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

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ROCK SPECIMENS

IN THE

MUSEUM OF PRACTICAL GEOLOGY,

WITH EXPLANATORY NOTICES OF THEIR NATURE AND MODE OF OCCURRENCE, AND OF THE PLACES WHERE THEY ARE FOUND.

BY

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OF THE SURVEY OF GREAT BRITAIN.

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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, recently published, 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 real service to the geological and mining student.

RODERICK I. MURCHISON,
Director.

Museum of Practical Geology,
Nov. 3, 1857.

INTRODUCTION.

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

1st. Lithological, illustrative of the nature of rocks.

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 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, indicating the stratigraphical relations of the specimens, or in other words, the order of succession in which the rocks were formed from whence the specimens were derived. (*See* p. 279.)

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 and sandstone. Such is the general nature of the rocks in England and Wales; but in other parts of the world there are local peculiarities, which 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 previous to 1856, and partly serve as type specimens illustrative of the maps and districts surveyed up to this date.

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. The specimens containing fossils 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. In these cases, and the catalogue which explains them, he will also find a description of the fossils and of the order of their succession in all 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 hand-book to British geology, which will be more complete if space is ever afforded for the arrangement of a strictly stratigraphical collection.

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 catalogueing the igneous rocks of Wales.

ANDREW C. RAMSAY.

Museum of Practical Geology,
Nov. 2, 1857.

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Arranged and described by A. C. Ramsay.

SPECIMENS ILLUSTRATIVE OF PHENOMENA CONNECTED WITH GLACIERS AND FLOATING ICE.

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

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quence 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 to be fastest in the middle and slowest at the sides. 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 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

Upper Gallery.
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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. 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 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 *lateral 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*, often as perfect as those that fringe the sides and ends of existing Alpine glaciers. Appearances of the kind adverted to are frequent in the mountains of the Vosges, Ireland, the Highlands of Scotland, and Wales; and specimens derived 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.

UPPER GALLERY. — Table-case in Recess 41.

1.—FINE MORAINE CLAY, derived from the *Finster Aar Horn,* in a heap on a rock *in place,* 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, $1\frac{1}{2}$ 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 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 generally convex. The cones are frequently 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.

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.

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Table-case in Recess 41.

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 eflux 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.

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.*

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.

UPPER GALLERY. — Table-case in Recess 41.

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,* } *Spain.*

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 af 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.*

Upper Gallery

Table-case in Recess 41.

27.—Quartz, polished and striated, from rock in place at the "*Lac des Morts*," on the road from the *Grimsel* to the *glacier of the Rhone.*

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 glacial 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 stones are mostly *angular* and *subangular*, and sometimes (as on parts of the Mer de Glace, Chamouni), they consist of pieces as fresh as if broken by the hammer. Occasionally

UPPER GALLERY.
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Table-case in Recess 41.

they are rounded, and even water worn, for it sometimes happens that stones 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.

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. Chevdule, Monte Rosa.*

37 to 39.—*Erratic pebbles transported by ice.*

37 and 38.—PEBBLES OF SCRATCHED BLACK LIMESTONE at *Torgni*, 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.*

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.

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

Upper Gallery. — Table-case in Recess 41.

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.

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*Specimens, described as moraine matter by M. Dolfus-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. It will have been gathered from preceding remarks, that the existence of glaciers where none are now found, and of ancient Tertiary icy-seas, was not confined to Britain. These subjects have attracted much attention among able observers; but long after Playfair had indicated the transporting power of

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

UPPER GALLERY.
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Table-case in Recess 41.

glaciers, and the ice-borne character of Alpine boulders that rest on the Jura, 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 recognise 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 scattered boulders over wide areas that had once been land. The grooves and striations on the ice-smoothed rocks (except where locally deflected) still bear witness to the general southward course of the winds and ocean currents that bore the ice from its birth-place into milder climates.

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 the *drift* rises on the mountains

UPPER GALLERY.

Table-case in Recess 41.

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 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 ice-bergs, and 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 eastern shores of England contain boulders drifted 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 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 *terminal moraines* frequently form the confining barriers of mountain lakes and tarns.* Llyn Idwal, in Nant Francon, and Llyn Llydaw on Snowdon, among others, form

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

Upper Gallery. — Table-case in Recess 41.

striking examples of this phænomenon. 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 debris; 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 confine 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 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.

UPPER GALLERY.

Table-case in Recess 41.

This amelioration did not, however, take place till after the re-elevation of the 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 the sides 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 precisely resemble what formerly took place 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

UPPER GALLERY.

Table-case in Recess 41.

in another instance generally to the west in the vast rocky amphitheatre of Glaslyn and Llyn Llydaw. In the higher part of such 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 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; and unless they were actually much deepened by the glaciers, it follows that at one period the ice of the Pass of Llanberis was 1,300 feet thick. If this 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 accumulation of snow and ice above that point must have been very great, so as partly to feed the glacier and produce that pressure from above that aided the ice on its course. When by degrees the glaciers diminished in size, then the minor 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 the climate, for in Wales there is perfect evidence of the 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, 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. 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.

