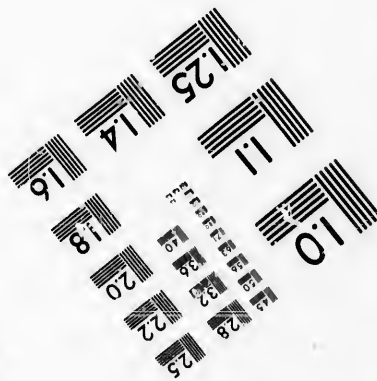
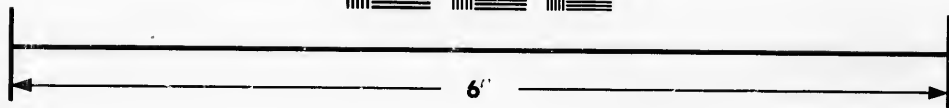
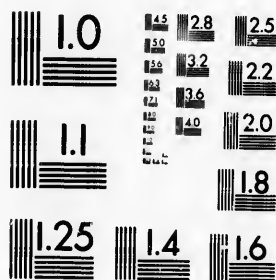


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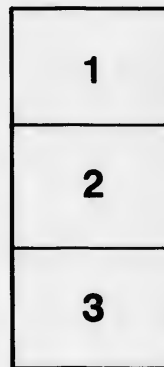
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ON
SOME POINTS IN AMERICAN GEOLOGY.

BY
T. STERRY HUNT, M.A., F.R.S.,
OF THE GEOLOGICAL SURVEY OF CANADA.

(From the American Journal of Science for May 1861.)

The recent publication of two important volumes on American geology seems to afford a fitting occasion for reviewing some questions connected with the progress of geological science, and with the history of the older rock formations of North America. The first of these works is the third volume of the Palæontology of New York by James Hall; we shall not attempt the task of noticing the continuation of this author's labors in the study of organic remains, labors which have by common consent placed him at the head of American palæontologists, but we have to call attention to the introduction to this 3rd volume, where in about a hundred pages Mr. Hall gives us a clear and admirable summary of the principal facts in the geology of the United States and Canada, followed by some theoretical notions on the formation of mountain chains, metamorphism and volcanic phenomena, where these questions are discussed from a point of view which we conceive to be of the greatest importance for the future of geological science. A publication of this introduction in a separate form, with some additions, would we think be most acceptable to the scientific public.

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The other work before us is Prof. H. D. Rogers' elaborate report on the geology of Pennsylvania, giving the results of the Survey of that State for many years carried on under his direction, and embracing a minute description of those grand exhibitions of structural geology, which have rendered that State classic ground for the student. The volumes are copiously illustrated with maps, sections and figures of organic remains, and the admirable studies on the coal fields of Pennsylvania and Great Britain add much to its value.

The oldest series of rocks known in America is that which has been investigated by the officers of the Geological Survey of Canada, and by them designated the Laurentian system. It is now several years since we suggested that these rocks are the equivalents of the oldest crystalline strata of western Scotland and Scandinavia.* This identity has since been established by Sir R. I. Murchison in his late remarkable researches in the north-western Highlands, and he has adopted the name of the Laurentian system for these ancient rocks of Ross, Sutherland, and the Western Islands, which he at first called fundamental gneiss.† These are undoubtedly the oldest known strata of the earth's crust, and therefore offer peculiar interest to the geologist. As displayed in the Laurentide and Adirondaek mountains, they exhibit a volume which has been estimated by Sir William Logan to be equal to the whole palæozoic series of North America in its greatest development. The Laurentian series consists of gneiss, generally granitoid, with great beds of quartzite, sometimes conglomerate, and three or more limestone formations, (one 1000 feet in thickness) associated with dolomites, serpentines, plumbago, and iron ores. In the upper portion of the series an extensive formation of rocks, consisting chiefly of basic feldspars without quartz and with more or less pyroxene, is met with. The peculiar characters of these latter strata, not less than the absence of argillites and talcose and chloritic schists, conjoined with various other mineralogical characteristics seem to distinguish the Laurentian series throughout its whole extent, so far as yet studied, from any other system of crystalline strata. It appears not improbable that future researches will enable us to divide this series of rocks into two or more distinct systems.

* *Esquisse Géologique du Canada*, 1855, p. 17.

† *Quar. Journal Geol. Society*, vol. xv, 353; xv.; 215.

Overlying the Laurentian series on Lake Huron and Superior, we have the Huronian system, about 10,000 feet in thickness, and consisting to a great extent of quartzites, often conglomerate, with limestones, peculiar slaty rocks, and great beds of diorite, which we are disposed to regard as altered sediments. These constitute the lower copper-bearing rocks of the lake region, and the immense beds of iron ore at Marquette and other places on the south shore of Lake Superior have lately been found by Mr. Murray to belong to this series, which is entirely wanting along the farther eastern outcrop of the Laurentian system. This Huronian series appears to be the equivalent of the Cambrian sandstones and conglomerates described by Murchison, which form mountain masses along the western coast of Scotland, where they repose in detached portions upon the Laurentian series.

Besides these systems of crystalline rocks, the latter of which is local and restricted in its distribution, we have along the great Appalachian chain, from Georgia to the Gulf of St. Lawrence, a third series of crystalline strata, which form the gneissoid and mica slate series of most American geologists, the hypozoic group of Prof. Rogers, consisting of feldspathic gneiss, with quartzites, argillites, micaceous, epidotic, chloritic, talcose and specular schists, accompanied with steatite, diorites and chromiferous ophiolites. This group of strata has been recognized by Safford in Tennessee, by Rogers in Pennsylvania, and by most of the New England geologists as forming the base of Appalachian system, while Sir William Logan, Mr. Hall, and the present writer have for many years maintained that they are really altered palæozoic sediments, and superior to the lowest fossiliferous strata of the Silurian series. Sir William Logan has shown that the gneissoid ranges in Eastern Canada have the form of synclinals, and are underlaid by shales which exhibit fossils in their prolongation, while his sections leave no doubt that these ranges of gneiss, with micaceous, chloritic, talcose and specular schists, epidotes, quartzites, diorites and ophiolites, are really the altered sediments of the Quebec group, which is a lower member of the Silurian series, corresponding to the Calciferous and Chazy formations of New York, or to the Primal and Auroral series of Pennsylvania. Prof. Rogers indeed admits that these are in some parts of Pennsylvania metamorphosed into feldspathic, micaceous and talcose rocks, which it is extremely difficult to distinguish from the hypozoic gneiss, which latter, however, he conceives to present a want of conformity with the palæozoic strata.

