , <i>Athyris subtilita</i> , <i>Chonetes verneulianus</i> cf. <i>glabra</i> , <i>Lopophyllum proliferum</i> , <i>Strapharollus subquadratus</i> and Fenestelloid bryozoa | 10 |
| 4. Shale, gray, calcareous, with thin nodular bands of limestone | 4 |
| 3. Shale, drab to black | 10 |
| 2. Limestone, impure nodular in two bands | 2½ |
| 1. Shale, drab to black, well exposed at Westerville | 8 |

These beds extend into Decatur County, being seen near Westerville on Sand Creek and on Grand River. It seems probable that the shale (No. 1) extends down to the top of the De Kalb or Fusulina limestone, which is exposed near Grand River and was at one time quarried at the old Madarasz quarry (Sec. 36, Tp. 70, W., R. xxvii W.). The best exposures of the latter limestone and the ones which may be taken as typical are found a short distance east of De Kalb station (Sec. 28, Tp. 70 N., R. xxvi W.). The section at this point is given below.

	Feet.	Inches.
5. Limestone, irregularly water-worn	6	
4. Shale, hard, drab	6	
3. Limestone, irregularly bedded	8	
2. Shale, calcareous, becoming in places a poor grade of lime rock	2	
1. Limestone in thick to thin ledges	4	

The limestone is quite fossiliferous, the forms collected including: *Productus costatus*, *Productus longispinus*, *Athyris subtilita*, *Spirifer camerata*, *Spirifer kentuckensis*, *Dielasma bovidens*, *Derbya crassa*, *Lopophyllum proliferum* and *Fusulina cylindrica*. This fauna is more abundant than is usually found in the same beds farther north, though no extensive collections have been made in the latter region and many of the species collected at De Kalb are known to be present, sparingly at least, in the Madison County outcrops. The marked predominance of the *Fusulina cylindrica*, which is so striking a characteristic of these beds in Madison County, is not so noticeable at De Kalb. This is probably due as much to the greater abundance at the latter point of the other forms mentioned as to any real decrease in the numbers of the *Fusulina*. It is nevertheless true that the Decatur County outcrops show much closer relations to the rocks as developed at Bethany than to the Winterset section in the earlier advent, or at least culmination, of *Fusulina*. It is for this reason in part, that the term De Kalb limestone is to be preferred to *Fusulina* limestone, since neither the presence nor the abundance of the latter form is found to be consonant with a constant stratigraphical horizon.

The beds below the De Kalb limestone are well developed and show no important variation from the standard sections already given. A point of interest is the persistence of the *Myalina* horizon, which is found on Grand River west of the town of Decatur only less perfectly developed than at Winterset.* The exposures in and near Davis City show the Earlham and Winterset limestone especially. The Fragmental limestone is shown but is almost non-fossiliferous, as at Bethany. As seen in Clarke County near Osecola it is also unfossiliferous, and the only abundant collections from this horizon were made in the central Iowa counties.

No attempt has been made to follow the subdivisions of the Bethany south of its type locality. Their persistence in Iowa however, with certain hurried observations at Kansas City and a study of the reports of the University Geological Survey of Kansas, indicates that a portion of the section at least may be

* Geology of Decatur County, Iowa Geol. Surv., vol. viii. In press.

looked for in the latter region. The persistence of these minor subdivisions over the territory where they have already been traced for more than one hundred and fifty miles, suggests that the differences are due to widely acting causes and brings into sharp contrast the unsettled and disturbed conditions which apparently prevailed during the deposition of the Des Moines beds.

This manifest change in conditions affords a legitimate basis for making the Bethany the dividing line between the two divisions of the Coal Measures, even though it be recognized that the faunal changes are in the proportion and abundance of the species present rather than in the introduction of new forms. The old fauna adapted itself to the new conditions and there was a change merely in the balance between the species.

The taxonomic rank of the Bethany and its subdivisions is indicated in the following table :

System	Series	Stage	Substage
Carboniferous	Missourian	Undifferentiated	
		Bethany	Westerville? De Kalb Winterset Earlham Fragmental
	Des Moines		

It is probable that the Westerville limestone will be found to be better included with the next higher division when that shall be studied, but for the present it may be conveniently considered in connection with the Bethany.

Des Moines, Iowa, April 18, 1898.

ART. LIV.—*A Psychrometer applicable to the Study of Transpiration*; by ROBERT G. LEAVITT.

THE rate at which the vapor of water is exhaled from plants has been quantitatively examined by three principal methods, viz.: (1) by noting the weight of water taken up by the plant, (2) by weighing the growing plant, with pot or jar, before and after the loss of the vapor in question, and (3) by collecting and weighing the escaped vapor itself. The first mode was employed by Woodward in 1699. The second method has been in general use since Hales's early experiments (1724). The collection of the transpired water has been accomplished either by means of an hygroscopic substance (Garreau, 1849), or by condensing it on the walls of a receptacle (Dehérain, 1873).

There remains the possibility of testing the air brought from a transpiring part for the amount of vapor present, without actually collecting the vapor. If the dew-point could always be speedily and accurately ascertained, it was thought that this would be the foundation of a method having some advantages; as, for example, in case it were desired to detect changes in short intervals of time.

The dry hygrometers in use, such as Dines's and Alluard's, require a steady fall of temperature until the dew is perceived upon the collecting surface. This changing of temperature creates a considerable uncertainty as to the actual point at which dew begins to form. The difficulty may be overcome by employing several hygrometric surfaces, at adjustable fixed temperatures, side by side. In the instrument to be described there are four nickel-plated tubes passing vertically through a glass chamber. Each conducts a stream of water and has a thermometer within it. The water is derived from two sources, warm and cold, in order that the temperature may be regulated at will. The water-tanks are of such capacity and the flow is so even, that the mixed streams maintain sensibly constant temperatures for many minutes together. Above the chamber the hygrometric tubes are of glass, allowing the thermometers to be read.

Through the chamber a steady current of air is drawn, bringing the transpired vapor from the receptacle holding the plant. The draft having been so suited to the activity of the plant as to give a dew-point within the range of temperatures at command, the tubes are set, let us say, at 6°, 10°, 14°, and 18°. If No. 1 alone shows dew the fact is noted, the warm water turned on to throw off the gathered moisture, and

the other three tubes set at 7°, 8°, and 9°. Should No. 2 show dew at 7°, No. 3 none at 8°, the dew-point is between these temperatures, and is found at the next move within one or two-tenths of a degree. When two tubes stand side by side, one at a constant temperature of 7°·1, dimmed with moisture, while the other at 7°·2 is free, the dew-point is known with certainty within one-tenth of one degree. The thermometers are graduated to tenths, and of course have been carefully compared.

The following experiment, made in the course of a study on the water-changes in a young bean-plant during sleep-movements, may be of interest as illustrating the workings of the method.

Plant, a bean-seedling with 10 leaves, in pot wrapped with rubber and placed under bell-jar of 8 lr. capacity. Heavy clouds, dull light. Temperature in bell-jar throughout 20°·25 C. Draft, $972 \pm 5^{\text{cc}}$ per minute.

Time.	Dew.	No dew.	Conditions, etc.
11: 23 A. M.	8°·5 C.	8°·8 C.	Leaves erect. Plant now first darkened.
11: 27	Not found.	8°·1	Little or no drooping. 11: 38, lower leaves have declined by 45°.
11: 30	"	7°·9	
11: 42	6°.	6°·3	Plant half asleep. No change.
11: 53	No change.	No change.	
12: 05	"	"	

The plant manifested nyctitropic movements only slowly, and never completely assumed a sleeping position. Diminution in the rate of transpiration was indicated in 4 minutes after change of light, by a fall of at least 0°·4 in the dew-point; in 7 minutes by a fall of over 0°·6; and in 19 minutes a nearly constant transpiration at a lower rate was definitely ascertained, giving a dew-point between 6° and 6°·3. As exact weights of water exhaled were not sought, a nearer determination of the dew-point was not made.

Botanical Laboratory of Harvard University,
May 4, 1898.

ART. LV.—*The Action of Carbon Dioxide on Soluble Borates*; by LOUIS CLEVELAND JONES.

[Contributions from the Kent Chemical Laboratory of Yale University.—LXX.]

IN a process for the separation and estimation of boric acid devised by Morse and Burton,* the liberation of carbonic, silicic and boric acids from a mixture of inorganic salts is effected by the action of sulphuric acid, using tropaeolin *OO* as an indicator of acidity. In the solution thus prepared, containing in free condition only carbonic, silicic and boric acids, the silicic acid is dehydrated and made insoluble by anhydrous copper sulphate. The boric acid is then extracted with absolute alcohol. To this alcoholic solution of boric acid, a known amount of barium hydroxide solution is added in excess over that required to form a barium metaborate, BaB_2O_4 . Carbon dioxide is then passed into the solution in accordance with the hypothesis that the excess only of barium is acted upon. The aqueous mixture of barium metaborate and barium carbonate is evaporated and the residue is heated to a constant weight over a triple burner. From the following proportion the boric acid present may be calculated. The molecular weight of boric acid—the molecular weight of carbon dioxide : the molecular weight of boric acid = the total weight found—the theoretical weight of barium as carbonate : the weight of boric acid present. It is obvious, inasmuch as the difference between the calculated weight of the barium as carbonate and the actual weight of the residue is multiplied nearly three times to get the boric oxide, that the actual error of the process, whatever it may be, is magnified three-fold by the method of computation.

I have made a study of this method applied to pure boric acid, but have been unable to obtain results similar to those of Morse and Burton.

For this investigation boric acid of standard strength was made by dissolving in a given amount of water a known weight of anhydrous boric oxide, prepared by igniting over a blast lamp boric acid several times recrystallized and washed. A solution of barium hydroxide was filtered free from carbonate and then standardized by precipitation as carbonate and also by the Phelps method with iodine.† To a measured amount of the boric acid solution an excess of barium hydroxide was added, carbon dioxide passed, and the whole evaporated and by successive ignitions brought to a constant weight. Below are tabulated some of the results :

* Am. Chem. Jour., x, 154.

† This Journal, ii, 70.

	Ba(OH) ₂ taken. Calculated as BaCO ₃ . gram.	B ₂ O ₃ taken. gram.	Weight of residue after successive ignitions. gram.	B ₂ O ₃ found. gram.	Error. gram.
I....	0.9391	0.2200	1st wt., 0.9860	0.1263	-0.0937
			2d " 0.9786	0.1663	-0.1137
II...	0.9318	0.1295	1st " 0.9605	0.0744	-0.0523
			2d " 0.9558	0.0646	-0.0649
			3d " 0.9510	0.0517	-0.0778
III..	0.9253	0.2192	1st " 1.0357	0.2972	+0.0780
			2d " 1.0248	0.2679	+0.0487
			3d " 1.0149	0.2412	+0.0220
			4th " 1.0064	0.2183	-0.0009
			5th " 0.9975	0.1944	-0.0248
			6th " 0.9855	0.1621	-0.0671
IV..	0.7301	0.0810	1st " 0.8017	0.1927	+0.1117
			2d " 0.7777	0.1281	+0.0471
			3d " 0.7642	0.0918	+0.0108
			4th " 0.7582	0.0757	-0.0053
			5th " 0.7517	0.0582	-0.0228
			6th " 0.7482	0.0487	-0.0323
			7th " 0.7447	0.0393	-0.0417
			8th " 0.7427	0.0339	-0.0471
			9th " 0.7422	0.0326	-0.0484
			10th " 0.7407	0.0285	-0.0525

Plainly the results vary with the degree of the ignition. At the outset the residue may or may not weigh more than the theory requires for the known amounts of barium hydroxide and boric acid taken upon the assumption that the residue is barium metaborate and barium carbonate. This is obviously natural, if the carbon dioxide acts upon the barium borate as well as upon the excess of barium hydroxide; for, it is to be expected that in the evaporation more or less of the free boric acid will volatilize, and that in the subsequent ignition the boric acid remaining will tend to recombine more or less completely, replacing carbon dioxide. If the boric acid present were to recombine completely with the barium carbonate to form a metaborate, the final result would always be low by just the amount of free boric acid volatilized in the process of evaporation and ignition. The evidence of an experiment, however, in which 0.25 gram. of previously prepared barium metaborate was fused in contact with 0.5 gram. of barium carbonate, resulting in a loss of 0.0871 gram., goes to show that the metaborate and carbonate of barium interact still further to liberate carbon dioxide.