UPPER GALLERY.

Table-case in Recess 41.

Allusion has been made to British *roches moutonnées.* These, when perfect, are rounded bosses of rock, polished by the sanded bottoms of the glaciers, and of all sizes. Some are only a few yards in diameter, others rather deserve the name of 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 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.

UPPER GALLERY. — Table-case in Recess 41.

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 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 slate still retain a perfect glassy polish, marked sometimes by flutings, and sometimes by numerous scratches as fine as if they had been made by the point of a diamond. After long exposure, these finer markings disappear, and though the general rounded form perfectly remains, the surface becomes roughened, and the planes of the highly-inclined cleavage 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 uncleaved rocks over which a glacier has passed. The original polished surface, on exposure, becomes roughened by atmospheric disintegration ; but the general form remains to attest its glacial origin, and in no case is there any danger of the experienced eye confounding this with those forms 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 it assumes an irregular and craggy outline, altogether distinct from the glaciated surface produced by the long-continued passage

Upper Gallery,
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Table-case in Recess 41

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 phænomena 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.*

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.*

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* 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.
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Table-case in Recess 41.

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 eflux. The *roches moutonnées* above alluded to, are covered with erratic blocks, 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 SCRATHED; *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 magnificent valley must have formed one of the chief and highest sources of glacier 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 perfectly regular and entire 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

UPPER GALLERY.

Table-case in Recess 41

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, 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. 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

UPPER GALLERY.
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Table-case in Recess 41.

underneath the present sea level to a height of about 2,300 feet on some of the mountains. Near the shore it has sometimes 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, and boulders. 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 Welsh glaciers shed their moraines in the sea, while drift was being deposited on neighbouring 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 impossible that in other portions of the same islands not possessed of the form requisite to originate massive glaciers, snow and 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 entirely 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 bergs 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.

UPPER GALLERY.
Table-case in Recess 41.

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.

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 glacial marine drift of Anglesea, Lancashire, Norfolk, and Suffolk.

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

UPPER GALLERY.

Table-case in Recess 41.

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.

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

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.

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.

97.—Same as 94 and 95.

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

Upper Gallery.
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Table-case in Recess 41

Specimens to illustrate the brecciated conglomerates of the Permian or lower Red sandstone series that occur 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 do not consist of fragments of the neighbouring rocks, but 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 of Longmynd rocks, and 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.* This limestone often occurs in the Breccia (as at Northfield) in large angular slabs, full of the peculiar assemblage of fossils that mark that

UPPER GALLERY.

Table-case in Recess 41.

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 or cross each other 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 unrounded 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 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.

UPPER GALLERY.

Table-case in Recess 41.

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 X; in this respect resembling the side of the stone marked X, 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.

109.—SUBANGULAR STONE (Cambrian grit), *scratched*, the scratches covered with a thin ferruginous coating; from *the outlier of Church Hill, Bayton.* This small outlier is entirely surrounded by Coal-measures, which lie on the Old red sandstone. The nearest spot where grit like this stone occurs in place is the Longmynd. The scratches at X 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.*

UPPER GALLERY. — Table-case in Recess 41.

112.—Part of STRIATED STONE, well marked on the edge marked X. 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 X 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 ferruginous crust. The rock consists of very coarse felspathic grit, and fine 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 GEENISH 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.*

UPPER GALLERY.

Table-case in Recess 41.

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, 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.

130 and 131.—FOSSILLIFEROUS 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 FOSSILLIFEROUS LIMESTONE, from *Permian brecciated conglomerate* of *Abberley Hill,* Hundred House.

UPPER GALLERY. — Table-case in Recess 41.

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

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 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 the encrinites of that formation 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;

UPPER GALLERY.

Wall-cases 40 to 44.

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 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.

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, shewing in **Wall-cases 41 & 43** how rocks of various kinds pass by insensible gradations into each other.

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

UPPER GALLERY.
Wall-case 40.

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 *stalactites, stalagmites,* and *calcareous tufas, &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 surfaee 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 them up, 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 aggregrations of various substances are in an analagous 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 - - - -	56·00
	100·00

Upper Gallery. — Wall-case 40.

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, shewing 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.

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.

8*a*.—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, Derbyshire.*

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

No. 10 is hung in the pendant position of a stalactite, and

UPPER GALLERY. — Wall-case 40.

No. 11 flat, in the manner in which such stalagmites are frequently formed, from the dropping of water containing lime.

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 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.—*Ilfracombe, 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.

UPPER GALLERY.

Wall-case 40

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 metalliferous matter 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.*)

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., F.R.S.

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

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

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

UPPER GALLERY.
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Wall-case 40.

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, and Map No. 10.

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. UPPER GALLERY. Wall-case 40.

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.—Penarch, Cardiff, Glamorganshire.*

35.—FLESHCOLOURED 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.

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 county, the salt being in large beds of

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Wall-case 40.

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 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 the 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) will 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, N. 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 foot-*

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prints, *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.)