To this notion of the existence of two groups of crystalline rocks similar in lithological character but different in age, we have to object that the hypozoic gneiss is identical with the Green Mountain gneiss, not only in lithological character, but in the presence of certain rare metals, such as chrome, titanium, and nickel which characterise its magnesian rocks; all of these we have shown to be present in the unaltered sediments of the Quebec group, with which Sir William Logan has identified the gneiss formation in question. Besides which the lithological and chemical characters of the Appalachian gneiss are so totally distinct from the crystalline strata of the Laurentian system, with which Prof. Rogers would seem to identify them, that no one who has studied the two can for a moment confound them. Prof. Rogers is therefore obliged to assume a new series of crystalline rocks, distinct from both the Laurentian and Huronian systems, but indistinguishable from the altered palæozoic series, or else to admit that the whole of his gneissic series in Pennsylvania is, like the corresponding rocks in Canada, of palæozoic age.* We believe that nature never repeats herself without a difference, and that certain variations in the chemical and mineralogical constitution of sediments mark successive epochs so clearly that it would be impossible to suppose the formation in adjacent regions of a series of crystalline schists like those of the Alleghanies contemporaneous with the sediments which produced the Laurentian system. We have elsewhere indicated the general principles upon which is based this notion of

* Dr. Bigsby in 1824 described an extensive tract of gneissoid rocks on Rainy Lake and Lake Lacroix, north of Lake Superior. The general course of the strata he states to be "from N. W. to N. by W., with a corresponding easterly dip;" but he elsewhere speaks of the gneiss as running (dipping?) E. N. E. This gneiss often contains beds and disseminated grains of hornblende, and passes in some places into micaceous, chloritic and greenstone slates, and syenite. Staurotide is abundant in the mica schists, and octahedral iron occurs in the chloritic slates. A porphyritic granite containing beryl is also met with in this region. This gneiss is regarded by Dr. Bigsby as belonging "to transition rocks, from its constant proximity to red sandstone, the oldest organic limestone, and trap." (*Am. Jour. Sci.*, (1) viii, 61). The lithological and mineral characters of these crystalline strata seem to be distinct from those of the Laurentian system, and to resemble those of the Appalachians. Too much praise cannot be ascribed to Dr. Bigsby for his early and extensive observations on the geognosy and mineralogy of British North America.

a progressive change in the composition of sediments, and shown how the gradual removal of alkalis from aluminous rocks has led to the formation of argillites, chloritic and epidotic rocks, at the same time removing carbonic acid from the atmosphere, while the resulting carbonate of soda by decomposing the calcareous and magnesian salts of the ocean, furnished the carbonates for the formation of limestones and dolomites, at the same time generating sea salt.*

Closely connected with these chemical questions is that of the commencement of life on the earth. The recognition beneath the Silurian and Huronian rocks of 40,000 feet of sediments analogous to those of more recent times, carries far back into the past the evidence of the existence of physical and chemical conditions, similar to those of more recent periods. But these highly altered strata exclude, for the most part, organic forms, and it is only by applying to their study the same chemical principles which we now find in operation that we are led to suppose the existence of organic life during the Laurentian period. The great processes of deoxydation in nature are dependent upon organization; plants by solar force convert water and carbonic acid into hydrocarbonaceous substances, from whence bitumens, coal, anthracite and plumbago, and it is the action of organic matter which reduces sulphates, giving rise to metallic sulphurets and sulphur. In like manner it is by the action of dissolved organic matters that oxyd of iron is partially reduced and dissolved from great masses of sediments, to be subsequently accumulated in beds of iron ore. We see in the Laurentian series beds and veins of metallic sulphurets, precisely as in more recent formations, and the extensive beds of iron ore hundreds of feet thick which abound in that ancient system, correspond not only to great volumes of strata deprived of that metal, but as we may suppose, to organic matters, which but for the then greater diffusion of iron oxyd in conditions favourable for their oxydation, might have formed deposits of mineral carbon far more extensive than those beds of plumbago which we actually meet with in the Laurentian strata.

All these conditions lead us then to conclude to the existence of an abundant vegetation during the Laurentian period, nor are there wanting evidences of animal life in these oldest strata. Sir William Logan has described forms occurring in the Laurentian

* Am. Journal of Science (2) xxv. 102, 445. xxx. 133; Quar. Journal Geol. Soc. xv. 488, and Can. Naturalist, December 1859.

limestone which cannot be distinguished from the silicified specimens of *Stromatopora rugosa* found in Lower Silurian rocks. They consist of concentric layers made up of crystalline grains of white pyroxene in one case and of serpentine in another, the first imbedded in limestone and the second in dolomite; we may well suppose that the result of metamorphism would be to convert silicified fossils into silicates of lime and magnesia. The nodules of phosphate of lime in some beds of the Laurentian limestones also recall the phosphatic coprolites which are frequently met with in Lower Silurian strata, and are in the latter case the exuviae of animals which have fed upon *Lingula*, *Orbicula*, *Conularia* and *Serpulites*, the shells and tubes of which we have long since shown to be similar in composition to the bones of vertebrates.* So far therefore from looking upon the base of the Silurian as marking the dawn of life upon our planet, we see abundant reasons for supposing that organisms, probably as varied and abundant as those of the palæozoic age, may have existed during the long Laurentian period.

Along the northern rim of the great palæozoic basin of North America the Potsdam sandstone of the New York geologists is unquestionably the lowest rock from below Quebec to the Island of Montreal, and thence passing up the valley of Lake Champlain and sweeping round the Adirondack mountains, until it reënters Canada and soon disappears to the north of Lake Ontario, where the Birdseye and Black River limestones repose directly upon the Laurentian rocks, and furthermore overlie the great Lake Superior group of slates and sandstones, which reposing on the unconformable Huronian system, constitute the upper copper-bearing rocks of this region. This Lake Superior group, as Sir William Logan remarks, may then include the Potsdam, Calciferous and Chazy, and thus be equivalent in part to the Quebec group hereafter to be described.

Passing westward into the Mississippi valley we again find a sandstone formation, which forms the base of the palæozoic series, and is considered by Mr. Hall to be the equivalent of the Potsdam. Here it occasionally exhibits intercalated beds of silico-argillaceous limestone, in which occur abundant remains of trilobites of the genera *Dikellocephalus*, *Menocephalus*, *Arionellus*, and *Conocephalus*. Passing upwards this sandstone is succeeded by the Lower Magnesian limestone, which is the equivalent of the Calciferous sand-

* Logan and Hunt, Am. Jour. Sci. (2) xvii. 235.

rock of New York, and in Missouri, where it is the great metaliferous formation, alternates several times with a sandstone, constituting the Magnesian Limestone series, which in Missouri attains a thickness of 1300 feet. The same thing is observed to a less degree in Wisconsin and Iowa; throughout this region the higher beds of the Potsdam sandstone are often composed of rounded oolitic granules, and the beds of passage are frequently of such a character as to lead to the conclusion that they have been deposited from silica in solution, and are not mechanical sediments.* For a discussion of some facts with regard to the chemical origin of many silicious rocks, see Am. Journal of Science, (2) xviii. 381.

