A DESCRIPTIVE CATALOGUE OF THE ROCK SPECIMENS IN THE MUSEUM OF PRACTICAL GEOLOGY.

A

DESCRIPTIVE CATALOGUE

OF THE

ROCK SPECIMENS

MUSEUM OF PRACTICAL GEOLOGY

WITH EXPLANATORY NOTICES OF THEIR NATURE AND MODE OF OCCURRENCE IN PLACE.

BY

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NOTICE.

The following Catalogue of the Rock Specimens, by Professor Ramsay, the Local Director of the Geological Survey, and his associates, is the first of a series now in preparation, to illustrate the several branches of science which are taught in the Government School of Mines.

Whilst the popular Descriptive Guide to the whole Museum has been found useful to the casual visitor, it is hoped that this detailed Catalogue, explanatory of the only public collection of specimens of the rocks of the British Isles, will prove of service to the geological and mining student.

RODERICK I. MURCHISON,
Director.

Museum of Practical Geology,
April 16th, 1859.

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INTRODUCTION.

A COMPLETE geological collection of the rocks of any country should comprise three suites :—

1st. Lithological, illustrative of the nature of

2nd. Stratigraphical, illustrative of their order of succession.

3rd. Topographical, illustrative of their geographical distribution.

The space available in the Museum for the display of rocks is barely sufficient for one of these classes, and the first has been chosen as affording a simple method of instructing all who wish to learn what are the external characters of such rocks as conglomerate, sandstone, grit, limestone, shale, schist, gneiss, granite, the different kinds of trap, lavas, volcanic tufas or ashes, and indeed all the varieties of stony substances that are of common occurrence. To descriptions of the rocks in the CASES an index has been added at the end of the volume, indicating the stratigraphical relations of the specimens, or the order of succession in which the rocks were formed from whence the specimens were derived. (*See* p. 361.)

Having mastered the characters of the rocks, by passing from specimen to specimen with the index in his hand, the student will be able to form as fair an idea as can be gathered in a museum of the lithological or stony structure of most of the British formations in their order of succession. He will find that in England and Wales the Tertiary rocks are mostly formed of gravel, sand, and clay, with a little soft limestone; the Secondary rocks of chalk, clay, soft shale, oolitic and hydraulic limestones, marls, sands, and conglomerates; the Carboniferous rocks, of harder shales, ironstones, sandstones, fireclays, beds of coal, and hard limestone; the Old Red Sandstone chiefly of red marl, sandstone, and conglomerate; and the Silurian and Cambrian rocks in great part of mudstones, grits, and slaty rocks, with occasional shales, limestones, and beds of conglomerate, sandstone, and grit. Such is the general nature of the rocks in England and Wales; but in other parts of the world there are local peculiarities. Thus the Secondary limestones of the Alps are often crystalline, and the shales are cleaved and slaty, or even changed into gneiss. This can be easily understood in reading special works after the student has studied the rocks of his own region.

The names of the places from which the specimens were taken are always mentioned, thus securing in some degree the advantages of a topographical collection.

Excepting the foreign specimens necessary for illustration, almost all the specimens were collected during the progress of the Geological Survey, and partly serve as type specimens illustrative of the maps and districts surveyed.

In the other CASES in the galleries of the Museum devoted to the collection of fossils the student will frequently find illustrative specimens of rocks. These specimens of themselves give a good idea of the nature of the different formations, and may be regarded as a kind of stratigraphical collection of rocks, and what is of more importance, in these CASES he will also find suites of fossils illustrative of their order of succession in the British formations.

The collections of ores and other minerals in the principal floor show the economic substances produced by the rocks. Together they form a kind of handbook to British geology, which will be more complete if space is ever afforded for the arrangement of a strictly stratigraphical collection.

In the Lower Hall is a geological map of Wales, Devon, and Cornwall, and the other western and central counties of England as far north as Derbyshire and the borders of Lancashire. It shows the state of the published maps of the Geological Survey of Great Britain up to 1858, on the one-inch scale, and by reference to it the general distribution of most of the formations illustrated by the specimens in the CASES will be understood.

In the description of the Cornish specimens much valuable assistance was derived from a MS. left by the late Sir Henry De la Beche.

The arrangement of the rocks described in this catalogue was planned, partly executed, and the whole superintended by myself. A very large part is the work of Mr. Bristow. The case of Vesuvian specimens was arranged by Mr. Bauerman, who also assisted in cataloguing the igneous rocks of Wales.

Since the printing of the first edition of the catalogue, and partly while this was passing through the press, a large number of specimens have been added, which are described in the Appendix. Now that the collection has become so large, before another edition of the catalogue is issued, it may be desirable to arrange the specimens stratigraphically.

ANDREW C. RAMSAY.

Museum of Practical Geology,
April 1, 1859.

Table-case D.

Arranged and described by A. C. Ramsay.

SPECIMENS ILLUSTRATIVE OF PHENOMENA CONNECTED WITH GLACIERS AND FLOATING ICE.

Upper Gallery. — Table-case D.

Specimens No. 1 to 53 were collected by M. Dolfuss-Ausset. No. 1 to 39 are illustrative of *existing Alpine glaciers*, and of their former extension.

No. 50 to 53 are derived from the remains of the *newer Pliocene glaciers of the Vosges*, and No. 55 to 58 are believed by M. Dolfuss-Ausset to have been connected with glacial action in the neighbourhood of Mulhouse, &c. &c.

No. 60 to 92 were collected by Mr. A. C. Ramsay, with the view of illustrating the *newer Pliocene glaciers* and other points connected with glacial action in *Caernarvonshire and Anglesea*. No. 93, 94, and 97 were presented by Mr. James Nasmyth; No. 95 and 96 by the Rev. John Gunn.

No. 100 to 144 were collected partly by Mr. Ramsay, but chiefly by Mr. Gibbs, under Mr. Ramsay's direction, to illustrate certain *drift-like phenomena connected with the Permian strata.*

Glaciers.—In the Swiss Alps the average snow-line is about 8,500 feet above the level of the sea. The glaciers which descend Alpine valleys are produced by the drainage of this snow, which, in its passage downward, in conse-

UPPER GALLERY. — Table-case D.

quence of the pressure consequent on the accumulation of snow, of the alternating seasons, and of frequent daily thaws and nightly frosts, becomes converted into ice. The slopes of valleys occupied by glaciers are various; sometimes only from 3° to 5°, sometimes steeper, and sometimes the descents are exceedingly abrupt. A large glacier passes down these slopes in a manner that may be compared to a broad and deep river of ice. Accordingly the whole mass bends and accommodates itself to the sinuosities and varying width of the valley, and its rate of progression has been ascertained, when the valley is straight, to be fastest in the middle and slowest at the sides; or when curved, to be most rapid in a line nearer the convex side of the valley. Professor J. D. Forbes' theory of glacier motion is this:—"*A glacier is an imperfect fluid, or a viscous body, which is urged down slopes of a certain inclination by the mutual pressure of its parts.*" On the other hand, it has lately been maintained by Professors Tyndall and Huxley that the progressive motion of glaciers is not due to a viscous movement of particles in the strict sense of the term, but to numerous and repeated fractures of the entire mass, and to rapid regelation, by means of which the general continuity of the glacier is maintained. In summer, on the surface of a glacier there is much waste by the thawing of the ice. At the lower extremity it is finally melted by the heat. This waste is replenished by the fall of snow on the high grounds, and thus it happens that a glacier drains a certain area of snow, much in the same manner that in lower or milder regions a river drains a certain area of water. Numerous stones and blocks fall on the marginal surfaces of glaciers from the mountain sides, and from rocky masses that project from its surface, and as the ice progresses, these are carried, as it were, floating on the surface in long, regular, and often very broad lines, termed moraines. Where the ice of two valleys coalesces, two of these side moraines also unite, and generally form one central moraine, which passes down the mid-surface of the glacier. Where glaciers finally melt at their lower extremities curved *terminal moraines* are formed by the stones and finer substances, that find their way so far, and are there shed by the glaciers. The surfaces of glaciers are seamed by *crevasses*, or small and large cracks partly caused by the passage of the ice over the unequal floors of the valleys, partly by tension, so that parts of the mass are torn asunder during the onward progress of the whole. Into these, stones from the surface frequently fall, and mud and other fine sediments are washed into them by running water that, during the heats of summer, often forms actual brooks upon the ice. These often find their way to the bottom of the moving masses, and the finer siliceous and other materials, acting like emery powder between the moving ice and its rocky floor, grind off asperities and smooth and polish the surface, often giving to it largely rounded and mammillated contours, termed by the French and Swiss *roches moutonnées*. The stones and larger blocks fixed between the ice and the rocky bottom scratch and groove these surfaces, such lines necessarily running in the direction of the flow of the glaciers, or in other words, of the trend of the valleys. The imprisoned stones, also, themselves become scratched and grooved in their onward passage. When, through changes of climate, glaciers have decreased in size, they have often left *laterâl moraines* high on the sides of the mountains, and *terminal moraines* at points far below the existing extremities. In many of the valleys of Switzerland, the Himalaya, &c., *roches moutonnées* and moraines are found far beyond the limits of existing glaciers, and all the *signs of glaciers* often force themselves on the notice in mountain regions where they have altogether disappeared, probably since the newer Pliocene or glacial epoch. These signs are *roches moutonnées*, often covered with *ice-borne boulders* ("*blocs perchés*"), *scratched*, *striated*, and *grooved surfaces*, and numerous *moraines*, sometimes as perfect as those that fringe the sides and ends of existing Alpine glaciers. Appear-

UPPER GALLERY. Table-case D.

UPPER GALLERY. — Table-case D.

ances of the kind adverted to are frequent in the mountains of the Vosges, Ireland, the Highlands of Scotland, and Wales. Specimens from the moraines of the Alps, the Vosges, and Wales are deposited in this case.

Specimens of the moraine matter of the Glaciers of the Alps. Lower glacier of the Aar.

1.—FINE MORAINE CLAY *in place*, derived from the *Finster Aar Horn*, in a heap on a rock 9,100 feet above the sea level, near the *lower glacier of Trift.* This glacier is nearly two miles east of the "Pavilion" of M. Dolfuss-Ausset, by the side of the lower glacier of the Aar ; and the lower extremity of *the glacier of Trift* is 1,625 feet above that part of the *Aar glacier.* The end of the lower glacier of the Aar is 5,900 feet above the sea.

2.—FINE MORAINE CLAY, derived from the *Finster Aar Horn*, in little heaps of several pounds on the surface of *the lower glacier of the Aar*, below the Pavilion.

3.—On the same glacier, as above, west of the Pavilion.

4.—QUARTZOSE SAND AND FINE GRAVEL, derived from the *Finster Aar Horn*, left by a block of ice upset on the left bank of the lower *glacier of the Aar*, below the Pavilion.

5.—SANDY GRAVEL, covering a large gravelly cone on the same glacier, 1½ miles from its terminal declivity.

These cones of ice are generally regular in form, steep on the sides, and often 5 to 20 feet in height. They originate in any stone or heap of earth or stones placed on the ice, so as to protect it from the heat of the sun. From the same cause moraines on the ice are convex. The cones are sometimes formed as follows :—Into slight hollows in the ice, mud, sand, and gravel are washed ; this in sunny weather absorbs heat, and aids in melting the ice so as to increase the size of the hollow in which it lies. By degrees, however, the accumulation of matter becomes so thick that the heat is no longer transmitted through it, and it acts as a protection from the rays of the sun, and prevents further melting of the ice that immediately underlies it: the surrounding ice then begins to dissolve and the inverted cone becomes converted into an erect cone, protected for a time from external heat by a covering of mud, sand, and gravel.

UPPER GALLERY. — Table-case D.

6.—VERY FINE SILICEOUS SAND, derived from the *Finster Aar Horn*, lying on a rock in place, touching the ice on the left bank of the *lower glacier of the Aar*, below the Pavilion.

Illustrations of the former extension of the lower glacier of the Aar.

7.—SILICEOUS SAND, derived from the rocks of the *Finster Aar Horn*, 32 feet below the terminal slope of the *lower glacier of the Aar.*

8.—SILICEOUS SAND, as above.

9.—FINEST SAND, separated by suspension in water (derived as above), from a moraine in the bottom of the valley on the left bank of the *Aarboden*, 1,625 feet beyond the present terminal slope of the glacier.

10.—As above.

11.—FINE SAND, separated by the sieve, from moraine, as above.

12.—SAND, separated by the sieve, from moraine, as above.

13.—COARSE SAND, as above.

14.—FINE GRAVEL, separated by the sieve, from moraine, as above.

15.—FINE MORAINE CLAY, *between the Grimsel and the glacier*, 5,850 feet above the sea; at the bridge at the efflux of the Aar from the Boden, on the right and left banks, 30 to 50 feet below the level of the torrent of the Aar.

More ancient extension of the glacier.

16.—FINE MORAINE CLAY, from a moraine at the bottom of the valley, containing blocks and rounded and angular pebbles, scratched and polished. It lies on a *roche moutonnée* of sandstone, on *the left bank of the Aar, at the new bridge of Tiefenau, on the new road to Berne.*

UPPER GALLERY.

Table-case D.

17.—MORAINE MUD, SAND, AND FINE ANGULAR GRAVEL, in place at *Roderichsboden*, between the *Grimsel* and *Handeck*, 9 feet above the level of the torrent, left bank.

18.—MORAINE MUD, SAND, AND FINE ANGULAR GRAVEL, in the valley of *Oberhasli*, at the *Chalets of Handeck*, on the Grimsel road, 1,616 feet above the sea.

19.—MORAINE MUD AND ANGULAR GRAVEL (containing very large erratic blocks), at *Kirchet, near Meyringen, Oberhasli.*

20.—MORAINE CLAY, containing scratched Alpine pebbles, and covering ice-polished limestone, in the quarry of Baumann, about three quarters of a mile north of Soleure. This spot on the banks of the Aar, below the Jura, is about 40 English miles from the nearest glaciers of the Bernese Alps.

Specimens illustrative of the difference between ordinary sea sand, and glacier sand and gravel.—The first is generally rounded and waterworn, the second comparatively rough and angular.

21.—BLOWN SEA SAND, *Dunes of Bayonne, France.*

22.—SEA SAND, *Mediterranean, Barcelona,* } *Spain.*
23.—SEA SAND, *do. Malaga,* }

Specimens illustrative of the polishing and striation produced by glaciers on the rocky bottoms and sides of the valleys down which they pass.—Lower glacier of the Aar.

24.—GRANITIC ROCK, polished and striated, in place, at *the Pavilion of M. Dolfuss-Ausset*, 263 feet above the surface of the *lower glacier of the Aar.*

25.—QUARTZ, polished, in place at the upper glacier of the Aar, 547 yards from its lower end.

26.—GRANITE, polished by the isolated glacier of the *Helle-Platte at Handeck, valley of Oberhasli.*

27.—QUARTZ, polished and striated, from a rock in place at the "*Lac des Morts*," on the road from the *Grimsel* to the *glacier of the Rhone*. UPPER GALLERY. — Table-case D.

28.—LIMESTONE ROCK, polished and striated, in place at the quarry of *Baumann* about three quarters of a mile from *Soleure*. Moraine matter from the Alps covers this rock, containing polished and striated pebbles of Alpine limestone, touching the "*roche moutonnée*."

29.—CONGLOMERATE, polished and striated, covered by 4 feet 8 inches of moraine matter; in place at *the hill of Chardonne* (Torat), 547 yards from Torgni, *Canton de Vaud*.

No. 30 *to* 39 *show the appearance of some of the stones in motion on the surface of the ice, and under the ice of glaciers, or that have been, or are inferred to have been transported by glacier action.*—These stones are derived from the mountains that skirt the glaciers, and they are of every possible size, from a grain of sand up to a block "100 feet long by 40 or 50 feet high," or, in another case, containing "244,000 cubic feet of slate;" (Forbes' Travels through the Alps, p. 46). The "blocks of Monthey" are "composed of blocks of granite (resting on limestone), thirty, forty, fifty, and sixty feet in the side; not a few, but by hundreds, fantastically balanced on the angles of one another, their grey weather-beaten tops standing out in prominent relief from the verdant slopes of secondary formation on which they rest." (Forbes, p. 52.)* Moraine

* Since the first edition of this Catalogue was published I had an opportunity of visiting these blocks, which lie upon and are often half or entirely buried in stratified sand and waterworn gravel. This may be seen in a cutting by the winding road that ascends the hill, and I

UPPER GALLERY. — Table-case D.

stones are mostly *angular* and *subangular*, and sometimes (as on the Mer de Glace, Chamouni, the Grindelwald and Aar glaciers, &c.), they consist of pieces as fresh as if broken by the hammer. Rarely, stones in moraines in motion on the ice are rounded, and even waterworn, for it sometimes happens that they are partially abraded in brooks in the higher mountain regions, and afterwards carried to the surface or the sides of glaciers, and so by degrees find their way to the terminal moraines, there to mix with the angular or worn stones that are shed from the surface of the glacier or are passed onward from beneath the ice.

30 to 33.—Partly rounded and subangular granite stones, *in motion on the lower glacier of the Aar.*

34.—Part of a pebble of limestone, taken from under *the glacier of Rosenlaui.*

35.—Pebble of scratched limestone, from the terminal moraine, touching the *lower glacier of Grindelwald.*

36.—Polished and scratched pebble of black limestone, from *the moraine of St. Theodule, Monte Rosa.*

Erratic pebbles transported by ice.

37 and 38.—Pebbles of scratched black limestone at *Torgui*, hill of Chardonne (Torat) near *Vevey*, Lake of Geneva.

39.—Pebbles from the wells at *Dornach*, stated to be from an ancient moraine.

40.—Rounded, well *waterworn* pebbles from *the Rhine*, contrasting with the *subangular* pebbles from *glaciers.*

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consider it most probable that they were deposited by icebergs detached from glaciers that reached the sea level during a part of the newer Pliocene period, when the stratified boulder clays, sands, and gravels were formed that cover the slopes by the Lake of Geneva, and much of the hilly ground that lies between the higher Alps and the Jura.

Specimens illustrative of ancient glaciers in the mountains of the Vosges, &c.—These glaciers were of the same age as those of the British Islands, viz., of *newer Pliocene* date.

UPPER GALLERY. — Table-case D.

50.—SLATY ROCK, POLISHED AND STRIATED, in place, in the valley of *Asto*, about two miles from the plain of Asto, *Pyrenees, France.*

51.—SLATY ROCK, POLISHED AND STRIATED, in place at *Wesserling* (Glattstein), *Vosges, France.*

52.—SCRATCHED MORAINE STONE, from the same locality.

53.—MORAINE SAND, in place in *the moraine of Rupt*, containing erratic blocks and covering polished rocks.

*Specimens, described as moraine matter by M. Dolfuss-Ausset, from the neighbourhood of Mulhouse and the Upper Rhine.**

55.—FINE SANDY CLAY, in place at Rudisheim, about 2 miles east of *Mulhouse* (*Upper Rhine*). Forms a hill 32 feet in height, above a "moraine" formed of Alpine pebbles.

56.—SAND, in place at *Rixhein*, about 5½ miles east of *Mulhouse.* This sand has been washed by the streams from a moraine.

57.—Same as above.

58.—VERY FINE SAND, forming a mound 32 feet high, at *Schliengen*, 1¼ miles from the right bank of the *Rhine.*

NEWER PLIOCENE GLACIERS AND DRIFT-ICE.

The following summary is chiefly derived from what I have elsewhere written on the subject.

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* In part, they may be derived from ice-drifted erratic matter.

UPPER GALLERY. — Table-case D.

The reader will have gathered from preceding remarks,* that there is evidence of the existence of glaciers where none are now found in Britain, and in several other countries. The greater part also of the north of Europe, Asia, and North America has been covered by late Tertiary icy seas. These subjects have attracted much attention among able observers; but long after the transporting power of glaciers, and the ice-borne character of Alpine boulders that rest on the Jura had been indicated, there was a powerful reaction among geologists; the true doctrine fell into discredit, and most writers adhered to the dogma that the heterogeneous mixtures that cover a great part of the northern continents were the result of mighty sea waves, which rushed from the north across Europe, Asia, and America, scattering rocky fragments which polished and grooved the rocks over which they passed. More correct views, however, at length prevailed; and there are now few geologists who have studied the effects of ice, but will readily recognize its familiar indications, and more especially those of glacier action in the Highlands of Scotland, in Cumberland, Wales, Ireland, and the mountains of the Vosges.

It is nearly universally allowed that all the more important general contours of hill and valley in the continents of the old and new world were the same as now previous to the glacial epoch. Much of the land was then slowly depressed beneath the sea; and as it sank, its minor features were somewhat modified, for terraces were formed on old shores, and icebergs drifting from the north, and pack-ice on the coasts, as they ground and grated along the coasts and sea bottoms, smoothed and striated the rocky surfaces over which they passed, and deposited, in the course of many ages, clay, gravel, and numerous boulders over wide areas that had once been land. The grooves and striations on the ice-smoothed rocks (except where locally deflected) still

* Page 4.

bear witness to the general southward course of th winds and ocean currents that often bore the ice from its birth-place into milder climates.

UPPER GALLERY: Table-case IX.

The intensity and wide-spreading effects of cold in what are now temperate climates is one of the greatest marvels of Tertiary geology. In our own latitudes these effects were clearly not confined to mountain regions when at their present elevation, or when perhaps by further upheaval of the land, they attained a still greater height; for it is certain that in Wales marine *drift* rises on the mountains to the height of more than 2,000 feet, in Derbyshire at least to 1,500 feet, and as high, or perhaps higher, in many parts of Scotland; and all between these elevations and the present sea level, the signs of ancient drift-ice are unmistakeable. Thus, for instance, in Pembrokeshire, north of St. Bride's Bay, the low country is covered with great boulders, derived from the greenstone hills that rise above the drift near St. David's Head; and so isolated and insignificant are these hills, that it is impossible they could ever have given birth to glaciers and icebergs, and therefore the large boulders derived from them must have been floated and scattered by coast-ice that in winter gathered round a few low islets. The same kind of evidence is conspicuous at and near Charnwood Forest in Leicestershire, where the highest hills are only 800 feet in height, from whence long trains of boulders of *greenstone* and *syenite* have been borne many miles to the south. The whole of the central counties of England are more or less dotted with boulders of limestone, granite, greenstone, &c., some of them transported from Cumberland, and perhaps from Scotland; and the drift of our eastern shores contains boulders borne from Scandinavia.

While much of this drift was transported from low coasts by shore-ice, it is, however, equally certain that great part of it originated in true glacier moraine matter that reached the sea by means of glaciers, that, when the country was at various elevations, descended to the sea-level, and their

UPPER GALLERY. — Table-case D.

extremities floating up and breaking off as icebergs, bore away large freights of moraine—earth, stones, and boulders, —to be dropped to the bottom of the sea wherever the bergs chanced to melt. This is evident in North Wales, from whence the moraine specimens of this case are derived, and the same kind of evidence is equally strong in other areas. In Wales (as in Switzerland at the present day) *terminal moraines* frequently form in part the confining barriers of mountain lakes and tarns.* Llyn Idwal, in Nant Francon, and Llyn Llydaw on Snowdon, among others, form good examples of this phenomenon; although it is not to be supposed that the depth of these moraines is necessarily equal to the profoundest depths of the lakes. The contrary is often the case, a good example of which occurs in the *Merjelen see*,† a lake nearly 8,000 feet above the sea, above Viesch, in the valley of the Upper Rhone. Before the artificial lowering of the water this lake was more than 100 feet deep, while the thickness of the bounding moraine is only about 25 feet.

* Also, in the Highlands, the Vosges, &c.

† This most interesting lake is bounded on the west by a small branch glacier descending from the *Great Glacier of Aletsch*, ending in a cliff of ice in places 60 feet high, from which large fleets of small icebergs frequently break. In older times this branch filled the space now occupied by the lake, and passing further east united the glaciers of Aletsch and Viesch. But (as in Wales, p. 14,) a change of climate lessened the size of the Alpine glaciers, the uniting stream of ice gradually melted, it shrunk upwards, and all that now remains is the short branch ending in an ice-cliff washed by the waters of the lake. Old moraines furrow the sides of the bounding hills, and its lower end is partially dammed by moraine matter, which, by approximate measurement, is about 20 feet thick from the surface of the water to the rock on which it lies, while, by seven accurate soundings, I ascertained that the depth of water by the ice-cliff varies from 34 to 97 feet. It may be that this inner hollow was originally made by a heavy load of ice, which in its onward grinding progress, scooped a deeper hollow in material softer than that which now partly forms the barrier ridge of the lake, and this action seems to be strictly analogous to the cause that scooped out the basins of the small lakes and tarns (*entirely surrounded by rock*) that lie in the hollows of high passes, like the *Lac*

UPPER GALLERY. — Table-case D.

Other moraines dam up lakes in a more peculiar manner. The mouth of a valley is surrounded by a mound or series of united mounds curving outwards, formed of earth, angular, subangular, and sometimes smoothed and scratched stones, so truly moraine-like in their arrangement, that their origin and the places whence they came are unmistakeable. A deep clear lake lies inside, and the drift of the glacial sea, full of boulders, slopes right up to the outside base of the moraine, with a long smooth outline, showing that the glacier descended to the sea level, and pushing for a certain distance out to sea, formed a marine terminal moraine, while ordinary drift detritus, partly scattered by floating ice, was accumulating beyond. In the meanwhile the space on and beyond the sea level occupied by the glacier was kept clear of débris; and when the land arose, and the climate ameliorated, the hollow within the terminal moraine became replenished with the water drainage of the surrounding hills, just as in earlier times it was filled with ice formed by a drainage of snow. Such, in Caernarvonshire, are the lakes of Llyn Dulyn, Melynllyn, Ffynnon Llugwy, Marchlyn-mawr, and Marchlyn-bach; and in Scotland it would not be difficult to find parallel cases. Judging by the present average elevation of these Welsh lakes, when the moraines that confined them were formed, the highest parts of the mountains of Caernarvonshire (*the snow drainage of which gave birth to the glaciers*) could not have been more than from 1,400 to 2,000 feet above the sea. The average great intensity of cold may be inferred from this circumstance, for the sea then flowed through some of the greater

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des Morts between the Grimsel and the Valley of the Rhone; or again, on high surfaces, like the tarns on some of the rough table lands between Ffestiniog, Nant Gwynant, and the river Conwy. The producing cause of these peculiar hollows was probably an immense weight of superincumbent ice pressing and grinding downwards and outwards, over high, flat, and sometimes broad watersheds, during that period of intensest cold, that produced the glaciers of Wales, and the great original extension of the glaciers of Switzerland.

UPPER GALLERY. — Table-case D.

valleys between the Menai Straits and Cardigan Bay, across the present watersheds of the Passes. The principal of these are the Vale of Conwy, and its upper branches to Capel Curig, &c.; the Pass of Nant Francon, and its continuation between Llyn Gwynant and Capel Curig; the Pass of Llanberis, opening into Cwm Gwynant (about 1,000 feet high at the watershed); and the Valley of Afon Gain, between Caernarvon and Beddgelert. The country was thus broken into a group of islands, each one of which in great part had its covering of snow and ice, permanent till large changes (perhaps of physical geography) produced a decided amelioration of climate.

This amelioration did not, however, take place till after the re-elevation of te land, and after this upheaval, in the greater valleys large glaciers were formed which in Wales ploughed the drift out of the Passes of Nant Francon and Llanberis, and left untouched the marine drift deposits that cover the broad spreading table lands that lie on either side of these valleys at their mouths.

Another proof of the former existence of glaciers is to be found in the polishing, scratching, grooving, and deep furrowing of the rocks over which the glaciers flowed, magnificent examples of which occur in many a Highland valley, in Cumberland, Wales, Ireland, and the mountains of the Vosges. These markings precisely resemble those formerly produced in Switzerland by the greater extension of the Alpine glaciers, and what is now produced underneath and at the sides of glaciers that still exist. In Wales, wherever a tributary glacier has flowed into a valley, a series of lines is to be found, branching from the general direction of the grooves that mark the bottom and sides of the main valley. In Nant Francon, for example, in the main valley, the striæ follow its course (20° to 25° W. of N.); and in the tributary valleys they run east and north-easterly, according to their curves; while in entering Cwm Idwal from Nant Francon they curve gradually round from E.S.E. to N.N.E. The same is equally striking in the neighbourhood of Snowdon where, in the Pass of Llanberis, the grooves and striæ first strike from 30° to 35° south of east, and gradually curve round to the south, as a portion of them pass into the high tributary valley of Cwm Glas; or, again, in Nant Gwynant, where, in the main valley, they strike to the south-west, and branch off first to the north-west, and gradually curve round to the north in the higher part of Cwm-y-Llan; and in another instance, where they run generally west in the vast rocky amphitheatre of Glaslyn and Llyn Llydaw. In the higher parts of these tributary valleys, such as Cwm-y-Llan, the grooves converge towards the hollows at acute angles to the main direction of the valleys, in the manner that might be expected from ice of considerable thickness pressing downward, while by the weight and partial tension of the whole mass, it was at the same time pushed and dragged onward to feed the main icy stream, a movement and a result necessarily aided by the fact that in general glacier ice flows faster at the centre and slower at the sides. On the sides of the Passes of Llanberis and Nant Francon longitudinal grooves are found running in the directions of the main valleys, at a height of 1,300 feet above the bottom, sometimes quite across and transverse to the mouths of the tributary valleys that enter these passes. Unless they were actually much deepened by the glaciers, it follows then that at one period the ice of the Pass of Llanberis was 1,300 feet thick, and in all probability actually for a space overflowed part of the S.W. lip of the valley formed by the Cambrian hills above Dolbadarn Castle in the same manner that S.W. of the Bettenhorn, I feel sure the great glacier of Aletsch, on the evidence of striations, once overflowed the ridge that now separates it from the Valley of the Rhone. If this great thickness in the Pass of Llanberis were the case, then, as the watershed at the top of the Pass is only 1,000 feet above the sea, it follows that the vertical accumulation of snow and ice above that point must have been very great, so as not only partly to feed the glacier, but also to produce that pressure from above that aided the ice on its course. When by degrees the glaciers diminished in size, then the minor

UPPER GALLERY. — Table-case D.

UPPER GALLERY. — Table-case D.

tributary glaciers were no longer over-ridden by the chief glacier, but each valley poured in its tributary stream of ice ; and thus it happens that in some cases, when carefully looked for at the mouths of tributary valleys, transverse striations are found crossing each other, one set true to the course of the original great glacier, and others formed by minor tributary streams of ice that moulded themselves to the branching valleys when the supply of snow had declined or else the average temperature had risen. By degrees these results were clearly produced by amelioration of climate, for in Wales there is perfect evidence of a gradual decline of the glaciers in the retreating moraines concentrically arranged one within another,—as, for instance, in three or four perfect moraine mounds on the west side of Cwm Idwal, or in the moraine of Cwm Llafar, below Carnedd Llewelyn,—in which a long narrow channel has been ploughed by the glacier clean out of the terraced boulder-drifts,* the remains of a small moraine crossing near its upper end—or in the upper part of Cwm Brwynog, and in Cwm Glas, on the sides of Snowdon. Near the mouth of the last, not far above the bottom of the Pass of Llanberis, there are three concentric elliptical moraine heaps, touching each other ; and further up the valley, beyond the great *roche moutonnée*, that lies half a mile south of Blaen-y-Pennant, there is a perfect British terminal moraine, forming across the valley a long curved ridge of clay, sand, and moraine stones and boulders, some of them well scratched, and so regular in form that an uninitiated eye might fancy the mound to be an artificial earthwork. Other cases of equal value could be cited, showing a gradual retreat of the glaciers, till at length we find only the last symptoms of the ice in the relics of tiny moraines far up amid the innermost recesses of the mountains.

Allusion has been made to British *roches moutonnées*. These, when perfect, are rounded bosses of rock, of all sizes,

* These terraces in the drift have been made by denudation during pauses in the elevation of the country after its submersion to a depth of more than 2,000 feet. See p. 11.

that were polished by the sanded bottoms of the glaciers. Some are only a few yards in diameter, others rather deserve the name of small polished hills than of bosses. In all the British regions where glaciers existed they may be plentifully found, and in Wales they may be counted by the hundred. Perfect examples occur by the lake in Cwm Orthin, near Ffestiniog, in the tributary valleys above the river Llugwy, in Nant Francon above the Penrhyn slate quarries, on the slopes below Llyn Idwal, by the bridge above the waterfall, and on the shores of Llyn Padarn and Llyn Peris; and further up the pass, some of large dimensions, plentifully sprinkled with great blocks of stone (*blocs perchés*), amaze the passing tourist, who often wonders how masses rolled from the neighbouring mountains have been arrested on precarious points, from whence they would naturally have made a final bound into the lower depths of the valley, while the well-pleased eye of the experienced glacialist at once divines that they were gently deposited where they lie by the thawing of the glacier that bore them from the higher recesses of the mountains.

For the further guidance of those who may wish to examine this subject for themselves, I must add a little about the appearance of the polish on rocks, and the weathering of glaciated surfaces.

In the Alps, when glacier ice is freshly removed, the rock underneath, whether of limestone, gneiss, granite, or even quartz, though striated, often possesses almost the polish of a sheet of glass. In our own country, when the impervious covering of till has been taken away, the surfaces of limestone (as at North Berwick), though grooved and striated, are often beautifully smooth. In a country so low, this may have been due to the grating of icebergs. In other cases, as in some parts of Wales, when the turf and glacier debris is lifted, the underlying surfaces of cleaved slate still retain a perfect polish, marked sometimes by flutings, and sometimes by numerous scratches almost as fine as if made by the point of a diamond. After long exposure, these finer markings disappear, and though the

UPPER GALLERY. — Table-case D.

general rounded form perfectly remains, the surface becomes roughened, and the highly-inclined cleavage planes present on their edges a slightly serrated aspect. The deeper flutings, however, often for a long time remain; but even these at length vanish, though it is not until long after this has been effected that the general rounded form of the *roches moutonnées* is entirely obliterated. Phenomena of the same general nature are observable in the igneous and other uncleaved rocks over which a glacier has passed. The original polished surface, on exposure, becomes roughened by atmospheric disintegration; but the general form for long remains to attest its glacial origin, and in no case is there any danger of the experienced eye confounding this with those forms in gneiss produced by spherical decomposition, about which so much has been written. Finally, in the long lapse of time, the air, water, and repeated frosts tell their tale, the rock splits at its joints, crumbles, masses fall off, and, by degrees, it assumes an irregular and craggy outline, altogether distinct from the glaciated surface produced by the long-continued passage of ice; and thus it happens that on the very summit of some tower-like crag, the sides of which have been rent by the frosts of untold winters, the student of glacial phenomena sometimes finds yet intact the writing of the glacier; while below on its sides all trace of the ice-flood has long since disappeared. These things may seem almost incredible to those who are unaccustomed to read the records of many terrestrial revolutions in the rocks; but, nevertheless, of these extinct glaciers it is true that just as a skilful antiquary, from the wreck of some castle or abbey of the middle ages, can, in his mind's eye, conjure up the true semblance of what it was when entire, so the geologist, from the signs before him, can truthfully restore whole systems of glaciers that once filled the valleys of the Vosges, the Highlands, or of Wales.*

* The part of Wales chiefly referred to in the preceding notice and in the following list of specimens is contained in Maps 75 and 78.

UPPER GALLERY. Table-case D.

Specimens illustrative of the ancient Glaciers of North Wales, and of the Glacial Drift (Newer Pliocene or Pleistocene).

60.—MORAINE MUD in its native state, from a well-marked *moraine at the upper end of Cwm-y-llan, south of the peak of Snowdon.* This mud, and that in the other trays containing Welsh moraine matter, bears the closest resemblance to the moraine mud of the Swiss glaciers in some of the trays between Nos. 1 and 20.

61.—MORAINE MUD, as above, containing small angular stones in native proportion; *Cwm-y-llan, Snowdon.*

62 and 63.—MORAINE MUD of two descriptions, partly separated from larger material, with small angular and scratched stones; *Cwm-y-llan, Snowdon.*

64 to 66.—ANGULAR QUARTZ AND SLATY AND FELSPATHIC STONES, partly *scratched,* from *moraine of Cwm-y-llan, Snowdon.*

67.—ANGULAR SLATY STONE, well *scratched,* from *moraine of Cwm-y-llan, Snowdon.*

68.—MORAINE MUD, WITH SMALL ANGULAR GRAVEL, unsifted, from *moraine at the lower end of Llyn Llydaw, Snowdon.* This moraine partly lies upon the great *roches moutonnées* that bound the lake, and it also partly dams up the lake at its efflux. The *roches moutonnées* above alluded to, are covered with erratic blocks (*blocs perchés*), transported from higher levels by the glacier.

69 and 70.—MORAINE MUD, WITH SMALL ANGULAR STONES; *Llyn Llydaw, Snowdon.*

71.—ANGULAR STONE, IMPERFECTLY SMOOTHED AND SCRATCHED; *moraine, Llyn Llydaw.*

72.—SANDY MUD, WITH ANGULAR STONES (unsifted), *Glaslyn, Snowdon.* This lake is at a higher level than Llyn Llydaw, in the same valley. Both are surrounded by polished grooved and scratched rocks, and patches of moraine matter. Other lines and patches of moraine occur in Cwm Dyli, below Llyn Llydaw, and the whole of this mag-

Upper Gallery. — Table-case D.

nificent valley must have formed one of the chief and highest sources of ice that helped to feed the great glacier of Llyn Gwynant.

73.—Moraine mud and small angular felspathic slaty stones, in native proportion, from *inner moraine*, south of the great *roche moutonnée*, *Blaen-y-Pennant*, *Cwm Glas*, *Pass of Llanberis*, *Snowdon*.

74.—Angular and partly scratched felspathic slaty pebbles, same locality as above.

This moraine is perhaps the most entire and regular of any in Caernarvonshire. Its precise position is as follows:—In the Pass of Llanberis, immediately above the 11th milestone, is the cottage of Blaen-y-Pennant. Nearly a quarter of a mile due S.W. of the cottage is a large well-rounded *roche moutonnée* of felspathic trap, partly weathered. The moraine lies less than a quarter of a mile S.W. of the top of the rock, and stretches across the hollow between two brooks, looking almost like an artificial mound, so perfect is its form. Many other traces of moraines occur higher in this valley, especially in the neighbourhood of the little lakes in the uppermost recesses of Cwm Glas.

75.—Moraine mud and small angular stones, in native proportion, from the *outer moraine*, N.W. of the great *roche moutonnée*, *Blaen-y-Pennant*, *Cwm Glas*, *Pass of Llanberis*.

76.—Felspathic and slaty scratched angular stones, from the same moraine as 75.

This moraine is elliptical in form, very stony, and divided into two or perhaps three mounds, one within another, showing, like the moraines of the glacier of the Rhone, but less perfectly, the gradual retreat of the glacier. In the same neighbourhood, between Blaen-y-Pennant and Pont-y-Gromlech, on the S.W. side of the Pass, at a short distance from the road, there is an immense mound of moraine debris, so lofty and solid looking that it forms an actual hill. This is probably the remains of a *great moraine* shed by the Cwm Glas glacier, when it was at that stage that it descended into the Pass, and its extremity abutted on the opposing slope of Y-Glyder-fawr. In such a case, the debris that fell from the glacier ***on the side that looked up the Pass*** would accumulate indefinitely against that side of the glacier, while the moraine matter shed from the side that looked down the Pass would in great part be destroyed, nearly as fast as it was formed, by water flowing from the glacier, as is often the case at the ends of Swiss glaciers now. Since the disappearance of the ice, part of the ***great moraine*** has been entirely destroyed by the ordinary drainage of the upper part of the Pass of Llanberis.

Moraine drift.—On the mountains of Caernarvonshire, and in North Wales generally, the surface is, over large areas, more or less covered by GLACIAL DRIFT. This drift rises from underneath the present sea level to a height of about 2,300 feet on some of the mountains. Near the shore it has often been re-arranged and waterworn by the sea during terrestrial oscillations of level, but in the higher grounds it is generally in its native state, consisting of clay, angular stones, gravel, and boulders, sometimes, as in Cwm Llafar below Carnedd Llewellyn, arranged in terraces marking pauses in the elevation of the country (see p. 16). Shells were found by Mr. Trimmer, on Moel Tryfan, 1,300 feet above the sea, in gravel, and others were found by myself in a boulder clay at about the same height, less than two miles west of the peak of Snowdon. It has been already stated that some of the Welch glaciers shed their moraines in the sea, while drift was being deposited on adjacent sea bottoms. Much of this drift precisely resembles ordinary moraine matter in the appearance and quality of its mud, and the angularity, scratched surfaces, and sizes of its stones. At a time when glaciers descended to the sea, the higher mountains rose as islands of not more than about 2,000 feet high, and yet gave birth to distinct glaciers. It is therefore not improbable that in other por-

UPPER GALLERY. — Table-case D.

tions of the same islands not possessed of the form requisite to originate massive glaciers, snow and glacier ice may yet have covered nearly their entire surfaces, for unless the cold were sufficient to produce such a result, it is difficult to understand how on other parts of these small islands good-sized glaciers, such as then certainly filled the valleys, could have been produced. If this covering did exist, it is very intelligible how the drift on the sides of the mountains is generally composed of stones from the hills close above, and also is more or less moraine-like in its character. It is not till we reach the comparatively distant lower ground of Caernarvonshire, near the sea, and the plains of Anglesea, that far-travelled fragments begin to occur in ordinary drift deposits. Under any circumstances, small icebergs and coast-ice grating along the shores would in the course of time be sufficient not only to polish the rocky coasts, but also to groove and scratch blocks and stones imprisoned in floating ice, such as are shown in the following specimens.

80.—FINE SIFTED MORAINE MUD, MARINE, from *Ceunant-Mawr*, near the top of *Cwm-Gwynant*, between Llyn-Gwynant and Pen-y-gwryd.

81.—MORAINE MUD AND ANGULAR STONES, in native proportion, from the above locality.

82.—SMALL ANGULAR AND SUBANGULAR STONES, separated from the mud; from the above locality.

83.—SCRATCHED SLATY STONE, from the above locality.

84.—FINE MORAINE MUD, WITH SMALL ANGULAR GRAVEL, partly sifted, from thick banks of drift matter, full of local fragments; *between Llyn-y-Gader* and *Yr Aran.*

85.—As above, with angular stones.

86.—SLATY PEBBLES, SCRATCHED; from same locality as above.

87.—FINELY POLISHED SCRATCHED SLATY STONE, as above. In this specimen the majority of the scratches run in the direction of the length of the stone.

88.—DRIFT CLAY MORAINE MATTER, with angular and rounded stones; north of *Moel*, above the *river Gorfai*, between Caernarvon and Llyn Cwellyn. UPPER GALLERY. Table-case U.

In this specimen some of the stones are *rounded* and *waterworn*. The hill-side whence it was derived lies open towards the sea.

89.—RECENT LAKE GRAVEL, *Llyn Padarn, Llanberis*, Caernarvonshire. Collected to contrast the waterworn shape of the stones with the angularity of the majority of moraine and drift stones in the Case.

Scratched and striated stones and boulders, from the ordinary marine Glacial Drift of Anglesea, Lancashire, Norfolk, and Suffolk.

90 and 91.—SUBANGULAR SMOOTHED AND SCRATCHED SLATY STONES, from cliff of *boulder clay* on the coast, *Yr Henborth, Llanfairynghornwy, Anglesea.*

92.—SUBANGULAR SMOOTHED AND SCRATCHED STONE, from *Anglesea;* underlying bed containing tooth of a *horse* (*Equus fossilis*).

92*.—ROUNDED WATERWORN STONE, OF QUARTZ ROCK, similar to the pebbles of the New red conglomerate, and perhaps derived from it; same locality as above. This stone, though well waterworn, (unlike the pebbles of the New red sandstone *in place*), shows traces of *glacial scratching.*

93 and 94. — ROUNDED WATERWORN STRIATED GRIT STONES; *Patricroft, Lancashire.* Presented by Mr. James Nasmyth. The striations of these stones run in the direction of their length. (Lower compartment.)

95.—ANGULAR BOULDER OF STRIATED GRIT, from the *lower drift boulder clay of Happisburgh, Norfolk.* Presented by the Rev. John Gunn. (Lower compartment.)

96.—Fragment of large SCRATCHED AND STRIATED SEPTARIAN, of the *Kimeridge clay*, from the *upper drift boulder clay*, near *Burgh Castle, Suffolk.* Presented by the Rev. J. Gunn. (Lower compartment.)

UPPER GALLERY. — Table-case D. Lower compartment.

This specimen, especially, clearly indicates the production of strongly striated and scratched surfaces on boulder stones imprisoned in drifting ice that grated along rocky coasts or sea bottoms; for the Kimeridge clay, from which this stone was probably at first derived, lies in England in the form of low plains, where it is improbable glaciers ever existed.

97. Same as 94 and 95. (Lower compartment.)

98.—Fragment of boulder, from the PERMIAN BRECCIATED CONGLOMERATE, near Hundred House, Abberley Hills. Placed for comparison. (Lower compartment.)

PERMIAN ICE-DRIFT.

Specimens to illustrate the brecciated conglomerates of the Permian or Lower Red sandstone series occurring at the south end of the Malvern Hills, at Howler's Heath, at Knightsford Bridge, on parts of the Abberley Hills, near Enville, on the Clent and Lickey Hills, &c.

On the Abberley Hills at Woodbury, and behind Hundred House, at Stagbury Hill, Warshill, and near Enville, the same *brecciated conglomerate* forms part of the Permian strata, in a long interrupted line. Also at Church Hill, six miles north-west of Hundred House, there is an outlier of breccia lying on coal-measures. It also occurs in beds 400 feet thick on the Clent and Bromsgrove Lickey Hills, at Frankley beeches, and at Northfield, on the east side of the south end of the South Staffordshire coal field. The fragments that form this remarkable rock are all angular and subangular. Some of them are from two to three feet in diameter, and deserve the name of boulders. Many of them are polished, and some are well scratched and striated. They are invariably embedded in a red marly clay, and in all cases they contain few or no fragments of the neighbouring rocks, and chiefly agree in lithological character with the Cambrian rocks of the Longmynd in Shropshire, the Llandeilo and Lingula slates and altered rocks, and the traps and ashes of the same distant area, together with certain *Pentamerus or upper Llandovery limestones and conglomerates*, which contain peculiar green pebbles derived from Longmynd strata. These Pentamerus beds when in place lie unconformably on the Longmynd Cambrian rocks and the Llandeilo flags, between the Stiper Stones and Chirbury. The pebbles and blocks therefore of the breccia chiefly consist of felstone porphyry, greenstone porphyry, greenstone amygdaloid, altered ribboned slate, black and green slate, felspathic ash, quartz rock, quartz conglomerate, purple and green Cambrian slate and coarse conglomerate, grey grit, and sandy *Pentamerus limestone*, all characteristic rocks of the Longmynd area or its neighbourhood. The Pentamerus limestone often occurs in the Breccia (as at Northfield) in large angular slabs, full of the peculiar assemblage of fossils that mark that ancient Silurian beach in the Longmynd country, and the inference is that they were transported from thence. Along with these "a well-rounded waterworn pebble is of rare occurrence. The surfaces of a great majority of the pebbles are much flattened, numbers are highly polished, and, when searched for, some of them are found to be distinctly grooved and finely striated. The striæ in some are clear and sharp, and run parallel to each other or cross at various angles; while in others, though you see their remains, age and surface decomposition have impaired their sharpness, and roughened the original polish of the stone." In general the surfaces, including the scratches, are covered by a thin ferruginous crust. The confused and irregular manner in which the whole is bedded, the angularity of all, and the great size of many of the stones, together with the clay in which they lie, present such strong resemblances to much of the "drift" boulder clays, that the appearances may almost be said to be identical. All the places where the breccias occur lie from 25 to 45 miles from the presumed parent rocks; and few English geologists now believe that un-

UPPER GALLERY

Table-case D.

UPPER GALLERY. — Table-case D.

rounded boulders sometimes several feet in diameter, and deposits of this kind generally, could have been carried so far, either by ordinary marine currents or by assumed violent floods. I believe that only the transporting power of floating ice, long continued, could have produced results of such magnitude, marked by the peculiarities above described. The rock is of the same age as the German Roth-todte-liegende, and is identical with much of it in general appearance. (For further details, see "Journal of the Geological Society," August 1855, p. 185. Ramsay.)

Pieces of Permian Brecciated Conglomerate, or stones and parts of stones collected from it.

100.—From *Woodbury Rock, Knightsford Bridge, Abberley Hills.*

101.—From *Howler's Heath*, south end of the *Malvern Hills.* These show, on a small scale, the general nature of the brecciated conglomerate, viz., the angularity of the stones, and the red marly paste in which they are embedded.

102.—*Berrow Hill*, near *Martley, Abberley Hills.*

103.—*Abberley Hills*, behind *Hundred House.*

104.—*Clent*, north of *Bromsgrove.*

105.—*Wars Hill*, near *Bewdley.*

106.—*Romsley*, near the Day House, *Bromsgrove Lickey.* These specimens were dug from the quarries and loosened to show the angularity of the smaller fragments.

107.—Part of a GROOVED SMALL BOULDER (of altered Cambrian grit) dug out of a quarry, *Berrow Hill*, near *Martley*, Worcestershire. The rubbing and grinding of the stone goes partly round the edge marked × ; in this respect resembling the side of the stone marked ×, from the glacial drift, No. 93.

108.—SUBANGULAR PURPLE FINE CAMBRIAN GRIT, *scratched on all sides; Six Ashes*, near *Enville*, Worcestershire. The scratches run chiefly with the length of the stone, but many of them cross each other in all directions. Compare with No. 35, from the glacier of the Grindelwald; 52, from the Vosges; 67, 76, from the moraines of Caernarvonshire; 83, 86, and 87, from the moraine drift; and 90 and 91, from the ordinary marine glacial drift of Anglesea. UPPER GALLERY — Table-case L.

109.—SUBANGULAR STONE (Cambrian grit), *scratched*, the scratches covered with a thin ferruginous coating; from *the outlier of Church Hill, Bayton.* This small outlier helps to mark the original wide extension of the brecciated conglomerate. It is entirely surrounded by Coal-measures, which lie on the Old Red sandstone, and the blocks that form it are not derived from the strata immediately around. The nearest spot where grit like this stone occurs in place is the Longmynd. The scratches at × show a tendency to pass round the curved edge as in 93 and 107.

110.—Part of a SUBANGULAR STONE (Cambrian grit ?), *scratched; Berrow Hill, Abberley Hills*, near *Martley.*

111.—FLAT ANGULAR STONE (Cambrian grit), *faintly striated; Bromsley*, near *Day House, Bromsgrove Lickey.*

112.—Part of STRIATED STONE, well marked on the edge marked ×. The remainder of the sides show rough fractures. The stone consists of fine banded conglomerate and grit. *Berrow Hill, Abberley Hills.*

113.—FLAT SUBANGULAR SCRATCHED STONE (greyish red Cambrian grit?); *Abberley Hill*, behind *Hundred House, Worcestershire.*

114.—SUBANGULAR STONES, *smoothed and finely scratched; Stagbury Hill*, near *Stourport.* The altered slaty fragment marked × is as finely striated as the specimen No. 36, from the moraine in motion in the *Pass of Chevdule.*

115.—SUBANGULAR PURPLE (Cambrian ?) GRIT, *with smoothed and striated side; Woodbury Hill, Abberley Hills.*

116.—SUBANGULAR STONE, with *scratched* surface; *Clent Hill*, near Clent. Banded (Cambrian ?) grit.

117.—POLISHED AND SCRATCHED SUBANGULAR STONE; scratches partly covered by a very thin ferruginous crust. The rock consists of very coarse felspathic grit, and fine

UPPER GALLERY. — Table-case D.

felspathic grit, equally polished, probably originally forming part of the felspathic ashy rocks, west of the Stiper Stones, Shropshire. From the lane between *Northfield* and *Bangham Pit*, on the east side of the south end of the *South Staffordshire coal field*, seven miles south-west of Birmingham.

118.—SMOOTHED ANGULAR STONE, *finely striated; Berrow Hill*, near *Martley, Abberley Hills.* Probably originally derived from a bed of altered slate.

119.—WATERWORN GREENISH PURPLE PEBBLE (Cambrian?), polished and *faintly scratched; Berrow Hills, Abberley Hills.*

120.—SUBANGULAR FRAGMENT of a *boulder* of felspathic greenstone; *Abberley Hill*, near *Hundred House.*

121.—SMOOTHED ANGULAR CONGLOMERATE; *Woodbury Hill*, near *Hundred House.* Like some of the Cambrian conglomerates.

122.—SUBANGULAR STONE, felspar porphyry; *Stagbury Hill, Stourport, Worcestershire.*

123.—SUBANGULAR FRAGMENT, greenstone; *Clent Hills.*

124.—Part of a SUBANGULAR STONE of altered (porcelainised Lower Silurian) slate; *Clent Hills.*

125.—SMOOTHED ANGULAR STONES, from lane between *Northfield* and *Bangham Pit*, Worcestershire. The large one is felspathic porphyry; the others are of banded fine altered grits.

126.—ANGULAR STONES, grit and fine felspar porphyry; *Abberley Hills.*

127.—Part of a SUBANGULAR STONE, *of quartz rock; Romsey*, near the *Day House, Bromsgrove Lickey.*

128.—ANGULAR STONE of *felspathic trap*, like that of the *Lower* Silurian rocks, Shropshire.

129 to 135 are from ANGULAR SLABS AND STONES, of calcareous sandstone and Silurian limestone, often of large size, embedded in the marly parts of the Permian brecciated conglomerate.

129.—SILURIAN LIMESTONE, *Pentamerus or Upper Llandovery beds; lane between Northfield and Bangham Pit,* east side of the south end of the South Staffordshire coal field. UPPER GALLERY. — Table-case D.

130 and 131.—FOSSILIFEROUS CALCAREOUS SANDSTONE AND LIMESTONE of the *Upper Pentamerus* or *Upper Llandovery* beds; from *Woodbury Rock, Knightsford Bridge.* The rock is like that of *Hope Hill*, and other parts of the same beds near Chirbury, and from thence skirting the edges of the Lower Silurian rocks, round to Church Stretton. (See Maps.) It contains the usual fossils, and fragments of green slate of the Longmynd, by which *its original position in place* is identified. Broken with the hammer to show the fossils.

132 to 134.—Fragments of similar rocks, from the lane between *Northfield* and *Bangham Pit, Worcestershire;* full of *Pentamerus oblongus*, &c. These were derived from very large angular slabs. The nearest rock of this kind in place is about 45 miles distant, resting on the lower Silurian rocks west of the Longmynd.

135.—Parts of stone of UPPER SILURIAN FOSSILIFEROUS LIMESTONE, from *Permian brecciated conglomerate* of *Abberley Hill, Hundred House.*

136.—Parts of stone of UPPER SILURIAN FOSSILIFEROUS LIMESTONE, from the *outlier* of *Church Hill, Bayton.* Both of these were probably originally transported from the Wenlock Edge country.

Specimens to illustrate the difference between waterworn stones in conglomerates and angular aqueous breccias.

140 and 141.—PERMIAN CONGLOMERATE, and stones from conglomerate; *Four Ashes*, near *Enville, Shropshire.*

142.—Ditto, *Galacre Hall*, near *Enville.* This conglomerate lies below the Permian brecciated conglomerate, and is separated from it by beds of red marl and sandstone. Almost all the pebbles in it are well waterworn and rounded, and they are invariably small. They are included in this

UPPER GALLERY. — Table-case D.

collection for the purpose of contrasting them with the angular stones of the breccia. The true conglomerate is so calcareous that it has sometimes been burned for lime. Unlike those in the breccia, the limestone pebbles have generally been derived from the Carboniferous limestone, and stems of Encrinites stand in relief on the weathered surfaces of the pebbles.

143.—Calcareous ORDINARY CONGLOMERATE, from the Permian rocks near *Bedworth, Warwickshire;* like 140 to 142.

144.—*Pebbles from the conglomerate of the New Red Sandstone* (Bunter). These are also placed in the Case to contrast with the angular stones No. 100 to 128. No scratches appear on them, but they are exceedingly waterworn, and have been smoothed like the pebbles of the Chesil bank, or any similar beach, by breakers or some such movement rattling them against each other. "Its component stones are often from three to nine inches in diameter, but unlike those in the breccias, they are all beautifully rounded, and where they touch in the rock they are not scratched, but indent each other at the points of contact; the indentations being, I believe, due to the fact that, while these gravels were still incoherent, over great areas, the upper parts of the New Red series, the Lias, and perhaps other newer strata, were piled upon them, and the vertical pressure consequent on this vast superincumbent pile induced a lateral pressure in the loose-lying pebbles of the conglomerate; so that being squeezed, not only downwards, but outwards, they ground on each other, and perhaps partly by the aid of intervening grains of sand, circular indentations were formed sometimes an inch in diameter." (Ramsay, Geological Journal, Feb. 1855, p. 200.) Some of them are fractured and re-cemented. The fractures were produced by pressure, generally close to faults.

ROCKS.

Wall-cases 40 to 44.

Wall-cases 40 to 44.

These contain suites of Specimens intended to illustrate the ***lithological characters of stratified rocks;*** or, in other words, the nature of the stony substances of which stratified rocks are formed. They are therefore not arranged in their stratigraphical order of succession, but rather according to their various compositions, showing in **Wall-cases 41 & 43** how rocks of various kinds pass by insensible gradations into each other.

Wall-case 40.

Wall-case 40

Nos. 1 to 32 chiefly consist of Specimens illustrating the manner in which depositions of carbonate of lime (limestone) are formed from a bi-carbonate of lime in solution in water. All rain water contains carbonic acid, which it abstracts from the air. Such part of the water as percolates through rocks containing lime is thus enabled to form a soluble bi-carbonate, and rising in springs or dropping from the roofs of caverns, evaporation takes place, and a portion of this mineral is deposited in the form of ***calcareous tufas, stalactites, stalagmites, &c.*** A familiar illustration occurs in the stalactitic pendants hanging like icicles from the arches of almost every stone bridge. In the same manner ***stalagmites*** are formed by the dropping and evaporation of calcareous water on the floors of caverns, &c., and calcareous tufas are frequently formed in the open air by the evaporation of the water which flows over the surface from springs highly charged with lime. The bones of many animals, mostly extinct species, have been preserved in numerous caves in the limestone rocks of Great Britain, partly through the agency of stalagmitic crusts, which cover up the clays, gravels, &c. in which they lie, UPPER GALLERY. — Wall-case 40

and protect them from the air. Nos. 1 to 19 especially illustrate the formation of *stalactites* and *stalagmites*. *Tufas* formed in the open air frequently encrust mosses, grasses, leaves, stems of plants, land and fresh-water shells, &c., which thus become fossilized before our eyes. (See Nos. 25 to 31.)

Laminated and crystalline aggregations of various substances are in an analogous manner frequently formed in the interior of lodes, and other cavities. (See Nos. 18 and 24.) A. C. Ramsay.

Wall-case 40.

SEDIMENTARY ROCKS.

Arranged and described by H. W. BRISTOW.

Some of the Specimens consist of nearly pure carbonate of lime. Carbonate of lime consists of—

Carbonic acid - -	44·00
Lime - - - -	56·0
	100·0

1.—STALACTITE from *Carboniferous limestone*, and stained of a red colour by iron.—*Forest of Dean.*

2.—CALCAREOUS DEPOSIT, formed in eighteen months, round the outside of the plunger-barrel of a pump used for feeding the boiler of a steam engine. The water was a very pure limestone stream, mixed with that flowing from the mine levels.—*Penydarren.* Presented by Mr. M. Moggeridge.

3.—Longitudinal polished section of a large STALACTITE, showing the mode of formation, by the deposit of successive layers of calcareous matter.—*From Derbyshire.* Presented by Prof. Tennant, F.G.S.

4.—Part of a STALACTITE from *Carboniferous limestone.* —*Forest of Dean, Gloucestershire.*

5.—STALACTITIC CARBONATE OF LIME, obtained in 1804, from the "*Blue John Mine," Derbyshire.*—Presented by Richard Phillips, F.R.S. Upper Gallery. Wall-case 49.

Nos. 1, 3, 4, 5 are placed in the positions in which they were formed in their natural pendant state.

6.—CALCAREOUS DEPOSIT, formed in the interior of an earthenware pipe.

7.—Long columnar STALACTITE, composed of concentric layers of carbonate of lime.

8.—CARBONATE OF LIME, deposited in the interior of a lead pipe.

8a.—LAMINATED deposition of CARBONATE OF LIME, from the interior of a wooden pipe. Taken from a mine supposed to have been closed 100 years.—Presented by the Rev John Gunn.

9.—STALAGMITE, OR STALACTITE, formed by the deposition of carbonate of lime upon botryoidal chalcedony.—*Aden.* Presented by the East India Company.

10.—CONCRETIONARY STALACTITE, from *Matlock, Derby shire.*

11.—STALAGMITE radiating crystals (*carbonate of lime*) producing a mammillated surface.

No. 10 is hung in the pendant position of a stalactite, and No. 11 flat, in the manner in which such stalagmites are frequently formed, from the evaporation of dropping water containing lime in solution.

12.—ARRAGONITE (*flos-ferri*).

13.—ARRAGONITE (*polished*).—*Ilfracombe, Devonshire.* Presented by Thomas Reynolds.

14.—FIBROUS ARRAGONITE (*flos-ferri*), with veins of calcareous spar.—*Alston Moor, Cumberland.*

15.—MEDALLION. Head of Jupiter, composed of *carbonate of lime*, deposited in a mould, from water charged with calcareous matter. The spring charged with calcareous matter is made to descend from a height upon some boughs of trees placed beneath, by which means it is divided into a fine spray. The mould of which a copy is

UPPER GALLERY, — Wall-case 40. required, or the other objects to be petrified, being placed where the spray will fall upon them, thus become gradually covered with a calcareous deposit by the evaporation of the water holding it in solution, and at length a cast of the original is procured.—From the springs of *San Filippo, near Radicofani, Tuscany.* Presented by Dr. Radford.—H.W.B.

16.—STALAGMITIC ARRAGONITE (*flos-ferri*), on clay slate. —*Ilfracombe, Devon.* Presented by T. Richardson.

17.—CORALLOID ARRAGONITE (*flos-ferri*), on clay slate. —*Ifracombe, Devon.* Presented by T. Richardson.

Arragonite differs from calcareous spar in containing a little strontia and water; example from Brisgau—

Carbonate of lime - -	97·0963
Carbonate of strontia -	2·4609
Water - - - - -	0·4102
	99·9674

"At *Dufton*, a silky, fibrous variety, called *satin spar*, (see 13 and 14,) occurs, traversing shale, in thin veins, generally associated with pyrites. In *Buckinghamshire, Devonshire*, &c. it occurs in stalactitic forms in caverns, and of snowy whiteness at *Leadhills* in *Lanarkshire.*"—Dana's "Mineralogy," 1854, vol. ii., p. 449.

18.—CRYSTALS OF CALCAREOUS SPAR lining a cavity, in *Marlstone.—Bridport, Dorset.*

19.—CALCAREOUS DEPOSIT, formed in the condenser of a steam engine, and obtained by John Dawes, Esq., Smethwick House, near Birmingham.

20.—SAND, *agglutinated by carbonate of copper*, derived from the decomposition of the ores in the heaps of refuse of *Huel Leisure, Cornwall.*

In this case the sulphuret of copper has been partly decomposed, and borne away in solution in the water that percolated through the refuse heaps, after which it was re-deposited as carbonate of copper amongst the sand, thus agglutinating the particles and forming a sand rock.—A.C.R.

21.—CALCAREOUS DEPOSIT formed on the heads of rivets in the interior of a boiler at *Mr. Sheppard's Cloth Factory, Frome, Somerset.*

22.—CALCAREOUS DEPOSIT from the walls of the *Piscina Mirabile, near Naples.*—Presented by Dr. H. C. Barlow.

23.—CALCAREOUS INCRUSTATION from the interior of a boiler.—Presented by Dr. Lyon Playfair, C.B., F.R.S.

Nos. 2, 6, 8, 8a, 19, 21, 22, and 23, illustrate the manner in which pipes and other vessels become choked by depositions from hard water containing lime in solution. In London and all other districts supplied with hard water most persons are familiar with this circumstance by the calcareous incrustations formed in their tea-kettles. (*A.C.R.*)

23a.—STALAGMITE forming the floor of a bone-cave.—*Brixham, Devon.*

23b.—CALCAREOUS DEPOSIT on Devonian limestone; found lying on the floor of a bone-cave.—*Brixham, Devon.*

24.—PART OF A LODE, consisting of angular fragments of *limestone,* cemented together, and encrusted with crystals of *calcareous spar.*—Presented by Dr. Lyon Playfair, C.B.

25.—CALCAREOUS INCRUSTATIONS upon the leaves of a tree.

26.—TRAVERTINE OR CALCAREOUS TUFA,* containing the impression of a leaf.—*Matlock, Derbyshire.*

27.—CALCAREOUS TUFA, encrusting stems of plants.—*From the Great Northern Railway.* Presented by Thomas Reynolds, Esq.

28.—CALCAREOUS TUFA, encasing plants.

29.—CALCAREOUS TUFA, encasing plants.—*Richmond, Yorkshire.*

30.—CALCAREOUS TUFA, deposited on the *fluvio-marine strata* of *Tollands Bay,* in the Isle of Wight, and containing concentric concretions of *lime* with numerous *land and freshwater shells* of existing species.

See "Survey Memoir on the Fluvio-marine strata of the Isle of Wight," Forbes, pp. 8 and 105, Map No. 10, and Vertical Sections No. 25.

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* See also Table-case B in Recess 6, Nos. 206 to 223.

UPPER GALLERY. — Wall-case 40.

31.—CALCAREOUS TUFA, deposited upon *Carboniferous limestone* by old springs now dried, and containing *stems and leaves of plants* with *land shells*.—Near *Llangollen, Denbighshire.*

The tufaceous deposits from 25 to 31 are all comparatively recent, and enclose plants and shells of living species.

32.—TUFACEOUS LIMESTONE, from the "cap" beds of *Portland stone.* See Map 17 and vertical sections No. 22. —*Hospital Quarry, Isle of Portland.*

In the Isle of Portland, interposed between the slaty limestone of the Purbeck and the true Portland stone there is a series of "dirt beds" and beds of hard irregular limestone, termed by the quarrymen "caps," from the positions occupied by them in reference to the latter. The thickness of these beds is very variable; even at short intervals, and in the same quarry, the upper bed, called "top cap," varies from four feet to four feet six inches in thickness; and the lower, or "skull cap," from six inches to four feet and more. A "dirt bed" frequently divides the "skull cap" from the Portland stone. The caps are hard tufaceous limestones, constituting, strictly speaking, the base of the lower Purbeck beds; and the late Professor Forbes, adopting this view in his classification of that group, retained the trivial name, as expressive of their mode of occurrence, designating them "soft" and "hard" cap respectively. Taken in connexion with the "dirt beds" or dry-land surfaces, it is not unreasonable to infer that, like other limestones of the same character, they were partly of lacustrine and partly of subaerial formation.—H. W. B.

BEDS FORMED BY CHEMICAL ACTION.

GYPSUM (SULPHATE OF LIME), ROCK SALT, &c.

33.—MASSIVE GYPSUM (ALABASTER), from *New Red Marl.* —*Syston, Leicestershire.*

34.—FIBROUS GYPSUM, from *New Red Marl.*—*Penarth, Cardiff, Glamorganshire.*

35.—FLESH-COLOURED GYPSUM, showing its mode of occurrence in the marls of the *New Red Sandstone.—Cardiff, Glamorganshire.* Presented by Sir H. T. De la Beche, C.B.

UPPER GALLERY. Wall-case 40.

36.—FIBROUS GYPSUM, from *New Red Marl.—Syston, Leicestershire.*

37.—WHITE GYPSUM, showing its mode of occurrence in the marls of the *New Red Sandstone.—Cardiff, Glamorganshire.*

38.—Thin fibrous laminæ and small irregular concretions of WHITE GYPSUM in *New Red Marl.—Syston, Leicestershire.*

39.—FIBROUS GYPSUM and SELENITE, occurring in large masses in the *lower Purbeck beds* of *Durlstone Bay*, and used for making plaster of Paris. (See Geological Map, No. 16, and Vertical Sections, sheet 22.) *Dorset.*

40.—Crystals of SELENITE from *Gault.—Dinton, Wilts.*

41.—Crystals of SELENITE, *from the Black Sea.*—Presented by F. Smith.

42.—Crystals of SELENITE, from *Lower Green Sand.—Atherfield Cliff, Isle of Wight.*

43.—ROCK SALT (*chloride of sodium*).—*North of Ireland.* Presented by the Marquis of Downshire.

44.—ROCK SALT from *New Red Marl*, used for the manufacture of salt.—*Cheshire.*

"The salt mines of Cheshire are worked in the New Red Sandstone of that country, the salt being in large beds of irregular form, associated with marl and gypsum. The number of saliferous beds in the district is five, the thinnest of them being 6 inches, but the thickest nearly 40 feet thick, and they are worked at a depth of from 50 to 180 yards below the surface. Upwards of 70,000 tons are obtained from the Cheshire mines, and a large quantity is also manufactured from brine-springs, and other similar sources in Cheshire and East Worcestershire." (Official Catalogue, Great Exhibition, 1851.)

These beds of salt are regularly stratified, and occur about the base of the Keuper marl. The greater part is like

UPPER GALLERY. — Wall-case 40.

the red specimens, being coloured by marly and ferruginous impurities; the pure and transparent kinds, although by no means scarce, are less common. The manner in which the salt was originally formed in the rock is obscure, but it is not improbable that it was deposited in salt lakes, where he evaporation of water being equal to the supply, no rivers flowed from them. All river waters contain small quantities of salts in solution, and by this means, in the course of time, the water of any lake (having no outlet) may become saturated with salts, after which, the supply continuing, deposition will ensue, in the manner in which it now takes place in the great salt lake of Utah, North America.—A. C. Ramsay.

Pure Rock salt consists essentially of chloride of sodium:

Chlorine - - -	59·5
Sodium - - -	40·5
	100·0

45.—Sulphate of Strontian, occurring in large quantities in *New Red Marl*, near *Yate, in Gloucestershire*, probably replacing sulphate of lime.—See "Memoirs of Geological Survey," vol. i., p. 267.

46.—Keuper Sandstone, with pseudomorphous crystals of Rock salt.

These beds of Keuper sandstone lie in the middle of the New Red marl, and contain fossils, namely, *Batrachian footprints, fish spines*, and a small bi-valve crustacean *Estheria minuta*, formerly called *Posidonomya minuta.* The majority of the crystals "are cubes, or modifications of cubes."

"Of substances which crystallize in cubes, the only ones which usually occur in the Triassic formations are sulphuret of iron, or iron pyrites, and chloride of sodium, or common salt. It is hardly possible that sulphuret of iron can have supplied the mould into which the sand was afterwards poured, as it would require a considerable time both for the formation and the removal of crystals of that mineral, whereas it is evident that the crystals in question must have been formed, and must have been afterwards removed, leaving an empty cavity, in the short interval between the deposition of one bed of sand, and of the one immediately superimposed. All these conditions, however, are supplied in the most satisfactory manner by supposing chloride of sodium to have been the material which formed the mould for these pseudomorphous crystals. The ripple marks—the cracks formed by desiccation in the argillaceous beds, and afterwards filled with sand poured in from above, and the not unfrequent impressions of the feet of air-breathing reptiles, all of which phenomena especially characterize the Keuper sandstones of our English counties, seem to point to a very shallow state of the sea, abounding with sand-banks and extensive salt-water marshes, often laid bare in the intervals of the tides. If now we suppose that at the locality in question a sandy marsh existed, which at high spring tide was covered by the sea, we can easily conceive that in the interval between two spring tides, or in the still longer one between two equinoctial tides, the sea water ponded up in such a marsh, had time to evaporate and to deposit its crystals of chloride of sodium, which being slowly and tranquilly formed would assume their normal shape of cubes. As the desiccation proceeded these crystals would be enveloped by the fine muddy sediment which usually forms the last deposit of water as it evaporates to dryness; when, after a given interval, the tide again overflowed the spot, the returning sea water (not being saturated) would dissolve these saline crystals, leaving cubical cavities in the mud which contained them. The tide would bring with it a fresh deposit of fine sand, a portion of which would pour into the cavities formed by the crystals, and the remainder would form a homogeneous stratum immediately above.—("On Pseudomorphous Crystals of Chloride of Sodium in Keuper Sandstone." H. E. Strickland, Esq., F.R.S., F.G.S. Journal of Geological Society, Dec. 1, 1852.)

UPPER GALLERY. — Wall-case 40

UPPER GALLERY.

Wall-case 41.

Wall-case 41. The Specimens from Nos. 1 to 48 are varieties of *Conglomerate.* They may be divided into two chief varieties, viz., those in which the embedded fragments are *angular,* constituting *brecciated conglomerates;* and those in which they are *rounded,* forming the most common class of *ordinary conglomerates.* In the brecciated conglomerates the specimens have not been subjected to much attrition, but have been dropped in a more or less angular state amid the finer sediment that forms the cementing base.—(Nos. 2, 5, 6, 16.)

In ordinary conglomerate the fragments have been rounded by attrition, by the action of breakers, &c., like the pebbles of an ordinary beach. In different specimens the cementing matter is of different kinds; in some the stones are cemented by lime, in others by oxide of iron, in others by both, in others the agglutination has perhaps been aided by the decomposition of felspathic matter, and the formation of new silicates of soda or potash; in others, which seem purely siliceous, it would appear as if small quantities of silica had been dissolved and re-deposited among the quartz grains and pebbles, and in many cases pressure has had a great deal to do with the consolidation of the rock.

Conglomerates are of all degrees of coarseness; in the Old Red Sandstone of Scotland, and the Lower Red or Permian sandstones (Roth-todte-liegende) of England and Germany, there are sometimes blocks of several feet in diameter, and from such conglomerates every gradation may be traced, until at length they pass imperceptibly into grits and sandstones, (see Nos. 45 to 51,) from these into marls, shales, and clays (see Nos. 127 to 146). True clays are necessarily more or less aluminous, but in other respects the difference between shales, sandstones, and conglomerates lies merely in the fineness of the grain. An examination of many sandstones with the magnifying glass shows that their component grains are more or less rounded by attrition in water, like the pebbles of the conglomerates, Nos. 14, 15, and 19. This naturally leads to the subject of the mode of formation of stratified rocks in general.

Stratified rocks are of two kinds, chemical and mechanical, the mechanical rocks by far predominating. The descriptions relating to **Wall-case 40** will give an idea of the manner by which stratified rocks are chemically deposited. Without entering into details, those formed mechanically are chiefly deposited in lakes, and in the sea, in the shape of sediment. All rivers carry sediment to the sea, by the disintegration and waste of the land through which they pass. All sea coasts are more or less wasted by the action of breakers, and this is the chief cause of irregularities in the outlines of shores. The sediment thus formed is spread abroad in the sea to form strata. Sea-weed, shell-fish, and other organic bodies live and die among it, and as the successive beds accumulate, they frequently consolidate, and the whole becomes petrified or turned into stone, partly by pressure, partly by chemical actions. In this manner fossils become imbedded and preserved in rocks. In this manner also sediments are being formed of every degree of fineness. There are gravelly beds on the beach, and by shifting movements in the water and the slope of the ground pebbles are, by degrees, carried along the sea bottom many miles from shore. (Darwin.) Other strata are formed *exclusively* of sand, some of mud or clay, others of lime, and others of two or more of these materials, mixed in every possible manner. Some strata are formed almost exclusively of organic remains, as, for instance, in the case of the oyster bed, in the Purbeck strata, (No. 173, **Wall-case 41,**) and in many other limestones. Specimen 32, in **Wall-case 43,** forms a good example, from the lower bed of Carboniferous limestone, in which, in South Pembrokeshire, there are strata 500 feet thick, formed almost exclusively of the remains of Encrinites.

The manner in which strata are now deposited is easily applicable to all the formations from which the rock specimens **(Cases 41 and 43,)** have been derived; and in

UPPER GALLERY. — Wall-case 41.

like manner, the study of the rocks themselves, in situ, re-acts in giving clearer conceptions of the manner by which great rocky deposits are now being formed. From this we learn, for instance, that ripple marks and sun cracks, (see specimens 179, 180, 181, 182, 183, 188,) made in the interval between high and low water mark, are, under favourable circumstances, sometimes preserved and fossilized. The same is the case of the foot-prints of animals that walked along the beach, (see slabs in opposite gallery,) and in innumerable instances plants, land, fresh-water, and marine shells, crustaceans, fish, reptiles, birds, and mammals, sometimes of living, but chiefly of extinct species, have been perfectly preserved.—A. C. Ramsay.

SPECIMENS ILLUSTRATIVE OF THE STRUCTURE OF CONGLOMERATES AND BRECCIAS, GRITS, SANDSTONES, SANDS, SHELLY AND OTHER CALCAREOUS SANDS, MARLS, CLAYS, SHALES, SLATE, COAL; AND OF RIPPLE AND CURRENT MARKS, &c., ON OLD SEA BOTTOMS.

Arranged and described by H. W. BRISTOW.

1.—CONGLOMERATE from the *Great Oolite*, composed of rounded fragments of slightly oolitic limestone in a base of calcareous matter.—*Stow-in-the-Wold, Gloucestershire.* (See "Memoir on Geology of Map 44," by Edward Hull, p. 60.)

2.—CALCAREOUS BRECCIATED CONGLOMERATE (*Permian*), chiefly composed of angular pebbles of Carboniferous limestone in a red marly base.—*Rowton, near Shrewsbury, Salop.*

3.—CALCAREOUS CONGLOMERATE (*Permian*), chiefly made up of waterworn rounded pebbles of Carboniferous limestone, containing fossils; *near Bridgnorth, Staffordshire.*

4.—CONGLOMERATE (*Inferior Oolite*), composed of rounded fragments of Carboniferous limestone and small pebbles of quartz in a calcareous base; from the junction of

Carboniferous limestone and Inferior Oolite.—*Vallis Vale, Frome, Somerset.*

UPPER GALLERY.

Wall-case 41.

5.—Permian calcareous BRECCIATED CONGLOMERATE.—*Alberbury, Salop.*

6.—Permian calcareous BRECCIATED CONGLOMERATE, consisting of angular pebbles of Carboniferous limestone, embedded in a red marly calcareous base. These rocks and No. 2 consist of a great mass, or bank of angular conglomerate of the Permian red marls and sandstones of Shropshire, and are probably the equivalents of the angular breccias of the Malvern, Abberley, and Clent Hills, &c. (Table-case Nos. 100 to 136.) They are burned for lime.—*Rowton, near Shrewsbury.*—A.C.R.

7.—CONGLOMERATE, composed of *Lias Limestone* and *Coprolites* in a calcareous base. This is part of the bone bed which lies at the base of the *Lias.*—*Aust Cliff, Gloucestershire.*

8.—CONGLOMERATE, from *Millstone grit;* pebbles of white quartz in a siliceous base (used occasionally for millstones for grinding corn).—*Clapham, near Lancaster.*

In the South of England and in Wales the Millstone grit generally forms a great band, sometimes 1,000 feet thick, lying between the Carboniferous limestone and the Coal Measures.

9.—CONGLOMERATE (*Puddingstone.*), composed of rounded pebbles of chalk flints in a siliceous base; from the diluvial gravel bed on *Hordwell Cliff, Hants.*

10.—CONGLOMERATE, from *Coal Measures.*—*Town Hill, Swansea, Glamorganshire.*

11.—PERMIAN CONGLOMERATE, composed of rounded waterworn pebbles of sandstone, quartz, and limestone in a sandstone base.—*Coventry, Warwickshire.*

12.—CONGLOMERATE of rounded waterworn pebbles of quartz in a sandstone base, from *Old Red Sandstone.*—*Mitcheldean, Gloucestershire.*

13.—CONGLOMERATE composed of Oolite fossils and small black pebbles in a calcareous base, from *Lower Green Sand.* —*Farringdon, Berkshire.*

UPPER GALLERY.
—
Wall-case 41.

14.—*Polished* CONGLOMERATE (*Puddingstone*,) composed of flint pebbles in a siliceous cement.—*Hertfordshire.*

15.—CONGLOMERATE of small pebbles of black flint in a siliceous base, forming *Whiting Shoal, Limehouse Reach.*—Presented by the Tidal Harbour Commissioners.

16.—BRECCIA, composed of angular fragments of granite, in limestone, *from the Crumlin Quarries, near Tallaght, Dublin County, Ireland.*

The limestone belongs to the "*calp*," or middle part of the *Carboniferous limestone* of Ireland, and is burned for lime. "The Crumlin quarries are four miles from the foot of the present granite hills, but similar fragments of granite are found in the limestone at one or two intermediate spots. These fragments were, probably, carried in the roots of trees, or other plants, swept from the old granite islands into the surrounding seas, during the carboniferous period." In corroboration of the foregoing mode of accounting for the occurrence of granitic fragments in the limestone, Mr. Jukes further states that "the only hard stones possessed by the natives of the coral archipelago of the Marshall Islands, in the North Pacific, are similarly thrown ashore in the roots of trees swept from the rivers of Asia, or North America, several thousand miles off."

17.—CONGLOMERATE (*Permian*), with waterworn rounded pebbles. This is from a different set of beds from the angular conglomerates Nos. 5 and 6.—*The Hollings, near Shrewsbury, Salop.*

18.—RECENT CONGLOMERATE, composed of waterworn siliceous pebbles, (mostly flint,) in a calcareous base. Pebbles cemented together by lime.—*Bill of Portland, Dorset.*

19.—CONGLOMERATE, composed of large rounded pebbles of iron ore.—*S. Wales.*

20.—CONGLOMERATE (*Cambrian*).—*The Burgs, Shrewsbury.*

21.—CONGLOMERATE. (*Puddingstone.*)—*Hertfordshire.*

21a.—CONGLOMERATE of siliceous (flint) pebbles, agglutinated by a ferruginous cement round the tire of the wheel of an old gun carriage.