Wall-case 41.

These Specimens from Nos. 1 to 48 are all varieties of *Conglomerates.* They may be divided into two chief varieties, viz., those in which the embedded fragments are *angular,* constituting *brecciated conglomerates ;* and those in which the embedded fragments are *rounded,* forming the most numerous 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 the ordinary conglomerates 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

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Wall-case 4

sandstones (Roth-todte-liegende) of England and Germany, there are sometimes blocks of several feet in diameter, and from conglomerates of this degree of coarseness every gradation may be traced, until at length they pass imperceptably 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 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. Many 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 embedded 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 movements in the water and the slope of the ground pebbles are, by degrees, carried along the sea bottom many miles from shore. Other strata are formed *exclusively* of sand, some of mud or clay, others

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Wall-case 41.

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 500 feet of strata 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 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 fossillized. 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.* UPPER GALLERY. Wall-case 41.

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.*

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

6.—Permian calcareous BRECCIATED CONGLOMERATE, consisting of angular pebbles of Carboniferous limestone, bedded in a red marly calcareous base. These rocks and No. 2 consist of a great mass, or bank of angular conglomerate in 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.*

Upper Gallery.
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Wall-case 41.

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.*

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.*

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Wall-case 41

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.*

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," p. 456, 457.)

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

UPPER GALLERY.
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Wall-case 41.

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 crystallised quartzose base. From *New Red Sandstone.*

31.—CONGLOMERATE, calcareous pebbles in a base of shelly limestone: bottom bed of *Lias.* (See "Memoirs of Geological Survey," pp. 244-252.)—*Craig-yn-cros, 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.*

UPPER GALLERY.

Wall-case 41.

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 the magnesian 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.*

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 White.*

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

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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.*

55.—SANDSTONE, from the "rag" or upper beds of the Upper Green-sand; used extensively as a building stone 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 freshwater 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.* UPPER GALLERY. Wall-case 41.

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.*

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

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

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.* (Sir H. De la Beche's "Memoir on S. W. of

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England," 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.*

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 Draýton, 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.* UPPER GALLERY. — Wall-case 41.

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 still remains. In the specimens that follow, from 98 to 109, the lime of the shells is preserved.—A. C. R.

97.—SANDSTONE, (white beds at the base of the *Keuper* strata, *New Red Sandstone*,) containing cavities lined with crystals of calcareous 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 a building stone.—*Ray Bridge, near Melksham, Wilts.*

100.—OLD RED SANDSTONE ("TILESTONE") containing *Trochus helicites* and *Cucullœa antiqua.—Bickton, southwest 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 cal-

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careous). Shells half dissolved out.—*Longhope, Gloucestershire.*

104.—

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 *Gryphœa aviculoides.*—*Three miles north of Devizes, Wilts.*

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

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 casts 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, *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

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

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 north of Brixton, Isle 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.

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

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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" (sheet 44), by Edward Hull, A.B., F.G.S., p. 29.

123.—Upper green-sand. Soft bed, with small green grains, underlying No. 60.—*Shaftesbury, Dorset.* Map 15.

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."

It is very tough and durable, and has been used for building materials in many of the old churches in marlstone districts; also used for road metal. Very calcareous, hard, marly sandstone, with fossils. *Rhynconella tetrahedra.—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, cider, and perry.—*Westbury, Gloucestershire.*

133.—CLAY—*Gault* (used for making bricks).—*Dinton, Wilts.* Map 15. UPPER GALLERY. Wall-case 41.

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. 53,000 tons of this clay were shipped from Poole in 1855; 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.

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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.*

140.—CLAY, occuring 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.

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 fossillized like those of 154 and 155. —*Outside the Chesil Beach, Weymouth, Dorset.*

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

146.—ARGILLACEOUS SHALE, from *Coal Measure,* 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.* UPPER GALLERY. — Wall-case 41.

149.—FIRE CLAY, (*from Coal Measures*,) exhibiting part of a root and rootlets of *Stigmaria.*—*Glascote Colliery, Tamworth.*

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.

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

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

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

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

Upper Gallery.

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is rendered unfit for being employed as fuel. The people of the neighbouring district used formerly to make 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 their 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 been found to prove 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 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 luminæ, 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.*

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, unmixed with smoke, and like that of a candle, which it gives out in burning. In Scotland, this coal is called *parrot*, from the loud cracking noise with

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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.

162, 162a.—PERMIAN COAL, with a laminated structure, and circular concentric concretionary markings.—*Bullock's Farm Pits, near Spon Lane, West Bromwich, South Staffordshire.* See Juke'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 162*a* were taken from a bed of *true Permian 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.)

163.—ANTHRACITE COAL, from *Coalbrooke,* between Slannon and Llangyndyrn, Caermarthenshire. Anthracite is so called from *ανθραξ*, (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

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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 separate masses also, a foot or so in thickness, sometimes occuring suddenly, not as detached fragrants, 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

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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 2000 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 coal is the underclay, (usually 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 terrestrial 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.