Evidences of disturbance during the period of its deposition are to be found in the brecciated beds, sometimes fifty feet in thickness, which occur in the Calciferous sandrock of the north-west, and are made up of the ruins of an earlier sandstone. In Missouri, the Birdseye and Black River limestones repose directly upon the Lower Magnesian limestone, while further north a sandstone intervenes, occupying the place of the Chazy limestone.

The Potsdam sandstone of the St. Lawrence valley, has for the most part the character of a littoral formation, being made up in great part of pure quartzose sand, and offering upon successive beds, ripple and wind marks, and the tracks of animals. Occasionally it includes beds of conglomerate, or as at Hemmingford, encloses large rounded fragments of green and black shale; it also exhibits calcareous beds apparently marking the passage to the succeeding formation, which although called a Calciferous sandrock, is for the most part here, as in the west, a magnesian limestone, often geodiferous, and including calcite, pearl spar, gypsum, barytes and quartz. Sir William Logan had already shown that the fauna of the Potsdam and Calciferous in Canada are apparently identical, (Can. Naturalist June 1860, Am. Jour. Sci. [2] xxxi. 18), and Mr. Hall has arrived at the same conclusion with regard to the more extended fauna of these formations in the valley of the Mississippi, so that these two may be regarded as forming but one group. While in the west *Dikellocephalus* occurs both in the lower sandstones and the magnesian limestones, *Conocephalus minutus*, found in the Potsdam on Lake Champlain, and identified by Mr. Billings, has lately been

* See Mr. Hall's Introduction, to which we are indebted for many of these facts regarding the formations of the west, and also the Reports of the Geological Survey of Missouri.

detected by him in specimens from the sandstones of Wisconsin with *Dikellocephalus*, which genus has there been found to pass upwards into the magnesian limestones. On the other hand, the sandstones of Bastard in Canada, having the characters of the Potsdam, contain *Lingula acuminata* and *Ophileta compacta*, species regarded as characteristic of the Calciferous, together with two undescribed species of *Orthoceras*, and in another locality a *Pleurotomaria* resembling *P. Laurentina*. The researches of Mr. Billings have extended the fauna of the Calciferous in Canada to forty-one species, and the succeeding Chazy formation to 129 species. The thickness of this latter division in the St. Lawrence valley is about 250 feet, and it includes in its lower part about fifty feet of sandstones with green fucoidal shales and a bed of conglomerate. The Calciferous has a thickness of about 300 feet, while the Potsdam may be estimated at not far from 600 feet.

We have then seen that along the north-eastern outcrop of the great American basin in Canada and New York, the base of the palæozoic series is represented by less than 1000 feet of sandstones and dolomites, reposing directly upon the Laurentian system. A very different condition of things is, however, found in the more central parts of the basin. According to Prof. Rogers, the older Primal slates, which form the base of the palæozoic system, attain in Virginia a thickness of 1200 feet, and are succeeded by 300 feet of Primal sandstone marked by *Scolithus*, which he considers the Potsdam, followed by the upper Primal slates, consisting of 700 feet of greenish and brownish talco-argillaceous shales with fucoids. To these succeed his Auroral division, consisting of sixty feet or more of calcareous sandstone, the supposed equivalent of the Calciferous sandrock, followed by the Auroral limestone, which is magnesian, and often argillaceous and cherty in the upper beds. Its thickness is estimated at from 2500 to 5500 feet, and it is supposed by Rogers to include the Chazy and Black River limestones, while the succeeding Matinal division exhibits first, from 300 to 550 feet of limestone, (Trenton), secondly, 300 to 400 feet black shale, (Utica), and thirdly, 1200 feet of shales with red slates and conglomerates, (Hudson River group), thus completing the Lower Silurian series.

In Eastern Tennessee, Mr. Safford describes, (1st.) on the confines of North Carolina, a great volume of gneissoid and micaceous rocks similar to those of Pennsylvania, succeeded to the

west by (2nd.) the Ocoee conglomerates and sandstones, with argillites, chloritic, talcose and micaceous slates, and occasional bands of limestone, all dipping, like the rocks of the 1st division, to the S. E. In the 3rd place we have the Chilhowee sandstones and shales, several thousand feet in thickness, including near the summit beds of sandstone with *Scolithus*, and considered by Mr. Safford the equivalent of the Potsdam. (4th.) The Magnesian limestone and shale group, also several thousand feet thick, and divided into three parts; first, a series of fucoidal sandstones approaching to slates and including bands of magnesian limestone; second, a group of many hundred feet of soft brownish, greenish, and buff shales, with beds of blue oolitic limestone, which as well as the shales, contain trilobites. Passing upward these limestones become interstratified with the third sub-division, consisting of heavy bedded magnesian limestone, more or less sparry and cherty near the summit. The limestones of Knoxville belong to this group, which with the 3rd or Chilhowee group is designated by Mr. Safford as Cambrian, corresponding to the Primal and Auroral of Rogers, or to the Potsdam and Calciferous sandrock, with the possible addition of the Chazy, being equivalent to the great Magnesian limestone series of Prof. Swallow in Missouri. To these strata succeed Safford's 5th formation, consisting of limestones, the equivalents of the Black River, Trenton and higher portions of the Lower Silurian.

In Eastern Canada we find a group of strata similar to those described by Rogers and Safford, and distinguished by Sir William Logan as the Quebec group. It has for its base a series of black and blue shales, often yielding roofing slates, succeeded by grey sandstone and great beds of conglomerate, with dolomites and pure limestones, often concretionary and having the character of travertines. These are associated with beds of fossiliferous limestones, and with slates containing compound graptolites, and are followed by a great thickness of red and green shales, often magnesian, and overlaid by 2000 feet of green and red sandstone, known as the Sillery sandstone, the whole from the base of the conglomerate, having a thickness about 7000 feet. These red and green shales resemble closely those at the top of the Hudson River group, and the succeeding sandstones are so much like those of the Oneida and Medina formations, that the Quebec group was for a long time regarded as belonging to the summit of the Lower Silurian series, the more so as by a great break and upthrow to

the S. E., the rocks of this group are made to overlap the Hudson River formation. "Sometimes it may overlies the overturned Utica formation, and in Vermont, points of the overturned Trenton appear occasionally to emerge from beneath the overlap."* This great dislocation is traceable in a gently curving line from near Lake Champlain to Quebec, passing just north of the fortress; thence it traverses the island of Orleans, leaving a band of higher strata on the northern part of the island, and after passing under the waters of the Gulf, again appears on the main land about eighty miles from the extremity of Gaspé, where on the north side of the break, we have as in the island of Orleans, a band of Utica or Hudson River strata. To the south and east of this line the rocks of the Quebec group are arranged in long, narrow, parallel, synclinal forms, with many overturn dips. These synclinals are separated by dark gray and black shales, with limestones, hitherto regarded as of Hudson River age, but which are perhaps the deep-sea equivalent of the Potsdam.