These results were so surprising in the light of the experience of Morse and Burton that the question of the possibility of breaking up by carbon dioxide the barium metaborate

already formed was put to the test directly. A known amount of barium hydroxide was taken in solution and to it added an amount of boric acid very little in excess of that theoretically necessary to form the barium metaborate. The solution was evaporated to dryness and the residue ignited. The weight obtained proved to be 0.0008 gm. less than the sum of the barium and boric oxides taken, doubtless because the slight excess of boric acid was somewhat volatile in the evaporation. The mass, presumably barium metaborate, was now dissolved as completely as possible in hot water, carbon dioxide was passed through the solution, the whole was evaporated, and the residue ignited and weighed. The increase in the weight showed that carbon dioxide had been absorbed, while a corresponding amount of boric acid had not volatilized.

	Ba(OH) ₂ taken. Calculated as BaCO ₃ . gram.	B ₂ O ₃ taken. gram.	Residue after ignition. gram.	Residue after CO ₂ treatment and igni- tion.—gram.
V	0.8377	0.2990	0.9491	-0.9771

After passing in carbon dioxide and igniting, the increase in weight was 0.0280 gm., representing the gas absorbed less the boric acid volatilized.

It was plain that barium metaborate is decomposed in solution by carbon dioxide. The possibility remained, however, that the action of carbon dioxide might be so regulated as to leave the metaborate practically unattacked. In experiment VI, therefore, carbon dioxide was passed above the stirred solution until no further precipitate formed upon the surface, the barium present being in excess of that required to form a metaborate.

	Ba(OH) ₂ taken. Calculated as BaCO ₃ . gram.	B ₂ O ₃ taken. gram.	Weight of residue after ignition. gram.	B ₂ O ₃ found. gram.	Error. gram.
VI ..	0.7094	0.2070	0.7710	0.1658	-0.0412

The variation of this result from the theory shows that under these conditions the metaborate is not unaffected by carbon dioxide, the loss being due, of course, to the escape of boric acid.

An attempt was now made therefore to gauge the amount of the carbon dioxide introduced by means of an indicator. In experiment VI phenolphthalein was added to the solution of boric acid containing an excess of barium hydroxide and the current of gas was stopped when the color of the indicator disappeared.

Ba(OH) ₂ taken. Calculated as BaCO ₃ . gram.	B ₂ O ₃ taken. gram.	Weight of residue after ignition. gram.	B ₂ O ₃ found. gram.	Error. gram.
VII . 0·6073	0·1573	1st wt., 0·6820	0·2011	+0·0438
		2d " 0·6783	0·1911	+0·0338
		3d " 0·6720	0·1742	+0·0169
		4th " 0·6700	0·1688	+0·0115
		5th " 0·6655	0·1567	-0·0006
		6th " 0·6630	0·1499	-0·0074
		7th " 0·6609	0·1443	-0·0130

This result is manifestly an improvement over those obtained without the careful restriction of the supply of carbon dioxide. A similar experiment, differing only in the single point that the carbon dioxide was made to act upon a boiling solution, resulted in like manner.

In the light of these observations it is plain that a sufficiently prolonged action of carbon dioxide should result in the displacement of all the boric acid if that acid can be removed from the field of action as fast as it is liberated. Experiments were made which clearly demonstrate the truth of this hypothesis. A small side-necked flask was charged with a solution of boric acid (0·1143 gram.) and barium hydroxide (0·3227 gram.) in proportion to form the metaborate. The mass was brought nearly to dryness by distillation and methyl alcohol (15^{cm}) added. Through this flask, in which the alcohol was kept boiling by a Bunsen burner, was passed the vapor of methyl alcohol, while carbon dioxide, purified by a neutral solution of silver nitrate, bubbled continually through the entire system. The methyl alcohol vapor coming from the side-neck flask was kept lighted by contact with the flame of a Bunsen burner and the distillation continued for two hours until the flame showed not the slightest tinge of green. The residue in the flask originally containing barium metaborate was brought to dryness and tested for boric acid. Only a trace was found and this was thought to be due to inclusion by the insoluble barium carbonate. In a similar experiment in which borax was used instead of barium borate, no trace of boric acid was found in the residue of sodium carbonate, either by tumeric or the flame test, while the distillation was continued only one-half the time of the preceding experiment. This result is quite in harmony with the views of P. Georgevic* to the effect that the large absorption of carbon dioxide in solutions of borax indicates that the boric acid is displaced from its union with the base.

Obviously, the division of the base between boric acid and

* Jour. Prac. Chim., xxxviii, 118.

carbonic acid falls under the principle of mass action, and if the boric acid is taken in sufficient excess over the barium hydroxide, the action of the carbonic acid should be inappreciable. This idea is sustained by an experiment in which about 1 gm. of boric acid was dissolved with 0.15 gm. of barium hydroxide. No precipitate could be obtained by passing carbon dioxide and boiling. In fact, in the French process of borax manufacture just this action of an excess of boric acid upon a boiling solution of sodium carbonate is used. On the other hand to prevent the formation of a carbonate this excess of boric acid must be considerable if the action of carbon dioxide is prolonged. Thus in an experiment in which a current of carbon dioxide was passed into a solution containing 0.1219 gm. of boric anhydride and one-half the amount of barium needed to form a metaborate, the solution (60^{cm}) deposited on boiling ninety per cent of the barium present in the form of the carbonate.

In view of the facts which I have described, it is difficult to see under what conditions Morse and Burton prevented the excessive action of carbon dioxide and obtained in their analytical method the excellent results which they record.

I wish to express my thanks to Professor Gooch, whose advice has been constantly sought and freely given.

ART. LVI.—*The Jerome (Kansas) Meteorite*; by HENRY S. WASHINGTON.

THE meteorite, described in the present paper, was acquired for the Yale University Collection about a year ago, through the generosity of members of the Class of 1857. Prof. Dana entrusted it to me for examination, for which kindness I desire to express my hearty thanks.

Little is known of the circumstances of its finding, and all that could be ascertained was published by Prof. Dana in a note in the Yale Alumni Weekly for May 6, 1897, from which I quote the following:—

“It was found April 10, 1894, by Mr. H. T. Martin, on the Smoky Hill River, Gove Co., Kansas, about 15 miles east of Jerome. Mr. Martin was then engaged in hunting fossils, and his attention was attracted by this mass, whose appearance was quite foreign to the rock of the neighborhood. It proved on examination to be a meteorite, of the circumstances of whose fall nothing has been learned. The same State has furnished a number of other meteorites at points considerably distant from that where the present one was discovered, and it is possible that some of them may prove to have been parts of the same original meteor. . . . The stone has been placed in the center of the case devoted to meteorites in the mineral room of the Peabody Museum.”

As the Smoky Hill River is several hundred miles long, and other meteorites may be found in the extended area of Gove Co., I propose for this mass the name of the Jerome Meteorite, after the nearest town.

The stone consists of several pieces, the largest weighing about 62 lbs. (30 kilos), with several smaller fragments, the largest of which weighs $2\frac{1}{2}$ lbs. and collectively $3\frac{1}{4}$. One of these was apparently broken off at the time of fall, as none of its surfaces are those of a fresh fracture.

The main mass measures some 12 inches in its largest diameter, the other dimensions being between 9 and 10 inches; it has roughly pointed ends, and its polyhedral form is vaguely suggestive of a dodecahedron drawn out in the direction of its vertical axis. One end is quite sharply pointed, while the other is blunter and irregular, showing some fresh and other older fracture surfaces, and is apparently the point of impact. From this broken surface a number of fine cracks radiate through the body of the mass.

The mass is bounded by fairly plane surfaces, some being quite flat, while others are more or less warped. The angles

are rounded. A few shallow pits are seen, and here and there ovoidal nodules, which project slightly above the main surface, or from the bottoms of shallow depressions. These measure several centimeters in length, with a width of about two-thirds of the length.

A thin, dark brown crust covers the surface, but this has suffered through atmospheric decomposition, and is much corroded, lacking in places, and often dull and rusty. No signs of ridges or other flow phenomena are to be seen on what is left of the crust. Small, rough, wart-like processes are seen generally over the surface, some due apparently to the projection of chondrules through weathering, while others are the less altered fragments of crust.

Parts of the meteorite, especially near the point of impact, and the fragment ($\frac{3}{4}$ lb.) which shows no fresh fracture surfaces, are covered with a fine, yellowish white powdery substance, which effervesces but slightly in acid, and is apparently a light clayish soil. The same substance is found in the cracks previously mentioned.

The fresh fracture is uneven, and the stone, as thus seen, is fine-grained and compact. The general color is dark rusty brown, which under the lens is seen to be a mottled brown and black. Small, glistening streaks of nickel-iron are scattered through it, but no troilite was seen. The lens also reveals translucent grains of olivine and bronzite. Small rounded chondrules are also seen here and there, but are not very numerous.

It is very evident that the oxidation of the iron from weathering extends far into the mass, though possibly a section through its center might reveal fresh substance. Of the stones in the Yale collection it resembles most that from Salt Lake City, and is also much like the decomposed portions of the Bluff, Fayette Co., Texas, meteorite.

Under the microscope the stone is seen to be composed of quite numerous chondrules of bronzite and olivine, with fragmental crystals of olivine, bronzite and a little pyroxene, in a rather brecciated groundmass of the same minerals, together with some interstitial matter, which seems to be glass. Nickel iron is present in the form of small, angular, irregular masses. Patches and veins of dark, reddish-brown, and yellow ferruginous substance are present, and show that considerable atmospheric decomposition has taken place. A few small fragments of plagioclase are also to be seen, but no troilite, and nothing which could be referred with certainty to maskelynite.

On the whole I am inclined to class this stone with Brezina's group 37, "krystallinisch Chondrit, breccienähnlich

(ckb),” * though I have no sections of either of his two examples for comparison. It will be remembered that it resembles megascopically the less fresh parts of one of these, the Bluff meteorite.

The chondrules of bronzite run up to nearly 2^{mm} in diameter, and show, in most cases, circular sections, or nearly so, though angular and fragmental forms are seen. They present the usual fibrous, eccentrically radiated structure.

The olivine chondrules are somewhat larger, up to 3^{mm} and show greater variety. Many are monosomatic, with parallel plate structure and border as figured by Tschermak.† The interstitial matter here is granular, colorless and isotropic, containing small, black, opaque particles. It is possibly a glass, as in the cases described by Tschermak, though its pronounced granular character is against this view, and points rather to the idea that it is maskelynite. These chondrules are usually small and round.

Porphyritic olivine chondrules are more numerous, as well as the largest in size, and are occasionally rounded, but usually irregular in outline. They consist of oblong grains and crystals (showing traces of pinacoids and domes) of colorless olivine, lying pellmell in a gray or colorless, finely fibrous ground-mass. This is formed of patches of straight narrow fibers parallel over small areas, each small area extinguishing as a unit, but unlike those adjacent, where the fibers run in another direction. It was supposed at first that these thin colorless rods were a rather basic plagioclase, since they extinguish at various angles up to 20° with their long axes, and their polarization colors are grays and pale yellows. Close examination under high powers, however, revealed the fact that in many places there is no break in continuity between the fibers and distinct adjacent olivine crystals, and that in these cases both crystal and fibers extinguish simultaneously. They must, therefore, be referred to olivine, and the apparent oblique extinction is due to the fact that the fibers project obliquely from the surface of the olivine crystal, seemingly in the direction of a domal or prismatic plane. That they are rods and not plates (as in the preceding type of chondrules) is shown by their sections in certain places, where they present the appearance of small rounded grains. Such skeletal development is a not uncommon feature of olivine, as is well known.

Other porphyritic chondrules are seen in which olivine crystals and fragments are embedded in a fine-grained mosaic of olivine and enstatite grains. One peculiar ovoidal chondrule was observed, composed of a long, seemingly corroded, olivine

* Brezina, *Ann. k. k. Nat. hist., Hofmuseums*, x, 261, 1895.

† Tschermak, *Mikr. Besch. d. Meteoriten*, pl. x, 2.

crystal, surrounded by a mosaic of small grains of the same mineral. There were a few monosomatic chondrules of olivine, with approximately circular outline, but curiously and irregularly hollow, the interstices between the separate patches of olivine being filled with granular bronzite. Others again were found with monosomatic borders and portions of the interior of bronzite, containing olivine grains.

The crystals and fragments of bronzite and olivine offer no features of special interest. They are colorless, except where stained by ferruginous decomposition products, and are quite fresh, even the olivine showing no traces of serpentinization. Each mutually encloses the other, so that they were apparently crystallized at the same period. Both include small angular fragments of iron. Only a few crystals and fragments, which could be definitely referred to pyroxene, were observed. In one case two pyroxene fragments, giving oblique extinction, are enclosed in a patch of bronzite. A few grains which may be referred to plagioclase were found, one of these showing traces of twinning lamellæ.

Grains of nickel-iron are quite abundant. They are all small and angular and irregular in outline; and apparently generally later than either the olivine or bronzite, as they are xenomorphic toward these and occupy the interstices between them, and also include crystals and fragments of these minerals. At the same time, as we have seen, small particles of iron are included in these minerals.