22.—FELSPATHIC BRECCIA.—*Rountain Mountain, Montgomeryshire.*

UPPER GALLERY. Wall-case 41.

23.—CONGLOMERATE, pebbles of slate, in a base chiefly composed of small quartz grains, cemented by oxide of iron. —*St. Agnes Beacon, (north side,) Cornwall.*

24.—BRECCIA, composed of flesh-coloured felspar and grey and green slate, in a base of clay. (*From Coal Measures.*) —*Muxton Bridge, Coalbrook Dale, Salop.*

25.—BRECCIA, fragments of slate and a few pebbles of quartz, in a calcareous base, inclosing fossils. *Upper Llandovery or Pentamerus beds*, at the base of the *Upper Silurian*, and forming part of an ancient beach, or sea bottom in shallow water, close to the island of the Longmynd.—*Longmynd, Little Stretton, Salop.* ("Geological Journal," vol. iv., p. 296. Ramsay.)

26.—BRECCIA, fragments of *Wenlock shale*, in a calcareous base.—*Upper Heblands, near Bishops Castle, Salop.*

27.—CONGLOMERATE, rounded pebbles of slate and white quartz in a calcareous base, composed of comminuted sea shells. Part of a consolidated raised beach, *near New Quay, Cornwall.* (See "Report on the Geology of Cornwall," &c., by Sir H. T. De la Beche, pp. 426, 427, and 431; and "Geological Observer," pp. 456, 457.)

28.—CONGLOMERATE, composed of black flints in a siliceous base.—*Whiting Shoal, Limehouse Reach.*

29.—MAGNESIAN CONGLOMERATE, from the *New Red series:* fragments of Carboniferous limestone in a base of Magnesian limestone. The specimen exhibits a weathered surface.—*Coast of Glamorganshire.*

Similar conglomerates are found at the base of the New red sandstone, marl, and part of the Lias in Glamorganshire, Somersetshire, and Gloucestershire. In one instance it contains Lias fossils.—A. C. R.

30.—CONGLOMERATE, pebbles of quartz in a partially crystallized quartzose base. From *New Red Sandstone.*

31.—CONGLOMERATE, calcareous pebbles in a base of shelly limestone: bottom bed of *Lias.* (See "Memoirs of

UPPER GALLERY. — Wall-case 41.

Geological Survey," pp. 244-252.)—*Craig-yn-cross, near Bridgend, Glamorganshire.*

32.—STALAGMITIC CONGLOMERATE, rounded pebbles of Carboniferous limestone embedded in stalagmitic carbonate of lime, and forming the floor of a bone cave (Bacon Hole).—*Gower, near Swansea, Glamorganshire.* Presented by A. C. Ramsay.

33.—CONGLOMERATE, pebbles of white quartz and slaty rocks in a siliceous base, showing a weathered surface. From *Denbighshire sandstone*, at the base of the Wenlock Shale.—*Garn Brys, near Yspytty Evan, Merionethshire.*

34.—*Bunter* CONGLOMERATE, pebbles of quartz in a quartzose base, cemented by micaceous oxide of iron. From the basement bed of the New Red Sandstone.—*Doblaston, Cheshire.*

35.—BRECCIATED CONGLOMERATE, subangular pebbles of slate and shells in a sandy calcareous base.—*Upper Llandovery or Pentamerus beds, Hope Quarry, Salop.*

36.—FOSSILIFEROUS CONGLOMERATE, composed chiefly of small pebbles of quartz and a few subangular fragments of grey slate in a siliceous base. From the range of sandstones and conglomerates on the hills, (*Lower Llandovery rocks,*) 4 or 5 miles north of *Caermarthen.*

37.—CONGLOMERATE, pebbles of Red Sandstone in a marly base. From the *Permian beds.*—*Wrexham, Salop.*

38.—CONGLOMERATE, *Wealden*, composed of calcareous pebbles in a siliceous base.—*Brixton Bay, Isle of Wight.*

39.—BRECCIATED ANGULAR CONGLOMERATE, occupying the place of the *Roth-todte-liegende*, below theMagnesian limestone, and made up of fragments of quartz, Coal Measure ironstone, &c., in a calcareous base.—*Kirkby Woodhouse, Notts.*

40.—CONGLOMERATE, rounded, and a few subangular pebbles of quartz (some exhibiting cleavage), with occasional fragments of black slate in a siliceous base. From the *Lower Llandovery beds, Abbey-cwm-hir*, near *Pen-y-bont, Radnorshire.*

41.—CONGLOMERATE (*Lingula flags*), composed of fragments of slate in a quartzose base.—*Stiper Stones, near Bishops Castle, Salop.* UPPER GALLERY. Wall-case 41.

42.—See 36.

43.—BRECCIA, chiefly made up of fragments of white quartz, with occasional fragments of red jasper, in a siliceous base; from the lowest beds of the *Old Red Sandstone.—Dulas, Anglesea.*

44.—CALCAREOUS CONGLOMERATE (*Permian*), underlying Magnesian limestone.—*Kirkby Woodhouse, Notts.*

45.—FINE CONGLOMERATE, made up of small quartzose pebbles and fragments of slate in a siliceous base. *From Coal Measures.—Baxterley, near Atherstone, Warwickshire.*

46.—FINE CONGLOMERATE GRIT, chiefly composed of quartz pebbles in a quartzose base, containing spangles of mica and fossils cemented by oxide of iron. *From Lower Green-Sand.—Atherfield Cliff, Isle of Wight.*

47.—FINE CONGLOMERATE, part of a raised beach, composed of pebbles and grains of quartz and slate cemented by iron. (See "Report on Geology of Cornwall," p. 432). —*Bareppa Cove, Falmouth Bay, Cornwall.*

48.—SILICEOUS GRIT, or fine conglomerate; small pebbles of quartz in a felspathic base; partly cemented by iron. *Lingula flags.—Stiper Stones, near Bishops Castle, Salop.*

49.—QUARTZOSE GRITS from *Denbighshire Sandstone*, at the base of the Wenlock Shale; Upper Silurian rocks. *Garn Brys, near Yspytty Evan, Merionethshire.*

50.—SILICEOUS GRIT, (*Lingula flags*), Lower Silurian rocks.—*Stiper Stones, near Bishops Castle, Salop.*

51.—SILICEOUS GRIT (*Coal Measures*).—*Scaffold Hill Quarry, Shire Moor, Tynemouth, Northumberland.* Presented by Sir Charles Grey, Bart.

52.—MILLSTONE GRIT, occurring in the chert series; Carboniferous rocks.—*Holloway, near Holywell, Flintshire.*

53.—CAMBRIAN GRIT, altered.—*Llyn Peris, Llanberis, Caernarvonshire.*

54.—MILLSTONE GRIT, *Coal Measures.—Grassington Lead Mines, Yorkshire.*

UPPER GALLERY. — Wall-case 41.

55.—SANDSTONE, from the "rag" or upper beds of the Upper Green-sand; used extensively as a building stone in the district in which it occurs.—*Shaftesbury, Dorset.*

56.—SANDSTONE containing Siphonia-like tubes. From *Plastic Clay;* Eocene.—*Alum Bay, Isle of Wight.*

57.—SILICEOUS GRIT, *altered Caradoc Sandstone.—Charton Hill, Salop.*

58.—YELLOW SANDSTONE, at the base of the *Carboniferous Limestone Shale.—Mitcheldean, Gloucestershire.*

59.—GRIT (*Cambrian*).—*Longmynds, Salop.*

60.—SANDSTONE underlying the "rag bed" (No. 55), and extensively used as a building stone in the district in which it occurs, for churches, &c.—*Shaftesbury, Dorset.*

61.—SILICEOUS GRIT (*Wealden*), containing casts of fresh-water shells; (*Unio.*)—*Cowleaze Chine, Isle of Wight.*

62.—SILICEOUS SANDSTONE, containing plant remains and carbonaceous matter. *Lower Coal Measures.—Felin-y-nant, between Halkin and Flint, Flintshire.*

63.—GRIT, altered Lower Silurian sandstone, from near the edge of granite.—*Pen Ferfyn, S. of Llanerchymedd, Anglesea.*

64.—SANDSTONE, exhibiting lines of stratification. From the white beds of the New Red Sandstone.—*At the base of the Keuper beds, Chatwell,* 4 *miles east of Newport, Salop.*

65.—SANDSTONE (*Keuper*), slightly micaceous, and containing plant remains; from the white beds of the New Red Sandstone.—*Bell Broughton, Worcestershire.*

66.—SILURIAN SANDSTONE (*Upper Llandovery Rock, or May-Hill Sandstone*), containing numerous casts of fossils: (*Pentamerus oblongus, &c.*)—*Norbury, Salop.*

67.—OLD RED SANDSTONE (*micaceous*).—*Mitcheldean, Gloucestershire.*

68.—OLD RED SANDSTONE, with laminæ of mica, which cause it to split into thin layers.—*Mitcheldean, Gloucestershire.*

69.—CAMBRIAN GRIT, grains of clear quartz in a base partly felspathic.—*Hills east of Harlech, Merionethshire.*

UPPER GALLERY. — Wall-case 41.

70.—OLD RED SANDSTONE, slightly micaceous, and containing fragments of plant roots.—*Clee Hills, Salop.*

71.—SANDSTONE (*Wealden*), showing a weathered surface and false lamination. See map 10, and horizontal section No. 47.—*Brook Point, Isle of Wight.*

71a.—SILICEOUS SANDSTONE ; from the lower division of the *Lower Green Sand.*—*Hythe, Kent.*

72.—CALCAREOUS SANDSTONE (*Upper Llandovery or Pentamerus beds*). *Hope Quarry, Bishops Castle, Salop.* This belongs to the same set of beds as 66 and 25. They show how, in a few miles, the same rock may change in character.

73.—GRIT (*altered Cambrian*).—*The Burgs, Shrewsbury, Salop.*

74.—GRITTY SANDSTONE (*Lower Silurian*), used for building.—*Rhyader, Radnorshire.*

75.—PENNANT GRIT (*Coal Measure sandstone*), containing micaceous laminæ.—*Forest of Dean, Gloucestershire.*

76.—Variegated red and white COAL MEASURE SANDSTONE, from beds immediately underlying Greenstone.—*Salisbury Crags, Edinburgh.*

77.—Variegated OLD RED SANDSTONE.—*Bell Rock Lighthouse, Scotland.*

78.—LIAS SANDSTONE, (bottom bed).—*Lower Penarch, Glamorganshire.*

79.—SANDSTONE, slightly micaceous and flaggy. *Lias bone-bed.* ("Memoir on S. W. of England," De la Beche. vol. i. p. 261.)—*Westbury-on-Severn, Gloucestershire.*

80.—RED SANDSTONE (*Permian*), very micaceous.—*Preston Boat, Shrewsbury, Salop.*

81.—SANDSTONE (*Upper Llandovery beds*), *near Shuslope Edge, 2 miles east of Walsall, Staffordshire.*

82.—DENBIGHSHIRE SANDSTONE.—*Pont Clettior, Yspytty Evan, Merionethshire.*

83.—SANDSTONE (*Llandeilo beds*), very felspathic.—*Dysgwylfa Hill, near Bishops Castle, Salop.*

84.—OLD RED SANDSTONE.—*Bonnington Fall, Falls of Clyde, Lanarkshire.*

UPPER GALLERY.

Wall-case 41.

85.—SANDSTONE, slightly micaceous, and containing the remains of plants; from the "white beds" of New Red Sandstone. Base of the *Keuper.—Bromsgrove, Worcestershire.*

86.—OLD RED SANDSTONE (decomposed micaceous beds). —*Mitcheldean, Gloucestershire.*

87.—Laminated NEW RED SANDSTONE. Lower soft red beds of the *Bunter strata.—Bromsgrove, Worcestershire.*

88.—Calcareous concretionary SANDSTONE, occurring in layers interstratified with sand, and overlying chalk.—*Goodwood, Sussex.*

89.—CARADOC SANDSTONE, exhibiting lines of stratification.—*Church Stretton, Salop.*

90.—Variegated SANDSTONE (*Permian*).—*The Hollings, near Market Drayton, Salop.*

91.—Laminated SANDSTONE ("TILESTONE"), from the junction of the Old Red Sandstone and Upper Silurian rocks.—*Longhope, Gloucestershire.*

91a.—"TILESTONE," from *Old Red Sandstone.—Kington, Herefordshire.*

92.—SILURIAN SANDSTONE, containing fossils: *Pentamerus bed of Upper Llandovery Rock, or Mayhill Sandstone,* occurring in contact with and containing pebbles of granite on the Worcestershire Beacon.—*Malvern Hills.*

This rock being quite unaltered by the granite, and containing pebbles of it, is evidently of later date than the granite.

93.—Thin-bedded, micaceous, concretionary SANDSTONE ("*Tilestone*").—*Storm Hill Lodge, Llandeilo.*

94.—Shelly micaceous SANDSTONE (*Lower Silurian*), with numerous casts of *Orthis calligramma.—Anglesea.*

95.—NEW RED SANDSTONE, from the *Keuper Sandstone,* in the middle of the marl.—*Newnham, Gloucestershire.*

96.—NEW RED SANDSTONE (*Keuper*). From the same beds as the above.—*Dimock, Worcestershire.*

None of the sandstones from 49 to 96 are calcareous, or, if any of them are so, the lime is in very small quantity. Nos. 61, 66, and 94 are shelly, but the lime of the shells having been washed away in solution, their casts alone remain. This is frequently the case in parts of strata near the surface of the ground; while deeper, the lime of the shells remains. In the specimens that follow, from 98 to 109, the lime of the shells is preserved.—A. C. R.

UPPER GALLERY. Wall-case 41.

97.—SANDSTONE, (white beds at the base of the *Keuper* strata, *New Red Sandstone,*) containing cavities lined with crystals of calc spar.—*Ashby-de-la-Zouch, Leicestershire.*

98.—Sandstone with fossil shells (*Silurian*).—*Church Stretton, Salop.*

99.—KELLOWAY ROCK; *calcareous sandstone,* occurring at the base of the Oxford clay in certain districts. It derives its name from Kelloway Bridge, in Wiltshire, where it was observed by Dr. Smith. It is chiefly remarkable for the beauty and abundance of its peculiar fossils, and is seldom used for building stone.—*Ray Bridge, near Melksham, Wilts.* Map 14.

100.—OLD RED SANDSTONE ("TILESTONE") containing *Trochus helicites* and *Cucullæa antiqua.*—*Bickton, south-west of Bishops Castle, Salop.*

101.—LOWER GREEN-SAND, containing numerous fossils (*Terebratula sella*).—*Atherfield, Isle of Wight.*

102.—LOWER GREEN-SAND, with *oysters* and other fossil shells.—*Sandgate, Kent.*

103.—ARENACEOUS SHALE (*Upper Ludlow*), slightly calcareous. Shells half dissolved out.—*Longhope, Gloucestershire.*

104.—BRACKLESHAM SAND (*Middle Eocene*) with *Venericardia planicosta.*—*Stubbington, Hampshire.* Map 11.

104a.—LOWER BAGSHOT SAND.—*Stoke Common, near Bishopstoke, Hampshire.* Map 11.

105.—LOWER GREEN-SAND, with *Perna Mulleti* and other fossils.—*Atherfield Point, Isle of Wight.*

106.—SAND, containing numerous marine fossil shells. (From *London Clay.*)—*Alum Bay, Isle of Wight.*

107.—UPPER GREEN-SAND, cementing shells of *Gryphæa aviculoides.*—*Three miles north of Devizes, Wilts.*

108.—SAND, cementing fossil shells (oyster bed of *Lower Green Sand.*)—*Atherfield Cliff, Isle of Wight.*

UPPER GALLERY. — Wall-case 41.

109.—*Eocene sand*, cementing numerous marine fossil shells, from the "Venus bed" of the *Middle Headon series.*—*Colwell Bay, Isle of Wight.* (See "Memoir on Fluvio-marine Formation of Isle of Wight," plate 10.)

110.—EOCENE SAND, containing *oysters* and other shells, from the "Venus bed" (another variety). A soft, sandy, shelly band.—*Headon Hill, Isle of Wight.*

111.—SOFT SANDY BED, consisting of *Eocene* sand, cementing univalve shells. (*From the Fluvio-marine series.*)—*Headon Hill, Isle of Wight.*

112.—HASTINGS SAND with cast of *Cyclas.* Very fine, soft, sandy rock.

Specimens 112 to 117, from *Hastings, Sussex.* Presented by Dr. Percy, F.R.S.

113, 114.—Finely laminated HASTINGS SAND. Soft, and imperfectly consolidated.

115, 116, 117.—HASTINGS SAND. Soft, as above.

118.—NEW RED SANDSTONE: *Lower red and mottled sandstone; Mansfield, Notts.* Fine-grained, micaceous sand, found at *Mansfield*, and of great value in the production of ornamental castings. Its excellence as a moulding sand arises from the fineness of its grain, its porosity, great purity and smoothness; the latter property contributing to give a high face and finish to the castings made with it. It is exported in considerable quantities to the Continent. The following is an analysis of the sand by Mr. Haywood:—

Silicates	Silica	84·00
	Alumina	9·40
	Potash	0·54
	Soda	0·10
Peroxide of iron, with a little manganese		4·00
Sulphate and carbonate of lime		0·05
Phosphate of iron		0·01
Free alumina		0·40
Chloride of sodium (a trace)		...
Moisture, with a little organic matter		1·30
		99·80

118a.—UPPER GREEN SAND, a very fine pale cream-coloured soft sandstone, locally termed "*Malm rock.*" UPPER GALLERY. Wall-case 41.

This rock has been found to contain 40·30 per cent. of soluble silica (that is, of silica soluble in solutions of caustic potash or soda, on boiling in open vessels), and 41·23 of insoluble silica, with 14·50 of alumina, &c. It furnishes a rich soil for growing hops, &c.—*From Farnham, in Surrey.* Presented by J. M. Paine.

118b.—UPPER GREEN-SAND, very calcareous and hardened by the cementing lime.—*One mile N. of Brixton, I. of Wight.*

119.—THANET SAND (*lower Eocene*), slightly calcareous, and containing an included pebble of flint.

This sand forms the lowest member of the tertiary series, and occurs between the Chalk and the Woolwich and Reading Beds, in the district comprised between Sandwich, Canterbury, and the Reculvers. In the eastern portion of the London basin it attains a maximum thickness of eighty to ninety feet, but disappears west of London, where the Woolwich and Reading Beds are based directly on Chalk. —Presented by Joseph Prestwich, Esq., F.R.S.

119a.—LOWER EOCENE SAND, underlying the red mottled clay of the Plastic Clay series, No. 139a.—*Fareham, Hampshire.* Map 11.

120.—PORTLAND SAND. Soft sand, underlying Portland limestone.—*Tisbury, Wilts.* Map 15.

121.—UPPER LIAS SAND, slightly micaceous.

These sands were until lately classed with the inferior oolite. Now they are by some considered more properly to belong to the *Lias* group, the researches of Dr. Wright having led to the conclusion that the chief fossils are liassic. Other geologists consider them beds of passage.—*North of Blackford, Somerset.* Map 18. A. C. R.

122.—UPPER LIAS SAND.—*Seizincote, Stow on-the-Wold, Gloucestershire.* See "Memoir on the Geology of the Country around Cheltenham" (Map 44), by Edward Hull, p. 29.

123.—UPPER GREEN SAND. Soft bed, with small green grains, underlying No. 60.—*Shaftesbury, Dorset.* Map 15.

Upper Gallery. — Wall-case 41.

124.—Red sand. } Used for making glass.—*Hartwell.*
125.—White sand. } Presented by Dr. Lee, F.R.S.

126.—Variegated eocene sands (from the *Middle Bagshot Beds*).—*Alum Bay, Isle of Wight.*

127.—Marlstone.—*Upper Lias*, locally called "brown rock." Very calcareous, hard, marly sandstone, with fossils: *Rhynconella tetrahedra.*—It is very tough and durable, and has been used for a building material in many of the old churches in Marlstone districts; also used for road metal. —*Dursley, Gloucestershire.*

128.—Marlstone, *Upper Lias*, with casts of fossil shells. *Terebratulæ, Rhynconellæ, and Belemnites.*—*Westcombe, Somerset.*

129.—Marlstone (another specimen). Softer, micaceous, more sandy, and less calcareous. Contains fossils; *Aviculæ, Cardiniæ.*—*Vineyard Farm, Cheltenham.*

130, 131.—Variegated marl (*Old Red Marl*). From the lower part of the Old Red Sandstone series, where the beds are chiefly marly. 130 is calcareous, forming an imperfect Cornstone.—*Mitcheldean, Gloucestershire.*

132.—Variegated new red marl.—(*Keuper*). The red marl countries are usually rich in fruit trees, and produce excellent cider and perry.—*Westbury, Gloucestershire.* Map 14.

133.—Clay (*Gault*), used for making bricks.—*Dinton, Wilts.* Map 15.

133a.—London clay, used for making bricks for the forts at *Elson*, near *Gosport, Hampshire.* Map 11.

134.—Clay (*Lower Lias*), used extensively for making bricks and tiles. See "Memoir on the Geology of the Country round Cheltenham" (sheet 44), by Edward Hull, p. 15.—*Stonehouse, Gloucestershire.*

Nos. 129 to 134 show a gradual passage from sandy into clay beds.

135.—Pipe clay, used in the manufacture of china and earthenware.—From the *Lower Bagshot Beds*, south of *Corfe Castle, Dorset.* Presented by the Messrs. Pike, Wareham. 58,840 tons of this clay were shipped from Poole in 1857; of these, the finer kinds are used for making earthen and stone ware, while the inferior qualities are used in the manufacture of alum. Map 16.

135a.—PIPE CLAY, from *Lower Bagshot Beds*, used for making stone ware, blacking jars, &c.

135b.—PIPE CLAY, from *Lower Bagshot Beds*, used for making bricks, &c.

The following analyses of the pipe clay of Branksea Island, by Professor Way, is extracted from a paper by J. Trimmer, F.G.S., in the "Journal of the Royal Agricultural Society of England," vol. xvi. part 1 :—

	White Clay.		Black Clay.
Silica - - - - -	65·49	-	72·23
Alumina - - -	21·28	-	23·25
Oxides of iron - -	1·26	-	2·54
Alkalies and alkaline earths	7·25	-	1·78
Sulphate of Lime - -	4·72	-	0·00
	100·00		99·80

Branksea Island, Dorset. Map 16. Presented by Col. Waugh.

136.—PIPE CLAY, with bright red ferruginous laminæ; from the *Lower Bagshot Beds.—Alum Bay, Isle of Wight.* See Forbes's "Memoir on the Isle of Wight," p. 139.

The clays 135 and 136 contain fossil leaves. See **Wall-cases 57 and 58.**

137.—CLAY, containing small rounded fragments of Chalk, forming a part of the *drift* of Suffolk, and used for making bricks.—*Hitcham, Suffolk.* Presented by Captain Ibbetson.

138.—CLAY, filling a fault between *New Red Sandstone* and *Wenlock Limestone.—Wood Green, May Hill, Salop.*

139.—RED MOTTLED CLAY, from the lower part of the *Plastic Clay* series, used extensively for making coarse red earthenware.

Some of the oldest potteries in England have obtained their clay from the pits in the locality, which still furnish sufficient coarse pottery to supply the neighbouring districts. —*Crendle Common, near Cranborne, Dorset.* Map 15.

139a.—RED MOTTLED CLAY (*Plastic Clay*), used for making coarse pottery.—*Fareham, Hampshire.* Map 11.

UPPER GALLERY. — Wall-case 41.

140.—CLAY, occurring in thin bands in *Upper Green Sand.—Shaftesbury, Dorset.*

141.—CLAY, from beneath the "sulphur coal," Coalbrooke Dale: used for making coarse pottery.—*Broseley, Salop.*

142.—FULLERS' EARTH CLAY, *Northleach, Gloucestershire.* These beds, which are sometimes 150 feet thick, were first called the "Fullers'-earth clay," by William Smith, because in places they contain that substance. The name applied to the whole "formation" has passed into geology.—A. C. R.

142a.—FULLER'S EARTH or WALKER'S EARTH, from *Lower Ludlow rock.—Hales' End, Malvern, Worcestershire.*

142b.—FULLER'S EARTH (*Walker's Earth*) from *Woolhope limestone.—Malvern, Worcestershire.*

143.—UPPER LIAS CLAY, *Northleach—Gloucestershire.*

144.—CLAY, containing recent shells. Compare with 154 and 155. Under favourable circumstances the shells of 144 might become fossilized like those of 154 and 155.—*Outside the Chesil Beach, Weymouth, Dorset.* Map 17.

145.—SANDY PIPE CLAY, containing numerous leaves of trees. (*From Plastic Clay*).—*East Bloxworth, Dorset.*

146.—ARGILLACEOUS SHALE (from *Coal Measures*), with impressions of *ferns;* overlying the "lowery vein."—*Forest of Dean, Gloucestershire.*

147.—FIRE CLAY, (from *Coal Measures,*) used for making fire bricks.—*Stourbridge, Worcestershire.*

148.—FIRE CLAY, with rootlets of *Stigmaria,* (from *Coal Measures*), locally termed "under clay," from its mode of occurrence immediately *under* the seams of coal.—*Forest of Dean, Gloucestershire.*

149.—FIRE CLAY (*from Coal Measures*), exhibiting part of a root and rootlets of *Stigmaria.—Glascote Colliery, Tamworth.* Vertical Sections, sheet 21, No. 1.

150.—FIRE CLAY (from *Coal Measures*), locally termed "over clay," with impressions of *ferns.—Forest of Dean, Gloucestershire.*

151.—FIRE CLAY, containing rootlets of *Stigmaria* (from *Coal Measures*).—*Donnington Wood, Salop.*

152.—CALCAREOUS SHALE (*Wenlock*).—*Rock Farm near*

Longhope, Gloucestershire. This rock is in places so soft, that it is used for brickmaking, and in other localities, where it has been subjected to greater pressure, it forms slabs and slates.—A. C. R. UPPER GALLERY. Wall-case 41.

153.—KIMERIDGE CLAY, containing numerous fossil shells. —*Seend Bridge, Devizes, Wilts.* Map 14.

154.—SHALY CLAY, *Oxford Clay*, with fossil shells; from near *Sherborne, Dorset.*—Presented by the Marchioness of Westminster. Map 18.

155.—SHALY CLAY, *Kimeridge Clay*, from the upper beds, containing fossil shells.—*Chapman's Pool, Isle of Purbeck, Dorset.* Map 16.

155 to 162 show a gradual increase of carbonaceous matter, indicating a kind of imperceptible gradation from shale to coal.

156.—ALUM SHALE; Coal Measures.—*Scotland.*

157.—KIMERIDGE CLAY, *Little Kimeridge Bay, Dorset*, bituminous shale used for manufacturing naphtha, &c.

This clay is strongly impregnated with bitumen, which causes it to give out a very disagreeable odour when burnt. It burns very readily, with a yellowish, rather heavy, and smoky flame, but owing to the large quantity of earthy matter it contains, combined with the disagreeable smell evolved during the process of combustion, it is unfit for being employed as fuel. The people of the neighbouring district formerly made use of it for this purpose. A manufactory was erected at Wareham a few years ago, for the purpose of extracting the volatile oil or spirit, and grease, &c., which were obtained from the shale by distillation, but the works were ultimately abandoned, in consequence of the disagreeable smell given out by the products in burning, which could not be effectually removed.

The residue, left after the distillation of the shale, formed a porous kind of coke, consisting of alumina and finely divided carbon, which has been used for manure, and has proved highly beneficial for the growth of turnips. Circular pieces of shale, about the size of a penny, and apparently turned in a lathe, have been found in great numbers buried in barrows, &c., in the Isle of Purbeck. This *Kimeridge*

UPPER GALLERY. — Wall-case 41. *coal-money*, as it has been called, is supposed to have passed for coin, or to have been used as tokens by the ancient inhabitants.—H. W. B.

158.—CARBONACEOUS SHALE, termed "*black bass*" in Lancashire, and "*black slag*" in Flintshire, forming the roof of Englefield Colliery, Holywell, Flintshire. "Batt" or "Bass" is a highly bituminous shale, commonly very compact, and splitting into the finest laminæ, almost invariably black, and often interstratified in layers with the coal. (See "Records of School of Mines;" Jukes on the "Geology of South Staffordshire Coal Field," p. 161).

159.—CARBONACEOUS SHALE, with distorted *Posidonia*, from the culm measures.—*Bickington, North Devon.*

160.—CARBONACEOUS SHALE, from Coal Measures.—*Madeley Pit, Salop.*

160a.—CARBONACEOUS SHALE, or Lignite, from *Torbane Hill*, Stirlingshire.

161.—CANNEL COAL.—*Iron Bridge, Salop.*

Cannel coal is a corruption of the word *candle*, which has been applied to a particular description of coal, from the bright flame, like that of a candle, which it gives out in burning. In Scotland, this coal is called *parrot*, from the loud cracking noise with which it flies to pieces when placed upon the fire. It is a bituminous substance, and is said to have been formed from decomposing vegetable matter in water, in the finest state of division. It differs from the purer kinds of ordinary coal and jet, from its containing extraneous earthy impurities, which render it specifically heavier than water; jet, on the contrary, being lighter. It is hard enough to take a fine polish, and is made into inkstands, snuffboxes, beads, and other articles.—H. W. B.

161a.—CANNEL COAL: *Glascote Colliery,* near *Tamworth, Warwickshire.* See Vertical Sections, No. 1, sheet 21.

162, 162a.—COAL, from *Upper Coal Measures,* with a laminated structure, and circular concentric concretionary markings.—*Bullock's Farm Pits, near Spon Lane, West Bromwich, South Staffordshire.* See Jukes's "Memoir on South Staffordshire Coal Field," pp. 159, 160; also map 62, and vertical sections, sheet 18, No. 25.

The specimens Nos. 162 and 162a were taken from a bed of *Coal*, 10 inches thick, resting on 3 feet 8 inches of fire-clay ; "Part of the 10-inch coal is shaly and rotten, but about two inches of it is a beautifully bright coal, highly bituminous, very brittle, with curious circular concentric concretionary markings." (See 162a.)

UPPER GALLERY. — Wall-case 41.

163.—ANTHRACITE COAL, from *Coalbrooke*, between Slannon and Llangyndyrn, Caermarthenshire. Anthracite is so called from ἄνθραξ, (charcoal). In general it contains from 80 to 95 per cent. of carbon, with 4 to 7 per cent. of water, and a variable proportion of earthy matter. It is difficult to ignite, but, when ignited, it burns without flame or smoke, and gives out intense heat, leaving very little residue in the shape of ashes.—H. W. B.

164.—ANTHRACITE COAL, *from Pont-y-Berein, or Coal Brook, Caermarthenshire.*

165.—COAL, with a peculiar structure, locally termed "crystalline, or cone-in-cone."—*Merthyr Tydfil, Glamorganshire.* Presented by W. Crawshay.

166.—SLIGHTLY ARGILLACEOUS SANDSTONE, interstratified with coal, *from Baremoor Pit, South Staffordshire.* In the Baremoor pit, a large oval cake of sandstone, 286 yards wide, and upwards of 400 yards long, is interposed in the measures, gradually cutting out bed after bed of the coal. "This mass of sandstone was very fine-grained, rather soft, slightly argillaceous, not at all differing from the usual argillaceous sandstones of the neighbourhood, which pass under the name of 'rock' or 'rock-binds.'" It was not only interstratified with the coal *en masse*, but at or near the junction of the two, they each split up into many beds that interlaced with the utmost regularity. Beds of sandstone 2 or 3 feet thick, extended many yards into the coal, gradually thinning out and splitting up, so that hand specimens could be procured of alternations of bright coal and pale sandstone, each little bed not being more than one tenth of an inch in thickness. Similarly, did small beds and thin laminæ of coal stretch into the mass of the sandstone ; a few

UPPER GALLERY. — Wall-case 41.

separate masses also, a foot or so in thickness, sometimes occurring suddenly, not as detached fragments, but as little independent beds in the sandstone. (See "Records of School of Mines," vol. i., part 2., pp. 183–5. Jukes.)

On the mode of the occurrence of Coal, and the manner in which it was formed.

Though coal occurs of different geological ages in various parts of the world,—in Europe, North America, and most other countries,—by far the greater proportion of valuable workable coal occurs in the Carboniferous (Coal Measure) series. In other formations, as in the Oolites of Yorkshire and Scotland, it is exceptional, and of little value. In Wales and the South of England the coal-bearing strata lie above the Carboniferous or Mountain Limestone. In the North of England and in Scotland, beds equivalent to the Carboniferous limestone of the south become interstratified with strata of sandstone, shale, and coal.

It is easy to trace every possible gradation from common shale into true coal, by the gradual admixture of carbonaceous matter with ordinary muddy sediment; for coal is a truly bedded rock, and, in its purer states, may be defined as consisting of beds of mineralized vegetable matter. These are interstratified with beds of sandstone, shale, and ironstone. The South Wales coal field affords a good example. The Carboniferous Limestone underneath the Coal Measures is there, where thickest, about 2,500 feet thick; the overlying Coal measures about 12,000. In this there are about 100 beds of coal, of varying thickness; and underneath each bed of these is the underclay, (often fire clay,) containing *Stigmariæ*. (See specimens 148, 149, and 151; also Coal-measure cases in the Lower Gallery, Nos. 44 to 54). This underclay was the soil on which the plants grew that formed the coal, and the coal itself is the mineralized vegetation formed partly by the decay of the

Sigillariæ, of which *Stigmariæ* were the roots.* It is not unlikely that after an early stage the decaying vegetable matter that went to form coal, in some respects resembled peat moss, which, in a humid and equable climate, accumulated with considerable rapidity.

UPPER GALLERY. — Wall-case 41.

The strata that lie between the beds of coal frequently contain numerous impressions of *Tree-ferns*, *Ferns*, *Calamites*, *Trees* allied to *Lycopodiums*, and other vegetable remains. Other strata contain freshwater estuary or lagoon shells (*Unio*, *Anthracosia*, *Cypris*, &c.); some are charged with *Productas*, and other marine mollusca; and occasionally plants have been entombed with both. In Haddingtonshire, on the coast of the Firth of Forth, east of Dunbar, beds of thin coal, underlaid by underclay, with *Stigmariæ*, are sometimes immediately overlaid by limestone charged with Productas, Spirifers, and remains of fish. Without entering into details, it is therefore evident that these interstratifications of coal, with other strata, indicate alternations of marine, estuary, lagoon, and perhaps even terrestrial conditions, and the lowest bed of coal in the South Wales coal field being about 12,000 feet below the highest bed of these Coal Measures, the whole mass of stratified deposits must have been formed during a period of average slow depression of the area, varied by pauses, during which part of the space was probably converted into salt marshes, where, under favourable conditions, the plants grew, by the decay and accumulation of which large strata of vegetable matter were prepared for being mineralized, or changed into coal. This was evidently effected by chemical changes, under pressure caused by the accumulation of overlying strata.

The coals (of the Coal Measures) may be broadly divided into three kinds: common ("bituminous") coal, anthra-

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* *Stigmariæ* were first observed by Sir William Logan to be constantly present in the Welch underclays, and he connected this circumstance with the occurrence of the overlying coal. Mr. Binney, of Manchester, first proved *Stigmariæ* to be roots of *Sigillariæ*.

UPPER GALLERY. — Wall-case 41.

cite, and cannel or parrot coal. Analyses of two varieties of common coal, from South Wales, give the following results :—

Carbon	71·08	90·94
Hydrogen	4·88	4·28
Nitrogen	0·95	1·21
Sulphur	1·37	1·18
Oxygen	17·87	0·94
Ash	3·85	1·45
	100·00	100·00

An anthracite from Swansea gave :—

Carbon	92·56
Hydrogen	2·33
Oxygen and hydrogen	2·53
Ash	1·58
Loss	1·00
	100·00

In Wales the same beds of coal sometimes change, by degrees, from bituminous into anthracitic coals, in their passage from east to west. It will be observed that as a rule anthracite coals are richer in carbon and poorer in hydrogen than bituminous coal; and the change seems, in general terms, to have been that a proportion of the carbon of the coal went off in the form of carbonic acid, and another portion as carburetted hydrogen. The proportionate quantity of hydrogen thus diminished, whilst the carbon became more concentrated. The change is analogous to that which takes place in the manufacture of coke. In that part of South Wales where these changes take place, the district occupied by the anthracite is much more disturbed than that occupied by the bituminous coal, and in South Pembrokeshire syenitic and other igneous rocks have been intruded amongst them.—A. C. Ramsay.

167.—GRAPTOLITE SHALE from Llandeilo flags.—*Conway, North Wales.* UPPER GALLERY. — Wall-case 41.

168.—ARENACEOUS HARDENED GRITTY SHALE (*of Cambrian date*), the surface covered with very fine ripple marks.—*Longmynd Hills, Salop.*

169 and 170.—ARGILLO-ARENACEOUS SLATE, very fine and soft: cleaved.—*Quarry near Black Head, St. Austell Bay, Cornwall.*

The specimens in the lowest shelf are mixed, being many of them of sizes too large for the higher shelves. Most of them represent ripple marks, and various other surface markings incidental to sea bottoms.

171.—ARGILLACEOUS LIMESTONE, containing iron pyrites, carbonaceous matter, and the *coprolites, teeth,* and *other remains* of *fish, Ichthyosauri,* &c. This bed, called the "bone bed," formed an ancient sea bottom at the base of the Lias, between the latter formation and the New Red Sandstone.—*From Westbury-on-Severn, Gloucestershire.* (See "Memoirs" by the late Mr. Strickland; "Proceedings of the Geological Society, vol. iii., pp. 585, 732, vol. iv., p. 16; "Transactions of the Geological Society," vol. v., p. 331; also "Memoirs of the Geological Survey of Great Britain," pp. 281-284, vol. i., Geological Map No. 35, and Horizontal Sections No. 12; also "The Geology of the Country around Cheltenham," sheet 44, by Edward Hull, F.G.S. p. 16.)

This bed, and some of those immediately associated with it, have been classed with the Keuper strata, by Sir Philip Egerton, in consequence of the presence of certain genera of fish. Mr. Strickland, and most other geologists, considered them to be Lias. They may be, probably, the attenuated representatives of the Koessen beds of the Austrian Alps. For a condensed account of these, see Supplement to the 5th edition of Lyell's "Elements of Geology," p. 26.—A. C. R.

172.—Upper Silurian bone-bed (top of the Upper Ludlow rocks), containing *bones, coprolites,* &c.—*Ludlow, Salop.*

UPPER GALLERY. — Wall-case 41.

173.—OYSTER BED, *from the middle Purbeck*; locally termed "*cinder*."

This bed, which is well displayed in Durlston Bay, is a mass of oysters, (*Ostrea distorta*,) twelve feet thick, associated with *Trigonia*, *Cardium*, and other shells. It is purely a marine formation. In this bed, the late Professor Edward Forbes found, for the first time, the Echinoderm, called by him *Hemicidaris Purbeckensis*. (See Vertical Sections No. 22, and Map No. 16.)

174.—CORAL RAG, with double burrows of sand worms (*Arenicola*), &c.—Between *Dairy House, and Abbotsbury Castle, Dorset.* Map 17.

175.—Part of a CONSOLIDATED RECENT BEACH now in process of formation. *Red Wharf Bay, Anglesea.*—Presented by Mr. J. D. T. Niblet. The consolidation is a result of the percolation of carbonated water, which dissolves part of the lime of the shells, and evaporating, re-deposits it among the fragments of stone and shell, thus cementing them together. —A. C. R.

176.—LOWER LLANDOVERY ROCK, with peculiar surface marks.—*Aberystwith, Cardiganshire.*

177.—CARBONIFEROUS LIMESTONE, bored by marine animals (*Lithodomus*).—*Murdercombe Bottom, near Frome, Somerset.* (See "Memoirs of Geological Survey," vol. i. p. 291.) Map 19.

Over a great portion of the district from which the specimen is taken, the Inferior Oolite rests unconformably on subjacent older rocks, partly on Carboniferous Limestone, and partly on Old Red Sandstone.

"Not only is a large portion of the area, wherein the Inferior Oolite is seen to rest on the Carboniferous Limestone, observed to have presented a marked even surface, viewed on the large scale, for the deposit of the former, but, throughout, this surface has been drilled into holes by lithodomous animals, which must have existed in the sea at the commencement of the Inferior Oolite. The holes which were observed by Professor John Phillips, in 1829, are of two kinds, one long, slender, and often sinuous, extending several inches into the carboniferous limestone, the other entering that rock a short distance only. In the former we find no traces of shells, in the latter we often discover them in the situations in which they lived. In both holes we find the *matter* of the Inferior Oolite, which entered them from above at the time of its deposit."—De la Beche.

177a.—DEVONIAN LIMESTONE, from the breakwater, *Plymouth.* Bored by *Saxifaga rugosa.* Placed here for comparison with No. 177.

178.—PURBECK LIMESTONE, the surface of the bed covered with ripple marks, *Cypris*, &c. From the Cypris shales of the Upper Purbeck.—*Mewps Bay, Isle of Purbeck, Dorset.* (See Vertical Section, No. 22.)

179.—PERMIAN SANDSTONE, exhibiting a combination of ripple marks and sun-cracks.—*Alberbury, Salop.* (See p. 66). Sun-cracks in rocks have been frequently formed on soft strata, lying probably between high and low water mark. In such cases the cracked and dried lines have been filled after an interval by other sediment, sometimes finer, sometimes coarser than the surface on which the crack was made, and it therefore happens, that after entire consolidation, when the strata are split, the lines of the original cracks become visible, and often on the bottom of the *upper bed* stand out in relief.—A. C. R.

180.—RIPPLE MARKS, annelid tracks and sun-cracks on Keuper Sandstone.—*High House, near Warwick.*

181.—RIPPLE MARKS AND SUN-CRACKS, from the *Lower Lias Limestone.* This specimen consists of two beds, on the surface of which the ripple marks run transversely to each other.—*Lower Penarch,* 4 *miles South of Cardiff, Glamorganshire.*

182.—Small RIPPLE MARKS on *Old Red Sandstone.*

183.—RIPPLE MARKS on white beds of the *New Red Sandstone.—Cubington, near Leamington, Warwickshire.*

184.—SANDY LIMESTONE with surface markings; from the "Horseflesh" beds of the *Middle Purbeck,* near the fifth milestone, on the east side of the road to Bridport.—*Upwey, Dorset.* Map 17.

UPPER GALLERY. — Wall-case 41.

185.—LIAS BONE BED with surface markings.—*Westbury-on-Severn, Gloucestershire.*

186.—DEEP RIPPLE MARKS on *Old Red Sandstone.*

187.—PURBECK LIMESTONE with fucoidal markings, from the limekiln quarry.—*Kingston, Dorset.*

188.—KEUPER SANDSTONE, exhibiting in relief the cracked markings of a dried surface.—*Newent, Gloucestershire.*

189 and 190.—LIAS BONE BED, (see Nos. 171, 181, and 185).—*Westbury-on-Severn, Gloucestershire.*

191.—LOWER LLANDOVERY ROCK with fucoidal markings. —*Aberystwith, Cardiganshire.*

Wall-case 42.

Wall-case 42.

FLINT, CHERT, AND OTHER SILICEOUS BODIES, *contained in rocks of various kinds.*

Arranged and described by H. W. BRISTOW.

A large part of the specimens in this case are chalk flints. These generally occur in layers, chiefly in the upper part of the chalk. It has been proved by Mr. Bowerbank that in almost all cases these bedded flints are silicified sponges. This remark also applies to many other flinty and cherty bodies, which occur in the lines of bedding of oolitic and other limestone rocks. The external forms of these bodies are often themselves suggestive of their origin, and when properly sliced, polished, and examined with the microscope, the minuter structure becomes apparent.—A. C. R.

1.—Two specimens of FLINT from the *Chalk.*

2, 3.—CHALK FLINT, the interior lined with mammillated chalcedony.

4.—CHALK FLINT.—*Freshwater Bay, Isle of Wight.*

5.—CHALK FLINT, showing surfaces fractured prior to its deposition in the drift.—*Hitcham.*

6.—CHALK FLINT.—*Arreton Down, Isle of Wight.*

UPPER GALLERY.

Wall-case 42.

7.—CHALK FLINT.—*Freshwater Bay, Isle of Wight.*

8.—Large specimen of CHALK FLINT; apparently, from its stained exterior, from *tertiary* beds immediately overlying a denuded surface of chalk.

9.—CHALK FLINTS, *Guildford, Surrey.* Presented by Colonel George Twemlow, Bengal Artillery.

10.—FLINT, showing an agatiform structure dissected out on a fractured surface.—*Swaffham, Norfolk.*

11.—FLINTS, with white spots, and exhibiting a characteristic conchoidal fracture.—*Swaffham, Norfolk.*

12.—CHALK FLINT, containing the cast of a decomposed sponge.—*Brixton Down, Isle of Wight.*

13.—Three specimens of CHALK FLINT, containing casts of decomposed sponges.—*Arreton Down, Isle of Wight.*

14.—FLINT, with a fossil shell (*Plagiostoma spinosa*) attached to its outer surface.—*From the Upper Chalk, Arreton Down, Isle of Wight.*

15.—CHALK FLINT, the interior lined with minute crystals of quartz.—*Arreton Down, Isle of Wight.*

16.—CHALK FLINT, from the junction of Chalk and Lower Tertiary, showing the peculiar green stains, frequently characteristic of flints occurring at the base of the Tertiaries. (See also specimen 8.)—*Studland Bay, Dorset.*

17, 18.—CHERT, overlying the sandstone beds Nos. 55 and 60 (**Wall-case 41**) of *Upper Green-Sand.* Used for road material, for which, from its hardness and toughness, it is well adapted.—*Shaftesbury, Dorset.*

19.—Polished chert in *Carboniferous Limestone.—Matlock Bath, Derbyshire.*

19a.—Polished specimen of CHERT, *from Carboniferous Limestone.—Middleton Moor, Wirksworth, Derbyshire.*

20, 20a.—CHERT in *Carboniferous Limestone.—Matlock Bath, Derbyshire.*

21.—CHERT, *in Carboniferous Limestone.—Middleton Moor, Wirksworth, Derbyshire.*

22.—CHERT, containing minute crystals of quartz: from *Carboniferous Limestone.—Middleton Moor, Derbyshire.*

UPPER GALLERY. — Wall-case 42.

23.—CHERT, containing silicified *Corals*. From *Carboniferous Limestone.—Masson Hill, Matlock Bath, Derbyshire.*

24.—CHERT, from *Carboniferous Limestone.—Middleton Moor, Derbyshire.*

25.—CHERT, containing casts of *Encrinites*, from *Carboniferous Limestone.—Bakewell, Derbyshire.*

26.—CHERTY FLINT: "*Hard Cap*" from *Lower Purbeck*. Cliff east of *Lulworth Cove, Dorset.* See Map 16; Sections, sheet 56.

27.—CHERT, *from Carboniferous Limestone*, showing a weathered surface.—*Cromford, Derbyshire.*

28.—CHERT, in dark-coloured carbonaceous beds of *Carboniferous Limestone.* (See "Memoirs of Geological Survey," vol. i., p. 134.)—*Cow's Hill Quarry, Oystermouth, Glamorganshire.*

29.—CHERT, forming the lower part of rocks which are the equivalent of *Millstone Grit.—Pen-ŷr-Hénblas, near Holywell, Flintshire.*

30.—CHERT, in Carboniferous Limestone.—*Quarry, north of Clogrenan Quarry, Queen's County, Ireland.*

31.—CHERT, from the upper calcareous beds of the *Upper Green-Sand.—One mile north of Brixton, Isle of Wight.*

32.—CHERT, from *Upper Green-Sand.—Arreton, Isle of Wight.*

33.—CHERTY FLINT, from *lower Purbeck beds.—Oakley Quarry, near Tisbury, Wilts.*

34.—CHERTY FLINT, from the upper beds of *Portland Stone.—Oakley Quarry, Wilts.* Map 15.

35, 35a.—CHERTY FLINT, containing fossil shells, and occurring in seams and irregular masses, and patches in *Portland Stone.—Newtown Quarries, near Tisbury, Wilts.*

36.—FLINT, from the ragstone beds of *Lower Green-Sand:* used for roads.—*From the Iguanodon Quarries, Maidstone, Kent.*

37.—MILKY QUARTZ, with chlorite, from a greenstone dyke traversing the slate quarries.—*Llanberis, Caernarvonshire.*

Quartz of this nature has frequently been carried in solution in water, probably sometimes hot, and deposited in cracks along with other substances, some of which now help to form metalliferous lodes—A. C. R. UPPER GALLERY. Wall-case 42.

38.—Part of the SILICIFIED TRUNK OF A CONIFEROUS TREE, probably allied to the pine; from the "pine-raft" (*Wealden*), which covers the shore between high and low water marks, at *Brook Point.—Brixton Bay, Isle of Wight.* Map 10. Horizontal sections No. 47.

39.—SILICIFIED FOSSIL WOOD, *from Gault.* The bark pyritized.—*Ridge, Wiltshire.* Map 15.

40.—Part of the SILICIFIED TRUNK OF A CONIFEROUS TREE, from the "dirt beds" overlying *Portland Stone.—Isle of Portland, Dorset.* Map 17.

41.—Another specimen, from the *Portland Stone Quarries at Newtown, near Tisbury, Wilts.* Map 15.

42.—Another specimen, partly converted into wood opal. —*Newtown, near Tisbury, Wilts.*

43, 44.—Another specimen, from the "*submarine forest.*" —*West Lulworth, Dorset.* Map 16. Horizontal sections No. 56.

45. SILICIFIED WOOD.

The specimens Nos. 40 to 44 occur in strata, called by the quarrymen the "dirt beds." These were the terrestrial soils in which the trees grew. Sometimes their stools are found erect, the roots spreading into the soils, and in other cases the stems lie prostrate. They lie very near the base of the Purbeck strata, a yellow limestone with cyprides lying immediately below. The area in which they occur, in Dorsetshire and Wilts, is comprised in maps 16 and 17, and the position of the beds is shown in horizontal sections Nos. 20, 22, and 56, and in vertical section No. 22 of the "Geological Survey."—A. C. R.

Wall-case 43.

Wall-case 43.

The higher shelves of this case contain limestones, arranged not stratigraphically, but, as far as the sizes of the

UPPER GALLERY. Wall-case 48.

specimens allow, generally with reference to their qualities. The highest shelf contains large specimens of various kinds. The second and part of the third shelves are devoted to the more solid and compact limestones, which, in Britain, chiefly lie in the older or palæozoic strata. This peculiarity is, perhaps, partly the effect of mere age, partly of the repeated disturbance and greater pressure to which many of the older rocks of the British area have been subjected. Shelves 3, 4, and 5, from No. 40 onwards, partly contain Secondary and Tertiary limestones, chiefly Liassic, Oolitic, Cretaceous, and Eocene or Lower Tertiary. The Lias, and some of the shelly oolitic limestones, are comparatively hard, but as a rule, the latter are softer than the more ancient limestones. Many of the Oolites form ordinary building stones, and the chalk is the softest of limestones. This may be due in part to the circumstance that in general in England the secondary rocks lie almost horizontally. They have been little disturbed, and no *intense* pressure has been applied to them comparable to that which has affected the old contorted strata. In the Alps, however, and other mountain regions, limestone strata of Secondary and Tertiary ages are as much indurated as our oldest limestones.

In this Case, all the limestones not marked *freshwater* are of marine origin. The Carboniferous Limestone lies beneath the Coal Measures, and in South Wales, Somersetshire, &c. attains a thickness of 2,500 feet. The Lias limestones occur in bands, and are interstratified with beds of clay. The Oolite limestones are often *shelly*, and *oolitic*, or composed of small rounded concretionary grains cemented together, and sometimes these characters are mixed. The shelly character is well shown in 41, 69, and 72, and the oolitic type in Nos. 58, 59, 60, and 74. The limestones are of all thicknesses up to about 100 feet, and on a large scale are interstratified with beds of clay and sand. Some of our chief building stones are from the Inferior, Great, and Portland Oolite. They are also occasionally burned for lime.—A. C. Ramsay.

LIMESTONES, IRONSTONES, &c., arranged and described by H. W. BRISTOW. UPPER GALLERY. — Wall-case 43

1.—PURBECK MARBLE. — Compact shelly limestone of freshwater origin, containing numerous casts of *Paludina carinifera.*—From the upper Purbeck beds, *Peveril Point, Swanage, Dorset.*

This stone furnishes the Purbeck marble, which was formerly extensively used, and is still occasionally employed in the construction of the slender shafts and columns of Gothic edifices, and for sepulchral monuments, instances of which occur in the Temple Church, London, and in Westminster Abbey ; likewise in Winchester Cathedral, for the tomb of William Rufus. The slender shafts and columns in the interior of Salisbury Cathedral are composed of Purbeck marble. (See also No. 9.) The Purbeck marble used in the older churches has sometimes a pinkish tint, and frequently weathers badly ; most probably it was procured from the neighbourhood of Swanage, from quarries which are now exhausted. The stone raised at the present day, in other parts of the neighbouring district, is of better quality than the above, but has not the pink colour of the older marble. See map No. 16, and vertical section No. 22.—H. W. B.

2.—BALA LIMESTONE, *impure compact limestone.—Near Bala, Merionethshire.*

This limestone is about 20 or 30 feet thick, and is made up in great part of the relics of Silurian life. It is also in general very impure, owing to the mixture of ordinary sediment with the lime.—A. C. R.

3. — COMPACT BITUMINOUS FRESHWATER LIMESTONE, *Swanage, Dorset.*—Part of the middle Purbeck limestone called the Feather Bed, and formed chiefly of the remains of *bivalve shells, Cyclas* or *Cyrena.*—H. W. B.

4.—STONESFIELD SLATE ; fissile limestone, quarried extensively for roofing slates.—*Benborough, Gloucestershire.*

UPPER GALLERY. — Wall-case 48.

"This is an exceedingly variable series of beds, being composed in some places of sandy flags, slates, and blue limestones; and in others of white oolite freestone, with much false bedding, and not unlike the freestones of the Inferior Oolite. Where the beds become sandy and fissile, as at Sevenhampton Common, Througham, Eyeford, and Naunton, they are capable of being split into *slates*, which form a very suitable roofing material, especially for buildings in the Tudor or other styles of Gothic architecture."—("Memoirs of the Geological Survey:" "The Geology of the Country round Cheltenham," p. 53, and Map 44. Hull.)

The rock is quarried in summer and exposed to the weather in winter, when it is split by the frost into thin slabs (*generally in the lines of false bedding*), which are capable of being dressed into slates generally of a heavy kind. The manner of the formation of these slates must not be confounded with that produced by slaty cleavage. (See **Wall-case 46**, and p. 121.)—A. C. R.

5. — CARBONIFEROUS LIMESTONE, *compact limestone*, chiefly composed of the jointed stems and detached rings of *Encrinites*. The lower beds of the Carboniferous Limestone are in places almost exclusively composed of *Encrinites*. In Pembrokeshire these Encrinite beds are 500 feet thick. —*Melwnly, near Stanwick Hall, Yorkshire.*

6.—SHELLY LIMESTONE, from the "freestone beds" of *Inferior Oolite.—Bourton-on-the-Hill, Gloucestershire.*

"Above Bourton-on-the-Hill, there are several quarries, some of the beds are traversed by bands of pure hæmatite, in which the fibrous structure is apparent. There is also a band of what might be called a "Terebratula conglomerate," 4 inches thick, made up entirely of these and a few other shells cemented together. The shells are frequently hollow, and encrusted with calcareous spar." (See "Memoir on the Geology of Map 44," by Edward Hull, p. 39.)

7.—OOLITIC LIMESTONE, *Great Oolite*, from the upper zone of the great oolite.—*Near the Bird's Nest Inn, Burford, Oxon.* (See the above Memoir, p. 63.)

UPPER GALLERY. — Wall-case 45.

8.—PURBECK MARBLE, *compact shelly limestone*, principally composed of *Paludina carinifera*. (See No. 1.— *Peveril Point, Swanage, Dorset.*

9.—CAMBRIAN LIMESTONE, a polished cube of red compact siliceous limestone.—*Porth-felen, near Aberdaron, Caernarvonshire.*

10.—CAMBRIAN LIMESTONE, polished cube of compact limestone, or grey marble, used for making lime.—*Bardsey Island, Caernarvonshire.*

This is an unfossiliferous metamorphic limestone, from the gneissic rocks of the Cambrian strata. It is from one of several small lenticular bands, all of which are usually very siliceous and difficult to polish.—A. C. R.

11.—WENLOCK LIMESTONE, polished specimen of Upper Silurian limestone, locally termed "*Ledbury marble*," *formed chiefly of small corals.*—*Malvern, Worcestershire.* Presented by the Rev. Francis Dyson.

11a.—OOLITIC WENLOCK LIMESTONE, (Upper Silurian).— *Croft Quarry, Malvern, Worcestershire.* Presented by the Rev. Francis Dyson.

12.—CARBONIFEROUS LIMESTONE, *compact and crystalline*, formed chiefly of fragments of Encrinites. Used as a flux in iron smelting. "Trivil white limestone."—*Sirhowy Iron Works, Monmouthshire.*

13.—WOOLHOPE LIMESTONE, (*Upper Silurian*,) containing fragments of trap rock, and rendered sub-crystalline by the neighbourhood of a mass of intrusive trap. Used in considerable quantities for making lime.—*Near Old Radnor, Radnorshire.* Map 56 S.E.

14.—ENCRINITAL LIMESTONE, (*Carboniferous Limestone*,) chiefly composed of *crinoidal* remains.—*Middleton Moor, Derbyshire.*

15.—CALCAREOUS SHALE of *Carboniferous Limestone*, with *Productus*.—*Campsie Hills, Stirlingshire.*

16.—CARBONIFEROUS LIMESTONE, compact grey limestone, underlying but not in contact with trap-rock.—*Campsie Hills.* Formed partly of *Encrinites*. Nos. 15 and 16 occur nearly together.

UPPER GALLERY.
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Wall-case 43.

17.—CARBONIFEROUS LIMESTONE, compact limestone, showing fossil Corals and Encrinites on a weathered surface. —*Slab House, Mendip Hills, Somersetshire.*

18.—WENLOCK LIMESTONE, (*Upper Silurian*,) compact limestone, containing fossil shells, and the stems of *Periechocrinus moniliformis*, or *Dudley Encrinite.—Much Wenlock, Salop.*

18a.—WENLOCK LIMESTONE, polished specimen of *shelly limestone*. Formed chiefly of *Rhynconella* and other shells. —*Winning's Quarry, near Malvern, Worcestershire.* Presented by the Rev. Francis Dyson.

19.—AYMESTRY LIMESTONE, (*Upper Silurian*,) compact, grey limestone, with *Pentamerus Knightii.—View Edge, Salop.*

20.—CARBONIFEROUS LIMESTONE, light grey, compact limestone, with *Productus* and *Orthis.—Little Island, Cork, Ireland.*

21.—PERMIAN LIMESTONE, compact, grey limestone, containing fossils, occurring in the marl of the *Magnesian Limestone*, which overlies the calcareous conglomerate of the Permian series.—*Kirkby Woodhouse, Notts.*

22.—CARBONIFEROUS LIMESTONE, compact limestone, with *Productus.—Near Cardiff, Glamorganshire.*

23.—CARBONIFEROUS LIMESTONE; "*Cumbernauld limestone*," compact, bituminous, and of a dark grey colour.—*Scotland.*—Presented by Wm. Murray.

24.—WENLOCK LIMESTONE, compact, grey: "DUDLEY LIMESTONE," (*Silurian*,) with *Corals and numerous stems of Crinoids.—Dudley, Worcestershire.*

25.—UPPER SILURIAN LIMESTONE, compact, grey limestone, with numerous fossil shells. —*Near Church Stretton, Salop.*

26.—BALA LIMESTONE, very impure compact limestone, exhibiting a weathered surface. (See No. 2.)—*Yr Hwylfa, Yspytty Evan, Merionethshire.*

26a.—CARADOC or BALA LIMESTONE, with *Orthis vespertilio and O. Actoniæ.—Y Gelli Grin, near Bala.*

27.—DEVONIAN LIMESTONE. *Brixham, Devon.*

28.—CARBONIFEROUS LIMESTONE, compact, light grey limestone, with numerous fossil Corals, on a weathered surface.—*Middleton, Derbyshire.*

UPPER GALLERY.

Wall-case 43

29.—COMPACT LIGHT GREY LIMESTONE, forming the lowest bed of the *Carboniferous Limestone.—Forest of Dean, Gloucestershire.*

30.—CARBONIFEROUS LIMESTONE, (*Compact grey limestone.*)—*Murdercombe Bottom, near Frome, Somersetshire.*

31.—COMPACT GREY LIMESTONE, containing bituminous matter.—*Point Levi, near Quebec, Upper Canada.*

Presented by Sir William E. Logan, F.G.S.

32.—CARBONIFEROUS LIMESTONE, *encrinital limestone,* chiefly composed of the stems of *Crinoids.* (See Nos. 5 and 14.)—*Mold, Flintshire.*

33.—BALA LIMESTONE, impure, compact, grey limestone, exhibiting a semi-concretionary character.—*Two miles north-east of Bala, Merionethshire.*

The banded or moulded form of its weathered surface arises from running water having dissolved part of the lime. It is also rudely and obliquely cleaved.

34.—CARBONIFEROUS LIMESTONE, compact, grey limestone, from the *carboniferous rocks, between Cockburnspath and Dunbar, Scotland.*

35.—CARBONIFEROUS LIMESTONE, (*light grey, compact limestone*).—*Mitcheldean, Gloucestershire.*

36.—WENLOCK LIMESTONE, coralline limestone, principally composed of *Catenipora escharoides.—Wood Green, May Hill, Gloucestershire.*

Quarried for lime-burning.

"The Wenlock limestone is the grand source of lime for agricultural and building uses in the May Hill district, and is for these purposes extensively quarried, in long continuous channels, along the crests of woody hills, especially on the western side of the summit ridge of May Hill. In this feature the district resembles that of Ledbury, Woolhope, and Abberley. The composition of the limestone is very similar—locally rich in corals, irregularly aggregated into

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Wall-case 43.

very solid and compact rock, or separated into a multitude of nodular beds, with intervening soft shales. The solid masses of limestone are locally termed "Woolpacks." They yield the finest and most abundant lime-flour, and seem to prevail along the high and prominent crests of the hills. The whole thickness of the Wenlock limestones, including the intervening beds, is about 220 feet. In the great majority of cases, throughout the Silurian regions, it is the lower part of the Wenlock limestone which is quarried for lime-burning. This, in fact, is in almost every case the most solid (and in mass the purest) part of the rock. It generally requires at least one ton of coal for the calcination of four tons of limestone. In this lower part of the rock corals are very abundant." (See "Memoirs of Geological Survey," vol. ii., part 1., pp. 185, 186. Phillips.)

37.—CARBONIFEROUS LIMESTONE, grey, coralline limestone.—*Near Wellington, Salop.*

38.—CARBONIFEROUS LIMESTONE, compact, bituminous limestone, containing fossil corals.—*Brown's Hill Quarry, County of Carlow, Ireland.*

39.—BALA LIMESTONE, very impure limestone, with numerous casts of *Orthis Actoniæ.*—*Half a mile south of Pont Rhiwaedog, Bala, Merionethshire.*

40.—FOREST MARBLE, *shelly limestone,* forming the upper beds of the Great Oolite.—*Bath, Somerset.*

This limestone usually shows much false bedding, and, like the Stonesfield slate, is frequently used for roofing purposes, and as slabs for flooring.

41.—FOREST MARBLE, *shelly limestone,* formed chiefly of Oyster shells.—*Frome, Somerset.*

42.—OYSTER BED, IN PORTLAND STONE, *shelly limestone,* locally known by the name of "*Purbeck-Portland.*"—*Isle of Purbeck, Dorset.*

This bed, eight feet in thickness, overlies the freestone beds of Portland stone which were formerly worked in the cliffs at Tilly-Whim. It consists of a mass of oyster shells

(*Ostrea solitaria*), cemented together by an infiltration of calcareous matter. Map 16.

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43.—FISSILE LIMESTONE, (*Stonesfield slate*), forming the lower beds of the Great Oolite, and quarried for roofing-slates. (See Nos. 4 and 62.)—*Stonesfield, Oxon.*

44.—INFERIOR OOLITE, *Oolitic limestone*, "to a large extent composed of shells, chiefly in a fragmentary state, cemented by oolitic carbonate of lime."—*Leckhampton Hill, near Cheltenham, Gloucestershire.*

This "shelly freestone bed" occurs in the middle division of the Inferior Oolite, which furnishes all the building stone afforded by that formation in the district. (See "Memoir on the Geology of Map 44," p. 35, and plate 2. Hull.)

45.—INFERIOR OOLITE, *Oolitic limestone*, containing numerous *Rhynconellæ* and *Terebratulæ*.—*Selsey Hill, near Stroud, Gloucestershire.*

46.—INFERIOR OOLITE, *Oolitic limestone*, containing fossils. ("Freestone bed.")—*Leckhampton Hill, near Cheltenham.*

"The upper freestone is twenty-eight feet thick at Leckhampton Hill, and consists of regularly stratified oolite, compact, and not so highly fossiliferous as the remaining beds of the Inferior Oolite series." (Hull, p. 39.)

47.—GREAT OR BATH OOLITE, *Oolitic limestone*, containing fossils.—*Stinchcombe, near Stroud, Gloucestershire.*

47a.—GREAT OR BATH OOLITE, *fossiliferous oolitic limestone*.—*Box Tunnel, Great Western Railway.*

48.—PORTLAND STONE, *bituminous oolitic limestone*, containing numerous casts of fossils, from the "*roach*" bed of Portland stone.—*Portland Isle, Dorset.*

This bed underlies the "cap" and "dirt" beds, and is the uppermost stone quarried. Its average thickness is from three to four feet. (For further details in reference to Portland stone, see R. Hunt's "Descriptive Guide," pp. 15 to 17.) The Roach bed is very hard, and is used for foundations of breakwaters, and in works where strength is

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required, but it will not bear a close even face. See Map 17, and horizontal section, No. 20.—H. W. B.

49.—CORAL RAG, *oolitic limestone.—Woodhouse Cross, near Gillingham, Dorset.*

The Coral Rag of this district is burned for lime, and furnishes a stone fit for rough building purposes. Further south, at Marnhull and Todbere, it becomes a thick bedded, white oolite, which is quarried for freestone. Some of the neighbouring churches have been built of the stone from the last-mentioned quarries. Map 18.—H. W. B.

50.—INFERIOR OOLITE LIMESTONE, "*Gryphite bed,*" from the ragstone or upper division of the *Inferior oolite series. —Painswick Hill, Gloucestershire.*

"At the fine old encampment on Painswick Hill, the ragstone is clearly developed. The rock is very fossiliferous, being charged with *Gryphæa*, *Trigonia*, *Modiola*, and *Lima*. The whole thickness of the zone cannot be less than forty-five feet." (See "Hull's Memoir on Map 44," p. 46.)

51.—GREAT OOLITE, *White oolitic limestone*, containing fossils.—*Hampton Common, near Stroud, Gloucestershire.*

52.—PORTLAND STONE, *Oolitic limestone*, underlying the chalky limestone No. 97, and containing the carbonised impressions of *plants.—Oakley Quarry, Tisbury, Wilts.*

This bed, termed by the quarrymen "the devil's bed," is quarried for freestone, and used for buildings. When first extracted from its bed, the stone is soft, and of a green colour ; but it becomes harder and nearly white on exposure to the air, and after the quarry water has dried off. It contains flints, both irregularly disseminated and in occasional layers. (See **Wall-case, 42**, Nos. 32 to 35.)—H. W. B.

53.—PORTLAND STONE, *Oolitic limestone* ("fretting bed" of Portland stone).—*Oakley Quarry, Tisbury, Wilts.*

In the Vale of Wardour the lowest beds quarried for stone are called by the quarrymen "fretting beds." They are hard, sometimes sandy, and of variable thickness, generally ranging from two to three feet. Flints occur sometimes at the top and bottom of the bed. Map 15.—H. W. B. UPPER GALLERY. Wall-case 43.

54.—CORNBRASH LIMESTONE, quarried for lime-burning. (See No. 55.)—*Bayford, near Wincanton, Somerset.* Map 18.

54a.—RUBBLY LIMESTONE (*Cornbrash*), with *Terebratula obovata* and *Rhynconella tetrahedra.*—*Chilcombe, Dorset.*

55.—CORNBRASH LIMESTONE.—*Dorsetshire.*

This limestone in the south-west of England is never oolitic, and is generally marked by the fertility of the crops which grow on it. It is a loose rubbly rock, which seldom furnishes stone fit for building, but it is largely converted into lime for the improvement of poorer soils in the neighbourhood. *Brash* is a provincial expression, used to designate any stony soil, and is derived from the Saxon, *brecan*, to *break* (whence *bræc, broken*). The word *Cornbrash*, therefore, means the *stony soil*, suited for the growth of corn. Map 17.—H. W. B.

56.—FULLER'S EARTH ROCK.—*Cock, near Holton, Somerset.* Map 18.

This limestone becomes well developed in Dorsetshire, where it is extensively quarried for lime for agricultural and other purposes. Like the Cornbrash, it is not oolitic, and furnishes a good soil.—H. W. B.

57.—FULLER'S EARTH ROCK, oolitic limestone, with broken shells, and part of the stem of a plant.—*Cotteswold Hills, near Cheltenham.*

The Fuller's Earth is a clay, generally separating the Inferior from the Great or Bath Oolite. It varies from a few feet to 150 feet in thickness, near Bath, and contains thin bands of shelly limestone, the thickest of which is called the Fuller's Earth Rock.—H. W. B.

58.—CORAL RAG, very fine oolitic limestone.—*Coast near Weymouth, Dorset.* Map. 17.

59.—CORAL RAG, *pisolitic* or large-grained oolitic *limestone.*—*Steeple Ashton, Somerset.*

60.—INFERIOR OOLITE, *Oolitic limestone*, composed of oolitic grains of hydrated peroxide of iron in a calcareous cement.—*Dorsetshire.*

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The lower part of the Inferior Oolite in Dorsetshire is represented by ferruginous beds, containing a large percentage of iron, in the form of oolitic grains.

61.—DISINTEGRATED PORTLAND STONE, loose oolitic grains of carbonate of lime, from Portland beds, immediately underlying Gault.—*Fonthill Giffard, Wilts.* Map 15.

62.—STONESFIELD SLATE, *fissile shelly limestone*, quarried for roofing tiles. (See No. 4.)—*Three miles east of Cheltenham.*

63.—FOREST MARBLE, *shelly limestone.—Frome, Somerset.*

64.—FOREST MARBLE, *shelly limestone.*

65.—FULLER'S EARTH ROCK, *impure grey shelly limestone*, formed of *oyster* shells.—*Sapperton Tunnel, six miles south of Stroud, Gloucestershire.*

66.—FULLER'S EARTH ROCK, *shelly limestone*, formed of *oysters* and other shells.—*Three miles east of Cheltenham.*

66 a.—FOREST MARBLE, *shelly limestone*, with numerous *oysters.—Westwell, near Burford, Oxon.*

67.—FOREST MARBLE, *shelly limestone*, containing pebbles of clay and fragments of drift wood.—*Frome, Somerset.*

(See "Memoirs of Geological Survey," vol. i., p. 285.)

68.—FOREST MARBLE, *dark grey shelly limestone*, containing *plant remains* (Lithodomus inclusus).—*Dorset.*

The Forest Marble of Dorsetshire affords in general a cold and wet soil, which is converted for the most part into pasture. This is more particularly the case where the clays predominate. The stone is quarried for flags, for building, and for road metal; but it is not burned for lime, except in the neighbourhood of Bridport (Bothenhampton), probably in consequence of the superiority of the lime afforded by the neighbouring Cornbrash and Fullers' Earth limestones.

69.—FOREST MARBLE, *shelly limestone*, partly oolitic, and containing *Mytilus* and numerous *oysters.—Bibury, Gloucestershire.*

(See Hull's Memoir on Map 44, pp. 65 and 70.)

69a. FOREST MARBLE (called Crackmore Marble) used for the chancel steps of the Abbey Church at *Sherborne, Dorsetshire.* Presented by the Rev. Francis Dyson.

70.—Forest marble, *shelly limestone*, with included pebbles of clay. These beds are quarried for flagstones, &c. —*Hilton, near Wincanton, Somerset.* Map 18. Upper Gallery. Wall-case 43.

71.—Forest marble, *shelly limestone*, occurring in the form of thin-bedded flagstones.—*Westwell, near Burford, Oxon.*

72.—Forest marble, *fissile shelly limestone*, composed partly of *Oysters, Pectens*, &c.—*Chapel Knap, Melksham, Wilts.*

73.—Forest marble, *shelly oolite*, forming a band of impure limestone in *Bradford clay.*—*Tetbury Road, Gloucestershire.*

The Bradford Clay consists of thin beds of clay, occurring here and there in the Forest Marble. At Bradford they contain *Apiocrinus Parkinsoni.* (See **Case 17.**)

74.—Inferior oolite, *pisolitic limestone.*—*Leckhampton Hill, near Cheltenham.*

This bed, locally termed "pea grit," forms the base of the Inferior Oolite, over the somewhat limited area where it occurs. Some of the nodules appear to be true concretions, and exhibit a series of concentric layers of calcareous matter, investing fragments of other materials round which they have formed; others, on the contrary, seem to be merely worn fragments of limestone, and present no appearance of any concentric structure. (See Edward Hull's "Memoir on Map 44 of the Geological Survey," pp. 32-35.)

74a. Oolitic Limestone, from upper beds of *Inferior Oolite.*—*Nailsworth, Gloucestershire.*

74b.—Coral Rag: *pisolitic limestone.*—*Buckland, three miles east of Farringdon, Berkshire.*

75.—Purbeck limestone, *impure limestone*, called the "devil's bed."—*Swanage, Dorset.* Map 16.

76.—Purbeck limestone, *impure limestone*, containing numerous shells, of brackish-water origin, from the *Corbula beds* of the middle Purbeck.—*Durlston Bay, Dorset.*

(See Map 16, Vertical Sections, sheet 22.)

UPPER GALLERY. — Wall-case 48.

77.—PURBECK LIMESTONE, *compact grey shelly limestone*, containing freshwater shells (*Cyclas, &c.*) from the Downs Vein of the Middle Purbeck: about 2 feet above the cinder bed.—*Durlston Bay, Swanage, Dorset.*

(See Map, No. 16, and Vertical Sections, sheet 22.)

78.—PURBECK LIMESTONE, *from the marble-rag beds of the upper Purbeck.—Peverel Point, Dorset.*

This bed contains much green matter, and its surface is covered with *Unios*, the scales and teeth of fish, numerous black *Cyprides* (*Cypris punctata*), *&c.*

79.—PURBECK LIMESTONE, *compact bituminous limestone.* "Pink bed," forming a part of the freestone series of the middle Purbeck.—*Swanage Quarries, Dorset.*

80.—PURBECK LIMESTONE, *hard compact bituminous limestone.* ("Roach bed," occurring in the freestone beds of the middle Purbeck.) The surface of the specimen is covered with *Hydrobia, Cyrena, Ostrea, &c.—Gully Quarry, near Swanage, Dorset.*

81.—FOREST MARBLE, *sandy calcareous flagstone.—Frome, Somerset.*

82.—PURBECK LIMESTONE, *thin bedded shelly limestone*, of brackish-water formation, with numerous valves of *Cyclas* or *Cyrena.—Limekiln Quarry, near Kingston, Dorset.*

83.—PURBECK LIMESTONE, *compact freshwater limestone,* occurring in thin bands in the upper cypris shales of the middle Purbeck beds, and containing numerous *Cyclas* or *Cyrena, Paludina carinifera, Cypris.—Peverel Point, Swanage, Dorset.*

84.—PURBECK LIMESTONE, *bituminous limestone,* from the "freestone bed" of the middle Purbeck.—*Swanage Quarries, Dorset.*

85.—PURBECK LIMESTONE, *shelly freshwater limestone,* with numerous *Cyclas* or *Cyrena.—Swanage Quarries, Dorset.*

This bed, which occurs in the "Laning" or "Leaning Vein" of the middle Purbeck series, is called in the Isle of Purbeck "Laper," and is quarried for paving-stones.

86.—PURBECK LIMESTONE, *hard blue limestone*, chiefly composed of broken freshwater or estuary shells (*Cyclas* or *Cyrena*) with specks of green matter.—*Peverel Point, Swanage, Dorset.* UPPER GALLERY Wall-case 43.

From the upper part, probably, of the comminuted shell limestone of the Upper Purbeck series: at Peverel Point this bed attains a thickness of ten feet. It is used for building purposes, and is called "soft burr" by the quarrymen.

87.—LIAS LIMESTONE, *she ly limestone.*—(Lower bed of the White Lias.)—*Charton Bay, Lyme Regis, Dorset.*

88.—PURBECK LIMESTONE, *hard shelly limestone,* made up of *Cyclas,* with *Paludina, &c.*—*Durlston Bay, coast of Dorset.*

89.—PURBECK LIMESTONE, *shelly limestone,* with brackish-water shells; small *Oyster, Cyrena, &c.*—*Kingston, near Swanage, Dorset.*

90.—SUSSEX MARBLE, polished specimen of shelly limestone (*Wealden*), containing numerous freshwater shells (*Paludina*).—*Weald of Kent and Sussex.*

From the occurrence of this limestone in the Wealden of Sussex, it has received the name of "Sussex marble," and has been much used for ancient tombs and sepulchral monuments. It bears a strong general resemblance to the Purbeck marble (see Nos. 1 and 8), but may always be distinguished from the latter by the greater size of the shells contained in it.—H.W.B.

91.—MIDDLE EOCENE LIMESTONE, containing numerous casts of *Paludina lenta.*—*One mile east of Ryde, Isle of Wight.*

This bed is from the Nettlestone grit series, that is, from the lower member of the two divisions, into which the Osborne group was divided by Professor Edward Forbes. This last constitutes the upper portion of the middle Eocene. "At the western extremity of the Isle of Wight, the Osborne series is represented by marls and clays, for the most part unfossiliferous, which, at the eastern extremity of the Island are replaced by grits and sands, with imperfect limestones, clays, and marls. At

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the west corner of Apley Wood a bed of calcareous sandstone, about four feet thick (full in places of casts of *Paludina*, associated with numerous large *Unio, Limnæa, Planorbis*, and occasional bones of *Turtle*) appears on the shore, beneath the sea wall, resting on ragstone, similar to that seen at Nettlestone, where it is 10 feet or more in thickness. The shells, which are as much crowded as in Sussex marble, (No. 90,) are sometimes filled with a greenish marl, and the rock itself is somewhat ferruginous, and of a pale ochreous colour." See Geological Map No. 10, Vertical sections No. 25, and "Survey Memoir on the Isle of Wight," p. 128. (Forbes.)

92 and 93.—HEADON HILL LIMESTONE, *earthy middle Eocene limestone*, of freshwater origin, with numerous shells of *Planorbis, &c.—Headon Hill, Isle of Wight.*

This limestone attains its greatest development at Headon Hill, from which circumstance it is generally called the Headon Hill limestone. It thins out gradually from the western extremity of the Isle of Wight, towards the north and east. (See "Survey Memoir on the Isle of Wight," plates 9 and 10, Horizontal sections No. 47, and Vertical sections No. 25. Map No. 10.) From the upper Headon series.

94.—PURBECK LIMESTONE, *shelly limestone*, principally composed of casts of *Cyrena*, from the intermarine beds of the middle Purbeck.—*Kingston, Dorset.*

In Dorsetshire, immediately resting on the "cinder bed," No. 173, **Case 41**, occurs a series of beds, partly of freshwater, partly of estuary and marine origin. From this circumstance, they have been called the *Intermarine series*, by Professor Edward Forbes, in his classification of the Purbeck strata. In Durlston Bay, these beds attain their maximum thickness of 45 feet; eastward, in common with the great mass of the Purbeck strata, they become much thinner. In the Isle of Purbeck, the Laning Veins, the Royal, Freestone, and Downs Veins, the four principal veins quarried, all lie in the Intermarine series.

See Map 16, and vertical section No. 22.

95.—Bembridge limestone, *upper Eocene, (freshwater) limestone.—Headon Hill, Isle of Wight.* Upper Gallery. Wall-case 48.

In consequence of its great development at Bembridge and Sconce Point, this limestone has been termed Bembridge or Sconce limestone; it is also known by the name of the Bulimus limestone, from the frequent occurrence in it of that shell (*Bulimus ellipticus*). (See Map 10, and Forbes, "Memoir on Isle of Wight," plates 9 and 10, and pp. 51 to 58 and 113 to 120, also horizontal sections No. 47, and Vertical sections No. 25.) This specimen contains the tooth of *Palæotherium crassum.*

96.—Chalk marl with fossils, forming the base of the chalk.—*One mile north of Brixton, Isle of Wight.*

It is burned for lime, and used for agricultural purposes.

97.—Purbeck limestone, *earthy freshwater limestone,* from the Insect marls of the lower Purbeck.—*North-east of Oakley Quarry (in a wood), near Tisbury, Wilts.* Map 15.

These marls contain comminuted fragments of plants in a carbonised state, and the wings and other remains of insects. In the Vale of Wardour, these beds are much less developed than in the Isle of Purbeck.

98.—Portland limestone, *earthy limestone.—Oakley Quarry, Tisbury, Wilts.* Map 15.

In the Vale of Wardour, the upper beds of Portland stone, which overlie the oolitic freestone, Nos. 52 and 53, assume the character and appearance of ordinary Chalk, with irregularly disseminated flints. They contain numerous and perfect specimens of *Trigonia, Oyster, Cardium,* &c., and are burned for lime.