The presence of conglomerates and sandstones, alternating with great masses of fine shales, indicates a period of frequent disturbances, with elevations and depressions of the ocean's bottom, while the deposits of dolomite, magnesite, travertine and highly metaliferous strata show the existence of shallow water, lagoons and springs over a great area and for a long period between the formation of the upper and lower shales. We may suppose that while the Potsdam sandstone was being deposited along the shores of the great paleozoic ocean, the lower black shales were accumulating in the deeper waters, after which an elevation took place, and the magnesian strata were deposited, followed by a subsidence during the period of the upper shales and Sillery sandstones.

Associated with the magnesian strata at Point Levis and in several other localities in the same horizon of the Quebec group, an extensive fauna is found, of which 137 species are now known, embracing more than forty new species of graptolites, which have been described by Mr. James Hall in the report of the Geological Survey of Canada for 1857, and thirty-six species of trilobites described by Mr. Billings in the *Canadian Naturalist* for August 1860. These species are as yet distinct from anything found in the Potsdam below or the Birdseye and Black River above;

* See Sir William Logan's letter to Mr. Barrande, *Canadian Naturalist* for Jan. 1861, and *Am. Journal of Science* (2) xxxi. 216.

although the trilobites recall by their aspect those found by Owen in the Lower Sandstone of the Mississippi. Seven species alone out of this fauna have been identified with those known in other formations, and of these one is Chazy, while six belong to the Calciferous, to which latter horizon Mr. Billings considers the Quebec group to belong. The Chazy has not yet been identified in this region, unless indeed it be represented in some of the upper portions of the Quebec group. The Calciferous sand-rock is wanting along the north side of the St. Lawrence valley from near Lake St. Peter to the Mingan Islands, but at Lorette behind Quebec, at the foot of the Laurentides, the Birdseye limestone is found reposing conformably upon the Potsdam sandstone.

It is not easy to find the exact horizon of the Potsdam sandstone among the black shales which underlie the Quebec group. The *Scolithus* of Rogers' Primal sandstone, and of the summit of Safford's 3rd or Chilhowee formation is identical with that found in the quartz rock at the western base of the Green Mts, and figured by Mr. Hall in the 1st volume of the Palæontology. It is however distinct from what has been called *Scolithus* in the Potsdam of Canada. The value of this fossil as a means of identification is diminished by the fact that similar marks are found in sandstones of very different ages. Thus a *Scolithus* very like that of the St. Lawrence valley occurs in the sandstone of Lake Superior and in the Medina sandstone, while in Western Scotland, according to Mr. Salter, the two quartzite formations above and below the Lower Silurian limestones of Chazy age are alike characterized by these tubular markings, which are regarded by him as produced by annelids or sea-worms. We find however in shales which underlie the Quebec group at Georgia in Vermont, trilobites which were described by Mr. Hall in 1859 as belonging to the genus *Olenus*, a recognized primordial type; he has since erected them into a new genus. Again at Braintree in Eastern Massachusetts occur the well known *Paradoxides* in an argillaceous slate. These latter fossils Mr. Hall suggests probably belong to the same horizon as certain slaty beds in the Potsdam sandstone, or perhaps even at the base of this formation. (Introduction, page 9.) In this connection we must recall the similar shales of Newfoundland, in which Salter has recognized trilobites of the same genus. These shales containing *Paradoxides*, like those underlying the Quebec group, thus appear to belong to the so-called Primordial zone, and are to be regarded as the equivalents of the Potsdam

sandstone, which both on Lake Champlain and in the Mississippi valley is characterized by primordial types. The intermingling of Potsdam and Calciferous forms to which we have already alluded, seems however to show that it will be difficult to draw any well defined zoological horizon between the different portions of these lower rocks, which at the same time offer as yet no evidences of any fauna lower than that of the Potsdam. So that we regard the whole Quebec group with its underlying Primordial shales as the greatly developed representative of the Potsdam and Calciferous (with perhaps the Chazy), and the true base of the Silurian system.

The Quebec group with its underlying shales is no other than the Taconic system of Emmons. Distinct in their lithological characters from the Potsdam and Calciferous formations as developed on Lake Champlain, Mr. Emmons was led to regard these strata as belonging to a lower or sub-Silurian group. We have however shown that the palæontological evidence afforded by this formation gives no support to such a view. To Mr. Emmons is however undoubtedly due the merit of having for a long time maintained that the Taconic hills are composed of strata inferior to the Trenton limestones, brought up into their present position by a great dislocation, with an upthrow on the eastern side. We would not object to the term Taconic if used as indicating a subdivision of the Lower Silurian series, but as the name of a distinct and sub-Silurian system it can no longer be maintained. The Quebec group evidently increases in thickness as we proceed towards the south, and the calcareous parts of the formation are more developed. In 1859, I visited in company with Mr. A. D. Hager the marble quarries of Rutland and Dorset, in Vermont. The latter occur in a remarkable synclinal mountain of nearly horizontal strata of marble and dolomite, capped by shales, and attaining a height of 2700 feet above the railway station at its base. I then identified these marbles with the limestones of the Quebec group, considering them to be beds of chemically precipitated carbonate of lime or travertine, and not limestones of organic origin.

The existence of great dislocations in the Appalachian chain is amply illustrated in the sections of Prof. Rogers, and in those given by Safford in Eastern Tennessee, where by the aid of fossils it becomes comparatively easy to trace them. See the Map accompanying his *Geological Reconnaissance of Tennessee*, 1855; where the magnesian limestones of formation IV, are shown to be not

only brought up on the east against the Upper Silurian and Devonian, but even to overlap the black shales at the base of the Carboniferous system. It is remarkable to find that as early as 1822, the idea of a great dislocation of this nature in Eastern New York was maintained by Mr. D. H. Barnes in his description of Canaan Mountain. [Am. Journal of Science, (1) v. pp. 15-18.]