The strata that lie between the beds of coal frequently contain numerous impressions of *ferns*, *calamites*, *trees* allied to *lycopodiums*, and other vegetable remains. Other strata contain freshwater shells (*unios*, &c.); some are charged with *Productas*, and other marine mollusca; and occasionally plants have been entombed with both. Without entering into details, it is therefore evident that these interstratifications of coal, with other strata, indicate alternations of terrestrial and subaqueous 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 deposita must have been formed during a period of average slow depression of the area, varied by pauses, during which part

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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*.

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of the space became converted into flat land, 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, anthracite, 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 Nitrogen	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

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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 Pemborkeshire syenitic, and other igneous rocks, have been intruded amongst them.—A. C. Ramsay.

167.—GRAPTOLITE SHALE from Llandeilo flags.—*Conway, North Wales.*

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, icthyosauri,* &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

UPPER GALLERY. — Wall-case 41.

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.*

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.*

175.—Part of a CONSOLIDATED RECENT BEACH now in process of formation. *Red Wharf Bay, Anglesea.*—Presented by Mr. G. Niblet. The consolidation is a result of the percolation of carbonated water, which disolves 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.)

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.

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Wall-case 41.

"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.

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. 64). 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

UPPER GALLERY. — Wall-case 41.

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 mile stone, on the east side of the road to Bridport.—*Upwey, Dorset.*

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.

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 they 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.

Upper Gallery.

Wall-case 42

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.*

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.

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.—*From the Chalk, 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, coast of 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.*

UPPER GALLERY.
Wall-case 42.

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.*

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.—

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.*

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

UPPER GALLERY. — Wall-case 42.

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.

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.*

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

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

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

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

43, 44.—Another specimen, from the "*submarine forest.*" —*West Lulworth, Dorset.*

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

Upper Gallery — Wall-case 42.

Nos. 20 and 22, and in vertical section No. 22 of the "Geological Survey."—A. C. R.

Wall-case 43.

The higher shelves of this case contain limestones, arranged not stratigraphically, but, as far as the sizes of the 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 great 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 2,300 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

UPPER GALLERY.
Wall-case 43.

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 Oolite. They are also occasionally burned for lime.—A. C. Ramsay.

LIMESTONES, IRONSTONES, &c., arranged and described by H. W. BRISTOW.

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 ot 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. It is always fossilliferous, 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.

UPPER GALLERY.

Wall-case 43.

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.*

"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, & 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 (*in the lines of 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. 118.)—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.)

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Wall-case 43.

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.)

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.

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.*

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

Upper Gallery.
Wall-case 43.

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.

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.* UPPER GALLERY. Wall-case 43.

27.—

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

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

UPPER GALLERY. — Wall-case 43.

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 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 in 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. UPPER GALLERY. Wall-case 43

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

UPPER GALLERY. — Wall-case 43.

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 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 ragtone 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.

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

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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Wall-case 43.

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.—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 Fuller's Earth limestones.—H.W.B.

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

(See Hull's "Memoir on Map 44 of the Geological Survey," pp. 65 and 70.)

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70.—FOREST MARBLE, *shelly limestone*, with included pebbles of clay. These beds are quarried for flagstones, &c. —*Hilton, near Wincanton, Somerset.*

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.)

75—PURBECK LIMESTONE, *impure limestone*, called the "devil's bed."—*Swanage, Dorset.*

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

(See Vertical Sections, sheet 22.)

77.—PURBECK LIMESTONE, *compact grey shelly limestone*, containing freshwater shells (*Cyclas, &c.*) from the

Upper Gallery.
Wall-case 43.

Downs Vein of the middle Purbeck : about 2 feet above the cinder bed.—*Durlston Bay, Swanage, Dorset.*

(See Geological 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.*

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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, *shelly 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

UPPER GALLERY. — Wall-case 43.

sands, with imperfect limestones, clays, and marls. At the west corner of the 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, 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, and Geological 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.—H.W.B.

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Wall-case 43.

95.—BEMBRIDGE LIMESTONE, *upper Eocene (freshwater), limestone.—Headon Hill, Isle of Wight.*

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.) 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.—H.W.B.

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.*

UPPER GALLERY. — Wall-case 43.

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.—

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.*

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 somesometimes "Cotham marble" from its occurrence at that place in the neighbourhood of Bristol. It is found in thin layers in Lias Clay.

109.—LIAS, *argillaceous limestone*, containing *Oysters.* —*Two miles east of Newport, Monmouthshire.*

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 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

UPPER GALLERY. — Wall-case 43.

Dorset. It has been extensively worked for *cement stone.* —*Broad Bench, 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.*

UPPER GALLERY.
Wall-case 43.

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.*

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.

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 the series, forming *ferrugious strata.* The iron of the Lower Green Sand is chiefly high up in that formation, and consists generally of thin 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.

Upper Gallery. — Wall-case 43.