The iron has suffered greatly from oxidation, being usually surrounded by yellow, or deep reddish-brown, translucent, doubly refracting, matter. This is probably limonite, since it answers to Pelikan's* description of limonite under the microscope, and since the analysis shows that there is no silica, above that necessary for the olivine, etc., to form a ferrous silicate, as it was suggested to be by Kunz and Weinschenk† in the case of the Washington, Kansas, meteorite. This ferruginous substance has penetrated all the crevices of the mass, being found in the interior of even the largest mineral grains, is seen in patches throughout all the sections, and is what gives the brown color to the mass.

A careful search revealed no grains of troilite, though the chemical analysis shows that about five per cent was probably present originally. It has possibly been entirely decomposed.

For the chemical analysis 25.2 grams were taken, of as fresh material as was available, with no crust attached. An attempt was first made on 13 grams to separate the nickel-iron by means of an electro-magnet. This proved to be a matter of

* Pelikan, *Tsch. Min. Petr. Mitth.*, xiv, 5, 1895.

† Kunz and Weinschenk, *Tsch. Min. Pet. Mitth.*, xii, 180, 1891.

great difficulty, on account of the very dense and compact texture, and after two days had been spent in successive separations under alcohol, and after analyses of the products had been partially completed, this method was abandoned.

Eggertz's iodine method* was finally employed and proved fairly satisfactory. It seems, however, very desirable that some method be devised for the determination of the separate amounts of Fe, Ni, Co, FeO, Fe₂O₃, NiO and CoO, which does not involve the use of either iodine solution or solutions of such salts as double mercury or copper, ammonium chlorides, whose employment involves considerable extra outlay of time and labor, and whose action on certain constituents of meteorites is not well known.† From a petrological, and indeed from a chemical and mineralogical, point of view, meteorites are analogous to terrestrial igneous rocks, and should be treated as such. In the analysis of terrestrial rocks the separation into soluble and insoluble portions has been long abandoned, except for certain special investigations, since the separations are never either constant or complete, and since they are generally unnecessary, because the microscope and methods of chemical calculation enable us to determine the mineral constituents and their relative amounts with great precision.

It is evident, however, that a complete analysis of a stony meteorite by the ordinary methods of such analysis is not sufficient, since the metallic Fe, Ni and Co would be necessarily confounded with the oxides in the usual analytical processes, and their amounts—an important feature—would not be known, except roughly through the excess of oxygen.

A line of work which has suggested itself seems promising. This would consist in determining the total iron as Fe₂O₃, Fe and FeO as FeO, by the usual methods; determining the increase in weight by ignition in a current of oxygen, and the decrease in weight by ignition in a current of hydrogen,‡ both before and after ignition in oxygen. From these oxygen data and the amounts of Ni and Co as determined in the usual course, the separate amounts of the various metals and oxides of the iron group could, it would seem, be determined. Our knowledge of the action of oxygen and hydrogen upon the various silicates that go to make up meteorites is as yet far too small for employing such a method at present, and many experiments both as to the character and constancy of the action

* Blair's Iron Analysis, 3d ed., p. 79. My thanks are due to Prof. H. L. Wells for the reference to and description of this process.

† Cf. Cohen, Meteoritenkunde I, 1894, 13.

‡ Reduction in hydrogen has been proposed by Baumhauer and Rammelsberg, cf. Cohen, op. cit., p. 12. Baumhauer reports that at sufficiently low temperatures silicates and troilite are not acted on by hydrogen. For this suggestion I am partially indebted to Prof. Pirsson, with whom I discussed the matter

of these reagents on the silicates, troilite, etc., would have to be undertaken. The end in view would, however, seem to justify such an investigation.

The results of the several analyses are given below, the total analysis being calculated from the data furnished by the others. Part of the Cr_2O_3 was determined as chromite—this being assumed to have the simple composition FeCr_2O_4 , the rest was precipitated as PbCrO_4 . H_2O was determined as such in the total meteorite by Penfield's method,* and referred to the soluble portion. S and P_2O_5 were likewise determined in the total meteorite. The separation of soluble and insoluble silicates was effected in the residue from the solution of the nickel-iron by digestion on the water-bath for three hours with dilute HCl (1 : 5), and subsequent treatment with dilute KHO solution. The extra oxygen of the soluble portion† is that belonging to the ferric oxide of the limonite. It was estimated by calculating the amounts of olivine, augite and diopside present, and deducting the amount of FeO belonging to them from the total FeO .

The specific gravity was found to be 3.466 at $15^\circ.5$ C., taken with the balance, on a mass of 11 grams. The first approximate composition is :

	Nickel-iron	4.25
Soluble	{ Troilite	5.16
	{ Silicates	54.47
Insoluble	{ Chromite	0.87
	{ Silicates	35.25
		100.00

The analysis of the nickel-iron yielded :

Fe	89.67
Ni	10.01
Co	0.32
Cu	not det.
	100.00

The analyses of the soluble and insoluble portions, together with the calculated total composition, are as follows :

* This Journal, *xlvi*, 31, 1894.

† Total iron in this being determined as FeO .

	Soluble in HCl.	Insoluble in HCl.	Total.
SiO ₂	21·34	56·44	33·11
TiO ₂	----	not det.*	not det.*
Cr ₂ O ₃	----	1·61	0·58
Al ₂ O ₃	0·27	4·85	1·77
FeO	41·38	9·16	27·97
Fe	----	----	3·81
NiO	2·67	trace	1·77
Ni	----	----	0·43
CoO	trace	----	trace
Co	----	----	0·01
MnO	----	trace	trace
MgO	22·86	22·03	21·59
CaO	0·46	2·87	1·31
Na ₂ O	not det.	1·79	0·65
K ₂ O	not det.	0·77	0·28
H ₂ O	5·08	----	3·03
P ₂ O ₅	0·62	----	0·37
S	3·15	----	1·88
Extra O	2·88	----	1·76
	<hr/>	<hr/>	<hr/>
	100·71	99·52	100·32
Less O = S	1·57		0·92
	<hr/>		<hr/>
	99·14		99·40

It is evident that the soluble portion is made up largely of olivine, with troilite and limonite, and small quantities of pyroxene and oxide of nickel; while the insoluble is chiefly bronzite, with accessory chromite, feldspar and augite. Calculation from the data furnished by the analyses shows that the mineralogical composition of the stone is approximately:

Nickel-iron	4·3
Troilite	5·2
Chromite	0·9
Schreibersite?	0·8
Olivine	30·2
Bronzite	23·6
Pyroxene	5·0
Oligoclase (Ab ₅ An ₁)	6·6
Orthoclase	1·6
Limonite	20·2
Nickel oxide	1·6
	<hr/>
	100·0

* Present in small amount.

In the above all the phosphorus is assumed to exist as schreibersite, soda and potash to belong to the feldspars, and the NiO to be the product of the oxidation of the nickel-iron. It will be evident that if, as seems certain from the microscopic examination, the limonite is derived entirely from the metallic iron, the amount of metallic Fe originally present was higher by some 12 per cent, and the nickel higher by 1.25 per cent. The nickel-iron present in the fresh stone would then have amounted to about 17.50. That the orthorhombic pyroxene is bronzite rather than enstatite is shown by its calculated composition, which is

SiO ₂	56.8
MgO	32.6
FeO	10.6
	100.0

The pyroxene is largely diopside, with less than 10 per cent of the aluminous augite molecule. The plagioclase is an oligoclase of the composition Ab₆An₁. The orthoclase molecule probably also belongs with it, in which case it must have about the composition Ab₆Or₁An₁.

On the whole the stone seems to belong to a rather widespread group, and does not differ essentially from several that have been recently described from this continent; e. g., the Salt Lake City,* the Bluff,† the Beaver Creek,‡ and the Washington, Kansas,§ meteorites.

* Dana and Penfield, *This Journal*, (3), xxxii, 226, 1886.

† Whitfield and Merrill, *This Journal*, (3), xxxvi, 113, 1888.

‡ Howell and Merrill, *This Journal*, (3), xlvii, 430, 1894.

§ Kunz and Weinschenk, *Tsch. Min. Petr. Mitth.*, xii, 177, 1891.

Locust, N. J. April 22, 1898.

ART. LVII.—*Comments on Bulletin No. 21. "Solar and Terrestrial Magnetism in their relations to Meteorology;"* by FRANK H. BIGELOW.

[Communicated by permission of the Chief of the Weather Bureau.]

COMPLYING with a suggestion by the editor of this Journal to set forth the leading conclusions contained in my Bulletin No. 21, recently published by the U. S. Weather Bureau, the following comments are made with the view of bringing out prominently the important features of the subject as now understood. Those who have been familiar with the general conditions of meteorology and terrestrial magnetism, as regards the explanation of the observed phenomena by means of current hypotheses, must be aware of the very unsatisfactory state of these subjects in many particulars. In meteorology the widely accepted view of the generation of cyclones was based upon the vertical convection currents from local centers, which Professor Ferrel used as his working hypothesis, in his attempt to construct the laws of observed circulation. But the revolt from this position has become general, and it is not too much to say in advance that the outcome of our cloud observations greatly strengthens the position of those who claim that a new theory must be constructed. In terrestrial magnetism affairs were even worse, because there has been only the vaguest approach to a definite conception of the laws likely to account for the diurnal and annual periods, or the disturbances of the elements, to say nothing of the secular variation and the undoubted synchronism observed between the solar and the terrestrial phenomena. It has long been my conviction that these entire subjects needed a thorough overhauling, and that this involved the cutting loose from several opinions generally received in scientific circles. To thus separate from common conceptions involved considerable risk from two sources, (1) lest it be impossible to secure a scientific demonstration of a clear theory, while running counter to public opinion, and (2) the impracticability of publishing in sufficient detail the data involved in the discussion. For it must be admitted that magnetism in its relation to meteorology is a paradise for all sorts of pseudo-scientists, and that the entire field is cumbered with unproved and pretentious propositions. Nevertheless it must also be noted that when an investigator passes away from the observations of precision afforded by astronomy, geodesy and physical laboratory experiments generally, to the fitful measures made at the bottom of the atmosphere, which represent complex stream lines, and also the resultants of many compo-

nent forces, it is only fair to bear in mind that we have no better material than this to work with. The observations of meteorology and magnetism are very hard to handle with sufficient precision to give perfect laws, and critics should always remember, (1) that laws which are even approximately made out become very valuable for further advances, and (2) that every criticism ought to make sure that the author's position is not only understood, but also that the critic knows more about the point in hand than the investigator himself.

Taking up now the details of Bulletin No. 21, it will be seen that an attempt has been made to overthrow two positions held in terrestrial magnetism, (1) that the sun is not a magnetic body because it is too hot, and (2) that the variations of the terrestrial magnetic field can be accounted for by electric currents in the cirrus cloud regions; also a promise is made to examine the meteorological problem in a forthcoming report on the International cloud observations. Before recapitulating the arguments used in sustaining these two propositions, it is to be observed that the method of handling the observations is the simplest possible, as explained in Bulletin No. 2, of the Weather Bureau, 1892. It consists in assigning a normal field at a given station, and then subtracting this from the observed field, whereby a system of components is obtained which go to make up the forces that deflect the actual field from its normal position. Three rectangular elements are combined into the corresponding vectors acting in space, at a given time, and the collection of these together builds up the total vector system, which can be studied by itself and on its own merits. This plan has recently been advocated by von Bezold, *Zur Theorie des Erdmagnetismus*, 1897; the coming Conference of Magneticians to meet at Bristol, England, Sept. 7-14, 1898, will discuss the same principle in different aspects; and indeed its use is so obviously advantageous that what astronomers have long been doing is now applied to terrestrial magnetism and meteorology. By computing the vector systems belonging respectively to the daily means and the hourly means, as published, two different auxiliary fields have been disentangled, which added to the normal field give the actual field as observed. These two fields are the bases of our discussions and conclusions, and they have characteristics which seem to indicate a simple interpretation of the entire range of phenomena.