To the southeast of this great fault in Canada we have as yet no evidence of Lower Silurian strata higher than those of the Quebec group. At the eastern base of the Green Mts. we find limestones of upper Silurian and Devonian age reposing unconformably upon the altered strata of the Quebec group, themselves also having undergone more or less alteration. Immediately succeeding are the chistolite and mica slates of Lake St. Francis, which as we have long since stated are probably also of Upper Silurian age.

The White Mountains as we suggested in 1849, (Am. Jour. Sci. (2) ix. 19) are probably, in part at least, of Devonian age, and are the representatives of the 7000 feet of Devonian sandstone observed by Sir William Logan in Gaspé. Mr. J. P. Lesley has more recently, after an examination of the White Mts. shown that they possess a synclinal structure, and has adduced many reasons for regarding them as of Devonian age. (Amer. Mining Journal, January 1861, p. 99.)

It will be seen from what has been previously said that we look upon the 1st and 2nd divisions described by Mr. Safford in Eastern Tennessee, as corresponding to the hypozoic series of Rogers and to the Green Mountain gneissic formation, which instead of being beneath the Silurian series, is really a portion of the Quebec group more or less metamorphosed, so that we recognize nothing in New England or south-eastern Canada lower than the Silurian system, nor do we at present see any evidence of older strata, such as Laurentian or Huronian, in any part of the Appalachian chain. The general conclusions which we have previously expressed with regard to the lithological, chemical and mineral relations of the Green Mts. rocks remain unchanged. [Am. Journal of Science (2) ix. 12.]

The remarkable parallelism between the rocks of Western Scotland and Canada has already been shown in the existence of the Laurentian, and Cambrian (Huronian) systems, overlaid by quartzites containing *Scolithus*, to which succeed limestones containing a numerous fauna, identified by Mr. Salter with that of the Chazy

limestone. These strata, with an eastward dip, are covered by other quartzites and limestones, to which succeeds the great gneissoid formation of the western Highlands, consisting of feldspathic, chloritic, micaceous, and talcose schists resembling closely the gneissoid rocks of the Green Mts. and including the chromiferous ophiolites of Perthshire, Banff and the Shetland Isles.

This gneissoid series was by Prof. Nicol suggested to be the older or Laurentian gneiss brought up by a dislocation on the east of the Silurian limestones, but Sir Roderick Murchison, with Messrs. Ramsay and Harkness, has shown not only from the differences in lithological character, but from actual sections, that the eastern gneissoid series is made up of altered strata newer than the Silurian limestones.* Thus in geological structure and age, not less than in lithological and mineralogical characters, the rocks of the western Highlands are the counterparts of the Laurentian and Silurian gneiss formations, as seen in the Laurentides and Adirondacks, and in the Green Mts. The same parallelism may be extended to Scandinavia, (where Kjerulf and Forbes have shown much of the crystalline gneiss to be of Silurian age,) marking as it would seem the outer edge of a vast Silurian basin, which may be followed in the other direction across the Atlantic to the Gulf of Mexico. We also remark in Great Britain as in America, that whereas the northern outcrop of the palæozoic basin offers at its base only a series of quartzose sandstones reposing upon the Laurentian system and characterized by fucoids and *Scolithus*, we find further south in England an immense development of shales, sandstones and conglomerates, which form the base of the Silurian system and correspond to the Primordial zone and the Quebec group.

We have said that upon Lake Huron and Superior the sandstones of the upper copper-bearing rocks are the equivalents of the Quebec group. The clear exposition of the question by Mr. J. D. Whitney in the *Am. Mining Jour.* for 1860 (p. 435) left little more to be said, but the sections made last year by Mr. Alex. Murray of the Canada Geological Survey place the matter beyond all doubt. On Campment d'Ours, a small island near St. Joseph's, the sandstones of Sault St. Mary are seen reposing horizontally on the upturned edges of the Huronian rocks, and overlaid by limestones which contain in abundance the fossils of the Black River and

* Murchison, *Quar. Jour. Geol. Society*, Vol. xv. 353 and xvi. 215.

Birdseye divisions. The only fossil as yet found in these sandstones is a single *Lingula* from near Sault St. Mary, which may be either of Potsdam or Chazy age. The sandstones in question form the upper member of a series of strata which on Lake Superior attain a thickness of several thousand feet, and passing downwards we find a succession of limestones, marls and argillaceous sandstones, interstratified with greenstone and amygdaloid, and followed by about 2000 feet of bluish slates and sandstones, with cherty beds containing grains of anthracite, the whole underlaid by conglomerates, and reposing unconformably upon rocks of the Huronian system. The presence of such slates is the more significant from the occurrence already mentioned of fragments of green and black slates in the coarse grained sandstones near the base of the Potsdam, at Hemmingford mountain, showing the existence of argillaceous shales before the deposition of the quartzites of the Potsdam; these are perhaps more recent than the lowest shales of the Primordial zone, to which however, palæontologically they appear to belong.

This Quebec group is of considerable economic interest inasmuch as it is the great metalliferous formation of North America. To it belongs the gold which is found along the Appalachian chain from Canada to Georgia, together with lead, zinc, copper, silver, cobalt, nickel, chrome and titanium. I have long since called attention to the constant association of the latter metals, particularly chrome and nickel, with the ophiolites and other magnesian rocks of this series, while they are wanting in similar rocks of Laurentian age. Am. Jour. of Science (2) xxvi. 237.

The immense deposits of copper ores in Eastern Tennessee, and the similar ones in Lower Canada, both of which are for the most part in beds subordinate to the stratification, belong to this group. The lead, copper, zinc, cobalt and nickel of Missouri, and the copper of Lake Superior, also occur in rocks of the same age, which appears to have been pre-eminently the metalliferous period.

The metals of the Quebec group seem to have been originally brought to the surface in watery solution, from which we conceive them to have been separated by the reducing agency of organic matter in the form of sulphurets, or in the native state, and mingled with the contemporaneous sediments, where they occur in beds, in disseminated grains forming *fahlbands*, or as at Acton, are the cementing material of conglomerates. During the subsequent metamorphism of the strata these metallic matters being taken

into solution by alkaline carbonates or sulphurets, have been redeposited in fissures in the metalliferous strata, forming veins, or ascending to higher beds, have given rise to metalliferous veins in strata not themselves metalliferous. Such we conceive to be in a few words the theory of metallic deposits; they belong to a period when the primal sediments were yet impregnated with metallic compounds which were soluble in the permeating waters. The metals of the sedimentary rocks are now however for the greater part in the form of insoluble sulphurets, so that we have only traces of them in a few mineral springs, which serve to show the agencies once at work in the sediments and waters of the earth's crust. The present occurrence of these metals in waters which are alkaline from the presence of carbonate of soda, is as we have elsewhere pointed out, of great significance when taken in connection with the metalliferous character of certain dolomites, which as we have shown, probably owe their origin to the action of similar alkaline springs upon basins of sea water.