135.—Ironstone, oolitic grains of hydrous oxide of iron, cemented by calcareous matter, forming the *upper beds of Coral Rag*, and worked for iron.—*Near the Railway Station, Westbury, Wilts.*

136.—Sandy clay ironstone, with an included pebble of flint.—*Hengistbury Head, Christchurch Bay, Hants.*

This ore forms layers of isolated reniform masses, of considerable 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 14), 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.*

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 east 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. UPPER GALLERY. Wall-case 43.

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 92,608. (See "Mineral Statistics for 1855," by R. Hunt, F.R.S., p. 48.)

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.

UPPER GALLERY.
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Wall-case 43.

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

156 and 157.—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.*

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.*

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.

Nos. 166, 167, and 168, from the Hastings Sands, of *Hastings in Sussex*, were presented by Dr. Percy, F.R.S.

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

168.—Concretion of CLAY IRONSTONE.—*Hastings, Sussex.*

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

Upper Gallery — Wall-case 43.

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

171.—Concretionary nodules of iron ore, *from Gault.—St. Bartholomew's Hill, Wilts.*

172.—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.—Iron ore, locally "*pisolitic ironstone*," *from the Lower Silurian Lingula beds.—Bettws Garmon, Llanberis, Caernarvonshire.*

174.—Stalactitic brown iron ore, with a fibrous structure, from *Old Red Sandstone.—Brendon Hill Mine, Somerset.* (Map 20.) Presented by Sir Charles E. Trevelyan, K.C.B.

Brown iron ore consists of peroxide of iron 85·3, and water 14·7, with occasional impurities, as silica, alumina.

175.—Botryoidal brown iron ore, with a fibrous structure, and coated externally with an iridescent lustre. From *Old Red Sandstone.—Brendon Hill Mine, Somerset.* Presented by Sir Charles E. Trevelyan, K.C.B.

176.—Black oxide of manganese, assuming a botryoidal appearance on the outer surface. From *Old Red Sandstone.—Brendon Hill Mine, Somerset.* Presented by Sir Charles E. Trevelyan, K.C.B.

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.

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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 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 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 body of the rock 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.—

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.)

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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.*

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.

16.—FLATTENED ELLIPTICAL SANDY CONCRETION, exhibit-

UPPER GALLERY.
Wall-case 44.

ing "*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 the junction of New Red Marl and Carboniferous Limestone.—Chepstow, Monmouthshire.*

Upper Gallery.

Wall-case 44.

(See "Memoirs of Geological Survey," vol. i., part 1, p. 246.)

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.*

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.

43.—Concretionary nodule of *clay ironstone*, from pipe-clay beds of the *Lower Bagshot* series.—*Branksea Island, near Poole.* Presented by Colonel Waugh.

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.*

48.—Septaria, cement stone occurring in occasional

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bands in *Upper Lias clay. Crickley Hill, near Cheltenham.*

(See "Memoir on Map 44 of the Geological Survey," 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 Wheal Friendship, near Tavistock, Devon.*

50.—Sections of COPROLITIC NODULES, polished to show the internal structure.—*Frith of Forth, Scotland.*

51.—CONCRETIONS 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.*

54.—CONCRETION of iron pyrites from the *Chalk.—Compton Bay, Isle of Wight.*

55.—CANNON BALL, forming a centre surrounded by concreted ferruginous matter.

56.—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, and its conversion into a carburet of iron, No. 56.

57.—AN OLD HORSE SHOE, found in the river *Trent, at Nottingham*, exhibiting the agglutinating power of iron while undergoing oxidation.

58.—

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Wall-case 45.

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 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 instances bears a peculiar relation 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, on sandstone in an iron furnace, and from this the student is readily led to those alterations which from common *sandstones* produced *quartz rocks* by the intrusion among them of melted matters, 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 a striking example, 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

Upper Gallery.
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Wall-case 45.

more or less crystalline, the rocks (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 produced these rocks are of a different kind from those 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. The most typical *gneiss* consists of alternating layers of *quartz, felspar*, and *mica*, these being the same constituents that form granite. Perfect and most 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 in their original sedimentary forms. 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.

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

* "Theory of the Earth."

has 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 common mica, the chief ingredients of which are silica, alumina, potash, and peroxide of iron. In all shales and slaty rocks these chemical ingredients will be found. Serpentines are also metamorphic rocks, p. 214.

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For long the laminar structure of gneissic rocks was a mystery. It frequently lies 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 as granite, 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 known that gneissic rocks and granites are of every geological age.

I must now refer to the phenomena of cleavage. (See **Case 46**, Nos. 26 to 47, and p. 123.) 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, 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

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absence of relation is more than doubtful if universally applied. 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 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 rocks cooled and consolidated slowly and deep beneath the surface. One result of this would be that, the rocks in contact with granite would also for a long time remain in a heated condition, and if a partial softening took place, or by any process the rock got into such a condition that internal movements of its particles occurred, then, these might probably congregate according to their affinities, in layers, wherever circumstances would allow, and 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 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. UPPER GALLERY. Wall-case 45.

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*, in contact with white igneous reck; rendered anthracitic and seamed by threads of calcareous spar.

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. (See "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." ("Geology of the South Staffordshire Coal Field," p. 241.)