The temperature argument.—It was easy to conclude that because an ordinary magnet loses its magnetic force under high temperature, therefore the sun *must* be non-magnetic; and it is so difficult to disprove this argument, that this opinion is not only widespread, but tenaciously held as a canon of modern science. Yet it has been treated too long a bogey to

frighten off serious attacks upon its validity, and in my judgment it has done great injury to the advancement of this branch of science. There are several good grounds for distrusting its truth, and it may be stated that expert opinion is gradually coming to the general conclusion that the sun, the earth and the moon, are three magnetic as well as gravitating bodies, and that thus several unexplained gaps in science become readily filled. It is plain that while the earth is hot in the interior a moderately strong magnetic field is sustained around it. This fact alone makes the earth, and not a steel magnet, the analogue of the sun. After the evidence brought together by van Bebbber in *Witterungskunde*, by Bulletin No. 21, and also by many other writers, it is quite impossible not to accept the conclusion that the variation of the sun's forces, as shown in the state of its visible surface, the spots, the prominences and faculæ, and the corona, are synchronous with changes in all the elements of the earth's atmosphere. We are therefore confined to two lines of thought, either to show that there are variations in the sun's electromagnetic field, that is in its insolation, or else to admit that the sun possesses a true magnetic field, which embraces the earth in its operations. Now there is at present no evidence whatever that the sunlight field has any variable intensity, and on the other hand Bulletin No. 21 shows that the earth is immersed in an external magnetic field of such a direction and strength as to make the inference necessary that its seat is in the sun. Else if one admits the above-mentioned synchronism between solar and terrestrial elements, it will be necessary to assert that the earth's changes are sufficiently strong to disturb the sun's state as observed, which is of course absurd.

That the earth is plunged in a variable external magnetic field is so simply proved as to be quite beyond controversy. On Charts 17 and 18 is seen a collection of the traces of the horizontal forces from the two hemispheres. They exhibit the phenomenon that the horizontal force rises and falls in strength simultaneously over the entire earth, which is the common and persistent fact, just as much as it is true that a body falls towards the center of the earth by gravitation. Likewise it can be shown throughout the observations that when the horizontal force diminishes, the vertical force increases its strength, as generally and as continuously. Charts 6, 7, 8, 12, 36, 37, 38, 39, exhibit in detail the effects upon a field surrounding a magnet, when immersed in an external field of alternately greater and less strength than its normal field. The closed curves are expanded or contracted on each side of the mean, and this involves such changes in the horizontal and vertical forces as are found to be taking place throughout the earth's field. I recommend that criticism begin at this point, and that its consequences be candidly followed out.

The third line of argument tending to show that the sun though hot is magnetic is found in the compilation of testimony contained in Chapter 6. There it is shown that the riffs seen in coronas of the sun during eclipses closely fit the structure of a spherical magnet whose lines are viewed in projection on a plane, and we need only to suppose that the magnetic lines of the sun tend to arrange the surrounding material of its envelopes in the same way that a steel magnet disposes iron filings in its neighborhood. The period of rotation for an assumed solar nucleus is such that at least three coronas seem to correspond to one and the same model, when located mechanically by astronomical coördinates. The distribution of the sun spots in the adopted period of 26.68 days, in the two hemispheres, gives back the characteristic type curve, in its direct and inverse forms, pointing at least to some subtle and perhaps unsuspected law of solar operation. The Chandler long period variation of the position of the earth's axis of rotation is in so close agreement with the well known 11-year sun spot period as to demand complete investigation. Finally, the peculiar phenomenon of inversion of the type curve semi-annually in all its characteristics, constitutes another delicate test of the general fact of the magnetization of the sun, since its turning points are precisely in harmony with the position of the sun's axis and nodes, so that an accidental coincidence is quite impossible. Such a long series of phenomena, as those just enumerated, if not proving that the sun is a magnet, at least demands the respectful attention of those who still adhere to the high temperature argument.

Electric currents in the cirrus region.—It is probable that the only real strength behind the hypothesis, that a system of electric currents in the cirrus level is the cause of the variations of the earth's magnetic field as observed at the surface, is due to the process of exclusion by which the direct action of the sun as a magnet, the Faraday idea of the magnetic action of the oxygen of the atmosphere under differences of heat, and also the thermoelectric currents of the ground, were thrown out of the discussion. Passing over the last two entirely, it is quite clear that insuperable difficulties stand against the electric current theory. These are supposed to originate in the general motions of the atmosphere, due primarily to convection over the hemisphere, and hence they depend upon meteorological phenomena. But why assign them to the cirrus region, except on the philosopher's plan of always keeping the causes just beyond reach of criticism. In fact the cirrus region is known to be about the best behaved stratum in the atmosphere, since it is entirely exempt from all the minor variations of temperature felt near the ground;

but this stratum sails eastward serenely while magnetic theory demands that it should move westward; and also no physical cause has been proposed to show why electric currents should especially originate at that level. There would be very much more probability of the desired variations occurring in the strato-cumulus or the alto-cumulus levels, if these had been chosen for the purpose.

But there are two main lines of argument against the theory, which are really serious. One is that the magnetic field demands a cosmical cause, and the other is that this field requires shorter vibrations, and also longer sustained states than the meteorological conditions of the atmosphere can furnish. Regarding the first, as already mentioned, it is evident that the magnetic field of the earth is changed as a whole in every part of the globe instantly and synchronously; also these perpetual fluctuations can readily be grouped in a solar period. Now meteorological conditions are very local affairs, and we have no evidence of *rapid short* variations occurring all over the world at the same time. If the deflecting forces of the magnetic field are spread out in long tabulations such as shown on pages 46, 47, 51-56, extending through several years, it is to be seen by mere inspection that the changes are periodic, and I made out the period to be 26.68 days, which corresponds closely with the rotation of the sun at its equatorial belt, as measured by the motion of the sun spots. Furthermore the direction of the deflecting vectors themselves is such, that a field of magnetic force is directed upon the earth, positive north and negative south of the ecliptic; this is also the direction from which the great disturbances come as illustrated on pages 72-78; this period and its direction is persistent through half a century as indicated on pages 100-102; it is subject to two peculiarities, namely that the field is of such a configuration at the earth's surface as to correspond to a permeable shell placed within a uniform field, pages 61-72; and it is as a whole subject to a peculiar inversion in the four parts of the orbit of the earth about the sun, indicated on pages 106-107. It appears that such phenomena are precisely adapted to the explanation offered by the Bulletin, namely that the earth is in an external field sustained by the sun, and on the other hand one is driven to conclude that the electric currents of the cirrus region are powerless to produce such effects. Of course we do not deny the existence of electric currents entirely, since these must exist in all variable magnetic fields.

The other difficulty consists in the proposition that the earth is subject to such long sustained general states, extending over years, as to preclude the electric current theory, though even these too may well be included as a part of the effects of a solar

magnetic field. Thus we have undoubted evidence that the entire magnetic and meteorological systems go through 11-year fluctuations, synchronous with the sun spots which register the solar conditions. These are indicated on pages 121-125, where the data is greatly abbreviated from the compilations in our hands. It may be said in passing that the brief abstract before us does but scant justice to the material of the research. This, however, it was very difficult to publish in its entirety, and scientists must feel at a real disadvantage in estimating the soundness of some of our conclusions, unless they go through the great labor of reproducing similar data for themselves. We might give much more evidence from several other sources in favor of the long period variations, but this subject is already well known, and our only contention here is that the electric current theory of the upper atmosphere looks like transposing an effect into an efficient cause, unless it is proposed to make the earth wag the sun to fill out the explanations.

I have made the position prominent in the Bulletin that the earth is plunged in two external magnetic fields, because we have two distinct vector systems which demand that interpretation. The first was concerned with the long and short aperiodic terms, the Eschenhagen very quick variations, the disturbances, and the long range fluctuations, as well as the period corresponding with the rotation of the sun on its axis. The second is wholly confined to the diurnal variations of the needle and the annual period within these elements. This second field is illustrated on pages 85-92, and it is characterized by the phenomenon of magnetic refraction at the surface of the earth, and by the existence of sets of couples, which also forces us to the conclusion that the earth has a permeable shell, and that the field itself is associated with the polar radiations of light. This vector system changes with the year northward and southward, and always follows the declination of the sun, but the material for showing that is entirely omitted from the Bulletin. At any rate the two vector systems each indicate that the outer shell of the earth is more permeable to these external fields than the entire body of the earth itself.

We have at this point broken with current opinion, and that too, curiously, in two opposite directions. It is objected that the electromagnetic field cannot act as a steady field because it is too rapid. We reply that it is so rapid that our exploring magnets by their inertia cannot pick up the changes, and that they register as if the field were steady. On the other hand it is objected that the common polar magnetic field is too quiet, has no currents of electricity, and therefore no power to produce changes of temperature by transmitting energy. But we quote some propositions from Heaviside's papers to show that

an unsteady polar field transmits energy accompanied by transient currents of electricity, and that half this energy goes into setting up the new state of the field and half into heat. Furthermore the most probable explanation of magnetic lines of force is that they are constructed of electric currents, in rotation around the axis of the vortex tubes stretching from the positive to the negative parts of the field. The whole agency being dynamic, we can easily conceive that there is a continuous effect upon the earth's atmosphere, either by direct additions of energy, or by modifying terrestrial radiations, since the solar field is perpetually in vibration.

Evidently there is an immense mass of testimony to show that something of the kind is going on continuously. For we find that all the characteristics of the magnetic periods are reproduced in the temperatures and pressures of the northwest; also in the location of the storm tracks from year to year, as given in compressed form on pages 108-130. The three elements, magnetic field, temperature and pressure, were all handled in precisely the same way, at first tentatively seeking to discover the law of inversion, which was forced upon our attention by trying to carry the type curve through the changes shown on the daily weather maps. As the outcome of much work we are in this position: The temperature and the pressure certainly must and do vary together, but the magnetic field on the average gives us curves agreeing with either of these elements, just as exactly as they do with each other; our final compilations being strictly mechanical along the lines of the general law. It must be remarked that in comparing the curves of the individual periods with each other there is much looseness and irregularity, so that even a friendly investigator may superficially conclude that I have been tempted to force my data to my conclusions, while an unsympathetic critic may find himself willing to throw out the entire subject on the ground of individual discrepancy. Neither would be right in such a decision, for there is no possible ground of intimating more than that I may have been mistaken in my judgments. Still, to guard against this possible issue, the work has been done over and over again in at least four combinations, in such a way that it would be impossible to remember former assignments of direct or inverse type. In all cases about 75 per cent of the curves get the same interpretation, and this was true for one of my assistants as well as for myself. There is some need of practice and aptitude in dealing with such curves as these, but perhaps nothing better can be done with the subject-matter itself at present. Even in such simple curves as the diurnal variations of the magnetic forces, wild discrepancies are encountered; in the case of our nine-crested curve,

seated in the unsteady sun for a base, we must expect to deal with just such fluttering curves as are herein described. At least my interpretation of the many hundred curves reduced to the 26.68 day period, is worthy of careful consideration.

It will be noticed that I terminated my discussion of the cause of the phenomenon, and the pure physics involved in the inversion of the type curve, rather abruptly, after showing its relations to the magnetic field of the sun in the several parts of the orbit. It is clear that the components are such as to produce opposite effects, the field lying now across and again along the orbit, the earth driving through it at the rate of a million miles a day. After long consideration of the complicated conditions involved, the three axial motions and the complex computations required, the lack of our knowledge about atmospheric transformations of energy and radiations, I conclude that the problem is beyond my powers for the time being. This is also the more the case because of the total lack of magnetic observations in the northwest of the United States and western Canada, upon which to do definite work. The European data are good, but Europe is too far away, and unfortunately it is located in the hollow of the external field, belt M, Chart 10, where the exflected and inflected branches come together, and where the forces are very fluctuating in their directions. To make matters worse, just at this time our American observations have been practically extinguished by the encroachments of the city electric trolley lines, and the material is now rendered useless for these refined purposes. The only alternative seems to be to remove the observatories far into the country, to some spot away from the advance of the improvements of civilization. However, in view of the unusual interest and importance of the material contained in Bulletin No. 21, even if only a portion of it sustains final criticism, it is evident that the duty of American Science is to set up some first class magnetic observatories, and to run them for a term of years, till we can get good data to work upon in the pure physics required. It is hoped that this paper will be considered a valid plea to bring this about before very long.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On Electrolytic Dissociation and Osmotic Pressure.*—It has been already shown by TRAUBE that if N gram-molecules be present in one liter of the co-volume* of any liquid, the pressure will equal $22.38 N$ atmospheres. If now we suppose water and a sugar-solution separated by a semi-permeable membrane, the water containing N molecules in each liter of its co-volume and the sugar solution N molecules of water to ν molecules of sugar, the author considers that the ν sugar molecules may enter into unstable union with a molecules of water, and the number of water molecules entering the membrane from opposite sides will be in the ratio $N : (N - a\nu)$; thus producing the observed contraction in volume. Consequently the pressure on the side of the solution will be less than on the side of the water by $22.38 a\nu$ atmospheres. If a be unity, the pressure observed is in accord with the theory of Van't Hoff; so that it follows that the decrease of pressure on the side of the solution, due to the combination of the water with the dissolved substance, is the osmotic pressure. It has been shown by Poynting† that if this origin be assigned to the osmotic pressure, we can at once account for most of the observed relations. Some exceptions have been noted in the case of electrolytes. But these may be explained by variations in the value of a ; so that it is not necessary to assume electrolytic dissociation in these cases.—*Ann. Phys. Chem.*, II, lxii, 490–506, October, 1897. G. F. B.