99.—Chalk, *earthy limestone,* with flints from the middle chalk. This specimen gives an idea of the manner in which flints lie bedded in Chalk.—*Arreton Down, Isle of Wight.*

100.—Chalk, *earthy limestone.* This chalk furnishes an excellent manure.—*Moncton, near Cranborne, Dorset.*

101.—Chalk, *earthy limestone.—Moncton, near Cranborne, Dorset.*

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Though dug from a pit at a very short distance from that from which the preceding specimen (No. 100) was procured, this chalk does not prove equally beneficial as a dressing for land.

102.—Earthy limestone, the equivalent, probably, of *Upper Green-Sand.—Hunstanton, Norfolk.*

103.—Red chalk, *earthy red limestone,* probably equivalent to the *Gault.—Hunstanton, Norfolk.*

104.—Lower or White Lias, *earthy argillaceous limestone.—Lyme Regis, Dorsetshire.* Map 22.

105.—Marlstone, *argillaceous limestone,* from the Lias, containing shells and the broken stems of *Crinoids.*—From foundered blocks on the sea-shore between *Down Cliff and Thorncombe Beacon, Dorset.* Map 17.

106.—Lower lias, *argillaceous limestone,* with numerous fossil shells, with the valves united, showing the gaping position in which, after death, the shells lay filled with calcareous mud in the sea bottom. See p. 39.—*Four miles south of Gloucester.*

107.—Lower lias, *argillaceous limestone,* with *Lima, Oysters,* and other fossils.—*Freathern Cliff, near Newnham, Gloucestershire.* Map 35.

108.—Lias, polished slab of *argillaceous limestone.* From its occasionally curiously marked appearance, bearing a rough resemblance to ruins and trees, this limestone is sometimes called " ruin or landscape marble," and sometimes " Cotham marble," from its occurrence at that place, in the neighbourhood of Bristol. It is found in thin layers in Lias Clay. Map 35.

109.—Lias, *argillaceous limestone,* containing *Oysters.—Two miles east of Newport, Monmouthshire.* Map 36.

The blue Lias limestones generally contain a good deal of clay, and are eminently useful as hydraulic lime, setting, it is said, better under water than the lime made from most other limestones.

110.—Lower or "white lias," *argillaceous limestone,* near the base of the Lias, with layers of bivalves (*Avicula decussata*) immediately overlying the *bone bed,* **Wall-**

case 41), Nos. 79, 171, 181, 185, 189, 190.—*Westbury-on-Severn, Gloucestershire.* UPPER GALLERY. Wall-case 43.

The fossils of the white beds were said by the late Professor E. Forbes to indicate an inland brackish sea, like the Caspian.

111.—COAL MEASURE LIMESTONE, commonly called the "*Freshwater limestone;*" from *Upper Coal Measures.—Le Botwood, Shropshire.*

112.—COAL MEASURE LIMESTONE, commonly and erroneously called "*Freshwater limestone;*" from the *upper part of the Warwickshire Coal Measures.* — *Baxterley, near Atherstone, Warwickshire.*

This limestone is only about two or three feet thick, and runs in a long band near the junction of the Carboniferous and Permian rocks of Warwickshire. Its only fossil seems to be *Microconchus Carbonarius.* It is probably the equivalent of 111 and 119.

113.—CARBONIFEROUS LIMESTONE, *argillaceous limestone,* from the lower beds of Carboniferous Limestone.—*Forest of Dean, Gloucestershire.*

114.—LIAS LIMESTONE, *dolomitic;* forming the lowest bed of the Lias.—*Parc, two miles north-west of Bridgend, Glamorganshire.*

See "Memoirs of Geological Survey," vol. i., p. 270.

115.—DARK GREY ARGILLACEOUS LIMESTONE, *from the upper beds of Carboniferous Limestone.* — *Henblâs, near Holywell, Flintshire.*

When burnt, this limestone furnishes a hydraulic cement, and is called "hydraulic limestone," or, in Welsh, "carreg aberdo."

116.—LIAS LIMESTONE. Concretionary argillaceous limestone, in a sandy marl, at the base of the Lias.—*Westbury-on-Severn, Gloucestershire.*

This specimen, on a weathered surface, shows the concretionary structure of the rock.

117.—ARGILLACEOUS LIMESTONE, occurring in tabular beds in the softer strata of *Kimeridge shale,* on the coast of *Dorset.* It has been extensively worked for *cement stone.—Broad Bench, Dorset.* Map 16, and horizontal sections No. 56.

UPPER GALLERY. — Wall-case 43.

117a.—MARLY LIMESTONE, from the Insect Marls (*Lower Purbeck*), with vegetable and insect remains.—*Swanage, Dorset.* Map 16.

118.—CARBONIFEROUS LIMESTONE, *argillaceous limestone*, used as a flux for smelting iron ore.—*White Head, Forest of Dean, Gloucestershire.*

119.—COMPACT GREY ARGILLACEOUS LIMESTONE, speckled with *Microconchus carbonarius*, from *Coal Measures.—Bedworth, Warwickshire.*

From the same beds as 112, but of a different colour.

120.—LAMINATED CALCAREOUS BAND, occurring in *Kimeridge clay.—Freshwater Bay, near Kimeridge, coast of Dorset.* Map 16.

121.—CORNSTONE, impure concretionary limestone, from *Old Red Sandstone.—Longhope, Gloucestershire.*

This limestone occurs in irregular concretionary masses in Old Red Sandstone, and from the scarcity of limestone in certain districts, it is occasionally burned for lime for agricultural purposes.

122.—CORNSTONE, impure concretionary limestone, in *Old Red Sandstone.—Mitcheldean, Gloucestershire.*

123.—MAGNESIAN CONGLOMERATE, from the *New Red Sandstone* or *Trias*, composed of fragments of Carboniferous limestone, in a calcareo-magnesian base, with a tooth of *Thecodontosaurus.—Durdham Down, Bristol.*—Presented by W. H. Bailey, F.G.S.

124.—DOLOMITE OR MAGNESIAN LIMESTONE, from the *Carboniferous Limestone.—Agasthorpe, Ashby-de-la-Zouche, Leicestershire.*

125.—MAGNESIAN LIMESTONE (*Permian*), cementing fragments of Carboniferous Limestone.—*Durham.* Presented by Mr. King.

126.—GRANULAR MAGNESIAN LIMESTONE OR DOLOMITE, *Carboniferous Limestone.—Breedon, Leicestershire.*

127.—MAGNESIAN LIMESTONE (*Permian*), exhibiting fretted divisional planes, produced by the percolation of water.—*Mansfield Woodhouse, Notts.*

128.—INDURATED MAGNESIAN LIMESTONE (*Permian*).—*Black Hall Rocks, Durham.* Presented by Mr. King.

129 and 129a.—MAGNESIAN LIMESTONE.—*Sully Island, five miles south of Cardiff, Glamorganshire.* UPPER GALLERY. Wall-case 43.

Magnesian limestones or Dolomites consist of carbonate of lime and carbonate of magnesia, in varying proportions. The specimens 123 to 129 show that magnesian limestones are of various geological ages. It is a lithological character, having no essential relation to the geological date of the rock.

129b.—MAGNESIAN LIMESTONE, locally called "lid-stone," from its lying on the top of the iron ore which occurs in the Carboniferous Limestone of the *Forest of Dean, Gloucestershire.*

130.—*Carbonate of lime and carbonate of magnesia.—Strontian, Argyleshire.*

IRONSTONES AND IRON ORES.

The two lower shelves (131 to 175) contain ironstones. In the Coal Measures these occur in stratified bands and nodules, generally in the shales of that formation. The Oolitic iron ores lie generally diffused in various members of that series, forming *ferruginous strata.* The iron of the Lower Green sand is chiefly high up in that formation, and consists generally of reticulating veins crossing in all directions the sandy strata in which they lie. The Tertiary ironstones are chiefly nodular, the nodules lying mostly in clays or clayey sands. Sometimes these nodules, as at Hengistbury Head, are several yards in diameter.—A. C. R.

131.—ARGILLACEOUS OR CLAY IRONSTONE, from the Crosstone beds (*Coal Measures*).—*Ironbridge, Salop.*

132.—ARGILLACEOUS OR CLAY IRONSTONE, "Pennystone band," from *Coal Measures.—Coalbrook Dale, Salop.*

133.—CLAY IRONSTONE, with veins of calc spar, *from Coal Measures.—Bedworth, Warwickshire.*

134.—CLAY IRONSTONE, part of a nodular concretion from the pipe-clay beds of the *lower Bagshot* series.—*Branksea Island, near Poole, Dorset.* Presented by Colonel Waugh.

135.—IRON ORE, oolitic grains of hydrous oxide of iron, cemented by calcareous matter, forming the *upper beds of*

UPPER GALLERY. — Wall-case 43.

Coral Rag, and worked for iron.—*Near the Railway Station, Westbury, Wilts.* Map 14.

135a. IRON ORE: (Blenheim ore) from Marlstone, ¼ mile S.E. of *Fawler*, S.E. of *Charlbury, Oxfordshire.*

136.—SANDY CLAY IRONSTONE, with an included pebble of flint.—*Hengistbury Head, Christchurch Bay, Hants.*

This ore forms layers of isolated reniform masses, of large dimensions, in the Bracklesham beds of the Middle Eocene, on the coast of Hampshire. As the coast line has been worn back, the ironstone has been detached from the cliffs and fallen on the shore, where it is found in large quantities. It is also extracted from the cliffs (map 16), and furnishes an ore of iron, which is not only valuable from the ductility of the metal it yields, but also on account of its tendency to promote the fusion of other ironstone. 13,000 tons were raised and sent to Newport, in South Wales, to be smelted, in 1856.—H.W.B.

137.—CLAY IRONSTONE, coated with peroxide of iron, from *Lower Green-Sand.*—*Bromham, Devizes, Wilts.*

138.—PEROXIDE OF IRON, with small included concretions of clay ironstone, from *Lower Green-Sand.*—*Seend, near Devizes, Wilts.* Map 14.

There is much ironstone scattered through parts of the Lower Green-Sand. Attention has been lately directed to this deposit of ore, which is now being worked.

139.—CLAY IRONSTONE, with rounded pebbles of flint. *From London clay.*—*East Bloxworth, Dorset.*

140.—Nodular concretions of CLAY IRONSTONE, externally coated with peroxide of iron. *From London Clay.*—*East Bloxworth, Dorset.*

141.—IRON SAND, containing 55·6 per cent. of metallic iron.—*Two miles E. of Freshwater Gate, Isle of Wight.*

This ore consists of grains of Iron derived from the destruction of cliffs of *Lower Green-sand;* from these it is washed by the sea, and afterwards deposited on the shore in considerable quantities, between high and low water mark. A button of iron, reduced from the ore, is placed with it for illustration.

141a.—SILICEOUS IRON ORE from *Plastic Clay.* From a thin layer resting on chalk, at the Brickyard, Beedon Hill, north of *Newbury, Berkshire.* Upper Gallery. — Wall-case 48.

142.—Brown iron ore.

143.—Stalactitic brown iron ore.

143a.—Sparry iron ore.

Nos. 142, 143, 143a, 143b, and 158, occur in the middle division of the Carboniferous Limestone of the Forest of Dean, where it is raised in considerable quantities. By the last returns, the number of tons of ore raised was 127,554. ("Mineral Statistics for 1857," by R. Hunt, F.R.S., p. 83.)

143b.—Ochrey brown iron ore (hydrous peroxide of iron), from *Carboniferous Limestone.*

144.—Ironstone, from the "Pennystone band" of the *Coal Measures.—Coalbrook Dale, Salop,*

145.—Ironstone, with fossils (*Productus*), "*Pennystone band," from Coal Measures.—Coalbrook Dale, Salop.*

146.—Ironstone, from the "crosstone beds" of the *Coal Measures.—Ironbridge, Salop.*

147.—Pyrolusite (*grey manganese ore*), from Magnesian Conglomerate.—*Mendip Hills, Somerset.*

148.—Pyrolusite (*grey ore of manganese*) with carbonate of lead (*white lead ore*).

149 and 150.—Cannel Coal (*Coal Measures*).—*Torbane Hill, Scotland.*

151.—Big vein "*coal brass,*" from *Coal Measures.—Donnington, Coalbrook Dale, Salop.*

152.—Ironstone (Pennyearth ironstone), from *Coal Measures.—Sirhowy Ironworks, Monmouthshire.*

153.—Flint coal bass, *from Coal Measures.—Donnington, Coalbrook Dale, Salop.*

154.—Black band ironstone *from Coal Measures,* carbonate of iron.—*Glamorganshire, South Wales.*

This is similar to the famous black band ironstone of the lower Coal Measures of Scotland, discovered by Mushet, in 1801.

154a.—Iron Stone, from *Coal Measures.**

154b.—Ironstone, from *Coal Measures.**

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* From *Cross Green Colliery, Yorkshire.* Presented by Captain E. J. Maude.

UPPER GALLERY. — Wall-case 43.

155.—IRON ORE, forming the lowest beds of the *Wealden, three quarters of a mile south of Horsepath, Oxfordshire.*

155a.—PIPE OF FERRUGINOUS GRIT, found in beds of iron sandstone, sometimes of considerable dimensions.—*Ightham, Kent.* Presented by Joseph Barling.

156 and 156a.—Rhombic masses of FERRUGINOUS GRIT, found in the gritstone or oak quarrystone overlying *Coal Measures*, on the tops of hills around Barnsley.—*Presented by Mr. Wilson.*

157.—SILICEOUS IRONSTONE, with crystals of quartz, (*Lower Eocene*).—*Boughton Hill, near Canterbury, Kent.* Presented by William Harris, Esq.

158.—IRONSTONE (peroxide of iron), containing numerous pebbles of quartz. *From Carboniferous Limestone.—Cinderford, Forest of Dean.*

159 and 160.—BROWN IRON ORE (*brown hæmatite*), from *Magnesian Conglomerate.—Mendip Hills, Somerset.*

Nos. 147, 148, 159, 160, 163, 164, and 165, are from the Dolomite or Magnesian Conglomerate of the Mendip Hills, Somerset (Map 19).—Presented by the "Little Down" and "Ebbw Rocks" Mining Company.

161.—IRONSTONE (peroxide of iron), containing numerous casts of freshwater shells (*Paludina*).—From the Wealden, *East end of Brixton Bay, Isle of Wight.* Map 10.

162.—PEROXIDE OF IRON, cementing freshwater shells (*Paludina*).—From the *upper Eocene beds of Hempstead Cliff, Isle of Wight.* Map 10.

163.—BROWN IRON ORE (hydrous peroxide of iron), from *Magnesian Conglomerate.—Mendip Hills, Somerset.*

164.—RED IRON ORE (peroxide of iron), commonly known by the name of "*reddle.*"—*Mendip Hills, Somerset.*

165.—SPARRY IRON ORE (with carbonate of copper), partly converted by decomposition into brown iron ore.—*Mendip Hills, Somerset.*

166.—Reniform nodule of CLAY IRONSTONE.*

167.—Flattened nodule of CLAY IRONSTONE, with *Cyclas.**

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* From the Hastings Sands, of *Hastings, in Sussex.* Presented by Dr. Percy, F.R.S.

168.—Concretion of CLAY IRONSTONE.—*Hastings, Sussex.* UPPER GALLERY. — Wall-case 43.

169.—Flattened nodule of CLAY IRONSTONE ("New Mine ironstone"), *from lower beds of the Coal Measures.—North of Oldbury, near Dudley, Worcestershire.*

170.—NODULES, forming septaria, and containing iron pyrites. From the walls of a copper lode, 30 fathoms from the surface, at *North Huel Friendship, near Tavistock, Devon.*

171.—CONCRETIONARY NODULES OF IRON ORE, *from Gault. —St. Bartholomew's Hill, Wilts.* Map 15.

172.—SILICEOUS IRONSTONE, *from Lower Green-Sand,* occurring abundantly on the surface of the ground at *Shotover, near Oxford,* where some of the field walls are entirely built of it.

173.—DITTO, another specimen containing the casts of fresh-water shells.

174.—IRON ORE, locally "*pisolitic ironstone,*" *from the Lower Silurian Lingula beds —Bettws Garmon, Llanberis, Caernarvonshire.*

175.—IRON ORE, from *Marlstone,* containing numerous *Rhynconella tetrahedra.—Steeple Aston, seven miles north-east of Woodstock.*

176.—STALACTITIC BROWN IRON ORE, with a fibrous structure, from *Old Red Sandstone.**

BROWN IRON ORE consists of peroxide of iron 85·3, and water 14·7, with occasional impurities, as silica, alumina.

177.—BOTRYOIDAL BROWN IRON ORE, with a fibrous structure, and coated externally with an iridescent lustre. From *Old Red Sandstone.**

178.—BLACK OXIDE OF MANGANESE, assuming a botryoidal appearance on the outer surface. From *Old Red Sandstone.**

This ore is composed of oxide of manganese 68·0, oxide of iron 6·5, water 17·5, carbon 1·0, baryta 1·0, and silica 8·0.

* From the *Brendon Hill Mine, Somerset.* (Map 20.) Presented by Sir Charles E. Trevelyan, K.C.B.

UPPER GALLERY.
Wall-case 44.

Wall-case 44.

NODULES, CONCRETIONS, GEODES, SEPTARIA, &c.

These bodies are of many forms and of different compositions, and occur in strata of all kinds and ages. Concretions are sandy, calcareous, phosphatic, ferruginous, &c., or of these and other substances variously intermixed. The spherical grains of the Oolitic rocks are small concretions of lime, and it frequently happens that in the centre of a concretion or nodule, a grain of sand, a fragment of a shell, or some other body, has served as a nucleus round which the matter forming the concretion has gathered. Small oolitic concretions may have been formed during the accumulation of the substance forming the rock, but many of the larger concretionary bodies, such as Nos. 42 and 46, have been formed in the stratum subsequent to its accumulation, and perhaps during the process of consolidation. Much remains to be done on this subject, and of some of the forms in this case no explanation has yet been given.—A. C. Ramsay.

Specimens arranged and described by H. W. BRISTOW.

1.—NODULAR CONCRETIONS (*Permian*), from Magnesian Limestone.

2.—RENIFORM NODULAR CONCRETION of white sand.

3.—NODULAR CONCRETIONS OF SAND, near *Beedon, Berkshire.*

4.—

5.—FIBROUS CARBONATE OF LIME, termed "BEEF" by the quarrymen in the Isle of Purbeck, and "HORSEFLESH" in the Isle of Portland. It occurs in beds or thin laminæ, in the middle Purbeck. (Map 16. See vertical section No. 22.)—*Durlston Bay, Dorset.*

"The crystals of this mineral are usually found shooting upward from a band of perished bivalves, and appear due to a change in the condition of the shells on which they rest." (Rev. O. Fisher "On the Purbeck strata of Dorsetshire," "Transactions of the Cambridge Philosophical Society," vol. ix., p. 5.)

6.—COLUMNAR LIMESTONE, exhibiting a fibrous structure resembling that of "BEEF" (see No. 5).—*Perth, Upper Canada.* Presented by Sir W. E. Logan.

7.—LIMESTONE, with a curved and waving structure.—*Frazers Mount, Nova Scotia.* Presented by Sir W. E. Logan.

8.—CALCAREOUS CONCRETIONS *from Portland Stone.—Tisbury, Wilts.*

9 and 10.—Flattened CALCAREOUS CONCRETIONS occurring in clay at *Graves' Brickyard, near Buckingham.*—Presented by Mr. Stowe.

11.—PHOSPHATIC NODULE, from *Gault,* with cracks filled with phosphate of lime; a small septarian.—*Longbridge Deveril, near Warminster, Wilts.*

11a.—PHOSPHATIC NODULE, from *Kimeridge Clay: Bedcister, Dorset.* Presented by John Mansell, F.G.S.

12.—PHOSPHATIC NODULES, *from Gault.—From the Brickyard, Dinton, Wilts.* Map 15.

13.—PHOSPHATIC NODULES, *from Gault.* These nodules have been analyzed by Dr. Hofmann, and found to contain silica, alumina, iron, lime, and magnesia;—a portion of the two last as phosphates.—*From the Brickyard, Lidhurst, Wilts.* Map 15.

14.—PHOSPHATIC NODULES, fragments of *bones, teeth, shells, &c.,* from *Chloritic marl,* at the base of the *Chalk.* These are extracted in large quantities, and after being ground and mixed with sulphuric acid, they constitute a valuable agricultural manure.—*Near Cambridge.*

15.—FLATTENED ELLIPTICAL CONCRETION, exhibiting the structure termed "*cone-in-cone,*" on one side of the specimen. It was found about six feet beneath the surface at the *Rheidol United Mine, Cardiganshire, three miles from the Devil's Bridge.*—Presented by Mr. William Spooner.

UPPER GALLERY. — Wall-case 44. 16.—FLATTENED ELLIPTICAL SANDY CONCRETION, exhibiting "*cone-in-cone*," *from Lower Silurian Rocks, Aberystwith, Cardiganshire.*

17.—CONCRETION, exhibiting an imperfect crystallization, termed "*cone-in-cone.*"—*From the cliff above Wallog, north of Aberystwith.* Presented by the Rev. Henry R. Lloyd.

18.—ARGILLACEOUS IRONSTONE, termed "*curl*," or "*cone-in-cone*," *from Coal Measures.—Priorslee, near Wellington, Salop.*

19.—ARGILLACEOUS IRONSTONE ("*curl*," or "*cone-in-cone*"), *from Coal Measures.—Coalbrook Dale, Salop.*

20.—ARGILLACEOUS IRONSTONE ("*curl*," or "*cone-in-cone*"), *from Coal Measures*, containing about 10 per cent. of iron, and used for making Roman cement.—From the Pennystone beds, *Ironbridge, Coalbrook Dale, Salop.*

21, 22, 23, 24, 25, and 31.—SPHERICAL CONCRETIONS of Magnesian Limestone, from the *Permian rocks.*

26, 27, 28, and 29.—CONCRETIONS of Magnesian Limestone, from the *Permian rocks.*

30.—CONCRETIONS of Magnesian Limestone, decomposed; *Permian.*

31.—See 21.*

32.—CONCRETIONS, filled with quartz, embedded in trappean ash. (See Nos. 107, 108, and 109, Case 4.) Lower Silurian rocks.—*Digoed, near Yspytty Evan, Merionethshire.*

33.—CONCRETIONS *in trappean ash;* as above.—*Tyn-y-bryn, north-west of Bala, Merionethshire.*

34.—NODULE of granular crystalline quartz, locally termed "boulders," and occasionally occurring in the *Coal seam* at *Alderwasley, Derbyshire.*

35 and 36.—GEODE, locally termed "*potato-stone*," lined with crystals of quartz, and containing acicular crystals of

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* Nos, 22 to 31, from *Durham*. Presented by W. King.

rutile (oxide of Titanium). *From junction of New Red Marl and Carboniferous Limestone.—Chepstow, Monmouthshire.* ("Memoirs of Geological Survey," vol. i., part 1,p. 246.) UPPER GALLERY. Wall-case 44.

37.—GEODE, composed of quartz and imperfect red jasper, *from the junction of New Red Marl and Carboniferous Limestone.—Chepstow, Monmouthshire.*

38.—Two specimens of NODULAR CONCRETIONS, *from Upper Green-sand.—One mile north of Brixton, Isle of Wight.* Map 10.

39.—NODULAR CONCRETIONS, *from Lower Green-sand.—Blackgang Chine, Isle of Wight.*

40.—NODULAR CONCRETIONS of sand, from the *Hastings sand.—East Cliff, Hastings, Sussex.* Presented by Dr. Percy, F.R.S.

41.—NODULE of argillaceous limestone, formed round the skeleton of a fish (*Mallotus*). From *Drift.—Upper Canada.* Presented by Sir W. E. Logan.

42.—Portion of a SEPTARIA, showing the internal concretionary structure, the cracks, and the filling of these by infiltration, with crystalline carbonate of lime.

42a.—SEPTARIAN NODULE, from the *Great Northern Railway.**

42b.—SEPTARIAN NODULE.*

43.—CONCRETIONARY NODULE of *clay ironstone*, from pipe-clay beds of the *Lower Bagshot* series.—*Branksea Island, near Poole.* Presented by Colonel Waugh. Map 16.

44.—Part of a SEPTARIAN NODULE of *clay ironstone, from Coal Measures.—Bedworth, Warwickshire.*

45.—NODULE of *argillaceous limestone*, in *Wenlock Shale*, showing the mode of occurrence of such nodules. Part of the surrounding Wenlock shale is attached.—*Seven miles north-east of Cerrig-y-druidion, Merionethshire.*

46.—NODULE of *argillaceous limestone*, from *Wenlock Shale.* (See horizontal section No. 5).—*Near Llanfaredd, Builth, Breconshire.*

47.—NODULE of ARGILLACEOUS LIMESTONE, from *Wenlock Shale.—Pen-y-bont, Radnorshire.*

* From *London clay.* Presented by Mr. Matthew Wright.

UPPER GALLERY. Wall-case 44.

48.—SEPTARIA, cement stone occurring in occasional bands in *Upper Lias clay.—Crickley Hill, near Cheltenham.* (See Memoir on Map 44 by Ed. Hull, F.G.S., p. 24.)

49.—SEPTARIAN NODULE, with iron pyrites filling cracks in the interior. Found in the walls of a copper-lode, 30 fathoms from the surface (see also No. 170, **Case 43.**) —*North Huel Friendship, near Tavistock, Devon.*

50.—Sections of COPROLITIC NODULES, polished to show the internal structure.—*Frith of Forth, Scotland.*

51.—CONCRÈTIONS OF IRON *from Plastic Clay beds.—Near Wimborne Minster, Dorset.*

52.—CONCRETIONARY NODULES of iron pyrites in felspathic rock. — *Gwernyfid rocks, Wye, near Builth, Breconshire.*

53.—NODULAR CONCRETIONS of iron pyrites from the *Chalk.—Compton Bay, Isle of Wight.* Map 10.

54.—CONCRETION of iron pyrites from the *Chalk.—Compton Bay, Isle of Wight.*

55.—FRAGMENTS OF SHELLS AND PHOSPHATIC NODULES, from upper beds of Gault. *East Wear Bay, Folkestone, Kent.*

56.—SANDY CLAY, containing phosphatic nodules; from upper beds of *Gault. East Wear Bay, Folkestone, Kent.*

57.—CANNON BALL, forming a centre surrounded by concreted ferruginous matter.

58.—Portions of an *iron grating* left on the *Bell Rock,* and exposed to the alternate action of the air and sea by the rise and fall of the tides from 1811 to 1853.

The two last-mentioned specimens (Nos. 55 and 56) are placed here to illustrate the rapid destruction of iron by the process of oxidation or rusting, leaving a spongy mass of graphite or impure carbon, No. 56.

59.—AN OLD HORSE-SHOE, found in the river *Trent, at Nottingham,* exhibiting the agglutinating power of iron while undergoing oxidation.

Wall-case 45.

UPPER GALLERY.

Wall-case 45.

Arranged and described by A. C. RAMSAY.

SPECIMENS TO ILLUSTRATE THE PHENOMENA OF ALTERATION AND METAMORPHISM OF ROCKS.

The subject of the alteration of rocks is so large, that, to enter upon it fully, would require greater space for specimens than the Museum affords. In **Cases 45 and 46,** some of the more striking phenomena are illustrated. 1st, *the simple effect of intense heat on various kinds of rocks;* 2nd, the more remarkable process of *metamorphism, by which new mineral combinations are developed,* as in *mica slate and all the rocks of the gneissic family.* In **Case 46,** the phenomena of *cleavage* are illustrated, which in some respects bears peculiar relations to *metamorphism.*

Nos. 1 to 75 have special reference to the first, or more direct action of heat, as shown by the *effects of fire, and the intrusion of common igneous rocks among various kinds of strata.* The list begins with alterations of the most obvious character, such as those produced on coal by the intrusion of trap dikes, on common slate by the burning of a house and on the sandstone floor of an iron furnace. From these the student is readily led to those alterations which from common *sandstones* produced *quartz rocks* by their association with melted matters, commonly called intrusive (many of which certainly are so), which, when cooled and consolidated, became *basalts, greenstones, syenites, and quartz porphyries.* Of the most intense alterations of this kind, Nos. 1 to 46 give striking examples, showing a passage by alteration from slate and grit into actual syenitic greenstone, for some of the grits and conglomerates have been on the very verge of fusion, if not undoubtedly fused, and though pebbles and some of the original granular character may (especially on the ground) be detected by the practised eye, the whole having become more or less crystalline, the rocks

UPPER GALLERY. — Wall-case 45.

(32 to 35) have more of an igneous than of an aqueous character.

The specimens which illustrate the *gneissic* series are necessarily imperfect, the geological survey not yet having been much engaged on metamorphic districts. The forces which altered these rocks are of a different kind from those produced by the mere contact of lavas, dykes, and other small masses of igneous with stratified rocks above adverted to. It will be observed that *mica-schist, gneiss,* &c., possess a *laminar arrangement,* in which various minerals are arranged, generally in wavy lines, more or less distinct. Typical *gneiss* consists of irregular alternating layers of *quartz, felspar,* and *mica,* these being also the constituents that form granite. Perfect and gradual passages may often be traced from common *shales, slates,* and *grits,* into true *mica-schist* and *gneiss,* and *gneiss* sometimes passes imperceptibly into *granite.* The evidence may therefore be considered as perfect, that gneissic rocks have been *metamorphosed,* or that they have assumed different mineral characters from what they possessed as original sediments. This has been understood and believed by most geologists since the days of Hutton,* but the causes that produce these changes are yet but imperfectly explained.

For long the laminar structure of gneissic rocks was a mystery. They frequently lie in wavy layers (No. 130), or else in small and rapid contortions (Nos. 126, 129, and 135). Many of the elder geologists contented themselves with the easy assumption that all the earth was originally formed of granite, the result of its first cooling from a state of igneous fusion; and that gneiss, being formed of the same constituents, was made from the sedimentary waste of that rock deposited in a primeval boiling sea, which accounted for its wavy and wrinkled structure. The metamorphic theory destroyed this ready hypothesis, and it is now universally

* "Theory of the Earth."

known that gneissic rocks and granites are of every geological age. UPPER GALLERY

The subject involves much discussion, but it may be briefly stated that enough is known to make it certain, that, when under metamorphic action, distinct minerals are developed that do not appear in the unmetamorphosed strata, it is not that new substances are created there, but as a rule simply that the rocks themselves originally contained certain constituents, which chemically re-arranged themselves according to their affinities, probably in all cases under the influence of slow and long applied heat and moisture. The only cases in which new substances could appear, would be by the occasional infusion of gases and moisture, containing new ingredients, and it is probable that the development of minerals in metamorphic rocks has sometimes been in this manner modified. It would be easy to find unaltered shale, slate, a piece of gneiss, and a piece of granite, of which the ultimate chemical constituents would agree as nearly as they would in two distinct pieces of gneiss. Gneiss is composed of free silica or quartz; felspar, which is essentially a silicate, of alumina, soda, potash, or lime; and of mica, the chief ingredients of which are silica, alumina, potash, and peroxide of iron. In any shale or slaty rock most of these ingredients occur, and in ordinary metamorphic rocks they are merely re-arranged and modified under peculiar chemical and physical influences. Serpentines are also metamorphic rocks (p. 218). Wall-case 44.

I must now refer to the phenomena of cleavage. (See **Case 46**, Nos. 26 to 47, and p. 126.) Mr. Charles Darwin, in his celebrated work on the "Geology of South America," showed that in part of the Andes *the strike and dip of the cleavage and foliation lines coincide*, and he, therefore, conceives that "*foliation may be the extreme result of the process of which cleavage is the first effect;*" or, in other words, that the process of re-arrangement of particles in the rocks began with cleavage, and ended in their entire crystalline re-arrangement in the same lines,

UPPER GALLERY. — Wall-case 45.

thus producing *foliation*. Mr. D. Sharpe observed that the foliated layers of the rocks of Scotland lie in large sweeping synclinal or anticlinal lines, which, he said, bear no relation to the original lines of stratification. This absence of relation is more than doubtful, if universally applied; and when examined in more detail, I believe it will be found that on a large scale foliation is often apt to coincide with the planes of stratification, and that the great anticlinal and synclinal lines actually represent the curvatures of the strata; or, in other words, that the foliated masses of the Highlands lie in great planes of stratification, like those of the Laurentine hills in Canada. Professor Henslow observed, in 1821, that the foliation of the rocks of Anglesea bears a general relation to the planes of bedding. This I can verify from personal knowledge. The same is the case in the Island of Arran. The rocks of North Wales are in general highly cleaved, (**Case 46,**) but it has been shown that the metamorphism of the Anglesea rocks preceded the disturbances that produced cleavage. There is, therefore, no necessary connection between cleavage and foliation; and it may now perhaps be considered at all events as a near approach to the truth, "that if rocks be uncleaved when metamorphism occurs, the foliation planes will be apt to coincide with those of bedding; but, if intense cleavage has preceded, then we may expect that the planes of foliation will lie in the planes of cleavage." (Ramsay, "Geological Quarterly Journal," 1853, vol. ix, p. 172.)

The relation of proximity of granite and gneissic rocks, and of their frequent passage into each other, is obvious, and, from their constant occurrence together, it may be considered that they are intimately related, the gneissic structure being in some manner connected with the fusion of associated granite. All geological evidence tends to prove that, as a rule, large masses of granite cooled and consolidated slowly and deep beneath the surface. One result of this would be, that neighbouring rocks, sometimes fused, or on the verge of fusion, would, on cooling, pass gradually into granite; and there is indeed no certainty that, in many cases, granite is not the actual result of the fusion and cooling of the very same strata that produced the gneiss, and this conclusion is often favoured by the circumstance, that the presence of granite, syenite, and their allies, often seems due, not to the intrusion of a mass violently thrust through opposing strata, but rather to the eating away by fusion of a portion of the strata themselves. Under any circumstance, both the granite and the adjoining rocks would for a long time remain in a heated condition; and, further off, if, under the influence of heat and moisture, chemical action in the softened rock occurred, then its constituents more or less re-arranged themselves according to their affinities, in layers, wherever circumstances would allow, most likely showing a tendency to form in the direction of pre-existing lines of stratification when these formed the principal planes, or of cleavage when in homogeneous masses it had been so strongly superinduced that the rock would split in the cleavage planes in preference to those of stratification.

Specimens illustrative of the effects of heat and intruded melted rocks on slates, coals, sandstones, and conglomerates.

1.—THICK COAL altered by the intrusion of "*white trap rock.*"

When this kind of alteration takes place, the coal is locally said to be "*blacked,*" when, by its proximity to an igneous rock, it has become so altered as to lose all its brightness, and nearly, if not quite, all its inflammability. It is not exactly coke, but is dull and earthy, and, on exposure to the atmosphere, is very friable. ("Geology of the South Staffordshire Coal Field," Jukes, p. 242.)

2.—HEATHEN COAL of *Dudley*, rendered anthracitic by contact with white igneous rock; and seamed by threads of calcareous spar.

Upper Gallery. — Wall-case 45.

3.—Coal altered by *porphyritic greenstone*, and enclosing nodules of magneso-calcite; near Bilston furnaces, *South Staffordshire.*

The igneous rocks mentioned above are probably of the age of the Carboniferous rocks. ("Geology of the South Staffordshire Coal Field," by J. B. Jukes, p. 248.) In the South Staffordshire coal field sheets of greenstone, known in the district as "green rock," have been injected among the Coal Measure beds. From these proceed dykes and veins of "white rock," known to be "truly an igneous rock by the way in which it cuts through the coal and other matters, often producing more or less alteration in them at the place of contact." (Ibid. p. 241.)

4.—Exhibiting the action of fire on slate.—From the premises of Messrs. Scott Russell and Co., burnt 10th September 1853. Presented by Superintendent Braidwood.

At the top is a piece of the slate scarcely altered, and showing its original thickness. Lower down the same fragment swells out and becomes spongy. This is still more obvious below. The slates have become spongy by the escape of watery vapour, air, or gases, and, being softened by heat, they have been bent. Similar rocks, altered by contact with igneous rocks under great pressure, *do not assume this vesicular structure.* For instances of strata altered by contact with melted rocks, see Nos. 9, 12, &c.

5.—Gornal sandstone, *unaltered. Coal Measures.*

6.—Gornal sandstone, *altered,* artificially.

This specimen formed part of the hearth of an old iron furnace. From long contact with the melted iron the stone was softened and partly vitrified, and cinders are embedded in it. The vitrification was assisted by the presence of numerous felspathic grains, which are mingled with the quartz grains of the unaltered Gornal sandstone.

7.—Quartz rock and greenstone *in contact. Old Radnor Hill.* The quartz rock, in its unaltered state, was probably the equivalent of the fossiliferous sandstone of Presteign;—(*Upper Llandovery or May Hill Sandstone.*)

8.—ALTERED SANDSTONE, *crystalline and calcareous.—Old Radnor Hill.* UPPER GALLERY. Wall-case 45.

This hill occurs on a line of great disturbance and fracture, into which syenitic and greenstone rocks have been protruded. On Old Radnor Hill the rock is so highly altered and so intimately intermixed with igneous matter, that in mapping it is impossible to separate the altered rock from the melted matter with which it is mixed. This specimen gives a good example of the intense alteration of the sandstone, and intimate intermixture of igneous matter with it.

9.—QUARTZ ROCK (*altered Llandeilo flags*).—*Moel-y-Golfa, Breidden Hills, Shropshire.*

10.—GREENSTONE of Breidden Hills, with which the altered rock No. 9 *is in contact.*

11.—GRANULAR QUARTZ ROCK, commonly called Lickey quartz, with grains of felspar.—From *Caradoc sandstone* of *Rubury Hill, Worcestershire.*

There is no igneous rock intruded into this mass, which, notwithstanding, has an altered character, and it is not unlikely that igneous rocks exist at no great depth beneath the surface.

12. —QUARTZ ROCK, *Lower Coal Measure sandstone, Salisbury Crags, Edinburgh.* It is in contact with and overlaid by intrusive greenstone, No. 13.

13.—GREENSTONE, composed of augite and felspar.—*Salisbury Crags, overlying and altering No.* 12.

14.—QUARTZ ROCK, *altered Caradoc sandstone,* 4 miles south-west of *Wellington, Shropshire.*

This rock is part of a considerable tract of quartz rock, altered *by intrusions of igneous rocks,* such as those of the Wrekin, Wrockwardine, and of Charlton Hill. No. 14 is from the immediate neighbourhood of No. 15.

15.—GREENSTONE. Hornblende with a little felspar.

16.—ALTERED CARADOC CONGLOMERATE, as above, from the *Wrekin, Shropshire.* The centre of the Wrekin is greenstone, and the adjoining rocks are often so intimately intermixed with it, and have been so much altered, that in

UPPER GALLERY. — Wall-case 45.

some cases the base has been fused, and there is great difficulty in separating the trap from the stratified rock.

17.—CARADOC CONGLOMERATE (*altered*), *Hope Bowdler Hill, Church Stretton, Shropshire*, containing small pebbles of slate, quartz rock, felspar, &c., bedded in a crystalline felspathic base, the result of *alteration by* No. 18.

18.—AMYGDALOIDAL GREENSTONE, with nests of epidote. *Hope Bowdler Hill.* (*In contact with* 17.) This greenstone is one of several bosses of rocks intruded into the Caradoc sandstone, viz., at *Ragleth Hill, Hope Bowdler Hill, Caer Caradoc*, and *the Lawley*. Hope Bowdler Hill seems to consist, at all events in a great measure, of Caradoc sandstone melted and re-consolidated. The Caradoc sandstone lies on it at a low angle, and lying, as it does, at the base of the sandstone of that particular locality, there is no space between it and the Wenlock shale for the thickness of lower Caradoc beds that ought to intervene.

19.—WENLOCK SHALE, *partially porcelainized.* In contact with greenstone: *Upper Heblands, Bishops Castle, Shropshire.*

20.—ALTERED CAMBRIAN CONGLOMERATE, *Skerries*, off the north-west shore of Anglesea. Many of the rocks of Anglesea are highly metamorphic; they are pierced by bosses and numerous veins of granite. (See p. 118.) The Skerry conglomerate is traversed by dykes, and contains pebbles of altered slate, quartz rock, granite, &c., and resembles rock No. 190 and 191, **Case 4.**

Specimens illustrative of the igneous and altered Cambrian rocks of Charnwood Forest, Leicestershire. Maps 63, N.E. and N.W.

21.—GREENISH GREY SLATY *rock, Greenhill, Charnwood Forest.* Very little altered.

22.—GREENISH PURPLE COARSE SLATY ROCK, *Markfield.* More hardened than 21.

23.—GREENISH GREY *ditto, Old John Hill. Porcelainized* by heat.

24.—GREY FINE AND GRITTY ROCK, *Tin Meadow. More altered* than 23. UPPER GALLERY. Wall-case 45.

25.—GREENISH GREY AND PURPLE banded argillaceous and fine gritty ROCK, *Billa Barrow Hill.* Very much *indurated and porcelainized.*

26.—GREEN AND GREY ALTERED FINE GRIT, *Old John Hill. Slightly porphyritic,* with a few small imperfect crystals of felspar and hornblende.

27.—ALTERED GRIT, *more felspathic : Green Hill.*

28.—ALTERED FINE GRIT : *Old John Hill. Stratification* in this specimen *nearly obliterated.* Rock chiefly composed of imperfectly crystallized felspar, with indications of a few imperfect crystals of hornblende.

The rock here appears to have been so far softened by heat that its constituents were partly at liberty to re-arrange themselves according to their chemical affinities.

29.—GRIT, *similar to* 28 : *Old John Hill.* Alteration a little further advanced, contains more hornblende.

30.—ALTERED ROCK : *High Cadman. Very much altered by heat.* Composed chiefly of felspathic matter, sometimes *imperfectly crystalline,* containing numerous specks of hornblende.

31.—ALTERED GRIT : *Green Hill.* Composed of a felspathic base, *containing crystals of felspar and a little* hornblende, small slaty fragments and grains of quartz. *Extremely altered.*

32.—ALTERED CONGLOMERATE : *Markfield.* Composed of *pebbles* of hardened purple and grey slate, &c., bedded *in a gritty crystalline* (*porphyritic*) *base,* containing crystals of felspar and grains of quartz.

The base of this is in part like 31, but the slaty fragments have resisted even partial fusion.

33.—GREENISH PURPLE ALTERED CONGLOMERATE : *Broad Hill.* Pebbles smaller than in the above and more indistinct. *Porphyritic character more marked.* Contains crystals of glassy felspar in a felspathic base and grains of quartz.

UPPER GALLERY. — Wall-case 45.

34.—ALTERED CONGLOMERATE : *Pedlar's Tor.*

This is a case of the most *extreme alteration.* In a dark base are large crystals of red felspar and granular crystalline quartz, set in a hornblendic (?) and felspathic base. In a hand specimen this looks like an igneous rock. On the ground the bedding is still traceable.

35.—ALTERED ROCK, *porphyritic and slightly talcose: Birchwood Plantation.* Felspathic base, with crystals of felspar. Hornblende rudely aggregated in nests. *Extremely altered.*

36.—ALTERED ROCK, *porphyritic.* Blue felspathic base, with crystals of felspar, and granular fragments and imperfect crystals of quartz. *Traces of pebbles in the mass very indistinct.*

From 30 to 36 the specimens are from rocks, all exceedingly altered, in which the amount of alteration gradually increases to a point beyond which further alteration could not take place without entire obliteration of any trace of original structure, such as seems to have taken place in No. 35.

37.—IMPERFECT GREENSTONE, consisting of imperfectly crystallised hornblende and felspar, with a few grains of quartz.—*Bardon Hill.*

38.—PURPLISH GREEN IGNEOUS ROCK, composed of red felspar and hornblende. This rock passes imperceptibly into syenite and granite. *Quorndon House, near Barrow-on-Soar.*

39.—SYENITIC ROCK : *Broad Hill.* Greenish rock composed of pink felspar, with a little hornblende and granular quartz.

40.—GREENSTONE : *Bowdon Hill.* Hornblende and pink felspar.

41.—GREENSTONE : *Coptoak Farm.* Similar to 40, but more felspathic.

42.—GREENSTONE : *Bowdon Hill.* Felspar and hornblende, the felspar predominating.

43.—GREENSTONE, *syenitic. Grooby.* Pink felspar and hornblende, well crystallized, with a few small granules of quartz. UPPER GALLERY. Wall-case 45.

44.—GREENSTONE, *syenitic. Markfield.* Pink felspar and hornblende well crystallized. Felspar rather predominates.

45.—GREENSTONE, *syenitic : Grooby.* Pink felspar and hornblende as above.

46.—SYENITE : *Cliff Hill.* Felspar, quartz, and hornblende.

The igneous rocks from 37 to 46 lie amid the Cambrian rocks of Charnwood Forest and the neighbourhood. Some of them are, however, entirely surrounded by unaltered New Red Marl, which conceals the Cambrian rocks among which the syenites, &c. lie. The Cambrian rocks in their neighbourhood are so much altered, that, becoming porphyritic, it is often impossible to trace a boundary line between them and undoubted igneous rock. Between Grace Dieu Wood and Charley Wood there is a tract of country from which Nos. 21, 23, 24 to 31, and 33, 34 and 36, were derived. Some part of it seems, in ordinary terms, to be undoubtedly igneous, as in the case of No. 39. Other parts show every degree of gradation, from a common unaltered slaty character, to rocks that seem in hand specimens to be igneous, but on a large scale on the ground, show traces of stratification and other signs proving them to be of sedimentary origin, only so much altered that they have been partly, and in some cases entirely, fused, *and thus pass into true igneous rocks* of deep-seated kinds. All the metamorphism of the Charnwood Forest rocks is of this nature, nor do they ever assume the character of gneissic rocks. It may be that the heating and cooling of the rocks took place with too much rapidity to allow of that slow chemical separation and reunion of constituents, according to their affinities, in layers (often of stratification or cleavage), which constitutes gneiss, and the igneous rocks themselves seem in great part formed of strata actually fused.

UPPER GALLERY. — Wall-case 45. 47.—ALTERED ROCK, SERPENTINOUS, with carbonate of lime and flaky layers of hornblende. Pierced by red crystalline felspathic veins.—*Charnwood Forest.*

Altered Cambrian grits and conglomerates, and quartz porphyry, Llanberis, Caernarvonshire. Map No. 78, *S.E., and horizontal section No.* 4, *in* **Wall-case 3,** *opposite.*

48.—CAMBRIAN GRIT : *Llyn Peris, Caernarvonshire, composed of grains of quartz and felspar.*

Though excessively hardened, there is no igneous rock in its immediate neighbourhood. The quantity of alkali in the felspar renders such a rock peculiarly liable to alteration by heat, and great alterations are found in similar rocks in the neighbourhood, when in contact with quartz-porphyry.

49.—CAMBRIAN GRIT, similar to the above, but *more felspathic.* Felspar grains retain their crystalline form.

50.—ALTERED CAMBRIAN CONGLOMERATE from the north-east shore of *Llyn Padarn, near Llanberis.*

This specimen is derived from a mass *very near the quartz porphyry No.* 52. It has originally been a conglomerate, with a very felspathic gritty matrix similar to No. 49. The base has been probably partially fused, the outlines of some of the pebbles rendered indistinct, and the whole hardened.

51.—CAMBRIAN GRIT, *altered.* Same locality, passing imperceptibly into No. 52.

52.—QUARTZ PORPHYRY : *Llyn Padarn, Llanberis.* Felspathic base, with crystals of felspar and granular crystals of transparent quartz. Part of a great mass of quartz porphyry, *which cuts through the Cambrian rocks* of Caernarvonshire in their line of strike between Llyniau Nant-y-llef and Bethesda Nant-Francon. For a more complete account see Nos. 185 to 192, **Case 4,** p. 215.

UPPER GALLERY.

Wall-case 45.

Series of altered carboniferous rocks with associated greenstones, Warwickshire Coalfield. Map 63, *S.W.*

53.—COAL MEASURE SHALE, *partially hardened* by heat (baked). Two miles south of *Atherstone, Warwickshire.* The unaltered shale of the neighbourhood resembles No. 146, **Case 41.**

54.—QUARTZ ROCK: *Hartshill, Atherstone, Warwickshire. Altered millstone grit, pierced by trap dykes,* similar to Nos. 56 and 57.

55.—QUARTZ ROCK with manganese, near *Nuneaton.* Pierced by 56 and 57, &c.

56.—GREENSTONE: *Hartshill, Atherstone.* Composed of felspar and hornblende, the former predominating. Part of a dyke *intruded between the beds of quartz rock.*

57.—GREENSTONE, *very hornblendic.* From the eastern line of greenstone, *south of Chilvers Coton,* near *Nuneaton. Intruded among Coal Measures, shales, and sandstones, Nos.* 58, 60, *and* 61.

58.—SANDSTONE, with iron pyrites. *Altered by the proximity of Nos.* 57 *and* 59, between which it lies.

59.—GREENSTONE, from the western mass south of *Chilvers Coton, Nuneaton; intruded* like 57.

60.—ALTERED COAL MEASURE SHALE: *Marston Jabet,* near *Bedworth, Warwickshire.*

61.—GREENSTONE, *below No.* 62: *Marston Jabet,* near *Bedworth.*

62.—ALTERED COAL MEASURE SHALE from another bed in the same quarry as No. 60, about 10 feet thick, *lying between two masses of intrusive greenstone.*

63.—GREENSTONE, *above No.* 62.

These greenstones are the cause of the alteration of 60 and 62, in which the ordinary soft shaly character has disappeared, and the beds have been simply much hardened by the action of heat. In the quarry there are two masses of greenstone, apparently interbedded like old lava beds; but the shales both above and below them being equally altered,

UPPER GALLERY. — Wall-case 45.

they are known to have been intruded *between the beds*. This is the case with the greenstones generally of the Warwickshire coalfield, which run in long lines between Atherstone and Marston Jabet, the longest being about six miles in length.

64.—ALTERED OLD RED MARL: *Brockhill*, 3 miles southwest of Abberley. Worcestershire, Map 55 N.E. *Pierced by a greenstone dyke.*

Altered Silurian rocks of Wales and Shropshire.

65.—WENLOCK SHALE, *altered: Upper Heblands*, near *Bishops Castle, Shropshire.* This rock is very calcareous, *and is pierced and much broken by a small dyke of greenstone.*

66.—SHALE, LINGULA FLAGS, *with Lingulæ, much hardened by heat: Moel-Hafod-Owen*, 6 miles north of *Dolgelly, Merionethshire*. Map 75 S.E.

The shales of this hill are *pierced by numerous small bosses of greenstone*, and are probably underlaid by a large mass of these rocks, of which *Rhobell-fawr*, &c. form part.

67.—SILURIAN SHALE OR SLATE, *altered and hardened*, near the twelfth milestone, *Pass of Llanberis.* From a thin band of altered slate in the felspathic trap of Snowdon. Both have been *pierced by greenstone*, which here, and near Pen-y-gwryd, alters the slate with which it is in contact into honestone. Map 75 N.E. Merionethshire.

68.—LLANDEILO FLAGS, *altered fossiliferous pyritous black slate. In immediate proximity to greenstone.* (Nos. 158, 163, and 164, **Case 4**).—*Banks of the Wye, Radnorshire*, near *Builth.*

68a.—LLANDEILO FLAGS: *Carneddau, Radnorshire*, near *Builth. Porcelainized by contact with greenstone.*

69.—DITTO, altered as above.

70.—LLANDEILO FLAGS, *Pant-Prinog, Montgomeryshire*, 3 miles south-east of Chirbury. *Altered by neighbouring greenstone*. See 151, **Case 4**. Map 60 S.E. UPPER GALLERY. — Wall-case 45.

71.—LLANDEILO FLAGS, near *Llanwnda, Fishguard, Pembrokeshire*. Banded fine siliceous rock, *partly porcelainised* by great *intrusive masses of greenstone. Pen Caer, Strumble Head*. Map 40.

72.—DITTO, more weathered.

73.—DITTO, still *more porcelainised.*

74.—DITTO, *more completely metamorphosed*, the silica having begun to crystallize in nests.

75.—SLATY SILURIAN ROCK, *porcelainised.* In the neighbourhood of *granites*, &c., near *Mona Copper Mine, Anglesea*. Map 78 N.W.

76.—ALTERED SLATE, a species of imperfect gritty snakestone; Llandeilo flags, *altered by the Corndon greenstone, Montgomeryshire.* Map 60 S.E. See No. 153, **Case 4**, page 206.

77.—ALTERED SLATE, snakestone: *Porth Treuddyn Quarries*, near *Tremadoc, Merionethshire.* Map 75 N.E. *Altered by intrusive greenstone.*

78.—TALCOSE SCHIST, with iron pyrites, traversed by gold lodes: *Tyn-y-Symdde*, 6 miles north of *Dolgelli, Merionethshire*, Map 75 S.E. Probably *metamorphic, the alteration being connected with the intrusion of masses of greenstone.*

79.—TALCOSE SCHIST, as above (with quartz vein). Diffwys Slate Quarry, *Ffestiniog, Merionethshire*, 75 N.E. This rock passes into felspathic ash.

80.—TALCOSE FELSPATHIC ROCK, between *Tan-y-Grisiau* and *Cwm Orthin*, 3 miles N.N.W. of *Ffestiniog, Merionethshire.*

This rock passes in places into felspathic ash. (See 23 to 26, **Case 4**, and section **No. 4**, near *Moelwyn*, 24 & 25.) It, however, also passes into snakestone, *for the rocks of the district are partly metamorphic, the metamorphism being connected with the presence of the Ffestiniog syenite, No.* 117, **Case 4.**

UPPER GALLERY. — Wall-case 45.

81.—TALCOSE ROCK; *altered Cambrian grit: Llyn Padarn Llanberis, Caernarvonshire*, 78 S.E. *Close to a great mass of quartz porphyry*, 124 and 186, **Case 4.** (See also section No. 4, Nos. 186 to 191, **Case 4.**)

82.—TALCOSE SCHIST: *Porth Lisky, St. David's, Pembrokeshire.* Map 4. Cambrian rock, *near a mass of syenite.* (See No. 167, **Case 4.**)

83.—FELSPATHIC CONGLOMERATE; decomposing, altered Cambrian rock: *Porth Lisky* as above.

84.—PORPHYRITIC CONGLOMERATE, undecomposed. From same locality as 82 and 83.

This rock has undergone the same kind of alteration as Nos. 16, 20, 32, and 49. The alteration of the rocks at Porth Lisky is similar to that illustrated by specimens 185 to 192, **Case 4.** (See also section 4, **Case 4,** Nos. 186 to 191.)

Passage of shales, slates, grits, &c., into talc schist, mica schist, gneiss, &c.

85.—ARGILLACEOUS SLATE (Devonian) containing corals. *St. Austell, Cornwall.* Sheet 31.

86.—ARGILLACEOUS SLATE, killas, (Devonian.) *Great Anchor, Perranzabuloe, Cornwall.* Map 29.

87.—ARGILLACEOUS SLATE, killas, (Devonian.) *Wheal Friendship, Tavistock, Devon.* Map 25. Bedding faintly traversed by cleavage nearly at right angles.

88.—ARGILLACEOUS SLATE, very *fine grained and talcose:* (Devonian.) *Watergate Bay, St. Columb Minor.* Map 30.

89.—BANDED MICACEOUS ARGILLACEOUS SHALE (Devonian.) Altered slate near Granite. *Penvivian Hill, near Bodmin, Cornwall.* Map 30.

90.—ARGILLACEOUS SLATE, *with mica and talc* (Devonian.) A finely arenaceous, micaceous, and schistose rock, forming the lower part of the calcareo-trappean series at *Bossiney, Cornwall.* Map 30.

91. — CLAY SLATE; white killas, *talcose,* (Devonian.) *Watergate Bay, St. Columb Minor.* Map 30. *Very talcose.*

UPPER GALLERY. — Wall-case 45.

92.—CLAY SLATE ; white killas (Devonian). *Huel Friendly Mine, St. Agnes, Cornwall.* Map 31. *Very talcose.*

93.—FINE GRAINED ARGILLO-CALCAREOUS SLATE, *with mica,* (Devonian). *Trebarwick Strand, near Tintagell, Cornwall.* Map 30.

94.—ARENACEOUS SCHIST, *with much mica,* (Devonian.) Banded and *slightly gneissic* in structure. *Breague, Cornwall.* Map 33. From junction of slate with granite.

95.—CLAY SLATE ; killas, *micaceous, with banded gritty lines,* (Devonian.) *Huel Vor Tin Mine, near Breague.* Map 33. One mile east of a boss of granite, and *partly metamorphic, being sparingly studded with imperfect crystals of staurolite, and* very small *crystals of schorl.*

96.—DITTO ; *Consols Mine, Redruth, Cornwall.* Map 31. *Near* Elvan Dyke and *a boss of granite.*

97.—MICACEOUS GNEISSIC ROCK : *Bolt Head, Salcombe, Devonshire.* Map 24. *Metamorphic rock,* composed of fine contorted *foliated* micaceous and quartzose interlaminated layers.

98.—MICACEOUS GNEISSIC ROCK : *Lizard Head, Cornwall.* Map 32. *Fine interlaminated layers of mica, talc, and felspathic matter.*

99.—ALTERED SANDY ROCK, *contorted and banded,* some of the bands somewhat felspathic : *St. Agnes Beacon, Cornwall.* Map 31. *Near a boss of granite.*

100.—SCHORLACEOUS CONTORTED ROCK, *metamorphic, and banded like gneiss in interlaminations of quartz and schorl.* From contact of slate and granite : *Castle on Dinas, Cornwall.* Map 33.

101.—TALCOSE AND MICACEOUS ALTERED SLATE, (Devonian.) *Camelford, Cornwall.* Map 30. Near junction of slate and granite. *Metamorphic rock, containing* imperfect *crystals of staurolite.*

102.—MICACEOUS SCHIST, (*altered* Devonian,) *Camelford, Cornwall.* Map 30. Near junction of slate and granite. *Metamorphic rock, containing* many small *crystals of staurolite.*

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——
Wall-case 45.

103.—MICACEOUS ROCK, *with crystals of staurolite. Metamorphic rock. Cornwall.* Locality unknown.

104.—MICACEOUS ARGILLACEOUS ROCK, *with* large *crystals of staurolite. Metamorphic rock* associated with chloritic micaceous and gneissic rocks. *Salcombe, Devonshire.* Map 24.

105.—HORNBLENDE SLATE, weathered: *Porthousestock, St. Keverne, Cornwall.* Map 31. From a set of *metamorphic rocks* that form great part of the county north of Lizard Head.

106.—HORNBLENDE SLATE, *metamorphic rock. Beast Head, Lizard, Cornwall.* Map 32.

107.—ALTERED ROCK, *slightly foliated, traversed by granite vein. St. Clement's Island, Mousehole, Cornwall.* Map 33.

The metamorphism of all the rocks of Cornwall and Devon seems intimately connected with large masses of granite, which lie among the palæozoic strata.

Metamorphic and igneous rocks from the Malvern District.

108.—GNEISSIC ROCK *composed of silvery mica, felspar, and a little chlorite.* A little north of the *Wych, Malvern, Worcestershire.* Map 55 S.E.

109.—GNEISSIC ROCK, similar to the above. Same locality.

110.—SYENITE; hornblende, felspar, and blue translucent quartz or siderite. A little north of the *Wych,* near *Malvern.* Map 55 S.E. This rock is associated with gneissic rocks, as above.

111.—QUARTZ AND FELSPAR, *coated with serpentinous matter.*

112.—DITTO. This specimen, when a fresh fracture of the interior is obtained, shows a kind of rude gneissic foliation. 111 and 112 are from rocks close to the eastern boundary fault of the Malvern hills. The ground seems much broken, and the fragments are coated with soft serpentinous matter, marked by "*slickenside*" polish. (See "Memoirs of the Geological Survey of Great Britain," Phillips, vol. ii., p. 44.)

113.—GNEISS, *very crystalline, exhibiting strong foliations* of felspar and quartz, interlaminated with mica. *North Hill, Great Malvern, Worcestershire.* Map 55 S.E.

114.—SYENITE, *very felspathic.* Felspar, quartz, and hornblende. *North Hill,* as above.

This rock shows a feebly foliated structure, and may possibly be the last stage before the gneiss passes fairly into granite, of which the Malvern Hills is partly composed. In these hills such passages are so frequent, that it is often impossible to draw any absolute line between the ordinary metamorphic rocks and crystalline syenite and granite.

Metamorphic rocks of Caernarvonshire.

115.—GNEISSIC ROCK, *foliated. Aberdaron, Caernarvonshire.* Map 76 S. Composed of foliations of *quartz, silvery mica,* and *calcspar.*

116.—DITTO, without mica, and with a little hornblende. Same locality.

117.—RED RIBBONED JASPAR. *Porth Dinlleyn Head, Caernarvonshire.* "The rock of Porth Dinlleyn Point is a kind of coarse serpentine, with nests of red jaspar apparently intruded amid the green quartzose and chloritic schists, which are much contorted on a small scale." (Sir Henry de la Beche.) See similar jasper from Aberdaron, Caernarvonshire, on top shelf. 115 to 117 are from a series of metamorphic schistose and gneissic rock, which stretch along the south side of Caernarvon Bay from Porth Nevin to Bardsey Island. They are associated with serpentine and crystalline metamorphic limestone, containing much silica.

Metamorphic rocks of Anglesea.

UPPER GALLERY.

Wall-case 45.

118.—MICACEOUS SLATE, *foliated.* Metamorphic Cambrian rock.—*Bodwrog, Anglesea.* Map 78 N.W. Composed of foliated *layers of quartz with mica slate.* Close to a mass of granite 10 miles in length, which extends from near Llanerchymedd to the sea near Llanfaelog.

119.—CHLORITIC SLATE. *Tregaian, Anglesea.* Map 78 N.W. *Chloritic matter,* with lenticular layers of *quartz.* Foliated metamorphic Cambrian rock.

120.—SCHISTOSE MICACEOUS ROCK, *foliated and contorted. Llaneilian, near Amlwch, Anglesea.* Map 78 N.W. Metamorphic Cambrian. Part of a series of foliated rocks that form great part of the north of Anglesea. Probably most of them are of Cambrian date; but the whole are so metamorphosed that some of the strata may be altered Lower Silurian.

121.—GNEISS. One mile N.E. of *Ceirchiog, Anglesea.* Map 78 N.W. *Metamorphic* Lower Silurian rock, composed of well *foliated* layers of *black mica and quartz.* From a small tract of Silurian slaty rock, lying in the midst of the granite.

122.—SERPENTINE. *Tregela, near Llanfechell, Anglesea.* Map 78 N.W. Mottled reddish rock. From a mass *included* in *metamorphic foliated Cambrian rocks* in the north of Anglesea.

123.—GREEN SERPENTINE, *Ceryg-moelion, Holyhead Island, Anglesea.* Map 78 N.W. From one of three masses of serpentine on the shores of the straits south of the Holyhead road. *Contained in metamorphic Cambrian rocks.*

The serpentinous rocks of Anglesea and Caernarvonshire are metamorphic, and not eruptive. They have a layered (and almost a foliated) look, and are full of numerous small twisted contortions, like the ordinary foliated rocks of the country. The major part of Anglesea consists of foliated rocks, which are probably the equivalents of the purple and green Cambrian slates and grits of Nant Francon and Llanberis.

124.—QUARTZO-FELSPATHIC ROCK, exhibiting obscure traces of lamination: probably an altered rock. *Rosevanion, St. Columb Major, Cornwall.* Furnishes a good road material. UPPER GALLERY. Wall-case 45

Metamorphic rocks from Scotland.

125.—GREENISH GREY SILICEOUS GRIT, *altered:* near *Shandon, Gare-Loch, Dumbartonshire.*

126.—GREY SILICEOUS GRIT, *metamorphic: Shandon, Gare-Loch, Dumbartonshire.*

This rock is much altered, and contains crystals of felspar and numerous semi-crystalline granules of white and pale blue quartz. The district is penetrated by felspathic dykes: No. 127.

127.—FELSPATHIC TRAP, with small crystals of black mica. Like some of the Cornish Elvans: **(Case No. 6.)** *Pierces No.* 126.

128.—GNEISSIC MICA-SCHIST, near *Arrochar, Loch Lomond, Argyleshire.* Rather finely *foliated laminæ of quartz and mica,* with a few quartz grains.

129.—GNEISSIC MICA-SCHIST: *Arrochar, near Loch Long Head, Argyleshire.* More *strongly foliated contorted* granular quartz and mica.

130.—DITTO, *wavy.*

131.—GNEISS, *passing into granite: Strontian, Argyleshire.* Felspar, quartz, and black mica faintly laminated, very crystalline.

132.—JUNCTION OF GRANITE AND MICA SLATE: *Strontian, Argyleshire.* Mica slate formed of black mica very metamorphic. Granite consists of quartz, felspar, and black mica. From the Great Exhibition of 1851.

133.—JUNCTION OF GNEISS AND GRANITE *with an interposed granitic vein* composed of felspar with a little quartz and mica. "At Strontian, in the western part of Argyleshire, a boss of granite is seen penetrating the gneiss which abounds in the district, and a little further to the west a large quantity of porphyry and trap occurs, covered in two or three places near Ardnamurchan by deposits of the oolitic

UPPER GALLERY. — Wall-case 45.

and liassic period."—Official Catalogue of the Great Exhibition, 1851, p. 127, vol. i. 132 and 133 may possibly not represent an actual junction, but be altogether gneissic.

From 125 to 133 the specimens belong to the great series of metamorphic, gneissic, and mica-chist rocks that form the Grampian Mountains.

134.—METAMORPHIC LIMESTONE: *Tiree marble, Island of Tiree, Western Isles.* Pink marble, with crystals of augite. In a mass about 100 feet in diameter associated with gneiss. M'Culloch's "Western Isles," vol. i., p. 49. See also polished cube, No. 28, in the Lower Hall, table-case of marbles.

Metamorphic rocks from Ireland.

135.—TALCOSE SLATE, with *contorted laminæ, slightly foliated with quartz. Croghan Kinshela Mountain, County Wicklow*, Ireland. Near contact with granitic porphyry.

136.—CLAY SLATE, *nearly unaltered. Dunlaven, County Wicklow*, Ireland.

137.—CLAY SLATE, *altered, near junction of slate and granite:* near *Hollywood, County Wicklow.* Seems somewhat micaceous with small imperfect crystals perhaps of staurolite.

138.—MICACEOUS SLATE, *near granite: Hollywood Glen, County Wicklow. Possesses a wavy structure*, probably induced by the development of imperfect crystals of *staurolite.*

139.—MICACEOUS SLATE, *near junction of slate and granite*, near *Hollywood, County Wicklow. Slightly foliated* and gneissic in structure. Contains crystals of *staurolite.*

140.—MICA SLATE, *from* the immediate *neighbourhood of granite, County Wicklow.* From a foliated rock containing much mica, *with small garnets and large crystals of staurolite.*

141.—SLATY ROCK, *highly metamorphosed at junction of slate and granite:* near *Hollywood, County Wicklow.* The slate has here been changed into a crystalline mass of felspar, quartz, and mica, and has *probably almost undergone absolute fusion.*

The specimens No. 136 to 141 partly show the gradual alteration or metamorphism of the Lower Silurian rocks of Wicklow as they approach the granite. Upper Gallery. — Wall-case 46.

These rocks at a distance from the granite are ordinary argillaceous slate. As they approach the granite, they become micaceous, with highly contorted, foliated, gneissic laminations, and near the junction there become developed in the rock crystals of andalusite, staurolite, and garnet, the effect of metamorphic action on some of the materials which constitute the slaty rock in its unaltered state.

Wall-case 46.

Arranged and described by A. C. Ramsay.

Specimens illustrative of Joints and Cleavage.

The jointed rocks in this case are not arranged according to any special system. There is so little known about joints, that any systematic arrangement according to definite laws is not yet practicable, although in certain districts systems of joints run in sets of parallel lines, which often cross each other. Their mode of occurrence and the geometrical forms they give to the rocks they traverse, are obvious in almost every quarry in rocks of all descriptions, and many of these forms are well represented on a small scale in the specimens. The practical use of joints is well understood by quarrymen, both in quarries where the wedge and lever are only used, and in those which are blasted. In both cases they guide the quarrymen as to the method by which masses of rocks may be obtained of the largest size, and with the least expenditure of labour. By using the joints as a guide, large blocks of sandstone, limestone, slate, granite, &c. are detached entire; and in cases where great blasting operations are conducted (as at Holyhead), by running judicious levels and galleries, in accordance with systems of joints, as much as 120,000 tons of quartz rock have been dislodged

UPPER GALLERY. — Wall-case 46.

and broken up by one explosion of 18,000 lbs. of powder. In slate quarries care is taken to blast so that the largest jointed masses are dislodged. These are again broken up along the lines of joints and cleavage by the use of the wedge and mallet, and the rock is thus prepared for the manufacture of slates.

JOINTS AND CLEAVAGE.

1.—IRONSTONE, *White Stone*, (Coal-measures.) *Russel's Hall, Dudley, South Staffordshire.* Map 62 S.W. The upper and under surfaces are *beds.* The sides are *joints*, and the ends *ordinary fractures.*

2.—IRONSTONE, *Big vein*, (Coal-measures.) *Sirhowy Iron-works, Monmouthshire.* Map 36. Contains fossils, *Anthracosia.* The surfaces of black shale are the top and bottom of the bed. The other sides are *joints.*

3.—IRONSTONE, (*Carboniferous rocks.*) *Netherton, Northumberland.* The *front* (marked) and *back* are split faces of the *beds*, the other sides are *joints* forming an irregular rhomb.

4.—CHERT, in *Carboniferous limestone: Matlock Bath, Derbyshire.* Map 82 S.W. The *numbered* (red) and *opposite sides* are *the faces of the bed.* The *top* is an accidental *fracture*, and the other three sides are *joints.*

5.—FELSPATHIC ROCK: near *Topleundy Hole*, Cave on coast near *St. Minver, Cornwall.* Map 30. *Four joints.* forming a rhomb.

6.—LIAS LIMESTONE: coast, 2 miles south of *Cardiff, South Wales.* Map 36. The *numbered* and the *opposite sides* are *planes of bedding.* The *other sides are joints* slightly wavy, forming a rhomb.

7.—SANDY SLATE (Devonian,) near *Topleundy Hole*, Cave on coast, *St. Minver, Cornwall.* The *upper and under sides are surfaces* of a bed. The *sides* are *joints.* Imperfect rhomb. Map 30.

8.—MICACEOUS SANDSTONE, (Denbighshire sandstone.) *Bwlch-y-fridd near Newtown, Montgomeryshire.* The *num-*

bered and *back surfaces* are *planes of bedding*, with scales of mica lying in them. The *other sides* are *joints* forming an irregular rhomb. Those at the sides are slightly curved.

UPPER GALLERY. — Wall-case 46.

9.—SLATE-PENCIL ROCK: *Shap, Cumberland.* (Lower Silurian.) Comes out of the quarries *in long jointed fragments*, which are afterwards cut into pencils.

Similar rocks occur in a great sea cliff of Lower Silurian rocks, Ramsey Island, opposite St. David's, Pembrokeshire. Map 40.

10.—TILESTONE, (uppermost beds of Upper Silurian.) *Longhope, Gloucestershire.* Map 43 S.E. The *numbered and opposite sides are planes of bedding*, the *ends* are *accidental fractures*, and *the other two sides* are *joints*, lying approximately in the same plane.

11.—FELSPATHIC SLATY ROCK altered. Lower Silurian, (Caradoc or Bala beds.) *Pass of Llanberis, Caernarvonshire.* Map 78 S.E. *The numbered and the opposite sides* are probably *planes of cleavage.* The *upper surface is a joint.* The under surface is partly a joint, ending in an irregular fracture. The direction of the opposite joints nearly coincides.

12.—PURPLE SLATE: *Cambrian rock. Llyn-Padarn, Llanberis, Caernarvonshire.* Map 78 S.E. The direction of the *bedding* is shown in the *green and purple lines* at the end marked ×. The *front and back surfaces* are *planes of cleavage.* The *upper* and *under surfaces are joints nearly parallel*, the regularity and continuity of which have apparently been interrupted by an alteration in the fineness of the grain of the rock at the end marked ×.

13.—PURPLE SLATE AND GRIT, as above. The *bedding* is shown by the *junction of slate and grit.* The *front* and *back* surfaces *are planes of cleavage*, the regularity and smoothness of the cleavage being interrupted where it enters the grit. The *bottom* plane *is an irregular fracture* nearly coincident with the bedding. *The other four lines are joints.*

UPPER GALLERY. — Wall-case 46.

14.—BANDED SLATE AND FINE GRITTY BANDS, as above. In this specimen *cleavage and bedding* probably *coincide.* The numbered side and its opposite are in these planes. The *other four planes are joints* producing a rhomb.

15 to 24.—PURPLE CAMBRIAN COARSE SLATES, as above. In all these the original muddy purple substance of the rock is so homogeneous that *the bedding in small specimens is usually indistinguishable.* The beds from which they come are exceedingly contorted, and the cleavage nearly vertical, so that cleavage and bedding only accidentally coincide. On the specimens *the figures are marked on the cleavage planes.* All the *other planes are joints,* giving various forms to the specimens.

In No. 15, the end joints if prolonged would form a triangle with the others. No. 16 is a rhomb; and nearly in the same planes as those on the right and left there are four joints in the body of the specimen marked by faint white lines filled with silica. 17 to 20 are also rhombs. The joints of 21 and 22 form scalene triangles, the latter imperfect from the interference of a small joint at the base. The joints of 23 originally formed a triangle, but one of the angles has been knocked off at another joint so as to form a four-sided figure. In 24, the planes of the joints if produced would meet at different points, and the same is the case in other specimens.

25.—CONGLOMERATE. (*Cambrian.*) St. David's, Pembrokeshire. Map 40. *Joints cutting through the pebbles.*

CLEAVAGE.

The remainder of the specimens in this case more especially illustrate some of the relations of cleavage, joints, and stratification. Cleavage may be defined to be a re-arrangement of the particles and larger substances that enter into the composition of certain rocks so as to produce a fissile structure or a tendency to split in given directions, sometimes accidentally coincident or nearly coincident with planes of stratification, but generally transverse to these at every possible angle. The origin of cleavage has been referred to "electric action" and to "polar" and "crystalline forces." These words, however, convey no definite impression to the mind when viewed in connexion with cleavage, and from the writings of Professor Phillips and Mr. Daniel Sharpe, but especially by the memoirs and experiments of Mr. Sorby and Professor Tyndal it now begins to be generally understood that *cleavage is the result of pressure induced by those disturbances that have frequently produced contortion of cleaved strata.* It is not the case, however, that all contorted strata are cleaved, although perhaps all cleaved rocks are contorted. Probably all the portions of strata intensely cleaved have been buried deep beneath superincumbent masses when those forces operated that produced cleavage, whereas uncleaved contorted rocks were generally so near the surface that they were able more easily to fracture and yield, so that their component particles were not forced by pressure to re-adjust themselves so as to produce cleavage. It is not necessary here to discuss the causes of these disturbances. It is sufficient to recognize the fact that *highly contorted rocks have been subject to pressure* (generally *lateral*) *and that " this force by changing the dimensions of the rock has so re-arranged the laminar particles as to cause a very great majority to lie in a plane perpendicular to it."*—(Sorby.) If these rocks contain water in minute interspaces, these cavities would necessarily be elongated in the same direction.—(Tyndal.) *The whole rocky substance has, therefore, often been compressed into narrower space and stretched in directions* at right angles *to the direction of the pressure,* so that *large bodies,* in many cases, *become visibly compressed, often flattened, and much distorted,* the distortion, for instance, sometimes elongating, and at other times broadening fossils far beyond their ordinary dimensions, and giving unsymmetrical shapes to forms that in their natural state are symmetrical. *The true slaty structure in rocks is always the result of cleavage,*

UPPER GALLERY. — Wall-case 46.

UPPER GALLERY. — Wall-case 46. examples may be seen in innumerable places in Wales, and in none more strikingly than in the well-known slate quarries of Penrhyn, Llanberis, and Ffestiniog.

26.—FINE SANDY ROCK, *calcareous and felspathic.* Top of *Snowdon, Caernarvonshire.* Map 75 N.E. Part of the *Caradoc or Bala beds imperfectly cleaved.* Cleavage crosses the bedding at an angle of about 11°, and *the fossils* (chiefly *Orthis flabellulum*) *are much distorted.*

27.—GRIT: *Caradoc rock or Bala beds. Pass of Llanberis Caernarvonshire.* Map 78 S.E. *Imperfectly cleaved.* The beds dip at angles of about 60° to 70°, and the *cleavage and bedding in this specimen form an angle of about* 10° (cleavage, 70° to 80°.)

28.—SLATE (*Upper Devonian*) fossiliferous, *cleavage coincident with bedding* or nearly *so. Spirifer disjunctus flattened and much distorted.*

29.—CLAY SLATE: *Upper Devonian* (carboniferous ?), *Petherwyn, Devonshire. Cleavage and bedding form an angle of about* 10°. *Strophalosia caperata flattened and distorted by cleavage.*

30.—CLAY SLATE, (*Upper Devonian.*) *Tintagel, Cornwall. Cleavage and bedding coincident. Spirifer disjunctus flattened and very much distorted.* Map 30.

31.—SLATY FELSPATHIC ROCK, *concretionary:* west side of *Carnedd Dafydd, Nant Francon.* Map 78 S.E. Cleavage and bedding form an angle of 19°. Bedding and cleavage both dip easterly at high angles. Shows a concretionary structure. *The concretions are flattened in the planes of cleavage.*

32.—SLATY CONGLOMERATE: *Cambrian.* North-east side of *Llyn Padarn, Llanberis, Caernarvonshire.* Map 78 S.E.

This remarkable specimen is derived from one of the Cambrian conglomerates below the slate of the great slate quarries of Llanberis. The whole country is intensely cleaved. The rocks at this point dip south-easterly at an angle of about 55° to 60°, and the cleavage in the same general direction about 80°. In specimens and even on *the ground the lines of bedding are exceedingly obscure, except to the most practised eye. They are coloured red in the specimen and show many minute contortions. The rock in its unaltered state was a slaty conglomerate, and by compression the pebbles have all been elongated in the direction of the planes of cleavage.* UPPER GALLERY. — Wall-case 46.

33.—FINE GRITTY AND SLATY BEDS. Purple and grey *Cambrian* rocks: near *Bangor, Caernarvonshire.* Map 78 S.E. The layers of *different colours show* lines of *stratification.* The *numbered and opposite surfaces* are planes of *coarse cleavage.*

34.—SLATE AND GRIT, purple and green. From the lower part of the *Cambrian* strata: *Llyn Padarn, Llanberis, Caernarvonshire.* Map 78 S.E.

This specimen shows lines of stratification, joints, and cleavage. On the left is a gritty band marked ×, with internal lines of wavy stratification, some of them marked in red. *It adjoins rather coarse slaty beds,* the different strata of which are marked by natural purple and green lines. *The plane marked A is a joint* with a wavy surface. The green beds are more gritty than the purple beds, and the waving plane of the joint slightly rises with the gritty bands, and becomes depressed in the spaces occupied by the finer slaty beds. This alteration of the direction of the joint is especially marked where it joins the coarser gritty band marked ×. *The surface marked B is a cleavage plane.* In the larger and more slaty portion of the rock the lines of cleavage are slightly wavy, in consequence of the different results produced by pressure on beds of various degrees of hardness and coarseness. Where the slate joins the coarser grit × the sudden change in the direction of the cleavage is especially remarkable. In the slaty portion the cleavage and bedding form an average angle of about 46°. In the coarser grit × the angle is about 16°.

35.—Small specimen from the same locality, showing the same kind of phenomena.

UPPER GALLERY. — Wall-case 46.

36.—COARSE GREEN AND PURPLE SLATE (*Cambrian*) *Llyn Padarn, Llanberis.* Shows lines of *stratification* marked green and ash grey, *traversed by coarse cleavage.*

37.—SANDY SLATE, *Lisburne Mines, Cardiganshire.* Map 57. The *red lines* show the direction of the *planes of bedding. The surfaces at the sides are planes of cleavage, and the bottom, top, and front planes are joints.*

38.—ROOFING SLATE: *Ffestiniog Slate Quarries, Caernarvonshire.* Map 75. The *red lines* show the direction of the *beds. The surfaces* of the slate (like all true slates) show *the planes of cleavage.*

39.—ANCIENT ROOFING SLATE, from *Carew Church, Pembrokeshire.*

Probably derived from the coarse *Cambrian* slaty beds south of St. David's. The green and purple lines show lines of bedding, and *the cleavage* which cuts them at an angle of about 30°, *is very coarse.*

40.—SLATE, *Westmoreland.* Exhibiting well marked *ribboned lines of wavy stratification* in various shades of ashy grey.

These beds are *traversed by seven small faults,* in which it is remarkable that the downthrow is on the opposite side from that which is usually the case in nature on a large scale. In most cases the downthrow is in the direction of the slope or "hade" of the dislocation. The polished front surface is a cleavage-plane.

41.—BANDED SLATY ROCK, showing lines of *bedding, joints, and cleavage.* The *front* and *back* are *cleavage planes.* The *upper* and *under surfaces* are *planes of bedding,* and other parallel beds, in narrow bands, lie between. *The sides are joints.*

42.—BLACK SLATE, *Dolwyddelan, Caernarvonshire.* Map 75 N.E. *Caradoc and Bala beds,* showing *joints and cleavage.* The *top, bottom, and sides are joints, and the planes in which it is split are cleavage planes.*

This specimen forms part of a small block bounded by joints, and suitable for splitting for the manufacture of small slates. It has been split into three pieces, but would have admitted of finer division. The value of slaty rocks much depends on the number of joints and their arrangement. The fewer the joints the larger are the slabs and slates that may be manufactured from the blocks extracted from the quarries. UPPER GALLERY. Wall-case 46.