The intervention of intense heat, sublimation and similar hypotheses to explain the origin of metallic ores, we conceive to be uncalled for. The solvent powers of solutions of alkaline carbonates, chlorids and sulphurets at elevated temperatures, taken in connection with the notions above enunciated, and with De Senarmont's and Daubrée's beautiful experiments on the crystallization of certain mineral species in the moist way, will suffice to form the basis of a satisfactory theory of metallic deposits.*

The sediments of the carboniferous period, like those of earlier formations, exhibit towards the east a great amount of coarse sediments, evidently derived from a wasting continent, and are nearly destitute of calcareous beds. In Nova Scotia Sir William Logan found by careful measurement, 14,000 feet of carboniferous strata; and Professor Rogers gives their thickness in Pennsylvania as 8000 feet, including at the base 1400 feet of a conglomerate, which disappears before reaching the Mississippi. In Missouri Prof. Swallow finds but 640 feet of carboniferous strata, and in Iowa their thickness is still less, the sediments composing them being at the same time of finer materials. In fact, as Mr. Hall remarks, throughout the whole palæozoic period we observe a greater accumulation and a coarser character of sediments along the line of the Appalachian chain, with a gradual thinning westward, and a deposition of finer and farther transported matter in that direction. To the

* *Quar. Jour. Geol. Soc.* vol. xv. 580.

west, as this shore-derived material diminishes in volume, the amount of calcareous matter rapidly augments. Mr. Hall concludes therefore that the coal-measure sediments were driven westward into an ocean, where there already existed a marine fauna. At length, the marine limestones predominating, the coal measures come to be of little importance, and we have a great limestone formation of marine origin, which in the Rocky Mountains and New Mexico occupies the horizon of the coal, and itself unaltered, rests on crystalline strata like those of the Appalachian range. In truth, Mr. Hall observes, the carboniferous limestone is one of the most extensive marine formations of the continent, and is characterized over a much greater area by its marine fauna than by its terrestrial vegetation.

"The accumulations of the coal period were the last that gave form and contour to the eastern side of our continent, from the Gulf of St. Lawrence to the Gulf of Mexico; and as we have shown that the great sedimentary deposits of successive periods have followed essentially the same course, parallel to the mountain ranges, we naturally inquire: What influence this accumulation has had upon the topography of our country, and whether the present line of mountain elevation from north-east to south-west is in any way connected with the original accumulation of sediments?" *Hall's Introduction*, p. 66.

The total thickness of the palæozoic strata along the Appalachian chain is about 40,000 feet, while the same formations in the Mississippi valley, including the carboniferous limestone, which is wanting in the east, have according to Mr. Hall, a thickness of scarcely 4000 feet.* In many places in this valley we find the Silurian formations exposed, exhibiting hills of 1000 feet, made up of horizontal strata, with the Potsdam sandstone for their base, and capped by the Niagara limestone, while the same strata in the Appalachians would give from ten to sixteen times that

* In Michigan, according to the late report of Prof. Winchell, the total observed thickness of the strata from the top of the Sault St. Mary sandstones to the top of the carboniferous series is little over 1700 feet, divided as follows:—Trenton and Hudson River groups, 50 feet, Upper Silurian 185, Devonian 782, Carboniferous 700; of this last the true coal measures constitute 123 feet, including from 3 to 10 feet of workable bituminous and cannel coals, while near the base of the carboniferous series are found 169 feet of gypsiferous marls, which yield strong brine springs.

thickness. Still, as Mr. Hall remarks, we have there no mountains of corresponding altitude, that is to say, none whose height like those of the Mississippi valley, equals the actual vertical thickness of the strata comprising them. In the west there has been little or no disturbance, and the highest elevations mark essentially the aggregate thickness of the strata comprising them. In the disturbed regions of the east on the contrary, though we can prove that certain formations of known thickness are included in the mountains, the height of these is never equal to the aggregate amount of the formations. "We thus find that in a country not mountainous, the elevations correspond to the thickness of the strata, while in a mountainous country, where the strata are immensely thicker, the mountain heights bear no comparative proportion to the thickness of the strata." "While the horizontal strata give their whole elevation to the highest parts of the plain, we find the same beds folded and contorted in the mountain region, and giving to the mountain elevations not one-sixth of their actual measurement."

Both in the east and west, the valleys exhibit the lower strata of the palæozoic series, and it is evident that had the eastern region been elevated without folding of the strata, so as to make the base of the series correspond nearly with the sea level, as in the Mississippi valley, the mountains exposed between these valleys, and including the whole palæozoic series, would have a height of 40,000 feet; so that the mountains evidently correspond to depressions of the surface, which have carried down the bottom rocks below the level at which we meet them in the valleys. In other words, the synclinal structure of these mountains depends upon an actual subsidence of the strata along certain lines.

"We have been taught to believe that mountains are produced by upheaval, folding and plication of the strata, and that from some unexplained cause these lines of elevation extend along certain directions, gradually dying out on either side, and subsiding at the extremities. We have, however, here shown that the line of the Appalachian chain is the line of the greatest accumulation of sediments, and that this great mountain barrier is due to original deposition of materials, and not to any subsequent forces breaking up or disturbing the strata of which it is composed."

We have given Mr. Hall's reasonings on this subject, for the most part in his own words, and with some detail, for we

conceive that the views which he is here urging are of the highest importance to a correct understanding of the theory of mountains. In the *Canadian Naturalist* for Dec. 1859, p. 425, and in the *Am. Jour. Sci.* (2) xxx, 137 will be found an allusion to the rival theories of upheaval and accumulation as applied to volcanic mountains, the discussion between which we conceive to be settled in favour of the latter theory by the reasonings and observations of Constant-Prevost, Scrope and Lyell. A similar view applied to mountain chains like those of the Alps, Pyrennees and Alleghanies, which are made up of aqueous sediments, has been imposed upon the world by the authority of Humboldt, Von Buch and Elie de Beaumont, with scarcely a protest. Buffon, it is true, when he explained the formation of continents by the slow accumulation of detritus beneath the ocean, conceived that the irregular action of the water would give rise to great banks or ridges of sediments, which when raised above the waves must assume the form of mountains; later, in 1832, we find De Montlosier protesting against the elevation hypothesis of Von Buch, and maintaining that the great mountain chains of Europe are but the remnants of continental elevations which have been cut away by denudation, and that the foldings and inversions to be met with in the structure of mountains are to be looked upon only as local and accidental.