2. *On a New Substance for increasing the Angle of Rotation.*—In his investigations on the malic acids WALDEN has made much use of their optical rotation. And since this rotation is slight, he has sought to increase its amount without changing its direction. The effect of oxygen salts of boron in this particular, had been observed by Biot and Pasteur; and that of the oxy-salts of arsenic, antimony, molybdenum and tungsten, by Gernez. But their action was feeble. In the salts of uranyl, however, the author found substances fulfilling all requirements. Either uranyl acetate or nitrate may be used, but the latter is preferable because of its greater solubility. To the solution to be examined, potassium hydrate solution is first added and then the solution of uranyl nitrate, the clear yellow solution thence resulting being examined in the polariscope in sodium light. The potassium hydrate solution contained 10.8 grams and the uranyl nitrate solution 40 grams to the 100^{cc}. Using *l*-malic acid solution alone (13 grams in 100^{cc}) the rotation in a tube 2 decimeters long was only -0.01° and the specific rotatory power -0.77° . When to 1^{cc} of the malic acid solution, 2^{cc} of the potassium hydrate solution was

* See this Journal, IV, iii, 479, June, 1897.

† *Phil. Mag.*, V, xlii, 289, 1896.

added and the whole diluted with 20^{cc} water, the specific rotatory power was -3.0° . With 1^{cc} malic acid solution and 5^{cc} uranyl nitrate solution (diluted with water to 20^{cc}) the value of $[\alpha]_D$ was -11° . With 1^{cc} malic acid solution, $\frac{1}{2}$ ^{cc} KOH solution and 1^{cc} uranyl nitrate solution, diluted to 20^{cc}, the value of $[\alpha]_D$ rose to -139° . And when to 1^{cc} of the solution of malic acid, 2^{cc} KOH solution and $1\frac{1}{2}$ ^{cc} uranyl nitrate solution were added, and diluted to 20^{cc}, $[\alpha]_D$ reached -475° . This maximum was attained when to 1 molecule malic acid about 4 molecules of KOH and from 1-4 molecules of uranyl nitrate was used; the value then being more than five hundred times greater than the value given by the malic acid solution alone. Similar results were obtained with tartaric acid and its mono-methyl ether; with quinic acid and with *l*-mandelic acid; though in a less degree. The inactivity of *i*-malic, *i*-mandelic and mesotartaric acid was not altered by the uranyl salt. Acids such as *d*-chlorsuccinic, *l*-bromsuccinic and *d*-amylacetic, which contains no free hydroxyl group, show no increase of rotatory power on adding the uranyl salt. The author summarizes his results as follows: (1) Alkaline solutions of uranyl salts produce both in aqueous and alcoholic solutions, a marked increase of rotatory power in the case of optically active acids; (2) this increase is conditioned upon the presence in the acid of a free hydroxyl group; and (3) it reaches its maximum when to one molecule of the oxacid (for example oxydicarbonic acid) at least one molecule of uranyl salt is added, together with the quantity of alkali required to neutralize the carboxyl groups and also the acid contained in the uranyl salt (i. e. about 4 molecules in all).—*Ber. Berl. Chem. Ges.*, xxx, 2889-2895, December, 1897.

G. F. B.

3. *On the Influence of the Silent Discharge on Atmospheric Air.*—A series of experiments has been made by SHENSTONE and EVANS on the influence exerted upon atmospheric air by the silent electric discharge. Their conclusions are as follows: (1) Oxygen diluted by nitrogen yields a higher proportion of ozone when submitted to the influence of the silent discharge under given conditions, than pure oxygen; the proportion of oxygen ozonized may be as high as 98 per cent. (2) If the process be not pressed too far, no nitrogen peroxide will make its appearance. (3) The presence of water vapor is very favorable to the production of a high yield of ozone and retards the appearance of nitrogen peroxide. (4) At a certain stage in the process, depending on the amount of vapor present and probably also on the temperature of the gas, nitrogen peroxide is formed; its appearance being almost immediately followed by a rapid disappearance of the ozone, this in its turn resulting in the destruction of most of the peroxide. (5) That, as Andrews has stated, the presence of a trace of nitrogen peroxide renders it impossible to convert oxygen into ozone by means of the silent electric discharge. And (6) nitrogen peroxide and ozone when moist do not mutually destroy each other at 0°, or do so at a very slow rate, unless they are under the

influence of the silent discharge.—*J. Chem. Soc.*, lxxiii, 246–254, April, 1898.

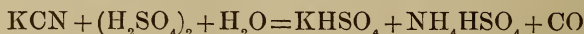
G. F. B.

4. *On the Action of Hydrogen on Sulphuric Acid.*—It has been observed by BERTHELOT that on passing a slow current of hydrogen through concentrated sulphuric acid for an hour at the ordinary temperature, there is no sulphurous oxide formed. If however the contact between the hydrogen and the acid be much prolonged, the gas is finally absorbed and a reduction of the acid takes place. Dilute sulphuric acid is not reduced by hydrogen. At the temperature of 250°, when the acid is concentrated, the reduction takes place somewhat rapidly, particularly in presence of a considerable excess of acid. When mixtures of oxygen and hydrogen are left in contact with sulphuric acid either at the ordinary temperature or at 250° both gases are absorbed. The rate of absorption of hydrogen however is the same as in the absence of oxygen, while the oxygen is absorbed in consequence of its combination with the sulphurous oxide formed by the reduction. If the hydrogen and the sulphurous oxide be dry, they do not act on each other either at 100° or at 280°. The reduction of concentrated sulphuric acid by hydrogen is an exothermic reaction, developing +15.1 Cal., this value being increased to +30.1 Cal. when the sulphuric acid is in large excess, owing to the heat of hydration. In the case of dilute sulphuric acid however the reaction would be endothermic.—*C. R.*, cxxv, 743–746, November, 1897.

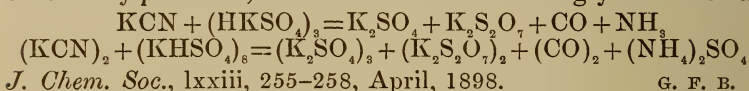
G. F. B.

5. *On the Preparation of dry Hydrogen cyanide and Carbon monoxide.*—While it is evident that both hydrogen cyanide and carbon monoxide may be formed by the action of sulphuric acid or potassium cyanide, yet WADE and PANTING have now shown for the first time that a practically quantitative yield of either product can be obtained at will by varying suitably the concentration of the acid. When the cyanide is distilled with the dilute acid, dilute hydrogen cyanide passes over; but when equal volumes of sulphuric acid and water are used, the distillate contains only small quantities of aqueous vapor; and this can be removed by passing it over warm calcium chloride. As the sulphuric acid becomes stronger a certain amount of carbon monoxide is formed, the quantity of the gas increasing with the concentration, while the hydrogen cyanide decreases. So that at last when sulphuric acid of the ordinary commercial strength acts on the cyanide nearly pure carbon monoxide is evolved in almost theoretical quantity. Thus when a mixture of equal volumes sulphuric acid and water (100° of each) is allowed to drop on 100 grams 98 per cent cyanide in a capacious flask, provided with U-tubes filled with calcium chloride and with condensing tubes cooled to -10°, about 40 grams (58°) of practically pure hydrogen cyanide is obtained; which on rectification from phosphorus pentoxide boils at 26.2°–26.3°; the average yield being 38.5 grams, theory requiring 40.8 grams. On the other hand, when 50 grams of cyanide are treated with cold concentrated sulphuric acid, 14

to 16 liters carbon monoxide is obtained, the calculated quantity being 17. At first sight, it might appear that the production of the carbon monoxide is simply a matter of hydrolysis and dehydration, the hydrogen cyanide being converted into formic acid and this into carbon monoxide:



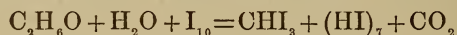
But since the result is equally well obtained by a mixture of two volumes of ordinary with one volume of Nordhausen acid, evidently water can play no part. Moreover hydrogen potassium sulphate may be used, a mixture of the dry salt with dry potassium cyanide evolving when heated to 230°–250°, anhydrous hydrogen cyanide, while a large amount of carbon monoxide is continually produced, and the residue smells strongly of ammonia:



J. Chem. Soc., lxxiii, 255–258, April, 1898.

G. F. B.

6. *On the Electrolytic production of Iodoform.*—Very satisfactory results have been obtained by FOERSTER and MEVES in the preparation of iodoform by means of electrolysis, the yield being 80 per cent of the potassium iodide employed. An ordinary battery jar closed with a plate of india rubber, contained three platinum plates as electrodes, the middle one, about 85 sq. cm. in area, being the anode and the cathodes being wrapped in parchment paper. Between the electrodes were two entrance tubes for gases and an exit-tube. A copper and a gas voltmeter were in the circuit. The charge consisted of 400^{cc} of a solution containing 60 grams potassium iodide, 20 grams sodium carbonate and 80 grams alcohol, the whole being kept at 65° by means of a water-bath. The current density was 2 amperes per sq. dm. and to obtain this two volts were required. The iodoform was removed every 8 ampere hours and the corresponding amount of potassium iodide and 20^{cc} alcohol was added. The reaction is



A slow current of CO₂ is passed through the cell to take up the KOH formed at the cathode.—*J. pr. Ch.*, lvi, 353–363, December, 1897.

G. F. B.

7. *Das physikalisch-chemische Institut der Universität Leipzig und die Feier seiner Eröffnung am 3 Januar, 1898.* Von Prof. Dr. W. Ostwald, Direktor des Instituts, pp. 44. Leipzig, 1898. (Engelmann.)—A description of the new Institute with Prof. Ostwald's admirable opening address.

8. *A Manual of Quantitative Chemical Analysis*; by E. F. LADD, B. S. 12mo, pp. vi, 82. New York, 1898. (John Wiley & Sons.)—This little book contains selected methods designed for the beginner in quantitative analysis, "not the ones that would always give the most reliable results in professional work," but "those that represent principles that will aid in developing the reasoning power of the student." For this purpose a set of questions is given at the end of each method. The methods seem well chosen and the processes are clearly described.

9. *Fluorescence and Actinic Electricity*.—In order to connect together by a reasonable hypothesis the various phenomena of luminescence, E. Wiedemann and G. C. Schmidt have suggested that in many cases the absorbed light energy in the ions of broken up molecules may determine when the molecules are again formed—the phenomena of fluorescence and phosphorescence. G. C. SCHMIDT has taken up the subject again in order to see whether the three phenomena *ionisirung*, *fluorescenz* and *actinoelectricität* are connected. He concludes from his researches that

(1) Ionizing and fluorescence do not stand in immediate connection with light-electric sensitiveness.

(2) In the case of elementary solid bodies and solid solutions fluorescence and actino-electric phenomena are not related.

(3) With the exception of uranium and thorium and their combinations, all bodies so far as they absorb ultra-violet light are light-electric sensitive at high potentials.

(4) Uranium and thorium and their combinations dissipate positive electricity as well as negative.

(5) The solid solutions of light-electric sensitive substances are also light-electric sensitive.

(6) Solid bodies which are light-electric sensitive preserve this property in their solid solutions.

(7) The solid solutions which hold uranium salts are not light-electric sensitive. They dissipate, however, equally well positive and negative electricity in the dark.

(8) In those bodies, which after being submitted to cathode rays become intensely thermo-luminescent when heated, negative electricity is strongly dissipated.—*Wied. Ann.*, No. 4, pp. 708-724, 1898.

J. T.

10. *New Method of determining the inclination and horizontal intensity of the earth's magnetism*.—Various attempts have been made to perfect the method of obtaining these quantities by means of the earth inductor, but the method has not been considered a precise one. G. MEYER describes an earth inductor which is kept in continuous rotation, and the neutral condition in which there is no current is determined by means of a telephone or capillary electrometer. The inclination can be measured to one-tenth of a degree. The instrument is especially fit for transportation, since no galvanometer is used.—*Wied. Ann.*, No. 4, pp. 742-751, 1898.

J. T.

11. *Röntgen Rays and ordinary light*.—Sir G. Stokes and Professor J. J. Thomson have lately developed the theory that these rays are evidence of electromagnetic impulses. LORD RAYLEIGH criticises this contention and is surprised by the theory "that the Röntgen rays are not waves of very short wave length but impulses," and asks if short waves are inadmissible why are not longer waves also, and what becomes of Fourier's theorem according to which any disturbance can be analyzed into regular waves. Lord Rayleigh refers to a paper in which he proved that

white light may be supposed to have the very constitution now ascribed to the Röntgen radiation, except that the impulse would have to be less condensed. The absence of refraction and diffraction of these rays could therefore be attributed to the extreme shortness of their waves.—*Nature*, April 28, 1898. J. T.