4.—Specimen 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 of this specimen is a piece of the slate scarcely altered, and showing the original thickness of the slate. Lower down the same fragment swells out and becomes

Upper Gallery.
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Wall-case 45.

spongy. This is still more obvious below. The slates have become spongy by the escape of 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 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 fossilliferous sandstone of Presteign :—(Upper Llandovery or May Hill Sandstone.)

8.—Altered sandstone, *crystalline and calcareous.—Old Radnor Hill.*

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 it is impossible to separate the altered rock from that which produced the alteration. 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

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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 an 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 rocks in its immediate neighbourhood have been so much altered by heat, that, in 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. *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*.

19.—WENLOCK SHALE, *partially porcelainised*. 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. 115.) The Skerry conglomerate is traversed by dykes, and contains pebbles of

UPPER GALLERY. — Wall-case 45. 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. Porcelainised* by heat.

24.—GREY FINE AND GRITTY ROCK, *Tin Meadow. More altered* than 23.

25.—GREENISH GREY AND PURPLE banded argillaceous and fine gritty ROCK, *Billa Barrow Hill.* Very much *indurated and porcelainised.*

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 crystallised 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 rearrange 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.*

Wall-case 45.

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.

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 maximum. Further alteration probably 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, *Quorndon House,* near Barrow-on-Soar, composed of red felspar and horn-

UPPER GALLERY. — Wall-case 45.

blende. This rock passes imperceptibly into syenite and granite.

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.

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 pierce the Cambrian rocks of Charnwood Forest and the neighbourhood, and probably form parts of a great mass concealed below. Some of them are, however, entirely surrounded by unaltered New red marl, which conceals the Cambrian rocks amid which they lie. The Cambrian rocks in their neighbourhood are so much altered, that, becoming porphyritic, it is often impossible to trace an accurate boundary line between them and the 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 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 on a small scale seem 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

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Wall-case 45.

so much altered that they have been partly, and in some cases entirely, fused, and thus pass into true igneous rock. All the metamorphism of the Charnwood Forest rocks is of this kind, nor do they ever assume the character of gneissic rocks. It may be that dry heat, through the intrusion of igneous rocks, was applied with too much rapidity to allow of that slow chemical separation and re-union of constituents, according to their affinities, in layers (often of stratification or cleavage) which constitutes gneiss.

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, **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 errupted igneous masses.

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.

UPPER GALLERY. — Wall-case 45.

51.—CAMBRIAN GRIT *altered.* Same locality, passing imperceptibly into No. 52.

52.—QUARTZ PORPHYRY, *Llyn Padarn*, Llanberis, Caernarvonshire. Felspathic base with crystals of felspar and granular crystals of transparent quartz. Part of a great intrusive mass of quartz porphyry *which cuts through the Cambrian rocks.* For a more complete account see Nos. 185 to 192, **Case 4**, p. 211.

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.* UPPER GALLERY. Wall-case 45.

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 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, 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. Map 55 N.E. Worcestershire. *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

UPPER GALLERY. — Wall-case 45.

Pen-y-gwryd, alters the slate with which it is in contact into honestone. Map 75 N.E. Merionethshire.

68.—LLANDEILO FLAGS, *altered fossilliferous 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. *Porcelainised by contact with greenstone.*

69.—Ditto, 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.

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 intrusion of 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 ordinary 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 intrusion of the Ffestiniog syenite, No.* 117, **Case 4.**

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.

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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. Colomb Minor.* Sheet 30. *Very talcose.*

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 Tintagel, 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, Wheal Vor Tin Mine*, Devonian, *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.* 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.

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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.*

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.

Upper Gallery. — Wall-case 45.

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 also "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 metamorphic and igneous rocks.

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 appa-

Upper Gallery. — Wall-case 45.

rently intruded amid the green quartzose and chloritic schists, which are much contorted on a small scale."—Sir Henry De la Beche. See similar jaspar 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 Barsey Island. They are associated with serpentine and crystalline metamorphic limestone, containing much silica.

Metamorphic rocks of Anglesea.

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 rocks* in the north of Anglesea.

123. Green serpentine, *Ceryg-moelion, Holyhead Island, Anglesea.* Map 78 N.W. From one of three masses of

Upper Gallery. — Wall-case 45.

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 irruptive. 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.—

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.

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 and liassic period."—Official Catalogue of the Great Exhibition, 1851, p. 127, vol. i.

From 125 to 133 the specimens belong to the great series of metamorphic, gneissic, and mica-schist 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.*

UPPER GALLERY. — Wall-case 45.

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 *Holywood, 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.

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. 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

UPPER GALLERY. — Wall-case 46.

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 118,000 tons of quartz rock have been dislodged and broken up by one explosion. 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 Ironworks, 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.

UPPER GALLERY. — Wall-case 46.

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.

8.—MICACEOUS SANDSTONE, Denbighshire sandstone, *Bwlch-y-fridd near Newtown, Montgomeryshire.* The *numbered* 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.