43 to 48.—SLATES OF VARIOUS KINDS. 43 and 48 are from the slate quarries of *Penrhyn and Llanberis*, in the Cambrian rocks of *Caernarvonshire;* 44 is from the Llandeilo flag slate quarries of *Barry Island, North Pembrokeshire;* 45 is from the *Ffestiniog* slate quarries; 46 from the slate quarries in the Caradoc or Bala rocks of *Dolwyddelan;* and 47 from the Devonian rocks of *Tintagell, Cornwall.*

49 to 53.—Various specimens of the DARKER CLEAVED PURPLE ROCKS of the *Cambrian* slaty region of *Llanberis.*

IGNEOUS ROCKS.

The contents of **Wall-cases 1 and 2** *and the table cases in recesses* 4 *and* 6, *are intended* to illustrate the igneous productions of tertiary and existing volcanos, and for comparison with similar products of more ancient date, collections of which are placed in **Wall-cases 4 to 7.** Wall-case 1 to 6.

Case 1 contains specimens of *the volcanic rocks of Aden,* 1 to 19; and of *the volcanic rocks and products of eruption of Hawaii,* numbered from 20 to 42 *a.* 43 to 121 are from *the (tertiary?) volcanic rocks of the mining district of Schemnitz,* in Hungary, from *Croatia,* and *Transylvania.*

The *lavas of the extinct tertiary (miocene?) volcanos of the Rhine* are represented by specimens 122 to 130 from the Eifel. 131 to 137 are from *the volcanic mountains of*

UPPER GALLERY. — Wall-cases 1 to 6.

St. Vincent, and 140 to 147 from *the nearly dormant volcano of the Island of Teneriffe.*

Case 2 is principally occupied by a series of specimens of lava and other *volcanic products from the Island of Ascension*, presented by Captain Ord and Mr. Charles Darwin, the latter of whom also contributed the series of *volcanic rocks from the Galapagos Archipelago*. These, with a few from the Cape de Verde Islands, Mexico, and Guyaquil, with others from White Island, New Zealand, and the Crimea, complete the collection.

Table-case A in recess No. 4 contains a collection of *lavas, ashes, simple minerals, and other products of eruption from Monte Somma and Vesuvius*, accompanied by a model, coloured geologically by M. Dufrénoy, to illustrate the localities and the nature of the accumulations, from which the specimens were taken.

These have been arranged chronologically, commencing with those erupted in the year 79, and terminating with those due to the eruption of 1855.

The remaining portion of the contents of this case consists of *simple minerals* occurring *in the lavas of Monte Somma and Vesuvius*.

In the **Table-case B in recess No. 6** will be found a collection of volcanic productions, simple minerals, and associated rocks from *the extinct volcanos of the Roman States*, together with a series of volcanic rocks and *products of eruption from Etna*. These specimens have been arranged, not chronologically, but mineralogically. A relief-model of the latter mountain, geologically coloured by M. Elie de Beaumont, is placed here to illustrate the collection of specimens from that locality.—H. W. Bristow.

UPPER GALLERY

Wall-case 1.

Wall-case 1.

Arranged and described by H. W. BRISTOW, F.G.S.

Shelf 2 *contains specimens of the volcanic rocks of the extinct volcano of Aden, numbered* 1 *to* 19.

Nos. 1 to 7 show the general character of the lava of that peninsula, and the passage from compact basalt into porous cellular lava; they also serve to exemplify the manner in which such lavas, after cooling, become coated and partly filled with Calc spar, Gypsum, Quartz, &c. 8 and 9 are varieties of the less fusible felspathic lava, Trachyte. 10 to 13 are the more intensely fused lavas, which by a more or less rapid rate of cooling pass from a real transparent volcanic Glass into Obsidian (12), and the more opaque substance Pitchstone.

The lighter lava or Pumice (14 to 16) has not flowed from the interior of the crater like an ordinary lava-stream, but has been ejected during the periodical explosions which take place simultaneously with the more quiet action of the volcano, when ashes, cinders, and fragments and masses of rock, and melted lava are hurled into the air, frequently to enormous heights, by the influence of pent-up steam and gases. Of the substances so ejected certain portions fall back again into the interior, or accumulating around its mouth serve to increase the height of the already existing crater, while other portions, being scattered far and wide, cover the surface of the country for many miles.

Pumice, one of the ejected substances in question, becoming cooled in its passage through the air, retains the porous, spongy structure it originally possessed, owing to the presence of the vapours or gases with which it was permeated.

"The ashes, cinders, and molten rock ejected, may often be considered as little else than modifications of the same substance," at one time in a state of fusion, at another driven off by vapours and gases in portions of different

UPPER GALLERY. — Wall-case 1.

volume, and so impregnated by them as to be rendered cellular. These, from the intensity and suddenness of explosions and other causes, often become divided and triturated into fine grains and powder, so light as to be borne great distances by the winds, and sometimes darkening the air. **Wall-case 2**, Nos. 65–67, and 133.) Under favourable circumstances, these becoming consolidated (**Case 2**, Nos. 64, 68 to 81) form Tufa, Peperino, &c., or falling into or being subsequently carried into the sea, enclose and fossilize shelly and other organic bodies **Case 2**, No. 66).—H. W. B.

Shelf 3, *containing specimens numbered from* 20 *to* 42*a*, *are from the modern volcanos of the Sandwich Islands.*

Nos. 21 to 32, and No. 34, furnish good examples of the cellular structure assumed by lava that has undergone perfect fusion, and has been permeated by gases or aqueous vapours. They also denote the manner in which streams of lava so penetrated by gases have had their vesicles or air-chambers elongated and drawn out during the process of flowing. So long as the lava retains sufficient heat for it to flow, and to allow its particles to move freely amongst themselves, the air-vesicles undergo a change of form, and are elongated or drawn out in the direction traversed by the moving mass. Examples of this result of the flow of a heated viscous mass are shown in **Wall-case 1**, Nos. 29, 30–36, and **Wall-case 2**, Nos. 7 and 8.

The outer portions of the stream, which have been most rapidly cooled, assume a scoriaceous or slag-like aspect, instances of which are afforded by 21 to 25, 27, 31, and 35.

A variety of this scoriaceous lava, 35, is partially coated with small crystals of specular iron, which have been deposited on its surface by decomposition of sublimed chloride of iron.

Other specimens, 36 to 41, *contain included crystals of augite and olivine.* The presence of these minerals is, probably, generally due to the separation of the substances of which they are composed, from the including mass during the process of slow cooling, and, possibly, is sometimes the result of the remelting of older lavas, into the composition of which they entered; in such cases, if less fusible than the more modern lava, they would be caught up by it and retained, undergoing but little change themselves.

Nos. 42 and 42*a* are specimens of *native sulphur*, a mineral frequently found sublimed in and around the craters of volcanos. The sulphur from the Sandwich Islands is chiefly remarkable for containing an admixture of *Selenium*, to which it owes the red colour that is more especially to be observed on 42*a*.

Shelf 4 and part of shelf 5 (43 to 93) contain specimens of the trachytes and associated volcanic rocks of the mining district of Schemnitz, in Hungary.—Of these, 44 to 47 are basaltic rocks. 48 to 55 are varieties of pearlstone, some of which (52 and 53) contain sphærulites. The formation of the latter is owing to the separation of certain parts from the general mass while passing from the melted into the solid or stony state, and is dependent upon the condition under which the cooling of the mass took place. 57 to 68 are varieties of greenstone; the first contains spherical concretions, and 66 to 68, which contain included crystals of other minerals, are known by the name of *Porphyries.*

Trachytes are represented by specimens 70 and 85. Of these eruptive rocks, there are no true representatives in the British Islands. The trachytes are, for the most part, less fusible than the ordinary augitic lava, into the composition of which silicate of lime enters largely, being formed chiefly of *orthoclase*, or *potash felspar.* These rocks derive their name from τραχὺς (rough), from the rough, uneven character of their fractured surface.

94 to 101 are from the Bannat and Croatia, principally to illustrate the rocks, associated with the ores, which are worked at Drey König Mine. Of these, 94 to 96 are *volcanic*, 97 and 98 are the rocks associated with and containing the ores.

102 to 121, from various localities chiefly in *Transylvania*, are illustrative of the *greenstones* (102 to 104), the *porphyries* (105 to 107), and the *trachytes* of that country.

On the lower shelf is a series of specimens (122 to 130) from the *extinct tertiary volcanos of the Eifel.*

131 to 137 are principally varieties of highly crystalline *porphyritic greenstones from the volcanic mountain of St. Vincent.*

138 is a curious variety of concretionary *greenstone from Corsica.*

Specimens of *lava, pumice, sulphur,* &c. (140 to 147) *from the Peak of Teneriffe,* are placed on the upper shelf, together with (139) a specimen of *stalactitic lava from Etna,* which is too large to accompany the collection to which it more properly belongs.—H. W. Bristow.

Wall-case 1.

Volcanic Rocks and Minerals from Aden.

Presented by the Honourable the Court of Directors of the East India Company.

The Peninsula of Aden, near the entrance to the Red Sea, is a promontory about $5\frac{1}{2}$ miles long by $2\frac{1}{4}$ to $3\frac{1}{2}$ miles broad. It is formed of a mass of dark, sombre-looking rocks, which attain an elevation of 1776 feet above the sea level. The town of Aden is built on the eastern side of the promontory, in a plain, surrounded by an amphitheatre of rocky mountains. This plain, which is nearly flat, and but slightly raised above the level of the sea, is three miles in circumference, and apparently the crater of an extinct volcano.—H. W. B.

1.—Basalt traversing the volcanic rocks *in dykes.*

2.—Grey massive basalt, very slightly vesicular, and with a few small crystals of *glassy felspar.*

3.—GREY VESICULAR LAVA, with the cells elongated in the direction in which the stream flowed. These became afterwards filled with a white mineral, which has subsequently, in most cases, decomposed, leaving the cells empty. UPPER GALLERY. — Wall-case 1.

4.—Reddish-brown VESICULAR LAVA, with a few crystals of *glassy felspar*. The vesicles have been filled with *calc spar*, which has decomposed in some cases, and the cells become lined with a thin coating of chalcedony and rock crystal.

5.—HIGHLY VESICULAR LAVA, with *calc spar*, and minute prismatic crystals of *quartz*.

6.—Reddish-brown VESICULAR LAVA, with a thin layer of *mammillated chalcedony*, upon which are small lenticular crystals of *sulphate of lime*.

7.—*Calc spar*, in imperfect crystals investing VESICULAR LAVA.

8.—GREY TRACHYTE passing into BASALT, and containing a few small specks of *glassy felspar*.

9.—Grey, slightly vesicular TRACHYTIC PORPHYRY, with a few small crystals of *glassy felspar*.

10.—PITCHSTONE, occurring in beds 18 inches thick, between lava streams.

11.—PITCHSTONE, with crystals of *augite*.

12.—GREENISH OBSIDIAN, with streaks and laminations of other colours. A familiar example of similar appearances may be noticed in the slags of iron furnaces, which are artificial lavas, composed of silicates of alumina and lime, with a little iron and other minor constituents. A.C.R.

13.—Light-green transparent OBSIDIAN, or VOLCANIC GLASS upon *lava*.

14.—PUMICE, with crystals of *gypsum* (*sulphate of lime*).

15.—PUMICE, with a fibrous silky structure.

16.—Vesicular PUMICE, coated with *sulphate of lime*.

17.—VOLCANIC ROCK traversing *pumice* in dykes.

18.—VOLCANIC BRECCIA passing into *basalt*.

19.—VOLCANIC BRECCIA with much *sulphur*, and a thin band of reddish-brown compact felspathic trap.

UPPER GALLERY.
Wall-case 1.

Specimens of volcanic rocks and minerals from Kilauea and Hawaii, in the Sandwich Islands, collected and presented by Count Strzelecki, C.B.

The three principal volcanic mountains in Hawaii are Mauna Loa, Mauna Kea, and Hualalai. Of these, the former is supposed to be 13,760 feet above the level of the sea, and the second 13,950. There are great numbers of minor craters scattered over their slopes, one of which, Kilauea (Lua Pélé), is situated on the flank of Mauna Loa, at a distance of nearly 20 miles from the summit; its height has been variously estimated by different observers—by Count Strzelecki at 4,101 feet. This last crater is described by Ellis, in his "Tour in Hawaii," as situated on a lofty elevated plain, bounded by precipices, and apparently sunk from 200 to 400 feet below its original level. "The surface of this plain was uneven, and strewed over with loose stones and volcanic rock, and in the centre was the great crater. Immediately before us yawned an immense gulf in the form of a crescent, about two miles in length, from N.E. to S.W., nearly a mile in width, and apparently 800 feet deep. The bottom was covered with lava, and the S.W. and northern parts of it were one vast flood of burning matter in a state of terrific ebullition, rolling to and fro its fiery surges and flaming billows. Fifty-one conical islands, of varied form and size, containing so many craters, rose either round the edge, or from the surface of the burning lake; 22 constantly emitted columns of grey smoke, or pyramids of brilliant flame; and several of these at the same time vomited from their ignited mouths streams of lava, which rolled in blazing torrents down their black indented sides into the boiling mass below. The side of the gulf before us, though composed of different strata of ancient lava, were perpendicular for about 400 feet, and rose from a wide horizontal ledge of solid black lava, of irregular breadth; but, extending completely round, beneath this ledge, the sides sloped gradually towards the burning lake, which was, as nearly as we could judge, 300 or 400 feet lower. It was evident that the large crater had been recently filled with liquid lava up to this black ledge." Upper Gallery. — Wall-case 1

The lavas of Hawaii appear to have been in a very fluid state, as will be seen on reference to specimen No. 20, &c.

They have also been poured out in enormous quantities; a stream of basaltic lava, two miles broad and 25 miles long, proceeded from an opening in Mauna Loa, 13,000 feet above the level of the sea. (Lyell's "Principles of Geology," p. 383.)

In June 1840 a stream of melted lava continued to flow for three weeks into the sea, in coming in contact with which it became shivered like melted glass poured into water, and heated it so much as to cause the shores to be strewed with dead fish for a distance of 20 miles. The area covered by the lava was calculated at about 15 square miles, with an average depth of 12 feet, and the lower pit of Kilauea, which was calculated to have held 15,400,000,000 cubic feet of molten matter, was emptied by the discharge of the lava through the fissures by which it was discharged at intervals.

The ejection of cinders and ashes appears to be comparatively of rare occurrence; they are, however, occasionally thrown out. Thus, in 1789, a large volume of cinders and sand is said to have been thrown to a great height, and to have fallen in a destructive shower for many miles around. Some men, belonging to an army then on its march, are described by Dana to have been killed by this shower of cinders, &c., while others perished from an emanation of heated vapour or gas.

The modern lava and volcanic glass of Kilauea are composed of silica, protoxide of iron, alumina, soda, potash, and lime, but these vary much in their relative proportions. They contain a large amount of oxide of iron. Professor Silliman, jun., asserts that soda is present to the exclusion of potash, but this is not borne out by Mr. Peabody's ana-

UPPER GALLERY. — Wall-case 1.

lysis of Pélé's Hair (No. 20), in which both potash and soda are given.—H. W. Bristow.

20.—CAPILLARY LAVA, or VOLCANIC GLASS.—Lava when in a very fluid state blown by the wind into hair-like fibres. It is called by the natives *Pélé's Hair*, after the principal goddess of the volcano. In chemical composition it closely resembles *augite*. The following analysis is given by Dana: —Silica, 39·74; alumina, 10·55; protoxide of iron, 22·29; lime, 2·74; magnesia, 2·40; soda, 21·62.

Kilauea, Island of Hawaii.

Dana describes the mode of formation of this substance from actual observation, as follows:—"It covered thickly the surface to leeward, and lay like mown grass, its threads being parallel and pointing away from the pool (of melted lava). On watching the operation a moment, it was apparent that it proceeded from the jets of liquid lava thrown up by the process of boiling. The currents of air blowing across these jets bore off small points and drew out a glassy fibre, such as is produced in the common mode of working glass. The delicate fibre floated on till the heavier end brought it down, and then the wind carried over the lighter capillary extremity. Each fibre was usually ballasted with the small knob which was borne off from the lava-jet by the winds."—("Geology of the United States' Exploring Expedition," 1828–42, p. 179.)

21.—VESICULAR SCORIACEOUS LAVA, showing on one side a smooth surface on which the melted lava flowed.

22.—VERY VESICULAR SCORIACEOUS LAVA.

23.—VESICULAR SCORIACEOUS LAVA from the outer portion of the stream.—*Kilauea.*

24.—Finely vesicular reddish brown SCORIACEOUS LAVA.

25 & 26.—VERY VESICULAR LAVA.

27.—SCORIACEOUS LAVA, or *volcanic slag; very vesicular.*

28.—CELLULAR BASALTIC LAVA, *Hawaii.*

29.—VESICULAR VOLCANIC SLAG, or *cellular obsidian.*

30.—VERY VESICULAR LAVA, or *cellular obsidian.* UPPER GALLERY. — Wall-case 1.

31.—SCORIACEOUS LAVA, enclosing fragments of *vesicular lava.*

32.—Finely vesicular BASALTIC LAVA.

33.—Compact BASALTIC LAVA.

34.—VESICULAR LAVA, coated with *gypsum* (*sulphate of lime*), which also fills some of the cells.

35.—SCORIACEOUS LAVA, with crystals of *specular iron.*

36.—VESICULAR LAVA, or *cellular obsidian,* containing *olivine.*

37.—BASALTIC LAVA, with crystals of *augite,* some of which are in a decomposed state.

37a.—COMPACT BASALTIC LAVA, with crystals of *augite,* mostly in a decomposing state, and minute brilliant octohedral crystals of *specular iron.*

38. AUGITIC LAVA, scoriaceous, and containing crystals of *olivine.*

39.—VESICULAR LAVA, with *olivine.*

40.—Scoriaceous AUGITIC LAVA, with crystals of *augite.*

41.—SCORIACEOUS LAVA, with large crystals of *augite* and *olivine.*

42.—NATIVE SULPHUR, *Kilauea.*

42a.—NATIVE SULPHUR, sublimed round the twigs of plants.—*Kilauea.*

The presence of Selenium in the sulphur from Kilauea has been determined by the analysis of Professor Silliman.

Specimens of the igneous rocks of the mining districts of Schemnitz, Hungary, the Bannat, Croatia, and Transylvania.

Presented by Warington W. Smyth, M.A., F.R.S.

"The Hungarian lavas are chiefly felspathic, consisting of different varieties of trachyte; many are cellular, and used as millstones; some so porous, and even scoriform, as to resemble those which have issued in the open air. Pumice occurs in great quantity; and there are conglomerates, or rather breccias, wherein fragments of trachyte

Upper Gallery. — Wall-case 1.

are bound together by pumiceous tuff, or sometimes by silex.

"It is probable that these rocks were permeated by the waters of hot springs, impregnated, like the Geysers, with silica ; or, in some instances, perhaps, by aqueous vapours, which, like those of Lancerote, may have precipitated hydrate of silica.

"It appears from the species of shells collected principally by M. Boué, and examined by M. Deshayes, that the fossil remains imbedded in the volcanic tuffs, and in strata alternating with them in Hungary, are of the Miocene type, and not identical, as was formerly supposed, with the fossils of the Paris basin."—(Lyell's "Elements of Geology.")

43.—Granite, composed of *felspar*, *quartz*, and *mica*, from the trachytes of the *Glashütte*, *Schemnitz*.

44.—Basalt.—*Top of Kalvarienberg.*

45.—Basalt, containing a very small quantity of *olivine*. —*Giesshübl.*

46.—Amygdaloidal basalt, the kernels filled with *zeolite* and *calc spar*.

47.—Basalt, enclosing fragments of *trachyte* and a *zeolitic mineral*, from the west edge of the basaltic mass of *Giesshübl*.

48—Compact pearlstone, from the western extremity of the *Vale of Hlinik*.

49.—Grey porphyritic pearlstone, composed of crystals of *quartz*, *glassy felspar*, and *black mica*, in a pearlstone base.—From the conglomerate in the *Vale of Hlinik*.

50.—Porphyritic pearlstone, another variety.

51.—Porphyritic pearlstone. } Two miles west of *Glashütte*.
52.—Pearlstone, *with sphærulite*. }

53.—Pearlstone, with *sphærulite* and specks of black *mica*, some in crystals.—Near the mouth of the *Vale of Hlinik*.

54.—Pearlstone, with a few small specks and laminæ of black *mica*. ("*Perlite Rétinique*" of Beudant.)—*Vale of Hlinik*.

UPPER GALLERY. — Wall-case 1.

55.—PEARLSTONE ("*Perlite-lithoide*" Beudant).—Two miles west of *Glashütte.*

56.—PITCHSTONE PORPHYRY, composed of crystals of *felspar* in a pitchstone base.—From a block at the foot of *Mount Altes Schloss, Glashütte.*

57.—PORPHYRITIC GREENSTONE, containing spherical concretions from the mine called *Stephani Schacht.*

58.—CONCRETIONS, from the *greenstone*, No. 57.

59.—COMPACT GREENSTONE.

60.—GREENSTONE, discoloured, and containing small cubes of *iron pyrites.*

61.—EARTHY GREENSTONE, west slope of *Schobobner-*

62 & 63.—ALTERED GREENSTONE, with a small quantity of *iron pyrites*, from the hanging wall of a branch of the Theres gang (Theresa vein), north of *Georg Stolln.*

64.—PORPHYRITIC GREENSTONE, from the summit of *Paradeisberg.*

65.—PORPHYRITIC GREENSTONE, from the east slope of *Paradeisberg.*

66.—GREENSTONE PORPHYRY, occurring in several varieties near the mouth of the Ferdinand Adit, being the first rock pierced by it.—*Georg Stolln.*

67.—EARTHY GREENSTONE PORPHYRY, composed of crystals of *Albite* (*soda felspar*) and prismatic crystals of black *mica*, with some *hornblende* in a felspatho-hornblendic base: 100 yards west of *Tepla.*

68.—EARTHY DIORITIC PORPHYRY, composed of crystals of *Albite* (*soda felspar*) in a hornblendic base: 400 yards west of *Tepla.*

69.—AUGITIC PORPHYRY, from the trachytes, east of *Mt. Szitna.*

70 & 70a.—EARTHY TRACHYTE, sent to Vienna, and used as porcelain earth; from the conglomerates, *west of Prinzendorf*, and *south of Mount Szitna.*

71.—PORPHYRITIC TRACHYTE, with *augite* and *glassy felspar*, summit of *Mount Szitna.*

UPPER GALLERY. — Wall-case 1.

71a.—PORPHYRITIC TRACHYTE with crystals of *mica, augite*, &c. south of the basalt of *Giesshübl.*

72.—SCORIACEOUS TRACHYTE, from a block near the rocks at the "Teich," or reservoir, half a mile south east of *Kremnitz.*

73.—SCORIACEOUS TRACHYTE, from a block near the rocks, at the reservoir, half a mile south east of *Kremnitz.*

74.—TRACHYTE, composed of crystals of black *mica, hornblende*, and *glassy felspar*, in a pinkish trachytic base ; west of *Calvarienberg*, near the aqueduct.

75.—GREEN TRACHYTE, with a little *glassy felspar* and black *mica ;* near the Altes Schloss, *Glashütte.*

76.—Concentrically striped TRACHYTIC BLOCK, from the conglomerate *below Antal.*

77.—TRACHYTE, with crystals of *hornblende*, and *glassy felspar ;* from a hill covered with loose blocks, 2 *miles below Antal.*

78.—TRACHYTIC PORPHYRY, one mile west of *Glashütte.*

79.—TRACHYTIC PORPHYRY, composed of crystals of *hornblende, mica*, and *glassy felspar*, in a white trachytic base, from the slope above the cliffs of *Glashütte.*

80.—Sphærulitic MILLSTONE TRACHYTE, *Hlinik.*

81.—TRACHYTE with *mica* and *hornblende*, west of road between *Bleyhütte* and *Antal.*

82.—TRACHYTE (another variety), west of road between *Bleyhütte* and *Antal.*

83.—From the junction of *trachyte* and *greenstone*, west of *Calvarienberg*, near the aqueduct.

84.—TRACHYTIC CONGLOMERATE, composed of fragments of decomposing crystals of *glassy felspar* in a base of trachyte, containing minute specks of black *mica.*—North slope of *Mount Vepor.*

85.—TRACHYTIC CONGLOMERATE, used as a material for building the Cathedral at Gran.—*Wissegrad.*

86.—PUMICEOUS CONGLOMERATE, above the *Vale of Hlinik on the Kremnitz road.* UPPER GALLERY. Wall-case 1

87.—PUMICEOUS TUFA, containing impressions of *leaves*, from the trachytic conglomerate of *Tepla*, in the *Vale of Glashütte.*

88.—From the TRACHYTES west of Mount Szitna, *between Antal and Prinzendorf.*

89.—FELSPATHIC ROCK, with crystals of *glassy felspar*, from junction of *trachyte* and *greenstone*, west of *Calvarienberg*, *Schemnitz*, near the aqueduct.

90.—FELSPATHIC ROCK, with a few crystals of *glassy felspar*, from the trachyte east of the road, a few hundred yards below *Bleihütte.*

91.—COAL, from a *clay slate*, occurring in the *Gross grube*, *Felso Banya.*

92.—COAL, (*anthracitic*,) occurring in *greenstone*, 70 fathoms from the surface.—*Andreas Shaft; Schemnitz.*

93.—GARNETS, washed by the rain from the *trachytic beds* at *Sajba*, *near Libethen.—Hungary.*

94.—SYENITE, from near its contact with limestone.—*Drey König Mine*, *Oravitza.*

95.—Decomposed SYENITE ("*Sand*,") near its junction with limestone.

96.—FELSPATHIC ROCK, *with much hornblende*, in contact with *syenite;* to it succeeds, firstly, grey limestone, and then granular limestone.

97.—CALCAREOUS SPAR AND GARNET ROCK, occurring between *syenite and limestone*, as matrix to the ore at *Drey König Mine.*

97*a*.—COMPACT GREY LIMESTONE, *occurring between granular limestone and syenite.*—From the upper adit of the *Drey König Mine.*

98.—*Granular limestone*, containing ores of copper.—*Drey König Mine.*

UPPER GALLERY. — Wall-case 1.

99.—WHITE CRYSTALLINE LIMESTONE, from *Ruszkberg in the Bannat.*

100.—FLESH-COLOURED CRYSTALLINE LIMESTONE, from *Ruszkberg in the Bannat.*

101.—MARL, *with nodules of Bitterkalk, Radoboj, Croatia.*

102.—DIORITE (or GREENSTONE), *Nagy Banya.*

103.—DIORITIC PORPHYRY, with *calc spar, Vale of Fernezely, Nagy Banya.*

104.—GREENSTONE PORPHYRY, with metalliferous threads, *Nagyag, Transylvania.*

105.—Non-metalliferous PORPHYRY forming the peaks of the mountains around *Nagyag.*

106.—AUGITIC (?) PORPHYRY, *Almas*, between *Zalathna* and *Nagyag.*

107.—QUARTZOSE PORPHYRY, between *Zalathna* and *Nagyag.*

108.—TRACHYTE, altered by the action of the gases issuing from the cavern on the *Büdos Hegy.*

109.—TRACHYTE, with black *mica, rubellane,* &c.—*Mount Büdos.*

110.—TRACHYTIC CONGLOMERATE, *Csetate Mines, Abrudbanya.*

111.—FELSPATHIC PORPHYRY, occurring among trachytic rocks.—*Piatra Dorni.*

112.—CONGLOMERATIC ROCK, probably in connection with the trachyte of *Tihutza* on the border of the *Bukovina.*

113.—GRANITE, with green *epidote.—Magurka,* near *Unter Franz Stollen, Northern Hungary.*

114.—TRACHYTE, containing a vein of *sulphur.—Kalinka, Sohler County.*

115.—ALTERED SANDSTONE with *specular iron, Magurka.*

Rock Specimens from the Taurus Mountains. UPPER GALLERY. Wall-case 1.

116.—FELSPATHIC PORPHYRY, tilting the slates around *Kieban Maden.*

117.—GREEN SERPENTINE, from the neighbourhood of ochreous Breccia.—*Argana Maden.*

118.—PORPHYRITIC ROCK, with *calc spar*, and occurring between serpentine (?) and limestone.—West of the *Serai*, at *Argana Maden.*

119.—ALTERED MARLY SHALE, capping hills of serpentine at *Argana Maden.*

119a.—REDDISH-BROWN LIMESTONE, altered by the intrusion of serpentine (?)—*Argana Maden.*

120.—Reddish-brown ALTERED MARLY SLATE, capping hills of serpentine at *Argana Maden.*

121.—LIMESTONE, altered by serpentine; from *Argana Maden.*

Volcanic specimens from the extinct Volcanos of the Eifel on the Lower Rhine.

Presented by G. Poulett Scrope, M.P., F.R.S.

NEWER VOLCANOS OF THE EIFEL.—The volcanos of the Eifel are of a date coeval with that of the "*brown coal*" of the Germans, which has been variously referred to the close of the Eocene, or to the commencement of the Miocene epochs.

"The fundamental rocks of the district are grey and red sandstones and shales, with some associated limestones, replete with fossils of the Devonian or Old Red Sandstone group. The volcanos broke out in the midst of these inclined strata, and when the present systems of hills and valleys had already been formed. The eruptions occurred sometimes at the bottom of deep valleys, sometimes on the summit of hills, and frequently on intervening platforms. In travelling through this district we often fall upon them most unexpectedly, and may find ourselves on the very edge of a crater before we had been led to suspect that we were

Upper Gallery. — Wall-case 1.

approaching the site of any igneous outburst. For this we have been prepared by the occurrence of scoriæ scattered over the surface of the soil. But on examining the walls of the crater we find precipices of sandstone and shale which exhibit no signs of the action of heat; and we look in vain for those beds of lava and scoriæ, dipping in opposite directions on every side, which we have been accustomed to consider as characteristic of volcanic vents. As we proceed, however, we find a considerable quantity of scoriæ and some lava, and see the whole surface of the soil sparkling with volcanic sand, and strewed with ejected fragments of half-fused shale, which preserves its laminated texture in the interior, while it has a vitrified or scoriform coating.

"The most striking peculiarity of a great many of the craters, is the absence of any signs of alteration or torrefaction in their walls, where these are composed of regular strata of ancient sandstone and shale. · · · There is, indeed, no feature in the Eifel volcanos more worthy of note than the proofs they afford of very copious aëriform discharges, unaccompanied by the pouring out of melted matter, except, here and there, in very insignificant volume. I know of no other extinct volcanos where gaseous explosions of such magnitude have been attended by the emission of so small a quantity of lava.

"In the Lower Eifel, eruptions of trachytic lava preceded the emission of currents of basalt, and immense quantities of pumice were thrown out wherever trachyte issued. The tufaceous alluvium called *trass*, which has covered large areas in this region, and choked up some valleys now partially re-excavated, is unstratified. Its base consists almost entirely of pumice, in which are included fragments of basalt and other lavas, pieces of burnt shale, slate and sandstone, and numerous trunks and branches of trees."—(Lyell's "Manual of Elementary Geology," 5th edition, pp. 545—548.)

122.—Vesicular lava, *Gebirge*, on the *Rhine*.

123.—Scoriaceous BASALTIC LAVA, remarkably hard and containing fine crystals of *augite*, with a few crystals of reddish coloured *felspar;* from the *Laacher-see.* (See Hibbert "On the Extinct Volcanos of the Rhine," p. 148.) UPPER GALLERY. — Wall-case 1.

124.—Vesicular BASALTIC LAVA, with crystals of *augite.* —*Biebrich.*

125.—Slightly vesicular BASALTIC LAVA, with crystals of *augite* and *olivine.*—*Norenberg.*

126.—Slightly vesicular BASALTIC LAVA, with a few crystals of *augite, glassy felspar*, and *quartz,* and small specks of *haüyne,* and containing entangled fragments of laminated *felspatho-hornblendic rock.*—*Mayen.*

(See Hibbert "On Extinct Volcanos of the Rhine," p. 116.)

127.—SCORIACEOUS BASALTIC LAVA.—*Weinfeld.*

128.—Slightly vesicular BASALTIC LAVA, composed almost entirely of crystals of *augite*, with a crystalline structure and partly scoriaceous; occurring in numerous large ejected blocks on the banks of the *Weinfelder Maar*, near *Daun, Vorder Eifel.*

129.—Part of a VOLCANIC BOMB, consisting of a core of vesicular augitic lava, surrounded by a coating of more compact lava.—*Pulver Maar.*

130.—OLIVINE coated with *scoriaceous lava;* a portion of an ejected mass.—*Dachweiler.*

(See Hibbert "On Extinct Volcanos," foot note, p. 24.)

Volcanic rocks from the summit of the Volcanic Mountain of St. Vincent.

Presented by Mr. Gilding.

131.—SCORIACEOUS LAVA, with crystals of *hornblende* and *felspar.*

132.—Slightly VESICULAR LAVA, with numerous crystals of *glassy felspar* and *hornblende.*

UPPER GALLERY. — Wall-case 1.

133.—Highly crystalline PORPHYRITIC GREENSTONE, composed of crystals of *glassy felspar* and *hornblende.*

134 & 135.—Highly crystalline PORPHYRITIC GREENSTONE (another variety), with *olivine* and included fragments of *scoriaceous lava;* the augite has undergone partial fusion.

136.—Fine-grained PORPHYRITIC GREENSTONE (another variety), with decomposing *olivine.*

137.—JASPIDEOUS ROCK.

138.—NAPOLEONITE, or ORBICULAR GREENSTONE,* from *Corsica.* It is composed of—

Felspar (*Anorthite*) - - - -	90·00
Hornblende - - - - -	10·00
	100·00

139.—SCORIACEOUS LAVA, assuming a stalactitic form in cooling, and containing, on one side, entangled fragments of a dark scoriaceous lava. *Etna:* from a bocca, or the cavernous opening, where a lava stream first commences to flow out at the side of a volcano.

Presented by W. W. Smyth, F.R.S.

Volcanic products from the Peak of Teneriffe.

Presented by Professor C. Piazzi Smyth, F.R.S.

TENERIFFE.—The island of Teneriffe, off the west coast of Africa, is the largest of the Canary Islands, being 36 miles long, with an area of 1,000 square miles. The Peak is situated at its N.E. end, and rises to a height of 12,158 feet above the level of the sea. The upper portion is a rugged conical eminence, 852 feet high, difficult of ascent on account of the loose ashes by which it is covered, and so narrow on the top as scarcely to afford standing room. A steep wall on the summit would prevent access to the crater,

* See also No. 275, Case 6, p. 259.

but for an opening in one place ; but in the interior there is a gentle slope for about 106 feet. The crater has long ceased to emit flame, but it still gives vent to aqueous vapours.—H. W. Bristow.

140.—LAVA, from the outer surface of the stream, of a twisted form, showing the result of a viscous flow.

141.—LAVA, with a wrinkled surface, the result of flowing while in a viscous state.—From the *Ice Cavern.*

142.—BLACK LAVA, overlying the pumice at *Alta Vista,* showing the smooth planes of joints, and a tendency to assume spheroidal forms.

143.—PUMICE, from *Alta Vista.*

144.—PITCH-STONE LAVA, lying under the pumice at *Alta Vista.*

145.—SULPHUR, from the interior of the crater.

146.—SULPHATE OF ALUMINA AND IRON, from the interior of the crater.

147.—SULPHATE OF IRON AND ALUMINA, containing also insoluble matter.—From the interior of the crater.

Wall-case 2.

Arranged and described by H. W. BRISTOW.

1 to 105, *from the Island of Ascension, were collected by Mr. Charles Darwin, F.R.S., and Captain Ord, R.E.*

The Island of Ascension, situated between the coasts of Africa and Brazil, is nine miles long by six in breadth. Its entire surface, which is broken into mountains, hills, and ravines, is covered with ashes, cinders, pumice, and lava. Its general appearance is that of a mass of smooth, bright red conical hills, with truncated summits, rising from a plain of black, sterile lava. The highest point on the island, Green Hill, is 2,870 feet above the sea level.

UPPER GALLERY. — Wall-case 2.

1 to 14e, are varieties of lava, of which 4 to 8 and 10 are more or less cellular, while 9, 11, and 13 are more compact. 14 to 14e, as well as 106, from Chatham Island, Galapagos Archipelago, from the superficial parts of a lava stream, are especially remarkable for their singular forms. They are described as being scattered over the surface of the ground, presenting the appearance of logs and branches of trees.

15 to 26 represent varieties of laminated beds, which alternate with and pass into obsidian.

The greater number of these are composed of pearlstone and pitchstone, with occasional nodules of obsidian, alternating with felspathic layers.

18, 22, and 23 are sphærulitic, while 16, 19 to 21, 24 and 25 contain included crystals of glassy felspar, lying lengthways, or with their longest axes parallel with the laminæ in which they are included ; an arrangement which is due to the motion of the mass while in a heated state.

27 to 31 show the passage from pitchstone into obsidian.

It may be observed that pitchstone and obsidian are merely different forms of the same substance, caused by the unequal rate at which the liquified mass of melted rock has been cooled. Obsidian (or the more perfect form of volcanic glass) is from the superficial portion of the mass which has cooled most rapidly, while the more dull, opaque interior portion, into which true obsidian passes at a slight depth, and which has cooled more slowly, is termed pitchstone.

31 to 31c are varieties of volcanic slag, exhibiting different degrees of fusion.

32 to 62 are from the series of trachytic rocks which form the more elevated and central, and likewise the south-east part of the island. 57 to 58 are augitic lavas, with included crystals of glassy felspar.

63 and 64 are pumiceous. 65 to 67 volcanic ashes and sand, or the more finely divided products of eruption.

68 to 73 are varieties of softer tufa, and 105 are concretions which occasionally occur in it.

85 to 92 are volcanic bombs and fragments of rocks which have been shot forth during aëriform explosions, and are now found mixed with masses of scoriæ. 86 to 88 exhibit striking proofs of their having been in a fluid state, and of having had a rotatory motion communicated to them when originally vomited from the crater. This is especially to be observed in 86.

UPPER GALLERY. — Wall-case 2.

Siliceous sinter is represented by 95 to 99. It occurs in the altered trachytes either in the form of irregular masses or in seams. The formation of these, as well as of the thin plate-like veins 93, has been produced by the segregation or infiltration of siliceous matter.

In the same manner the jasper, (100 to 102,) which also forms large irregular masses in the altered trachyte, was probably produced by a process (as suggested by Mr. Darwin) analogous to that by which wood becomes gradually silicified; that is, by the gradual removal, particle by particle, of the original rock, (in this case a basaltic rock,) accompanied by the simultaneous substitution of siliceous matter and iron.

106 to 109 are varieties of scoriaceous lava from Chatham Island, Galapagos Archipelago; while 110 to 113 are cellular basaltic lavas, the latter containing crystals of olivine.

116 to 117 are from the Cape de Verde Islands.

Various kinds of lava from New Zealand (White Island) are represented by Nos. 121 to 126. 127 and 128 are specimens of siliceous sinter. 129 and 130, gypsum; 131 and 132, native sulphur; and 133, the ashes with which the country around Auckland is covered.

134 and 135 are from volcanic springs at Kertch, in the Crimea.

Volcanic rocks from the Island of Ascension.

Presented by Charles Darwin, F.R.S., and Captain Ord, R.E.

1 & 2.—VOLCANIC SLAG, OR CINDER.

3.—RED SCORIACEOUS LAVA, partly vesicular, from the outer portion of the stream.

UPPER GALLERY. — Wall-case 2.

4 & 5.—CELLULAR OF VESICULAR BASALTIC LAVA.

6.—SLAG, *from an iron furnace* at Wolverhampton, for comparison with the two preceding specimens.

7.—Vesicular BASALTIC LAVA, showing the elongation of the vesicles in the direction of the current.

8.—BASALT, in one part slightly scoriaceous.

9.—Vesicular BASALTIC LAVA, some of the vesicles filled with crystals of *glassy felspar.*

10.—Compact brown BASALTIC LAVA (slightly vesicular in places) with crystals of *glassy felspar.*

11.—Vesicular BASALTIC LAVA, with crystals of *augite.*

12.—Compact brown BASALTIC LAVA, with crystals of *olivine.*

13, 13a, 13b, 13c, 13d, and 13e.—Six specimens of fragments from the superficial parts of a BASALTIC LAVA CURRENT, presenting singularly twisted and convoluted forms, and exhibiting lines formed by the flowing of the stream while in a viscous or slightly fluid state.

(See Darwin " On Volcanic Islands," p. 35.)

Laminated beds alternating with and passing into Obsidian.

14.—PEARLSTONE, with a lamellar structure, and containing slightly waved tortuous layers in the upper part.

15.—PEARLSTONE, containing small irregular masses of *obsidian* in thin, slightly tortuous layers, with included fragments of somewhat cellular lava, in which are small crystals of *glassy felspar.*

16.—PITCHSTONE, with thin parallel and slightly tortuous felspathic layers, containing crystals of *glassy felspar.*

17.—Small irregular NODULES OF OBSIDIAN, either standing separately or united into thin layers, and cemented together by soft, white and pale greenish matter, resembling pumiceous ashes.

(See Darwin " On Volcanic Islands," p. 57.)

18.—Thin, slightly tortuous layers of pale grey-coloured FELSPATHIC STONE, between which are layers of opaque brown *sphærulites* (*obsidian globules*) in a soft, pearly base.

UPPER GALLERY.

Well-case 2.

19.—Irregular nodules of OBSIDIAN (*pearlstone*) alternating with thin layers of a felspathic rock, which contain crystals of *glassy felspar.*

(See Darwin "On Volcanic Islands," p. 57.)

20.—COMPACT HEAVY ROCK, with a crystalline felspathic base, mottled with a black mineral, and abounding with crystals of *glassy felspar.*

(See Darwin "On Volcanic Islands," pp. 56 and 57.)

21.—Compact CRYSTALLINE ROCK, banded in straight lines, with numerous, extremely thin, white and grey laminæ, composed chiefly of *felspar*, and containing numerous perfect crystals of *glassy felspar*, placed lengthways; they are also studded with microscopically minute amorphous black specks of *augite* or *hornblende.*

(See Darwin "On Volcanic Islands," p. 56.)

22.—Thin slightly tortuous layers of GREY FELSPATHIC STONE, passing into *pearlstone*, alternating with minute globules of *obsidian* (*dark brown opaque sphærulites*). In the specimen a thin layer of the brown sphærulites, closely united, intersects a layer of similar composition, and after running for a short space in a slightly curved line, again intersects it and likewise a second layer, lying a little way beneath that first intersected.

(See Darwin "On Volcanic Islands," pp. 58 and 59.)

23.—Slightly tortuous layers of light grey PEARLSTONE, sometimes passing into *pitchstone*, with numerous lines of minute white sphærulites, which are dissected out on two of the weathered sides of the specimen: (allied to No. 18.)

24.—Irregular nodules of OBSIDIAN, united into thin layers, which alternate with other thin felspathic layers, containing crystals of *glassy felspar.*

25.—Irregular layers of PEARLSTONE, with crystals of *glassy felspar*, and passing into *pitchstone*, alternating with irregular dull red-coloured trachytic layers.

UPPER GALLERY. — Wall-case 2.

26.—Irregular layers of PITCHSTONE and greenish-grey *felspathic layers.*

27, 27a, and 27b.—PITCHSTONE, showing the characteristic conchoidal fracture and sharp cutting edges.

28.—GREEN PITCHSTONE, or OBSIDIAN.

29, 29a to 29g.—BLACK OBSIDIAN or VOLCANIC GLASS, with a conchoidal fracture and sharp cutting edges.

30.—BLACK OBSIDIAN, full of minute globular vesicles, which become gradually less perfectly defined until the whole passes into compact obsidian. The vesicular structure is owing to the expansion of included gases or aqueous vapour, which were not entirely driven off during the fusion of the melted mass.

31.—OBSIDIAN, passing into vesicular, scoriaceous lava, and presenting an appearance of perfect fusion.

31a.—VOLCANIC SLAG, SCORIA, or CINDER, presenting an appearance of partial fusion, and converted in some places, into layers of obsidian.

31b.—VOLCANIC SLAG, SCORIA, or CINDER, presenting an appearance of imperfect fusion.

31c.—VOLCANIC SLAG, SCORIA, or CINDER, presenting an appearance of imperfect fusion, and covered, superficially, in some places, with an iridescent lustre. The specimen contains a few small fragments of scoriaceous lava, which have become entangled with and taken up by the partially fused slag.

Trachytic series of rocks occupying the more elevated and central, and likewise the south-eastern, parts of the Island of Ascension.

32.—Somewhat friable WHITE TRACHYTE, appearing when viewed in mass, like a sedimentary trachytic tufa. The specimen is earthy and in a decomposing state, passing into china clay. It also contains some cavities, with crystals of *glassy felspar.*

33.—Pale greenish-grey, decomposing TRACHYTIC POR-

UPPER GALLERY. — Wall-case 2.

PHYRY, with crystals of *glassy felspar*, black microscopical specks, and brown stains (decomposed crystals of *augite*).

(See Darwin "On Volcanic Islands," pp. 42 and 43.)

34 & 35.—Slightly laminated pale grey TRACHYTE.

36.—Pale grey LAMINATED TRACHYTE. The specimen contains a few crystals of *glassy felspar*, and has a weathered surface.—From the base of *Garden Hill*.

37.—Pale greenish-grey TRACHYTE, containing crystals of *glassy felspar*, and decomposing crystals of *augite*. The specimen is covered with a white efflorescence of *chloride of sodium*, probably derived from the sea-water with which it has been saturated.

38.—Pale greenish-grey TRACHYTE, with numerous crystals of *glassy felspar* and *augite*, and black microscopical specks.

39.—Pale grey TRACHYTE, with crystals of *glassy felspar* and a few decomposed crystals of *augite*.

The specimen shows a weathered surface.

40.—Pale grey TRACHYTIC ROCK, honeycombed with irregular cavities, presenting a carious appearance, and a strong resemblance to silicified wood.

41.—*Another specimen*, having some of the cavities filled with a white powder.

42.—GREENISH TRACHYTE, with embedded fragments of *obsidian*.

43.—BLUISH-GREY TRACHYTE, with pale brown markings.

(See Darwin "On Volcanic Islands," p. 55.)

44.—Pale purplish EARTHY TRACHYTE, with crystals of *glassy felspar*, and presenting a weathered surface, which is scoriaceous in places.

45.—GREY TRACHYTE, with a contorted lamellar structure, minute black specks, and crystals of *glassy felspar*.

46.—*Another variety:* LIGHT GREY TRACHYTE, with crystals of *glassy felspar and angular scoriaceous fragments*, and streaked with numerous slightly tortuous white lines, which frequently expand into small cavities. These con-

UPPER GALLERY. — Wall-case 2.

tain white crystals of *quartz* and minute, brown, acicular, transparent crystals of *augite* (*diopside*).

(See Darwin "On Volcanic Islands," p. 55.)

47.—LIGHT GREY TRACHYTE, with layers of *pitchstone*, in contact with and passing into paler earthy trachyte, with included fragments of *pearlstone*.

48.—Reddish-brown AUGITIC LAVA, with crystals of *glassy felspar*.

49.—Laminated TRACHYTIC LAVA, with crystals of *glassy felspar*.

50.—LAMINATED LAVA, with crystals of *glassy felspar*, and composed of alternate layers of augitic and felspathic lavas.

51.—BRICK-RED TRACHITE, with decomposing crystals of *glassy felspar*.

52.—AUGITIC LAVA, with crystals of *glassy felspar* and crystals of *specular iron* on one side of the specimen.

53.—GREENISH TRACHYTE, with crystals of *glassy felspar* and a few brown stains.

54.—TRACHYTE, in a decomposing state, with crystals of *glassy felspar*.

55.—TRACHYTE, partially coated with a thin deposit of *quartz*.

56.—Reddish-brown AUGITIC LAVA, with numerous crystals of *glassy felspar*.

57.—DITTO (*another variety*), covered on one side with crystals of *gypsum*.

58.—Slightly cellular greyish AUGITIC LAVA, with numerous well-defined crystals of *glassy felspar*.

59.—TRACHITIC PORPHYRY, composed of crystals of *glassy felspar*, with brown spots in a light brown trachytic base, and forming veins of hard compact trachyte, in the earthy trachytes.

60.—CELLULAR PORPHYRY, with opaque white crystals of decomposing *glassy felspar*, and decomposed crystals of *oxide of iron*. Some of the cells contain minute hair-like crystals of ***analcime.*** Found embedded in the earthy trachyte.

UPPER GALLERY. Wall-case 2.

61.—BRECCIA, composed of fragments of ***trachyte*** and ***obsidian*** in a trachytic base, which also contains a few crystals of ***glassy felspar.***

62.—BRECCIA, composed of fragments of ***pitchstone*** and ***pearlstone*** in a trachytic base.

63.—PUMICE (porous felspathic ***volcanic scoria.***)

64.—PUMICEOUS CONGLOMERATE.

65.—VOLCANIC ASH (in a bottle).

66.—Consolidated VOLCANIC ASHES, enclosing a *Pecten.*

67.—VOLCANIC SAND (in a bottle).

68.—Soft white PUMICEOUS TUFA.

69, 70, 71, & 72.—Varieties of TRACHYTIC TUFA (in bottles).

73.—Bright-red VESICULAR TUFA.

74.—Fine-grained, partially consolidated TUFA or PEPERINO, with coarser loose scoriæ.

75 & 76.—PEPERINO, formed of ***volcanic sand and ashes*** cemented together.

77.—BLACK TRACHYTIC TUFA OR PEPERINO, from the bottom of the volcano.—*St. Vincent.*

78.—SCORIACEOUS LAVA or *pozzolana.—Sheepwalk.*

79 & 80.—SCORIACEOUS LAVA or *pozzolana.—High Peak.*

81.—VOLCANIC SCORIA AND ASHES.

82, 83, & 84.—VOLCANIC SCORIA, CINDERS, AND SLAGS.

VOLCANIC BOMBS.

85.—VOLCANIC BOMB OF OBSIDIAN.—"The specimen was found, in its present state, on a great sandy plain between the rivers Darling and Murray, in Australia, and at the distance of several hundred miles from any known volcanic region. The external saucer consists of compact obsidian, of a bottle-green colour, and is filled with finely cellular lava, much less transparent and glassy than the obsidian. The external surface is marked with four or five not quite perfect ridges. The lip of the saucer is slightly concave,

Upper Gallery. — Wall-case 2.

exactly like the margin of a soup-plate, and its inner edge overlaps a little the central cellular lava. This structure is so symmetrical round the entire circumference, that one is forced to suppose that the bomb burst during its rotatory course before becoming quite solidified, and that the lip and edges were thus slightly modified and turned inwards."—Darwin "On Volcanic Islands," pp. 38 and 39.

86.—Fragment of a spherical VOLCANIC BOMB, with the interior parts coarsely cellular, coated by a concentric layer of compact lava, and this again by a crust of finely cellular rock, forming the external surface. "This structure may be explained, by supposing a mass of viscid scoriaceous matter to be projected with a rapid rotatory motion through the air ; for whilst the external crust from cooling became solidified, the centrifugal force, by relieving the pressure in the interior parts of the bomb, would allow the heated vapours to expand their cells ; but these being driven by the same force against the already hardened crust would become, the nearer they were to this part, smaller and smaller or less expanded until they became packed into a hard solid concentric shell."—Darwin "On Volcanic Islands," pp. 36 and 37.

87.—Part of A VOLCANIC BOMB of a similar description to the preceding specimen, and showing the internal structure.

88.—Portion of a VOLCANIC BOMB, composed of coarse and finer cellular rock, of an irregularly scoriaceous structure : probably the central portion of the bomb.

89.—EJECTED GRANITIC FRAGMENT, consisting of a brick-red mass of felspar, quartz, and small dark patches of a fused mineral, ascertained by its cleavage to be hornblende. (See Darwin " On Volcanic Islands," p. 40.)

90.—EJECTED GRANITIC FRAGMENT (*syenite*), streaked and mottled with red, and composed of white ***potash-felspar***, numerous grains of ***quartz***, and small crystals of ***hornblende***.

91.—EJECTED FRAGMENT (*white granitic rock*), composed of confusedly crystallized white *felspar*, with little nests of a dark-coloured mineral, often carious, externally rounded, and with no distinct cleavage, probably *fused hornblende.* This rock was ejected amongst cinders from one of the more recent volcanos.

(See Darwin "On Volcanic Islands," p. 41.)

92.—EJECTED FRAGMENT, *greenstone*, composed of crystals of *Labrador Felspar*, a little *altered hornblende*, and scales of black *mica*, with white granular *felspar*, filling the interstices.

(See Darwin "On Volcanic Islands," p. 41.)

93.—EJECTED FRAGMENT, portions of hard SILICEOUS PLATE-LIKE VEINS, of varying thickness, intersecting the earthy trachytic masses on the flanks of the "crater of the old volcano."

(See Darwin "On Volcanic Islands," pp. 44 and 45.)

94.—Seams of compact OXIDE OF IRON, occurring conformably in the lower parts of a stratified mass of ashes and fragments.

"This seam of compact stone, by intercepting the little rainwater which falls on the island, gives rise to a small dripping spring, first discovered by Dampier. It is the only fresh water on the island, so that the possibility of its being inhabited has entirely depended on the occurrence of this ferruginous layer."—Darwin "On Volcanic Islands," p. 39.

95.—WHITE SILICEOUS SINTER, occurring in altered trachyte.

(See Darwin "On Volcanic Islands," p. 45.)

96.—SEAMS OF SILICEOUS SINTER, occurring in altered trachyte.

97.—WHITE SILICEOUS SINTER.

98.—Cream-coloured SILICEOUS SINTER.

99.—SILICEOUS SINTER, formed of thin irregular plates of *chalcedonic quartz*, occurring in altered trachyte.

100.—Ochreous-brown coloured *jasper*, occurring in large irregular masses, and sometimes in veins, both in altered trachyte, and in an associated mass of scoriaceous basalt.

(See Darwin "On Volcanic Islands," p. 46.)

UPPER GALLERY. — Wall-case 2.

101.—*Another variety,* inclosing irregular angular patches of *red jasper,* with their edges blending into the surrounding mass.

102.—SCORIACEOUS ROCK, occurring near veins of siliceous sinter (Nos. 96, 97, and 98), having the cells lined and filled with fine concentric layers of *white chalcedony,* which are coated and studded with bright-red *oxide of iron.*

103.—SILICEOUS CONGLOMERATE, with small prismatic crystals of *tourmaline* and crystals of *quartz,* and coated with a thin layer of *siliceous sinter.*

104.—ROCK RESEMBLING SYENITIC GNEISS, probably from one of the laminated beds alternating with and passing into obsidian, noticed in Darwin "On Volcanic Islands," pp. 56 and 57.

105.—CONCRETIONS *from pumiceous tufa,* composed of a very tough, compact, pale brown stone, with a smooth and even fracture, and containing a small proportion of carbonate of lime. Some of the larger concretions are described as mere shells filled with slightly consolidated ashes. (See Darwin "On Volcanic Islands," p. 47.)

Volcanic Specimens from the Galapagos Archipelago, Chatham Island.

(Collected and presented by Charles Darwin, F.R.S.)

The Galapagos Archipelago consists of ten islands, situated under the equator, 500 or 600 miles westward of the coast of America. They are all formed of volcanic rocks, and are chiefly remarkable for the immense number of craters with which they are covered. These are formed either of lava and scoriæ, or of tufa; in the latter case they present beautifully symmetrical forms, which appears to be owing to their having been formed while standing out at sea, by the eruptions of volcanic mud, without any lava.

Chatham Island is the largest of three islands, intersected by the parallel of 43° 45″ S., and by the meridian of 176° 40′ W. It contains 477 square miles. The rocks are chiefly volcanic, and the island itself presents a rugged, arid appearance; the dark basaltic lava, of which the surface is composed, being covered by a dwarfed and parched brushwood. H. W. BRISTOW.

UPPER GALLERY. — Wall-case 2

106.—BASALTIC LAVA from the surface of the stream, slightly scoriaceous, and twisted and convoluted by flowing while in a viscous state. From the road near *Dead Man's Cove.*

107.—VESICULAR AND SCORIACEOUS LAVA, *Dead Man's Cove.*

108.—SCORIACEOUS LAVA, *Evans' Well.*

109.—VOLCANIC SLAG or CINDER, mixed with fine-grained, friable, brown-coloured *tufa* or *peperino:* from the mouth of the crater.

110.—CELLULAR BASALT, containing *olivine* and *calc spar.—North Hill.*

111.—BASALTIC LAVA, with numerous small vesicles.—Road from First Well, *Charles' Island.*

112.—CELLULAR BASALT, with *olivine,* and minute crystals of *calc spar.—Salt Lake, Chatham Island.*

113.—CELLULAR BASALT, some of the cells containing *olivine,* and others crystals of *calc spar.*—From the bottom of the well near *Quebrada.*

114.—TRACHYTIC LAVA, *Evans' Well.*

115.—COMPACT GREENSTONE, *Dalrymple Rock.*

116.—PORPHYRITIC GREENSTONE, composed of crystals of *hornblende* and flesh-coloured *felspar,* and weathered crystals of *glassy felspar* in a felspathic base. From near the summit of **Pico d'Estacia, Boã Vista, Cape de Verde Islands.*

117.—GREEN PITCHSTONE, *Mayo Island, Cape de Verde group.*

117a.—Cellular BASALTIC LAVA. Some of the cells are elongated, and partly filled with earthy *carbonate of lime.—St. Jago, Cape de Verde Islands.*

See "Darwin on Volcanic Islands," p. 10.

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* 1260·5 feet above the level of the sea.

UPPER GALLERY. — Wall-case 2.

118.—SEMI OPAL between two layers of *chalcedony*, the lowest of which has been formed upon crystals of *calc spar*, which have disappeared, leaving their casts.—*Hicaron Island, Coiba.*

119.—OBSIDIAN, *with sphærulitic concretions*, shewing an olive-green colour, on the thin cutting edges, by transmitted light.—*Mexico.*

120.—BASALT with *greenstone, Kattewar, East Indies.*

Volcanic Products from White Island, New Zealand.

Presented by the Lords of the Admiralty.

White Island, or Puhia-i-Wakari, is situated in the Bay of Plenty, in the south-east district of New Zealand. It is six miles in circumference. It contains an active volcano, and yields considerable quantities of sulphur. The flames issuing from its crater are visible at dusk, while its position is marked during the day-time by a white cloud, which rests upon its summit.—H. W. B.

121.—VOLCANIC BOMB, composed of *basaltic lava*, with numerous crystals of *glassy felspar.*

122.—*Scoriaceous* BASALTIC LAVA, with crystals of *augite* and *glassy felspar*, from the summit of *Kokibako*, an extinct volcano.—*Upper Waipa.*

123.—Vesicular BASALTIC LAVA, some of the vesicles partly filled with *calc spar.*—From the central part of White Island.

124.—Part of a pentagonal column of BASALTIC LAVA, five feet in height.—From the interior of the crater, being lava of September 1831.

125.—BASALTIC LAVA, forming the sides of extinct volcanos in the vicinity of Auckland, on the neck of land which separates the Frith of Thames from Manukau ; *it assumes a columnar form in some places.*

Most probably this specimen is not, in reality, *basaltic lava*, but a portion of a *mud stream*, which has been poured out of the volcano, and subsequently covered by a lava stream, by which it has been baked, while the columnar form has been caused by its subsequently cooling slowly under pressure.

UPPER GALLERY. — Wall-case 2.

126.—OBSIDIAN, with a conchoidal fracture and sharp-cutting edges, and presenting a lamellar structure from the presence of lines of a white powder. There are also a few disseminated crystals of *glassy felspar*, some of which have apparently undergone partial fusion.

127.—SILICEOUS SINTER, *Motu-hora.*

128.—SILICEOUS SINTER, sometimes assuming the form of *chalcedony.*

129.—GYPSUM, in radiating crystals.

130.—GYPSUM, in thin prismatic crystals.

131.—Crystals of NATIVE SULPHUR, sublimed on more earthy impure sulphur.

132.—BRECCIATED CONGLOMERATE, partly covered with *native sulphur*, from the rock of which the island is chiefly formed.

133.—VOLCANIC ASHES, forming much of the surface of the country in the neighbourhood of Auckland.

134.—MUD *from a volcanic spring* at Kertch in the Crimea, and used, when mixed with sand, for making pavements.—Presented by Dr. Mac Pherson.

135.—NAPHTHA, from bituminous springs at Kertch, and used for various purposes instead of pitch.—Presented by Dr. Mac Pherson.

Wall-cases 2 & 3.

MODELS OF ROCKS *by M. Bardin.*

From the Paris Exposition of 1855.

No. 1 is a model of part of the limestone rocks near Sablé (Sarthe). The beds are inclined at an angle of about 52°, and are somewhat jointed.

UPPER GALLERY. — Wall-case 3.

No. 2 is a model of part of the (Permian?) sandstones of the Vosges (Grès des Vosges). They form tabular hills, the strata lying nearly horizontally. They are much jointed, and it will be observed that there are caverns in the main cliff, and in front of it there are many outstanding fragments and pinnacles, like the Needles of the Isle of Wight or of Studland Bay, giving evidence that, like these chalk cliffs, this sandstone, when it stood at a different level, was formed into cliffs by the same kind of marine denudation that now forms the cliffs of the chalk.

Nos. 3 & 4 are models of inclined limestone rocks in the neighbourhood of Sablé (Sarthe).

Nos. 5 & 6 are models of parts of a country formed of gneiss. In No. 5 the numerous vertical and highly-inclined joints are remarkable, especially the curved form they assume on the side next the printed title. (Gneiss rocks at the entrance of the Bay of Morlaix.) The great irregularity of the coast line is evidently partly due to the multitude of joints, parts of the rocks having offered less resistance than others to the denuding force of the waves.

On the outside of Case 3 is a model of the volcanic isle of Bourbon, No. 7. See Appendix, page 301.—A. C. Ramsay.

Table Case A in Recess 4.

Topographical and Geological Model of Vesuvius, and Specimens illustrative of Vesuvius and its Neighbourhood.

In the model, constructed by M. Dufrénoy in 1838, the horizontal and vertical scales correspond. The order of age, or superposition, of the different rocky masses, seems to be as follows, beginning with the oldest.

1st.—Trachyte spreading from Portici to Pompeii on the coast and up to the base of Somma.

UPPER GALLERY — Table-case A. in Recess 4

2nd.—Leucitic lavas of Somma. Many of the specimens from No. 66 onward are derived from these, and where the locality is certain they are marked "Somma."

3rd.—Pumiceous tufa or ashes, &c., spreading from Naples to Portici, and round the further side of the mountain to Pompeii. These are chiefly marine and contain sea shells. These rocks are intimately connected with No. 2.

4th.—Tufa of Pompeii.

5th.—Modern lavas, &c., Nos. 1 to 65, erupted since A.D. 79.—A. C. Ramsay.

"From the first colonization of Southern Italy by the Greeks, Vesuvius afforded no other indications of its volcanic character than such as the naturalist might infer, from the analogy of its structure to other volcanos. The ancient cone (of which Somma forms a part) was of a very regular form, with a flattish summit, where the remains of an ancient crater, nearly filled up, had left a slight depression, covered in its interior by wild vines, and with a sterile plain at the bottom. On the exterior, the flanks of the mountains were clothed with fertile fields richly cultivated, and at its base were the populous cities of Herculaneum and Pompeii. But the scene of repose was at length doomed to cease, and the volcanic fire was recalled to the main channel, which, at some former unknown period, had given passage to repeated streams of melted lava, sand, and scoriæ.

"The first symptom of the revival of the energies of this volcano was the occurrence of an earthquake in the year 63 after Christ, which did considerable injury to the cities in its vicinity. From that time to the year 79, slight shocks were frequent; and in the month of August of that year they became more numerous and violent till they ended at length in an eruption. The elder Pliny, who commanded the Roman fleet, was then stationed at Misenum; and in his anxiety to obtain a near view of the phenomena he lost his life, being suffocated by sulphureous vapours. His nephew, the younger Pliny, remained at Misenum, and has given us,

Upper Gallery. — Table-case A. in Recess 4.

in his "Letters," a lively description of the awful scene. A dense column of vapour was first seen rising vertically from Vesuvius, and then spreading itself out laterally, so that its upper portion resembled the head and its lower the trunk of the pine, which characterizes the Italian landscape. This black cloud was pierced occasionally by flashes of fire as vivid as lightning, succeeded by darkness more profound than night. Ashes fell even upon the ships at Misenum, and caused a shoal in one part of the sea—the ground rocked, and the sea receded from the shores, so that many marine animals were seen on the dry sand. The appearances above described agree perfectly with those witnessed in more recent eruptions, especially those of Monte Nuovo in 1538, and of Vesuvius in 1822."—Lyell's "Principles of Geology," 1847, p. 351.

"It does not appear that in the year 79 any lava flowed from Vesuvius; the ejected substances, perhaps, consisted entirely of lapilli, sand, and fragments of older lava," and it was in these that the cities of Herculaneum and Pompeii were buried.

The first recorded stream of lava, after the year 79, flowed in 1036, and after that period eruptions took place in 1049, and 1138 or 1139; "after which a great pause ensued for 168 years," when an eruption took place in 1306, another in 1500, another at Monte Nuovo in 1538, when a new hill was formed 440 feet in height." For nearly a century after the birth of Monte Nuovo, Vesuvius continued in a state of tranquillity. There had been no violent eruption for 492 years. Bracini, who visited Vesuvius not long before the eruption of 1631, gives the following interesting description of the interior:—

"The crater was five miles in circumference and about a thousand paces deep: its sides were covered with brushwood, and at the bottom there was a plain on which cattle grazed. In the woody part wild boars frequently harboured. In one part of the plain, covered with ashes, were three small pools, one filled with hot and bitter water, another salter than the sea, and a third hot but tasteless. But at length these forests and grassy plains were consumed, being suddenly blown into the air, and their ashes scattered to the winds. In December 1631, seven streams of lava poured at once from the crater and overflowed several villages on the flanks and at the foot of the mountain. Resina, partly built over the ancient site of Herculaneum, was consumed by the fiery torrent. Great floods of mud were as destructive as the lava itself—no uncommon occurrence during these catastrophes; for such is the violence of rains produced by the evolutions of aqueous vapour that torrents of water descend the cone, and becoming charged with impalpable volcanic dust, and rolling along loose ashes, acquire sufficient consistency to deserve their ordinary appellation of 'aqueous lavas.' A brief period of repose ensued, which lasted only until the year 1666, from which time to the present there has been a constant series of eruptions, with rarely an interval of rest exceeding ten years."—Lyell's "Principles of Geology," 1847, pp. 358, 359.

The analyses given of the simple minerals represent their average per-centage composition; the formulæ give the usual mineralogical notation.

LIST OF SPECIMENS OF VESUVIAN ROCKS AND MINERALS ARRANGED AND DESCRIBED BY H. BAUERMAN.

1.—ASHES, eruption of 1760; *Bocco Tre Case.*

2.—VOLCANIC SAND, (rounded *fragments and crystals* of *augite and idocrase*) from the eruption of 1794.

3.—Similar to the last; locality, &c., not stated.

4.—VOLCANIC CONGLOMERATE, fragments of decomposing and incrusted lava cemented.—Eruption of 1794; found on the *Piano del Cinestro.*

5.—YELLOW TUFA, with *felspar crystals.*—Eruption of 1794; locality not stated.

6.—LAPILLI, small fragments of scoriaceous lava from the eruption of 1813; found at *Resina.*

UPPER GALLERY. — Table-case A. in Recess 4.

7.—FINE RED, FERRUGINOUS, ASHES from the eruption of 1822; found at *Resina.*

8.—LAMINATED FELSPATHIC ASHES; from *Monte Nuovo.*

9.—*White pumiceous lava,* with a few transparent *white felspar crystals;* from *Real Capo di Guoglio.* Date of eruption not stated.

10.—GREY PUMICE. Date not stated. *Fossa Grande.*

11.—VESICULAR LAVA (externally weathered brick-red). Date of eruption not stated; found at *Fossa Grande.*

12.—SCORIACEOUS LAVA, with crystals of *augite and felspar,* externally coated with a brick-red, earthy, crust. Date of eruption and locality not stated.

13.—VESICULAR FELSPATHIC LAVA, with a few *augite* crystals; from *La Scala.* Date of eruption not stated.

14.—COMPACT GREY LAVA, with crystals of *olivine* and *sodalite;* externally coated with *atacamite (oxychloride of copper.)*—Eruption of 79; found at *La Scala.*

15.—GREY LAVA, covered with crystals of *sodalite.* Externally, coloured red.—Eruption of 79; found at *La Scala.*

16.—LAVA, with *sodalite,* flowed when Pompeii was destroyed.—Eruption of 79; found at *La Scala.*

17.—LAVA, with crystals of *augite.*—Eruption of 79; found at *La Scala.*

18.—BLACK SCORIACEOUS LAVA, with crystals of *augite.*—Eruption of 79; found at *La Scala.*

19.—AUGITIC LAVA, covered with crystals of *sodalite.*—Eruption of 1427; locality not stated.

20.—LAVA, with crystals of *augite* and *iron glance (specular iron ore).*—Eruption of 1429; found at *Fortino di Calastro.*

21.—BASALTIC LAVA, with crystals of *leucite* and *augite.*—Eruption of 1440; found at *Bosco Reale.*

22.—LAVA, with small crystals of *augite* and *leucite.*—Eruption of 1533; found at *Santa Maria di Pagliano.*

23.—LAVA, with *augite* crystals.—Eruption of 1551; found at *Granatello di Portici.*

24.—LAVA, with crystals of *leucite* and *black augite*.—Eruption of 1554; found at *Bocco Tre Case*.

UPPER GALLERY.

Table-case A. in Recess 4.

25.—LAVA, with crystals of *augite*, externally crusted with *calc spar*.—Eruption of 1631 ; found at *Fortino di Calorto*.

26.—VESICULAR LAVA, crusted with *calc spar*.—Eruption of 1655 ; *Portico del Granatello Portici*.

27.—LAVA, with crystals of *augite* and *olivine*.—Eruption of 1659 ; locality not stated.

28.—LAVA, with small crystals of *meionite*.—Eruption of 1760 ; found at *Santa Masiello*.

29.—LAVA, with crystals of *augite*.—Eruption of 1767 ; found at *Fossa Grande*.

30.—LAVA, with crystals of *felspar* and *augite*.—Eruption of 1767.

31.—LAVA, with crystals of *augite*, some coated with a brick-red crust, from the crater of Vesuvius.—Eruption of 1779 ; found at *Atrio del Cavallo*.

32.—Similar rock to the last.—Eruption of 1786 ; found at *Fossa del Vetraro*.

33.—BLACK SCORIACEOUS LAVA.—Eruption of 1786 ; crater of *Pagliatone*, *Atrio del Cavallo*.

34.—LAVA, with crystals of *augite* and *olivine*.—Eruption of 1794 ; found at *Torre del Greco*.

35.—VESICULAR LAVA, externally coated with crystals of *iron glance*.—Eruption of 1803 ; found at *Camandoli delli Torre del Greco*.

36.—BASALTIC LAVA, with crystals of *augite*.—Eruption of 1803 ; found at *Camandoli*.

37.—SCORIACEOUS LAVA, with *obsidian*.—Eruption of 1804 ; found at *Camandoli*.

38.—LAVA, with small crystals of *mica*.—Eruption of 1804 ; found at *Camandoli*.

39.—SCORIACEOUS LAVA, with crystals of *felspar*.—Eruption of 1806 ; found at *Camandoli*.

40.—LAVA, with crystals of *augite*.—Eruption of 1809 ; found at *Camandoli*.

UPPER GALLERY. — Table-case A. in Recess 4.

41.—LAVA, with crystals of *leucite*, *augite*, and *mica*.—Eruption of 1810; found at *Piano del Cinestro*.

42.—LAVA, with crystals of *mica* and *augite*.—Eruption of 1810; found at *Piano del Cinestro*.

43.—DARK SCORIACEOUS LAVA, weathered, brownish-red with a few *augite* crystals.—Eruption of 1811; found at *Giesovito*.

44.—BLACK VESICULAR LAVA, with a few crystals of *felspar* and *augite*.—Eruption of 1812; found at *Vicilo del Vesuvio*.

45.—FELSPATHIC LAVA, with *augite* crystals.—Eruption of 1814; locality not stated.

46.—Red laminated FELSPATHIC LAVA, with interspersed *felspar* crystals: apparently part of an ejected fragment.—Eruption of 1815.

47.—LAVA, with crystals of *augite*.—Eruption of 1815; found at *Croce di Croris*.

48.—Granular white FELSPATHIC LAVA, with interspersed black scoriaceous fragments.—Eruption of 1817; found at *Grotto del Mauro*.

49.—SCORIACEOUS LAVA, coated with a crust of *sylvine* (*chloride of potassium*.)—Eruption of 1817; found at *Grotto del Mauro*.

50.—BASALTIC LAVA, with crystals of *augite*.—Eruption of 1818; *foot of Vesuvius*, towards *Monte Somma*.

51.—SCORIACEOUS LAVA, with crystals of *augite* and *olivine*.—Eruption of 1818; locality not stated.

52.—VESICULAR BLACK LAVA.—Eruption of 1819; locality not stated.

53.—BASALTIC LAVA, with small crystals of *augite*.—Eruption of 1819; *Piano del Cinestro*.

54.—LAVA, with large black *augite* and decomposing *leucite* crystals in a reddish base.—Eruption of 1820.

55.—VESICULAR LAVA, with decomposing crystals of *leucite*, coated with a yellow crust.—Eruption of 1820.

56.—GREY LAVA, with crystals of *sodalite*.—Eruption of 1821; found at *Mauro*.

57.—VOLCANIC BOMB, apparently a rounded fragment of No. 54 : from the crater of October 12th, 1822. UPPER GALLERY. — Table-case A. in Recess 4.

58.—Similar specimen to No. 55.—Eruption of 1822.

59.—LAVA, with small crystals of *augite* and *leucite*.—Eruption of February 1822.

60.—LAVA, with crystals of *leucite* and fibrous crystals of *hornblende*.—Eruption of 1822 ; found at *Mauro*.

61.—VESICULAR LAVA, with crystals of *augite*, *leucite*, and *olivine*.—Eruption of 1828 ; from the *Cone of Vesuvius*.

62.—BLACK SCORIACEOUS LAVA, containing a *coin* imbedded while in a fluid state.—Eruption of 1842.

63.—BLACK SCORIACEOUS LAVA, similar to the last.

64.—SCORIACEOUS BLACK LAVA, externally weathered yellow.—Eruption of 1855.

65.—STALACTITIC LAVA, showing lines of viscous flowing, cooled close to the mouth of a crater.

65a.—LAVA.—Eruption of 1858 ; *Atrio del Cavallo*. Presented by Dr. Strange.

SIMPLE MINERALS.

SPINEL (*aluminate of magnesia*.)

$\dot{\mathrm{Mg}}\ \dddot{\overline{\mathrm{Al}}}$ = Magnesia 28; Alumina 72.

66.—BLACK SPINEL, *mica* and *idocrase*, with *meionite* in limestone.—*Monte Somma*.

67.—BLACK SPINEL, with *green augite* and *mica*, partly clouded and decomposed.—*Vesuvius*.

68.—BLACK SPINEL, with *green augite* and *mica*.—*Coestani*, *Vesuvius*.

69.—BLACK SPINEL, with *augite*, *epidote*, and *mica*.

70.—SPINEL, *mica* and *green augite*.

71.—SPINEL AND MEIONITE, in *green granular augite*.

SPECULAR IRON ORE (*peroxide of iron*).

72.—LAVA, with crystals of *augite* and *leucite*. Externally coated with crystallized *iron glance* (*peroxide of iron*).

UPPER GALLERY. — Table-case A. in Recess 4.

73.—Similar specimen to the last.

74.—CRYSTALLINE CALC SPAR enclosing masses of *iron glance;* partly altered to *brown iron ore* (*hydrated peroxide*). *Fossa Grande.*

HAÜYNE (*silicate of soda and alumina with sulphate of lime*).

75.—HAÜYNE with *felspar, mica, augite,* and *spinel.*

76.—HAÜYNE *in felspatho-augitic lava,* similar to the last.

77.—HAÜYNE with *mica* in felspathic lava, from *Mauro.*

78.—MEIONITE AND HAÜYNE in limestone.—*Monte Somma.*

LEUCITE; *cubical felspar* (*silicate of potash and alumina*).
Silica, 55; Potash, 22; Alumina, 23.

79.—LEUCITE, a large trapezohedral crystal in *lava,* from *Monte Somma.*

80.—LAVA with *leucite* crystals, from *Capo di Sobotoniello.*

81.—VESICULAR RED LAVA with crystals of *leucite.* The material of which part of Pompeii is built.

82.—BASALTIC LAVA with crystals of *augite* and *leucite.* —*Monte Somma.*

83.—VESICULAR LAVA, with crystals of *leucite* and *bronzite-augite.*

NEPHELINE; *hexagonal felspar* (*silicate of potash, soda, and alumina*).

$$\dot{R}\ 2\ \dddot{Si} + 2\ \dddot{\text{Al}}\ \dddot{Si},\ \text{in which}\ \dot{R} = (\dot{Na}, \dot{K}).$$

$$(\dot{Na}, \dot{K})\ {}^{2}\dddot{Si} + 2\ \dddot{\text{Al}}\ \dddot{Si}.$$

Silica, 44; Soda, 17; Potash, 5; Alumina, 34.

84.—NEPHELINE AND AUGITE, eroded and rounded crystals in limestone.

85.—NEPHELINE, with *mica* and *augite.*

86.—NEPHELINE, with *granular augite.*

87.—NEPHELINE, transparent crystals in *augitic lava*, with *augite* and *idocrase*.

88.—NEPHELINE, large crystals, with transparent crystals of *green augite* in limestone.

UPPER GALLERY. — Table-case A. in Recess 4.

FELSPAR (*silicate of potash and alumina*).

$$\dot{K}\,\dddot{Si} + \dddot{\bar{Al}}\,\dddot{Si}^{3}.$$

Silica, 65 ; Potash, 17 ; Alumina, 18.

89.—ICE SPAR (*glassy felspar*), with *green augite* and *mica*.

90.—LAVA, with crystals of *glassy felspar*.—*Fossa Grande*.

91.—LAVA, with crystals of *augite* and *leucite*, and small sphærulitic masses of *obsidian* (*impure felspar or volcanic glass*).

92.—LAVA, with crystals of *felspar*, *mica*, *augite*, and *olivine*.

93.—AUGITIC LAVA, with *felspar*, *mica*, and *epidote*.

94.—LAVA, with *felspar*, *black mica*, and *augite*.

95.—AUGITIC LAVA, with *black mica* and *felspar*.

96.—AUGITIC LAVA, with crystals of *black mica* and *meionite*.—*S. Anastasia di Somma*.

97.—AUGITE, *idocrase* and *mica*.

98.—AUGITIC LAVA, with *black mica* and *felspar*.

99.—GREEN AUGITE, with *mica* crystals.—*Monte Somma*.

MEIONITE ; *Vesuvian Scapolite* (*silicate of lime and alumina*).

$$\dot{Ca}^{3}\dddot{Si} + 2\,\dddot{\bar{Al}}\,\dddot{Si}.$$

Silica, 42 ; Alumina, 32 ; Lime 26.

100 to 111.—Various specimens of MEIONITE in limestone, from Monte Somma. The clouded and rounded masses form the variety "NUTALLITE" of Brooke, which is distinguished by its inferior hardness.

UPPER GALLERY.
Table-case A. in Recess 4.

IDOCRASE ; *Vesuvian* (*silicate of alumina and lime*).

$$\dot{R}^3 \overset{\cdots}{Si} + \overset{\cdots}{\underline{R}} \overset{\cdots}{Si} \text{ where } R = (\dot{Fe}, \dot{Ca}, \dot{Mg}, \dot{Mn})\ \&$$

Silica, 39; Alumina, 23 ; Lime, 29 to 36 ; Protoxide of Iron, 0·30.

112.—BROWN IDOCRASE, with *augite* and *mica.*

113.—IDOCRASE, with *felspar, augite*, and *mica.*

114.—REDDISH-YELLOW IDOCRASE, with *felspar.*

115.—YELLOW IDOCRASE, with *felspar, mica*, and *augite.*

116.—IDOCRASE, with *augite* and *nepheline* in limestone.

117.—IDOCRASE in rounded crystals, with *mica* and *meionite.*

118.—MEIONITE and *idocrase* on limestone.—*Monte Somma.*

OLIVINE (*silicate of magnesia, and protoxide of iron, with variable quantities of lime and protoxide of manganese*).

$$\dot{R}^3 \overset{\cdots}{Si}.$$

119.—OLIVINE, filling the hollows of a vesicular lava.

120.—GREEN OLIVINE, with granular *green augite.*

121.—VESICULAR LAVA, with acicular *hornblende crystals.*

MICA ; *Biotite* (*silicate of magnesia, potash, peroxide of iron and alumina.*)

$$\dot{R}^3 \overset{\cdots}{Si} + \overset{\cdots}{\underline{R}} \overset{\cdots}{Si}$$

122.—Crystals of *greenish-black mica* much eroded.

123.—Small *mica crystals*, with *augite* in limestone.

124.—MICA CRYSTALS, with *chondrodite* (*silicate of magnesia*) in limestone.

125.—LAVA, with *augite* crystals and a little *chondrodite.—Capo di Guoglio.*

126.—*Similar specimen* from the same locality.

UPPER GALLERY.
Table-case A. in Recess 4.

ZEOLITIC MINERALS.

(*Hydrous silicates not containing magnesia*).

127.—VESICULAR LAVA, with crystals of *Phillipsite* (*hydrous silicate of lime, potash, and alumina*).

128.—AMYGDALOIDAL LAVA, the vesicles mostly empty, some containing a little *Phillipsite.*

129.—PHILLIPSITE, cruciform macled crystals in *amygdaloid.*

130.—VESICULAR LAVA, with crystals of *analcime* (*hydrous silicate of soda and alumina*).—*S. Anastasia di Somma.*

131.—LAVA, with crystals of *laumonite* (*hydrous silicate of lime and alumina*) *and mica.*

132.—VESICULAR LAVA, with crystals of *aragonite* (*prismatic carbonate of lime*).