In 1856 Mr. J. P. Lesley published a little volume entitled *Coal and its Topography*, (12 mo. pp. 224,) in the second part of which he has, in a few brilliant and profound chapters, discussed the principles of topographical science with the pen of a master. Here he tells us that the mountain lies at the base of all topographical geology. Continents are but congeries of mountains, or rather the latter are but fragments of continents, separated by valleys which represent the absence or removal of mountain land [p. 126]; and again "mountains terminate where the rocks thin out." (p. 144.)

The arrangement of the sedimentary strata of which mountains are composed may be either horizontal, synclinal, anticlinal or vertical, but from the greater action of diluvial forces upon anticlinals in disturbed strata it results that great mountain chains are generally synclinal in their structure, being in fact but fragments of the upper portion of the earth's crust, lying in synclinals, and thus preserved from the destruction and translation which have exposed the lower strata in the anticlinal valleys, leaving the intermediate

mountains capped with lower strata. The effects of those great and mysterious denuding forces which have so powerfully modified the surface of the globe become less apparent as we approach the equatorial regions, and accordingly we find that in the southern portions of the Appalachian chain many of the anticlinal folds have escaped erosion, and appear as hills of an anticlinal structure. The same thing is occasionally met with further north; thus Sutton mountain in Canada, lying between two anticlinal valleys, has an anticlinal centre, with two synclinals on its opposite slopes. Its form appears to result from three anticlinals, the middle one of which has to a great extent escaped denudation.

The error of the prevailing ideas upon the nature of mountain chains may be traced to the notion that a disturbed condition of the rocky strata is not only essential to the structure of a mountain, but an evidence of its having been formed by local upheaval, and the great merit of De Montlosier and Lesley, (the latter altogether independently,) is to have seen that the upheaval has been in all cases not local but continental, and that the disturbance so often seen in the strata is neither dependent upon elevation nor essential to the formation of a mountain. The synclinal structure of portions of the Alps, previously observed by Studer and others, has been beautifully illustrated by Ruskin in the fourth volume of his *Modern Painters*, and in a late review of Alpine geology we have endeavoured to show that the Alps, *as a whole*, have likewise a synclinal structure. (Am. Jour. Science, xxix. 118.)

Such was the state of the question when Mr. Hall came forward bringing his great knowledge of the sedimentary formations of North America to bear upon the theory of continents and mountains. These were first advanced in his address delivered before the American Association for the Advancement of Science, as its president, at Montreal in August, 1857. This address was never published, but the author's views were brought forward in the first volume of his *Report on the Geology of Iowa*, p. 41, and with more detail in the introduction to the third volume of his *Paleontology of New York*, from which we have taken the abstract already given. He has shown that the difference between the geographical features of the eastern and central parts of North America is directly connected with the greater accumulation of sediment along the Appalachians. He has further shewn that so far from local elevation being concerned in the formation of these

mountains, the strata which form their base are to be found beneath their foundations at a much lower horizon than in the undisturbed hills of the Mississippi valley, and that to this depression chiefly is due the fact that the mountains of the Appalachian range do not, like those hills, exhibit in their vertical height above the sea the whole accumulated thickness of the palæozoic strata which lie buried beneath their summits.

Mr. Hall has made a beautiful application of these views to explain the fact of the height of the Green Mountains over the Laurentides, and of the White Mountains over the former, by remarking that we have successively the Lower and Upper Silurian strata superimposed on those of the Laurentian system. The same thing is strikingly shown in the fact that the higher mountain chains of the globe are composed of newer formations, and that the summits of the Alps are probably altered sediments of tertiary age. (*Am. Jour. Sci.* xxix. 118.)

The lines of mountain elevation of De Beaumont are according to Hall, simply those of original accumulations, which took place along current or shore lines, and have subsequently, by continental elevations, produced mountain chains. "They were not then due to a later action upon the earth's crust, but the course of the chain and the source of the materials were predetermined by forces in operation long anterior to the existence of the mountains or of the continent of which they form a part." p. 86.

It will be seen from what we have said of Buffon, De Montlosier and Lesley that many of the views of Mr. Hall are not new but old; it was, however, reserved to him to complete the theory and give to the world a rational system of orographic geology. He modestly says, "I believe I have controverted no established fact or principle beyond that of denying the influence of local elevating forces, and the intrusion of ancient or plutonic formations beneath the lines of mountains, as ordinarily understood and advocated. In this I believe I am only going back to the views which were long since entertained by geologists relative to continental elevations." p. 82.

The nature of the palæozoic sediments of North America clearly shows that they were accumulated during a slow progressive subsidence of the ocean's bed, lasting through the palæozoic period, and this subsidence, which would be greatest along the line of greatest accumulation, was doubtless, as Mr. Hall considers, connected with the transfer of sediment and the variations of local pres-

sure acting upon the yielding crust of the earth, agreeably to the view of Sir John Herschel. This subsidence of the ocean's bottom would, according to Mr. Hall, cause plications in the soft and yielding strata. Lyell had already in speculating upon the results of a cooling and contracting sea of molten matter, such as he imagined might have once underlaid the Appalachians, suggested that the incumbent flexible strata, collapsing in obedience to gravity would be forced, if this contraction took place along narrow and parallel zones of country, to fold into a smaller space as they conformed to the circumference of a smaller arc, "thus enabling the force of gravity, though originally exerted vertically, to bend and squeeze the rocks as if they had been subjected to lateral pressure.*

Admitting thus Herschel's theory of subsidence and Lyell's of plication, Mr. Hall proceeds to inquire into the great system of foldings presented by the Appalachians. The sinking along the line of greatest accumulation produces a vast synclinal, which is that of the mountain ranges, and the result of such a sinking of flexible beds will be the production within the greater synclinal of numerous smaller synclinal and anticlinal axes, which must gradually decline toward the margin of the great synclinal axis. This process the author observes appears to furnish a satisfactory explanation of the difference of slope on the two sides of the Appalachian anticlinals, where the dips on one side are uniformly steeper than on the other. p. 71.