12. *A Method of Measuring the Pressure at Any Point on a Structure, due to wind blowing against that Structure*, vol. viii, No. 1, of the Transactions of the Acad. of Science of St. Louis; by FRANCIS E. NIPHER.—This paper describes a collecting device which is unaffected by wind, but responds to any change in pressure due to wind. When the collector is held in wind in the free air, the gauge with which it is connected shows no effect, but it responds at once if the collector is sheltered by the hand, or if the hand be held to leeward of the collector.

The author has also checked the device by determining either directly or by interpolation the pressure at 108 points on the front and an equal number of points on the back of a pressure board having an area of 3x4 feet. The results check to within about one per cent., with the simultaneous measurements, by a spring balance, of the force required to hold the pressure board in position. The author concludes that the instrument may be used in determining the distribution of pressures over large and important structures, about which little is at present known.

The experiments were made from the roof of a railway car, at speeds of 54 miles per hour and less.

II. GEOLOGY AND MINERALOGY.

1. *Geological Survey of New Jersey. The Physical Geography of New Jersey*; by ROLLIN D. SALISBURY, with appendix by CORNELIUS C. VERMEULE, Vol. IV of the Final Report of the State Geologist, pp. 1-200, relief map. Plates i-xv with extras 24 in all, figures in text 1-37, 1898.—Professor Salisbury has shown in this report the intimate relationship existing between the physical geographical features of a region and the geological history it has undergone in the past. Its mountains, valleys, ridges, plains, lakes and rivers, are traced to their origins in the original geological formation underlying the surface, and their gradation, and the distribution of the derived materials to form new sheets of geological deposits. The guidance of the course of changes by the differential uplifts and submergences and emergences, and by the surface contours and relative hardness of the rocks is traced; and thus the successive stages in the history of the region are portrayed. The text is fully illustrated by profiles and illustrations of landscape. A large colored profile map of the state accompanies the report, which was prepared under Mr. Vermeule's supervision. "It is based upon the topographical survey, and is therefore an accurate picture of the surface relief. . . . A leading object in the publication of the map has been to put it in every school-house in the state as

an aid in the study of geography," and to stimulate inquiry into the origin of the topographic forms so graphically illustrated. Mr. Vermeule's appendix consists of valuable statistical tables on topography and magnetism, etc.

H. S. W.

2. *The Cretaceous of Athabasca River*; by J. B. TYRRELL. (Ottawa Naturalist, vol. xii, No. 2, pp. 37-41.)—Mr. Tyrrell gives an abstract of the results of his explorations of the geology of the Athabasca region west of Hudson Bay. The study of the fossils collected has led him to modify the classification of the Cretaceous reported by Mr. McConnell as follows, viz:

"The paleontological evidence thus appears to show that it is necessary to modify Mr. McConnell's correlation of the Cretaceous of the Athabasca River to the extent of taking all the beds below the base of the Pelican Shales out of the Colorado Group, and of grouping together the Grand Rapid Sandstone, the Clear-water Shales, and the "Tar Sands" as one formation. This is a marine formation, stratigraphically equivalent to the Dakota, the fossils of which are practically the same throughout, and although no corresponding marine fossils are known elsewhere in the west, it appears to represent the marine conditions of the Dakota Period.

3. *The Mineral Resources of the United States for 1896*; by DAVID T. DAY.—Part V of the Eighteenth Annual Report of the United States Geological Survey, 1896-97 (Charles D. Walcott, Director) has recently been distributed. This promptness of publication, which we have noticed in regard to the earlier issues of the same work, deserves high commendation and enhances much the value of the material here brought together. This report is in two volumes, the first of which includes metallic products and coal; the second non-metallic products (except coal). The work has been carried on in the same lines as hitherto and includes contributions from a considerable number of workers. It is impossible to do more here than call general attention to it and indeed those interested are too well aware of its value to require more than this.

4. *Artificial Production of Diamond in Silicates corresponding to the Actual Mode of Occurrence in South Africa*.—The following abstract of an important paper by DR. I. FRIEDLÄNDER is quoted from the last number of the Geological Magazine. "In the recent diamond-making experiments of M. Moissan, fused iron rich in carbon was allowed to cool in such a way that the separation of the excess of carbon took place under pressure, and it was thought that a high pressure was necessary to the success which had been attained. It is now known that the necessary pressure is not very high, for microscopic diamonds have been found as normal constituents of ordinary cast iron. In South Africa no iron is present in the metallic state in the diamond-bearing rock, although it is largely present as a chemical constituent of the stony matter. Hence, in regarding Moissan's method as being possibly identical with the one by which the South

African diamonds had been formed, it was necessary to surmise that the crystals, after formation in the molten iron at some great depth below the earth's surface, had floated into the molten silicate-material above. It was, however, soon pointed out that the diamond-bearing rock, if in a state of fusion at small pressure, dissolves any diamonds contained in it."

Dr. Friedländer fused a small piece of olivine, a centimeter in diameter, by means of a gas-blowpipe, kept the upper portion in the molten state for some time by playing upon it with the flame, and stirred it with a little rod of graphite. After solidification the silicate was found to contain a vast number of microscopic crystals, but only in the part which had been in contact with the carbon. These Dr. Friedländer has subjected to a careful examination. They are octahedral or tetrahedral in form, are unattacked by hydrofluoric and sulphuric acids, have a high refractive index, sink slowly in methylene-iodide, burn away when heated in a current of oxygen, and are unaltered if heated in a current of carbonic acid: the stony matter containing them scratches corundum. Hence Dr. Friedländer infers that they are diamond, and that the South African diamond may have been actually formed, as already suggested, by the action of a molten silicate, such as olivine, on graphite: carbonaceous shales are interrupted by the diamond-bearing rock, and numerous fragments of the shale, much altered, are found enclosed in the rock itself. The paper is illustrated with seven micro-photographs.

5. *Contribution to the Petrography of the Boston Basin*; by T. G. WHITE (Proc. Boston Soc. Nat. Hist., vol. xxviii, 117-156, 1897).—This article contains the results of a study under the microscope of the petrographic characters of the complex of rocks occurring in the Boston Basin district, especially those of igneous types, and will be found of interest and service to those engaged in the study of the local geology of that region. L. V. P.

III. BOTANY.

1. Mr. WALTER GARDINER, of Clare College, Cambridge, continues in the *Proceedings of the Royal Society*, for Oct. 29th, his researches into *the structure of the cell-wall*, with special reference to the mode of communication between cells. In 1883, Mr. Gardiner pointed out the simple methods of demonstrating protoplasmic intercommunication in plants, and opened up a plain path in which he has had many followers. It became evident early in the minute study of this subject that the lines of communication were by no means as simple as were at first naturally thought. Improved methods of staining brought out new features, and these suggestions led to still further advance. During all this period Mr. Gardiner has devoted much time to the improvement of methods, and he now publishes a preliminary paper on his latest technique. In brief, the present method is as follows: after causing the cell-walls to swell by any one or all three of the agents usually employed, namely, picric acid, zinc chloride, or

sulphuric acid, he uses Kolossow's reagent, commonly described as osmic-acid-uranium-nitrate, as a fixative, and then stains with safranin or its equivalent. As a preservative he has had excellent results with thymol water. For details and for the important inferences, the reader is referred to the paper itself. The paper indicates the magnitude of the work still to be done in this direction, and suggests well-tried methods for the work. The most interesting generalization in the paper is that in regard to the sieve-cells, which are regarded by the author as presenting, on the whole, but slight differences from certain other active elements.

G. L. G.

2. *The Phytogeography of Nebraska: I. General Survey*; by R. POUND, Ph.D., Director of the Botanical Survey of Nebraska, and F. E. CLEMENTS, A.M., Assistant Instructor in Botany, University of Nebraska. Lincoln, Nebraska, 1898. (Jacob North & Co.)—This interesting work is a substantial contribution to our knowledge of North American plants. While making themselves familiar with the Flora of Nebraska, the authors undertook the serious task of examining the species with relation to the surroundings. The results of their exhaustive study are presented here in a form wholly creditable to American science; there is no pretension about the volume; it assumes to be simply an account of the diversified vegetation of a single state, with respect to origin, distribution and adaptation. A sound sense of proportion and perspective characterizes the entire general survey thus given. With some of the minor matters we do not agree, but we accept freely the fact that the authors have acted according to their best judgment, and since they have investigated this disputed matter on the spot, we are inclined to give great weight to their decisions. The philosophic spirit and clear insight which mark the volume give it much value as an aid in the further prosecution of State botanical surveys. Since there is not a dull chapter in the whole treatise, it can be recommended to general students who may desire to see what new life has been infused into dry details of form and habitation of plants, and it will be accepted by botanists as a distinct and valuable contribution to ecology.

G. L. G.

3. *A Text-book of Botany*; by Drs. STRASBURGER, SCHIMPER, NOLL and SCHENCK of the University of Bonn. Translated from the German by H. C. Porter, Ph.D., Assistant Instructor of Botany, University of Pennsylvania. London and New York, 1898. (The Macmillan Company.)—The German edition of this admirable work has been already reviewed in this Journal. Attention was then called to its excellence as an ideal text-book, and emphasis was laid on the clearness and succinctness with which the essentials of modern botany are presented in it.

We have now to notice the same work in an unexceptionable English dress. The translator has borne steadily in mind the maxim that an exact translation must make short work of idioms. In this case, the translator has broken up sentences into frag-

ments, and has consolidated fragmentary sentences, with a freedom which lends much charm to the whole work. Some of the English words chosen do not seem to us to be the most felicitous equivalents, but so far as a pretty careful search has gone, no misleading renderings have been observed. The authors may be congratulated on their choice of a translator who carries their useful work into a wider circle of students and general readers, and we extend our sincere congratulations to the translator for the success which he has attained in his work.

G. L. G.

4. *Fossil Plants: for students of Botany and Geology*; by A. C. SEWARD, M.A., F.G.S., Lecturer in Botany in the University of Cambridge, vol. i, Cambridge, University Press. (N. Y., Macmillan, 1898.)—This work comes to us with a preface bearing the date March, 1898. The present volume consists of two parts: first, a general section, dealing with important generalia, and a second comprising the systematic treatment of certain fossil cryptogamia. The second volume promises to conclude the systematic treatment of plants, and then consider "such subjects as geological floras, plants as rock-builders, fossil plants and evolution, and other general questions connected with paleo-botany."

The historical sketch is very short and tantalizing. The author is critical and discriminating, and we should be glad to have his views as to the relative value of the works of some of the writers whom he dismisses with a mere mention. Chapter second, although very brief, brings out with great clearness some of the relations of paleobotany to botany and geology, and embodies a spirited protest against "the narrowness of view which too often characterizes paleobotanical literature." The next chapter treats of the successive strata, and is followed by an extremely interesting chapter on the preservation of plants as fossils. Then comes a frank statement of the difficulties and sources of error which environ the entire subject of determination of fossil plants. A whole chapter of the generalia is worthily devoted to a conservative statement of the vexed question of nomenclature and priority.

The systematic portion of the treatise secures confidence from the very start. Caution is shown at doubtful points, and the reader is at such places put properly on his guard, but where the pathway, although obscure, is safe, the author speaks boldly. Moreover, the style is attractive and the tone throughout is philosophical. We shall wait impatiently for the completion of the useful work.

G. L. G.

5. *Contributions to Japanese Characeæ*; by T. F. ALLEN, LL.D.—In the midst of the cares incident to an exacting practice of the medical profession, Dr. Allen continues his fruitful studies of the Order Characeæ. The present work is on the same lines as his former valuable contributions, and exhibits independent treatment, especially in the demarcation of the limits of species. It is earnestly to be hoped that he will continue to derive recreation from researches which are of so much importance to botanists.

G. L. G.

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Wind pressure measured, Nipher, 468.

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X-rays, impulse theory, Thomson, 301.

literature, bibliography, Phillips, 71.

source of, Trowbridge and Burbank, 129.

and mineral phosphorescence, Burbank, 53.

See also *Röntgen Rays*.