133.—CALCAREOUS BRECCIA, with fragments of green *altered limestone.*—*Monte di Ottajano.*

134.—VOLCANIC ASHES, with included fragments of limestone.—*Monte Somma.*

135.—Soft granular WHITE LIMESTONE.—*Fossa Grande.*

136.—WHITE LIMESTONE, similar to the last, but harder.

137.—WHITE LIMESTONE, like 136.

138.—CHRYROPRASE (*light green amorphous quartz*).

139.—FIBROUS GYPSUM, coating *lava.*

140.—Similar specimens to 138.

141.—TRACHYTIC LAVA, with crystals of *felspar* (*ryacolite*), from the *Solfatara,* near Naples.

142.—Soft SILICEOUS SINTER, from the *Solfatara.*

143 and 144.—PITCHSTONE PORPHYRY, ***obsidian,*** with embedded crystals of *glassy felspar,* from the *Island of Ischia.*

145.—GRANITE (*quartz,* white and red *felspar,* and black *mica*), from *Montagna di Castellamare,* near Naples.

146.—NITRE OF NITRATE OF POTASH (Sal-ammoniac), on Scoriacious Lava. (*Nitric acid* 53·54, ***Potash*** 46·46.) From the eruption of February 1850.

147.—DIMORPHINE.—(Sulphur 24·55, Arsenic 75·45.) From a fumarole of the *Solfatara, Phlegræan fields,* near *Naples.*

UPPER GALLERY.

Wall-case 4.

Wall-case 4.

IGNEOUS ROCKS OF WALES AND SHROPSHIRE.

ARRANGED BY A. C. RAMSAY.

INTRODUCTORY REMARKS.

The specimens in this case illustrate the igneous rocks of the Cambrian and Lower Silurian region of Wales and Shropshire.—The sections at the top of **Cases 3, 4, and 5** show the manner in which these rocks are associated with the strata. Each section has a title showing the country it traverses. The rest of the writing indicates the names, places, and, in some degree, the nature of the different kinds of rocks that form a great part of Wales, &c. A careful inspection of these sections, with a little knowledge and, thought, will show the order of superposition of the different stratified masses that compose the country.

The *Cambrian rocks lie at the base of all*, and are coloured *grey*. (Sections **1, 4, and 6** on the left, and **5** on the right.)

The *Lower Silurian rocks* succeed these, and consist at the base of Lingula beds, above which lie the Llandeilo flags, and these are succeeded by the Caradoc or Bala beds. All of them are coloured *light purple* except the *Bala limestone* marked by a thin streak of *blue*. These *Lower Silurian beds* form the great mass of the country traversed by the sections, and *in* them, are all the volcanic rocks interbedded or contemporaneous with the Lower Silurian rocks of Wales.

The Upper Silurian rocks are coloured *dark purple*, and lie quite *uncomformably* on the older strata. (Sections **2, 3, 5, and 6.**) The former in Shropshire and Wales *are always destitute of igneous rocks*, and were deposited long after the cessation of the volcanic eruptions that marked the Lower Silurian epoch.

The IGNEOUS ROCKS are of two kinds, *eruptive* and *contemporaneous*. By *eruptive* is meant *those bosses, dykes,*

&c., not surface lavas, that have been forced in a melted condition from below among the other rocks, or may even consist of parts of strata amid which they lie, that have themselves been melted. The word *contemporaneous,* applied to igneous rocks, means, that, according to their nature, *they were poured out as lavas, or showered abroad as ashes,* in general terms, *contemporaneously with the formation of the* strata amid which they immediately lie. Volcanic ashes or tuffas are truly stratified deposits, and lava-flows may also in a measure be spoken of as strata, in the sense that they are *inter-bedded.* UPPER GALLERY. — Wall-case 4.

The *eruptive rocks* of the sections are of two chief kinds :—

1st. FELSPATHIC AND QUARTZ PORPHYRIES AND SYENITE.

2nd. GREENSTONES.

The first are coloured deep scarlet (Sections **1, 4, and 8**). Their nature will be seen by referring to the specimens in **Case 4.** *Numbers corresponding to those on the specimens are written on the sections above the masses of rock from which the specimens were derived.*

117.—*Syenite.* See Section **4.**

124, 184, and 185.—*Quartz porphyry.* See Sections **1 and 4.**

These and others of like nature occur in large masses, the strata adjoining them being altered all round. (Section **4,** and specimens 186 to 191.) In the sections (**No. 1 and 4**) four of these masses lie among the Cambrian, and three among the Lower Silurian rocks. Many others occur in Wales not crossed by any of the sections. Their structure, mode of occurrence, and the effects they produce, show that those parts of them we now see, being melted ; *cooled, and consolidated deep beneath the surface,* that is to say, that *the surfaces now exposed were originally covered up by great and thick masses of overlying rocks, which have since been removed by denudation,* or in other words by the gradual stripping away of such overlying masses by atmospheric and various watery agencies.

UPPER GALLERY.—V. Wall-case 4.

The *greenstones* are coloured *deep crimson*, and appear in all the sections, breaking indiscriminately through the Lower Silurian strata, and sometimes through the associated inter-bedded igneous rocks. *They are all composed of felspar and hornblende*, sometimes somewhat amorphous or indistinctly crystallized (specimens 152, 164, &c.), at other times well crystallized, as in 118, 119, 182, &c. *These*, and others of similar kinds, *occur sometimes in great masses*, as in the Breidden Hills (section 3), Corndon Hill (section 5), and Craig-das-Eithen (section 7). In general, however, in Wales and Shropshire, they run in long lines, *many of which have been intruded more or less between the beds* of stratified rocks.—(See *Moel Siabod*, section 1; section 2; *Cynicht and Moelwyn*, section 4; and *Cader Idris*, section 8). In some instances they run for miles directly in the strike of the strata, and then break slightly, or in other cases quite suddenly, across it. It is more than doubtful if they are ever truly *contemporaneous*, one proof of which is, that the slates or other beds which they pierce, are found to be alike altered at their points of contact *both with the under and upper surface of the greenstone.* Had the greenstones been poured out on ordinary sediments they might have altered the sedimentary surfaces over which they flowed, but being cooled, the muddy sediments, which fell on the upper surfaces of the lavas, would remain unaltered. This is the case with all the truly bedded felspathic traps, afterwards to be mentioned. Another proof of the intrusive character of the greenstones is that they frequently branch. They are often columnar, the columns lying at right angles to the dip of the rock. In the district under review they never penetrate the Upper Silurian strata, and as they generally partake of the curves or contortions that affect all the rocks of Wales, it is inferred that they were injected amid the beds before the disturbances took place that produced the sweeping undulations of the strata. (See sections named above.)

The *contemporaneous igneous rocks* of the district are also of two kinds.

UPPER GALLERY. Wall-case 4.

1st. FELSPATHIC PORPHYRIES OR LAVA BEDS.

2nd. FELSPATHIC AND CALCAREOUS VOLCANIC ASHES.

The first are coloured light vermilion. The specimens from Nos. 94 to 110 are characteristic of this class of rocks, especially those from 97 to 101. In 97 the *porphyritic* character is well exhibited, small crystals of yellow felspar being set in a dark blue base. 98 shows the *scoriaceous surface* of an old lava bed, and 100 and 101 the streaked and tortuous structure incident to the flowing of *viscous substances.* The manner in which they are associated with the other rocks is especially well shown in sections Nos. 1, 4 and 7, in the heights of the Y Garw and Y Glyder-fawr, on Snowdon and Moel-wyn, and on Y Dduallt and Aran Mowddwy. They lie perfectly interbedded among the slaty and gritty strata and partake of all their curves, showing that, long after the formation of sedimentary and igneous rocks they have been disturbed together. (See section No. 1. Y Garw and Y Glyder-fawr, and No. 4 Snowdon and Moel-wyn.) *Under* each bed of *felspathic trap the slate or grit is altered*, that is to say, it is hardened, and, as it were, porcelainised or baked, and *above* each lava-bed the stratum is in its ordinary condition, proving that the lava flowed over the under stratum in a melted condition, and that after, or during the process of cooling, the upper sediments were deposited upon it. The strata amid which these felspathic traps lie are charged with ordinary Lower Silurian fossils (see the horizontal cases in the gallery below), and this indicates that the Silurian volcanos of the time in this area were partly submarine, or, at all events, that, being volcanic islands rising in the midst of the ocean, many beds of lava flowed far into the sea.

FELSPATHIC AND CALCAREOUS VOLCANIC ASHES OR TUFFAS are associated with the other rocks. They are coloured vermilion in the sections, of a paler hue than the felspathic traps, and when calcareous, or when they contain much ordinary sediment, they are streaked with blue and light purple. The specimens Nos. 5 to 71 will give an idea of

UPPER GALLERY. — Wall-case 4.

their structure. Nos. 5, 9, 18, 21, 26, 31, 33, 69, and 71 are eminently typical kinds.

5 shows the ***bedded character.***

9 shows the ***porphyritic character.***

18 shows the ***porphyritic character*** partly decomposed.

21 shows the ***porphyritic compact*** nature of the rock.

26 shows the *porphyritic* character, with ***scales of slate*** associated.

31 shows the ***scoriaceous*** character.

33 shows the ***scoriaceous*** character somewhat ***conglomeratic.***

69 and 71 show *brecciated* and also *porphyritic* structures.

The relation of the ashes to the other rocks is especially well shown in section No. **2**, between Castell and Little Hill; in No. **3**, on the right of the Breidden Hills; in No. **4**, on the top of Snowdon; in various streaks in No. **5**, on both sides of Corndon Hill; in No. **6**, on the Carneddau; in No. **7**, between Y Dduallt and Careg Aderyn, and on the left of the felspathic trap that forms the summit of Aran Mowddwy; in No. **8**, on the left of Cader Idris, beneath the felspathic trap in the hollow of Llyn-y-Gader, and in No. **9** between the top of Arenig-fawr and the road to Tyn-y-Mynydd. It will be seen that *they are marked as perfectly stratified. Rarely they contain fossils.* Under the traps of Cader Idris and Aran Mowddwy they are chiefly felspathic, sometimes brecciated and conglomeratic, and occasionally calcareous. They are much intermingled with ordinary slaty sediments, as might be expected of volcanic ashes showered into Silurian seas. On *Aran Mowddwy* and *Cader Idris they are about 2.500 feet thick, the accumulated result of many eruptions.* Passing northward they thin entirely away. On the left side of Arenig-fawr (section **9**) the trap marked 98 is the equivalent of that marked 94 and 97 on the Aran Mowddwy and Y Dduallt section (**7**). There is no ash *under* 98; it has thinned out; but there are other ashes of later date *above* 98 forming the summit of the mountain.

The porphyritic traps, ashes, and conglomerates of Moelwyn (section 4) are the general equivalents of those of Aran Mowddwy and Y Dduallt. They consist of felspathic porphyritic lavas, and volcanic conglomerates and ashes, dipping north at angles of about 45°. The fossils of the ordinary stratified rocks in which they immediately lie belong to the *Llandeilo group*, and the overlying slaty rocks of Cynicht, &c., to the *Caradoc or Bala series*, on a high part of which an *outlier* of felspathic porphyry rests to the right of Nant-y-Mor. *This outlier belongs to the felspathic rocks of Snowdon, which are, therefore, of much later geological date than the similar rocks of Moelwyn* and *Aran Mowddwy.* UPPER GALLERY. — Wall-case 4.

The Snowdon trap lies on highly fossiliferous sandstones, and the solid mass that forms the base of Snowdon splits into several large divisions as it passes northward to Y Glyder-fawr (section 1). The Snowdon mass is, therefore, the result of several eruptions. On the top of the mountain are ashes, sometimes very solid and felspathic, at other places mixed with calcareous impurities and fossiliferous.

As a whole, *the North Wales rocks show two principal epochs of eruption, the first indicated by the rocks of Aran Mowddwy (section 7), Cader Idris (section 8), Arenig (section 9), and Moelwyn; the second, by Snowdon (section 4) and Y Glyder-fawr (section 1).* In No. 4 both sets occur in the same section, showing a clear order of superposition. It is worthy of remark, that the interbedded felspathic igneous rocks of Moelwyn, dipping under the rocks of Cynicht and Snowdon on the south, do not rise on the north side of the Snowdon synclical axis (or basin) between the higher part of the mountain and the Cambrian rocks near Y Tryfau. The older interbedded igneous rocks, therefore, thin out between Moelwyn and Snowdon deep under the surface. (See section 4.)

The *eruptive* felspathic and quartz porphyries and syenites (see p. 203) always lie amid rocks deep under or of older date than the *contemporaneous* felspathic traps

UPPER GALLERY. — Wall-case 4.

and ashes, and it is probable that they indicate parts of great masses of deep-seated melted matter or volcanic centres, that lay much deeper than the craters, but from which the melted rocks and ashes proceeded that were ejected from these vents. As they now stand, these bosses have only been exposed by denudation long after the disturbance of all the rocks of the country.

Though all these rocks are volcanic, or connected with volcanic action, *it is not to be supposed that any true traces of volcanic craters now remain.* The whole country has been so much disturbed by subsequent contortion of that part of the crust of the earth, and it has been besides so long and so often subject to denudation, that nothing now remains but fragments of great lava streams and beds of ashes, sometimes *cropping out* and spreading over considerable areas, but in general showing little more than their edges, the sections of volcanic areas, their major portions being continued beneath thousands of feet of overlying slates and sandstones under which they lie buried.—A. C. Ramsay.

Catalogue of Specimens by A. C. Ramsay, assisted by Hilary Bauerman.

Cader Idris, Aran, Arenig and Moelwyn Series.

1.—Slate, with talcose and felspathic slaty bands, consisting of alternations of *purple slate* with greenish-grey *felspathic sediment.*—Y-Graig-wen, Dinas Mowddwy, Merionethshire. Map 60, N.W. In this specimen the felspathic bands predominate.

The slaty band from which it is derived occurs in the midst of a great mass of felspathic lava. The rock is affected by cleavage, and the layers of which it is composed being of various degrees of fineness, the cleavage and fracture are coarse and irregular. The bedding and cleavage form an angle of about 30°.

2.—Talcose and felspathic slaty beds, dark greenish-grey, with black layers separating the different kinds of sediment.—Half a mile from Pant-yr-onen, 1 mile south of Dolgelli, Merionethshire. Map. 59, N.E.

UPPER GALLERY — Wall-case 4

From the upper part of the Lingula flags, composed principally of consolidated fine *felspathic sediment*, interstratified with what were originally *black muddy layers*. The felspathic part is possibly chiefly of volcanic origin direct or re-arranged. The rock is cleaved nearly at right angles to the planes of bedding. The outer surface is irregularly weathered, the purer felspathic layers having been most easily decomposed.

3.—TALCOSE AND FELSPATHIC SLATY BEDS. — Near Dolgelli, Merionethshire. Map 59, N.E. Light greenish-grey *felspathic matter* irregularly cleaved, with included *concretionary felspathic spheroids*.

From the uppermost part of the Lingula flags or base of the Llandeilo beds, underlying the thick ashy strata on the north slope of Cader Idris. Principally formed of consolidated *felspathic dust and talc*, subsequently cleaved.

4. — CALCAREOUS, TALCOSE, AND FELSPATHIC SLATY ASHES. — Allt-Lwyd, 4½ miles south of Barmouth, Merionethshire. Map 59, N.E. Dark greenish-grey sediment, with specks and films of black slate; cleavage very imperfect.

From near the top of a great series of thick beds of volcanic ashes which underlie the solid crystalline felspathic trap of Cader Idris, Aran Mowddwy, Arenig, &c. It occurs about the junction of the Llandeilo and Caradoc or Bala beds.

5.—COMPACT FELSPATHIC ASHES (slightly talcose?) *with cherty layers*.—Mynydd Gader, Dolgelli, Merionethshire. Map 59, N.E. Banded alternations of felspathic and cherty matter; the more purely felspathic layers thin and deeply eroded. Original colour light greenish-grey. Covered on the divisional planes with ferruginous stains.

From the lower part of the above (No. 4). *Principally formed of consolidated felspathic ashy dust or mud.*

Upper Gallery. Wall-case 4.

6.—Compact, BRECCIATED FELSPATHIC ASHES, slightly talcose.—Mynydd Gader, Dolgelli, Merionethshire. Map 59, N.E. Light greenish-grey felspathic substance, with included felspathic and grey cherty fragments. Weathers grey, and assumes a brecciated appearance on the weathered surface.

From the same strata as No. 5.

7.—BRECCIATED FELSPATHIC ASH, slightly talcose.—Mynydd Gader, Dolgelli, Merionethshire. Map 59, N.E. Similar in composition and colour to No. 6, but of a finer structure. The brecciated structure is chiefly shown on weathered surfaces.

From the same strata as Nos. 5 and 6.

8. — COMPACT FELSPATHIC ASHES, *talcose*. — Mynydd Gader, Dolgelli, Merionethshire. Map 59, N.E. Varying from a finely granular to a compact structure. Reddish or brownish-grey, weathering to a light greenish-grey.

From the same strata as Nos. 5, 6, and 7.

9.—*Calcareous* FELSPATHIC PORPHYRITIC ASHES, *talcose*. —Llyn Aran, Cader Idris, near Dolgelli, Merionethshire. Map 59, N.E. Consisting principally of entire and broken crystals of *felspar* embedded in a talcose and felspathic base, and including filmy layers of *black slate*, slightly calcareous (from infiltration ?). Weathers dark brown; when newly fractured, colour dark bluish-green.

The upper portion of the thick beds of ashes which underlie the crystalline traps of Cader Idris exhibits a mixture of ordinary slaty sediment with felspathic material, which originally consisted of fine volcanic dust and broken crystals of felspar.

The rocks immediately north-west of the Dolgelli and Bala road are repeated by a great fault at the river Wnion, which is a downthrow on the north-west. See section No. 7 above. This fault passes from the neighbourhood of Dolgelli by the Bala road through Bala lake, repeating the rocks of the Cader Idris and Aran range in the manner shown in the section.

UPPER GALLERY.

Wall-case [illegible].

10.—FELSPATHIC SANDY AND SLATY BEDS, ***black slaty bands***, interstratified with ***dark grey felspathic layers***, which are unequally affected by cleavage.—Moel Offrwm, near Dolgelli, Merionethshire. Map 75, S.E.

This and the rocks up to No. 13 are from the geological equivalents of the lower part of the thick beds of ashes which underlie the crystalline felspathic trap of Cader Idris. On Moel Offrwm the tuffas are mixed with a large quantity of ordinary slaty and sandy sediment.

11.—*Highly indurated* FELSPATHIC SANDSTONE.—Moel Offrwm, near Dolgelli, Merionethshire. Dark blackish-green finely granular rock, with a flat conchoidal fracture. Weathers to dark brown.

From the same beds as No. 10.

12.—*Sandy* FELSPATHIC AND TALCOSE LAYERS alternating with purer felspathic bands. Fresh fracture grey, but weathers white and pale yellow.—Moel Offrwm, near Dolgelli, Merionethshire.

From the same beds as Nos. 10 and 11.

13.—FELSPATHIC AND PORPHYRITIC ASHES.—Y Wenalt, 6 miles south-west of Bala, Merionethshire. Map 74, S.W. *Grey felspathic base*, including light grey elongated *felspathic fragments.*

From a bed *overlying* the felspathic porphyry of Y Graig and Arenig. This porphyry is the same bed as that of Aran Mowddwy, but separated from it by the great Bala fault. These ashes do not occur above the felspathic porphyry on the Aran Mowddwy range. They extend from Y Graig, 8 miles south-west of Bala to the river Machno, near Llyn Conwy, a distance of 13 miles.

14.—BRECCIATED CONGLOMERATE *and felspathic sandstone.*—Arenig, Merionethshire. Map 74, S.W. Light brown rock, consisting of alternations of sandy and fine brecciated felspathic fragments. The *upper* and *lower* parts are finely laminated, and include a thin band of fine breccia.

Upper Gallery. — Wall-case 4.

This specimen shows three different conditions of mechanical deposition, and is less purely ashy than the immediately preceding specimens.

15.—Decomposing felspathic ash.—East side of Y Graig, Merionethshire, 8 miles south-west of Bala. Map 74. Light yellowish-grey, with cavities resulting from the decomposition of crystals of *felspar*, which are partly filled with ochreous matter.

16.—Felspathic and talcose ashes.—Moel-y-Menyn, 2 miles south-south-east of Arenig, Merionethshire. Light grey rock, with imperfect cleavage. Weathers to a light brown colour on the joints. *Emits a strong argillaceous odour.*

17.—Decomposing felspathic ashes.—Top of Arenig, Merionethshire. Yellowish felspathic rocks, with cavities produced by the removal of decomposed crystals of *felspar*, which are replaced by ochreous matter. Weathers very irregularly of a light greenish-grey colour. *Emits a slight argillaceous odour.*

These beds form the top of Arenig-fawr. (See section No. 9, above.) They are often largely and distinctly bedded, but sometimes much jointed and massive, and also, when undecomposed, so much resemble the melted traps that for short spaces they are not easily separated. Frequently they are porphyritic, even where most distinctly bedded. (See also 20 and 21.)

18.—Porphyritic felspathic ashes (*decomposing*).—Mynydd Nodol, five miles west-north-west of Bala, Merionethshire. Grey felspathic rock, with white specks and patches of *decomposing felspar*. Weathers of a light brown colour. *Emits a strong argillaceous odour.*

This specimen is from the same set of thick ashy beds that form the Arenig, &c. See description of No. 13.

19.—*Thin bedded, compact,* GREENISH-GREY ASHES, slightly porphyritic ; weathering light brown. East side of Y Graig, about eight miles south-west of Bala, Merionethshire. *Consolidated fine felspathic dust.*

This and the two following specimens are from parts of the highest beds of this volcanic series.

20.—COMPACT FELSPATHIC ASHES.—Top beds on the east slope of Arenig, Merionethshire. Dark grey, finely laminated felspathic rock. Weathers light grey or brownish-black.

21.—BEDDED FELSPATHIC PORPHYRY.—Llyn Arenig, Merionethshire. Compact, dark greenish-grey rock, with small embedded crystals of *felspar* and grey *felspathic and cherty fragments.* Weathers very unequally, the included fragments projecting from the surface.

In hand specimens, this rock might be mistaken for a porphyry that had been melted. On the spot its bedded character tells its true origin.

22.—PORPHYRITIC ASHES, *calcareous* and *felspathic.*—West of Moel Llyfn-nant, Merionethshire. Map 75, S.E. *Slightly talcose.* Fragmentary crystals of *felspar, with slaty particles* included in a felspathic base. Weathers to a dark blackish-brown.

From the same beds as Nos. 5 to 9. It resembles No. 9. The crystals of felspar were probably originally showered out in a broken state and mixed with felspathic dusty sediment.

23.—TALCOSE SLATY BEDS.—Bright green, talcose, slaty beds, cleaved with blue slaty alternations, intersected by *veins of calcite.* This specimen is filled with small brilliant crystals of *iron pyrites.* This and similar beds pass gradually into felspathic ashes. Maps 75, N.E., and 74, N.W., S.W.

Diffwys slate quarry, north of Ffestiniog, Merionethshire. This bed, and several others with which it is associated, are exceedingly thin in the neighbourhood of the slate quarries, and thin away entirely a little further west. Eastwards they gradually thicken, and their equivalents swell out into the great masses that run from Llyn Conwy to the Arenigs.

24.—FELSPATHIC ASH, TALCOSE AND SILICEOUS.—Between

UPPER GALLERY. — Wall-case 4.

Tan-y-Grisiau and Cwm Orthin; Ffestiniog, Merionethshire. Map 75, N.E. See 24, section 4 above. Brownish-grey rock, mottled with black, showing a coarse slaty structure; bleached and partly decomposed on the outer surface. These rocks sometimes pass into well-marked felspathic ashes, and sometimes into fossiliferous sandstones, equivalent to the base of the Llandeilo beds. In places they also assume the appearance of rocks termed Variolite.

24a.—THE SAME ROCK, *pounded and fused in a furnace.* It has the general appearance of *obsidian*, but is vesicular and spherulitic. See No. 138, **Wall-case 1,** and also 30, **Wall-case 2,** where the same general structure is shown in obsidian, from Ascension.

25.—FELSPATHIC AND TALCOSE BEDS.—South-east of Cwm Orthin Lake, Ffestiniog, Merionethshire. Map 75, N.E. Very *compact bands* of grey, dark green, and black *felspathic sediment*, the surfaces of the bed soft, and coated with talcose slate, showing ripple marks. It belongs to the same set of rocks as No. 24.

26.—CALCAREOUS FELSPATHIC ASH, TALCOSE, imperfectly PORPHYRITIC.—South east end of Cwm Orthin Lake, Ffestiniog, Merionethshire. Map 75, N.E. Blackish-grey, with *white crystals and fragments of felspar*, and scales and short layers of black slate interspersed; rudely laminated. Crossed by section above, No. 4, near No. 26.

SNOWDON SERIES AND THEIR EQUIVALENTS.

27.—FELSPATHIC SANDY AND SLATY CALCAREOUS BEDS. —Snowdon, Caernarvonshire. Map 75, N.E. *Somewhat ashy.* Alternations of blue slaty and brownish-grey sandy beds, the latter full of small cavities on the weathered surfaces. The cavities probably formed by the decomposition of lime, originally derived from fossils.

28.—SANDY VOLCANIC ASH.—North side of Crib Goch, Snowdon, Caernarvonshire. Map 75, N.E. Alternations of grey and bluish-grey sandy calcareous sediment, weathering brownish; shows a coarse slaty cleavage. From the same beds as 27.

29.—SANDY CALCAREOUS ASH.—Crib Goch, Snowdon, Caernarvonshire. Map 75, N.E. Finely-bedded bluish-grey sandy calcareous sediment; weathers in bands unequally. Contains small interspersed crystals of iron pyrites. Freshly broken surfaces show a slaty lamination.

30.—CALCAREOUS ASH.—North-east end of Llyn Llydaw, Snowdon, Caernarvonshire. Map 75, N.E. Dark, blackish-grey, very calcareous rock. Weathers black, with an irregular honeycomb surface, caused by decomposition of the contained lime. Slightly laminated, and hard, and brittle.

31.—SCORIACEOUS FELSPATHIC AND CALCAREOUS ASH.—Crib Goch, Snowdon, Llanberis, Caernarvonshire. Map 75, N.E. Bluish-grey felspathic sediment, with a little calcareous cement; weathers very unequally, exhibiting the rough scoriaceous surface.

32.—BRECCIATED FELSPATHIC ASH.—Clogwyn du'r Arddu, Snowdon, Caernarvonshire. Map 75, N.E. Greenish-grey felspathic sediment, with included angular felspathic fragments, which project on the weathered surface.

33.—VOLCANIC ASH.—Dolwyddelan, Caernarvonshire.—Map 75, N.E. Dark greenish *brecciated and scoriaceous-looking*, enclosing rough angular, and a few rounded felspathic fragments. Hard and brittle.

34.—FELSPATHIC ASHY BRECCIA.—Castell Cader Dinmael, 3 miles south-east of Cerrig-y-Druidion, Merionethshire. Map 74, N.W. Roughly bedded, dark-grey rock, with small included fragments of grey felspathic substances. Weathers brownish-grey.

35.—FELSPATHIC BRECCIA.—Same locality as 34. Light grey rock, made up of angular felspathic porphyritic fragments, imbedded in a felspathic base, containing crystals of *felspar*. Bleached and weathered surface, very irregularly eroded, and covered with ferruginous stains.

36.—FELSPATHIC SEDIMENT.—Same locality as 35. Dark greenish-grey, with fragments of black sandy slate, and

UPPER GALLERY. — Wall-case 4.

fragmentary and entire crystals of white, brown, or yellow felspar, some much decomposed. The specimen has a coarse slaty structure, and gives a strong argillaceous odour.

The mechanical origin of this rock is very apparent, the crystals being mechanically imbedded in felspathic and slaty sediment, containing a few grains of quartz.

37.—SANDY FELSPATHIC ASH.—Same locality. Similar to the last, but of a lighter colour, with large fragments of included rock, and numerous broken and entire crystals of felspar; also contains impressions of fossils (*Orthis*), the lime of which has been carried away in solution by the percolation of rain water. The fossils in this specimen, embedded along with felspar crystals, prove the mechanical origin of the rock.

38.—FELSPATHIC ASH.—Craig Gwel, Montgomeryshire, 8 miles south-east of Bala. Map 74, S.W. *Greenish-grey felspathic sediment*, with black slaty specks and particles. Weathers greyish-white.

39.—PORPHYRITIC FELSPATHIC GRIT.—Llechrydau, 5 miles south of Llangollen, Montgomeryshire. Map 74, S.E. Yellowish-brown sediment, with fragments and crystals of *white and red felspar*, some very much decomposed; gives out an earthy odour.

This is the equivalent of the lower ashy beds that underlies the Bala limestone near Bala, and they are probably continuous underground in the synclinal curve that lies between the Bala country and the Berwyn hills.

The specimens from Nos. 27 to 39 are all from one set of rocks, viz., the tuffaceous or ashy rocks that lie on the felspathic traps (lava beds) of Snowdon, Moel Hebog, near Beddgelert, in the valley above Cwm Idwal, between Y Glyder-fawr and Y Garn, and in the valley of Dolwyddelan. These ashes are sometimes so purely felspathic and porphyritic, that it is difficult (except for the bedding) to distinguish them from felspathic porphyries that have been ejected as lavas; but the greater mass on and around Snowdon is rough and scoriaceous-looking (near Llyn Llydaw), or sometimes sandy, slaty, and calcareous, according as the volcanic tuffas were variously intermingled with ordinary sediment. Their uppermost part, on Snowdon, and in the outlier of Dolwyddelan, is the equivalent of the Bala limestone, which, even near Bala, is sometimes ashy in structure. The ashy beds on Snowdon, &c., in places, contain Bala fossils. They are about 1,000 feet thick on Snowdon, (see section above, No. 4;) but ranging east to Dollwyddelan, and from thence by Cerrig-y-Druidion to the neighbourhood of Bala, and on the north and west flanks of the Berwyn hills, they gradually thin out, and, with the rest of the Snowdon igneous rocks, they finally disappear a few miles south of Bala lake. The meaning of this is, that in the middle of the period when the Bala beds were formed, the area of what is now Caernarvonshire was the centre of a volcanic district, which did not extend far to the south.

39a and 39b.—The same, fused in a common air furnace.

40.—CONCRETIONARY FELSPATHIC ASH. — Pen-y-rhiw, three quarters of a mile north-west of Bala, Merionethshire. Map 74, N.W. Felspathic layers, much decomposed, and containing ochrey particles, alternating with felspathic concretions.

41.—BRECCIATED VOLCANIC CONGLOMERATE AND GRIT.— Three quarters of a mile W. by S. of Pwllheli, Caernarvonshire. Map 75, S.W. Alternations of fine and coarse volcanic breccia and grit. Greenish, with pebbles of greenish and black chert and jasper.

ASHY SERIES OF THE LLANDEILO FLAGS, BREIDDEN HILLS MONTGOMERYSHIRE. MAP 60, N.E., SECTION NO. 3 ABOVE.

42.—COMPACT FELSPATHIC PORPHYRITIC ASH.—Breidden Hills, Montgomeryshire. Dark and greenish-grey granular felspathic rock, with small brilliant felspar crystals interspersed.

These bedded igneous rocks lie in the Llandeilo flag series, and are probably the general equivalents of some of

UPPER GALLERY. — Wall-case

the higher igneous rocks that lie in the Llandeilo rocks between the Stiper stones and Chirbury, from four to six miles east of Montgomery.

43.—FELSPATHIC ASH.—Moel-y-Golfa, Breidden Hill, Montgomeryshire. White compact felspathic rock, with green chloritic particles interspersed; weathers to white earth (Kaolin); gives out a strong argillaceous odour. From the same set of rocks as No. 42.

44.—FELSPATHIC CONGLOMERATE.—Moel-y-Golfa, Breidden Hill, Montgomeryshire. Greenish-grey felspathic sediment, with rounded fragments of felspathic porphyritic rocks, and crystals of glassy felspar.

This specimen very much resembles the ashy rocks (No. 63) of Marrington Dingle, near Chirbury (Map 60, S.E.), and is probably a continuation of one of the Marrington beds, repeated in a synclinal curve of Llandeilo flags, underneath the Upper Silurian rocks of the Long Mountain.

45.—ASHY BRECCIA AND CONGLOMERATE.—Breidden Hills, Montgomeryshire. Large, angular, and rounded fragments of porphyritic and other rocks in an argillaceous and highly calcareous cement. Gives out a strong argillaceous odour.

Some of the embedded fragments appear to have been well rounded and water-worn on the sea shore. They have sometimes been found crusted with Silurian corals.

46.—FELSPATHIC AND PUMICEOUS BRECCIA.—Breidden Hill, Montgomeryshire. Dark blackish-grey, with white angular felspathic fragments and pumiceous fragments included. Odour slightly argillaceous.

Some of the felspathic fragments in this locality appear as if they had been ejected in the form of pumice stone.

ASHY SERIES OF THE LLANDEILO FLAGS BETWEEN THE STIPER STONES AND CHIRBURY, SHROPSHIRE, AND OF MONTGOMERYSHIRE. Maps 60, N.E. and S.E., and Horizontal Sections, Sheets, No. 32, 34, and 36.

47.—FELSPATHIC ASH TALCOSE.—Disgwylfa Hill, 3 miles north of Bishops Castle, Shropshire. Map 60, S.E.

Greenish-grey slaty rock, with talcose matter, and calcareous particles giving it an amygdaloidal appearance.

UPPER GALLERY. — Wall-case 4.

48.—COMPACT SANDY FELSPATHIC ASH.—Disgwylfa Hill, near Bishops Castle, Shropshire. Dark greenish-grey felspathic sediment, close-grained, with a few broken crystals and grains of silica.

49.—FINE FELSPATHIC TUFA.—Disgwylfa, near Bishops Castle. Map 60, S.E. Soft brownish-grey felspathic and argillaceous sediment, with yellow-brown patches of decomposing felspar crystals ; outer surface very earthy.

50.—FELSPATHIC ASH.—Disgwylfa Hill, near Bishops Castle, Shropshire. Felspathic rock, very compact, made of very fine sediment, marked by lines of concentric weathering.

This rock is composed of exceedingly fine consolidated felspathic volcanic dust.

51.—VERY COMPACT FELSPATHIC ASH.—Yr Ynys, 4 miles north of Bishops Castle, Shropshire. Map 60, S.E. A slightly porphyritic greenish-grey compact rock, with specks and films of black slaty matter, and a few scattered crystals of felspar, very calcareous ; weathers light brown.

52.—VOLCANIC SEDIMENT.—Pitchels, 2½ miles north of Bishops Castle. Brownish-black compact sandy rock, with small fragments and crystals of felspar ; surface weathers to a light brown crust.

The rocks from 47 to 52 lie in bedded lines, very near the base of the Llandeilo flags, west of the Stiper Stones.

53.—FINELY BRECCIATED ROCK, *felspathic* and *porphyritic*, Hyssington, near Bishops Castle, Shropshire. Map 60, S.E. Dark greenish-grey granular felspathic rock, with crystals of felspar and strings of calc spar. From beds of ashes equivalent to 51 and 52, near the base of the Llandeilo flags.

54.—PORPHYRITIC FELSPATHIC ASH.—Brook House, 5 miles north of Bishops Castle, Shropshire. Map 60, S.E. Dark greenish-brown and black rock, with slaty particles and crystals of felspar. Impressions of *fossils* and some

Upper Gallery. — Wall-case 4.

calcareous matter; weathers to a brownish-grey earth. From the same beds as 51 to 52.

55.—Felspathic breccia.—Heath Mynd, 3 miles north of Bishops Castle, Shropshire. Map 60, S.E. Dark greenish-grey compact felspathic rock, with crystals of felspar and cherty fragments included.

56.—Felspathic brecciated ash.—Hyssington, Bishops Castle, Shropshire. Map 60, S.E. Dark bluish-grey rock, with grey felspathic fragments and altered black slate. Contains a good deal of lime. From the same bed as 53.

57.—Felspatho-siliceous sandy ash.—Marrington Dingle, one mile East of Chirbury, Shropshire. Map 60, S.E. Green granular rock, felspathic and siliceous, with large and small fragments of black slate, and angular fragments and crystals of felspar. Slightly calcareous. From the higher beds of the Llandeilo flags west of the Stiper Stones.

58.—Felspathic sandy ash.—Marrington Dingle, south-east of Chirbury, Shropshire. Map 60, S.E. Bluish-grey felspathic fine grained sandstone, with a few calcareous kernels and small angular felspathic fragments. Same beds as 57.

59.—Felspathic sandstone.—Marrington Dingle, east of Chirbury, Shropshire. Map 60, S.E. Variegated light and dark greenish-grey fine grained sandstone, made of fine felspathic grains. Smells rather argillaceous or earthy. Same beds as above.

60.—Felspathic brecciated conglomerate.—Marrington Dingle, as above. Felspathic sandstone matrix, similar in structure to the preceding, containing small angular and subangular fragments of felspathic and porphyritic rocks.

61.—Felspathic sandy ash.—Marrington Dingle, as above. Rock contains fragmentary films of slate, irregularly dispersed in a matrix, similar to Nos. 59 and 60.

62.—Felspathic ashy rock.—Hope Common, between Chirbury and Minsterley, Shropshire. Map 60, N.E.

Chiefly composed of triturated felspar and small dark (hornblendic?) grains, with small crystals of glassy felspar. From the same beds as Nos. 50 to 56, near the lower part of the Llandeilo flags. UPPER GALLERY — Wall-case

63.—SANDY FELSPATHIC ASH.—Marrington Dingle, as above. Light greenish rock, consisting of felspathic grains and broken crystals, similar to those of No. 61, but coarser in texture.

64.—SANDY FELSPATHIC ASH.—The Ridge, 2 miles north-east of Chirbury, Shropshire. Map 60, N.E. Light yellowish-brown sandstone, granular, with fragments of crystallized felspar and impressions of fossils.

65.—FINE CONGLOMERATE.—Hagley, 1 mile E.S.E. of Chirbury, Shropshire. Map 60, S.E. Dark brownish-grey rock made of small fragments of dark felspathic porphyry, and entire and broken crystals of felspar imbedded in a felspathic matrix. Somewhat calcareous.

Same beds as 64, &c.

66.—FELSPATHIC BRECCIA.—North of Maes-isaf Green, near Hyssington, Montgomeryshire. Map 60, S.E. Dark greenish brecciated rock. Felspathic base with angular fragments of green felspathic rock, entire and broken crystals of felspar, and angular fragments of altered siliceous rocks. Slightly calcareous.

From beds of volcanic ash low in the Llandeilo flags.

67.—FELSPATHIC BRECCIA.—The Ridge, 2 miles north-east of Chirbury, Shropshire. Map 60, N.E. Contains fragments of black slate, large fragments of green felspar porphyry, with distinct crystals of felspar, and large grey felspar fragments set in a dark greenish-grey felspathic base.

68.—FELSPATHIC BRECCIA.—The Ridge, 2 miles north-east of Chirbury, Shropshire Map 60, N.E. Decomposing felspathic rock with fragments of slaty rock included, and numerous crystals of felspar.

69.—BRECCIATED FELSPATHIC PORPHYRY.—Rocky bank, 1½ mile north-east of Chirbury, Shropshire. Map 60, N.E. Light greenish-grey rock. Contains many angular felspathic

UPPER GALLERY. — Wall-case 4. fragments, set in a granular felspathic base containing numerous broken and perfect crystals of felspar.

70.—FELSPATHIC BRECCIA.—Hope Common, between Chirbury and Minsterley, Shropshire. Map 60, N.E. Similar in structure to the last, but much darker and less weathered. Contains hard grey felspathic fragments and broken and entire crystals of felspar in a dark green matrix.

47 to 70, as a whole, are specimens of ashy beds which were spread contemporaneously amid the Lower Silurian rocks of the Llandeilo flag series. The slates interstratified with them contain the ordinary Llandeilo flag fossils, and some of the ashy beds are also fossiliferous. They are partly arranged so as to show the passage of fine felspathic ashes into coarse breccias.

Nos. 47 to 56, 62, 66, and 70 are all from a set of ashy beds that lie low in the Llandeilo flags, between the Stiper Stones and the road from Rorrington to the turnpike road, half a mile east of Church Stoke. Maps 60, N.E. and S.E. Nos. 57 to 61, 63 to 65, and 67 to 69, are from higher bands of ash in the same series near Marrington Dingle, Chirbury. These last, in their line of strike, pass gradually from sandstones worked for building purposes, into coarse brecciated and conglomeratic volcanic ashes. The Marrington beds are the equivalents of the eastern ashy igneous ridge of the Breidden Hills. See sections above **No. 3**, 42 to 46, and **No. 5**, 57 to 71.

71.—PORPHYRITIC FELSPATHIC ASH.—Moat by Nant Cribba Hall, 2½ miles north-west of Chirbury, Montgomeryshire. Map 60, N E. Greenish-grey rock. Dark green felspathic base, containing light green and grey fragments of felspar porphyry, and crystals of felspar.

This rock is very similar to, and may be the equivalent of, the volcanic beds of Marrington Dingle, but is not immediately connected with them. It occurs in a small boss, separated from the Chirbury rocks by an intervening tract of Wenlock shale, which rests on the Llandeilo beds unconformably, and in Wales never contains volcanic ashes or lava.

SPECIMENS OF FELSPATHIC SANDSTONES AND ASHES FROM THE LLANDEILO FLAGS, RADNORSHIRE, NEAR BUILTH. Map 56, S.W. and S.E., and Section No. 2, above.

UPPER GALLERY. — Wall-case 4.

72.—SANDY FELSPATHIC ROCK.—Carneddau, Radnorshire; near Builth, Breconshire. Map 56, S.W. Yellowish-brown granular hard felspathic rock, with hard siliceous or cherty bands.

73.—DECOMPOSING FELSPATHIC SANDSTONE.—South-east of Llansaintffraid Church, Radnorshire. Map 56, S.E. Dark brown porous rock, made of broken felspar crystals loosely cemented. Contains fragments of fossils.

72 and 73 are more properly sandstones made from volcanic material, than true ashes. Such rocks, however, in this neighbourhood pass gradually into true felspathic ashes.

74.—FINE FELSPATHIC BRECCIATED ASH.—Range of Carneddau, Radnorshire, near Builth. Map 56, S.W. Breconshire. Light brownish-grey felspathic rock, enclosing angular fragments similar in color and texture to the matrix ; the specimen is apparently bleached.

75.—VOLCANIC CONGLOMERATE.—Carneddau, Radnorshire. Map 56, S.W. Near Builth. Dark brownish-black felspathic rock, chiefly formed of angular fragmentary crystals of felspar, enclosing rounded pebbles, and angular felspathic fragments which project on the weathered surface.

76.—FELSPATHIC BRECCIA.—North end of the Carneddau, Builth, as above. Very hard rock, full of white hard felspathic angular fragments set in a black base.

77.—FELSPATHIC, ASHY, FINE, BRECCIATED ROCK.—Llandegley Mountain, west of "the Rocks," Llandegley, Radnorshire. Map 56, S.E. Brownish-grey rock, with fragments of felspathic and slaty rocks included, and crystals of felspar, and containing fragments of fossils (*Orthis*). These rocks are from the same set of beds with those of the Carneddau and Llansaintffraid, near Builth. They pass from ordinary

UPPER GALLERY. — Wall-case 4.

sandy sediment into decided ashes or tufas, and are frequently fossiliferous.

CAERMARTHENSHIRE.

78.—BRECCIATED FELSPATHIC ASH.—Carn Blaendyffryn, Llangadock, Caermarthenshire, South Wales. Map 41. Brown brecciated rock, containing large decomposing felspathic fragments in a yellowish-brown felspathic base, with fragments of felspar crystals.

From the Llandeilo flags.

PEMBROKESHIRE.

79.—BRECCIATED FELSPATHIC ROCK, interstratified in thick beds with slates of the Llandeilo flag series. Strumble Head, Goodwick, near Fishguard, Pembrokeshire. Map 40.

80.—Fragment of THE SAME, Strumble Head, Goodwick, near Fishguard, Pembrokeshire.

FELSPATHIC PORPHYRIES, &c.—LAVA STREAMS.

SPECIMENS FROM FELSPATHIC LAVA BEDS THAT ARE ASSOCIATED WITH AND CHIEFLY OVERLIE THE VOLCANIC ASHES OF CADER IDRIS AND ARAN MOWDDWY, &c.; *the whole lie near the base of the lowest part of the Llandeilo flags.*

91.—CALCAREOUS AMYGDALOID.—Ridge of Cader Idris, one mile south of Tyn-y-Nant, south-west of Dolgelly, Merionethshire. Map 59, N.E. Green talcose rock, full of kernels of *calc spar*.

This specimen has originally been part of a scoriaceous vesicular mass (a cellular lava like No. 4, **Case 2**), the vesicles of which have afterwards been filled by infiltrations of carbonate of lime. On the surface the lime has subsequently been dissolved out, and it has again become vesicular.

92.—AMYGDALOID.—Buarth Glas, by turnpike road $2\frac{1}{2}$ miles north-west of Dinas Mowddwy, Merionethshire. Map 60, N.W. Blackish-green felspathic rock, with kernels of quartz interspersed.

UPPER GALLERY. Wall-case 4.

This specimen is from the great masses of felspathic porphyries, &c., that overlie the volcanic ashes, No. 1 to 12, of Cader Idris, Aran Mowddwy, Moel Offrwm, &c..

93.—FELSPATHIC TRAP.—Locality as above. Specimen similar to the last. Amygdaloidal substances in part decomposed out of the cavities, which contain calc spar.

94.—FELSPATHIC TRAP.—Top of Aran Mowddwy, Merionethshire. Map 74, S.W., and *horizontal section No.* 28, also section above, No. 7. Compact greenish-grey felspathic rock; weathers white. Continuation of the same set of rocks as 92 and 93.

95.—FELSPATHIC TRAP.—Penmaen, Merionethshire, west of turnpike between Dolgelly and Bala, near the eighth milestone. Map 64, S.W., and *horizontal section No.* 37, *line* 3; also section above, No. 7. Compact greenish felspathic rock; weathers brown.

This is the equivalent of the Aran Mowddwy and Carreg Aderyn rocks, Nos. 94, 95, and 96, repeated by a fault at the river Wnion. Section No. 7.

96.—DECOMPOSING FELSPATHIC TRAP.—Penmaen, Merionethshire, as above. Similar to No. 96, but bleached and porphyritic, from interspersed yellow felspar crystals, partly decomposed.

97.—FELSPATHIC TRAP.—Clogwyn-yr Eglwys, 7 miles south-west of Bala, Arenig range, Merionethshire. Map 74, S.W. Dark bluish-grey porphyritic felspathic rock, with interspersed white crystals of felspar, from same set of traps as above.

This is a good typical specimen of this set of rocks, when freshly fractured and undecomposed.

98.—FELSPATHIC PORPHYRY.—West of Llyn Arenig, 6 miles west of Bala, Merionethshire. Map 74, N.W. Dark greenish felspathic rock, with interspersed crystals and concretions. Felspar shows an irregular scoriaceous surface.

UPPER GALLERY. — Wall-case 4.

From a continuation of the same rocks as No. 97.

99.—FELSPATHIC TRAP.—Quarter of a mile south of Moel-y-Menyn; 6 miles west-south-west of Bala, Merionethshire. Map 74, S.W. Compact dark bluish-grey felspathic rock. Conchoidal fracture. Weathered white to the depth of a quarter of an inch on the exposed faces.

This is also the equivalent of the Aran and Penmaen felspathic trap in its north range, on the west side of the River Wnion or Bala fault (see section above, No. 7); and in this neighbourhood the thick beds of ashes disappear that, further south, underlie these felspathic lavas. From Nos. 91 to 99 the rocks belong to the *lower* set of lavas that lie near the base of the Llandeilo flags, and, associated with many beds of ashes, circle in a crescent form from the neighbourhood of Dolgelli to Tremadoc, including the mountain of Cader Idris, the Arans and Arenigs, the Manods, and Moelwyn Mawr and Moelwyn bach. See Maps 59, N.E., 74, S.W. and N.W., 75, S.E. and N.E., and sections Nos. 4, 7, 8, and 9, above.

FELSPATHIC LAVA BEDS OF THE HIGHER OR SNOWDON SERIES, LYING IN THE CARADOC OR BALA ROCKS.

100.—FELSPATHIC TRAP.—Clogwyn du'r Arddu, Snowdon, Caernarvonshire. Map 75, N.E. *Compact greenish-grey felspathic rock*, with irregular bands of a white felspathic substance. The latter resist weathering, and form projecting lines on the weathered surfaces. These lines probably originated from the same cause that produced the laminated structure in the lava from Ascension. Nos. 26 and 50, **Case 2.**

Clogwyn du'r Arddu forms a lofty cliff about a mile north-west of the peak of Snowdon, in which the felspathic traps (old lava beds) are faulted against the calcareous ashy beds that form the mass of the summit of Snowdon. See section No. 4, above.

101.—FELSPATHIC TRAP.—Clogwyn du'r Arddu, Snowdon, Caernarvonshire. Map 75, N.E. Compact bluish-grey felspathic rock, with banded lines, showing viscous flowing. These lines, invisible in the freshly fractured interior, become visible on weathered surfaces, and are probably analogous to those shown in specimens No. 45 and 46, Case 2.

UPPER GALLERY. Wall-case 4.

From the same set of lava beds as No. 100.

102.—FELSPATHIC TRAP.—Esgair-felen ! Y Glyder-fawr, Llanberis, Caernarvonshire. Map 78, S.E. Grey compact felspathic rock, with patches of pink felspar. Upper part filled with elongated cavities, partly empty, partly filled with pink felspar, partly with siderite, and some with ochreous brown iron ore, from the decomposition of the latter mineral.

From the northern continuation of the highest of the three beds of felspathic trap that form the cliff of Clogwyn du'r Arddu.

103.—CONCRETIONARY FELSPATHIC PORPHYRY.—Y Glyder-fawr, Llanberis, Caernarvonshire. Map 78, S.E. Bluish-grey felspathic rock, with crystals of felspar, full of spheroidal felspathic concretions, themselves porphyritic.

From the felspathic trap north of Pen-y-Gwryd, between the top of the Pass of Llanberis and Capel Curig. Equivalent to a high part of the Snowdon felspathic traps of Clogwyn du'r Arddu, &c.

104.—BRECCIATED FELSPATHIC TRAP.—Crib Goch, Snowdon, Caernarvonshire. Map 75, N.E. Dark bluish-grey felspathic rock formed of angular fragments of felspathic rocks.

This specimen belongs to one of 8 small isolated patches of compact felspathic trap that *overlie* the ashy rocks of Snowdon and Moel Hebog. It is generally columnar, and overlying the ash, once formed a large continuous sheet of lava, the greater part of which has been destroyed by denudation.

105.—CALCAREOUS AMYGDALOID.—Moel-yr-Ogof, Beddgelert, Caernarvonshire. Map 75, N.E. Green felspathic

Upper Gallery. — Wall-case 4.

rock, full of cavities. Containing *calc spar* on the surface. The lime has been dissolved out of the cavities.

From an outlying patch of the above, lying on the ashy beds of Moel Hebog.

106.—Compact felspathic trap.—Digoed, 3½ miles south of Bettws-y-Coed, Caernarvonshire. Map 75, N.E. Light greenish-grey felspathic rock, with inclosed chalcedonic or cherty concretions.

107.—Siliceous and felspathic concretionary rock, made of light grey felspathic and bluish chalcedonic spheroids.

108 and 109.—Similar specimens.—Same place as 108. Specimens 106 to 109 are derived from bosses of felspathic trap that lie in horizons, not far beneath the Bala limestone, and are, therefore, probably, approximately equivalent to the felspathic rocks under the calcareous ashes of Snowdon, which are partly the equivalents of the Bala limestone.

110.—Compact felspathic trap.—Yspytty Evan, Caernarvonshire. Map 74, N.W. Light bluish-grey compact felspathic rock, containing a few felspar crystals. From the same rocks as the preceding.

111.—Felspathic vesicular trap.—Castell Caer Seion, Conway, Caernarvonshire. Map 78, N.E. North end of the felspathic traps of Snowdon, Y Glyder-fawr, Carnedd Dafydd, and Carnedd Llewelyn.

112.—Ancient celt, *unfinished*, found in Anglesea, and probably formed from one of the preceding felspathic porphyries of the Snowdon district.

From 108 to 111 the specimens are all derived from the same set of rocks that underlie the ash-beds of Snowdon, &c., and their equivalents. These old lava beds extend from Moel Hebog on the South to Conway on the North. South of Snowdon they form one chief mass. On Snowdon and Y Glyder-fawr the felspathic trap splits into three or four separate beds. See Section No. 1 above, and Maps 75, S.E. and 78 N.E. The ashy beds near Bettws-y-Coed are the equivalents of those of Snowdon.

113.—Blue felspathic rock, with a few cavities.— Craig Rhiwarth, near Llangynnog, Montgomeryshire. Map 74, S.W. Upper Gallery. — Wall-case 4.

114.—White felspathic rock, the cavities filled with crystallized carbonate of lime. Craig Rhiwarth, near Llangynnog, Montgomeryshire. Map 74, S.W.

115.—Compact felspathic rock, with a few interspersed crystals of *felspar*, some of them brown from decomposition.—Y Garn, 3 miles W. N. W., near Llanrhaidr-yn-Mochnant, Montgomeryshire. Map 74, S.E.

It is uncertain whether 113 and 115 are of the date of the Snowdon traps or of those of Cader Idris and the Arans; the latter is probable. It is also uncertain whether they are contemporaneous or intrusive.

Intrusive Igneous Rocks, North Wales.

Rocks intruded among and altering the Cambrian and Lower Silurian strata.

116.—Hornblende porphyry.—Ridge of Cader Idris, Cyfrwy, south-west of Dolgelly, Merionethshire. Map 59, N.E. Light grey felspathic base, containing small crystals of light and dark green hornblende, slightly bleached on the exposed edges.

This specimen is from the cliffs on the north side of Cader Idris, and though the rocks here lie *between* the strata (see section No. 8 above, No. 116,) they are known to be intrusive, as they *break across the strike* on Mynydd Pennant, east of Lyn Cae. Map 59, N.E.

117.—Syenite.—Two miles north-west of Ffestiniog, Merionethshire. Map 75, N.E. Greenish grey felspathic base with a little quartz, with irregularly interspersed fragments of a platy hornblende (*bronzite*).

From a large boss of intrusive Syenite piercing the Lingula flags, and altering them all round the points of junction. (See No. 117, section No. 4 above.)

UPPER GALLERY. — Wall-case 4.

118. — GREENSTONE. — Bwlch-yr-Hendref, near Capel Arthog, 6 miles south-west of Dolgelly, Merionethshire, Map 59, N.E. Dark green hornblende base, containing crystals of white potash felspar and large crystals of a platy variety of hornblende.

Part of a line of greenstone intruded *between* beds of the Lingula flags. The rocks are altered both above and below the greenstone, proving its intrusive character.

119. — GREENSTONE. — Bwlch-y-Hendref. As above. Dull greenish-black rock, obscurely laminated in structure, made of acicular felspar crystals and plates of hornblende in alternate layers, the former projecting on the weathered surface.

120. — GREENSTONE. — Bryn Prydydd, 4 miles north of Dolgelly, Merionethshire. Map 75, S.E. Greenish-grey rock, made of an intimate mixture of light and dark green hornblende and potash felspar indistinctly crystallized, with strings of felspar traversing the mass.

From a mass of greenstone intruded among the Lingula flags.

121.—GREENSTONE.—Bwlchau-yr-Figen, 3 miles north-west of Dinas Mowddwy, Merionethshire. Map 60, N.W. Finely granular mixture of felspar and dark coloured hornblende.

From one of several lines of greenstone intruded into the felspathic trap of the Aran range.

122.—CALCAREOUS GREENSTONE.—Ffestiniog, Merionethshire. Map 75, N.E. Intimate mixture of felspar and very small hornblende crystals, with kernels of calc spar.

From one of many dykes intruded into the Lingula flags.

123.—CALCAREOUS DYKE.—Blaen-y-ddol, half a mile north of Ffestiniog, Merionethshire. Map 75, N.E. Compact grey felspathic rock, with slaty cleavage, somewhat calcareous. Same as above.

124.—QUARTZ PORPHYRY.—Llyn Padarn, Caernarvonshire. Map 78, S.E. Decomposing felspar (nearly china clay, full of granular quartz crystals), mostly stained brown or yellow. Strings of quartz traverse the mass. It is an altered condition of No. 185.

Part of a large intrusive mass which extends from Llanllyfni (75, N.W.) to St. Ann's Chapel, Nant Francon (Map 78, S.E.), about 13 miles in length and 2 miles wide at the broadest part. It lies among the Cambrian grits, conglomerates, and slates, which, near the points of junction, are much altered. See section No. 4 above, and specimens Nos. 185 to 192 in this case.

125.—HORNBLENDIC PORPHYRY.—Mynydd Mawr, Llyn Cwellyn, Caernarvonshire. Map 75, N.E. and N.W. Light pink felspar base, with small specks of hornblende included.

Intruded among the Lower Silurian slates, which are altered by it, and rendered hard and porcellaneous at the tion. It is about 2 miles wide, of a circular shape, and forms the mountain of Mynydd-mawr (or the Great Mountain).

126.—REDDISH-BROWN FELSPATHIC ROCKS, *compact or* FINELY GRANULAR, with transparent quartz crystals filling the cracks and cavities, and dendritic infiltrations of *oxide of manganese.*—Craig Ddu (Black Crag), 5 miles south-west of Clynog fawr, Caernarvonshire. Map 75, N.W.

From a high cliff which rises from the sea, and forms part of the intrusive masses of the Rivals, or Yr Eifl.

127.—FELSPATHIC PORPHYRY.—Mynydd-tir-y-cwmmwd, 4 miles south-west of Pwllheli, Caernarvonshire. Map 75, S.W. Light yellowish-brown felspathic base, with a few hornblende particles much decomposed, and large white felspar crystals.

Part of a mass 5 miles in length, intruded among the Bala beds.

128.—SYENITE.—Cefn Amwlch, 8 miles west of Pwllheli, Caernarvonshire. Map 76, S. Felspar base, with white quartz crystals included, and a few specks of hornblende.

GALLERY. — Wall-case 8.

Part of a boss of syenite, piercing Lower Silurian slates, about three-quarters of a mile wide.

129.—SYENITE.—Gyrn Goch, 1½ mile south of Clynog fawr, Caernarvonshire. Map 75, N.W. Reddish-brown finely granular mixture of quartz and felspar crystals, with a few small hornblende crystals interspersed.

Part of an intrusive mass 3 miles long, forming the hills of Bwlch-mawr, Y Gyrn-Goch, Y Gyrn-ddu, and Moel Penllechog.

130.—FELSPATHIC TRAP.—Mynydd-tir-y-cwmmwd, 4 miles south-west of Pwllheli, Caernarvonshire. Green felspathic base, with a few hornblende and white felspar crystals interspersed.

From the same mass as No. 127.

131.—FELSPATHIC PORPHYRY.—Carn Neddol, 5 miles west-south-west of Pwllheli. Dark grey felspathic base, including white felspar crystals, and a little hornblende, often decomposed.

From the same mass as 127 and 130.

132.—FELSPATHIC GREENSTONE.—Yr Eifl or the Rivals, Caernarvonshire. Map 75, N.W. Grey and white crystallized felspar, with small hornblende crystals diffused through the mass.

133.—FELSPATHIC GREENSTONE.—Pink felspar with crystals of white felspar and hornblende. Hornblende more abundant than in No. 132.

From the same locality as No. 132.

134.—GREENSTONE.—Penmaen-mawr, between Conway and Bangor, Caernarvonshire. Map 78, S.E. Intimate mixture of felspar and hornblende, the felspar predominating.

135.—GREENSTONE.—4½ miles south-west of Clynog fawr, Caernarvonshire. Map 75, N.W. Finely granular mixture of pink and transparent white felspar crystals and small crystalline particles of hornblende.

From the same rock as 120.

136.—FELSPATHIC GREENSTONE.—Pen-ar-fynydd, 3 miles east of Aberdaron, Caernarvonshire. Map 76, S. Greenish-grey felspar base (somewhat decomposed), with black hornblende and white felspar crystals. Largely crystalline structure. Upper Gallery. — Wall-case 4.

From the same mass as No. 128.

137.—Greenstone.—Half a mile south-west of Clynog fawr, Caernarvonshire. Map 75, N.W. Dark greenish-grey felspathic base, with a few white felspar and large platy black hornblende crystals.

Small boss of intrusive rock on the coast.

138.—Greenstone.—Gymblet Rock or Carreg-y-rhim-bill, Pwllheli, Caernarvonshire. Map 75, S.W. Blackish-green finely granular rock, composed of dark-green hornblende and some white felspar crystals.

139.—Felspar porphyry.—Bwlch-mawr, 1½ mile south-east of Clynog fawr, Caernarvonshire. A kind of greenstone porphyry, composed of a black hornblende base, with simple and geniculated felspar crystals scattered through it.

This rock is continuous with No. 129, and is a good example of the change in general character and composition which the same mass of rock exhibits.

140.—Greenstone Porphyry.—Tan-y-Graig, 1½ mile north north-east of Pwllheli, Caernarvonshire. Imperfect crystals of light green felspar in a black hornblendic base.

From a mass, 4½ miles in length, intruded among the Caradoc or Bala beds, between Pwllheli and Plas dû.

141.—Porphyritic greenstone.—Carn Fadryn, 6 miles west of Pwllheli, Caernarvonshire. Dark green granular hornblendic base, containing crystals of felspar.

From a continuation of the same mass as Nos. 127, 130, and 131. These specimens show variations of character in the same mass in different localities.

142.—Greenstone.—Llanfaglan, about 1½ mile south-west of Caernarvon. Map 78, S.W. Large platy crystals of black hornblende, with pink, green, and grey felspar; the latter mineral in less quantity than the former.

UPPER GALLERY. — Wall-case 4.

From a mass about a mile in length intruded among the Lingula flags.

143.—GREENSTONE.—Pen-ar-fynydd, 3 miles east of Aberdaron, Caernarvonshire. Map 76, S. Large black hornblende crystals irregularly scattered through a white or brownish felspathic base.

From the same mass as No. 136.

144.—GREENSTONE.—Pen-ar-fynydd, 3 miles east of Aberdaron, Caernarvonshire. Large plates or scales of hornblende, with a very few small felspar crystals.

From the same mass as Nos. 136 and 143.

145.—GREENSTONE.—Llyn Cwm-y-ffynon, near the top of the Pass of Llanberis, Caernarvonshire. Map 75, N.E. Light green hornblende and white felspar crystals. Largely crystalline in structure.

From an intrusive line of greenstone about a mile in length. Alters the slaty rocks with which it is in contact into hone-stone.

146.—GREENSTONE.—Pont-y-Gromlech, Llanberis, Caernarvonshire. Map 75, N.E. Similar to the last.

From a mass of greenstone which pierces the felspathic trap, Nos. 100 and 101, that underlies the calcareous ashes of Snowdon. (Section No. 4, above.)

147.—GREENSTONE.—Llyn-Pen-Craig, 1½ mile north of Bettws-y-Coed, Caernarvonshire. Map 78, S.E. Consists of felspar and hornblende in distinctly crystallized fragments with slender crystals of felspar often traversing both of the other minerals. Felspar predominates.

From a line of greenstone injected between beds of slate and felspathic ashes, equivalents of the calcareous ashes that form the top of Snowdon.

The greenstone rocks of Merionethshire and Caernarvonshire chiefly run in lines, which, in many cases, have been

UPPER GALLERY. — Wall-case 4.

injected between the beds, or nearly so, as shown in the sections at the top of the case. At first sight, on the ground, they might often be supposed to be truly interbedded rocks, like the felspathic lavas of the same district, but their nature is easily distinguished by the circumstance that the rocks both above and below the greenstones are altered, whereas only the beds *on* which the felspathic lavas lie are altered, those above them being quite unchanged. (See p. 177, and sections above.)

INTRUSIVE ROCKS OF LOWER SILURIAN AGE, BREIDDEN HILLS, and of the Hills between the STIPER STONES AND CHIRBURY, MONTGOMERYSHIRE and SHROPSHIRE.

148.—GREENSTONE.—Breidden Hills, Shropshire. Map 60, N.E. Black hornblende and white and greenish felspar in small indistinct crystals; containing some quantity of calc spar.

From a mass of greenstone intruded among Llandeilo flags that underlie the volcanic ashes, Nos. 42 to 46.

149.—GREENSTONE.—Cefn. Dark grey or greenish felspar with small black hornblende crystals. Mass slightly calcareous, seams of calc spar traverse it in places.

From a small intrusive mass of greenstone by the turnpike road, 3 miles north-east of Welshpool, Montgomeryshire. Map 60, N.E.

150.—FELSPATHIC TRAP.—Welshpool, Montgomeryshire. Map 60, N.E. Compact felspathic rock, with a few felspar crystals.

This rock is columnar, and alters the Caradoc or Bala beds among which it has been intruded.

151.—GREENSTONE.—Simmond's Castle, near Bishops Castle, Montgomeryshire. Map 60, S.E. Dark green hornblendic rock, with a few indistinct felspar and black hornblende crystals.

UPPER GALLERY. — Wall-case 4.

From a line of greenstone 5½ miles in length, which has been injected in branches into beds of volcanic ashes and slaty rocks of the Llandeilo flags.

152.—GREENSTONE.—Cross Roads, 1 mile south-west of Hyssington, Montgomeryshire. Map 60, S.E. Dark compact felspathic rock, with a few small hornblende crystals and kernels of calc spar.

153.—GREENSTONE.—Corndon, 3 miles south-east of Chirbury, Montgomeryshire. Map 60, S.E. Green hornblendic base, with light greenish felspar crystals.

An intrusive boss of greenstone, forming a bold round hill in the Llandeilo flag region, north of Bishops Castle.

154.—GREENSTONE PORPHYRY.—Cefn Gwynnlle, near Bishops Castle, Shropshire. Map 60, S.E. White imperfect felspar crystals and kernels of calc spar in a light green matrix ; also some strings of calc spar.

A very felspathic greenstone running in a narrow line along the strike of the Llandeilo flags, into which it has been injected between the lines of bedding.

155.—GREENSTONE AMYGDALOID.—Lower Ridge, 2 miles east of Chirbury, Shropshire. Map 60, S.E. Dark grey felspar and small black hornblende crystals, with a few large kernels of calc spar ; the mass of the rock slightly calcareous.

In a line similar to No. 154.

156.—GREENSTONE.—South-east of Radley, and 2 miles east of Churchstoke, near Chirbury, Shropshire. Map 60, S.E. White and greenish felspar and black hornblende. Mass of the rock somewhat calcareous.

From a small boss of intrusive greenstone in the Llandeilo flags.

157.—GREENSTONE AMYGDALOID.—Todlethr, Church Stoke, Montgomeryshire. Map 60, S.E. Greenish-grey felspathic rock, with cavities filled with small spheroids of calc spar, coloured externally with protosilicate of iron.

From the south end of the same mass as No. 151.

Series of Intrusive Rocks from the Llandeilo flags, Radnorshire, near Builth.

Upper Gallery. — Wall-case 4.

158.—Greenstone amygdaloid.—Wellfield, 1½ mile north-west of Builth, Brecon. Map 56, S.W. Fine grained green rock, with small white crystals of felspar and many cavities filled with calc spar; some of the outer ones, from which the calc spar has been decomposed, are lined with brown iron ore.

From an intrusive branching mass, about 1½ miles in length. The porcellaneous alteration it produces on the Llandeilo flags is well seen on the banks of the river Wye, north-west of Builth. *Unaltered* Upper Llandovery or May Hill sandstone rests on its south-east margin, charged with *Pentamerus oblongus*. The same is the case in the quarry behind Wellfield house. These Pentamerus beds here lie highly unconformably in the Llandeilo flags. For Pentamerus oblongus see 66, **Case No. 41.**

159.—Greenstone.—Garth, north end of the Carneddau, Radnorshire, near Builth, Brecon. Map 66, S.W. Crystalline mixture of felspar and light and dark green hornblende. Felspar predominates.

From a mass 3 miles in length between Llanelwedd and the north end of the Carneddau. It is intruded among slates and felspathic ashes of the Llandeilo flags, but principally overlies them. See section above, No. 6, rocks Nos. 159 to 163.

160.—Vesicular felspathic trap.—The Rocks, Llandegley, Radnorshire. Map 56, S.E. Yellowish-grey felspathic rock, filled with felspar crystals decomposing of a dark brown colour.

From an intrusive mass forming a bold hill called the Rocks. It seems like a bed of lava, having been intruded *between* the beds of slate, which have been altered both

UPPER GALLERY. — Wall-case 4.

on its under and *upper* surface. Were it a true lava bed the rocks in contact with its upper surface would remain unaltered.

161.—GREENSTONE.—Craig Quarry, near Llandegley, Radnorshire. Light green granular felspathic rock, with patches of white felspar and a few small hornblende crystals: quarried for building stone.

From the north end of the same rocks as No. 160, near which they are overlaid by unaltered Wenlock shale.

162.—GREENSTONE.—South-west of Bwlch-Llyn-fawr, near Llandegley, Radnorshire. Map 56, S.E. Dark blackish-grey rock, hornblende and felspar mixed, not distinctly crystalline except near the outer surface, where the felspar crystals become apparent from decomposition.

From a line of greenstone 2½ miles in length intruded between beds of slate. See *horizontal sections, sheet* No. 6.

163.—GREENSTONE.—Carneddau, Radnorshire, near Builth, Breconshire. Compact dark green rock, with a few small crystals of felspar; amygdaloidal structure, with large calc spar nodules.

From the same mass as No. 159.

164.—GREENSTONE.—Gaer Einon, Carneddau, 1½ mile north-east of Builth, Breconshire. Compact black hornblendic rock, with a little felspar.

From a boss, like an old volcanic neck, piercing Llandeilo flags, and felspathic volcanic ashes.

INTRUSIVE IGNEOUS SERIES, St. David's, Pembrokeshire.

165.—FELSPATHIC TRAP.—Between Trewellell and Caerforiog, 3 miles north-east of St. David's. Map 40. Bluish-green compact felspathic rock, with dark green stripes and small diffused crystals of iron pyrites.

From a great mass of syenitic and felspathic rock 7 miles in length, intruded among and very much altering the

Cambrian slates, grits, and conglomerates. It extends from Porth Lisky, on the coast, 2 miles south-west of St. David's, to Carn-ymyl, north-east of Llanhowel.

UPPER GALLERY.

Wall-case 4.

166.—CLAYSTONE PORPHYRY.—Porth-bynawyd, south coast, at the north-east angle of St. Bride's Bay, St. David's. Map 40. Yellowish-white felspathic rock, with black particles of hornblende and white felspar crystals. Emits a strongly argillaceous odour.

This rock is in places nearly granitic, and is probably connected underground with the granite which runs from Brawdy, by Hay's Castle, to the neighbourhood of St. Lawrence.

167.—SYENITIC ROCK.—East side of Porth Lisky, 2 miles south-west of St. David's. Felspar and quartz, with a light green hornblendic mineral.

From the same mass as No. 165.

168.—AMYGDALOIDAL FELSPATHIC TRAP. — Penmaen Melyn, opposite Ramsey Island, $2\frac{1}{2}$ miles south-west of St. David's. Green felspathic rock, with kernels and crystals of pinkish felspar; those near the outer surface browned by oxidation, or entirely removed.

This rock belongs to a mass which, in general character, belongs to the greenstone family, and, like the neighbouring syenite of Porth Lisky, alters the Cambrian rocks so much that, on the ground, it is difficult to determine where the igneous rock ends and the altered rock begins.

169. — GREENSTONE. — Penmaen Melyn, St. David's. Dark blackish-green compact hornblende and felspar rock.

170.—CAMBRIAN ROCK, altered by Nos. 167 and 168.—Porth Lisky, St. David's.

170a.—Cambrian rock, as above,—Penmaen Melyn, St. David's.

In places these rocks have been so much altered that, like the rocks of Charnwood forest (p. 106), they have evidently been actually fused, or nearly so. Sometimes they become porphyritic, and exhibit crystals of felspar. See Nos. 83 and 84, Case 45.

UPPER GALLERY. — Wall-case 4.

171.—FELSPAR TRAP.—West side of Solva Harbour, St. David's. Dark bluish-grey felspathic rock, with small white felspar crystals. Outer surface bleached, with a pumiceous look.

172.—FELSPAR PORPHYRY.—Whitchurch, near Solva, St. David's. Map 40. Greenish-grey and white felspar, the latter crystallized; and a few small hornblendic crystals.

This rock occurs in four bosses north of St. Elvis. They are all of the same character, and very much decomposed on the surface.

173.—GREENSTONE.—Solva, St. David's. Light green matrix with white felspar crystals and small dark hornblende crystals; felspar predominates.

Similar and belonging to the same set of rocks as No. 171. Intruded in lines.

174.—GREENSTONE.—West side of Porth Lisky, St. David's. Compact dark green rock, composed of felspar and hornblende, rendered porphyritic by small black hornblende crystals diffused through the mass.

175.—GREENSTONE.—Pen Berry, 3 miles north-north-east of St. David's. Bluish-grey crystalline rock; white felspar, and small dark hornblende crystals in about equal quantities.

This begins a series of greenstone rocks, which occur in small bosses, and run in lines intruded between the beds between St. David's Head and the country round Fishguard.

176.—GREENSTONE.—South side of Porth Melgan, near St. David's Head. Dull bluish mass, fine grained hornblende and felspar, with large crystals of greenish felspar and strings of felspar. Weathers to a reddish brown.

177.—GREENSTONE.—West end of Carn Llidi, St. David's. Light green felspathic base, with very small black hornblende crystals. Weathers much whiter than 176.

178.—GREENSTONE.—Carn Llwyd, 2 miles north of St. David's. Finely crystalline white and dark greenish felspar with much hornblende in small black crystals.

179 to 183.—GREENSTONES of St. David's Head. Felspar and hornblende, showing the differences in size of the crystals of felspar and hornblende from the same mass of rock. Felspar, grey and white; hornblende in cleaved plates and prismatic crystals. UPPER GALLERY. — Wall-case 4

Rocks largely crystalline are presumed, generally, to have cooled more slowly than those more finely crystallized.

184.—GREENSTONE AMYGDALOID.—Tremynydd range, from 3 to 4 miles north-east of St. David's. Dull green felspathic base, with large black hornblende crystals and kernels of calc spar.

A line of greenstone, about 2 miles in length, intruded between beds of Llandeilo slate.

SERIES OF ROCKS ILLUSTRATIVE OF THE ALTERATION OF THE CAMBRIAN ROCKS OF LLANBERIS, IN CONTACT WITH OR NEAR QUARTZ PORPHYRY, described at No. 124.

185.—QUARTZ PORPHYRY.—North-east side of Llyn Padarn, near Llanberis, Caernarvonshire. Map 78, S.E. Grey compact felspathic base, with interspersed quartz crystals, and a few crystals of felspar. (See No. 124.)

186.—CAMBRIAN GRIT, much altered. It was probably nearly in a state of fusion by heat, and is in close proximity to No. 185, into which it almost imperceptibly passes. Like No. 185, it contains granular quartz, which may either be grains of silica in the original grit, or attempts at crystallization in the silica of the altered mass. Locality as above.

187.—CAMBRIAN GRIT, talcose and felspathic, and containing numerous granules of quartz similar to those in No. 185, but less crystalline in form. This rock on the ground is a little further removed than No. 186 from No. 185. Locality as above.

188.—CAMBRIAN CONGLOMERATE, altered, near No. 185, and a little further removed from it than No. 187. The

UPPER GALLERY. — Wall-case 4.

pebbles of the original conglomerate are indistinctly visible in a greenish-grey felspathic looking matrix, full of granular quartz crystalline grains. Pebbles and matrix are alike highly altered, and the approach to absolute fusion has been so great that the forms of the pebbles seem to melt into the surrounding matrix, which, perhaps, was fused. Locality as above.

189.—CAMBRIAN CONGLOMERATE, a little further removed from No. 185. This rock is talcose. In general appearance it resembles No. 188, but the alteration produced is less extreme, and the component pebbles are somewhat more distinct. Locality as above.

190.—CAMBRIAN CONGLOMERATE.—A little further removed from No. 185 than No. 189. Base and pebbles both crystalline as above, but the alteration being less than in No. 189 the pebbles of the conglomerate begin to be distinctly visible. Some of the pebbles are of quartz, others of quartz rock containing granular crystals of quartz, and some of felspar. Some of them seem made of felspar porphyry, and others are of green and purple slate similar to that of the neighbouring slate quarries of Llanberis and Penrhyn. The conglomerate is, however, at the base of the series in which the slate quarries are worked, and the pebbles have been derived from an unknown older territory, similar in structure to the Cambrian and Silurian rocks of Caernarvonshire. Locality as above.

191.—CAMBRIAN CONGLOMERATE.—Locality as above. Further removed and less altered. The pebbles in their original form are now distinctly visible. The base, from alteration, is still porphyritic and contains numerous imperfect crystals of felspar and granular quartz.

For the geological general position of these rocks see Sections above, No. **1 and 4**. The altered rocks are marked Nos. 186 to 191.

192.—COARSE CAMBRIAN GRIT, *or fine conglomerate*, somewhat talcose, consisting of numerous grains of silica, sometimes blue and transparent. Also small pebbles of quartz rock. North-east side of Llyn Peris, near Llanberis, Caernarvonshire. Map 78, S.E. UPPER GALLERY — Wall-case 4

This is the usual appearance of the Cambrian grits in this neighbourhood in a comparatively unaltered form. It is placed in this collection to show the extreme amount of alteration which the rocks numbered 186 to 191 have undergone.

GREENSTONE DYKES, piercing intrusive and igneous rocks, of Llyn Padarn, and the Cambrian slates and grits above it.

193.—GREENSTONE.—Llyn Padarn, south-west side, near Llanberis, Caernarvonshire. Dark green, finely crystallized, hornblende and felspar mass, with interspersed radiated nests of epidote. It pierces No. 185.

194.—GREENSTONE.—South-west side of Llyn Padarn, Llanberis. Dark green rock ; felspar and hornblende finely crystallized, with large interspersed patches of felspar. It pierces No. 175.

195.—GREENSTONE.—South-west side of Llyn Padarn, near Llanberis. Light green felspathic base, with *hornblende* crystals and veins of fibrous hornblende (*asbestos*). It pierces No. 185.

196.—GREENSTONE.—South-west side of Llyn Padarn, Llanberis, Caernarvonshire. Fine grained dark green rock, composed of *hornblende* and *felspar*, with kernels of *calc spar*. It pierces No. 185.

197.—GREENSTONE.—North-east side of Llyn Padarn, below slate quarries, Llanberis. Compact dark green rock with large stripes of *epidote* and *quartz*.

These dykes, No. 193 to No. 197, run in narrow lines, indiscriminately piercing the quartz porphyries and Cambrian and Silurian rocks of Llanberis. They are, however, probably of much later date than the large intrusive masses and the Lower Silurian traps and ashes ; and containing

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occasionally *cleaved* fragments of slate, which they pierce (at Penrhyn quarries), they have perhaps all been intruded after those disturbances which contorted all the rocks of the country, and during which the cleavage was produced by mechanical pressure.

Wall-case 5.

Wall-case 5.

Arranged and described by H. W. BRISTOW.

1.—CURLING STONE. Used in Scotland in playing the national game of *curling*, which is practised upon the ice during the winter.

The stone is made of the rock of Ailsa Craig in the Firth of Clyde. Ailsa Craig consists of a single rock of greyish compact felspar, with small grains of quartz and very minute particles of hornblende.—Presented by the Royal Commissioners of the Great Exhibition of 1851.

SERPENTINE, DIALLAGE, &c.

Serpentine is a silicate of magnesia combined with water, with the addition of a minor proportion of oxide of iron.

Some serpentines are said to be intrusive igneous rocks. The serpentine of the Lizard district in Cornwall reposes on hornblende slates and rock, and is said to have been erupted previously to the granite of the same district, the former being traversed by veins of the latter.

(For details of the Serpentine and associated rocks of Cornwall, see "Report on the Geology of Cornwall," De la Beche, pp. 9 to 100, 473 to 499, and 500.)—H. W. Bristow.

Serpentines are, however, often true metamorphic rocks, good examples of which occur in Anglesea, where thin streaks of Serpentine are truly interlaminated in the foliated rocks, and even the larger masses possess a wavy structure undulating in the direction of the foliations of the country, proving their metamorphic origin. Probably *all* serpentines are metamorphic. See p. 97.—A. C. Ramsay. UPPER GALLERY. — Wall-case 5.

[Nos. 2, 3, and 4, are at present omitted until illustrative specimens can be procured.]

5.—GREEN SERPENTINE. Map 31.—Penare Barn, Veryan, Cornwall.

6 and 7.—RED AND GREEN SERPENTINE. Map 32.—Kynance Cove, Lizard, Cornwall.

8.—Red and green STRIPED SERPENTINE, with a few minute cracks filled with *steatite*. Map 32.—Cadgwith, Lizard, Cornwall.

9.—Dark green and red SERPENTINE, showing a weathered surface. Map 31.—Carnhalla, Porthalla, St. Keverne, Cornwall.

10.—POLISHED RED SERPENTINE, containing a few disseminated crystals of *diallage*. Map 32.—Ruan Minor, Lizard, Cornwall.

11.—RED AND GREEN SERPENTINE, with steatitic lines and disseminated crystals of *diallage*. Map 32.—Near Ruan Minor Church, Lizard, Cornwall.

12.—OLIVE-GREEN SERPENTINE, with red veins and occasional crystals of *diallage*. Map 32.—Flagstaff, Cadgwith Lizard, Cornwall.