9.—SLATE-PENCIL ROCK, *Shap, Cumberland,* Lower Silurian. Comes out of the quarries *in long jointed fragments,* afterwards cut into pencils.

Similar rocks occur in a great sea cliff of Lower Silurian rocks, Ramsey Island, opposite St. David's, Pembrokeshire.

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 ×.

Upper Gallery.

Wall-case 46.

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.*

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 orignally 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 rocks*, St. Davids, Pembrokeshire. Map 40. Planes of *joints cutting through the pebbles.*

Upper Gallery.
Wall-case 46.

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 but little 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 the disturbances that have frequently produced contortion of cleaved strata. It is not the case, however that all contorted strata are cleaved, although most 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 to readjust 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 cavities, these cavities would necessarily be elongated in the same direction. *The whole rocky substance has,* *therefore, often been compressed into narrower space and stretched in other directions according to the direction of the pressure*, so that *large bodies*, in many cases, *become visibly compressed, often flattened, and generally much distorted*, the distortion, for instance, sometimes elongating, and at other times broadening fossils far beyond their ordinary dimensions, and frequently giving an unsymmetrical shape to forms that in their natural state are quite symmetrical. *The true slaty structure in rocks is always the result of cleavage.*

UPPER GALLERY.

Wall-case 46.

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*, fossilliferous, *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.*

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.*

UPPER GALLERY.
Wall-case 46.

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.*

33.—FINE GRITTY AND SLATY REDS. 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°. Upper Gallery. Wall-case 46.

35.—Small specimen from the same locality, showing the same kind of phenomena.

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. 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, and *the sides are joints.*

UPPPR GALLERY. — Wall-case 46.

42.—BLACK SLATE, *Dolwyddelan, Caernarvonshire.* Map 75 N.E. *Caradoc or 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 into pieces 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 small 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.

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 *Tintagel, Cornwall.*

49 to 53.—Various specimens of the DARKER CLEAVED PURPLE ROCKS of the *Cambrian* slaty region of *Llanberis.*

IGNEOUS ROCKS.

Wall-cases 1 to 6.

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.**

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 St. Vincent*, and 140 to 147 from *the nearly dormant volcano of the Island of Teneriffe.* UPPER GALLERY. — Wall-cases 1 to 6.

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 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 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 fossillize 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 sublimation.

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

UPPER GALLERY.

Wall-case 1.

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. Ofthese, 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.*

UPPER GALLERY. — Wall-case 1.

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.

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.—Vescicular 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.

Specimens of volcanic rocks and minerals from Kilauea and Hawaii, in the Sandwich Islands, collected and presented by Count Strzelecki, C.B. Upper Gallery. — Wall-case

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, 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

Upper Gallery. — Wall-case 1.

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."

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," 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 analysis of Pélé's Hair (No. 20), in which both potash and soda are given —H. W. Bristow.

Upper Gallery.

Wall-case 1.

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, shewing 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.*

UPPER GALLERY. — Wall-case 1.

30.—VERY VESICULAR LAVA, or *cellular obsidian.*

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.*

42 a.—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.G.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 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.

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
52.—Pearlstone, *with sphærulite.* } *Glashütte.*

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 Retinique*" 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 *Schobobnerberg.*

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.*

71a.—PORPHYRITIC TRACHYTE with crystals of *mica*, *augite*, &c. south of the basalt of *Giesshübl*. UPPER GALLERY.

72.—SCORIACEOUS TRACHYTE, from a block near the rocks at the "Teich," or reservoir, half a mile south east of *Kremnitz*. Wall-case 1.

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 Grand Cathedral.—*Wissegrad*.

Upper Gallery.

Wall-case 1.

86.—Pumiceous conglomerate, above the *Vale of Hlinik on the Kremnitz road.*

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*, 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.*

99.—White crystalline limestone, from *Ruskzberg in the Bannat.* Upper Gallery. Wall-case 1.

100.—Flesh-coloured crystalline limestone, from *Ruszkberg in the Bannat.*

101.—Marl, *with nodules of Bitterkalk,* Radoboj.

102.—Diorite (or greenstone), *Nagy Banya.*

103.—Dioritic porphyry, with *calc spar, Vale of Fernezely, Nagy Banya.*

104.—Greenstone porphyry, with metalliferous threads, *Nagyag.*

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 trychyte of *Tihutza* on the border of the *Bukovina.*

113.—Granite, with green *epidote.—Magurka,* near *Unter Franz Stollen.*

114.—Trachyte, containing a vein of *sulphur.—Kalinka, Sohler County.*

115.—Altered sandstone with *specular iron, Magurka.*

UPPER GALLERY

Wall-case 1.

Rock specimens from the Taurus Mountains.

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.*

119 a.—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 Poulett Scrope, Esq.

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 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.

UPPER GALLERY

Wall-case 1.

"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*.

UPPER GALLERY.
Wall-case 1.

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.)

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.—*Weinfield*.

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 under one 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.G.S.

Volcanic products from the Peak of Teneriffe.

Presented byProfessor 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. 255.