Z

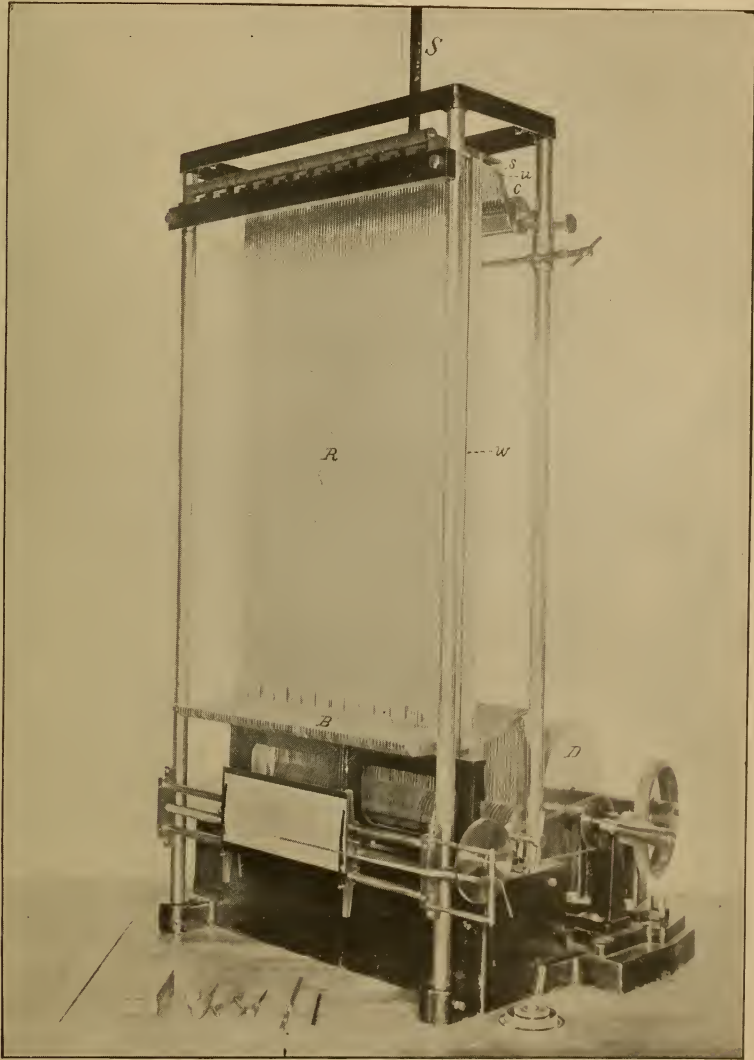
Zoology, international congress, 1898, 238.

text-book, Parker and Haswell, 319.

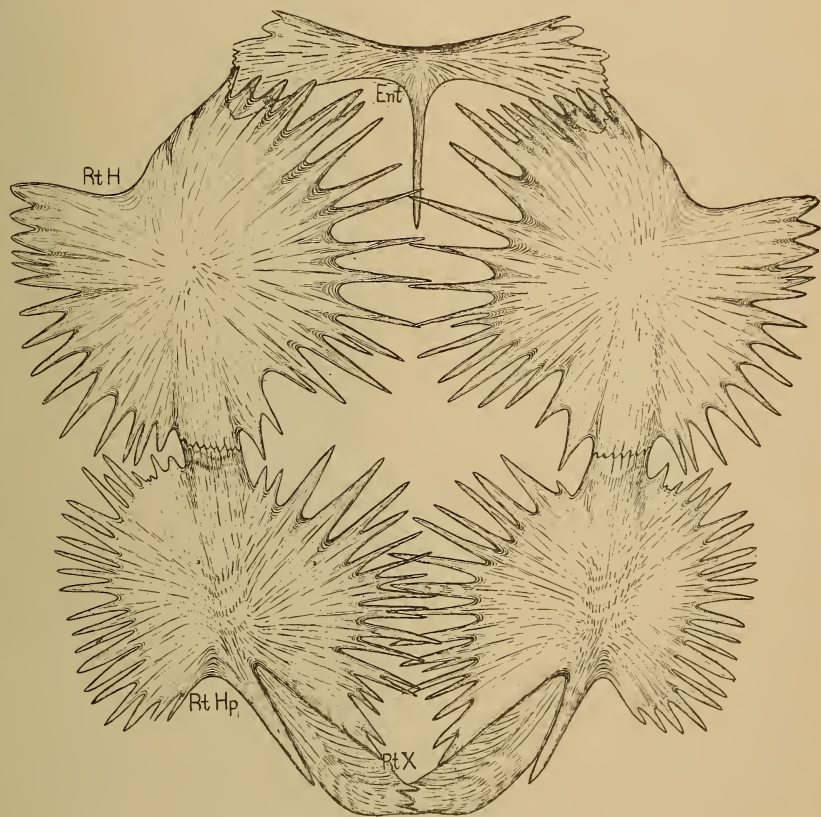
ERRATA TO THE MARCH NUMBER.

p. 191, line 17 from bottom, after *mineral*, add *with zircon*.

p. 192, line 6 from top, for *magnetic* read *magnatic*.



A NEW HARMONIC ANALYZER.



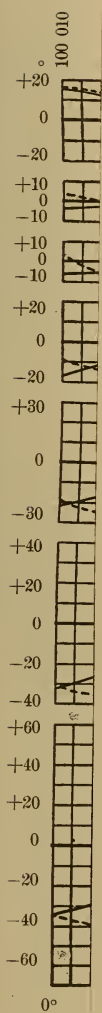
THE PLASTRON OF *PROTOSTEGA ISCHYRA* (Wieland).

The under or external view of a series of elements, all of which were found in contact relatively in the above position and beneath all other skeletal parts present.

One-twentieth natural size.

- | | | | |
|---|---------|---|-------------------------|
| { | Rt. H | = | Right Hyoplastron. |
| { | Rt. Hp. | = | " Hypoplastron. |
| { | Rt. X. | = | " Xiphiplastron. |
| { | Ent. | = | The Entepiplastron (?). |

Am.



Th

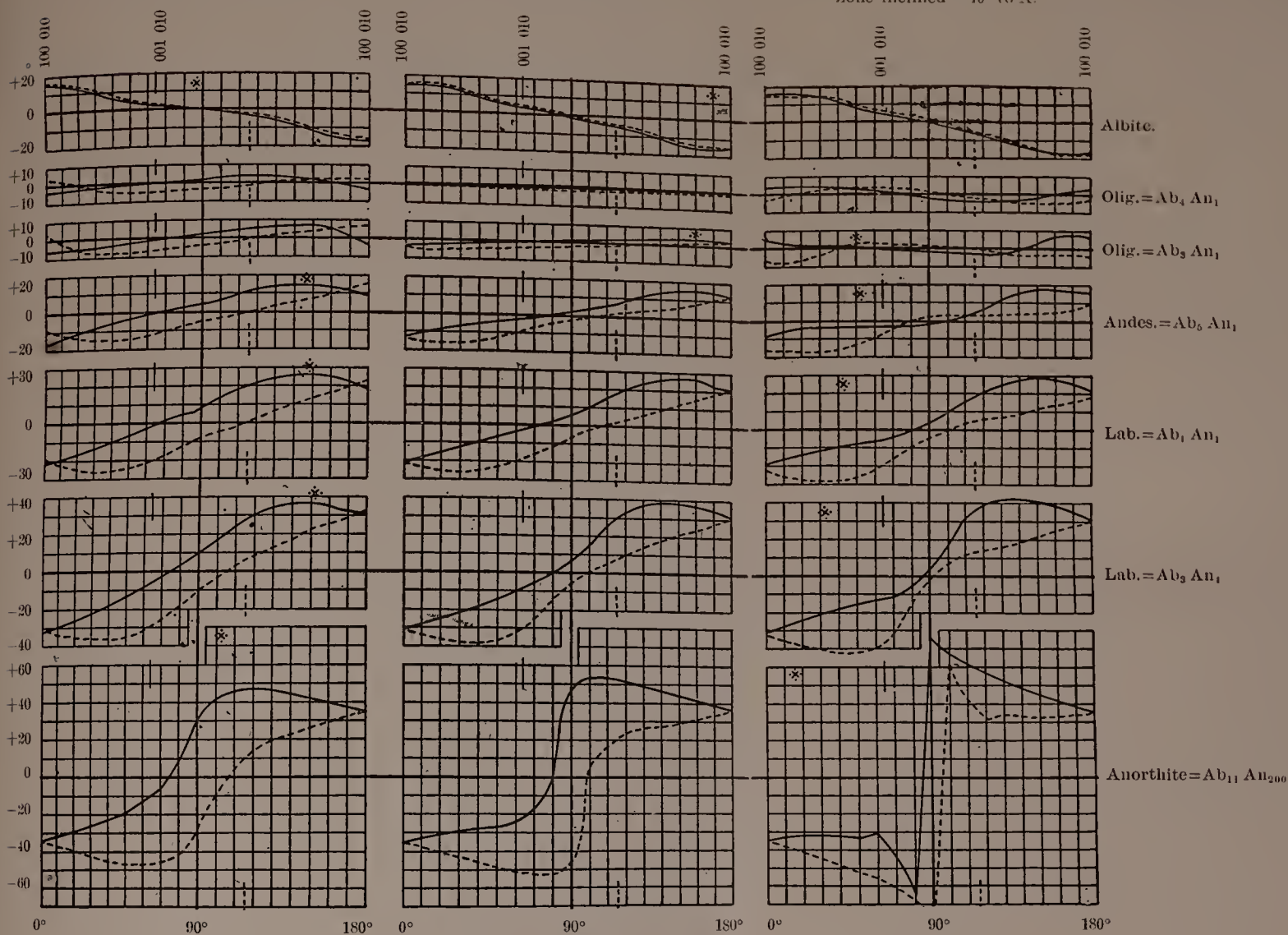
Th

Th

Zone inclined $+10^\circ$ to A.

Zone A, \perp 010.

Zone inclined -10° to A.



EXTINCTION OF TRICLINIC FELDSPARS IN AND NEAR THE ZONE \perp 010.

Compiled from M. Michel-Lévy's *Étude sur la détermination des Feldspaths*, 1894, Plates I-VII.

The extinctions are referred to the trace of the twinning plane and are represented by ordinates. The zero point of the zone answers to the front edge of the prism.

The full line shows the extinction of an untwinned crystal, or of one lamella of an albite twin. The dotted line shows the extinction of an associated lamella rotated according to both the albite law and the Carlsbad law.

The stars (*) are placed on ordinates answering to most frequent extinctions, the abscissas corresponding nearly to the crystallographic position of these points.

1.



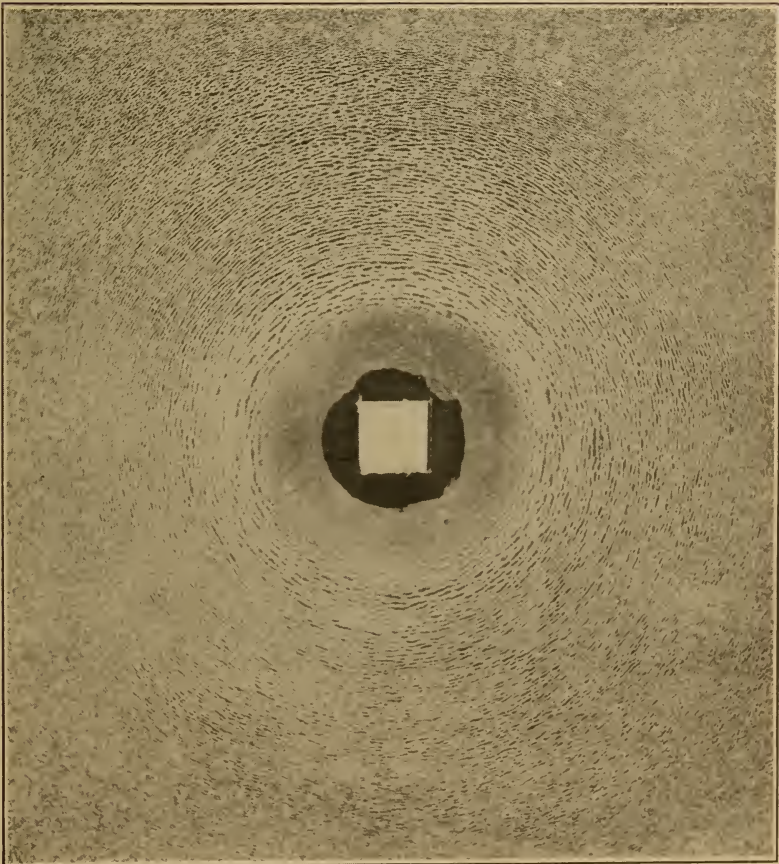
2.