13.—RED AND GREEN SERPENTINE, with a small quantity of *diallage* in disseminated crystals; from a vein in serpentine. Map 32.—Flagstaff, Cadgwith, Cornwall.

14.—Olive-green and red SERPENTINE, with a few crystals of *diallage* and veins of *steatite*. Map 32.—Flagstaff, Cadgwith, Cornwall.

15 and 16.—GREEN AND RED SERPENTINE, with veins of *teatite* and a small quantity of *diallage*. Map 32.—Flagstaff, Cadgwith, Cornwall.

17.—GREEN AND RED SERPENTINE, with a vein of *steatite*. Map 31.—Treraboe, Goonhilly Downs, Lizard, Cornwall.

18.—DARK GREEN AND RED SERPENTINE, with dissemi-

UPPER GALLERY. — Wall-case 5.

rated crystals of *diallage*, and a few veins of *steatite*. Map 32.—Trezoddern, Ruan Minor, Lizard, Cornwall.

19.—DARK REDDISH-BROWN SERPENTINE, with a few. small crystals of *diallage*. The specimen exhibits a weathered surface.—Maen Midgee, Kernick Sands, Lizard, Cornwall.

20.—DARK GREEN AND RED SERPENTINE, containing disseminated crystals of *diallage*.—The specimen exhibits a weathered surface. Map 32.—Black Head, Lizard, Cornwall.

21.—GREEN AND RED SERPENTINE, with a few crystals of *diallage*, and a weathered surface.—North of Poltreath, Lizard, Cornwall.

22.—GREEN SERPENTINE, with a few crystals of *diallage*, —Careglooz Point, St. Keverne, Cornwall.

23 and 24.—DARK GREEN SERPENTINE, with a few minute cracks filled with *steatite*. Map 31. (This serpentine rises through hornblende slate and greenstone).—Porthalla, St. Keverne, Cornwall.

25.—Light green SERPENTINOUS ROCK, showing a weathered surface and containing small cracks filled with *steatite*; from the outer portion of the mass. Map 31.—Porthalla, St. Keverne, Cornwall.

26.—REDDISH-BROWN SERPENTINE, with a few crystals of *diallage* and veins of *steatite*.—Downas Cliff, St. Keverne, Cornwall.

27.—SERPENTINOUS ROCK, with a schistose structure.—Treraboe, Goonhilly Downs, Cornwall.

28.—Dark reddish-brown SERPENTINE, with a schistose structure.—Treraboe, Goonhilly Downs, Cornwall.

29.—Dark red and green SERPENTINE with disseminated crystals of *diallage* and veins of *steatite*.—Downas Cliff, St. Keverne, Cornwall.

30.—Part of a VEIN OF STEATITE, polished, and containing large angular fragments of *green serpentine*. Map 32.—Lizard, Cornwall. Presented by Lieut. Brewer, R.N.

31.—SERPENTINE, with veins of *asbestos*.—Tredavoe, Goonhilly Downs, Cornwall.

32.—DIALLAGE ROCK, from a vein traversing greenstone. —Coast near St. Keverne, Cornwall. UPPER GALLERY. Wall-case 5

33.—DIALLAGE ROCK. Map 32.—Coverack, Lizard, Cornwall.

34.—DIALLAGE ROCK, composed of crystals of *diallage* disseminated in a base of serpentine ; used for ornamental purposes, chimney-pieces, &c. Map 32. See "Report on Cornwall," p. 499.—Cadgwith, Cornwall.

35 and 36.—DIALLAGE ROCK. Map 78, N.W.—Ceryg-moelion, Anglesea.

37.—GREEN SERPENTINE, with *diallage*.—Ceryg-moelion.

38.—GREEN SERPENTINE, with white *calc spar*.—Ceryg-moelion, Anglesea.

39.—LIGHT GREEN SERPENTINE.—Anglesea.

40.—Green compact SERPENTINOUS ROCK.—Ceryg-moelion, Anglesea.

41.—Light green SERPENTINOUS ROCK. Map 78, N.W. —Near Four Mile Bridge, Anglesea.

42.—Compact SERPENTINE ROCK. Map 78, N.W.—Llanfechell, Anglesea.

43.—GREEN SERPENTINE, *with steatitic veins*.—Llanfechell, Anglesea.

44.—GREEN SERPENTINE, with apparently a schistose structure.—Llanfechell, Anglesea.

45.—GREEN SERPENTINOUS ROCK, with apparently a schistose structure.—Llanfechell, Anglesea.

The schistose appearance of specimens 44 and 45 is owing to the presence of minute steatitic veins, in the direction of which the rock is most easily broken.

46.—Green SERPENTINOUS MARBLE, with numerous veins of white *calc spar*. Map 78, N.W.—Ceryg-moelion, Anglesea.

47.—SERPENTINOUS ROCK (*marble*).—Ceryg-moelion, Anglesea.

48.—Reddish SERPENTINOUS MARBLE with fragments of *slate* and numerous veins and lines filled with white *calc spar*.—Llanfechell, Anglesea.

UPPER GALLERY. — Wall-case 5.

49 and 50.—Compact SERPENTINOUS BRECCIATED MARBLE, with lines of white *calc spar*.—Tre-gela, near Llanfechell, Anglesea.

51.—SERPENTINOUS BRECCIA MARBLE. Map 78, N.W.—Pen'r allt, Llangefni, Anglesea.

52 and 53.—Reddish SERPENTINOUS BRECCIA, with fragments of *purple slate* and lines and veins of white *calc spar*.—Llanfechell, Anglesea.

54.—SERPENTINOUS BRECCIA, composed of fragments of dark greenish *serpentine* cemented with veins of *steatite*.—Llanfechell, Anglesea.

55.—GREEN SERPENTINE, with numerous veins of *steatite* and *calc spar*.—Llanfechell, Anglesea.

56.—Compact brecciated SERPENTINOUS MARBLE.—Llanfechell, Anglesea.

57.—SERPENTINOUS BRECCIA. Map 78, N.E.—Tyddyn dû, one mile south of Amlwch, Anglesea.

58.—ELVAN (*felspathic trap*), containing fragments of *serpentine*, with included crystals of *diallage* and a few *steatitic lines*.—From the Serpentine Quarry, Llanfechell, Anglesea.

59.—Green SERPENTINOUS BRECCIA, of Cambrian date, traversed by a line of *calc spar*. Map 75, N.W.—Porth Dinlleyn Head, Caernarvonshire.

60 and 61.—Green SERPENTINOUS ROCK, with veins of *calc spar* and subangular patches of *red jasper*.—Porth Dinlleyn, Caernarvonshire.

62 to 64.—Green SERPENTINOUS ROCK, with a few veins of *calc spar*.—Porth Dinlleyn, Caernarvonshire.

65.—ALTERED ROCK, occurring in serpentine.—Anglesea.

Wall-cases 6 and 7.

Upper Gallery.

Wall-cases 6 and 7.

Igneous Rocks of various Kinds.

Preliminary Remarks by A. C. Ramsay.

The rocks in these cases are in common geological nomenclature all considered igneous. *They are arranged lithologically, or according to their structure and composition,* and without reference to their geological ages. As near as possible, *they follow each other so as to show the manner in which igneous rocks merge, or show a tendency to merge, into each other.*

Nos. 1 to 4 show familiar examples of the minerals of which granite is composed, viz., *quartz*, *felspar*, and *mica*.

Nos. 5 to 25 exhibit different varieties of granite, a ternary (or triple) compound of the above minerals. The specimens from 5 to 9 are *grey granites*, and show a passage from largely crystalline to the finer grained varieties. Nos. 10 to 21 are *reddish granites*, the red tint being due to the colour of the *felspar*. They also show similar differences in the size of their component crystals.

Nos. 22 to 25 are other ordinary varieties. Nos. 26 to 34 are from the outer portions or margins of certain granitic masses, and contain a fourth mineral, viz., *schorl* (see p. 228), which also enters into the composition of many of the granitic porphyries and other specimens. From 35 to 56 all the specimens are *schorlaceous*, and exhibit the gradual increase of that mineral, till, from 59 to 63, it predominates, and they are termed *schorl-rock*. 64 and 65 are pure *schorl*, and 66 shows the manner of its occurrence in *a vein* in *granite*.

Nos. 67 to 74 are from *granite veins* or dykes, most of which traverse other masses of granite. They are generally *fine-grained*, that is to say, their crystals are small.

Nos. 75 to 114, with a few exceptions, are chiefly from *Elvan dykes* and *dykes of felspar porphyries*, and other rocks of like nature. Many of these, if not true *granites*,

UPPER GALLERY. — Wall-cases 6 and 7.

are of a *granitic* nature. They are generally characterized by an *absence of mica.* Many of them are porphyritic. Being dykes, from the smallness of their masses, they probably cooled with comparative rapidity, radiating heat into the rocks which they traversed. Hence their component substances have not had time to crystallize out separately in the manner of those in true granites, although their general composition is the same.

115 to 118 are specimens of *granitic veins,* traversing other larger-grained granites, and *slates* which are invariably *altered* at the points of junction. (See pp. 99—103.)

120 to 123 are specimens of *decomposing granite and felspar trap,* from the felspar of which china clay is derived. (See porcelain Case near Case 3, in the floor below.)

124 to 139 are *felspathic traps* of various kinds. Most of them are uncrystalline, as, for instance, 125 ; others are slightly porphyritic (136 and 137). Some are exceedingly felspathic, like 126 ; and others contain much associated silica, like 125.

142 and 144 to 146 are *syenitic granites,* that is to say, they contain a little *hornblende,* in addition to the other minerals.

143 is a *schorlaceous* syenite, and 148 to 152 are true SYENITES, being composed of *felspar, quartz,* and *hornblende.* This prepares the way for a passage into *hornblendic* GREENSTONE, by the disappearance of the *free silica or quartz.* Typical *hornblendic greenstone* consists of felspar and hornblende. Nos. 155 to 174 show these minerals distinctly crystallized in the rock. From 175 to 214 most of the specimens are *fine-grained,* that is to say, the crystals are either very small, or else they present no appearance of crystallization at all. 215 to 217 are *hornblende rocks,* being formed entirely of hornblende.

220 to 235 are from Devonshire, and placed so as not to separate them from the Cornish and Devon series above. They are otherwise not especially connected with the passage of the various kinds of rock into each other. They

are strictly volcanic products, of the date of the Carboniferous rocks, and may be advantageously compared with some of the specimens in **Cases 1 and 2.**

Nos. 236 to 255 are chiefly *vesicular traps and amygdaloids.* In some the vesicles are empty, in others they are filled with calcareous spar, quartz, or other bodies, generally crystalline, which have been slowly filtered into the cavities in solution. (See No. 236, p. 255.)

The remainder of the specimens on the lower shelf of this case are chiefly *Canadian.* The upper shelf contains a few specimens, mostly duplicates, and generally too large to go in their proper places below.

Wall-cases 6 and 7.

Arranged and described by H. W. BRISTOW.

1.—Hexagonal crystals of translucent QUARTZ (*rock-crystal; nearly pure silica*) on greenstone.—Penrhyn Slate Quarries, Caernarvonshire. Presented by Dr. Percy, F.R.S.

2.—MILKY QUARTZ.—Snowdon.

3.—FELSPAR (*silicate of alumina and potash*), a large tabular crystal on granite.—Huel Damsel, Gwennap, Cornwall.

4.—MICA *in foliated plates,* forming a dyke 12 feet wide, traversing granite at St. Dennis Consols, near St. Austell, Cornwall. Presented by R. Hunt, F.R.S.

The above specimens are placed here to show the appearance of quartz, felspar, and mica, the minerals of which typical granite is composed.

5.—LARGE GRAINED GRANITE, a ternary compound, made up of large crystals of *white felspar, translucent quartz* (*free silica*), and *black* and *silvery mica,* the latter comparatively rare.—Lundy Island.

6.—GRANITE composed of two varieties of *felspar* (white and flesh-coloured), the former with a tendency to form

UPPER GALLERY. — Wall-cases 6 and 7.

separate crystals: *black mica* (some in good crystals) and *quartz.*—Bars Oban, Argyleshire. Presented by the Marquis of Breadalbane.

7.—GREY GRANITE, composed of *translucent quartz*, crystals of *white felspar* and *black* and *silvery mica.*—Dalkey, Dublin.

8.—GREY GRANITE, composed of crystals of *white felspar* (*orthoclase*), much *black mica and quartz.* — Strontian, Argyleshire.

9.—GREY GRANITE, a ternary compound, in nearly equal proportions, of *orthoclase* (*white potash-felspar*), *black mica, and quartz.*—Aberdeen, Scotland.

10.—RED GRANITE, a ternary compound of two varieties of *felspar* (*white and flesh-coloured*), *quartz,* and a small quantity of *mica.* Presented by the Duke of Argyle.

11.—RED GRANITE, composed of two varieties of *felspar* (*white and flesh-coloured*), *quartz* and *mica.*

Extensively used as a building material; the steps at the entrance of the Museum in Jermyn-street are of this granite. —Peterhead, Aberdeenshire.

12.—RED GRANITE, composed of two varieties of *felspar* (white and flesh-coloured), *mica* and *quartz.* In the specimen the felspar constitutes the predominant ingredient, while the mica is comparatively scarce.—Blackhill, Stirlingshire.

13.—GRANITE, composed of *quartz, flesh-coloured felspar,* and *black mica.* This specimen shows the general character of the mass of granite which extends, north and south, from Camelford to St. Neotts and St. Cleer, and east and west from St. Breward and Blisland to Five Lanes and Trebartha. (See Geological Maps, 25 & 30.) In some places the granite is porphyritic, containing large crystals of felspar, and, occasionally, on the skirts of the mass it is schorlaceous, containing schorl, which often appears in little radiated bundles in the granite. The highest point of this mass of granite is the rocky hill named Brown Willy, 1,368 feet above the level of the sea, according to

UPPER GALLERY. — Wall-cases 6 and 7.

the Ordnance Survey. This mass of granite varies, as usual, in different places, affording fine building stones in several localities, more particularly at St. Breward and Blisland.—Rough Tor, near Camelford, Cornwall.

14.—GRANITE, composed of two varieties of *felspar* (white and light brown), the former with a tendency to form separate crystals; common *black mica* and some *silvery mica* in foliated plates, and *quartz*.—St. Mary's Isle, Scilly Islands.

15.—GRANITE, composed of two varieties of *felspar*, white and light brown, the former with a tendency to crystallize separately—*quartz* and *dark-coloured and silvery mica*. The specimen shows a weathered surface of quartz and white felspar, from the decomposition of the mica and brown felspar.—Trescoe, Scilly Isles, near Oliver Cromwell's monument.

16.—GRANITE, composed of *quartz*, *felspar*, and two varieties of *mica*, *black and white*. It belongs to the mass of granite noticed, No. 13. Used for building. Map 30.—Camelford, Cornwall.

17.—FINE-GRAINED GRANITE, composed of *quartz*, *flesh-coloured felspar*, and *black mica*. Used for building.—Guernsey.

18.—FINE-GRAINED GRANITE.—*Quartz*, *felspar*, and *black mica*. The specimen shows a weathered surface and is apparently decomposing throughout.—Bryers, Scilly Isles.

19.—SMALL-GRAINED GRANITE.—*Quartz*, *flesh-coloured felspar*, and *mica*, both *black* and *silvery*.—St. Mary's, North End, Scilly Isles.

20.—FINE-GRAINED GRANITE, part of a vein traversing serpentine. Map 32.—Poltesco, Lizard, Cornwall. ("Report on Devon and Cornwall," p. 173.)

21.—FINE-GRAINED GRANITE (very micaceous). This specimen shows a weathering surface of a ferruginous-brown colour, owing to the decomposition of the felspar. Map 31.—Near Tolvorn Passage, Falmouth Estuary, Cornwall.

UPPER GALLERY. — Wall-cases 6 and 7.

22.—FINE-GRAINED GRANITE, composed of *quartz, felspar*, and *black and silvery mica.*—Strontian, Argyleshire.

23.—FINE-GRAINED GRANITE.—*Quartz, felspar*, and *black mica.*—Strontian, Argyleshire.

24.—FINE-GRAINED GRANITE.—*Quartz, felspar* (sometimes with a tendency to form larger separate crystals), and much *black mica.*—Strontian, Argyleshire.

25.—FINE-GRAINED GRANITIC ROCK, composed of *felspar, quartz*, and *silvery mica.*—Pains Bridge, near Warleggon, Cornwall. Map 30. Forms a projecting granite point, apparently thrust in amongst the adjacent slates. Might be usefully employed for architectural purposes.

26.— GRANITE. Quaternary compound, composed of *felspar* (two varieties), *light brown and white ; quartz, mica* (two varieties) *black and white,* and a small quantity of *schorl.*—Near Giant's Punch Bowl, St. Agnes, Scilly Isles.

Schorl contains about 10 per cent. of boracic acid, 39 of silica, 31 of alumina, a variable quantity (4 to 12 per cent.) of protoxide of iron, 2 to 9 of magnesia, with a few other subordinate substances, as lithia, soda, and potash. (Hermann.)

The researches of Ebelman prove that boracic acid, at a high temperature, acts like water as a solvent with regard to other substances.

Hence, if boracic acid be used as a solvent, a portion would be removed at a considerable heat, while other portions of the substances held in solution by it, would crystallize. It is on account of this easy removal of boracic acid at high temperatures, that the schorlaceous portions of rocks are principally situated on the outer part of the main mass ; and that the skirts of masses of granite are more schorlaceous than the more central portions.

27.—GRANITE, composed of much *silvery mica, quartz, felspar, and schorl.* Map 33.—Tregender, near Ludgvan, Cornwall.

Upper Gallery. — Wall-cases 6 and 7.

28.—Small-grained granite, composed of *quartz, felspar, mica, and schorl.* Map 33.—Castle an Dinas, Cornwall.

29.—Granite, composed of much *felspar*, forming separate crystals; *quartz*, also with a tendency to form separate crystals; a little *mica*, and a small quantity of *schorl*. Map 33.—Near St. Hilary, Cornwall. (See "Report on Geology of Cornwall," p. 175.)

30.—Granite on the side of a tin lode, and composed of *felspar* in a decomposing state, *quartz* with a tendency to crystallize separately, a green *steatitic mineral*, a small quantity of *silvery mica*, and a little *schorl*. Map 31.—Beam Mine, Cornwall.

31.—Granite, composed of *quartz*, *mica*, *schorl*, and *felspar*.

The hill on which St. Dennis Church stands, constitutes an island of granite, varying much in its mineralogical structure, and forming a remarkable boss on the skirts of the Hensbarrow granite. Map 30.—St. Dennis' Hill, Cornwall.

32.—Granite, composed of *quartz*, *white felspar*, forming large separate crystals, *black mica*, and a little *silvery mica*, with a small quantity of *schorl*. This forms the main mass of the rock, the skirts of which, adjoining the slate district, is schorlaceous. Map 30.—Penvivian Hill, near Bodmin, Cornwall.

33.—Granite, *highly crystalline*, composed of two varieties of *felspar*, light-brown and reddish-brown, (the latter forming separate crystals,) with *quartz*, *silvery mica*, and a small quantity of *schorl*. Map 31.—Huel Damsel, Gwennap, Cornwall.

34.—Fine-grained granite, composed of *quartz*, *felspar*, and a green *steatitic mineral*, with a small quantity of *schorl*. Map 31.—Burthy Quarry, near St. Stephens, Cornwall. (See "Report on Cornwall," p. 185.)

35.—Granite (granitic porphyry), composed of crystals of *quartz*, *schorl*, and *mica*, in a quartzo-felspathic base.

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Wall-cases 6 and 7.

Forms part of a granitic dyke, extending towards the east. (See Geological Map, No. 30.)

Is employed for roads, for which it is a good material, and might be used for ornamental purposes.—Near Lower Woodley, Lanivet, Cornwall.

36.—PORPHYRITIC GRANITE, large crystals of *light flesh-coloured felspar*, in a quartzo-felspathic base, with a small quantity of *schorl*. Map 33.—Bossullow Down, Morvah, Cornwall.

37.—GRANITE, composed of *felspar*, with a tendency to form separate crystals, *quartz*, *schorl*, and *mica*. Map 33. —Rosemodris, St. Buryan, Cornwall.

38.—GRANITE, composed of two varieties of *felspar* (white and light brown), *quartz*, *schorl*, and *mica* (the latter scarce and small). Map 33.—Knill's Monument, St. Ives, Cornwall.

39.—GRANITE, chiefly composed of *quartz*, *light-coloured felspar*, a little *black mica*, with disseminated crystals of *roseate and white felspar*, and a few specks of *schorl*. (See "Report on Cornwall," p. 162.) Map 31.—Cligga Point, Cornwall.

40.—FINE-GRAINED GRANITE, composed of white *felspar*, *quartz*, *schorl*, and *silvery mica*. The granite from which the specimen is taken forms part of a dyke extending east and west across the southern side of Belovely Beacon, through Castle Downs to Higher Rosewastes, near St. Columb Major. (See Geological Map, No. 30.) The felspar of this dyke is occasionally liable to decomposition in parts of its course, especially near the little village under Castle an Dinas, where it resembles a white clay containing quartz and a little mica.—Belovely Beacon, Cornwall.

41.—GRANITE, composed of *white felspar* (some in large crystals), *translucent quartz*, *schorl*, and *black mica*. Forms a portion of the Hensbarrow mass of granite. Map 30. St. Dennis Down, St. Dennis, Cornwall. (See "Report on Geology of Cornwall," p. 160.)

42.—GRANITE, composed of two varieties of *felspar* (*light flesh-coloured and white*), *mica*, two varieties (*black* and *white*), *quartz*, and *schorl*, the latter in small quantity. Map 33.—Near Penzance, Cornwall. UPPER GALLERY. Wall-cases 6 and 7.

43.—GRANITE, composed of *quartz*, *white and flesh-coloured felspar*, and *silvery mica*. This granite forms a mass which rises through a system of slate beds, having an east and west strike, and seen to be fossiliferous, near New Quay. The slates are much altered around this granite, which is schorlaceous along its northern boundary. This rock might be advantageously employed for purposes in which granite is used ; large blocks of it are scattered over the northern flank of Belovely Beacon. Passes into No. 63. Map 30.—Belovely Beacon, near Roche, Cornwall.

44.—FINE-GRAINED GRANITE, composed of *quartz*, *schorl*, and much *silvery mica*. Map 25.—Dartmoor, Devonshire.

45.—GRANITE, a base of *quartz* and *felspar*, containing large crystals of *felspar* (in a decomposing state), and semi-crystallized *quartz*, with *schorl*, a *green steatitic mineral*, and a little *mica*. (See "Report on Cornwall," p. 162.) Map 31.—West side of St. Agnes Beacon, Cornwall.

46.—LARGE-GRAINED GRANITE, composed of highly crystalline *pink felspar*, with *white felspar* (also in crystals), *schorl*, *quartz*, and a little *black mica*. Map 33.—Trink Hill, near St. Ives, Cornwall.

47.—PORPHYRITIC SCHORLACEOUS GRANITE, composed of large well-defined crystals of *flesh-coloured felspar* and semi-crystalline *quartz*, in a base of felspar and quartz, with a few specks of *schorl*. (See "Report on Cornwall," p. 162.) Map 31.—West side of St. Agnes Beacon, Cornwall.

48.—SCHORLACEOUS GRANITE, composed of a small-grained mixture of *felspar* and *quartz*, with disseminated portions of *schorl*, and a little *mica*.

This rock cuts the great mass of the granite in the manner of an elvan dyke, and holds a north-western course

UPPER GALLERY. — Wall-cases 6 and 7.

towards the west of Chapel Carn Brea. Map 33.—Mayon or Mean, near the Land's End, Cornwall.

49.—SCHORLACEOUS GRANITE, composed of *felspar, quartz, silvery mica,* and *schorl.*—Penvivian Hill, near Bodmin, Cornwall.

50.—SCHORLACEOUS GRANITE, composed of *schorl, dark flesh-coloured felspar* (some in crystals), and *quartz,* the latter somewhat rare.

This is a variety of the schorlaceous granite of the boundary portions of Penvivian Hill, which, with some of the other varieties, might be employed for ornamental purposes. They could easily be obtained in large masses. Map 30.—Penvivian Hill, near Bodmin, Cornwall.

51.—GRANITE, a compound of *schorl, quartz, silvery mica,* and *felspar.* It constitutes an outer portion, in a north-western direction, of the great Hensbarrow mass of granite, and exhibits the passage of the more ordinary kinds of granite of the district into schorl rock, upon which repose the altered schistose beds. The rock itself is situated on the southern part of Fat Work Hill, and from its elevated position forms an object visible from a large portion of country in a western direction.

There is a considerable mineralogical variation even in the mass of Caryquoita rock itself, illustrative of the great changes to which rocks of this kind are subject. Map 31.—Caryquoita Rock, near St. Enoder, Cornwall.

52.—GRANITE, composed of *schorl, flesh-coloured felspar* (some in large crystals), *quartz,* and *black mica.*—St. Brelade's quarry.

53.—GRANITE, composed of *schorl, quartz,* and *felspar,* and much *silvery mica.*—Above St. Martin's Bay, St. Martin's, Scilly Islands.

54.—PORPHYRITIC GRANITE, composed of imperfect crystals of light flesh-coloured *felspar,* in a quartzo-schorlaceous base, with a few minute spots of *silvery mica.* Map 31.—From the skirt of the Carmarth granite, near St. Day, Cornwall.

55 and 56.—PORPHYRITIC SCHORL-ROCK, composed of *quartz* and *schorl*.

The rock from which the specimen is taken contains large crystals of felspar. In some parts of it, as is the case in the specimen described (No. 56), the felspar crystals have been removed by decomposition, and the cavities filled by crystals of schorl crossing each other in various directions. In such cases the schorl-rock base adjoining these refilled, or nearly refilled, cavities, contains less schorl than around the crystals of felspar which have not been decomposed, as may be seen in the specimen. (See "Report on Cornwall," pp. 160 and 161.) Map 33.—From the skirts of the granitic mass close to Trevalgan, near St. Ives, Cornwall.

57 and 58.—SCHORL-ROCK, composed of a small-grained mixture of *felspar* and *translucent quartz*, with larger disseminated portions and lines of *schorl*, traversing granite in the manner of a dyke (elvan course), and holding a northwestern course towards the west of Chapel Carn Brea. (See "Report on Cornwall," pp. 174 and 175.) Map 33.—Mayon or Mean, near the Land's End, Cornwall.

59.—SCHORL-ROCK, formed of nearly equal parts of *schorl* and *quartz*, and containing larger detached portions of the latter. This rock forms part of an elongated east and west mass on the north of Belovely Beacon, and is separated from the latter by an interval of altered slate, though probably it is connected with the granite and schorl-rock of Belovely Beacon, at a comparatively insignificant depth. Map 30.—Small Money, Belovely Beacon, Cornwall.

60.—SCHORL-ROCK, an equal mixture of *schorl* and *quartz*, with occasionally included larger portions of the latter. It forms part of the schorlaceous granite of the line and mass noticed below, No. 61. Map 30.—Penvivian Hill, near Bodmin, Cornwall.

61.—SCHORL-ROCK, *schorl* and *quartz* in nearly equal proportions.—Roche Rock, Roche, Cornwall.

This rock evidently forms a portion of the granitic mass on the south of it, and of which Hensbarrow (1,034 feet

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above the level of the sea) forms the highest part. The skirts, generally, of this mass of granite from Penvivian Hill, round by the Indian Queen Inn (Map No. 30), are schorlaceous. It is remarkable, also, that the granitic veins and dykes (elvan courses) of the neighbouring country, and which may readily be supposed to be connected, at various depths, with the main mass of granite, are frequently schorlaceous.

This schorlaceous granite generally appears to prevail when a peculiar kind of argillaceous slate is brought into contact with the granitic mass, such slates when near the latter having also a schorlaceous character. There would seem to have been a reciprocal and chemical action along the line of junction, when the whole was in a heated state.

Roche Rock forms a conspicuous object in the country, rising abruptly from an undulating surface of elevated land, constituting a portion of a mass of schorl-rock, which has an east and west direction.

Although this portion of the schorl-rock rises abruptly above the surface of the adjoining land it is by no means so hard a substance as might at first sight be supposed ; hence when employed as a building stone, however ornamental its appearance, it would not, probably, be attended with the success that might be otherwise anticipated. Map 30.

62.—SCHORL-ROCK, composed of *schorl* and *quartz* in nearly equal proportions. Map 33.—Laity, near Lelant, Cornwall.

63.—SCHORL-ROCK, composed of small grains of *schorl* and *quartz*, with occasional included fragments of the latter. The granite of Belovely Beacon (No. 43) passes into this rock. Map 30.—North end of Belovely Beacon, Cornwall.

64.—SCHORL, showing a tendency to form prismatic crystals in places. From a mass in Schorl Rock. Map 33.—Botallack Mine, St. Just, Cornwall.

65.—SCHORL, illustrative of the numerous schorlaceous veins which are found in the district ; these (sometimes several inches in thickness) are composed of little else than crystals of schorl, radiating from different centres, and crossing or pressing against each other. Map 33.—Rosemergy, near Morvah, Cornwall. (See "Report on Cornwall," p. 161.)

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66.—SCHORL VEIN, *traversing granite,* illustrative of the mode of occurrence of such veins in Cornwall. Map 33.—Morvah, Cornwall.

67.—Fine-grained SCHORLACEOUS GRANITE, composed of *felspar, schorl,* and *quartz.* From a vein of granite cutting serpentine. Map 32.—Flagstaff, Cadgwith, Cornwall.

68.—Fine-grained SCHORLACEOUS GRANITE, composed of *quartz, felspar,* a little *schorl,* and small occasional specks of *silvery mica.* From a granite vein cutting coarser-grained granite. Map 33. (See "Report on Cornwall," p. 172.)—Rosemodris, St. Buryan, Cornwall.

69.—Portion of A GRANITE VEIN: the specimen is composed of *pink felspar,* with a few small specks of *schorl.* Map 32.—Poltreath, Lizard Town, Cornwall.

70.—GRANITE VEIN, composed of a *quartz* and *felspar base,* with crystals of *white felspar,* and a scattered equivocal dark substance, probably *schorl.*

This forms part of a long granitic dyke (see Geological Map No. 30) extending from the main mass of granite eastward toward St. Mabyn. It has been employed for building and for roads; the more compact parts of the dyke afford a good material for the latter purpose.—Hellagon, near Helland, Cornwall. (See "Report on Geology of Cornwall," p. 180.)

71.—GRANITIC DYKE, *light-coloured felspar, quartz,* and *mica,* containing disseminated crystals of light-coloured *felspar.* It forms a portion of the granitic dyke noticed No. 88. Employed for roads, for which it is an excellent material, and for building. Map 30.—Tregreenwell, near St. Teath, Cornwall.

72.—GRANITIC DYKE, the central portion of the dyke, and composed of *quartz, felspar,* and *mica,* with separate crystals of felspar and spots of *decomposed iron pyrites.*

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This dyke traverses the fossiliferous rocks of the district at right angles to their line of strike (see Geological Maps Nos. 30 and 31), and can readily be traced from the cliffs in Watergate Bay in a southerly direction through St. Columb Minor, Chapel, Benewalls, and Trerice, towards St. Michael or Mitchell.

It is opened in several places along this line for quarries, and the central portions, being somewhat decomposed, are termed "*freestones,*" and employed for building, &c. Map 30.—Near St. Columb Minor, Cornwall.

73.—Fine-grained SCHORLACEOUS GRANITE, composed of *pink felspar*, *quartz*, and *schorl.* It forms a vein traversing serpentine. (See "Report on Cornwall," p. 172.) Map 32.—Kynance Cove, Cornwall.

74.—GRANITIC PORPHYRY, from the central part of a dyke, and composed of small crystals of *flesh-coloured felspar*, and isolated and radiating *nests of schorl* in a felspathic base. Much employed for economic purposes. Map 31. (See "Report on Cornwall," p. 177.)—Seveock Water, between Redruth and Truro, Cornwall.

75.—FELSPAR PORPHYRY, composed of crystals of *light-coloured felspar*, with small radiating *nests of schorl* and a little *quartz*, in a felspathic base. Part of a granitic dyke. Map 33.—Near St. Hilary, Cornwall.

76.—FELSPAR PORPHYRY, composed of a quartzo-felspathic base, containing crystals of *felspar*, *quartz*, and *schorl.* The specimen shows the composition of the inner parts of a dyke which juts out on the coast from beneath that great mass of calcareous sandhills known as Piran Sands, which extend from Piran Porth on the south to Penhale on the north.

This dyke is seen to cut through argillaceous slates on the south side, on the north its junction was concealed by the sands from view in 1835. Included fragments of the adjoining slate are seen among the mass of porphyry, and have, for the most part, been somewhat altered in their character, though they have not lost their schistose structure. Map 31.—Piran Sands, Cornwall.

77.—FELSPAR PORPHYRY (*elvan dyke, near a lode*), composed of crystals of *quartz* and *felspar*, and *nests of schorl*. Map 31.—Consols Mines (west end), Cornwall.

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78.—FELSPAR PORPHYRY, composed of a grey felspathic base, containing disseminated *hornblende*, and vessels filled with calcareous matter. Forms part of one of several elongated trappean masses which occur near Endellyon. (See Geological Map, No. 30.) These vary in mineral structure, even at short distances, in the same mass. Judging from the phenomena observable on the adjacent coast, these masses of trap have been intruded among the slates of the district, which slates are fossiliferous. Map 30.—Endellyon, Cornwall.

79.—FELSPAR PORPHYRY, composed of crystals of *flesh-coloured felspar*, *quartz*, and *schorl* with veins of quartz in a felspatho-quartzose base. It forms an elvan dyke in which tin branches are found. (See "Report on Cornwall," p. 175.) Map, 33.—Tregurtha Mine, near St. Hilary, Cornwall.

80.—GRANITIC ROCK, composed of a grey quartzo-felspathic base, with included imperfect crystals of *lighter coloured felspar* and points of *iron pyrites*. It forms the north-east end of a long narrow line of granitic rock (see Map, No. 30) extending through St. Kew, towards Padstow Harbour. —Treburget, near St. Teath, Cornwall.

81.—FELSPATHIC PORPHYRY, (*part of an elvan dyke*,) composed of a brown *flesh-coloured* felspathic base, containing *light pinkish crystals of felspar*, crystals of *quartz* and apparently others of *schorl*. It forms a variety of No. 102; it would be a beautiful ornamental stone. Map 30.—Tremore, near Bodmin, Cornwall.

82.—FELSPATHIC PORPHYRY, forming part of the same dyke (No. 89), where it abuts against the slates among which it has been intruded. The different structures of the different parts of the dyke may be explained as at No. 97. Map 31.—Cliff, South of Penhale, Crantock, Cornwall.

Upper Gallery. — Wall-cases 6 and 7.

83.—Felspathic porphyry, composed of crystals of *schorl* in a felspatho-quartzose base. Map 33.—Rose-angrouz, near St. Erth, Cornwall.

84.—Felspathic porphyry, composed of crystals of *quartz* and *flesh-coloured crystals* of *felspar* in a *lighter-coloured base.* This forms the continuation westward of the Tremore Porphyry No. 81. It might be employed for ornamental purposes. Map 30.—Near St. Wenn, Cornwall.

85.—Felspathic porphyry, composed of crystals of *felspar*, *quartz*, and *schorl* in a felspathic base. Map 30.—From the junction of granite and slate, near Dolcoath Mine, Cornwall.

86.—Granitic porphyry, composed of crystals of *felspar* and spots of *schorl*, in a roseate felspathic base. *It forms part of an elvan dyke.* Map 31.—Creegbroaz Quarries, near Chacewater, Cornwall.

87.—Felspathic porphyry, composed of crystals of *light-coloured felspar*, *quartz*, and *schorl* in a quartzo-felspathic base. It forms an elvan dyke traversing granite. Map 31.—Croft Michel, near Crowan, Cornwall.

88.—Porphyritic granite, composed of a light grey felspathic base, containing crystals of *quartz*, *flesh-coloured felspar*, and plates of *mica*.

This forms part of a granitic dyke, extending from Grey Lake, near Camelford, by Trecligoe and Helstone to Treforde, and varies much in its mineral character; it clearly cuts the lodes. This (as well as Nos. 94, 98, &c.) is one of the rocks named *Elvans* by the Cornish miners, several varieties of which have been and still are employed for architectural purposes, for which in general they are well suited. At present they are employed for the corners of houses, for rough buildings, walls, and for roads. Map 30,—Trecligoe, near Camelford, Cornwall.

89.—Granitic porphyry, from the central parts of a dyke, and composed of *quartz*, a small proportion of *mica*, and *felspar* and *schorl*, some in crystals. Map 31.—

Quarried for building stone.—Penhale Cliffs (South side). Cornwall.

90.—*Part of a* GRANITE DYKE, apparently cutting through the schistose rocks of the district, and is probably the continuation eastward of No. 89. Map 31. It is quarried for building stone and road material.—St. Cubert, Cornwall.

91.—FELSPATHIC PORPHYRY, composed of disseminated crystals of *schorl*, in a fine-grained felspathic base. It forms part of an elvan dyke traversing granite. Map 31.—Penstruthal Mine, Cornwall.

92.—GRANITIC PORPHYRY, composed of a roseate felspathic base, containing imperfect crystals of white *felspar* and plates of *brown mica*. (See No. 104.) Map 30.—Tremore, near Bodmin, Cornwall.

93.—GRANITIC ROCK. Crystals of *flesh-coloured felspar* and *quartz* in a felspathic and hornblendic base. Map 30. It forms part of the granitic rock noticed No. 80, and is employed for roads.—Hill on the south side of Endellyon, Cornwall.

94.—GRANITIC PORPHYRY, composed of crystals of *quartz* and specks of *mica* in a greyish-white quartzo-felspathic base. Map 30.

It forms part of the same granitic dyke noticed Nos. 71 and 78. It is used for roads and buildings, for both of which it is a good material.—Near Camelford, Cornwall.

95.—GRANITIC DYKE; the northern portion, as far as is visible above the level of the sea, of the dyke noticed 97. Map 30. It is a mixture of *quartz*, *felspar*, and *mica*. Used as a building material under the name of "*freestone*." —Watergate Bay, Cornwall.

96.—GRANITIC ROCK, felspathic base containing disseminated *quartz* and imperfect crystals of *felspar*.

Forms part of a line of granitic rock extending from Treburget, near St. Teath, nearly to Padstow Harbour. Map 30. It cuts through a series of variegated slates.

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Employed for building and for roads. Large quarries are opened on the St. Kew Hills.—St. Kew Hills, St. Kew, Cornwall.

97.—OUTER PORTION OF A GRANITIC DYKE, showing a porphyritic arrangement of the same substances, and beautifully illustrating the igneous origin of the granitic matter of the dyke ; that portion which necessarily took the longest time to cool, being most crystalline, while the external portions, cooling more rapidly, were less crystalline, and partook more of the porphyritic structure.

The exterior portions of this dyke, being not so readily worked with the tool, are not so much used for common architectural purposes as its interior portions; though, where expense is no great object, the ornamental parts of a building would be far more durable if made of its outer portions. Map 30. — Near St. Columb Minor, Cornwall.

98.—PORPHYRITIC ROCK, greyish-white quartzo-felspathic base, containing imperfect crystals of *white felspar* and plates of *brown mica*. Map 30.—Helstone, near Camelford, Cornwall.

99.—FELSPAR PORPHYRY, a fine grained compound of *felspar* and *quartz* with crystals of *mica*. Forms part of an elvan dyke, known as the Pentuan elvan or *Pentuan stone*. (See "Report on Cornwall," pp. 182 and 183.) Map 31. —Pentuan, St. Austell, Cornwall.

100.—GRANITIC PORPHYRY, crystals of *felspar*, somewhat decomposed, with a small quantity of *quartz*, and a little *silvery mica* in a greenish-coloured felspathic base. Forms part of an elvan dyke. Map 31. (See "Report on Cornwall," p. 177.)—Creegbroaz Quarries, near Chacewater, Cornwall.

101.—FELSPAR PORPHYRY.—Part of a granitic vein, proceeding from the main body of granite to the eastward of this locality, (see Map 30,) and composed of a quartz and felspar base, in which plates of *black mica* and crystals of *white felspar* are included.

This is one of the many granite veins (see Map 30,) which cut through the slates in the neighbourhood of Blisland. It is employed for the roads, for which it is a good material.—London Inn, near Cardinham, Cornwall.

102.—FELSPAR PORPHYRY.—Flesh-coloured felspathic base, containing crystals of *white felspar* and *quartz*. (See No. 104.) Part of an elvan dyke. Map 30.

Would form a very beautiful material for ornamental purposes; there are also some grey varieties that would be by no means inferior.—Tremore, near Bodmin, Cornwall.

103.—GRANITIC ROCK, composed of a grey base of *felspar* and *hornblende*, containing imperfect crystals of *light-coloured felspar* and *quartz*. Map 30. A variety of No. 83.—Treburget, near St. Teath, Cornwall.

104.—FELSPAR PORPHYRY.—Flesh-coloured felspathic base, reddish-pink crystals of *felspar*, mixed with others of *quartz*, and with a greenish substance not very determinable. Forms part of a long line, apparently intruded among the adjacent beds of porphyritic matter (see Map 30), extending from Tremore near Bodmin to Tregotha near St. Wenn.

In the lane leading from St. Wenn Church to Lancorlar, and also in the road to Restigen, this dyke is seen to be irregularly decomposed so as to appear like a white or pink clay containing quartz crystals, and crystals of felspar, the latter being decomposed. This decomposition does not extend beyond the distance of five-eighths of a mile. If polished it would form a valuable ornamental stone.—St. Wenn, Cornwall.

105.—GRANITIC PORPHYRY, composed of crystals of *flesh-coloured felspar* and *translucent quartz*, with a few spots of *schorl* in a light-grey felspatho-quartzose base, and containing cracks filled with translucent quartz and schorl.

It forms a dyke which can be traced for 12 miles from Huel Darlington, near Marazion, into the Carnbrea granite, cutting into the latter on the west of Camborne Beacon.

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(See "Report on Cornwall," p. 174.) Map 33.—Marazion Mines, Cornwall.

105a.—PORPHYRITIC ROCK, composed of crystals of *felspar* and *quartz*, in a felspatho-quartzose base, from an elvan dyke adjoining the copper and tin lodes.—Map 33.—Marazion Mines, Cornwall.

106.—FELSPATHIC PORPHYRY, composed of *quartz* and crystals of *felspar*, some of which are weathered out in a quartzo-felspathic base. It forms part of an elvan dyke. Map 31.—Enys, Cornwall.

107.—PART OF AN ELVAN DYKE, a whitish rock composed of a fine grained compound of *quartz* and *felspar*; a continuation of the Penstruthal elvan, No. 91. Map 31. —Newham Quarry, near Truro, Cornwall.

107a.—A variety of the above elvan dyke. (See "Report on Cornwall," p. 177.)

108.—FELSPATHIC PORPHYRY, containing prismatic crystals of *schorl*, and fragments of *quartz* in a quartzo-felspathic base.—Map 31.—Pentuan, St. Austell, Cornwall.

109.—FELSPATHIC PORPHYRY, a variety of the Pentuan elvan, composed of a base of *felspar* and *quartz*, with a few small specks of *silvery mica*, and numerous large fragments of the *slate rocks* which it traverses. From the outer portion of the dyke. (See "Report on Cornwall," p. 182.) Map 31.—Pentuan, St. Austell, Cornwall.

109a.—Another variety of the Pentuan elvan, containing included *fragments of slate*.

110.—Another variety of the Pentuan elvan, from the *outer* portions of the dyke, containing an included fragment of the adjoining rock.

111.—FELSPATHIC PORPHYRY, composed of crystals of *flesh-coloured felspar*, and *translucent quartz*, with spots of *schorl*, in a light-grey felspatho-quartzose base. Map 33. —Corbus Quarry, near St. Erth, Cornwall.

112.—Another variety of the above elvan dyke. Map 33.—Herland Mine, Gwinnear, Cornwall.

113.—FELSPATHIC PORPHYRY, (part of an elvan dyke,) cutting through granite.—St. Mary's, (near the Telegraph,) Scilly Islands.

114.—ELVAN, slightly conglomeratic, with decomposing crystals of *felspar*, and associated with the slate of the vicinity, which is seen to be fossiliferous near the same locality. Map 30.—Opposite Cant Hill, Padstow Harbour, Cornwall.

115.—GRANITIC VEIN, traversing altered slates. Map 33.—St. Michael's Mount, Cornwall.

116.—SCHORLACEOUS GRANITE, in contact with and altering slates. The granite is fine grained, and composed of *quartz*, *felspar*, *schorl*, and a little *mica*. (See "Report on Cornwall," p. 172.) Map 33.—Mousehole, Cornwall.

117.—SCHORLACEOUS GRANITE, composed of *quartz*, *white felspar*, *schorl*, and varieties of *mica*, with a vein of fine-grained granite. (See "Report on Cornwall," p. 161.)—Round Rock Point, St. Martin's Bay, Scilly Islands.

118.—GRANITE VEIN, traversing altered slates. Map 33.—St. Michael's Mount, Cornwall.

119.—BRECCIA, containing variously-sized angular fragments of argillaceous slate. The cementing matter is sometimes slightly calcareous, and the whole is traversed by veins both of quartz and of carbonate of lime. (See "Report on Cornwall," p. 89.) Employed for roads and rough building purposes. Map 30.—South side of Dinas Hill, near Padstow, Cornwall.

Upper Gallery.

Wall-cases 6 and 7.

Decomposed Granites.*

120.—Decomposed granite, *a hard variety*.—Morley Clay Works, Dartmoor, Devon. Map 25.

120a.—Decomposed granite, *a white variety*, with much quartz and white felspar and silvery mica.—Morley Clay Works, Dartmoor, Devon. Map 25.

121 and 122.—Decomposed granite, *a white variety*, with much silvery mica.—Morley Clay Works, Dartmoor, Devon. Map 25.

123.—Decomposing felspathic trap.—Porth Hagog, Ramsey Island, St. David's, Pembrokeshire. Map 40.

124.—Felspathic porphyry (*elvan*.) Map 78, N.W.—South of Hafod-onen, near Amlwch, Anglesea.

125.—Felspathic porphyry ("*elvan*") ("*Carreg lwyd*.") Map 78.—Llanfechell, Anglesea.

126.—Pink felspathic trap.—Near Lanark, Scotland.

127.—Felspathic trap. Map 60, S.E.—Dysgwylfa Hill, near Bishops Castle, Salop.

128.—Columnar felspathic trap.—Owlbury, near Bishops Castle, Salop.

129.—Light green felspathic trap, showing a white weathered surface.—Tinnacarrig Hill, near New Ross, Ireland.

130.—Felspathic trap. Map 40.—Clegyr Bridge, St David's, Pembrokeshire.

131.—Porphyritic rock, traversing red sandstone and slates. (See "Report on Cornwall," p. 65.) Map 24.—Cawsand, Plymouth, Devon.

* See "Report on Cornwall," pp. 509 to 513; also Mr. Hunt's Descriptive Guide, pp. 78 to 80. 81,078 tons of china clay were exported from Cornwall and Devon in 1857: of these the best quality is used for making porcelain, while the inferior description is used by calico and paper makers.

132.—VESICULAR FELSPATHIC TRAP (used for building). —Llandegley Rocks, Radnorshire. Map 56, S.E.

133.—FELSPATHIC TRAP.—Llandegley Rocks, Radnorshire. Map 56, S.E.

134.—CONCRETIONARY FELSPATHIC TRAP.—Hafnant, 3 miles south-west of Yspytty Evan, Merionethshire.

135.—FELSPATHIC TRAP, forming the base of the Snowdon rocks; showing an unevenly weathered and laminated surface.—Clogwyn-du'r-arddu, Llanberis, Caernarvonshire.

136.—Light grey compact FELSPATHIC TRAP, with white weathered surface and joints.—Quarter of a mile south of Moel-y-menin, Arenig range, Merionethshire. Map 74, S.W.

137.—Grey thin bedded TRAP.—Y Wenallt, 1¾ miles north-west of Llanuwchllyn, Merionethshire. Map 74, S.W.

138.—Compact greenish FELSPAR TRAP, with occasional thin lines and veins of red *felspar* and *calc spar*.—Winds Point, Little Malvern, Worcestershire. (See "Survey Memoirs," vol. ii., part I., pp. 31 and 32.) Map 43, N.E.

139.—FELSPATHIC PORPHYRY.—Tinnacarrig Hill, near New Ross, Ireland.

140.—Greenish FELSPATHIC PORPHYRY, weathering white. —Carrick-a-daggan, near New Ross.

141.—A kind of TRAPPEAN ROCK, having a semi-mechanical origin, and associated with a conglomerate of the slate series. It is quarried for building-stone at the cliff, close to the river. Map 30.—Opposite Cant Hill, Padstow Harbour, Cornwall.

SYENITE.

142.—SYENITIC GRANITE, composed of large crystals of *hornblende* with *white quartz*, and *flesh-coloured felspar* in nearly equal proportions; and occasional *black mica*, apparently replacing the hornblende.—Strontian, Argyleshire.

143.—SYENITE, composed of large crystals of *pink felspar*, with *quartz*, occasionally in prismatic crystals, and some *schorl* in a base of *hornblende*.

UPPER GALLERY. — Wall-cases 6 and 7.

This rock occurs in large detached blocks, which probably formed portions of a dyke traversing the granite of the district. (See Column 35 in the Hall.) The sarcophagus for the late Duke of Wellington is formed of a single block of this stone. (See "Descriptive Guide," p. 26.)—Luxulion, 3½ miles south-west of Lostwithiel, Cornwall.

144.—SYENITIC GRANITE, composed of *quartz*, *flesh-coloured felspar*, *black mica*, and a small proportion of *hornblende*.—St. Brelade's Quarry, Jersey.

145.—SYENITIC GRANITE, composed of two varieties of *felspar* (*white and light flesh-coloured*), a small quantity of *quartz* and *hornblende*, and a little *black mica*.—Strontian, Argyleshire.

146.—SYENITIC AND PORPHYRITIC GRANITE, composed of large crystals of white and light-pinkish *felspar* in a base of *translucent quartz*, *hornblende*, and black *mica*.—Strontian, Argyleshire.

147.—GREY SYENITIC GRANITE, composed chiefly of *hornblende*, with *felspar* and *quartz* and a few specks of *iron pyrites*. Black *mica* occasionally replaces a portion of the hornblende.—Used as a building stone.—Guernsey.

148.—SYENITE, composed of *white milky quartz* in a felspathic base, with lines and specks of *hornblende*.—Mynydd Cefn-amwlch, 9 miles west of Pwllheli, Caernarvonshire. Map 76, S.

149.—Red felspathic SYENITE, chiefly composed of *reddish felspar*, with *hornblende* and a little *quartz*.

This rock may be regarded as the fundamental rock of the chain of the Malvern Hills.—(See "Memoirs of the Geological Survey," vol. ii., part I., pp. 40 and 41.)—Great Malvern, Worcestershire. Map 55, S.E.

150.—SYENITE, a compound of *felspar* and *hornblende*, the latter with a tendency to form separate aggregations.—1½ mile north-west of Ffestiniog, Merionethshire. Map 75, N.E.

151.—SYENITE, composed of *quartz*, white *felspar* (some in crystals) and *hornblende*, with a very few minute specks of *iron pyrites*. Used as a building-stone.—Guernsey.

152.—SYENITE, chiefly composed of *pink felspar* with *hornblende* and a small proportion of *quartz.*—Strontian, Argyleshire.

153.—GREY SYENITE, or, SYENITIC PORPHYRY, composed of prismatic crystals of *hornblende*, with *white felspar* and *quartz*, and a few specks of *iron pyrites.*—Used as a building stone.—Guernsey.

154.—Fine-grained, reddish-grey GRANITIC ROCK, containing imperfect crystals of a *lighter coloured felspar.*

This rock forms part of a granitic dyke which extends from the western end of Penvivian Hill towards Belovely Beacon. See Map 30.—Great Brin, near Roche, Cornwall.

155.—PORPHYRITIC GREENSTONE, chiefly composed of prismatic crystals of *hornblende*, with *felspar*, a little *translucent quartz*, and a few occasional spangles of *mica.*—Pen-ar-fynydd, 3 miles east of Aberdaron, Caernarvonshire. Map 76, S.

GREENSTONE, HORNBLENDE ROCK, TOADSTONE, AMYGDALOID, &C.

156 to 158.—GREENSTONE (*variety—hypersthene rock*) composed of *hypersthene* and *felspar.* Hanter Hill is a picturesque mass of rock, rising to a height of 1,250 feet above the sea level, and altering and contorting the Upper Silurian strata, amongst which it is injected along a great line of dislocation. It forms an extension of the same range of eruptive Trap as the Stanner Rocks, No. 178, Map 56, S.E., and *Horizontal Sections, Sheet* No. 27.—Hanter Hill, Kington, Herefordshire.

159.—FINE-GRAINED GREENSTONE, composed of *brownish felspar* and *hornblende*, in nearly equal proportions.—Sea coast 4½ miles south of Clynnog-fawr, West of Yr Eifl, Caernarvonshire. Map 75, N.W.

160.—LARGE-GRAINED GREENSTONE, forming some remarkable rocky tors near the cliffs. It might be usefully employed for roads and in massive structures.—Tintagell, Cornwall. Map 30.

Upper Gallery. — Wall-cases 6 and 7.

161.—Large-grained PORPHYRITIC GREENSTONE, forming part of a line of trappean rock to Bray Hill in Padstow Harbour, where it is clearly seen to have been intruded among the slates.

Employed for building and for roads; the more compact varieties are excellent for the purpose.—St. Minver, Cornwall. Map 30.

162.—PORPHYRITIC GREENSTONE, forming part of a long line of trappean rocks extending to and beyond St. Clether, and which are for the most part schistose in that direction and occasionally vesicular.—Davidstow, Cornwall. Map 30.

163.—PORPHYRITIC GREENSTONE, containing crystals of *felspar* and kernels of *green earth* in a decomposing hornblendic base.—Carneddau, Builth, Breconshire.

164.—PORPHYRITIC GREENSTONE, containing a vein of *hornblende*.—Boswednan Cliff, Zennor, Cornwall. Map 33.

165.—PORPHYRITIC GREENSTONE, composed of crystals of *felspar* in a hornblende base. Part of a dyke.—Brynian-geirwen, Anglesea. Map 77, N.

166.—FINE-GRAINED GREENSTONE, composed of nearly equal proportions of *felspar* and *hornblende*. The specimen shows the natural joints, the surfaces of which have weathered of a brownish colour.—Broom Close Bay, Veryan, Cornwall. Map 31.

167.—PORPHYRITIC GREENSTONE, composed of crystals of *felspar*, a small quantity of *quartz*, and a few minute specks of *iron pyrites* in a base of *hornblende*.—Grange Hill, near Chair of Kildare, County Kildare, Ireland. Map 119.

168.—PORPHYRITIC GREENSTONE, composed of crystals of *felspar* in a hornblende base.—Beyond Goodrevy Cove, St. Keverne, Cornwall. Map 31.

169.—PORPHYRITIC GREENSTONE: var: "*Porfido Verd'-antico*;" "*Carreg Eiarn*" (Anglesea). Composed of a few crystals of *white felspar* disseminated in a base of *compact greenstone*.—Llanfechell, Anglesea. Map 78, N.W.

170.—PORPHYRITIC GREENSTONE, composed of crystals of *light green felspar* in a base of *hornblende*.—Tan-y-graig, 1¼ miles N.N.E. of Pwllheli, Caernarvonshire. Map 75, S.W.

171.—PORPHYRITIC GREENSTONE, composed of crystals of *white felspar* in a felspatho-hornblendic base.—Bwlch Mawr, 1½ miles south-east of Clynnog-fawr, Caernarvonshire. Map 75, N.W.

UPPER GALLERY. — Wall-cases 6 and 7.

172.—PORPHYRITIC GREENSTONE, in a decomposing state, composed of crystals of *white felspar* in a hornblende base. —Dun, Coast of Ayrshire, Scotland.

173.—FELSPATHIC GREENSTONE, composed of *felspar* and *hornblende* in nearly equal quantities. Furnishes a good building stone.—Careg-y-rimbill ("Gimblet Rock"), Pwllheli, Caernarvonshire. Map 75, S.W.

174.—GREENSTONE, composed of *felspar* and *augite* in nearly equal proportions—Salisbury Crags, Edinburgh.

175.—FELSPATHIC GREENSTONE, containing crystals of *iron pyrites*. (Part of a dyke.) This and some other trappean rocks of the neighbourhood might be usefully employed on the roads of the vicinity, which are too frequently mended with quartz.—West Pentire, Crantock, Cornwall. Map 30.

176.—SMALL-GRAINED GREENSTONE, composed of an intimate mixture of *felspar* and *hornblende* (?), and weathering ferruginous-brown.—Campsie Hills, Stirlingshire, Scotland.

177.—CONCRETIONARY GREENSTONE, weathering into ferruginous-brown concentric concretions (*from Coal Measures*).—2 miles south of Atherstone, Warwickshire.

178.—GREENSTONE, composed of *hornblende* and *felspar*, with small specks of *black mica*, often steatitic on surfaces. An eruptive rock intruded among and altering Upper Silurian (Ludlow) strata. Map 56, S.E.—Stanner Rocks, near Kington, Herefordshire.

179.—COMPACT GREENSTONE, from a dyke traversing Cambrian Rocks.—Baily Lighthouse, Howth, County Dublin.

180.—COMPACT GREENSTONE.—Between Lay Point and St. Ives, Cornwall. Map 33.

181.—GREENSTONE. (See "Report on Cornwall," p. 82.) —St. Mewan, Cornwall. Map 31.

182.—GREENSTONE. Trenoweth, Cury, Cornwall. Map 31, UPPER GALLERY — Wall-cases 6 and 7.

183.—GREENSTONE, of a somewhat hypersthenic character. It pierces the soil in different places, and is scattered over the country in large blocks. This rock forms part of a mass of trappean rock extending north and south, and is apparently somewhat altered from exposure to the influence of the neighbouring granite. It makes an excellent material for roads.—Michaelstow Beacon, Cornwall. Map 30.

184.—COMPACT GREENSTONE (weathering brown) in close contact with slate.—Carn Llidi, St. David's, Pembrokeshire. Map 40.

185.—FINE-GRAINED GREENSTONE (weathering brown) a little removed from contact with slates.—South-east side of Carn Llidi, St. David's, Pembrokeshire. Map 40.

186.—BASALTIC GREENSTONE.—Clee Hills, near Ludlow Salop.

187 and 187a.—COMPACT GREENSTONE.—Gurnard's Head, Zennor, Cornwall. Map 33.

188.—GREENSTONE (*locally termed "toadstone"*), composed of an intimate mixture of *felspar* and *hornblende.*—From a mine near Hartshill Hall, Derbyshire.

189.—COMPACT GREENSTONE, composed of an intimate mixture of *felspar* and *hornblende*, in nearly equal proportions. Weathers ferruginous brown.—North of Strathaven, Lanarkshire, Scotland.

190.—GREENSTONE ("*toadstone*"), a crystalline compound of *felspar* and *hornblende*, weathering brown.—Near Fairfield, Buxton, Derbyshire.

191.—GREENSTONE ("*toadstone*"), in contact with a vein of *aragonite.*—Allport, Bakewell, Derbyshire.

192.—GREENSTONE, from a dyke cutting through Cambrian rocks.—Longmynd, Shropshire.

193.—COMPACT GREENSTONE, associated with slates and grits. (See "Report on Cornwall," p. 82.)—Black Head, St. Austell, Cornwall. Map 31.

194.—COMPACT GREENSTONE.—Between Lay Point and St. Ives, Cornwall. Map 33.

195.—COMPACT GREENSTONE, containing a little *iron pyrites.*—From a dyke traversing chlorite and mica schist.—The Skerries, Anglesea. Map 78, N.W.

UPPER GALLERY. Wall-cases 6 and 7.

196.—COMPACT GREENSTONE, with a weathered surface.—Rhosmynach, Anglesea.

197.—DIALLAGE ROCK, apparently cutting through serpentine. (See "Report on Cornwall," p. 98.)—Penvose, Landewednack, Cornwall. Map 32.

198.—COMPACT GREENSTONE, apparently intruded among argillaceous slates. Employed for roads, for which it is an excellent material.—Egloshayle, Cornwall. Map 30.

199.—GREENSTONE.—Bryn Fuches, Anglesea.

200.—GREENSTONE (*fine grained*), formed of *hornblende, felspar*, and *carbonate of lime.* This forms a boss of rock, apparently forced up among the adjoining slates and breccias. It may be remarked that the latter, which occur on the southern part of the hill, do not contain any portion of the trappean rock near them.—Dinas Hill, near Padstow, Cornwall. Map 30.

201.—A kind of TRAPPEAN ROCK, having a semi-mechanical origin, and associated with a conglomerate (No. 119) of the slate series. This rock is quarried, for building stone, at the cliff close to the river.—Opposite Cant Hill, Padstow Harbour, Cornwall. Map 30.

202.—GREENSTONE.—This rock occurs at the extreme point of the head, and is continued outwards in a western direction under the sea-level, as is seen by rocks which appear at low water. Without the protection of its greenstone point, Park Head would be cut back, by the incessant action of the breakers, to the general line of coast on each side of it.—Park Head, St. Eval, Cornwall. Map 30.

203.—GREENSTONE with a small quantity of *iron pyrites.* This rock forms the northern part of the Head, and constitutes the range known as the Millup, or Mirrup Rocks, which extend eastward into Polventon Bay. The greenstone has evidently been intruded among the adjacent schistose rocks.—East side of Trevose Head, Cornwall. Map 30.

UPPER GALLERY. — Wall-cases 6 and 7.

204.—GREENSTONE associated with contemporaneous argillaceous slates.—Near Trereiffe, Penzance, Cornwall. (See "Report on the Geology of Cornwall," p. 100.) Map 33.

205.—COMPACT GREENSTONE, locally termed "*ironstone.*" —Botallack Mine, St. Just, Cornwall. Map 33.

206.—COMPACT GREENSTONE, locally termed "*ironstone.*" —Huel Cock, St. Just, Cornwall. Map 33.

207.—COMPACT GREENSTONE.—Burncoose, near Gwennap, Cornwall. (See "Report on the Geology of Cornwall." p. 176.) Map 31.

208.—GREENSTONE, a finely divided mixture of *felspar* and *hornblende*.—Drana Point, St. Keverne, Cornwall.

209.—GREENSTONE, *somewhat hypersthenic*.—One of the numerous trappean masses of the vicinity which appear to have been intruded among the fossiliferous slates. Employed for roads and building. It is an excellent material for the former purpose.—Hill, west from Dinham, Padstow River, Cornwall. Map 30.

210.—GREENSTONE, composed of *hornblende*, with a small proportion of *felspar*. (See "Report on Cornwall," p. 100.) Gwavas Hill, Newlyn, near Penzance, Cornwall. Map 33.

211.—BASALT.—Little Wenlock, Buildwas, Salop. Map 61, N.W.

212.—DIALLAGE ROCK, a compound of *felspar*, *hornblende*, and *diallage*. (See "Report on Cornwall," pp. 98 and 99.) —Gilly Cliff, St. Keverne, Cornwall. Map 32.

213.—GREENSTONE, composed of veins and laminæ of fibrous *asbestus* in a light green felspathic base.—Conway, North Wales. Map 78, N.E.

214.—GREENSTONE, with veins of *asbestus*. From a dike traversing the trap rock of Llyn Peris.—Llanberis, Caernarvonshire. Map 78, S.E.

215.—HORNBLENDE ROCK.—Greeb Rock, Mount's Bay, Cornwall. Map 33.

216.—HORNBLENDE SCHIST, an irregular aggregation of hornblende in imperfect crystals. Used for building-stone. —Guernsey.

217.—HORNBLENDE ROCK.—Llanerchymedd, Anglesea. Map 78, N.W. UPPER GALLERY. Wall-cases 6 and 7.

218.—Crucible, containing fused portions of the above rock.

219.—TRAPPEAN ROCK of a hypersthenic character, apparently a greenstone altered, together with the slates with which it is associated, by the intrusion of the neighbouring granite.—Higher Fenternadle, near Camelford, Cornwall. Map 30.

220.—GREENSTONE, *schistose trappean rock*, composed of *felspar, hornblende*, and *mica*. This is a continuation of a line of greenstone extending across Titch Beacon to beyond Davidstow, one of those facts common to the system of rocks of which it forms a part. Calcareous matter is associated with this rock near Grylls, and attempts have been made to burn this variety for lime, for which it is altogether unfit, the trappean matter speedily melting into a glass, and the lime assisting the process; that very fusible substance, silicate of lime, being soon produced.—Grylls, near Camelford, Cornwall. (See "Report on Geology of Cornwall, &c." pp. 57 and 58.) Map 30.

221.—VESICULAR TRAPPEAN ROCK.—Forms part of a trappean rock that extends west north-westward to Davidstow, and east south-eastward to St. Clether. It is associated with argillaceous slate, and with a line of rocks which frequently contain calcareous matter, and even limestones.

The calcareo-trappean series sweeps round the north of Dartmoor, and, after making a southern curve towards Callington, again sweeps round the Brown Willy and Rough Tor granites, which appear to have forced it out by Tintagell. This series is occasionally fossiliferous in its course.—St. Clether, Cornwall. Map 30.

222.—FINE GRAINED GREENSTONE, *partly vesicular*.—Forms part of one of several elongated trappean masses which occur near Endellyon. (See Map 30.) They vary in mineral structure, even at short distances, in the same mass. Judging from the phenomena observable on the

UPPER GALLERY. — Wall-cases 6 and 7.

adjacent coast, these masses of trap have been intruded among the fossiliferous slates of the district.—Endellyon, Cornwall.

223.—VESICULAR TRAPPEAN ROCK (GREENSTONE).—Another variety. These varieties are often employed as building stones.—Endellyon, Cornwall. See "Report on Geology of Cornwall," p. 88.) Map 30.

224.—*Vesicular trappean rock* (GREENSTONE) crosses the village in a north-east and south-west line; becomes schistose towards the north-east. Is traversed by veins of quartz in some places.—Tintagell, Cornwall. Map 30.

225.—VESICULAR TRAPPEAN ROCK.—Part of a trappean mass, which extends from near Burlarroe to Lower Croan. The northern parts of the mass are vesicular, and the southern more compact. In the coppice (see Geological Map 30) the rock is quarried for road-stone. It is the same kind of rock so much prized and so well known to the South Devon farmers by the name of *honeycombe dun.*—Near St. Mabyn, Cornwall.

226.—*Vesicular trappean rock* (GREENSTONE).—Forms part of a large mass, apparently intruded among the adjoining slates, which varies in composition from very compact greenstone to this kind of vesicular trap.—Pentire Point, Padstow Harbour, Cornwall. Map 30.

227.—TRAPPEAN ROCK (*greenstone*) in a decomposing state.—Porthleven, near St. Breague, Cornwall. Map 33.

228.—*Vesicular trappean rock* (GREENSTONE.)—Polurian Cove, Mullion, Cornwall. Map 32.

VOLCANIC TRAPPEAN ROCKS, ASH-BEDS, AND CINDERS, *from Brent Tor, Devonshire.* (See "Report on Geology of Devon and Cornwall," pp. 120 and 121.) Map 25.

229.—COMPACT TRAPPEAN ROCK (*with ash*). (See "Report on Geology of Cornwall," p. 121.)

230.—*Vesicular trappean rock* (GREENSTONE), with *green earth* and *calc spar.*—Brent Tor.

231.—*Schistose vesicular* VOLCANIC ASH. Some of the vesicles are filled with *calc* spar.—Tavistock.

UPPER GALLERY. Wall-cases 6 and 7.

232.—*Schistose vesicular* VOLCANIC ASH, showing the bedding, joints, and cleavage planes.—Tavistock.

233.—*Very vesicular* VOLCANIC CINDER.

234.—*Vesicular* VOLCANIC CINDER (some of the vesicles filled with *calc spar*), with more solid portions, probably of contemporaneous lavas, upon the whole resembling a substance composed of finely comminuted volcanic matter consolidated.—Brent Tor.

235.—SCORIACEOUS LAVA, *volcanic cinder*.—Brent Tor.

TOADSTONE AND AMYGDALOID.

236.—TOADSTONE,* containing pebbles of limestone.—From the deep shaft at the High Rake, near Tideswell, Derbyshire.

The name toadstone is applied to the greenstone which is interstratified with the Carboniferous limestone of Derbyshire and the north of England.

The term is derived from the German *todtstein* (deadstone), denoting the absence of minerals in the beds with which it is associated.—H. W. Bristow.

Toadstone is a volcanic rock or lava truly interbedded in the Carboniferous limestone of Derbyshire, and is of the same general geological age with the volcanic rocks of the Carboniferous limestone and Lower Carboniferous rocks of some parts of Scotland.

It frequently assumes a cellular structure. Sometimes the cells are empty, while at others they are filled with calc spar, green earth, and other minerals, and in the latter form they are termed amygdaloids. The vesicles have originally been formed by the escape of gases, as in modern lavas (see Nos. 4 and 5, **Case 2**), and the kernels with which they are filled have been formed by the gradual infiltration of lime or other matters into the cavities. Frequently, on

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* See also Nos. 188, 190, 191, and 253.

UPPER GALLERY. — Wall-cases 6 and 7.

the surface, the kernels are re-dissolved out, and the rock then resumes its original structure, or the emptied cells are wholly or partially filled a second time with extraneous matter.—A. C. Ramsay.

237 and 238.—AMYGDALOIDAL GREENSTONE ("*toadstone*"). A greenstone base, containing cavities filled with kernels of calc spar.—Allport, Bakewell, Derbyshire. Map 81, S.E.

239.—AMYGDALOIDAL GREENSTONE ("*toadstone*"), composed of greenstone containing cavities and cracks filled with kernels and veins of *calc spar*.—Mine near Hartshill Hall, Derbyshire.

240.—AMYGDALOID, composed of a base of *greenstone*, containing numerous cavities filled with kernels of *calc spar*, some of which have been subsequently removed by infiltration.—North of Colzean Castle, Ayrshire, Scotland.

241.—Large kernel of CALC SPAR, detached from the above *amygdaloid*.

242.—AMYGDALOID, containing a portion of a large kernel of *quartz*.—North of Colzean, Ayrshire, Scotland.

243.—AMYGDALOID, containing cavities lined with kernels of *calc spar* and others lined with crystals of *quartz*.—Cliff, near Colzean, Ayrshire, Scotland.

244.—AMYGDALOID, with kernels of *calc spar* and a few of *quartz*.—Sea cliff, north of Colzean, Ayrshire, Scotland.

245.—AMYGDALOID, containing cavities filled with kernels of *calc spar*, *quartz*, and *chlorite*.—Sea cliff, north of Colzean, Ayrshire, Scotland.

246.—AMYGDALOID, composed of kernels of *calc spar* in a greenstone base.—Charfield Green, Gloucestershire. Map 35.

247.—AMYGDALOID, composed of nests of *epidote* in a base of greenstone.—Caer Caradoc, Church Stretton, Salop. Map 61, S.W.

248.—AMYGDALOID, composed of kernels of decomposing *green earth*, and *compact mesotype*, in a greenstone base.—Caradoc Hill, Church Stretton, Salop. Map 61, S.W.

249.—AMYGDALOIDAL GREENSTONE, the cavities filled with *calc spar*, which have almost entirely been removed.—Gaer fawr, Carneddau, Builth, Breconshire. Map 56, S.W.

Upper Gallery. — Wall-cases 6 and 7.

250.—Porphyritic greenstone, composed of imperfect crystals of *felspar*, in a base of compact greenstone.—Opposite Ramsey Sound, St. David's, Pembrokeshire. Map 40.

251.—Amygdaloid, with crystals of *quartz* replacing *calc spar*.—East of Bettws Disserth, Radnorshire. Map 56, S.E.

252.—Amygdaloid, containing a large kernel of *calc* spar.—Lower Ridge, 1½ mile east of Chirbury, Salop.

253.—Vesicular greenstone ("*toadstone*"), the air-vesicles, originally formed when the rock was in a fused state, have been filled with kernels of *calc spar*, which last were subsequently removed by the percolation of water.—Masson Hill, Matlock Bath, Derbyshire. Map 82, S.W.

254.—Serpentinous greenstone.—Damory Bridge, Wotton-under-Edge, Gloucestershire. Map 35.

255.—Trappean conglomerate, composed of fragments of quartz, sandstone, and slate in an arenaceous cement chiefly, and associated with grey argillaceous slates. (See "Report on Cornwall," pp. 120 and 121. De la Beche.) —Carne Mere Point, near Nare Head, Cornwall. Map 31.

256.—

257.—

258.—

259.—

Canadian Specimens, &c.*

260.—Felsite porphyry (*Euritique*, &c.), part of a boulder.—Near Montreal, Lower Canada.

261.—Gneissoid rock, *containing garnets*.—La Prairie, near Montreal, Lower Canada.

262.—Quartz (*from a veinstone*), containing crystals of *garnet*. From a boulder.—Banks of the St. Lawrence, Montreal, Lower Canada.

263.—Part of a granite boulder, containing numerous *garnets*.—Banks of the St. Lawrence, Montreal, Lower Canada.

* American rocks, chiefly presented by Sir William E. Logan.

Upper Gallery. — Wall-cases 6 and 7.

264.—Granite, composed of *felspar* (some in fine crystals), *quartz*, and *black mica*.—Mount Johnstone, St. John's, River Richelieu, Lower Canada.

265.—Granulite, leptynite, or felspathic granite, a compound of *roseate felspar* and *quartz*. From a boulder. —Near Montreal, Lower Canada.

266.—Syenite, composed of large fragments of *hornblende*, with flesh-coloured *felspar* and *quartz*. From a dyke occurring in a range of syenitic hills.—Maskmenga, St. Lawrence, Lower Canada.

267.—Syenitic granite, containing *garnets*, and composed of crystals of *white felspar*, *quartz*, *hornblende*, and *silvery mica*.—Saddleback Mountain, State of Maine, United States.

268.—Syenite, composed of *light flesh-coloured felspar* (some in crystals), with *quartz*, and *hornblende*,—Near Montreal, Lower Canada.

269.—Syenite, composed of *flesh-coloured felspar*, *quartz*, and *hornblende*. Part of a boulder.—Near Montreal, Lower Canada.

270.—Syenite, composed of *flesh-coloured felspar*, *quartz*, and a small proportion of *hornblende*. Part of a boulder.— Near Montreal, Lower Canada.

271.—Greenstone, composed of, for the most part, imperfect crystals of *white felspar* in a base of *hornblende*. The specimen shows a weathered surface, with decomposing felspar.—Beleiul Mountain, near Chambley River, Lower Canada.

272.—Syenite, an irregular mixture of *pink felspar*, *quartz*, and *hornblende*.—Bytown Canal, Johnson Falls, Upper Canada.

273.—Syenite, composed of *hornblende* in a felspatho-quartzose base. Part of a dyke.—Montreal Mountain, Lower Canada.

274.—Syenite, composed chiefly of *labradorite* with *hornblende*, and a small quantity of *translucent quartz*. Part of a boulder.—Near Montreal, Lower Canada.

275.—NAPOLEONITE, or ORBICULAR GREENSTONE,* composed of spheroidal concretions of *white felspar* and *hornblende*, in a more hornblendic base. The specimen is traversed by a fissure filled principally with white felspar, which has cut through the spheroids, displacing the divided portions from their original positions after the manner of a fault — Corsica. UPPER GALLERY. — Wall-cases 6 and 7.

276.—SYENITE, composed of *felspar*, *hornblende*, and *quartz*, in contact with a basalt dyke.—Montreal Mountain, Lower Canada.

277.—FELSPAR PORPHYRY, composed of crystals of *felspar* in a felspathic base, with small cavities, containing minute cubes of *purple fluor spar;* part of a dyke.—Chambley Canal, Lower Canada.

278.—SYENITE, composed of *hornblende*, *flesh-coloured felspar*, and a small quantity of *quartz*.—Australia. Presented by J. B. Jukes, F.R.S.

279.—BASALT, containing crystals of *hornblende*, *felspar* (*Albite*) and *olivene;* Australia.—Presented by J. B. Jukes, F.R.S.

280.—COMPACT GREENSTONE, composed chiefly of *hornblende*, with a small quantity of *felspar*. The specimen has an irregularly weathered surface. Part of a boulder. —Berthier, St. Lawrence, Lower Canada.

281.—BASALT, showing a weathered surface, and containing large crystals of *hornblende*.—Montreal, Lower Canada.

282.—AMYGDALOID TRAP, the kernels filled with crystals of *stilbite* (coated with *green earth*), which are sometimes replaced by *quartz* (*rock crystal*). Part of a boulder.—Hostis Bluff, Nova Scotia.

283.—AMYGDALOID, with decomposing kernels of *green earth*.—Mountain of Montreal, Lower Canada.

284 and 285.—HORNBLENDE ROCK, composed of crystals of *hornblende* and *analcime*, in a hornblende base.—Longeuil, near Montreal, Lower Canada.

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* *See* also No. 138, Case 1, page 148.

UPPER GALLERY. — Wall-cases 6 and 7.

286.—TRAP ROCK, crystals of *analcime* in a hornblendic base.—Longeuil, near Montreal, Lower Canada.

287.—TRAP ROCK, composed of crystals of *augite*, and *analcime* in a hornblende base.—Montreal Mountain, Lower Canada.

288.—LABRADORITE. Part of a boulder.—Montreal, Lower Canada.

289.—SERPENTINOUS ROCK, with small octohedral crystals of *chromate of iron* on a weathered surface.—Brompton Pond, Canada West.

290.—SLATY TOURMALINE, Levant Mine, St. Just, Cornwall.

291.—MICA ROCK, principally composed of laminæ of *black mica.* Part of a boulder.—Near Montreal, Lower Canada.

292.—BRECCIA, composed of fragments of *quartz grit*, cemented with *black chert.* Part of a boulder.—Near Montreal, Lower Canada.

293.—ACTYNOLITE.

294.—BASALTIC DYKE, cutting through slates, and containing crystals of *hornblende*, *black mica*, and kernels of *calc spar*.—Toulinquet, north coast of Newfoundland. Presented by J. B. Jukes, F.R.S.

Table-case B in Recess 6.

Collection of Lavas, Ashes, Simple Minerals, &c., from the district of the Extinct Volcanos of the Papal States.

Arranged and described by H. W. BRISTOW.

The date of the extinct volcanos of the Roman States has been satisfactorily determined by the researches of Sir Roderick Murchison and Sir Charles Lyell, by both of whom it has been referred to the Coralline Crag period of the older Pliocene. The earlier volcanic rocks of this district rest conformably on, and are interstratified with, the shelly marls of the Subapennine Hills, the fossils of which have a specific agreement with those of the Suffolk crag of this country.

UPPER GALLERY. — Table-case B. in Recess 6.

Hence it appears that the volcanic rocks in question are of submarine origin, and that they were formed by eruptions which took place during the period when the strata forming the Subapennine Hills were in the course of deposition. (Lyell's "Manual of Elementary Geology," p. 535.)

1—VOLCANIC BOMB of scoriaceous lava, from the beds near the Villa Falconieri, above Frascati.

2.—Fine-grained MARLY TUFA, beyond Sta. Agnese, 3 miles from Rome.

3.—TUFA, composed of minute fragments of *earthy leucite, mica, augite,* &c., beyond Sta. Agnese, 3 miles from the Porto Piafuori at Rome.

4.—YELLOWISH TUFA, with impressions of a *fern.*—From the end of the road from Ponte Porphio to Frascati.

5.—TUFA, with yellow *decomposed pumice, augite, leucite,* and a few small scales of *mica,* forming erratic blocks scattered over the Aventine and Esquiline Mounts inside Rome.

6.—BRICK-RED TUFA, with fragments of *grey lava, leucite, augite,* and *calc spar,* forming a great deposit beyond Sta. Agnese.

7.—GREY TUFA, composed of minute fragments of *lava, leucite, augite,* and *mica,* forming a great deposit on the Capitoline Mount, inside Rome.

8.—TUFA, composed of fragments of *augite, mica,* and *earthy leucite,* with *lava, decomposed pumice,* &c., from the prolongation of Monte Esquilino, beyond Porto San Giovanni, 3 miles from Rome.

9.—BRICK-RED TUFA, from the Aventine Mount. Presented by Warington W. Smyth, F.R.S.

10.—TUFA, with fragments of *lava, augite, mica, calc spar,* &c., forming the nucleus of the Capitoline Hill.

UPPER GALLERY. — Table-case B. in Recess 6.

11.—Tufa, composed of decomposing *glassy felspar*, small fragments of *grey lava, augite*, and specks of *silvery mica*.—From the basin of Lake Baccano, on the road to Monte Rossi.

12.—Brown cellular tufa, some of the cells filled with yellow *pumiceous remains*, with *earthy leucite, augite*, a little *mica*, &c.—Monte Pincio, inside Rome.

13.—Compact tufa, with earthy *leucite*, fragments of *pumice, mica*, and *augite*.—From the Olive Grove of Valdo Ambrini.

14.—Brick-red tufa, with fragments of *lava, pumice, earthy leucite, augite, mica*, and *metamorphic marble*.—From Monte Verdi, 2 miles from Rome.

15.—Spongy tufa, full of yellow *pumice*, partly stained with oxide of iron and fragments of *glassy felspar*.—From the basin of the ancient lake Baccano, on the road to Monte Rossi.

16.—Brown tufa, with *earthy leucite* and fragments of *brown lava, augite*, &c.—From the summit of the Quirinal, 5 feet below the roadway in front of the Palazzo della Consulta, Rome.

17.—Granular tufa, composed of pieces of *pumice, augite*, and *leucite*, overlying No. 12.—Monte Pincio, inside Rome.

18.—Reddish-brown tufa, with fragments of *grey lava, mica*, and much *earthy leucite*.—From the summit of the Quirinal, inside Rome.