An important question here arises, which is this;—while admitting with Lyell and Hall that parallel foldings may be the result of the subsidence which accompanied the deposition of the Appalachian sediments, we inquire whether the cause is adequate to produce the vast and repeated flexures presented by the Alleghanies. Mr. Billings in a recent paper in the *Canadian Naturalist* (Jan. 1860), has endeavoured to show that the foldings thus produced must be insignificant when compared with the great undulations of strata, whose origin Prof. Rogers has endeavoured to explain by his theory of earthquake waves propagated through the igneous fluid mass of the globe, and rolling up the flexible crust. We shall not stop to discuss this theory, but call attention to another agency hitherto overlooked, which must also cause contraction and folding of the strata, and to which we have already alluded. (*Am. Jour. Sci.* (2) xxx. 138.) It is the condensation which must take place when porous sediments are converted into crystalline rocks like

* Travels in North America, 1st visit, vol. i. p. 78.

gnesis and mica slate, and still more when the elements of these sediments are changed into minerals of high specific gravity, such as pyroxene, garnet, epidote, staurotide, chiasstolite and chloritoid. This contraction can only take place when the sediments have become deeply buried and are undergoing metamorphism, and is, as many attendant phenomena indicate, connected with a softened and yielding condition of the lower strata.

We have now in this connection to consider the hypothesis which ascribes the corrugation of portions of the earth's crust to the gradual contraction of the interior. An able discussion of this view will be found in the *American Journal of Science* (2) iii. 176, from the pen of Mr. J. D. Dana, who, in common with all others who have hitherto written on the subject, adopts the notion of the igneous fluidity of the earth's interior.

We have however elsewhere given our reasons for accepting the conclusion of Hopkins and Hennessy that the earth, instead of being a liquid mass covered with a thin crust, is essentially solid to a great depth, if not indeed to the centre, so that the volcanic and igneous phenomena generally ascribed to a fluid nucleus have their seat, as Keferstein and after him Sir John Herschel long since suggested, not in the anhydrous solid unstratified nucleus, but in the deeply buried layers of aqueous sediments which, permeated with water, and raised to a high temperature, become reduced to a state of more or less complete igneo-aqueous fusion. So that beneath the outer crust of sediments, and surrounding the solid nucleus, we may suppose a zone of plastic sedimentary material adequate to explain all the phenomena hitherto ascribed to a fluid nucleus. (*Quar. Jour. Geol. Society*, Nov. 1859. *Canadian Naturalist*, Dec. 1859, and *Amer. Jour. Sci.*(2)xxx. 136.)

This hypothesis, as we have endeavoured to show, is not only completely conformable with what we know of the behaviour of aqueous sediments impregnated with water and exposed to a high temperature, but offers a ready explanation of all the phenomena of volcanos and igneous rocks, while avoiding the many difficulties which beset the hypothesis of a nucleus in a state of igneous fluidity. At the same time any changes in volume resulting from the contraction of the nucleus would affect the outer crust through the medium of the more or less plastic zone of sediments, precisely as if the whole interior of the globe were in a liquid state.

The accumulation of a great thickness of sediment along a

given line would, by destroying the equilibrium of pressure, cause the somewhat flexible crust to subside; the lower strata becoming altered by the ascending heat of the nucleus would crystallize and contract, and plications would thus be determined parallel to the line of deposition. These foldings, not less than the softening of the bottom strata, establish lines of weakness or of least resistance in the earth's crust, and thus determine the contraction which results from the cooling of the globe to exhibit itself in those regions and along those lines where the ocean's bed is subsiding beneath the accumulating sediments. Hence we conceive that the subsidence invoked by Mr. Hall, although not the sole nor even the principal cause of the corrugations of the strata, is the one which determines their position and direction, by making the effects produced by the contraction not only of sediments, but of the earth's nucleus itself, to be exerted along the lines of greatest accumulation.

It will readily be seen that the lateral pressure which is brought to bear upon the strata of an elongated basin by the contraction of the globe, would cause the folds on either side to incline to the margin of the basin, and hence we find along the Appalachians, which occupy the western side of such a great synclinal, the steeper slopes, the overturn dips or folded flexures, and the overlaps from dislocation are to the westward, so that the general dip of the strata is to the centre of the basin, on the other side of which we might expect to find the reverse order of dips prevailing. The apparent exceptions to this order of upthrows to the south-east in the Appalachians appear to be due to small downthrows to the south-east, which are parallel to and immediately to the north-west of great upheavals in the same direction.

Mr. Hall adopts the theory of metamorphism which we have expounded in the paper just quoted above, *Canadian Naturalist*, Dec. 1859, (see also *Am. Jour. Sci.* (2) xxv. 287, 435, xxx. 135,) which has received a strong confirmation from the late researches of Daubrée. According to this view, which is essentially that put forward by Herschel and Babbage, these changes have been effected in deeply buried sediments by chemical reactions, which we have endeavored to explain, so that metamorphism, like folding, takes place along the lines of great accumulation. The appearance at the surface of the altered strata is the evidence of a considerable denudation. It is probable that the gneissic rocks of Lower Silurian age in North America were at the time of their crystallization overlaid by the whole of the palæozoic strata, while the

metamorphism of carboniferous strata in eastern New England points to the former existence of great deposits of newer and overlying deposits, which were subsequently swept away.

On the subject of igneous rocks and volcanic phenomena, Mr. Hall insists upon the principles which we were, so far as we know the first to point out, namely their connection with great accumulations of sediment, and of active volcanos with the newer deposits. We have elsewhere said: "the volcanic phenomena of the present day appear, so far as are aware, to be confined to regions of newer secondary and tertiary deposits, which we may suppose the central heat to be still penetrating, (as shewn by Mr. Babbage,) a process which has long since ceased in the palæozoic regions." To the accumulation of sediments then we referred both modern volcanos and ancient plutonic rocks; these latter, like lavas, we regard in all cases as but altered and displaced sediments, for which reason we have called them exotic rocks. (*Am. Jour. Sci.* (2) xxx. 133). Mr. Hall reiterates these views, and calls attention moreover to the fact that the greatest outbursts of igneous rock in the various formations appear to be in all cases connected with rapid accumulation over limited areas, causing perhaps disruptions of the crust, through which the semi-fluid stratum may have risen to the surface. He cites in this connection the traps with the palæozoic sandstones of Lake Superior, and with the mesozoic sandstones of Nova Scotia and the Connecticut and Hudson valleys.

It may sometimes happen that the displaced and liquified substratum will find vent, not along the line of greatest accumulation, but along the outskirts of the basin. Thus in eastern Canada it is not along the chain of the Notre Dame mountains, but on the north-west side of it that we meet with the great outbursts of trachyte and dolerite, whose composition and distribution we have elsewhere described. (*Report of Geological Survey for 1858, and Am. Jour. Science*, (2) xxix. 285.)

The North American continent, from the grand simplicity of its geological structure and from the absence, over great areas, of the more recent formations, offers peculiar facilities for the solution of some of the great problems of geology; and we cannot finish this article without congratulating ourselves upon the great progress in this direction which has been made within the last few years by the labors of American geologists.

Montreal, March 1, 1861.