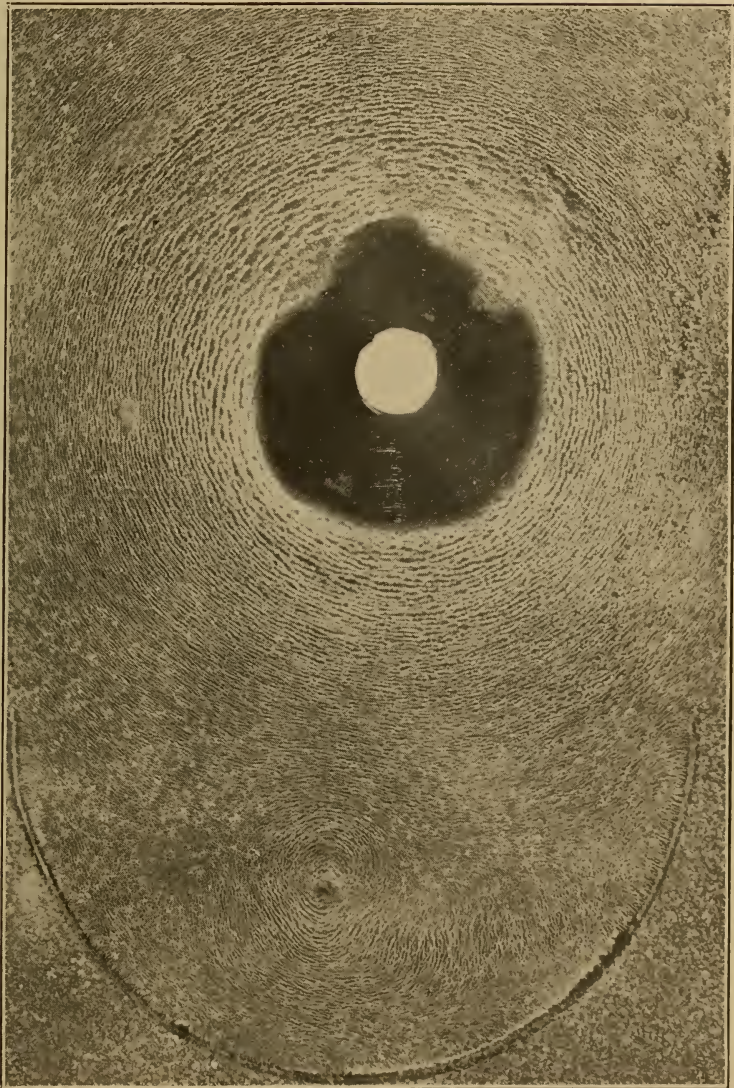
3.



4.



5.



MR. ENGLISH'S EUROPEAN TRIP



It will interest our customers to learn that Mr. English's European trip, just ended, has proved to be the most successful one in the history of our business. The trip was planned with the aim of adding largely to our stock of each of the five classes of minerals enumerated below. As the amount of material secured has been far greater than we expected, and as Mr. English's return home has been consequently delayed, the bulk of the fine specimens will not be on sale before July.

EXTRA FINE CABINET SPECIMENS.

We merely mention at present a very few of the minerals which will be on sale by June, leaving for next month some of our most important announcements.

- Dioptase**; a few choice groups
- Pyromorphite, Ems**; a number of exceptionally good specimens.
- Manganite**; several extra fine Ilfeld groups.
- Cassiterite**; groups of superb, large and brilliant crystals and twins.
- Torbernite**; a few of the showiest and best crystallized ever in stock.
- Chalcociderite**; a fine lot of specimens, much better than ever before.
- Camphylite**; quite a number of good old-time specimens.

LOOSE CRYSTALS.

We were surprised to find so few really good crystals among European dealers, nevertheless by securing a few here and a few there, and by personal visits to localities, we have made large and most important additions to our stock, which is now unquestionably by far the best in the world.

- Sphene**; a large lot of choice twins of two different types.
- Epidote, Tyrol**; a fine lot of single and twin crystals.
- Vesuvianite, Wilui**; a little lot of those very choice and rare crystals.
- Cuprite, Chessy**; large dodecahedrons, modified octahedrons, etc.
- Emerald, Bogota**; one fine, little, gemmy, crystal.
- Boracite**; a splendid assortment of the best crystals ever found.

RARE SPECIES.

Our purchases embrace approximately 400 distinct species, the great rarity of many of which has, of course, made it possible to secure only one or two, or, at most, a very few specimens of each, while of others we have obtained a good supply. We have room to name but a very few:

Argentopyrite	Dyscrasite	Greenockite (xled)	Palladium
Argyrodite	Epiboulangerite	Gonnardite (new)	Rittingerite
Aikinite	Ettringite	Homilite	Skutterudite
Calomel	Euclase	Hielmite	Sternbergite
Connellite	Fuggerite (new)	Lehrbachite	Vauquelinite

CHEAP EDUCATIONAL SPECIMENS.

We would call special attention to our large accessions of low-priced, yet thoroughly illustrative specimens for students. These have been most carefully selected by Mr. English, and our prices will be found lower and our stock better than ever before.

NEW MINERALS FOR BLOWPIPE ANALYSIS.

Our standard is so much higher than that of any other house that experience has taught us not to buy European minerals without first examining them, as a large proportion are always below our standard. From several new sources of supply we have selected much excellent material never before in stock. Our new list will be the most extensive one ever issued, and our prices lower than ever, owing to the larger quantities which our rapidly increasing trade enables us to buy. Further information and price lists on application.

GEO. L. ENGLISH & CO., Mineralogists;
64 East 12th St., New York City.

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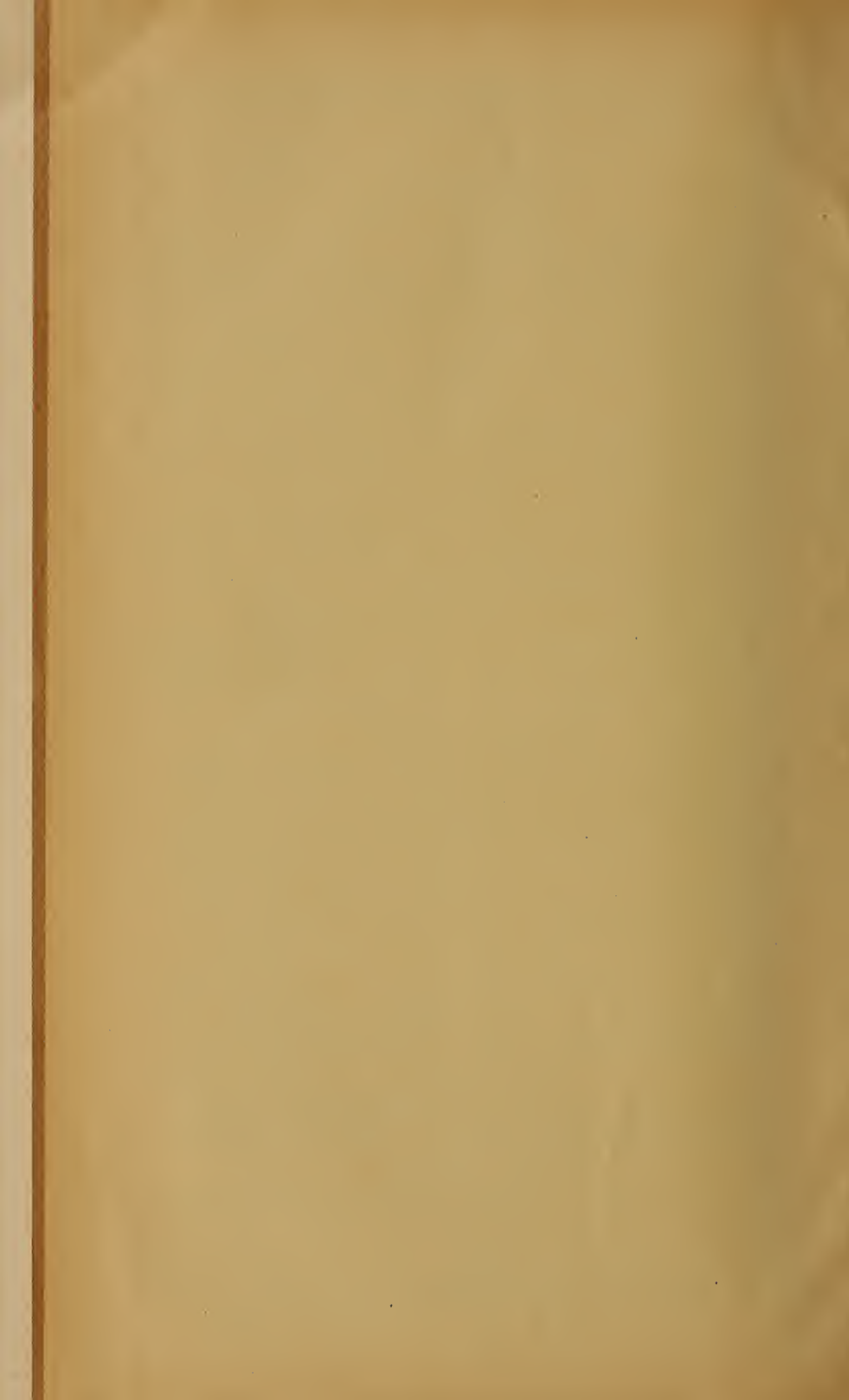
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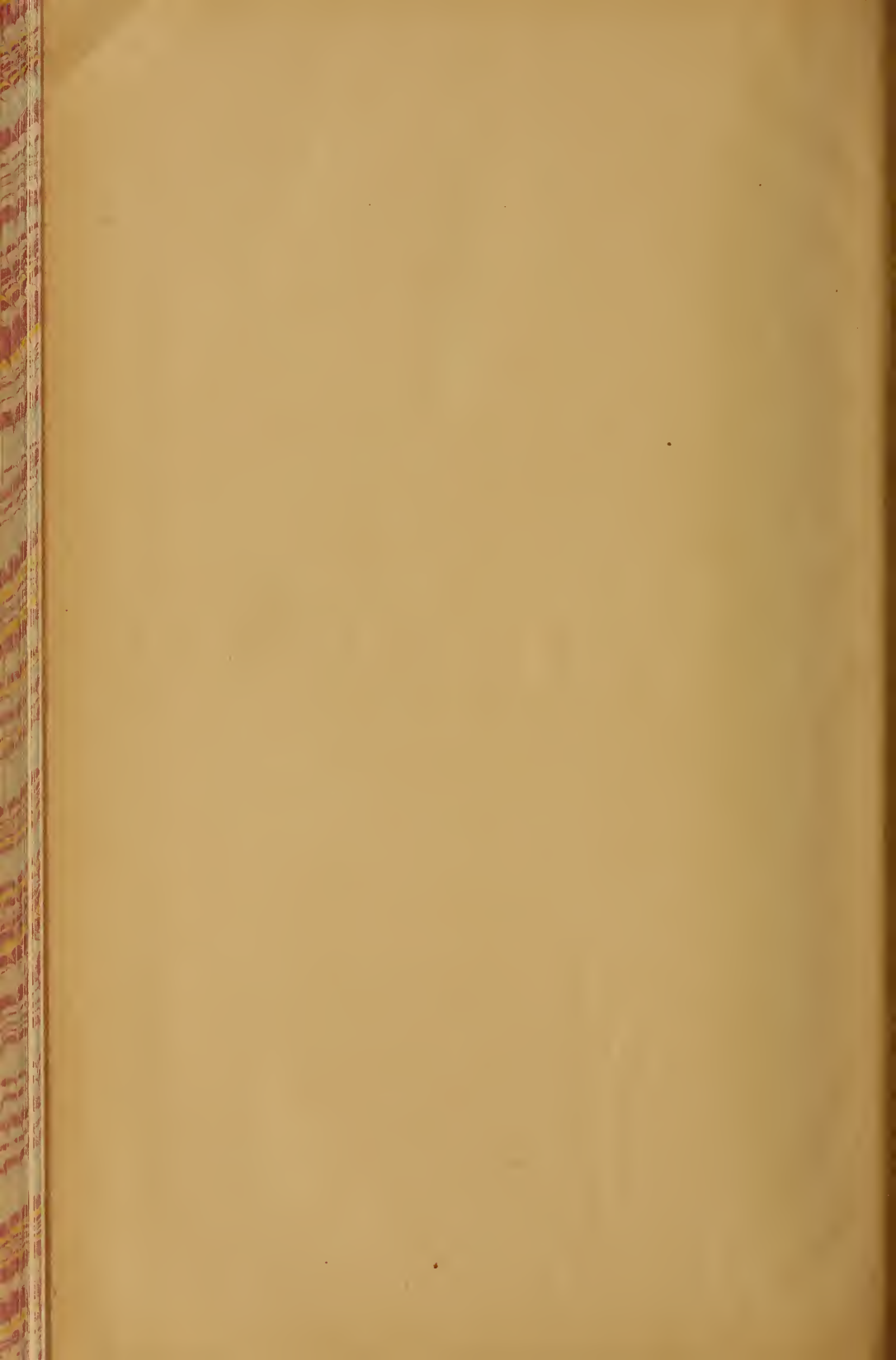
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