19.—Grey tufa, with *leucite*, &c.—Near the gate of Santo Spirito, inside Rome.

20.—Stony tufa, composed of pieces of *lava, pumice*, and *ashes*, with *augite, mica*, and *earthy leucite*.—From the Vatican at Rome, found in 1818 in digging the foundations of the Chiaramonti Museum.

21.—Tufa, with included fragments of *pumiceous lava*, with *earthy leucite*, crystals of *glassy felspar*, &c., occurring at the surface near the first gate beyond Tor Di Quinto.

UPPER GALLERY. — Table-case B. in Recess 6.

22 and 23.—Varieties of TUFA from Monte Verdi, used for the ordinary building stones of Rome.—Presented by Warington W. Smyth, F.R.S.

24.—GREY PEPERINO, with *augite*, *calc spar*, *mica*, &c., from the lower portion of the mass.—Albano. Presented by Warington W. Smyth, F.R.S.

25.—GREY PEPERINO, with fragments of *scoriaceous lava*, *augite*, *mica*, and *carbonate of lime*.—From Marino.

26.—GREY PEPERINO, with fragments of *scoriaceous lava*, *augite*, *mica*, and large fragments of *carbonate of lime* (*metamorphic limestone*).—Marino.

27.—GREY PEPERINO, with fragments of *lava*, *augite*, *leucite*, and *mica*.—From the great cavern under Marino.

28.—GREYISH PEPERINO, with *mica*, *calc spar*, and crystals of *augite*.—Gensano.

29.—GREY PEPERINO, containing green and black *mica*, with crystals of *leucite*, *augite*, and *olivine*.—From the lake below Marino.

30.—GREY PEPERINO, with fragments of *lava*, *augite*, *leucite*, *mica*, and *calc spar* (some in crystals).—Pantanello, 3 miles from Marino.

31.—ASH-GREY PEPERINO, with fragments of *lava*, *augite* and *mica*, and a large crystal of the latter.—From the ascent to Ariccia.

32.—GREY PEPERINO, with *augite*, small scales of *mica*, *leucite*, and fragments of *metamorphic limestone*.—Albano.

33.—VOLCANIC ASH, with small fragments of *augite*.—From Tempesta, in the basin of Lake Albano.

34.—BRICK-RED ASHES, with fragments of *augite* and *leucite*, forming the bed of the basaltic lava stream of Capo di Bove.

35.—*GREYISH-WHITE ASHES.—Monte Artemisio, near Velletri.

* These are used, when mixed with lime, for making the cement called Pozzuolana.

UPPER GALLERY. — Table-case B. in Recess 6.

36.—*GREY ASHES.—Monte Albano and Monte Artemisio, near Velletri.

37.—*RED ASHES.—From the lava on the hills near San Paolo, 3½ miles from Rome.

38.—*VOLCANIC CINDERS, composed of pieces of *scoriæ*, *earthy leucite*, &c.—Lake Nemi.

39.—Fragments of VOLCANIC CINDERS.—Monte Cavo, above Albano.

40.—CINDERS.—Forming a part of Monte Cappuccini, near Velletri.

41.—*CINDERS.—From Monte Cimino, between Velletri and Gensano.

42.—PUMICE.—From Caprasola, east of Monte Cimino.

43.—YELLOWISH PUMICE.

44.—PUMICEOUS LAVA, with included fragments of grey *scoriaceous lava*, similar to the lava of the Phlegræan Fields, near Naples.—From the neighbourhood of Ronciglione.

45.—SCORIACEOUS (approaching to *pumiceous*) LAVA, with included crystals of *decomposed felspar*.—Braccianesse.

46.—SCORIACEOUS LAVA, SLIGHTLY POROUS.—Forming the base of the basaltic lava stream of Capo di Bove, near Rome.

47.—Brown vesicular SCORIACEOUS LAVA.—Ticchiana, in the Campagna.

48.—Grey vesicular SCORIACEOUS LAVA.—From a rapidly flowing stream below the mills on Lake Nemi.

49.—SCORIACEOUS AND VESICULAR LAVA, some of the cavities containing *leucite*.—From the summit of Monte Malchio, near Velletri.

50.—Reddish-brown vesicular SCORIACEOUS LAVA.—Monte Cappuccini, near Velletri.

51.—GREYISH LAVA.—Lake Albano.

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* These are used, when mixed with lime, for making the cement called Pozzuolana.

UPPER GALLERY.

Table-case B. in Recess 6.

52.—SEMI-VITRIFIED SCORIACEOUS LAVA.—From the most ancient summit of Monte Artemesio, near Velletri.

53.—Brown vesicular SCORIACEOUS LAVA.—Monte Porfio and the Tusculan hills above Frascati.

54.—SCORIACEOUS LAVA, finely vesicular in the interior, and with some of the cavities filled with *leucite.*—Monte Cappuccini.

55.—SCORIACEOUS LAVA, with a crystal of *augite.*—From the lower portion of the basaltic lava stream of Capo di Bove.

56.—LAVA, with very minute cubical crystals of *hyacinth* (*zircon*).—From the summit of Tusculum, above Frascati.

57.—TRACHYTIC LAVA, with *glassy felspar*, angular fragments of black and grey vesicular *scoriaceous lava* and decomposed crystals of *felspar* in a felspathic base.—East-south-east of Viterbo.

58.—TRACHYTIC LAVA, with crystals of *glassy felspar.*—Mansiana, near Bracciano.

59.—TRACHYTIC LAVA, with *glassy felspar*, *oxide of iron*, &c.—Near Bracciano.

60.—EARTHY TRACHYTIC LAVA, with crystals of *mica* and *glassy felspar.*—From volcanic conglomerate, on the ascent to Cignanello, east of Monte Cimino.

61.—TRACHYTIC LAVA, crystals of *glassy felspar* and *mica* in a felspathic base.—North of Monte Cimino.

62.—TRACHYTIC LAVA, with crystals of *glassy felspar*, *black mica*, &c.—Bagnaja, near Viterbo.

63.—TRACHYTIC LAVA, with crystals of *glassy felspar* (one of large size), and *mica*, in a decomposing felspathic base.—Monte Soriano and Monte Cimino.

64.—TRACHYTIC LAVA, with crystals of *glassy felspar*, *mica*, and small fragments of *augite.*—From Madonna del Poggio, between Bassano and Bomasto.

65.—TRACHYTIC LAVA, with crystals of *augite* and *glassy felspar.*—From the hills near Vignanello, south-east of Monte Cimino.

UPPER GALLERY. — Table-case B. in Recess 6

66.—TRACHYTIC LAVA, with crystals of *glassy felspar* and *mica*, and fragments of *augite*.—From the mountain about a mile from Viterbo.

67.—TRACHYTIC LAVA, with crystals of *glassy felspar* and *mica* and small specks of *augite*.—Near Baslanello, east south-east of Monte Cimino.

68.—TRACHYTIC LAVA, with crystals of *glassy felspar*, *mica*, and small fragments of *augite*.—From Bomargo, east north-east of Monte Cimino.

69.—TRACHYTIC LAVA, with crystals of *glassy felspar*, *mica*, and *augitic fragments*.—Near Bagnaja, east of Monte Cimino.

70.—DECOMPOSED EARTHY TRACHYTE.—San Leonardo, near Fabbrica, east of Monte Cimino.

71.—COMPACT PORPHYRITIC ROCK.—Forming the upper portion of Monte della Cava Grande, at the alum works near Tolfa.

72.—PORPHYRITIC ROCK, with *decomposed felspar*.—Forming the second stratum which alternates with the alum rocks at Monte della Cava Grande.

73.—SILICEOUS AND FELSPATHIC ROCK.—Forming the upper stratum at the Great Cavern, near Tolfa.

74.—GREY LAVA, with crystals of *glassy felspar*.—Monte Fogliano, above Vitralla.

75.—SCORIACEOUS (*approaching to pumiceous*) LAVA, with crystals of *glassy felspar*.—From Civita Castellana.

76.—LAVA, with crystals of *glassy felspar*.—From the neighbourhood of Bracciano.

77.—LAVA, with *glassy felspar*, *&c.*—From Capo le Grotti, near Bassano nella Teverone.

78.—LAVA, with crystals of *glassy felspar* and small black *augite*.—From Lago di Vici, Ronciglione, near Monte Cimino.

79.—COMPACT LAVA, with small crystals of *glassy felspar* and *augite*, forming a columnar mass, with a rhombic base. —Near the mill, east-south-east of Viterbo.

80.—BASALTIC LAVA, with *felspar* and brown *calc spar*. —From Capo di Bove, near Rome.

UPPER GALLERY. — Table-case E. in Recess 3.

81.—LAVA, with *augite* and *calc spar*, and cracks filled with *ochreous iron ore* (*graphic lava.*)—From the border of Lake Nemi, near the Mills.

82.—LAVA, with crystals of *glassy felspar*, *leucite*, *black mica*, and *augite.*—From the fountain near Bassano, east of Monte Cimino.

83.—LEUCITE (*amphigène*, *white garnet*), in detached trapezohedral crystals.—From the neighbourhood of the Tusculan and Alban Hills.

84.—LAVA, with crystals of *altered leucite.*—From Borghetto, 3 leagues from Civita Castellana.

85.—LAVA, with numerous crystals of *leucite.*—Monte Cavo, above Albano.

86.—POROUS LAVA, with crystals of *leucite.*—From the hollow under Canapino, Monte Cimino.

87.—LAVA, with large crystals of LEUCITE, and a little *haüyne* and *augite.*—From the rock of Travignano, Lake Bracciano.

88.—BASALTIC LAVA, with *leucite*, a little *haüyne* and *breislakite* (*white augite*).—Capo di Bove.

89.—COMPACT LAVA, with altered LEUCITE.—Rock of Travignano, Lake Bracciano.

90.—BASALTIC LAVA, with LEUCITE, &c.—Capo di Bove.

91.—SCORIACEOUS LAVA, with numerous small crystals of *leucite.*—Hannibal's Plains on Monte Lassiale, above Albano.

92.—VESICULAR LAVA, with crystals of *leucite*, occurring in cavities in Pozzuolana (volcanic ashes), on Monte Albano.

93.—LAVA, with large crystals of *leucite* and *augite*, *haüyne*, &c., occurring in volcanic conglomerate, near Osteria, on the road to Albano.

94.—CELLULAR LAVA, with opaque decomposed crystals of *leucite.*—Strada della Fontanella, near Cariapina, Monte Cimino.

95.—CELLULAR LAVA, with opaque crystals of *decomposed leucite.*—Strada di Carbognano, Monte Cimino.

UPPER GALLERY. — Table-case B. in Recess 6.

96.—LAVA, with crystals of *altered leucite*, found in cavities in friable tufa.—Vignanello, Monte Cimino.

97.—FINELY VESICULAR GREY LAVA, approaching to pumice, with lines of ashy laminæ, and a few crystals of *leucite*.—Found in large masses north-east of Monte Cimino.

98.—GREY LAVA, in places finely vesicular, and containing crystals of *leucite* and a crystal of *garnet*.—From the rock, halfway up Monte Maschio, near Velletri.

99.—*Brown scoriaceous and finely vesicular* LAVA, containing trapezohedral crystals of *leucite*, and disseminated scales of *black mica*.—Monte Cavo.

100.—BASALTIC LAVA, with *leucite, augite, &c.*—Strada di Bracciano.

101.—Detached CRYSTALS OF AUGITE, from the Tusculan and Alban Hills.

102.—AUGITE AND LEUCITE, found in the ashes on the plains of Monte Albano.

103.—BASALTIC LAVA, with *breislakite* (*white augite*), *leucite*, &c.—Capo di Bove.

104.—BASALTIC LAVA, with crystals of *leucite* and *augite*,—Capo di Bove.

105.—LAVA, with *leucite, augite*, and *haüyne*, forming masses occurring in a bed of volcanic conglomerate, near Osteria, on the road to Albano.

106.—LAVA, composed of *augite, leucite*, &c.—Near Albano.

107.—BASALTIC LAVA,* *with augite*.—Capo di Bove.

108.—GREY LAVA,* with crystals of *augite*.—Monte di Pofi, near Ceprano, in the Campagna.

109.—AUGITIC LAVA,* interior of the basin of Lake Albano.

110.—PITCHSTONE LAVA, with crystals of *glassy felspar*.—From the mass on the plain of Galli, near the Alum Works at Tolfa.

* Nos. 107 to 109 attract the magnetic needle.

Upper Gallery. — Table-case B. in Recess 6.

111.—Obsidian, *with sphærulitic pearlstone*, occurring in large masses on the east of Monte Cimino.

112.—Obsidian, ditto, ditto.

113.—Obsidian (*volcanic glass*), showing a conchoidal fracture and sharp cutting edges.—From an isolated mass found on the Tusculan Hills above Frascati, and similar to that found in the Lipari Isles in the Mediterranean.

114.—Basaltic lava, *with mellilite, felspar, calc spar,* and acicular prismatic *crystals of apatite* (*phosphate of lime*). —Capo di Bove.

115 and 116.—Basaltic lava,* *with mellilite.*

117.—Basaltic lava,* *with augite, mellilite, nepheline, and felspar.*

118.—Scoriaceous lava,* *with breislakite, leucite, augite, and pseudo-nepheline.*

119.—Basaltic lava,* *with mellilite, decomposed felspar,* &c.

120.—Basaltic lava,* *with decomposed felspar.*

121.—Basaltic lava,* *with mellilite, leucite, and augite.*

122.—Basaltic lava,* *with mellilite, nepheline, and leucite.*

123.—Basaltic lava,* *with mellilite, abrazite, nepheline, apatite,* &c.

124.—Compact lava,* with *calc spar* stained by *oxide of manganese, mellilite,* and acicular crystals of *apatite.*

125.—Basaltic lava,* *with crystals of apatite, mellilite, nepheline, and augite.*

126.—Basaltic lava,* *with mellilite, apatite, and abrazite.*

127.—Olivine,* *with green augite,* occurring in pozzuolana, on the plains of the Tusculan and Alban Hills.

128 and 129.—Basaltic lava,† *with nepheline, mellilite, apatite, and breislakite.*

130.—Basaltic lava,† *with breislakite and apatite.*

* Nos. 115 to 127 are from Capo di Bove; and Nos. 115, 116, 117, 119, 120, 124 attract the magnetic needle.

† Nos. 128 to 130, from Capo di Bove, attract the magnetic needle.

UPPER GALLERY. — Table-case B. in Recess 6.

131.—BASALTIC LAVA,* *with breislakite* (stained by oxide of manganese), *apatite*, and *abrazite*.

132.—COMPACT BASALTIC LAVA,* *with abrazite*.

133.—BASALTIC LAVA,* *with abrazite on calc spar*.

134.—BASALTIC LAVA,* with crystals of *nephlinee, carbonate of copper, leucite, &c.*

135.—BASALTIC LAVA,* *with augite, leucite, breislakite, nepheline, and apatite*.

136.—BASALTIC LAVA,* *with mesotype*.

137.—IDOCRASE, with small scales of *mica*, and pale grey decomposed *nepheline*.—From the decomposed ashes of Monte Albano.

138.—GRANULAR ICESPAR, iridescent *augite, melanite*, and scales of *black mica*.—Found lining cavities in peperino round the sides of Lake Albano.

139.—ICESPAR, with rhombic dodecahedrons of *melanite*. —From the peperino in the neighbourhood of Albano.

140.—*Detached prismatic crystals of* MICA.—From the Tusculan and Alban Hills.

141.—LAMELLAR MICA.—From the ashes of the Roman States.

142.—MICA, *with augite and felspar*.—From the loose peperino of Latium.

143.—MICA, crystallized on small green crystals of *augite*. —From the borders of Monte Cavo.

144.—HEXAGONAL PRISMS OF MICA, *with augite, haüyne, olivine*, &c.—From Monte Cavo, above Albano.

145.—MICA in green laminæ, and in black hexagonal crystals, with *chrysolite* (*olivine*) and *phillipsite*.—Monte Albano.

146.—AUGITE, *with black mica*.—From Monte Albano.

147.—LEUCITE, *with idocrase and mica*.—From the neighbourhood of Lake Albano.

148.—MICA, *augite*, and crystals of *melanite*.—From Monte Albano.

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* Nos. 131 to 136, from Capo di Bove, attract the magnetic needle.

149.—GREEN MICA *with haüyne.*—Found in grey peperino round the basin of Lake Albano. UPPER GALLERY. Table-case B. in Recess 6.

150.—HAÜYNE, with scales of *green mica.*—Occurring in hollows in the peperino at the base of Monte Cavo, above Albano.

151.—HAÜYNE, *mica*, *olivine*, &c.—Monte Cavo.

152.—*Mass of* CRYSTALS OF AUGITE, with black *mica.*—Found in the red ashes on the plains of Monte Cimino.

153.—Detached dodecahedral crystals of MELANITE (*black garnets of Frascati.*)

154.—GREEN MICA and octohedral crystals of *pleonaste* (*black spinel*) in a base of *granular augite.*—From the decomposed ashes on the plains of Monte Albano.

155.—SPINEL (*some in small octohedral crystals*).—From decomposed ashes on the plains of the Tusculan and Alban Hills.

156.—WAD OF EARTHY MANGANESE.—From the mountains near Civita Vecchia.

157.—TITANIFEROUS IRON, with *quartz.*—From the neighbourhood of Marino.

158.—TITANIFEROUS IRON (ILMENITE), in detached grains, which attract the magnet.—Tusculan and Alban Hills.

159.—SAND, composed of small grains of *titaniferous iron*; with fragments of *augite*, *ashes*, and pieces of *leucite.*—From Lake Albano.

160.—SAND, composed of small grains of *titaniferous iron*, fragments of *augite*, *glassy felspar*, *olivine*, *scoriaceous lava*, and *pumice.*—From the Lake of Bossena.

161.—IRON PYRITES (*sulphide of iron*).—From Monte di Salisano.

162.—SPATHIC IRON (*carbonate of iron*).—From Monte Ernici, in the Campagna.

163.—PEROXIDE OF IRON.—From Guercino, in the Campagna.

164.—Nodule of CLAY IRONSTONE.—From the Umbrian Hills.

UPPER GALLERY. — Table-case. 8. in Recess 6.

165.—Nodule of CLAY IRONSTONE.—From Magnano, north of Monte Cimino.

166.—GREY SULPHIDE OF ANTIMONY.—From the hills near the Alum Works on Mount Tolfa.

167.—BITUMEN, *with white limestone.*—From Castro, in the Campagna.

168.—BITUMEN (ASPHALTE).—From the hill under the lighthouse of Sabina.

169.—SULPHUR on PEPERINO, which has been decomposed by sulphurous acid gas.—From the road to Albano.

170.—*Minute* CRYSTALS OF SULPHUR, on a rock composed of *felspar*, *augite*, and *mica*, which has been decomposed by sulphurous acid gas.—From a mass near Bracciano.

171.—Detached hexagonal prisms of ROCK CRYSTAL* ("*Tolfa diamonds*") with double pyramidal terminations. —From a rock near Tolfa.

172.—QUARTZ ROCK,* in which the rock crystals No. 171 are found.

173.—CHALCEDONIC QUARTZ.*—From a hill amongst the Alum Works at Tolfa, near Civita Vecchia.

174.—SEMI-OPAL* (*quartz résinite*).

175.—*Concretionary and aluminous* QUARTZ ROCK,* with small cavities, which are lined and filled with cubical and octohedral crystals of *alumstone.*—Found in the hollows of the rock; used for making alum at the works at Tolfa.

176.—FLUOR SPAR.*

177.—GALENA (SULPHIDE OF LEAD)* *with fluor spar.*

178.—BLENDE (SULPHIDE OF ZINC)* *with galena, copper pyrites, and fluor and calc spar.*

179.—ALUMSTONE.*—From the White Cavern.

180.—ALUMSTONE.*—From the Basaltic Cavern.

181.—ALUMSTONE.*—From the Castellina Cavern.

182.—ALUMSTONE.*—From the Great Cavern.

183.—SILICEOUS ALUMSTONE.*—From the Great Cavern.

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* Nos. 173 to 187 are from the neighbourhood of the Alum Works at Tolfa, near Civita Vecchia.

184.—ALUMINOUS ROCK.*—From the Old Cavern.

UPPER GALLERY. — Table-case B.

185.—ALUMSTONE* which has been roasted.

186.—ALUMSTONE* which has been roasted and macerated in water.

187.—PURIFIED ALUM* (*the alum of commerce*), obtained from *alumstone* by roasting and macerating in water, from which it has been deposited in crystals.

188.—ALTERED FELSPATHIC ROCK, with white *felspar*.—From the mass composing the hills between Tolfa and the Alum Works.

189.—ALTERED FELSPATHIC ROCK, with cubical crystals of *alumstone*.—From the Alum Works near Tolfa.

190.—SAND, composed of *titaniferous iron*, *augite*, *leucite*, *olivine*, &c.—From the road to Bracciano.

191.—SAND, composed of *fragments of felspar*, *augite*, *tufa*, *lava*, *and pumice*.—From the Chian Hills, north of Monte Cimino.

192.—FELSPATHIC SAND, with *fragments of scoria*, *tufa*, *lava*, *and augite*.—From the base of Monte Cimino.

193.—SAND composed of minute grains of augite, leucite, &c., forming a bed below the foundry, on the road to Lake Bracciano.

194.—WHITE AND BROWN CALC SPAR, the latter probably discoloured by organic matter, accompanying the *brown iron ore* (No. 162.)

195.—CLAY.—From the decomposed trachyte of Monte Cimino.

196.—GREY CALCAREOUS PIPECLAY, used for making pottery.—From the Vatican Hill, south of St. Peter's, in side Rome.

197.—FETID LIMESTONE (*stinkstone*).—From the peperino of Monte Albano.

198.—WHITE MARBLE (*metamorphic limestone*).—From the peperino of Monte Albano.

* Nos. 184 to 187 are from the neighbourhood of the Alum Works at Tolfa, near Civita Vecchia.

Upper Gallery. — Table-case B. in Recess 6.

199.—Selenite.—From the Great Altar, near Tolfa.

200.—White gypsum (*alabaster*).—Tolfa.

201.—Aragonite.—Monte Capuccini, near Orta.

202.—Bole.—Found in crevices of tufa near the church of San Lorenzo, outside the walls of Rome.

203.—Bole.—Found in a large hollow in decomposed peperino, outside the Porto San Giovanni, four miles from Rome.

204.—Bole.—Found in crevices of the basaltic lava stream of Capo di Bove.

205.—Fine clay.—Found in the veins of alum rock in the Great Cavern.

206.—Travertine.—From the lake near Tivoli.

207.—Calcareous Tufa (*stinkstone*).—Travertine from Lake Tartarus, below Tivoli.

208.—Travertine, deposit of carbonate of lime with spherical cavities produced by the escape of carbonic acid gas.—From the spring near the lake of the floating island below Tivoli.

209.—Travertine, calcareous deposit inclosing the *shells of snails*.—Occurring in the volcanic tufa at the descent from Porto Solaro, 2 miles from Rome.

210.—Travertine ("*Tivoli travertine*").—Calcareous deposit from the neighbourhood of the lake of the floating island below Tivoli.

211.—Limestone, with a portion of a *univalve shell*.—Monte Mario, near Rome.

212.—Limestone, enclosing a fossil *bivalve shell*.—Monte Mario.

213 and 214.—Metamorphic limestone.—From the Apennine chain of the Roman States.

215.—Stalactitic carbonate of lime.—From the grotto of Collepardo, on Monte Ernici, in the Campagna.

216.—Stalactitic carbonate of lime.—From the Cascade below the temple of the Sibyl, at Tivoli.

217.—Stalactitic carbonate of lime.—From Subiaco, in the Campagna.

218.—STALAGMITE (*commonly called "travertine of Tivoli"*), and found in hollows of large masses at the limestone cavern, near Lake Tartarus.

UPPER GALLERY. — Table-case B. in Recess 6.

219.—CALCAREOUS TUFA OR TRAVERTINE, a stalactitic carbonate of lime.—From the cascade near Torni.*

220.—TUFA, a calcareous deposit investing *stems of plants.*—From below the bastion of Paul V., on the Aventine Mount, inside Rome.

221.—CALCAREOUS TUFA, *with impressions of vegetables.*—Forms the Pincian Hill, both inside and outside Rome, underlying volcanic tufa.

222.—CALCAREOUS TUFA, *with the impression of a leaf.*—Monte Pincio.

223.—CALCAREOUS TUFA, *incrusting stems of vegetables.*—Below the bastion of Paul V., on Mount Aventine, inside Rome.

224.—CONGLOMERATE (*puddingstone*) calcareous and siliceous pebbles in a hard calcareo-arenaceous base.—From the bridge of St. Onofrio, near Monte Mario.

225.—CONGLOMERATE.—Forming Monte Sacro, and overlying the elephant gravel, near Ponte Salaro, 3 miles from Rome.

226.—CONGLOMERATE, *with augitic fragments,* overlying brecciated tufa.—From the deposit below the bridge beyond Sta. Agnese, 3 miles from Rome.

227.—CONGLOMERATE, composed of calcareous and siliceous pebbles in a silicio-calcareous base.—Forms a portion of Monte Mario, near Rome.

228.—COMPACT CALCAREOUS CONGLOMERATE.—From the Vatican Hill, outside Rome.

* "The calcareous waters of the Anio incrust the reeds which grow on its banks, and the foam of the cataract of Tivoli forms beautiful pendant stalactites. On the sides of the deep chasm into which the cascade throws itself, there is seen an extraordinary accumulation of horizontal beds of tufa and travertine, from four to five hundred feet in thickness."—*Lyell's Principles of Geology,* p. 241.

UPPER GALLERY. — Table-case 8. in Recess 6.

229.—CALCAREOUS BRECCIA, *composed of fragments of metamorphic limestone*, and found in the crevices of the limestone forming the Apennine chain of mountains.

230.—PUMICEOUS CONGLOMERATE, overlying beds of calcareous breccia, and associated with beds of volcanic tufa.—From Sta. Agnese, 3 miles from Rome.

231.—CONGLOMERATE *of yellowish pumice cemented by earthy tufa*, overlying brown granular tufa on the Pincian Hill, inside Rome. This conglomerate forms the upper portion of all the hills inside and around Rome.

232.—*Fragment of a* FOSSIL ELEPHANT'S TUSK.—From the interior of Monte Sacro, near Ponte Salaro, 3 miles from Rome.

LAVAS AND OTHER PRODUCTS OF ERUPTION FROM ETNA.

ETNA.—"After Vesuvius (see p. 164) our most authentic records relate to Etna, which rises near the sea in solitary grandeur to the height of nearly 11,000 feet. The base of the cone is almost circular, and 87 English miles in circumference; but, if we include the whole district over which its lavas extend, the circuit is probably twice that extent.

"The cone is divided by nature into three distinct zones, called the *fertile*, the *woody*, and the *desert* regions. The first of these, comprising the delightful country around the skirts of the mountain, is well cultivated, thickly inhabited, and covered with olives, vines, corn, fruit-trees, and aromatic herbs. Higher up the woody region encircles the mountain, an extensive forest six or seven miles in width, affording pasture for numerous flocks. The trees are of various species, the chestnut, oak, and pine being most luxuriant; while in some tracts are groves of cork and beech. Above the forest is the desert region, a waste of black lava and scoriæ, where, on a kind of plain, rises the cone to the height of about 1,100 feet, from which sulphureous vapours are continually evolved. The most grand and original feature in the physiognomy of Etna is the multitude of minor cones which are distributed over its flanks, and which are most abundant in the woody region. These, although they appear but trifling irregularities, when viewed from a distance, as subordinate parts of so imposing and colossal a mountain, would, nevertheless, be deemed hills of considerable altitude in almost any other region."—Lyell's "Principles of Geology," 7th edition, chap. xxv.

UPPER GALLERY. — Table-case B. in Recess 6.

The positions and mode of occurrence of the minor cones are marked on the relief model by M. Elie de Beaumont, which accompanies the specimens. Being constructed on a true scale (that is, on the same scale for heights as for distances), it shows the more clearly the very gradual rise of the surface from the sea to the foot of the great crater, and the extremely insignificant size of the lateral cones when compared with that of the principal crater. It also renders evident, that enormous volumes of matter must have been discharged to have formed an accumulation of such magnitude as that forming the base of the mountain, or more correctly, of the great cone, which constitutes the present mountain.

"Without enumerating numerous monticules of ashes thrown out at different points, there are about 80 of these secondary volcanos, of considerable dimensions, 52 on the west and north, and 27 on the east sides of Etna. One of the largest, called Monte Minardo, near Bronte, is upwards of 700 feet in height, and a double hill near Nicolosi, called Monte Rossi, is 450 feet high, and the base two miles in circumference, so that it somewhat exceeds in size Monte Nuovo. Yet it ranks only as a cone of the second magnitude amongst those produced by the lateral eruptions of Etna." (See model.) "The greater number of eruptions happen either from the great crater or from lateral openings in the desert region."—Lyell's "Principles of Geology," chap. xxv.

Etna is known to have been in activity for at least 2337 years, the earliest authenticated eruption having taken

UPPER GALLERY. — Table-case B. in Recess 6.

place about 480 B.C., but there is geological evidence to prove that it has been an active volcano for a far greater period.

The deep valley on the eastern side of Etna, called the Val del Bove, which extends from the woody region nearly to the summit, is especially deserving of notice from the insight it affords into the structure of the entire mountain. (See model.) In the nearly perpendicular precipices, varying from 1000 to 3000 feet in height, which enclose on three sides the great plain forming the Val del Bove, the volcanic beds composed of tuffs, lavas, and breccias, which form its sides, are well displayed. These are pierced in all directions by innumerable vertical dykes, varying in width from two to twenty feet, and composed of trachyte or of compact blue basalt, containing olivine. In consequence of their greater hardness these dykes are better able to resist the disintegrating effects of atmospheric influences than the rocks traversed by them; they, therefore, waste away less rapidly than the latter, and project from them in vast tabular masses, of various forms, and of great height.

"There are no records within the historical era which lead to the opinion that the altitude of Etna has materially varied within the last 2000 years. Of the 80 most conspicuous minor cones which adorn its flanks, only one of the largest, Monte Rossi, has been produced within the times of authentic history. Even this hill, thrown up in the year 1669, although 450 feet in height, only ranks as a cone of second magnitude. Monte Minardo rises even now to the height of 750 feet, although its base has been elevated by more modern lavas and ejections. * * *

"To some, perhaps, it may appear that hills of such incoherent materials, as the loose sand and scoriæ of which the lateral cones of Etna are composed, cannot be of very great antiquity, because the mere action of the atmosphere must, in the course of several thousand years, have obliterated their original forms. But there is no weight in this objection, for the older hills are covered with trees and herbage, which protect them from waste; and in regard to the newer ones, such is the porosity of their component materials, that the rain which falls upon them is instantly absorbed; and for the same reason that the rivers on Etna have a subterranean course, there are none descending the sides of the minor cones. * * * * *

UPPER GALLERY — Table-case B. in Recess 6.

"No sensible alteration has been observed in the form of these cones since the earliest periods of which there are memorials; and there seems no reason for anticipating that in the course of the next 10,000 or 20,000 years they will undergo any great alteration in their appearance, unless they should be shattered by earthquakes or covered by volcanic ejections."—Lyell's "Principles of Geology," 7th edition, chap. xxv. (H. W. Bristow.)

233.—TRACHYTE, with crystals of *augite*, from the neighbourhood of Milo.

234.—TITANIFEROUS IRON-SAND, from the crater of 1819.

235.—LAVA, with minute crystals of *specular iron*, from Monte Calvano.

236.—BASALTIC LAVA, *with mellilite and Thomsonite.*

237.—SPECULAR IRON, crystallized on scoriaceous lava, from Monte Rossi. (Eruption of 1669.)

Monte Rossi is a double cone, rising to a height of about 450 feet, about 20 miles from the summit of Etna. It was formed during the eruption of 1669.

238.—SCORIACEOUS LAVA, with crystals of *glassy felspar*, from below Monte Vituri.

239.—SULPHUR, crystallized on scoriaceous lava, from the interior of the crater of 1819.

240.—VOLCANIC ASHES.

241.—CONSOLIDATED VOLCANIC ASHES *cementing sea shells*, from the extinct volcanos south of Etna.

242.—BASALTIC LAVA, *with olivine and a little augite*, from the hill of Paterno,

262.—LAVA from a "*bocca*," showing the manner in which, when the head of a lava stream has been forced through a narrow aperture, it assumes a stalactitic form in cooling during its descent.

UPPER GALLERY.
Table-case B. in Recess 6.

APPENDIX.

SPECIMENS ADDED SINCE THE PRINTING OF THE PRECEDING PART OF THE CATALOGUE.

Table-case D.

SPECIMENS connected with the phenomena of GLACIERS and DRIFT ICE, collected, arranged, and described by A. C. RAMSAY.

29a.—ANGULAR STONES WITH NATURAL FRACTURES, from moraine in motion near the junction of the *Finster Aar and Lower Aar glaciers.* Table-case D

34a.—DITTO,—*Upper Grindelwald glacier.*

34b.—GRANITE PEBBLE, rounded and waterworn, in motion on the *side-moraine Upper Grindelwald glacier.*

These specimens (29a and 34a) are intended to illustrate the angularity of the majority of moraine stones on the surfaces of glaciers, most of which are, in the first instance, detached by the effects of frost from the solid rocks of the mountain sides, or from smaller bosses that project through the ice like islands. They are of all sizes, from grains of sand up to blocks, occasionally 20 yards in diameter, and the majority of them never having been *under* the ice are not scratched like Nos. 35 and 36a. Rarely a rounded pebble like 34b occurs among them, especially in the lower part of the glacier, owing to the circumstance that occasionally stones that have been rounded by attrition in mountain brooks, find their way to the surface of a glacier.

34c.—ANGULAR SCRATCHED LIMESTONE PEBBLE.—Terminal moraine, *Upper glacier of Grindelwald.*

35a.—ANGULAR SCRATCHED LIMESTONE PEBBLE, from under the ice.—*Lower glacier of Grindelwald.*

This specimen, like the other loose scratched stones, has been scratched by being imprisoned between the massive ice and its rocky floor during the downward passage of the

Table-case D. glacier. It was found, among other stones and glacier mud, by creeping up an ice-cavern at theend of the glacier.

35b.—ANGULAR SCRATCHED LIMESTONE PEBBLE.—Terminal moraine, *Lower Grindelwald glacier.*

35c.—SCRATCHED GRIT STONE, in motion, on the side moraine GREAT ALETSCH GLACIER, close above the tributary Middle Aletsch glacier.

This stone was probably marked by one of the higher tributary glaciers, in its passage to form part of the great side moraine.

35d.—ANGULAR STONES AND SMALL MORAINE DEBRIS, part of an old terminal moraine at the outlet of the *Merjelen See*, Great Aletsch glacier.

The Merjelen See is a lake below the Eggischhorn, on the east side of the Aletsch glacier, and the glacier sends off a branch into the upper end of the lake where the ice forms a cliff above the water in places about 60 feet high. The total thickness of the ice (by soundings) is about 107 feet. This branch once filled the area now occupied by the lake, and descending into the Valley of Viesch, united the Aletsch and Viesch glaciers. Both glaciers have since decreased in size from climatal changes, and at the outlet and on the banks of the Merjelen See there are still left striations and moraine heaps, marking the gradual recession of the glacier. (See text and note to page 12.)

36a.—SCRATCHED PIECE OF LIMESTONE, from old moraine, on the road from the Rhone valley to the Gemmi, *above Leuk.* Presented by Professor Huxley.

36b.—FRAGMENTS OF GNEISS AND GRANITE, from the *Blocks of Monthey*, valley of the Rhone, opposite Bex.

36c.—SUBANGULAR, but chiefly ROUNDED STONES, from waterworn stratified gravel, on and in which the Blocks of Monthey lie. (See note, p. 7.)

98a.—GREENSTONE WITH GLACIAL STRIATIONS.—Part of the rock on which *North Berwick* pier is built.

98b.—CARBONIFEROUS LIMESTONE SHOWING GLACIAL GROOVES AND SCRATCHES.—*North Berwick.*

The specimens 98a and 98b are from the low shores of the south coast of the Firth of Forth. On both sides of the valley of the Firth, and far inland, there are numerous indications of glacial action, both in the drift clay, gravel, and boulders that more or less cover the country, and in the frequent striation of the rocks where the drift has been freshly cleared. By the Firth, these striations run roughly east and west in the main line of the valley, and they are commonly believed to have been caused, not by a great glacier, but by the grating of icebergs over the rocky floor of the sea when the land was partially submerged. (See page 11.) Table-case D

98c.—STRIATED NIAGARA LIMESTONE.—A loose stone from a terrace of northern drift, near the railroad above Clifton House, *Niagara, Canada.*

98d.—SCRATCHED STONE, from a terrace scooped in the northern drift.—*Montreal, Canada.*

98e.—STRIATED NIAGARA LIMESTONE.—Top of the gorge of the river, near Clifton House, *Niagara, Canada.* (Lower compartment.)

The specimens from 98c to 98e are placed for comparison, and to show the universality of glacial action in the northern hemisphere.

From the great Lawrentian chain to the banks of the Ohio the Central plains of North America are more or less covered by drift, often several hundred feet in thickness. When removed, the strata on which it rests are found to be very generally grooved and striated, the striations chiefly running more or less from north to south. Examples are so common that they scarcely need enumeration. They may be well seen down the road from Clifton House, near the Falls of Niagara. On the shores of the Hudson, and the eastern flanks of the Catskill mountains near Catskill, they are also frequent, running along the side of the escarpment from north to south, till we reach the high minor gorge that traverses the range from east to west, and there by Mountain House, nearly 3,000 feet above

Table-case D. the sea, the striations bend round and cross the watershed, as if, when the land was submerged to a certain level, the ice, previously grating along the side of the escarpment, had found a passage to the west through what is now an upland valley. (See page 10.)

98f.—SHELLS from deposits OVERLYING GLACIAL DRIFT. —*Quebec, Canada.* The strata in which these shells occur, consist in great part of *remodelled drift,* made during the erosion of terraces while the country was being re-elevated from the sea.

99.—STONES, showing in part the COMPOSITION OF THE DRIFT, *Shropshire.*—Presented by Colonel Legge.

116a.—SCRATCHED GRIT STONE, from the drift, railway cutting, *Wigan,* Lancashire.

Placed for comparison with 116 from the Permian conglomerate. Both are naturally scratched by the agency of ice, and both have received accidental scratches by the pickaxe or shovel.

ROCK SPECIMENS,

Wall-case 40. Arranged and described by H. W. BRISTOW.

28a.—TUFACEOUS LIMESTONE: (*Hard Cap-bed: Lower Purbeck.*)

28b.—TUFACEOUS LIMESTONE. Soft Cap-bed of the *Lower Purbeck.* The bed from which the specimen was taken, immediately overlies that containing the stools of Cycas.

At the base of the Lower Purbeck, immediately resting upon the Portland Stone, there are beds of tufaceous limestone, which, from their position relatively to the latter, are called "cap-beds." They contain dirt-beds, and, silicified fragments of coniferous trees, together with the stems of plants allied to *Zamia* and *Cycas;* the presence of the latter indicates the existence of a warmer climate than that of the present period. The dirt-beds are the remains of former land surfaces, that is of the soil in which the plants grew, while the tufaceous limestones formed over them are, probably, for the most part, of subaërial origin, and deposited from water highly charged with calcareous matter. Wall-case 40.

From the cliff east of *Lulworth Cove, Dorsetshire.*

(See Map 16. Horizontal and vertical Sections, sheet 56.)

33a.—Large crystal of SELENITE : (*Sulphate of Lime*), showing the natural fracture, or smooth plane along which that mineral may be cleaved.

47.—KEUPER SANDSTONE with fine pseudomorphous crystals of rock salt. From *New Red Sandstone.*

Epworth, Island of Axholme, Lincolnshire.

48.—HARD GREY, THIN-BEDDED, OR SLATY LIMESTONE, the upper and under surfaces covered with pseudomorphous crystals of rock salt.

The upper part of the Cypris freestone and the Hard Cockle beds in the West Lulworth district, are remarkable for containing numerous pseudomorphous crystals of rock salt, indicating the existence of conditions at the time the beds were forming similar to those of a part of the Keuper period. (See p. 38, No. 46.) The surfaces of these thin bands of limestone are also thickly covered on both sides with *Cypris legumenella* (E. Forbes), and with occasional small pebbles.

From a bed of limestone 2 feet 6 inches thick, towards the upper part of the Cypris Freestone series (*Lower Purbeck*) : in the cliffs a short distance east of *Lulworth Cove, Dorsetshire.*

(Map 16, and Horizontal and Vertical Sections, sheet 56.)

ROCK SPECIMENS,

Arranged and described by H. W. BRISTOW.

10a.—FERRUGINOUS AND SILICEOUS CONGLOMERATE, formed of angular and subangular pebbles of chalk flint in a ferruginous base. Wall-case 41.

The low-level gravel in the neighbourhood of Romsey is of considerable thickness, and is used for making the roads of the district. The specimen furnishes a striking example of the manner in which sand, gravel, and other

Wall-case 41. naturally loose and incoherent materials become hardened and consolidated into sandstones, grits, conglomerates, &c. by the cementing power of iron, and exposure to the atmosphere. Portions of gravel, owing to the presence of iron, are occasionally converted into masses of hard conglomerate and puddingstone, as may be seen in the road at *Kippernham*, whence the specimen was procured. Map 11. —*Kippernham*, near *Romsey*, *Hampshire*.

18a.—CONGLOMERATE, composed of rounded pebbles of Chalk flints, cemented together by carbonate of lime, and forming a recently raised beach, in *East Wear Bay*, *Folkestone*, *Kent*.

30a.—CONGLOMERATE formed of pebbles of iron ore in a ferruginous base: from *New Red Sandstone*.

Bridgenorth, *Shropshire*. Map 61. S.E.

34a.—SILURIAN CONGLOMERATE (*Upper Llandovery rock*) with *Petraia*. Map 43 N.E.—*Malvern*, *Worcestershire*.

Presented by Miss Phillips.

41a.—FINE CALCAREOUS CONGLOMERATE, forming the basal bed of *Portland Sand*; at *Hartwell*, near *Aylesbury*, *Buckinghamshire*.

56.—HARD BLUISH-GREY LIMESTONE (*Kentish Rag*), from the lower division of *Lower Green Sand*: extensively used as a building material.—*Hythe*, *Kent*.

57a.—SILICEOUS SANDSTONE.—*Overton Down*, near *Avebury*, *Witshire*.

Scattered blocks of this saccharoid siliceous sandstone or grit lie on the surface of the country in Dorsetshire and Wiltshire, sometimes (as in the Valley of Stones, west of Black Down, Map. 17, and on the Chalk Downs in the Vale of Pewsey), in such numbers, that a person may almost leap from one stone to another without touching the ground.

The stones are frequently of considerable [illegible] size, many being four or five yards across, and abo[illegible] four feet thick. In Bride Bottom (the Valley of Sto[illegible]es) they often become conglomeratic, being composed [illegible] of rounded, sometimes of angular Chalk flints in a base [illegible] of white siliceous grit, and, in many instances, the same block furnishes an example of this structure, one portion of it consisting of sandstone, and another of conglomerate, occurring with a well defined line of separation between them. Wall-case 41.

In the village of Little Bredy, they may be seen in the brook which flows by the side of the road; and, in many instances, when it has been possible to do so, advantage has been taken of their position to build them into the walls of the houses: partly, perhaps, to avoid the trouble of removing so great a weight, partly to save the labour of breaking up a mass of such hardness and magnitude.

The Trilithons or larger stones forming the outer circle of Stonehenge, as well as the larger stones used in the construction of Avebury, were, probably, procured by the Druids from the immense blocks scattered over the neighbouring Downs. Those found, at the present day, on Marlborough Downs are hammer-dressed into rectangular blocks, which are used for paving and building stones, while near Marlborough and Fyfield, where they are extremely abundant, the roads are mended with them, and the walls by the turnpike road are built of them.

Their original geological position was, probably, in the sands of the Plastic Clay series, out of which they were worn by denudation, and subsequently hardened by exposure to the atmosphere.

On the turnpike road from Dorchester to Broad Maine, blocks of this stone are visible (apparently in place) by the road side at Little Maine, in sands which rest immediately on the Chalk, while several other blocks of it are scattered over the surface of the adjoining fields.

The name *greywether*, by which these sandstones are known, has been given to them from their supposed resemblance, when scattered over the ground and seen from a distance, to (wether) sheep.

The name *Druid Sandstone* has reference to their employment by the Druids in the erection of their temples.

Sarsen Stone is, probably, a corruption of *Saracen Stone*, originating in the popular belief that the stones had been

Wall-case 41. originally brought over to this country, and placed in their present positions by foreigners. The term Saracen is applied in some parts of England to *any* foreigner, and has probably been in vulgar use since the time of the Crusades. In Cornwall large heaps of refuse from the mines are, to this day, known by the name of Attle-Saracen, or heaps of rubbish that have been left there by the Saracens.

(See Survey Memoir on the Geology of Map 34. p. 41.)

57b.—CALCAREOUS GRIT (*Coral Rag*) used for building and road-stone. The bed from which the specimen was taken is about four feet thick, and forms the lowest bed of the quarry. It rests upon sand. Near the Lamb and Flag Inn, 6 miles E. of *Farringdon, Berkshire.*

77a.—SANDSTONE (*Lower Carboniferous*), containing small specks of mica, lines of iron pyrites, and numerous plant remains (*Cyclopteris*).

From beds of carbonaceous shale, in the bed of a brook, 4 miles south of *St. Andrew's, Scotland.*

97a.—ARGILLACEOUS SANDSTONE, from *London Clay*, with *Pectunculus brevirostris, Natica Hantoniensis,* and other fossil shells.—Artesian well, *Southampton.* Map 11.

103a.—GRITTY SLATE.—*Llanfechell, Anglesea.*

119b.—LOWER BAGSHOT SAND (*Middle Eocene*), immediately underlying the pebble bed No. 48. Wall-case 42. Map 11.—*Stoke Common*, near *Bishopstoke, Hampshire.*

125a.—BLOWN SAND, forming low hills on the south-west corner of *Hayling Island, Hampshire.* Map 11.

126a.—BRACKLESHAM SAND (*Middle Eocene*).—*Bevois Valley, Southampton.* Map 11.

No. 104 in Case **41**, the above specimen, and Nos. 138c and 138d are from the Bracklesham beds, or the lower member of the Middle Bagshot series, which rests upon the Lower Bagshot sands and clays.

Throughout the district over which these beds extend in Map 11, they are only locally fossiliferous. When, however, shells occur, they are generally very abundant, as is the case at Stubbington, on the coast, where *Cardita planicosta*, *Cerithium*, and other characteristic shells are found crowded together like those in No. 104, in a bed about 4 feet thick. Wall-case 41.

133b.—Hard green marl, with *Cyrena*. From the upper part of the *Corbula beds*: (*Middle Purbeck.*)—Map 16. Vertical Sections, Sheet 22, No. 1.—*Durlstone Bay, Dorsetshire.*

138a.—Papery mountain leather, occurring in fissures of *New Red Marl.—Seaton, Devonshire.* Map 22.

Presented by Sir Walter Trevelyan.

138b.—Sandy clay, from *Lower Green Sand, Folkestone, Kent.*

138c and 138d.—Bracklesham clay (*Middle Eocene*), used for making bricks.—*Netley*, near *Southampton.* Map 11.

The clay affording brick-earth varies very much in quality. No. 138d is of a very mild description, but, on other parts of the ground, at the same depth below the surface, the clay is too stiff for use alone, and requires to be mixed with $\frac{1}{12}$th of its bulk of sand: (No. 126a.) The best bricks are made with a mixture of the two clays, Nos. 138c and 138d, and 5,000,000 are made annually and used for the erection of the Military Hospital at Netley.

139b.—Pipe clay, mottled Clay from *Plastic Clay series*, Map 15.—*Chalbery Hill*, near *Horton, Dorsetshire.*

141a.—Sandy clay, from second division (B) of *Lower Green Sand, Folkestone, Kent.*

165a.—*Crystallized Coal.* Presented by Mr. James Hunt.

26a.—Chert in limestone, containing freshwater shells, *Valvata, Paludina, Cypris*, &c. From limestone beds in the "Cherty Freshwater" series of the Middle Purbeck. See Map 16 and Sections, Sheet 56.—Cliff east of *Lulworth Cove, Dorsetshire.* Wall-case 42.

Wall-case 42. 34a.—FLINT from *Portland Stone.* In this specimen siliceous matter has replaced the calcareous skeleton of a coral (*Isastræa oblonga*) commonly called the Tisbury coral, (after the locality in which it most abundantly occurs), and by so doing converted the whole into a solid mass of flint. Map 15.—*Tisbury, Wiltshire.*

46.—ROUNDED PEBBLES, from the Chesil beach, midway between *Abbotsbury* and *Burton Bradstock, Dorsetshire.* Map 17.

The Chesil Bank, on the coast of Dorsetshire, affords a good example of the driving forward of shingle in a particular direction by breakers, produced by the action of prevalent winds. It is nearly 15 miles long, connecting the island of Portland with the mainland, and for about eight miles from that island is backed by a narrow belt of tidal water, known as the Fleet. From its position, the heavy swells and seas from the Atlantic often break furiously on this bank, which protects land that would otherwise soon be removed by them.

In this instance, also, we seem to have an example of the Atlantic breakers not having reached the land behind, since the relative levels of the sea and land were such as we now find them. A gradual sinking of the coast would appear to afford an explanation of the phenomena observed. (De la Beche's "Geological Observer," 2nd edition, p. 56.) The pebbles are based, near the Isle of Portland, upon tenacious Kimeridge clay, which is frequently laid bare after heavy gales from the eastward, when the beach is often swept away in places. It is, however, soon restored, under the piling influence of westerly winds, to its original height, which, opposite Abbotsbury, nearly midway between its two extremities, is about 40 feet.

The pebbles forming the bank are derived from rocks situated to the westward, and gradually increase in size in an easterly direction, that is towards the Isle of Portland; the reason of which is that the larger pebbles, presenting a broader surface to the action of the wind and waves, are driven forward more rapidly than the smaller stones. Examples of this action are frequently afforded by very rapid brooks, where the larger stones may be seen to be pushed onwards by the force of the stream, while those of less size remain comparatively quiescent. Wall-case 42.

The variation in the size of the pebbles forming the Chesil Bank is so well known to the people of the adjacent coast, that it is said by them that persons familiar with it can tell the exact position of any part on which they may happen to land on the darkest night, merely by feeling the size of the pebbles forming the beach. Map 17.

47.—SMALL ROUNDED PEBBLES, from *Lower Green Sand.* —*Guildford, Surrey.*

48.—GREEN-COATED FLINT PEBBLES, from the base of the *Plastic Clay*, overlying Chalk.—Railway cutting, *Reading, Berkshire.*

49.—BLACK FLINT PEBBLES, occurring at the base of the Bracklesham beds (*Middle Bagshot series*).

Stoke Common, near *Bishopstoke, Hampshire.* Map 11.

50.—ROUNDED FLINT PEBBLES, from the basement-bed of the *London Clay* (the shell-bed).

Immediately resting on the Plastic Clay there is a bed of varying thickness, which has been named by Mr. Prestwich "the basement-bed," from its position relatively to the main mass of the London Clay, which rests immediately upon it. This bed is generally composed of brown, ferruginous, and somewhat clayey sands, and, in addition to its peculiar fossils, it almost invariably contains rounded pebbles of black flint disseminated in it towards the lower part, sometimes sparingly, but occasionally, especially in the London Basin, forming thick beds of pebble gravel.—*Hurst, east of Reading, Berkshire.*

51.—ROUNDED FLINT PEBBLES, from the basement bed of the London Clay.—*Sherborne St. John, Hampshire.*

52.—RECENT SHELLS, cemented by calcareous matter, forming a consolidated raised beach 40 feet 10 inches above the present high water-mark, on the east side of the island of *Kerera*, near *Oban, Argyleshire, Scotland.*

Presented by Commander E. J. Bedford, R.N.

Wall-case 42. 53.—Part of a RAISED BEACH, containing recent shells. —*Hopes Nose*, north of *Tor Bay, Devonshire.* Map 22.

54.—RECENT SHELLS.—Neighbourhood of *St. Andrew's, Scotland.*

Wall-case 43. LIMESTONES, IRON ORES, &c. arranged and described by H. W. BRISTOW.

2a.—CHERTY LIMESTONE from *Landeilo Flags*, with *Murchisonia Angustata.—Durness, Sutherland, Scotland.*

8a.—GREY ARGILLACEOUS LIMESTONE (*Lower Lias*). The cliffs east of Charmouth consist, for the most part, of blue Lias-shales, and clays which underlie the Marlstone, while interstratified with the clays are bands of impure limestones, two of which, situated 50 feet apart, furnish excellent cement stone. Map 17: Horizontal Section, Sheet 21.—*Charmouth, E. of Lyme Regis, Dorsetshire.* Presented by Mrs. Napier Stuart.

8b.—DARK GREY ARGILLACEOUS LIMESTONE. (*Coal Measures.*) This stone, called Aberdaw stone, is burnt for lime, and used for setting masonry under water. Several thousand tons of it have been used in the construction of the Liverpool and Birkenhead Docks.

Grange Quarry, Holywell, Flintshire. Presented by Sir Pyers Mostyn, Bart.

16a.—Compact GREY SILICEOUS LIMESTONE, passing into a fine conglomerate, which is composed of small rounded pebbles of white quartz and yellow sandstone, and contains fragments of *Iguanodon* bones, and teeth of fish (*Pycnodus* and *Tetragonolepis.* From Tilgate beds of *Hastings Sands*, (*Wealden*). *Well, St. Mary Magdalen's School; St. Leonard's-on-sea, Sussex.*

21a.—KELLOWAY ROCK with *Pectunculus*, from the base of the *Oxford Clay; Kellaways, Wiltshire.* Map 34. (See No. 99, page 51; also Survey Memoir on Map 34, pp. 18, 19.)

39a.—COMPACT LIMESTONE (*Devonian*), quarried for marble.—*Babbacombe*, near *Torquay, Devonshire.*

39b.—OOLITIC LIMESTONE (2 specimens) from *Coral Rag.* Both specimens are from the same quarry, but from different beds; one being loose and earthy in texture, while the other is harder and more compact, and of a ferruginous-yellow colour, owing to the presence of iron. Both specimens contain fossil shells.—Quarry near the Lamb and Flag Inn, 6 miles E. of *Farringdon, Wilts.* Wall-case 43.

39c.—GREY OOLITIC LIMESTONE (*Portland Stone*), used for roads and building. Map 34. See also Survey Memoir on Map 34, page 23.—*Swindon, Wiltshire.*

39d.—OOLITIC LIMESTONE, from *Carboniferous Limestone,* locally called Clee Hill marble. Used for tombstones, &c. and burned for lime.—*Clee Hills, Shropshire.*

48a.—PORTLAND STONE, with numerous casts of fossils, the shells of which have disappeared, leaving only the empty spaces they once occupied. This specimen is very similar to the roach-bed of Portland stone in the Isle of Portland, and may be compared with the large specimen in lower compartment of table-case D

See Survey Memoir on Map 34, Page 23.—*Swindon, Wiltshire.*

49a.—MARLSTONE (*Upper Lias*). The brown sandstone forming the upper part of the Marlstone, is used for building stone in the district where it occurs. In some localities it furnishes a rich ore of iron. The specimen contains several fossils, *Bellemites rugieri, Pecten æquivalvis, Ostrea, Serpula,* &c.—Map. 35. Horizontal Sections, Sheet 14, No. 1.—*Uley, Gloucestershire.*

49b.—HIRNANT LIMESTONE, showing a weathered surface. From the upper part of *Caradoc* or *Bala beds.*

Pen-y-Dall-gwm, 4 miles S.E. of *Bala, Merionethshire.*

49c.—PORTLAND STONE; oolitic, shelly, pale-grey limestone, with the shells replaced by calc spar. Slightly argillaceous. From upper beds of *Portland Stone.* Map 16, *Westman, Swanage, Dorsetshire.*

58a.—COMPACT LIMESTONE, from the upper zone of the *Great Oolite.* "This limestone is generally very hard, and, along the Cheltenham and Oxford road, produces the best

Wall-case 43. available road material. It weathers to a degree of whiteness scarcely surpassed by the Chalk." *Wychwood Forest, Oxfordshire.* See Hull's Memoir on Map 34, Page 61.

90a.—Pale cream-coloured MARLY LIMESTONE, containing casts of freshwater shells (*Bithynia*, small *Planorbis*, *Valvata*, *Limnæa*, *Cypris*).

The Purbeck strata of Swindon are very slightly developed, and, of inconsiderable thickness compared with those of Dorsetshire or even of the Vale of Wardour. At Swindon they consist chiefly of white and cream-coloured limestones with ferruginous stains, which also line the cavities left by decomposed shells, whose casts only now remain. The total thickness of these beds does not exceed 10 or 12 feet. —*Swindon, Wiltshire.*

See Survey Memoir on Map 34, Page 23.

100a.—CHALK ROCK.—Hard blocky chalk, jointed perpendicularly to the plane of bedding; with lines of irregularly shaped, hard, calcareo-phosphatic nodules, which are green outside, but cream-coloured within. The "chalk-rock" breaks with an even fracture, and rings when struck with the hammer.

This bed occurs in the Chalk district of Wiltshire, Berkshire, and Oxfordshire. About three miles S.S.W. of Marlborough it is twelve feet thick, and contains 6 lines of nodules; but generally it is only from 4 to 6 feet thick, and with 2 or 3 lines of nodules. Wherever the "chalk-rock" has been seen, in the above-mentioned country, it forms an exact boundary between the Chalk with flints and the Chalk without flints. It never contains flints, nor are any found below it, whilst a bed of them often occur immediately above it.—North of *Henley-on-Thames, Oxfordshire.*

100b.—One of the nodules from the "chalk-rock" (see No. 100a.), 3 miles S.S.W. of *Marlborough, Wiltshire.* Map 14.

103a.—SOFT MARLY LIMESTONE, from the Insect marls of the *Lower Purbeck*, containing insect remains and specks of vegetable matter. Map 17.—*Osmington, Dorsets ire.*

103b.—Compact close-grained limestone. The specimen was taken from the east side of Lulworth Cove, and exhibits the effect of weathering upon such beds, after long exposure. The original colour of the rock was blue, a small patch of which colour is still visible in the interior of the specimen, and the pinkish tint is due to the peroxidation of the included iron, consequent on exposure to atmospheric and other influences, while the outer surfaces of the bed, being still further acted upon, have assumed a cream-coloured or pale ferruginous-yellow tinge. The bed, 2 feet 4 inches in thickness, belongs to the marly freshwater series, or upper division of the Lower Purbeck, and contains scales of freshwater fish (*Lepidotus*), and numerous, small, freshwater univalve shells, *Limnæa*, *Hydrobia*, *Physa*, and *Planorbis*. It is slightly argillaceous. Map 16, Sections, No. 56.—East side of *Lulworth Cove, Dorsetshire.* Wall-case 43.

107a.—Oolite marl, containing a coral (*Cladophyllia*). This stone forms a well-defined zone, distinguished by its chalky aspect, over almost the whole range of the Cotteswold, from the vale of Moreton to the plain of Gloucester. It varies in thickness from 4 feet near Turkdean to 8 feet at White Hill, south-west of Pitchcomb; *Terebratula fimbria*, *T. carinata*, and many other fossils abound in this sub-division of the Inferior Oolite.—*Condicote*, near *Miserden, Gloucestershire.* See Memoir on Map 44 of the Geological Survey (Hull), p. 37.

114a.—Impure lias limestone, occurring in the upper part of the *Marlstone*, and containing *Ammonites serpentinus*, *A. annulatus*, *A. communis*, and *Belemnites*.—From an ironstone pit at *Steeple Aston*, 7 miles N.E. of *Woodstock, Oxfordshire.*

127a.—Shelly limestone (*Forest Marble*), containing numerous fossils, *Ostrea Sowerbyi*, *Rhynchonella obsoleta*, *R. farcta*, *Cidaris* (*spines*), *Terebratula maxillata*, *Apiocrinus rotundus* (*oscicles*). Map 17.—*Well Down*, E. of *Abbotsbury, Dorsetshire.*

Wall-case 48. 130a. FISSILE LIMESTONE, from the Tilgate beds of the *Wealden*.—North of *Ore Church*, 2½ miles N. of *Hastings, Sussex*.

134a. and 134b.—IRON ORE from the Tilgate beds of the *Wealden;* peroxide of iron, investing clay ironstone. In No. 134a, only the chambered covering of peroxide is left, the clay ironstone having been removed from the cavities. These beds of iron ore, 4 and 3 inches thick respectively, are divided by 5 inches of yellow sand, which on exposure to the weather hardens into sandstone.—North of *Ore Church*, 2½ miles N. of *Hastings, Sussex*.

136a.—IRON NODULE, showing concentric layers: from *Oolite Sands*. The sands from which the specimen was obtained must not be confounded with those *underlying* the Inferior Oolite, and which have, until lately, been called "Inferior Oolite Sands," their position being *above* the stony beds of the Inferior Oolite, and immediately beneath the Great Oolite of the district. They are, therefore, the equivalent of the Stonesfield slate.

Upper Worton, Oxfordshire.

142a.—RED IRON ORE.

142b.—Stalactitic RED IRON ORE (*hæmatite*), with a fibrous structure.

142c.—Botryoidal RED IRON ORE (*hæmatite*), with a fibrous structure, and partly invested with lenticular crystals of sulphate of barytes.

This ore of iron, Nos. 142a to 142c, occurs in *Devonian Limestone*, with sulphate of barytes. It is worked in the cliffs at Sharkham Point, and is sent into Wales to be smelted. The softer portions of the ore, when washed, are made into colour, which is used for painting ships' bottoms. Map 23.—Near *Brixham, Devonshire*.

148a.—CARBONACEOUS SHALE from *Mountain Limestone*, with tooth of *Rhizodus Hibberti*.—*Fifeshire, Scotland*.

179.—CLAY IRON ORE from *Coal Measures*.*—*Crossgreen Colliery, Yorkshire*.

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* Presented by Captain Edward James Maude.

ANALYSIS. Wall-case 23.

	Per cent.	
Protoxide of iron -	46·56	corresponding to 36·13 metallic iron.
Carbonic acid - -	30·34	
Lime - - -	2·50	
Phosphoric acid -	0·60	
Manganese - -	trace	
Sulphur (as pyrites) -	trace	
Organic matter - -	0·77	
Insoluble matter, (clay, sand, silica) - -	14·72	
Water (expelled at 212°) - -	1·12	
	96·51	

180.—CLAY IRON ORE, from *Coal Measures*.* — *Cross-green Colliery*, *Yorkshire*.

ANALYSIS.

	Per cent.	
Protoxide of iron -	42·59	corresponding to 25·76 metallic iron.
Carbonic acid - -	14·11	
Lime - - -	2·34	
Phosphoric acid -	0·67	
Sulphur (as pyrites) -	trace	
Organic matter -	1·44	
Insoluble matter (sand, clay, &c.) - -	32·38	
Water (expelled at 212°) - - -	1·36	
	94·89	

* Presented by Captain Edward James Maude.

Wall-case 43. 181.—CLAY IRONSTONE with *Unio*, from *Coal Measures.* —*Glascote Colliery, near Tamworth, Warwickshire.*

182.—CONCRETIONARY IRON ORE from the lower part of the *London Clay. Reading, Berkshire.*

Wall-case 44. 42c.—SEPTARIAN NODULE *from London Clay,* containing a fossil shell, *Pyrula Smithii.—Isle of Sheppey.*

This specimen shows the manner in which such concretions are formed; generally round some organic substance, as a nucleus, about which the more stony matter has collected.

Wall-case. 45. 3a. ALTERED COAL, ¼ mile S.E. of *Rock and Spindle, St. Andrew's, Scotland.*

75a. ALTERED FELSPATHIC ROCK.—*Withielgoose, near Withiel, Cornwall.*

75b. QUARTZO-FELSPATHIC ROCK, exhibiting obscure craces of lamination; probably an altered rock. Furnishes a good road material.—*Rosevanion, St. Columb Major, Cornwall.*

75c. JASPER (ALTERED ROCK), occurring with the trap-rock placed beneath it.—*Isle of Rum, Scotland.*

Wall-case 46. 47a. Three specimens of roofing SLATE (*Bala beds*) from the slate quarries at *Cwm Eigia, Caernarvonshire.* Map 78, S.E. The slates from some parts of this quarry contain tubes of iron pyrites disseminated through them, which do not decompose on exposure to the atmosphere, as is proved by the circumstance that the slates forming a roof which nas been built for 26 years, still retain their original brightness.

Wall-case 1. 20a. FILAMENTOUS OR CAPILLARY LAVA, (Pélé's hair). obtained from near the bottom of the great crater of *Kilauea*, by a party from H.M.S. "Vixen," February 1, 1858.

42b. Crystals of NATIVE SULPHUR, with a hot, soft, and greasy earth; obtained at a bank N.E. of the great crater of *Kilauea*, February 1, 1858, by a party from H.M.S. "Vixen."

42c. Crystals of NATIVE SULPHUR, obtained from the mouths of hot-air holes in a bank N.E. of and above the great crater of *Kilauea*, by a party from H.M.S. "Vixen." February 1, 1858. Wall-case 1.

42d.—CONDENSED VAPOURS, from heated air passing through fissures in the rock, in the N.E. bank above the great crater of *Kilauea.* Obtained, February 1, 1858, by a party from H.M.S. "Vixen."

MODEL OF THE ISLE OF BOURBON. Wall-case 3.

BY MON. LS. MAILLARD.

Presented by Mons. Dufrénoy, Director of the Ecole des Mines, Paris.

The Isle of Bourbon, or Mascarenhas (as it has been called after its discoverer), is situated in the Indian Ocean, in S. lat. 21°, and E. long. 55°, about 90 miles W.S.W. of Mauritius, and 370 miles east of Madagascar. It is elliptical in shape, about 90 miles in circumference, and 45 miles across in its widest part, in a N.W. and S.E. direction. From a distance it appears to rise gradually from the sea to a high central peak—the Piton des Neiges—9,450 feet high. The island is composed of two volcanic mountains, the Gros-morne or Salazes, 7,200 feet in height, and the volcano. Of these, the former, which is the largest, and situated towards the centre of the island, has long ceased to be in activity, but that it was so formerly is fully proved by the aspect assumed by the features of the surrounding country. During the long interval which has elapsed since it has been in repose, the action of the atmosphere has disintegrated its former bleak surface, and converted it into a fertile soil, which is now in a state of high cultivation.

Towards the S.E. of the island the country is, on the other hand, scorched and barren, owing to the scarcity of water and the neighbourhood of the volcano, and the Pays brûlé, as the district is called, is a continuous desert, the barren dreary aspect of which, forms a frightful picture of desolation. Since 1785 the volcano has vomited lava at least

Wall-case 3. twice every year, which in nine instances flowed to the sea.

The rivers are not supplied by springs, but are derived from the rain which falls on the mountains, and the snow and mists upon their summits. In consequence of this, they all partake, more or less, of the nature of mountain torrents rather than of ordinary rivers, and rush through deep gullies, which have been worn by them in the sides of the mountains, during a long succession of ages. These torrents sometimes rush with such impetuosity, as to carry down vast fragments of rock, which, by accumulating at the mouths of the rivers, block them up with lofty and impassable barriers. "The isle of Bourbon is surrounded by coral reefs, only broken through at the embouchures of the rivers, and opposite the chief ravines. The channels or passages through the reefs are kept open by the streams of fresh water passing outward through them, without which they would be otherwise soon filled up; as it is, they are considered to have decreased in size, in consequence of a diminished quantity of rain having, of late years, fallen on the Isle of Bourbon."

De la Beche's Geological Observer, (2nd Edition, p. 179).

H. W. Bristow.

Table-case A. in Recess 4.

Model of Graham's Island.

Constructed by M. Constant Prevost.

Presented by Dr. Fitton, F.R.S.

This island has been variously called Nerita, Ferdinanda, Hotham, Graham, Corrão, Sciacca, and Julia, but the name most generally adopted is that of Graham's Island, which was given to it by Captain Senhouse, R.N., the first person who succeeded in effecting a landing upon it.

It was situated in lat. 37° 11′ N., long. 12° 44′ E., 33 miles N.E. of Pantillaria, and 31 S.W. of Sciaca in Sicily.

The island was first actually seen by the captain of a Sicilian vessel, on the 18th July 1831, when it appeared as a small island 12 feet high, throwing out volcanic matter and immense columns of vapour from a central crater. Table-case A. in Recess 4.

The eruption continued with great violence till the end of the month, when it was from 50 to 90 feet high, and $\frac{3}{4}$ of a mile in circumference.

By the 4th of August it had attained a height of 200 feet and a circumference of three miles. After the latter date it grew less under the action of the waves, until on the 25th of August it was only two miles round; on the 3rd of September it was still further reduced to $\frac{3}{5}$ths of a mile in circumference, and 107 feet in height, and on the 29th of the same month it was only 700 feet in circumference.

On the latter day it was visited by M. Constant Prevost, by whom the model in the case was constructed out of the ashes and lapilli thrown out by the volcano. The island was found by M. Prevost to be entirely composed of scoriæ, pumice, and other incoherent ejected matter, few of the stones thrown out exceeding a foot in diameter. By the end of October no trace of the crater remained, and the island was nearly level with the water's edge.

At the commencement of 1833 there was merely a shoal and discoloured water to mark the spot, and at the end of 1833 a dangerous reef existed about $\frac{3}{5}$ths of a mile in extent, and of an oval shape.

Thus little more than three months intervened between the first appearance of the island and its final destruction; during which period there is no reason to suppose that the original bed of the sea was subjected to any elevatory movement.

Sir Charles Lyell conjectures that the cone must have been as large as one of the lateral volcanos on the flank of Etna, and about half the height of Jorullo in Mexico, which was formed in nine months. He also supposes that a hill at least 800 feet high was formed by a submarine volcanic vent, of which the upper part only (about 200 feet high) emerged above the sea to form the island. The

Table-case A. n Recess 4. lava ejected contained augite, and the only gas evolved in any considerable quantity was carbonic acid. (Lyell's Principles of Geology, 7th edit. p. 414.)

H. W. Bristow.

Volcanic Specimens from Hecla, Iceland.

Collected and presented by J. W. Bushby, Esq.

Hecla is a volcanic mountain 6,131 feet in height, situated on the S.W. part of Iceland, in lat. 63° 59′ N., long. 19° 42′.

The volcanos of Iceland are known to have been in activity as early as the ninth century. Since 1004 or 1005 no less than 23 marked eruptions have taken place; no interval exceeding 40 years, and seldom one of 20 years, having elapsed without the occurrence of either an eruption or a great earthquake.

Some of the eruptions have been of great violence, and have lasted six years without ceasing. During the eruption of 1766, smoke and clouds of ashes obscured the sunbeams to such an extent, that in Glaumbär, about 100 miles distant, men could only find their way by groping.

Again in 1783, Skaptar-jökull, which had remained dormant as far as any human records of the land extend, suddenly burst into activity, and did not again become quiescent for two years.

Immense quantities of volcanic matter were thrown out during this period. Two of the lava streams, 40 and 50 miles in length, flowed in opposite directions, attaining a width of seven miles and from 12 to 15 miles respectively, while the height of both currents, which was ordinarily 100 feet, became as much as 600 feet in narrow defiles.

During this eruption many villages were inundated by water, 20 were destroyed, and more than 9,000 human beings perished, together with immense numbers of cattle, while the coasts were deserted by fish.

On the 2d September 1845, a Danish vessel was covered with ashes, during an eruption, near the Orkney islands, 537 miles from the volcano.

In the intervals between eruptions, innumerable hot springs burst forth, and solfataras discharge copious streams of inflammable matter.

The most remarkable of the intermittent springs or geysers, are situated in the south-western part of Iceland, more than 30 miles distant from Hecla. They rise through a thick bed of lava, in such numbers, that nearly a hundred of them may be counted in a circumference of two miles.

"Few of them play more than five or six minutes at a time, and, the intervals between each eruption are very irregular.

"The Great Geyser rises out of a spacious basin at the summit of a circular mound composed of siliceous incrustations deposited from the spray of its waters. The diameter of this basin, in one direction, is fifty-six feet, and forty-six feet in another."

Lyell's "Principles of Geology," 7th edit. pp. 406–530.

De la Beche's "Geological Observer," 2d edit. p. 343.

1.—SCORIACEOUS LAVA from *Hecla.*

2.—SCORIACEOUS LAVA, from the extinct volcano a *Svinahraun.*

3.—VOLCANIC BOMB, from the sulphur banks of *Yousavatn.*

4.—SILICEOUS SINTER, with impressions of leaves, from the *Little Geyser.*

5.—SULPHATE OF LIME now being formed at *Krusivik.*

6.—NATIVE SULPHUR, from banks or mines at *Mount Hengill.*

7.—NATIVE SULPHUR: another specimen, from *Krusivik.*

H. W. BRISTOW.

ROWLEY RAG (BASALT).

"The *Rowley Rag* is a basalt; a hard, heavy, black, close-grained rock, weathering brown outside, having a tendency to form spheroids, that envelope with several concentric coats a solid ball in the middle, and consequently often assuming a columnar structure, that in some instances becomes nearly as regular as that of the Giant's Causeway.

Table-case A. in Recess 4. This is the stone of the Rowley Hill, Barrow Hill, at Pensnett; Park Hill, at Bentley, and other spots. It is 200 or 300 feet thick, resting here upon the Coal Measures." —(On the Geology of the South Staffordshire Coal Field. J. Beete Jukes, F.R.S., page 241.)

These specimens are placed here to show the manner in which certain igneous rocks, when melted, assume different appearances, according to their more or less rapid rate of cooling from a state of fusion. In this instance about 31 cwt. of the basalt having been melted, in a large double reverberatory furnace, at the Eagle Foundry, Birmingham, was broken up, after cooling slowly, during thirteen days. It was then found that the outer portions of the fused rock, that is, those portions which had cooled the most rapidly from their contact with the air, had assumed the appearance and structure of obsidian, while those from the bottom and middle, which had cooled more gradually, bore a resemblance to pitchstone. Some of the more glassy portions near the top were sphærulitic and vesicular, and may be compared with actual volcanic products of a similar nature, in wall-case 1. See also Case VII. in the Hall.—Presented by William Hawkes, Esq.

1.—ROWLEY RAG in its natural state.

2.—From the bottom of the cooled mass.

3.—From the middle of the cooled mass.

4.—ARTIFICIAL OBSIDIAN, or *Volcanic glass*, from near the top of the cooled mass. See wall-case 2, Nos. 29 to 31.

5.—ARTIFICIAL OBSIDIAN, vesicular and sphærulitic See wall-case 2, Nos. 30, 119.

6.—ARTIFICIAL OBSIDIAN, showing the effect of rapid cooling, produced by pouring the melted rock into water. See wall-case 1, Nos. 20, 29, 30, 36.

148.—32 polished specimens of volcanic rocks, from Vesuvius.

149.—SCORIACEOUS LAVA, enveloping a pebble.—From the neighbourhood of *Bonn*.

Presented by Sir Roderick I. Murchison, G.C.S.S.

3a.—FELSPAR, from a vein in granite: used for making glaze for earthenware.—*Roche, Cornwall.* Wall-case C.

260 to 270.—Ten specimens of POLISHED GRANITE, from *Aberdeen.* Presented by — Macdonald.

H. W. BRISTOW.

ROCK SPECIMENS, illustrating the Geology of the Counties of Haddington, Edinburgh, and Linlithgow, Table-case E. in Recess 41.

Arranged and described by ARCHIBALD GEIKIE.

This series of specimens is arranged in stratigraphical order, beginning with the lowest. The igneous rocks of contemporaneous age are intercalated in their proper order in the series, so that the specimens exhibit, as completely as can be shown in the space at command, the sequence of geological phenomena in the district from which they are collected. The intrusive traps, whether as dykes or amorphous masses, are put together in Table-case C (lower compartment), and may be studied as a group by themselves.

Table-case E in Recess 41.

The specimens in this case are entirely illustrative of the geology of Haddingtonshire, more especially of the trappean region between Haddington and Dunbar. They show that between the deposition of the old red sandstone and that of the mountain limestone, the north-eastern part of that county was the site of a long-continued series of volcanic eruptions, by which loose ashes, stones, and sheets of melted lava were thrown out to a depth of many hundred feet. The series begins with several specimens from the old red sandstone of Dunbar, followed by one or two from the very base of the carboniferous rocks, above which commences the set of ash beds, with their included stones, and intercalated limestone bands. These are followed by the later lava eruptions of the Garleton Hills, and lastly by the carboniferous limestone which appears to have been deposited after the volcanic action in this district had ceased.

Tablecase E. in Recess 41. 1.—RED SANDSTONE, finely laminated (Old Red Sandstone).—A little east of Dunbar.

2.—RED SANDSTONE, variegated with green spots (Old Red Sandstone).—A little east of Dunbar. On the origin of such green mottlings see 1st vol., Geol. Surv., Mem. p. 53.

3.—GREY SANDSTONE (Old Red Sandstone).—A little east of Dunbar. Speckled with iron-stained grains.

4.—GREY MICACEOUS SANDSTONE (Lower Carboniferous). —150 yards S.W. of Long Craigs, Dunbar.

5.—RED FERRUGINOUS IRONSTONE (Lower Carboniferous). —150 yards S.W. of Long Craigs, Dunbar. Contains fragments of fish scales.

ASH BEDS OF DUNBAR.

Immediately to the west of Dunbar the coast is fringed by a range of tall cliffs. They consist of ash, dull red in colour and roughened over with the inclosed fragments which protrude from the rock in great numbers. The matrix of the ash is highly felspathic and ferruginous, and varies in texture from a fine paste to a coarse agglomeration of sub-angular and rounded fragments. The enclosed stones are of all sizes up to masses a foot or more in diameter, the smaller pieces being frequently somewhat angular, while the larger bombs show a rounded outline, sometimes with a vesicular surface, indicating the former melted condition of their exterior. Although the dust and stones, of which the ash has been formed, were deposited at the sea bottom, the stratification can often be seen but rudely, and on the large scale only, and in many places it can be made out merely from the lines of rounded stones which mark what was at one time the floor of the sea. The more characteristic features of the ash cannot, however, be exhibited in a collection of detached specimens, but must be studied in the field.

6, 7, 8.—FELSPATHIC ASH.—West of Dunbar (Lower Carboniferous). In No. 6 the lapilli, or included fragments, are mostly subangular, and consist of different felspathic

rocks, imbedded in a dull red, granular, felspathic paste. Table-case E. in Recess 41.
In No. 7 they are more rounded, and smaller in size, while the matrix is likewise more ferruginous. No. 8 shows a dull red ferruginous paste, with few fragments of larger size than its component grains. This specimen also illustrates the manner in which some of the finer-grained portions of the ash are stratified.

9–26.—STONES FROM THE ASH. (Lower Carboniferous). — West of Dunbar.

9.—FRAGMENT OF AMYGDALOIDAL FELSTONE, broken from large irregular mass in ash, near Dunbar.

10.—PIECE OF SANDSTONE, (Old Red Sandstone?) from ash, West of Dunbar.

11.—NODULE OF RED MARL, crusted with carbonate of lime, West of Dunbar.

12, 13.—FRAGMENTS OF LIMESTONE, (Burdie House Limestone?) in the ash of Dunbar.

14.—FRAGMENT OF LIMESTONE (Burdie House Limestone?).—This specimen from the Dunbar ash shows on the one side the original surface of the stone as ejected from the ancient volcano, and on the other, which has been broken across, a confused mass of fish remains.

15–19.—CALCAREOUS NODULES, perhaps pieces of altered limestone.

20.—VESICULAR FELSTONE, showing the rounded exterior of the igneous fragments in the ash, with a vesicular lava-like interior.

21, 22, and 23, are unbroken felspathic stones like No. 20.

24.—AMYGDALOIDAL FELSTONE, part of a large mass in the Ash.

25.—NODULE OF CALCEDONY.

26.—NODULE OF JASPER.

27.—COLUMNAR FELSTONE (Lower Carboniferous).—Below the Battery, Dunbar. This rock appears to have a bedded form, but its relations are very doubtful. It was regarded by Dr. Macculloch as an altered sandstone.

of Dunbar. The coast line for about four miles to the east of North Berwick, exhibits a magnificent series of sections of ash with inclosed limestone seams and intruded masses of greenstone. The ash in its lower beds has a greenish tint, getting redder in the higher parts till it acquires the same colour that characterises the rocks at Dunbar. In this upper red zone there occurs at different localities, a thin-bedded fissile grey limestone, answering closely in texture, colour, and mode of stratification to the limestone of Burdie House, with which also it appears to correspond in geological position. No fossils have been detected in it except some which resembles pieces of bone. Throughout the ash, fragments of ejected rock of various kinds are abundant, varying in size up to large masses from 1 to 2 yards in diameter. Tortuous veins and dykes, of greenstone also occur, traversing and contorting the ash-beds in all directions.

28.—FELSPATHIC ASH (Lower Carboniferous).—North Berwick. Granular, stratified, without enclosed fragments.

29.—FELSPATHIC ASH.—North Berwick. Granular, stratified, with small rounded felspathic fragments.

30.—FELSPATHIC ASH.—North Berwick. Granular, with numerous rounded and subangular felspathic fragments. This and the two preceding specimens are from the lower green zone.

31.—STRATIFIED FELSPATHIC ASH.—North Berwick. Very granular, with numerous rounded and subangular felspathic fragments. This specimen is from the upper red part of the ash.

32.—FELSPATHIC ASH (Lower Carboniferous).—Amisfields Mains, 2 miles east of Haddington.—This specimen belongs to the highest part of the ash, and shows numerous scattered crystals of felspar, many of which are broken.

33. COMPACT GREY LIMESTONE (Lower Carboniferous).—Rhodes Quarry, 1 mile south-east of North Berwick. This limestone occurs among the ash-beds and attains a thickness at this locality of 30 feet. Similar seams, probably on the same horizon, are also met with further to the east, near Tantallon Castle, and also southward from Tynninghame to Traprain Law. These calcareous bands are believed to represent the Burdie House Limestone of Mid-Lothian.

34.—STRIPED LIMESTONE, from an upper part of the same quarry. This specimen exhibits exactly the peculiar stratified appearance of the Burdie House limestone, and may be compared with No. 117, in Table-case C, from the Edinburghshire bed.

35.—SHALY LIMESTONE, also from the same quarry. The wrinkled appearance of this specimen, and its finely mamillated surface, bear a strong resemblance to some of the depositions of calcareous springs, and possibly such may have been the origin of this bed. Compare Nos. 165–167 in Table-case C.

36.—ALTERED LIMESTONE. The Leithies, between North Berwick and Canty Bay.—Apparently with enclosed igneous matter obtained from bed close to a large mass of greenstone, of which No. 50 is a specimen.

37.—ALTERED LIMESTONE, from junction with the same mass of igneous rock at the Leithies near North Berwick.

38.—ASH with angular fragments of limestone. North Berwick.

39.—Angular fragment of STRIPED LIMESTONE. (Burdie House Limestone), from ash at North Berwick.

40.—Subangular fragment of crystalline limestone, from ash at North Berwick.

Table-case E. In Recess 41. 41.—Felspathic ash, with impression of a plant, from ash at Tantallon Castle.

42.—Piece of LIMESTONE fragment from ash, at North Berwick.

42, 43, 44.—Fragment of RED SANDSTONE (Old Red ?) from ash, at North Berwick.

45.—IRONSTONE fragment, from North Berwick ash.

46.—Stone from the same ash, showing the common rounded form of the fragments.

47, 48, 49.—Fragments of felspathic trap, North Berwick ash.

50.—AMYGDALOIDAL GREENSTONE, from intrusive mass in ash at the Leithies, east of North Berwick.

51.—ZEOLITIC GREENSTONE, from intrusive sheet in ash, at Canty Bay, North Berwick.

FELSTONES OF GARLETON HILLS.

The ash beds of North Berwick extend southwards for nearly three miles, and then sweep round the eastern and southern slopes of the Garleton Hills, extending as far as the town of Haddington. They are succeeded by a higher group of trappean rocks, consisting of felstones and felstone porphyries, which have a bedded form and dip below the mountain limestone of Aberlady. These rocks are old lava streams, which flowed out over the ash with its accompanying limestones, and had hardened into solid rock previous to the deposition of the mountain limestone. The vents from which the ejected materials proceeded may perhaps be represented by the bosses of Traprain and North Berwick.

52.—FELSTONE.—Black Cove, Traprain Law. Compact pinkish felspathic rock, with disseminated specks of augite (?).

53.—FELSTONE PORPHYRY.—Black Cove, Traprain Law. Compact grey felspathic rock, with crystals of glassy felspar, and a striped arrangement of the particles similar to that in the Ascension Island lavas (Nos. 49 and 50 i

Wall-case 2), and the felstones of Snowdon (Nos. 100 and 101 in Wall-case 4). Table-case E. in Recess 41.

Traprain Law, from which these two specimens were obtained, is an irregularly oval hill, rising abruptly from out a set of lower carboniferous limestones below the ash beds already described. It is undoubtedly an intrusive mass, and resembles an old volcanic rock. Possibly it may have been the vent from which some of the succeeding felstones were ejected.

54.—Felstone porphyry.—Top of North Berwick Law. Compact crystalline felspathic rock, with scattered crystals of glassy felspar.

55.—Felstone porphyry.—Quarry on north side of North Berwick Law. A looser-textured, more granular rock than the last. North Berwick Law, like Traprain Law, is a rounded patch of felstone, and rises with a conical form out of the surrounding ash beds, which dip away from it, where seen on the south-west side, at an angle of 30°. It has the same neck-like outline with Traprain, and may perhaps have been another vent from which felspathic matter was ejected during lower carboniferous times.

56–78 illustrate the felstones and porphyries of the great trappean region between North Berwick and Haddington, including the Garleton Hills. The beds have a gentle dip to the west, and, as stated above, are intermediate in age between the carboniferous limestone above and the Burdie House limestone below. The eastern or lowest part of the group is more or less augitic in composition, passing up into a set of compact felstones, which are succeeded by a more porphyritic series of similar rocks.

56.—Felstone (Lower Carboniferous).—Longskelly Point, North Berwick. Compact felspathic rock, with scattered crystals of augite and veins of carbonate of lime.

This and the two following specimens are from the base of the felstone series, resting immediately above the ash beds already described.

57.—Felstone porphyry.—Blaikie Heugh, near Standingstone, five miles east of Haddington. Dark red felspathic base, with large crystals of augite.

Table-case E. In Recess 41. 58.—AUGITIC FELSTONE.—Chesters Quarry, Whitelaw Hill, four miles and a half south-east of Haddington. A compact rock, with numerous small augite crystals disseminated through a pinkish felspathic base.

59–63.—AMYGDALOIDAL FELSTONE PORPHYRY.—Cowton Rocks, a quarter of a mile west of North Berwick. These specimens are from the Garleton Hill beds, where they thin out towards the sea, and are probably on the same horizon with those which follow.

64.—FELSTONE PORPHYRY.—Shore opposite Broadsands, west of North Berwick. Red earthy felspathic rock, with disseminated crystals of felspar, and cavities filled with carbonate of lime.

65–67.—FELSTONE PORPHYRY.—Longskelly Rocks, two miles west of North Berwick. The Longskelly Rocks appear to be a repetition of the Cowton beds, brought up by a fault which skirts their south-eastern edge. No. 67 shows a vesicular structure, the cavities being drawn out in the direction in which the mass moved when in a melted state. Many of these cavities are filled with decomposing carbonate of lime, or lined with green earth.

68.—FELSTONE PORPHYRY.—Hailes Mill, four miles north-east of Haddington. Compact dark red felspathic rock, with crystals of glassy felspar.

69.—FELSTONE PORPHYRY.—Hopeton Monument, Garleton Hills. Earthy, fine-grained felspathic rock, weathers dark brown, greenish yellow on fresh fracture.

70.—FELSTONE PORPHYRY.—Skid Hill, two miles north of Haddington. Light blue compact felspathic rock, with crystals of glassy felspar; weathers light greyish brown.

71.—FELSTONE.—Wallace's Cave, Craigy Hill, Garleton Hills. Light purplish grey granular felspathic rock, with iron-stained grains and veins of jasper. With this specimen compare No. 27 in this case, and also 72.

72.—FELSTONE PORPHYRY.—Silver Hill, Garleton Hills. Crystalline felspathic rock, with concentric rings of iron stains and crystals of glassy felspar; weathers with a reddish crust.

73.—FELSTONE PORPHYRY.—Garleton Hills. Very compact blue felspathic rock, with crystals of glassy felspar; weathers with light brown crust. Table-case E. in Recess 41.

74.—FELSTONE PORPHYRY.—Peppercraig Quarry, a quarter of a mile north-west of Haddington. Compact felspathic rock, with numerous crystals of glassy felspar; weathers dull brown.

75.—FELSTONE PORPHYRY.—Garleton Hills. Compact blue felspathic rock, with crystals of felspar, in a somewhat dull granular base.

76.—FELSTONE PORPHYRY.—Dirleton, two miles and a half west of North Berwick. Earthy felspathic rock, with large crystals of white and glassy felspar.

77.—FELSTONE, slightly porpyritic.—Kea Haughs, Garleton Hills. Pinkish earthy felspathic rock, with crystals of a yellow decomposing mineral.

78.—FELSTONE.—Hopeton Monument, Garleton Hills. Dull earthy yellow felspathic rock with cavities probably formed by the decomposition of the felspar crystals.

The felspathic traps of the Garleton Hills form the last of that long series of igneous rocks erupted during lower carboniferous times over the area of Haddingtonshire. They are succeeded by sandstones and shales with imbedded plants, above which lies a series of thin limestone beds—the representatives in Scotland of the thick mountain limestone of England. Unlike the English formation their organic remains are not exclusively marine, for between the limestone beds we frequently meet with coal seams resting on fire-clay, that contains the rootlets of the plants which went to form the coal. They are, moreover, interbedded with sandstones and shales, in which similar vegetable remains occur, so that in the group of strata known as the mountain limestone series of Scotland, which may attain a total thickness of perhaps 300 to 400 feet, the amount of limestone is comparatively small. The coast-line at Aberlady and south-east of Dunbar affords admirable sections of these deposits. The following specimens chiefly illustrate the coast-section at the latter locality

Table-case E. in Recess 41. 79.—CORAL LIMESTONE, containing a mass of *lithostrotion irregulare*.—Cat Craig, Dunbar. (Lowest bed of group.)

80.—FIRE-CLAY.—Cat Craig. Underlies a thin seam of coal among the limestone, and contains numerous stigmaria rootlets.

81.—SHALE, containing *Orthis resupinata*, &c.—Cat Craig. Underlies second limestone (82).

82.—CORAL LIMESTONE.—Cat Craig. Compact crystalline rock, containing *clisiophyllum* and *cyathophyllum*. (Second limestone).

83.—COMPACT CRYSTALLINE LIMESTONE.—Cat Craig. Full of encrinites.

84.—SHELL LIMESTONE.—Aberlady Bay. Containing a mass of *Rhynconella pleurodon* and *Athyris ambigua*. Equivalent of No. 83.

85.—SHALE.—Skateraw, S.E. of Dunbar, containing *Spirifer trigonalis*, &c. Under third limestone.

86.—Compact grey LIMESTONE.—Cat Craig. Third limestone from base.

87.—Shaly SANDSTONE, with double annelid burrows, showing the transference of material by the operation of worms.—Above third limestone. Skateraw Bay.

88, 89.—LIMESTONE.—Aberlady Bay.

90.—LIMESTONE.—Cat Craig. Showing a cellular surface covered with small oolitic grains.

91.—SANDSTONE, with worm tracks. The Vaults, Dunbar.

92.—SANDSTONE, with encrinal rings. Same locality.

93.—LIMESTONE, showing *Cauda-galli* markings on weathered surface.

Table-case F. in Recess 43.

ROCKS OF EDINBURGHSHIRE AND LINLITHGOWSHIRE.

Table-case F. in recess 43.

Rocks of Pentland Hills.

The Pentlands are a chain of hills from 600 to 1,900 feet high, running in a south-westerly direction from near the town of Edinburgh for about 15 or 16 miles, till they merge into the hills of Peebles and Lanark. They consist fundamentally of vertical slates and grits, belonging to the Upper Silurian, above which lie unconformably a series of conglomerates and grits of Old Red Sandstone age. Interstratified with the upper part of these later deposits, and piled over them to a depth of several thousand feet, occurs a great series of felspathic traps, disposed in regular beds with intercalated ashes and conglomerates, which appear to form the upper part of the Old Red Sandstone formation in this locality, since they dip below a set of calcareous grits and conglomerates which pass upwards into plant-bearing beds of Lower Carboniferous age. This chain of hills rises out of a great plain of carboniferous rocks which dip away from it on both sides, but it is not a mere anticlinal ridge, for the dip of the surrounding strata has been much influenced by a series of large parallel faults by which the limits of the older rocks of the hills are definitely marked.

Table-case F. in Recess 43.

Reference to the sketch-section which accompanies the specimens in this case will illustrate the structure of the Pentland Hills. On the left or west side, the lower Carboniferous strata (C) are seen reclining at a high angle upon the fault which has brought them down against the Silurian slates and grits (1). On the truncated edges of these latter beds rests the lowest felspathic trap (4–6a), the intervening conglomerates not occurring at the point where this section crosses. Two overlapping patches of Lower Carboniferous Sandstone and shale cover part of this lower felstone, as far as a long north-east and south-west fault, which runs along the flanks of the hills. The effect of this fault, as shown in the section, is to bring down the lower felstone (4-6a) and its overlying strata against Silurian slates ; in short, to repeat the structure observable at Warklaw Hill. From this fault across to the south-eastern flank of the hills the rocks follow each other regularly, dipping S.E. at an average angle of about 25° to 30°. The felstones occur in distinct beds, alternately dark and pale, so that even at some distance their true bedded form

Table-case F. in Recess 43. can be made out from the difference in colour which the exposed crags present. Each of the felstone beds represents a lava-flow. The ashy layers (22, 28-9, 35-8) which occasionally separate them, mark the dust and lapilli ejected between the successive eruptions of lava, and the conglomerate bands (9a, 19, 22) point to periods of rest when the waves and submarine currents acted upon the hardened lava-streams, breaking off fragments from them, and forming in this way beaches of coarse gravel and shingle, or of finer felspathic mud and sand, which vary in colour and composition with the character of the rocks whence they were derived. The history of the Pentland Hills accordingly is briefly as follows:—During the period of the Old Red Sandstone, the site of these hills was marked by a series of low slate islands, which the waves were ever wearing down and covering with sand and coarse shingle, represented now by the great masses of conglomerate and grit, which, at the south end of the chain, are seen to fringe round the exposed hills of slate. When the hollows between the islets had become more or less filled up, and the islets themselves, wasted by the abrading power of the sea, had probably in large measure disappeared, a volcanic vent opened somewhere near the north end of the range, and poured out the sheet of lava (4–6a); subsequently another flow (7–9) of a different kind of rock was thrown out over the surface of the former, and the portion of it left can be traced for upwards of two miles. A pause then ensued, when the ocean recommenced the work of destruction, and formed, partly out of the subjacent lava-flows, and partly out of the sand-banks and islets not yet covered by igneous rock, a bed of sandstone and conglomerate (9a). Another series of felspathic lavas (12–14), was thereafter erupted, the existing remains of which form a chain of hills about five miles long. The stratum (19), consisting of felspathic grits and conglomerates, indicates another pause, and a condition of things similar to that of 9a. These sedimentary materials were eventually covered over by a stream of dark crystalline felstone (20), which, after a pause, marked by the felspathic, ashy, and conglomeratic beds (22), was followed by another eruption of a similar lava (23, 4), which runs south to Carlops, a distance of about ten miles. The next eruption was that of the ash (28, 9), and then followed the great stream of light pink felstone (30-4) which now forms the highest peaks of the hills, and can be traced in a south-westerly direction for six or seven miles. The upper part of this bed shows indications at several points of another shower of ashy fragments (35-8), which was succeeded by a series of dark crystalline and vesicular lavas (40-48), forming the last of the eruptions of this Old Red Sandstone volcano. When the igneous materials ceased to be ejected, the appearance of the locality must have been widely different from what it was when they began. The islands of slate had probably been almost entirely covered up either by the accumulation of their own debris, or by the volcanic matter thrown around and over them. A long bank of lava and ashes, scarcely, if at all, raised above the sea-level, occupied their site, and suffered in turn the same abrading effects from the action of the sea. In time a mass of sand and shingle, represented by the grits and conglomerates of the upper Old Red and Lower Carboniferous groups, accumulated on the site of the ancient volcano; the whole area underwent a gradual process of subsidence until several thousand feet of sand, mud, lime, and peaty matter—the sandstones, shales, limestones and coals of the Carboniferous series—had gathered over the submerged reef. In long subsequent times a re-elevation took place, denuding agencies again commenced to abrade the rising land, until the whole of the superposed strata, to the depth of 5,000 or 6,000 feet, were worn away, and the ancient lava-flows, and parts of the old slate-islands, once more appeared above the waves, to form what we now know as the chain of the Pentland Hills.

Table-case F. in Recess 48.

1.—Purple Grit (Upper Silurian).—Habbie's Howe. One of the thin gritty beds intercalated among vertical

Table-case F. in Recess 23.

shales, containing *Orthoceras MacLareni, and Rhynconella compressa.*

2.—GREEN QUARTZY CONGLOMERATE (Old Red Sandstone).—Side of River Esk, Fairliehope. The matrix is granular and chiefly quartzy, with a few specks of yellow felspar. The pebbles are here small, well-rounded, and derived from the hard green grits of the underlying Silurians.

3.—GRIT (Old Red Sandstone).—Bed of Esk, below Fairliehope. Granular quartzy rock, not distinguishable in hand specimens from some of the vertical grits of the Silurians below. The old red sandstone of the Pentland Hills has nearly always a greenish colour, corresponding to the green tint of the slates and grits from which it has been derived.

4, 5, 6, 6a.—From the lowest bed of felstone, Warklaw Hill.

4.—FELSTONE (Old Red Sandstone).—Warklaw Hill. A very compact dark felspathic rock from the under part of the bed.

5.—FELSTONE PORPHYRY.—North side of Torduff Reservoir. This specimen, from a higher part of the bed, shows a granular crystalline texture largely impregnated with carbonate of lime.

6.—AMYGDALOIDAL FELSTONE PORPHYRY.—North side of Torduff Reservoir, from the highest part of the bed, showing the vesicular cavities of the upper layer of a lava stream, once filled with gas or steam, and subsequently filled up with calcedony, quartz, or carbonate of lime, carried in solution by water and deposited round the walls of the vesicles.

6a.—AMYGDALOIDAL FELSTONE PORPHYRY.—South-west corner of White Hill Plantation. This specimen is from the same bed, where it is repeated on the eastern side of the fault.

7–10.—From the second felspathic bed in the section forming Torduff Hill on the west side of the fault, and repeated on Harbour Hill on the east side.

7.—FELSTONE.—South side of Torduff Reservoir, from under part of second bed, where the rock is darker in colour. Table-case F. in Recess 43

8.—FELSTONE.—South side of Torduff Reservoir. Light flesh-coloured dull felspathic rock with scattered crystals of felspar. Torduff Hill is entirely formed of a felstone of this character, often with a mottled and brecciated appearance.

9.—FELSTONE.—Stream south of Whitehill Plantation. Earthy, dull, fine-grained felspathic rock; from same bed as last two specimens, but on east side of fault.

10.—FELSTONE PORPHYRY.—Ravine west of Green Craig. Dull, meagre, felspathic rock with crystals of felspar. Weathers light brown, from upper part of last-named bed.

At the north end of the hills above the two felstone beds just described there is a good deal of confusion, owing to the number of small lenticular patches of different felspathic traps. From the fact of the number, and of the greater thickness of the igneous rocks generally towards this end of the chain, it may be inferred that in this neighbourhood, lay the vent from which they proceeded. The felstone (7–10) is followed at the Bonally pond by a thin seam of sandstone and conglomerate, marked 9a in the section.

11.—FELSTONE.—Green Craig. Dark compact, crystalline felspathic rock, from one of the narrow lenticular patches at the north end of the hills.

12–14.—From felstone bed above the conglomerates 9a.

12.—FELSTONE.—Glen between Belld Hill and Harbour Hill. Dull, earthy felspathic rock, mottled yellow and yellowish purple, with small black decomposing grains, perhaps of felspar.

13.—FELSTONE.—From same locality; a whiter, more crystalline felspathic rock, without felspar crystals. It decomposes with a white surface, and its bleached fragments strew the hill sides as long grey lines of rubbish.

14.—FELSTONE.—North Black Hill. A light flesh-coloured felspathic rock, very compact; breaks with a

Table-case F. in Recess 48. conchoidal fracture. The rock, in mass, is much traversed by joints, two of which are shown on the sides of this specimen.

15.—Felstone.—Quarry on north side of Shearer Knowe north end of Pentlands. Dark blue compact rock; breaks with conchoidal fracture, weathers greenish yellow. This specimen belongs to a higher lenticular patch at the north end of the hills, and, with the following three, passes northwards into the Braid Hills, which are a prolongation of the beds of the Pentland Hills.

16.—Felspathic ash.—Roadside, quarter of a mile north of Swanston. Felspathic rock made up of angular fragments of different felstones, chiefly of a soft white variety. This ash bed occupies a very limited area among the lenticular felstones.

17.—Mottled felstone.—1st Quarry west of Upper Braid. Compact mottled felspathic rock, one of the lower beds of Braid Hills.

18.—Compact felstone.—Cayiside Quarry, 2 miles south of Edinburgh. This dark fine-grained rock occurs above the ash No. 16, and appears to pass northwards into the darker felstone of the Braid Hills.

19.—Green felspathic conglomeritic grit.—Quarry between Belld Hill and Knightfield Rig. This rock appears to be made up in great measure of the debris of the felstone bed (12–14) and of the green Silurian grits. The pebbles are partly of yellow felstone, partly of green grit, and all well rounded.

20.—Felstone.—North side of north-east corner of Loganlee Reservoir. Compact crystalline rock veined with carbonate of lime, and sprinkled with hæmatite, from bed overlying No. 19, and running along the north side of the Logan House Valley for upwards of four miles.

21.—Felstone.—Mouth of Howlet's House Burn. Compact pinkish white felspathic rock like No. 14; occurs in thin beds above the dark felstone No. 20.

22.—Felspathic ash.—North-east side of Loganlee Reservoir. This rock occurs in thin strata, consisting of fragments of different felstones imbedded in a pale yellowish pink felspathic base. It rests immediately upon the white thin-bedded felstone 21. Further north-east, this intercalated band becomes more conglomeratic until it finally passes, below Castlelaw Hill, into a coarse conglomerate of rounded felstone and grit fragments.

Table-case F. in Recess 48.

23.—Felstone.—South side of south-west corner of Loganlee Reservoir. Compact crystalline rock lying above the ash beds (22). This bed is one of the most marked of the series; it runs from Carlops to beyond Caerketton Hill, a distance of about 10 miles. In the upper part it becomes highly amygdaloidal (No. 24).

23a.—Compact blue Felstone.—Stream on the west side of Castlelaw Hill; from same bed as last specimen, but further north.

24.—Amygdaloidal felstone.—East Kipp Hill. Chocolate coloured felspathic rock, with numerous cavities, some of which are filled up with quartz crystals, others being empty from the decomposition of the enclosed mineral. This specimen forms part of the same bed as 23.

Between this and the next felspathic trap are intercalated thin lenticular patches of grit and conglomerate that appear to have filled up hollows existing on the surface of the underlying lava-flow. The next two specimens (25 and 26) illustrate these sedimentary interstratifications.

25.—Grit.—Road side, quarter of a mile north of Carlops. Dark quartzy felspathic rock, scarcely distinguishable from some of the more granular felstones.

26.—Felspathic conglomerate.—West side of South Black Hill. Rounded felspathic fragments, imbedded in a granular felspathic paste.

27.—Felstone.—Above turnpike road, a quarter of a mile N. of Carlops. Dull, compact, slightly vesicular felspathic rock from lenticular bed among the grits and conglomerates represented by No. 25.

28.—Felspathic ash.—South-west side of Castlelaw Hill.

Table-case F. in Recess 46. 29. Felspathic ash.—Quarry between Scald Law and Carnethy; from the same bed but further south, where it overlies the grits and conglomerates (25 and 26).

30–34 are from the bed which forms the highest peaks of the chain, and runs from Caerketton Hill 7 miles to Walstone. They are arranged to show the changes of the rock in its course along the hills.

30.—Brecciated felstone.—Top of Caerketton Hill. Fragments of hornstone-like felstone imbedded in a looser-grained dull felstone. From the north end of the bed.

31.—Brecciated felstone.—S.W. side of Castlelaw Hill. Collected about 1½ mile S.W. of the last specimen.

32.—Felstone.—Castlelaw Hill, very compact, hornstone-like rock from the same locality as 31.

33.—Felstone.—Quarry between Scald Law and Carnethy. White dull felspathic rock with crystals of a black decomposing mineral, possibly augite, 2 miles S.W. of 32.

34.—Vesicular felstone.—Braid Law. Dull earthy felspathic rock, concentrically mottled; weathers with a rough orange-coloured surface, 1½ mile south of 33.

35–38. Illustrate an ashy layer which rests upon the last described bed of felstone (30–34). They are also arranged to show the different changes of the rock from north to south.

35.—Felspathic ash.—Top of Caerketton Hill, north end of range. Angular fragments of white and pink felstone embedded in a granular felspathic matrix.

36.—Felspathic ash, from the same locality. Showing angular and rounded felspathic fragments in a pinkish felspathic paste.

37.—Felspathic ash.—Roadside north of Camp Hill 5 miles south of 35 and 36. The fragments here are mostly sub-angular, the paste being of a pinkish colour and granular texture.

38.—Felspathic ash.—Walstone. 1 mile south of 37. The beds at this locality are finely stratified, of a light yellow colour and nearly vertical, against a large fault which skirts the whole of the south-eastern flank of the Pentlands. Table-case F, in Recess 48.

39.—FELSTONE PORPHYRY.—Quarry above Woodhouselee. White dull felspathic rock with crystals of pink felspar and small rounded granules of dark-coloured quartz.

40–45 are from the dark-coloured felstone that overlies the Scald Law, Carnethy, and Castlelaw bed, and runs from Walstone northwards for about 8 miles, till lost among the upper felstones of the Braid Hills, which are probably on the same horizon. Although referred to here as one bed it is not unlikely that there may be several, so similar, however, in composition and so obscured by the herbage and debris of the south-eastern declivities of the hills that their limits cannot be traced. The specimens are arranged to show the varieties of this felstone from the south end at Walstone to the north end at the Braid Hills.

40.—FELSTONE PORPHYRY.—Quarry west of road between Braidwood and Walstone. Decomposing felspathic rock with numerous crystals of white felspar.

41.—FELSTONE PORPHYRY.—North side of Camp Hill. Dull, meagre felspathic rock, finely vesicular with small scattered crystals of felspar. Collected about three-quarters of a mile north of 40.

42.—FELSTONE PORPHYRY.—Quarry south-east side of Carnethy. Very compact crystalline rock with small granules of amethyst and large felspar crystals. These crystals have a thin tabular form, sometimes half an inch broad, and are disposed in planes which give a rudely fissile structure to the rock. Collected about a mile and a half north of the last.

43.—FELSTONE.—East end of Hillend Hill. Red crystalline rock with disseminated crystals of glassy felspar.

44.—AMYGDALOIDAL FELSTONE.—East end of Hillend Hill. Red and crystalline like 43, of which it forms an upper part, with numerous kernels of calcedony, quartz, and sometimes green earth.

Table-case F. in Recess 43. 45.—Felstone.—Quarry on roadside south of Hillend Hill, 4 miles south of Edinburgh. An upper part of same bed, showing the same red crystalline texture, all the jointed surfaces being slicken-sided and covered with a thin coating of serpentine. This is the highest bed of the Pentland Hills; the next specimens illustrate what seems to be the same felstone, or one on the same horizon in the Braid Hills.

46.—Felstone.—Blackford Hill Quarry. Very compact crystalline rock, joints coated with hæmatite and carbonate of lime.

47.—Felstone from same quarry, finer grained than 46, with a trace of the striped character so marked in the rock of Traprain Law, Haddingtonshire. (Table-case **E** No. 53.)

48.—Felstone.—Quarry west of Liberton Tower, Braid Hills. Very compact, dull felspathic rock, with crystals and veinings of carbonate of lime.

At Habbie's Howe, and also at Liberton, the felstones of the Pentland Hills are covered by a conformable series of conglomerates and conglomeritic grits belonging apparently to the upper Old Red Sandstone. These graduate upwards into a set of calcareous conglomerates and reddish sandstones, forming here the bottom beds of the carboniferous rocks.

49.—Conglomerate (Upper Old Red Sandstone).—Habbie's Howe, Pentland Hills. The pebbles are well rounded, consisting of felstones, jaspers, and grits imbedded in a granular quartzy and felspathic paste, the whole being derived from the waste of the Silurian and Old Red grits with their overlying felstones.

50.—Calcareous Conglomerate (Passage beds between Old Red Sandstone and Lower Carboniferous).—Liberton Hill, Edinburgh. The basis is a calcareous sand, and the pebbles, generally well rounded, consist partly of a compact cherty limestone, partly of different felstones, and sometimes of various grey micaceous grits.

51.—Sandy Conglomerate (Lower Carboniferous).— West side of Harbour Hill, at the point marked × in the section. The basis here is sandy, micaceous, and considerably felspathic; the pebbles are chiefly well rounded pieces of yellow and pink felstone, like that of the upper part of Harbour Hill, from which they were probably derived. Table-case F. in Recess 48

52.—Sandstone (Lower Carboniferous).—From a higher bed at the same locality as 51.

The town of Edinburgh stands upon Lower Carboniferous Sandstones and shales, higher in position than the sandstone at Harbour Hill [52]. They dip eastwards and pass under the traps of Arthur's Seat and Calton Hill; two hills of which the remainder of the specimens in this case are illustrative. The section accompanying the specimens is drawn through the central ridge of the town from a point west of the Castle rock to the coal-field beyond Portobello, a distance of about five miles. The lowest strata are the sandstones and shales which recline against the fault on the east side of the Castle rock. They continue with an easterly dip to Arthur's Seat, where their higher portions, retaining the same general character, are seen interstratified among different traps. The general contour of Arthur's Seat, as well as the area of some of the rocks described below, is shown on the model in Recess 2.

Rocks of Arthur's Seat.

Arthur's Seat, is the name of a hill about 820 feet high, and a square mile in extent, forming the eastern boundary of Edinburgh. It consists of two parts, separated by the deep valley of the Hunter's Bog; that to the west rises from the streets of the town in a steep slope crowned by a semicircular mural escarpment, called Salisbury Craigs, which descends on the other side into the Hunter's Bog. The eastern portion of the hill is formed of successive terraces with dividing valleys, running north and south, their southern terminations being marked off by a confused

Table-case F, in Recess 43.

pile of rock which slopes up from the north and east, and descends precipitously on the other sides. This higher part of the hill which, seen from certain localities looks like a great irregular cake laid down upon the lower ridges, is crowned by a crag of basalt forming the summit, or Arthur's Seat proper. To this peculiar contour the geology of the hill bears special reference. The ridges are all of hard trap; the intervening valleys consist of softer rocks, which have yielded more readily to disintegration; while the higher irregular mass of rock at the south side belongs to a much later age, and is really what it appears to be, a newer group of ridges set down on the tops of the older ones. The hill is thus of two distinct geological ages. The older rocks form part of the Lower Carboniferous series, and are all inclined to the east at an average angle of about 20°. The under or westerly part consists of a set of white, red, green, and mottled sandstones, fine conglomeritic grits, coarse limestones, and red and green shales, among which are intercalated intrusive beds of greenstone, that harden and otherwise disturb the strata above and below them. The upper or eastern portion displays a great group of contemporaneous trap-rocks, that is, basalts, greenstones, felstones, and felspathic ashes, which were ejected over the sea-bottom after the sandstones and other strata below had been deposited. All these are arranged in beds which follow with great regularity the dip and direction of the underlying sedimentary rocks, and pass under a higher series of sandstones and shales, the whole forming part of the great Lower Carboniferous group.

The newer rocks of Arthur's Seat belong to a much later period, for they rest upon the upturned denuded edges of the beds below. The older traps had been covered over by several thousand feet of newer deposits; the rocks of the whole country had been bent into troughs and ridges, and then the whole of this superincumbent mass had been worn away from the site of Arthur's Seat, whose trap beds again stood up as ridges, with the sea excavating valleys through the softer rocks between;—all this had elapsed before the rocks of the summit and south side of the hill were ejected. They were suspected by the late Professor Edward Forbes to be of Tertiary age, a supposition which future investigations in other parts of the country may not improbably confirm. The lowest and of course oldest of these newer rocks consist of a coarse ash or volcanic conglomerate, which lies upon the inclined edges of the greenstone beds below, as a great irregular mound, forming the centre and highest part of the south side of the hill. Local patches of other trappean materials occur on the top and sides of this mound, while its summit is pierced by a column of basalt, forming the crag at the top of the hill. Along the steep cliffs below the western front of this crag, a section can be seen of part of the column in its descent through the ash. Several veins, proceeding from its sides, traverse the adjacent rocks, and in one locality completely envelope a large mass of ash. The arrangement of these later materials leaves little room to doubt that they were erupted from a crater of which the site is now occupied by the summit of Arthur's Seat. The ash contains large masses of nearly all the rocks of the hill, and must at one time have filled up all the neighbouring valleys, and perhaps even a considerable area of the surrounding district, for only a fragment round the old crater now exists. It thus appears, that Arthur's Seat has been, at a widely separated interval, the site of two distinct volcanos; one during the Lower Carboniferous period, after the Pentland Hill crater had been long extinct; the other, at a far later time, when the physical aspect of the country had been totally changed, and a new vent burst through the deposits of the ancient one. After successive eruptions had formed a mass of rock and débris several hundred feet deep, represented now by the ash, there rose through the crater a column of melted lava, which ejected veins into the sides of the cavity, but seems to have cooled ere reaching the top, for there remains no evidence of its ever having flowed down the sides of the

Table-case F. in Recess 43

Table-case F. in Recess 48. hill as a lava-stream. This was the last of the eruptions which forced their way by the central crater. There are traces however, of what seem to have been two later eruptions, through at least one lateral fissure, where a thick bed of columnar basalt is connected with a narrow neck, rising from out a mass of ashy débris, and is overlapped by a mass of felstone. The present contour of the hill has been in large measure determined by later denuding agencies, which have stripped off the softer ashy covering, save where protected by some of the harder traps, and scooped out anew the gently undulating valleys. Glacial action has also contributed to give the rocks a smoothed and rounded form.

The following specimens are arranged stratigraphically, beginning with the lowest, and for the sake of local connexion the intrusive traps, instead of being inserted in Table-case **C** (Lower Compartment), are grouped in the order of succession here.

(Lower Carboniferous.)

53, 54.—Porphyritic Greenstone, Heriot Mount.—This is the lowest of the intrusive traps. It is surmounted and underlaid by red and white altered sandstones. The usual character of the rock is that of a hard blue greenstone with disseminated crystals of felspar (as in No. 53), but in other parts it becomes much redder in colour, more compact in texture, and very sparingly porphyritic. (No. 54.)

55.—Conglomeritic sandstone, at the Hawse, Queen's Drive.—This specimen is from a bed a little way below the next bed of greenstone. Like a large number of conglomerates in the lower part of this series, it contains a considerable admixture of lime, both as limestone fragments and in the base. (See under 48–50.)

56.—Augitic greenstone.—Salisbury Craig. Intruded among sandstones, shales, &c. This is the second sheet of intrusive trap.

57.—JUNCTION OF GREENSTONE AND SANDSTONE, from base of greenstone bed, south side of Salisbury Craig. Both rocks are much altered; the greenstone has acquired a fine texture and red colour, while the sandstone shows a vitrified aspect like quartz rock. The greenstone is marked *a*, the altered sandstone *b*. (See also 235 and 236, in Table-case C, Lower Compartment.) Table-case F. in Recess 43.

58.—AUGITIC GREENSTONE from dyke, cutting through greenstone of Salisbury Craig, full of crystals of carbonate of lime.

59.—RIPPLED SANDSTONE, from quarries above greenstone of Salisbury Craig.

60.—WHITE SANDSTONE, from same quarries.

61, 62.—AUGITIC GREENSTONE, porphyritic, from the Dasses. This is the highest of the intrusive greenstones. It forms a low irregular ridge parallel with the Hunter's Bog, and consists of several beds intruded among sandstones and shales. A short slope, probably covering similar sedimentary rocks, intervenes between this and the crag called Long Row.

63.—GREENSTONE, Long Row; very black compact, approaching a basalt, with scattered crystals of augite and amygdaloidal nodules. This bed has a rudely columnar structure, and is the oldest of the contemporaneous traps. It is succeeded by ashy beds, the junction being seen on the south side of the Queen's Drive.

64.—AMYGDALOIDAL GREENSTONE, below St. Anthony's Chapel, contains grains of specular iron, veins of hæmatite, and cavities filled with carbonate of lime, calcedony, &c. It is covered immediately by 65.

65.—ASHY CARBONACEOUS SHALE, with remains of plants and scales of Holoptychius, &c.—Below St. Anthony's Chapel.

66—GREEN FELSPATHIC ASH.—Dry Dam. Greenish, granular, felspathic rock, well stratified, containing numerous angular fragments of greenstone, altered shale, &c., with irregular fragments of cherty limestone.

In Recess 43. 67.—Basalt.—Lowest bed above ash of Dry Dam; compact black rock with granules of green serpentine.

68–70.—Three specimens, to illustrate the passage of a basalt, like No. 67, into a felstone porphyry.—South end of Whinny Hill. Collected within a space of 15 yards.

71.—Felstone Porphyry.—Side of Queen's Drive, east of St. Anthony's Loch. Dull felspathic rock, with crystals of specular iron, and felspar with vesicular cavities, filled with a brown decomposing mineral. This bed succeeds the basalts and passes into them imperceptibly, as in 68–70. It is followed by other felstone beds, of which the next three specimens are examples.

72.—Amygdaloidal felstone porphyry.—Queen's Drive, east of St. Anthony's Loch.—Cavities numerous, often large, filled with calc spar, calcedony, and green-earth; generally lined with green-earth, frequently empty.

76.—Felstone porphyry.—East of St. Anthony's Loch. Red, compact, with grains of specular iron and crystals of felspar.

74.—Felstone.—East of Queen's Drive, east end of the hill. This is the highest visible bed on Arthur's Seat. It is darker, more homogenous and crystalline than most of the felspathic rocks below, and has a granular texture, sparingly porphyritic.

Lower carboniferous contemporaneous Traps of Calton Hill.

To the north-west of Arthur's Seat, from which it is separated by a deep valley, lies the conical rounded emi nence called the Calton Hill. It consists of different bedded felstones, with intercalated seams of ash, and corresponds closely with the eastern part of Arthur's Seat, of which, indeed, it forms geologically a part, the two hills being separated by a large fault. The bed marked 67 of Arthur's Seat, answers to the lowest visible bed of Calton Hill [75], and the porphyries which supervene have the same general character on both hills. The ashy beds of the Calton Hill have not indeed been detected on Arthur's Seat, but such beds throughout the carboniferous rocks of central Scotland, are usually of very limited extent. The Calton Hill beds may be regarded, therefore, as the northward prolongations of Nos. 67–74 of Arthur's Seat, separated by a fault which is a downthrow on the north.

Table-case F. in Recess 48.

75.—GREENSTONE.—Below Regent Bridge, Edinburgh. Lowest of Calton Hill beds. Compact fine-grained rock, with granules of green serpentine.

76.—FELSPATHIC ASH.—Below Nelson's Monument. Greenish stratified felspathic rock, with rounded felstone fragments.

77.—FELSTONE PORPHYRY.—Below Nelson's Monument. Dull compact felspathic rock, with crystals of pink felspar and carbonate of lime, from bed interposed between 76 and 78.

78.—FELSPATHIC ASH.—Below Nelson's Monument. Rounded and subangular fragments of different coloured felstones, imbedded in a dull reddish granular felspathic paste. The two flat surfaces of this specimen show the thickness of a stratum of this ash.

79.—FELSTONE PORPHYRY.—Below Nelson's Monument.

80–83.—Stones from bed of ash, east of Nelson's Monument. 80 and 81 show the rounded form of most of the enclosed fragments; 82 and 83 are pieces of larger stones, broken, to show the nature of the rock, which is an amygdaloidal felstone porphyry, resembling 77.

84.—FELSTONE.—East of Nelson's Monument. This concentrically stained compact rock forms the highest bed of the hill, and agrees closely with the highest bed of the Arthur's seat series, as shown in the railway cutting at St. Margaret's.

ROCKS OF CRAIGLOCKHART HILL.

Craiglockhart Hill, about 3 miles S.W. from Edinburgh, belongs to the same series of traps as Arthur's Seat and Calton Hill. It consists of a bed of light yellowish-green

Table-case F. in Recess 48. felspathic ash, dipping westward, and capped by a bed of columnar greenstone.

85.—Felspathic ash, Craiglockhart Hill. Soft yellowish felspathic rock, with scattered felspar crystals.

86.—Amygdaloidal greenstone.—Craiglockhart Hill, from thick columnar bed above ash.—This rock may be compared with 67 and 75, with which it is not improbably contemporaneous. The ash (85), too, may be compared with the Arthur's Seat bed (66) underlying a bed of augitic trap, as is the case here.

Newer (Tertiary ?) Volcanic Rocks of Arthur's Seat.

The relations of these rocks, which, as already explained, belong to an age much later than any of the other rocks of these countries, and are introduced here merely for the sake of local connexion, are shown in the section.

87–89.—Felspathic ash.—S. side of Queen's drive. The later ash of Arthur's Seat is an irregular mass of rounded and angular blocks of different greenstones, felstones, and sandstones, sometimes several feet in diameter, imbedded in a felspathic paste. Sometimes this paste is loose and granular, with few imbedded stones, as in 87; sometimes it presents a harder consistency, as in 88, while at one point on the south-eastern declivity of the hill, the rock is as hard and compact as any greenstone, as in 89.

90–95.—Stones from later ash.

90.—Fragment of sandstone.

91, 22.—Fragments of cherty limestone. These specimens show the rounded form characteristic of most of the imbedded fragments.

93, 94.—Fragments of amygdaloidal greenstone. Compare these specimens with bed No. 64.

95.—Fragment of felstone porphyry. Probably broken off from some of the beds, 71–74.

96.—Basalt.—Top of Arthur's Seat. Where not weathered, this rock has a black very compact texture, but on exposure it acquires a red tinge visible along the joints, and in spots in the interior. Table-case F. in Recess 48.

97.—PORPHYRITIC BASALT.—Lion's Haunch, with large crystals of augite, and grains of olivine. This bed is distinctly columnar and seems to have proceeded from a narrow vent on the south side of the hill.

98.—FELSTONE PORPHYRY.—Head of Dry Dam. Granular felspathic rock, with crystals of specular iron and felspar. This is the latest of the eruptions of which any trace remains. It covers the ash (87–89), and overlaps the basalt (97).

Table-case C. (Upper Compartment.)

ROCKS OF EDINBURGHSHIRE AND LINLITHGOWSHIRE.

The specimens in this case continue the geology of Edinburghshire, through the higher rocks of the series up to the Coal Measures of Linlithgowshire. They are arranged to show not only the different stratified rocks, but also the contemporaneous traps as these occur in the ascending series. The Lower Carboniferous group, or that which lies below the Scotch mountain limestone is made up of a set of white sandstones, blue and black shales, and ironstones, thin limestones, with occasional meagre seams of coal. Throughout this series occur beds of stratified ash and masses of intrusive and occasionally contemporaneous greenstone and basalt. The mountain limestone of Linlithgowshire consists of several beds intercalated between seams of ash, greenstone, sandstone, shale, coal, &c.; the limestone itself being not unfrequently ashy in composition. Above these marine beds the true Coal Measures occur with enormous sheets of contemporaneous greenstone, sometimes 300 or 400 feet thick, interstratified among the beds. These igneous rocks do not affect the quality of the coal, and have been bored through to reach the coal-seams, which are extensively worked below them. Table-case C.

Table-case C.

LOWER CARBONIFEROUS ROCKS IN ASCENDING SERIES FROM THE PENTLAND HILL CHAIN INTO LINLITHGOWSHIRE.

99.—BRECCIATED LIMESTONE.—Cock Burn, near West Brook, 10 miles S.W. of Edinburgh. This specimen and 100, are illustrative of the numerous thin calcareous bands in the lower carboniferous rocks of Edinburghshire.

100.—LIMESTONE.—Railway, at Selms, Kirknewton.

101.—FELSPATHIC ASH.—Bed of Linhouse Water, at felspathic dyke. South end of Calder Wood, Edinburghshire: sandy felspathic rock with white angular felspathic fragments.

102.—ALTERED SANDSTONE.—Bed of Linhouse Water, below Red Craig. This rock is traversed by a mass of felspathic greenstone [254] similar to that which occurs with 101.

103.—BLACK SHALE.—Hanging Craig, Granton. Plants and coprolitic nodules occur in these beds. Below the Granton and Craigleith sandstones [104–5] there is a set of black shales, which at Wardie enclose nodules of clay ironstone, containing coprolites and other fish remains. These shales are remarkably persistent, extending southward for several miles until they abut against the fault which flanks the Pentland Hills.

104.—WHITE SANDSTONE.—Granton Quarry. This rock, extensively used as a building material, forms part of a great series of white sandstones, which occupy a large part of the western area of Edinburghshire, and the contiguous portion of Linlithgowshire. They overlie the dark shales [103], and graduate upwards into the shales and sandstones that contain the Burdie House limestone.

105.—WHITE SANDSTONE.—Craigleith Quarry. Out of this famous quarry most of the New Town of Edinburgh has been built. The rock forms part of the same sandstone as that of Granton.

106.—FELSPATHIC ASH.—Lauriston Cottage, two miles W. of Granton. Compact sandy felspathic rock, with white felspathic fragments and irregular pieces of hardened shale. Table-case C.

107.—FELSTONE.—Railway cutting 1½ mile N.E. of Harburn Station. Dull compact felspathic rock forming part of the large bed of Corston Hill. The section displayed at the railway shows several intercalations of ash, of which 108 is a specimen.

108.—FELSPATHIC ASH, from same locality.—Angular and sub-angular fragments of different felstone in a dull yellow felspathic paste. Many of the fragments in these ash-beds resemble parts of the Pentland Hill rocks.

109.—SANDSTONE, with iron-stains.—Bed of Linhouse Water at foot-bridge, half a mile above Camilty Bridge.

110.—QUARTZY GRIT.—Bed of Linhouse Water, 300 yards above Camilty Bridge.

111.—FELSPATHIC ASH.—Bed of Crosswood Water Harbour Hill Works, Edinburghshire. Calcareous felspathic rock, with large admixture of crystalline carbonate of lime, in greenish felspathic paste.

112.—FELSPATHIC ASH.—South end of Binny Craig, Linlithgowshire. This specimen is taken from a circular patch of dull brownish black argillaceous ash, occupying the top of an anticlinal dome-shaped ridge. It underlies a set of calcareous shales (Burdie House limestone), and may be connected with a series of similar patches which, by the convolutions of the strata throughout the eastern part of this county, are found on the denuded tops of the anticlinal axes, dipping below similar shales (113).

113.—FELSPATHIC ASH.—Tor Hill, Ecclesmachan, Linlithgowshire. Dull greenish grey brecciated felspathic rock, consisting of green angular felspathic fragments which contain rounded grains of quartz, and are imbedded along with rounded pebbles of cherty limestone, in a dull grey felspathic and calcareous paste. The rock in mass frequently shows angular fragments of yellow baked shale and balls of different traps. It underlies a set of shales similar to those near 112. (See 126.)

Table-case C.

The next important stratum in ascending order, illustrated by the specimens in this case, is the Burdie House limestone. That rock, where it occurs typically, at Burdie House, four miles south-east of Edinburgh, attains a thickness of 27 feet. It there has a dull yellowish or blueish grey colour, and in certain strata has a finely-striped appearance, owing to the greater or less amount of carbonaceous matter in the layers. It is compact, not crystalline, or only sparingly so in certain bands, and contains in some parts thin laminæ of coaly matter, which impart a fissile structure. Fossils are abundant, and consist of *Ferns*, *Stigmariæ*, *Lepidostrobi*, *Lepidodendra*, and other carboniferous plants, along with the cases of minute crustaceous animals called *Cyprides*, and teeth, scales, bones, and coprolites of several genera of fishes. (For these fishes, see Lower Gallery, wall-case 43.) The position of the limestone at Burdie House is about 800 feet below the Mountain Limestone of Gilmerton, a distance, however, which greatly varies in the districts to the west.

South of Burdie House the limestone ceases to be traceable, owing to the depth of the covering of drift. In several of the streams which descend from the Pentland Hills, however, blocks of it can be seen, indicating its probable continuity southwards, and at Carlops, ten miles south of Burdie House, it is found among the vertical strata in the river Esk, but as two beds, four and five feet thick respectively. Its prolongation north of Burdie House is wholly uncertain: probably it is cut out by the great fault which, running by Liberton to Portobello, brings down the Mountain Limestone and overlying Coal Measure almost vertically against the bottom beds of the Carboniferous group. The thickness of the rock at Burdie House is probably exceptional, the rock there seeming to have been formed in a hollow or lagoon, which shallowed southwards —a supposition rendered probable from the appearances presented by the rocks of Linlithgowshire.

In that county there occurs, sometimes fully 1,000 feet below the mountain limestone, a seam of grey compact stratified limestone, averaging about 9 feet thick. In colour, texture, and fossils it corresponds closely with the rock of Burdie House, of which, indeed, there can be no doubt that it is the equivalent. Along the shore, between Queensferry and Midhope Glen, the beds undergo frequent reversals of dip, and the limestone, with its associated shales and sandstone, can be seen crossing the beach five times. There it has the usual texture (see 120), but as we trace it inland it gradually becomes more argillaceous, splits up into thin layers, and passes finally into calcareous shales (126), with little resemblance to the limestone, except that they contain the same fossils. Still further to the south the rock regains its purity, and has been extensively worked at Dechmont, but to the south-east of that district it again becomes shaly and argillaceous, till it takes the form of fissile grey shales, whose identity with the limestone of Burdie House could hardly at first sight be suspected. Beyond this it re-assumes its typical character, and at Midcalder and Murieston occurs in great basin-shaped cavities 40 to 70 feet deep. At the Mid Calder quarries it exactly resembles some parts of the rock at Burdie House, being full of plants, especially of *Stigmariæ* which spread out their long roots in regular layers, with the rootlets branching freely in all directions, as if, when the limestone existed as soft calcareous mud, the plants grew upon the spot where we now find their remains (119). From these different facts it appears that the Burdie House limestone was formed very slowly, probably in brackish water, across a series of lagoon-like depressions, separated from each other by muddy shoals; that in these hollows cyprides and ganoidal fishes abounded, while even the larger placoids became occasional visitors; and that in some localities there rose up from the muddy bottom a thick growth of marshy plants. The next thirteen specimens (114–612) illustrate the limestone with its shales, as typically developed at Burdie House, and as it varies in its course through the eastern part of Linlithgowshire. Table-case C.

Table-case C.

114–117.—LIMESTONE.—Burdie House. Nos. 114 and 115 show the usual compact grey texture of the rock, with its numerous *Cyprides*, *Coprolites*, and fragmentary plants. In 116 the texture is looser and the colour lighter, as in the upper portions of the rock. No. 117 shows the striped appearance so characteristic of the Burdie House limestone. The darker shade of some of the layers is owing to the carbonaceous matter they contain. Such a specimen as 117 points to a slow condition of deposit, when drifted macerated plants sank at intervals to the bottom among the calcareous mud, each layer of such vegetable detritus being marked now by a corresponding lamina of darker limestone. In some cases, however, the difference of tint may be owing to occasional inroads of a darker mud over the light calcareous marl at the bottom.

118.—CALCAREOUS SHALE.—Above limestone, at Burdie House. This stratum contains, in immense abundance, the cases of the cyprides, along with well-preserved plants and numerous coprolites.

119.—LIMESTONE.—Raw Camps Quarry, Mid Calder. This specimen shows the stigmaria roots referred to above. The bed from which it is taken attains a thickness of 40 feet, and lies in two detached basins. It is distant about 11 miles due west of Burdie House, on the other side of the intervening Pentland Hills.

120.—LIMESTONE.—Port Edgar Quarry, South Queensferry. Black compact rock, with crystals of iron pyrites, fish-scales, and plant remains. This lower part of the rock is much darker and more compact than the upper parts, which closely resemble some bands in the limestone at Burdie House.

121.—BLACK SHALE.—Above limestone, at Port Edgar.

122.—LIMESTONE NODULE, containing coprolite.—From shales above limestone, Newhalls, South Queensferry.

123.—GRIT, slightly calcareous, with crystals of carbonate of lime. Above shales capping the limestone, Newhalls.

124.—COARSE SHALY LIMESTONE.—Cutting of Edinburgh and Glasgow Railway, Priestinch, Linlithgowshire. Table-case C.

125.—COARSE LIMESTONE, or "*cement-stone*," from same locality.

These two specimens (124 and 125) show the change which the limestone undergoes in its passage from Port Edgar to the south-west. The rock is an impure argillaceous limestone, with a considerable per-centage of iron, and has been burnt for a cement. The fossils in these beds are similar to those at Queensferry and Burdie House.

126.—CALCAREOUS SHALE, with scales of *Palaeoniscus.* —Ecclesmachan, Linlithgowshire. The beds from which this specimen is taken lie above the ash (113), and show the Priestinch beds in a still more argillaceous form as these pass southward. Beyond Ecclesmachan, however, they appear to become purer, for where next seen, at Dechmont, they take the typical form of a pure compact limestone.

Above the Burdie House limestone of Linlithgowshire there follows a great series of white sandstones, with intercalated ashes and greenstones. These sandstones are well displayed in the large quarries at Binny, and the group may be distinguished as the Binny Sandstone Series. The next eight specimens (127–134) illustrate the features of this series.

127.—BRECCIATED ASH.—Railway Cutting, Niddry, Linlithgowshire. Angular and subangular felspathic fragments and pieces of shale, in a dull black argillaceous paste. The felspathic lapilli are of a light grey colour, and contain small quartz granules, with angular specks of what seems to be black shale. The rock in mass contains enormous blocks of shale, with contorted beds of shale and ironstone. (See 275.)

128.—FELSPATHIC ASH.—Three hundred and fifty yards south of Dechment House, Linlithgowshire. White angular felspathic fragments, in a dull blueish black felspathic paste.

Table-case C. 129.—FELSPATHIC ASH.—Shore a quarter of a mile east of Society, Hopetown, Linlithgowshire. Dull, sandy felspathic rock, containing small rounded grains of quartz.

130.—FELSPATHIC ASH.—Wood, a quarter of a mile south of West Binny. Contains subangular white felspathic fragments and grains of quartz, in a dull greenish brown felspathic paste.

131.—SANDSTONE.—Binny Quarry, Linlithgowshire.—Extensively used as a finer kind of building stone.

132.—SANDSTONE.—Humbie Quarry, Linlithgowshire. White compact quartzy rock, extensively used as a building material.

133.—GREENSTONE.—Road, 300 yards south of Newbigging Tile Works, Linlithgowshire. Crystalline compact rock with glassy felspar crystals. This specimen is from a bed near the top of the Binny Sandstone group.

134.—GREENSTONE.—Quarry on Peace Knowe, 1¾ mile south-east of Linlithgow, from bed corresponding in position to No. 133.

The Binny Sandstone group is covered by a set of thin shaly sandstones and shales, the distinguishing bed of which is a seam of coal, known as the Houston Coal, whence the group of strata may be termed the Houston Coal series. The next thirteen specimens (135–148), illustrate this series.

135.—CONCRETIONARY SANDSTONE.—Cutting of Edinburgh and Glasgow Railway, Priestinch, Linlithgowshire, from bed underlying Houston Coal.

136.—Coal ("Houston Coal"), altered by proximity to neck of Greenstone (277). Railway Cutting, Craigton, Linlithgowshire.

137.—CLAY IRONSTONE AND CYPRIS SHALE, from beds above Houston Coal.—Old pit south of Newbigging Tile Works, Linlithgowshire.

138.—GREEN MARLY SHALE.—Above Houston Coal, Cutting of Railway, Craigton. This rock assumes sometimes a reddish colour and is of a crumbling nature. It

occurs all over the eastern part of the county, and is Table-case C.
always a reliable indication of the position of the Houston Coal.

139.—Felspathic ash.—Wood half a mile south of Gateside, 3½ miles east of Linlithgow. Stratified greenish granular felspathic rock, with angular fragments of black shale and small felspathic lapilli in a light green felspathic paste.

140.—Felspathic ash.—Bank-head, 3 miles south-east from Linlithgow. Granular felspathic rock with sub-angular fragments of shale and felspathic matter.

142.—Felspathic ash.—Stream a quarter of a mile west of Wester Ochiltree, Linlithgow. Coarse conglomerate of rounded nodules, chiefly trappean, imbedded in a dull granular and crumbling felspathic base.

143–5.—Three stones from same ash, showing the rounded form of its imbedded fragments.

146.—Felspathic ash.—Binns Hill, Linlithgowshire.—This hill consists of a large sheet of greenish felspathic ash interbedded among the shales and sandstone above the Houston Coal. Its summit is occupied by a circular patch of Basalt (147), filling up the vent from which the ash appears to have been ejected.

147. Basalt, top of Binns Hill, Linlithgowshire. From neck in felspathic ash.

148.—Greenstone, from bed above stream, east of Longmuir Plantation, Linlithgow.

Above the Houston Coal series lies a set of sandstones and shales, to which the name of the Kingscavel sandstones may be applied, since the strata are well seen in the large quarries at that locality. The specimens 149 to 153, illustrate this group.

149.—White sandstone.—Kingscavel Quarry one mile east of Linlithgow. Extensively quarried as a building stone.

150.—White sandstone with *stigmaria*.—Kingscavel Quarry.

Table-case C.

151.—Laminated micaceous sandstone.—Above 149 and 150 in Kingscavel Quarry.

152. Carbonaceous shale.—Highest beds in Kingscavel Quarry. Highly impregnated with carbonaceous matter, and forming in consequence a coarse kind of coal.

153.—Greenstone.—Stream below Broomyknowes Farm 1½ mile south of Linlithgow. From thick bed above Kingscavel sandstones.

The Kingscavel Sandstone series is followed by the Mountain Limestone strata. These consist of several beds of limestone intercalated among shales, sandstones, and occasionally thin coals, with numerous beds of felspathic ash, greenstone, and basalt. The whole group is indeed eminently characterized by the number of its igneous rocks, pointing to a period of great volcanic activity, when showers of dust and ashes and streams of lava were thrown out over a sea-bottom swarming with corals and shells. The completest section is that shown at the south end of the Bathgate Hills along the line of Quarries from Petershill to Kirkton. In the suite of specimens (154–195), which follows, an attempt has been made to exhibit the interstratifications of ash limestone and greenstone as completely as the space would allow.

154.—Limestone.—Mid-Tartraven, 3 miles south of Linlithgow. Compact grey rock with traces of shells and joints of encrinites. This rock cannot be traced southwards beyond this locality, inasmuch as the whole country is deeply covered with drift, the only rocks observable being greenstone and ashes. It is probably, however, on the same horizon with the lower limestones of Kirkton (162–8).

155.—Basalt.—Above limestone (154), Mid-Tartraven. Black crystalline with amygdaloidal kernels of carbonate of lime. This and the next four specimens are put along with the limestone 154, for the sake of local connexion, and in order that the Kirkton beds (160–175) may be taken in uninterrupted series.

156.—Felspathic ash.—Carsie Hill, 1 mile S.E. of Linlithgow. Dull yellowish felspathic rock, with yellow sub-angular felspathic fragments. Table-case C.

157.—Felspathic ash.—Pilgrims Hill, Linlithgow. This ash is a dull granular felspathic rock, without marked stratification, and contains in addition to the usual felspathic lapilli of all sizes, numerous fragments of carbonized coniferous wood. It is a prolongation of No. 156.

158.—Felspathic ash.—350 yards west of Wester-Drumcross, Bathgate. Greenish felspathic rock in well-marked beds.

159.—White sandstone.—Hill House Quarry, Linlithgow. This sandstone forms a good building stone, and overlies the ash 156–158.

160–195.—Specimens illustrative of the Mountain Limestone strata as developed in the neighbourhood of Bathgate, Linlithgowshire.

160.—Greenstone.—Kirkton Quarry. From the top of a great sheet which underlies the lowest limestone of Kirkton.

161.—Felspathic ash.—East Kirkton Quarry. Loose pulverulent felspathic rock, underlying the lowest limestone of Kirkton, and resting on the greenstone (160).

162.—Ashy limestone.—East Kirkton Quarry. A mixture of felspathic fragments in a base of grey limestone. A piece of fish-bone is visible at the side, marked *a* on the specimen. This is the character of the limestone immediately above the ashy bed 161.

163, 4.—Two calcareous nodules, from ashy bed in Kirkton limestone, a short way above the seam 162. East Quarry, Kirkton. The irregular rounded and sub-angular form of the stones is shown by these specimens.

165–7.—Cherty limestone.—Lower part of Kirkton limestone, East Quarry. In 165 the cherty matter is interspersed in an irregular brecciated and nodular manner. In 166 and 167 the rock consists of fine laminæ alternately of silica and lime. These laminæ in the former

Table-case C. specimen occur in regular horizontal layers (marking the stratification of the rock), with occasional cherty lumps between them. In 167 they have a concentric and contorted arrangement. The origin of this limestone must doubtless be connected with the action of some thermal spring, which, like the geysers of Iceland, rose in what must have been at that period a highly volcanic region, and deposited the silica and lime carried up by it in solution.

168.—Upper part of KIRKTON LIMESTONE.—East Quarry. The rock is finely laminated and fissile, and shows a mamillated surface on some of the laminæ. The bedding is often greatly contorted. Ferns and other common carboniferous plants occur in this limestone along with occasional coprolites and other fish remains.

169.—ASHY SHALE.—Above limestone, East Quarry, Kirkton. Contains numerous plants, as *Lepidodendron*, *Sigillaria*, &c.

170.—BASALT.—Above limestone, East Quarry, Kirkton. This rock occurs in a columnar bed resting immediately on the shale 169. This is the highest bed visible in this quarry. From this point west to the next quarry no rock is seen but basalt, so that the whole space may be occupied by this bed. The dip of the rocks is west, and the next observed bed in ascending order is 171, which occupies the lowest place in the Kirkton West Quarry.

171.—FELSPATHIC ASH, below limestone, West Quarry. Kirkton ; fine grained green felspathic rock in thin layers.

172.—LIMESTONE with fragments of *producti* and encrinal joints. This bed rests above the greenish ash (171), and becomes very ashy at top.

173.—ASHY LIMESTONE, with shells and encrinal joints. This specimen, taken from the upper surface of bed 172, contains green felspathic matter interspersed through a grey crystalline limestone.

174.—CALCAREOUS FELSPATHIC ASH, from thin bed above limestone 172. Above this bed occur other thin limestones intercalated among seams of ash and ashy shale, the whole being capped by the basalt 175. Table-case C.

175.—Basalt from columnar bed above ashes and limestones, Kirkton West Quarry. Like most of the augitic traps in the district this rock contains a considerable quantity of magnesia.

From the quarry westward to that of Petershill, where the next limestone bed is seen, no rock appears but basalt and possibly in this case, as in 170, there may be only one great sheet of basalt intervening between the upper beds of Kirkton and the lower beds of Petershill. The excavations at Petershill form the southern termination of a great chain of quarries extending northward by Sunnyside and Silvermine to Hillend near Linlithgow. They have been opened in a bed of marine limestone varying from between 30 and 40 to 70 or 80 feet in thickness. It rests upon ash (176) covering the basalt 175, and is succeeded by ashy beds (184) sandstones, shales and thin coals over which lie enormous sheets of greenstone and basalt (185, 186).

176.—Calcareous felspathic ash.—Below Limestone, Sunnyside Quarry. The upper part of this ash immediately below the bottom of the limestone contains producti and encrinal joints.

177.—Limestone.—North Mine Quarry, 3 miles S. of Linlithgow. Compact grey crystalline limestone with encrinal joints and *cyprides* (?). This rock occurs in a massive bed about 70 feet thick, resting on ash (176). With the limestones, sandstones, and shales above and below, it represents the Mountain or Carboniferous Limestone, as that formation is developed in Scotland. The next five specimens (178 to 182) are from different parts of the same great bed.

178.—Limestone.—North Mine Quarry. Hard compact grey limestone with *Productus gigantens*, *cyprides* (?) and encrinites.

179.—Limestone, with cubes of Galena.—North Mine Quarry. The crystals here occur in a vein cutting through the limestone at nearly right angles to the plane of bedding.

Table-case C. A larger vein containing a considerable admixture of silver was formerly worked here, the name Silvermine being still applied to the quarry.

180.—LIMESTONE, consisting of a mass of the coral, *lithostrotion.*—Sunnyside Quarry, one mile north of Bathgate.

181.—CHERT, filling a *Productus giganteus.*—Sunnyside Quarry. The limestone contains irregular nodular lumps of chert, sometimes ranged along the lines of bedding or interspersed through the rock. Not unfrequently, as in the present instance, the cherty matter is found filling and enveloping organic remains.

182.—LIMESTONE.—Upper part of bed, Hillhouse Quarry, 1½ mile S. of Linlithgow.

183.—CALCAREOUS FELSPATHIC SANDSTONE, from hole in limestone quarry south of Knock Hill, 2 miles north of Bathgate. This specimen is taken from a mass of ashy and sandy matter, with large rounded stones filling up a cavity in the limestone, which increases in width as it descends.

184.—CALCAREOUS FELSPATHIC ASH, from hard bed in soft ash, above limestone in North Mine Quarry. Angular fragments of green and grey felspathic matter in a base of sandy grey limestone.

185.—BASALT, from columnar bed above limestone, Hillhouse Quarry, 1½ mile south of Linlithgow. This bed is beautifully columnar, its under surface corresponding with the bedding of the underlying strata till near the south end of the quarry, when it cuts across the beds obliquely, altering them considerably along the line of contact.

186.—AMYGDALOIDAL MAGNESIAN GREENSTONE.—Immediately underlying limestone of Wardlaw Quarry. Between the basalt of Hillhouse (185) and this greenstone no rock is observable except greenstone or basalt. This specimen is from the upper part of a thick bed, and is succeeded by a limestone (187) higher in position than that of Petershill, Sunnyside, North Mine, and Hillhouse (177–182).

187.—LIMESTONE, consisting of a mass of corals [*Lithostrotion irregulare*]. Lower part of bed intercalated between greenstone beds, Wardlaw Quarry.

188.—LIMESTONE, containing same coral, from hard bed in middle of the limestone.—Wardlaw Quarry. The limestone is capped by shales, with a thin limestone bed, the whole being surmounted by an amygdaloidal greenstone (189) much broken by joints. Table-case C.

189.—FELSPATHIC GREENSTONE, at junction with shales, Wardlaw Quarry. This is a common appearance presented by the greenstones of the district, where they can be seen infringing upon other rocks, though usually they are then not quite so compact as in this specimen.

190.—GREENSTONE.—Crag east of Witch Craig, 2½ miles south of Linlithgow. From a bed forming part of a great sheet that overlies the Wardlaw limestone, and at one locality contains a bed of felspathic ash (191).

191.—FELSPATHIC ASH.—Preston Burn, three-quarters of a mile S.W. of Linlithgow. Green granular felspathic rock, containing rounded trap fragments in a dull green earthy paste, from stratified seam between beds of greenstone.

191 a.—GREENSTONE.—Upper part of bed 190, above the ash 191. Kettleston Quarry, 1 mile S.W. of Linlithgow.

192.—CALCAREOUS GRIT, with *cauda-galli* markings. Base of coal measure strata.—Shore east of Carriden House.

193.—FELSPATHIC ASH.—Lower part of Coal Measures, below Carriden House, Linlithgowshire.

194.—MICACEOUS SANDSTONE, showing false bedding. Lower part of Coal Measures.—Carriden House.

195.—COARSE LIMESTONE with encrinites.—Lower part of Coal Measures, below Carriden House.

Above the Mountain Limestone of the Bathgate Hills there lies a great sheet of trap, (190, 191 a,) extending northwards to Linlithgow. It is covered by the sandstones, shales, and coals of the Coal Measures, with their interbedded greenstones. These strata run northwards from Bathgate, getting gradually thinner in their progress, while the traps become proportionately thicker, until in the district round Cocklerue the coal-bearing strata appear to

Table-case C. have almost died out, their place being occupied by thin sandstones, and ash-beds with great sheets of greenstone and basalt (196–198). North of the ridge on the side of Bonnytoun Hill above Linlithgow, the coals re-appear, and seem gradually to increase in thickness as they proceed northwards. It seems probable that after the deposition of the Mountain Limestone, a ridge of volcanic materials, gradually formed between Bathgate and Linlithgow, which increasing in extent, eventually rose above the level of the water as a low island. In the swampy marshes to the north a luxuriant vegetation sprang up, and its petrified remains now form the Borrowstounness coal seams, while a similar growth to the south resulted in the coal seams of Bathgate. During the accumulation of peaty matter and silt in these two localities, streams of lava were occasionally ejected from the volcanic vent between, and flowed northward to form the thick greenstone beds (202–205) interposed in the coal-field of Borrowstounness, and the thinner ones in that of Bathgate. On the surface of these hardened lava-flows, sand and mud silted up, forming a soil for the accumulation of new morasses, of which the remains exist in the upper coals of the two Coal fields. The whole area throughout this period was undergoing a process of subsidence until the hollows of Bathgate and Borrowstounness were filled up with sand, mud, peat, and volcanic matter, and the bottom of the water was reduced to a nearly level surface. Upon this floor, depressed considerably below the sea-level, a seam of limestone was formed, consisting in large measure of the broken stems of crinoids and pieces of shells (217). Occasional volcanic eruptions succeeded, marked now by the greenstones (218) and ashes (219), and eventually another seam of limestone (221) gathered over the sea-bottom. Sand and mud thereafter settled down upon the corals and shells, and subsequently another lava-stream (223, 224) was ejected. With this last eruption the series illustrated by the specimens in this case, terminates.

196–8.—From the volcanic bank which seems to have separated the coal-swamps of Bathgate from those of Borrowstounness. Table-case C.

196.—Sandstone.—Quarry at south end of Cocklerue, 1½ mile S.W. of Linlithgow.

197.—Felspathic sandstone.—Same quarry. Contains white felspathic fragments in a greenish white sandy base.

198.—Greenstone.—Same locality. From bed overlying 196 and 197.

199.—Greenstone.—Lower part of Coal Measures, below Carriden Manse, Linlithgowshire. Earthy, decomposing, magnesian rock, forming a bed above "Smithy Coal."

200.—"Parrot" coal.—Chance Pit, Borrowstounness. This is the "Cannel" Coal of England, and is used for gas-making. It occurs in the Coal Measures above the Carriden beds (193–5, 199), and below the thick trap (202–5) which divides the coal field into an upper and under group.

201.—"Black band" ironstone.—Chance pit, Borrowstounness. This ironstone is associated with the parrot coal (200), part of which is seen adhering to the specimen. The distinguishing feature of black-band ironstone as compared with ordinary clay-ironstone, is the large amount of carbonaceous matter it contains; so large, indeed, as to admit of the ore calcining itself with the addition of little or even no fuel.

The Borrowstounness Coal field, as has just been mentioned, is divided into an upper and under set of strata, by two sheets of greenstone, having a united thickness of nearly 400 feet. This mass of rock seems to have flowed from the south, across the swampy morasses in which the lower coals of the district originally grew. It does not affect the quality of the seams, and throughout the coal field the pits are invariably sunk through the whole or part of it, to reach the coal and ironstone seams below. In the borings at the Snab pit, which were continued to a depth of 1,179 feet, no fewer than eight beds of greenstone were passed through, Tablecase C. having a total thickness of 468 feet. Specimens 202–205 are from this series of interbedded traps.

202.—Greenstone below "Wester Main Coal," west side of Chance Pit, Borrowstounness.

The Wester Main coal occurs about the middle of the mass of greenstone, subdividing it into two parts, but its thickness is very variable, and at the Snab Pit borings, no trace of it could be found, the only rock between the greenstones being some soft carbonaceous shale.

203.—Greenstone.—Side of tramway, east of Mingle Pit, Borrowstounness, from junction with upper surface of Wester Main coal. Soft, earthy, felspathic, finely amygdaloidal rock.

204.—Greenstone.—Above Wester Main coal, tramway east of Mingle Pit. Compact, granular, finely amygdaloidal rock.

205.—Basalt, Kipps Hill.—This rock is finely amygdaloidal, and probably belongs to a southward prolongation of the greenstones 202–204.

Above the thick sheets of greenstone another set of coal-bearing strata supervenes, similar to that below. They contain several seams of coal and one of ironstone (205), regarded as of inferior quality to those of the under group.

206.—Black-band ironstone.—No. 23 Pit, Borrowstounness.—This seam occurs among the upper coals, and is about 18 inches thick.

207.—Carbonaceous shale, from beds with the ironstone 206, from same pit.

208.—Greenstone.—Capie's Point, ¼ of a mile west of Borrowstounness, from bed 6 to 8 feet thick, among the upper group of coals.

209.—Coarse limestone, with *producti*, &c.—Same locality, occurs a few feet above the greenstone 208.

210.—Hard fireclay. Quarry west of Distillery, Kinneil, Borrowstounness.—This bed overlies the limestone (209), and is used for making fire-brick.

211.—GRITTY SANDSTONE.—From thick bed overlying the fire-clay 210. Same locality. Table-case C.

212.—GREENSTONE.—Two hundred yards south of Woodcockdale Cottage, river Avon. This is from a bed running north by Linlithgow Bridge, and underlying the ash 213.

213.—FELSPATHIC ASH.—Banks of river Avon, Little Mill, Linlithgow.—Coarse dull felspathic rock, consisting of rounded fragments of greenstone, &c. imbedded in a greenish felspathic paste.

214, 215.—Stones from same ash.

216.—COMPACT SANDY SHALE.—Bed of river Avon, above Woodcockdale Cottage. The rock in mass contains numerous *Producti*, *Spiriferæ*, *Fenestellæ*, &c.

As stated after 195 the Coal Measures of Borrowstounness are overlaid by a series of sandstones and shales, containing two seams of marine limestone. These higher strata are well displayed along the banks of the river Avon, and in the district round Carribber, whence most of the following specimens have been taken. The bed 216, occurs a few yards below the under limestone (217).

217.—COMPACT LIMESTONE, with iron pyrites.—Banks of river Avon, Carribber, three miles S.W. of Linlithgow. This rock is the under of the two limestones referred to, and contains encrites, &c.

218.—GREENSTONE.—300 yards east of Bowdenhill farm, three miles S.W. of Linlithgow. Compact crystalline rock from bed above lower limestone.

219.—FELSPATHIC ASH.—Stream between Lochcote and Gormyre Hill, two miles S.W. of Linlithgow. Calcareous dull greenish felspathic rock with nodular pieces of limestone and angular felspathic fragments.

220.—COARSE QUARTZY SANDSTONE. — Craigenbuck Quarry.—Two miles West of Kinneil, Linlithgowshire.—From thick bed underlying upper limestone.

221.—LIMESTONE, with iron pyrites and encrinal joints. Bowden Hill Quarry, three miles S.W. of Linlithgow.

Table-case C. Bowden Hill consists of a sheet of greenstone (223, 4) overlying the upper limestone (221), which has been excavated in long galleries extending underneath the hill from side to side.

222.—LIMESTONE.—Craigenbuck, west of Kinneil. Same bed as 221, but four miles further north.

223, 4.—GREENSTONE, from the bed overlying upper limestone; 223 is from the banks of the Avon at Carribber; 224 from the side of Bowden Hill above the lime quarries.

Table-case C. Lower Compartment.

SPECIMENS illustrative of intrusive rocks in the counties of Haddington, Edinburgh, and Linlithgow. Table-case C. (Lower Compartment.)

In the arrangement of the following specimens a stratigraphical order has been followed, the dykes cutting through old red sandstone strata being put first, and so on up to those traversing the upper coal measures. But this order, of course, must not be regarded as at all a chronological one, as in the case of the rocks previously described from the same localities, since it is evident that the dykes in the oldest rocks might have erupted long after those in the newest.

225.—GREENSTONE, from narrow dyke in old red conglomerate bed of river Esk, Fairliehope, Pentland Hills. The dykes in old red sandstone strata in this district and also in Haddingtonshire are generally fine-grained, and have a dull reddish brown colour.

226–7.—GREENSTONE from dyke in Lower Carboniferous rocks.—East side of Belhaven Bay, Dunbar. Contains small amygdaloidal cavities filled with amethyst.

228.—GREENSTONE. Earthy amygdaloidal in Lower Carboniferous.—Long Craig, three-quarters of a mile W. of Dunbar.

299.—BASALT, from intrusive boss like volcanic vent in Lower Carboniferous.—Castle Rock, Edinburgh.

229a.—GREENSTONE. Dyke in Lower Carboniferous shale.—Bell's Mills, Water of Leith, Edinburgh.

230.—FELSPATHIC GREENSTONE. Dyke in Lower Carboniferous shale.—St. George's Well, Water of Leith, Edinburgh. Table-case C. Lower Compartment.

231.—COMPACT GREENSTONE. Dyke in Lower Carboniferous.—Albany Street, Edinburgh.

232.—GREENSTONE. Dyke in Lower Carboniferous.—Western Breakwater, Granton, near Edinburgh.

233.—FELSPATHIC GREENSTONE. Dyke in Lower Carboniferous.—Western Breakwater, Granton.

234.—GREENSTONE, sparingly amygdaloidal. Dyke in Lower Carboniferous.—Currie, 5 miles S.W. of Edinburgh.

235–6.—Two specimens, showing junction of greenstone and altered sandstone (Lower Carboniferous) base of Salisbury Craigs, Edinburgh. For the character of the altering green-stone, see Table-case F in recess 43, Nos. 56 and 57. In the specimens the greenstone is marked *a* and the sandstone *b*.

237.—GREENSTONE, from dyke in Lower Carboniferous.—Stream above East Kenleith, 5 miles S.W. of Edinburgh.

238.—CRYSTALLINE GREENSTONE, from intrusive mass in Lower Carboniferous.—Fauch Hill, 15 miles S.W. of Edinburgh.

239.—GREENSTONE, from intrusive beds in Lower Carboniferous.—Dalmahoy Hill 8 miles S.W. of Edinburgh.

240.—FELSPATHIC GREENSTONE, from intrusive sheet in Lower Carboniferous.—Quarry west of Newlands, parish of Kirknewton.

241.—GREENSTONE, from intrusive mass in Lower Carboniferous.—Selms Tops, Kirknewton.

242.—GREENSTONE, from intrusive mass in Lower Carboniferous.—Hallcraigs, 10 miles S.W. of Edinburgh.

243.—GREENSTONE, from dyke in Lower Carboniferous.—Green Burn, Dalmahoy, Edinburghshire.

244.—GREENSTONE, from intrusive bed in Lower Carboniferous.—Corstorphine Hill, 3 miles W. of Edinburgh. This rock is a mixture of felspar and hornblende, and differs in this respect from the other greenstones of the district, which are mixtures of felspar and augite.

Table-case C. Lower Compartment.

245.—GREENSTONE, from dyke in Lower Carboniferous Tombstone, 2 miles west of Granton.

246.—CRYSTALLINE GREENSTONE, from intrusive sheet.—Ratho Quarry, 8 miles W. of Edinburgh.

247.—FELSPATHIC GREENSTONE, from a vein in the greenstone of Ratho Quarry, No. 246.

248.—GREENSTONE, from intrusive mass.—North end of Craigie Hill, 6 miles W. of Edinburgh.

249.—FELSPATHIC GREENSTONE, from dyke in Lower Carboniferous.—Shore at Newhalls, South Queensferry.

250.—GREENSTONE, from intrusive mass in Lower Carboniferous.—Carmel Hill, Linlithgowshire.

251.—Earthy felspathic decomposing GREENSTONE, from dyke in Lower Carboniferous.—Quarry behind Dalmeny Church, Linlithgowshire.

252.—BASALT, from intrusive mass in Lower Carboniferous.—Quarry S. of Dalmeny Church.

253.—CRYSTALLINE GREENSTONE, from intrusive sheet in Lower Carboniferous.—Dundas Hill, Dalmeny Parish, Linlithgowshire.

254 and 255.—FELSPATHIC TRAP, from dyke in Lower Carboniferous.—Bed of Linhouse Water, below Red Craig, Edinburghshire. (See 102.)

256.—GREENSTONE, from intrusive mass in Lower Carboniferous.—South end of Glenpuntie Wood, Cramond, Linlithgowshire.

257.—GREENSTONE, from intrusive sheet in Lower Carboniferous.—Lindsay's Craigs, Kirkliston, Linlithgowshire.

258.—GREENSTONE, from intrusive sheet.—Side of road at Crossall Hill, Dalmeny, Linlithgowshire: highly crystalline rock containing large scattered crystal of augite and pink felspar.

259.—PORPHYRITIC GREENSTONE, intrusive mass.—Burning mount, near Traprain Law, Haddingtonshire.

260.—VESICULAR GREENSTONE, from dyke in Lower Carboniferous ash, Dunbar.

261.—BASALT, from intrusive mass in same ash.—Dunbar Castle.

262.—GREENSTONE, from intrusive mass in same ash.—Leithies, North Berwick. Table-case C. Lower Compartment.

263.—BASALT, with grains of olivine and crystals of augite and felspar, from intrusive mass in same ash.—Yellow Craig, North Berwick.

264.—BASALT, porphyritic, from intrusive mass in same ash.—Gin Head, Tantallon Castle.

265.—BASALT, from similar intrusive mass.—Longskelly rocks, North Berwick.

265a, 265b.—AMYGDALOIDAL GREENSTONE, from intrusive mass in ash.—Gas Works, North Berwick.

266.—GREENSTONE, from similar intrusive mass.—Saddle rock, Tantallon Castle.

267.—GREENSTONE, vesicular and porphyritic, from dyke in Lower Carboniferous.—Millstone Neuk, 1¼ mile S.E. of Dunbar.

268.—GREENSTONE, emitting a bituminous odour when freshly broken.—From intrusive bed in Lower Carboniferous shales below Burdie House limestone.—Dechmont Law, Linlithgowshire.

269.—GREENSTONE, from intrusive sheet in beds below Burdie House limestone.—Port Edgar, South Queensferry.

270.—BASALT, bituminous when freshly broken. From intrusive sheet in Lower Carboniferous shales (Burdie House limestone), south end of Binny Craig, Linlithgowshire.

271.—VESICULAR GREENSTONE, from dyke in Burdie House limestone strata, bed of river Esk, below Carlops, Edinburghshire.

272, 2a.—Two specimens showing junction of greenstone and sandstone from side of greenstone dyke in Burdie House limestone bed.—Raw Camps Quarry, Edinburghshire.

273.—AMYGDALOIDAL GREENSTONE, from dyke in beds above Burdie House limestone, 350 yards south of Dechmont House, Linlithgowshire.

274.—GREENSTONE, emitting bituminous odour when

Table-case C, Lower Compartment.

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BY A. C. RAMSAY AND H. W. BRISTOW.

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