UPPER GALLERY. — Wall-case 1.

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 a tendency to assume spheroidal forms, and the smooth planes of joints.

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.*

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, 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.

UPPER GALLERY.

Wall-case 2.

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 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.

Siliceous sinter is represented by 95 to 99. It occurs in the altered trachytes either in the form of irregular masses

Upper Gallery. — Wall-case 2.

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, were 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; while 110 to 113 are cellular basaltic lavas, the latter containing crystals of olivine.

116 to 117 are from the Cape de Verd 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 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.—H. W. B.

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 or vesicular basaltic lava.

6.—Slag, *from an iron furnace* at Wolverhampton, for comparison with the two preceding specimens.

7.—Cellular basaltic lava. Some of the cells are elongated, and partly filled with *carbonate of lime.*

8.—Vesicular basaltic lava, showing the elongation of the vesicles in the direction of the current.

9.—Basalt, in one part slightly scoriaceous.

10.—Vesicular basaltic lava, some of the vesicles filled with crystals of *glassy felspar.*

11.—Compact brown basaltic lava (slightly vesicular in places) with crystals of *glassy felspar.*

12.—Vesicular basaltic lava, with crystals of *augite.*

13.—Compact brown basaltic lava, with crystals of *olivine.*

14, 14a, 14b, 14c, 14d, and 14e.—Six specimens of fragments from the superficial part 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.

15.—Pearlstone, with a lamellar structure, and containing slightly waved tortuous layers in the upper part

16.—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.*

17.—Pitchstone, with thin parallel and slightly tortuous felspathic layers, containing crystals of *glassy felspar.*

17a.—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.)

Upper Gallery.
Wall-case 2.

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.

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.

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, 27 a, & 27 b.—PITCHSTONE, shewing the characteristic conchoidal fracture and sharp cutting edges.

28.—GREEN PITCHSTONE, OR OBSIDIAN.

29, 29 a to 29 g.—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.

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.*

Upper Gallery.
Wall-case 2.

33.—Pale greenish-grey, decomposing TRACHYTIC PORPHYRY, 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 contain white crystals of *quartz* and minute, brown, acicular, transparent crystals of *augite* (*diopside*).

UPPER GALLERY.

Wall-case 2.

(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 TRACHYTE, 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.—TRACHYTIC 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 OF PEPERINO, with coarser loose scoriæ.

75 & 76.—PEPERINO, formed of *volcanic sand and ashes* cemented together.

77.—BLACK TRACHYTIC TUFA OF PEPERINO, from the bottom of the volcano.—*St. Vincent.*

78.—SCORIACEOUS LAVA OF *pozzolana.—Sheepwalk.*

79 & 80.—SCORIACEOUS LAVA OF *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, 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.

UPPER GALLERY. — Wall-case

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*.

UPPER GALLERY.
Wall-case 2.

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.

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*. Upper Gallery. — Wall-case 2.

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.

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 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 it presents a rugged, arid appearance ; the dark basaltic lava, of which the surface is composed, being covered by a dwarfed and parched brush-wood.

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 summit 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'Estamia, Boa Vista, Cape de Verde Islands.*

117.—Green pitchstone, *Mayo Island, Cape de Verde group.*

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.

UPPER GALLERY.
Wall-case 2.

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.

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.*

UPPER GALLERY. — Wall-case 2.

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-case 3.

MODELS OF ROCKS *by M. Bardin, from the Paris Exposition*, 1854.

On the upper shelf is a model of the volcanic isle of Bourbon, No. 1.

No. 2 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.

No. 3 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

Upper Gallery.
Wall-case 3.

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. 4 & 5 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.

Nos. 6 & 7 are models of inclined limestone rocks in the neighbourhood of Sablé (Sarthe).—A. C. Ramsay.

Table Case 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.

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.

Upper Gallery.

Table-case in Recess 4.

"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 volcanoes. 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 depresssion, 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, 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.

UPPER GALLERY.

Table-case in Recess 4.

"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 tranquility. 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 pro-

UPPER GALLERY. — Table-case in Recess 4.

duced 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.

List of Specimens of Volcanic Rocks and Minerals arranged and described by H. Bauerman.

1.—Ashes from the eruption of 1760; found at *Bocco Tre Case.*

2.—Volcanic sand (rounded *fragments and crystals* of *augite and idocrase*) from the eruption of 1794.

3.—Similar specimen to the last; locality and date of eruption 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.—Lapillia, small fragments of scoriaceous lava from the eruption of 1813; found at *Resina.*

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 of eruption not stated; found at *Fossa Grande.*

11.—Vesicular lava (externally weathered brick-red). Date of eruption not stated; found at *Fossa Grande.*

UPPER GALLERY.
Table-case in Recess 4.

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.*

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.

UPPER GALLERY.

Table-case in Recess 4.

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.*

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.

UPPER GALLERY.

Table-case in Recess 4.

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* crystals in a reddish base of *leucite* crystals.—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.

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*.

UPPER GALLERY.
—
Table-case in Recess 4.

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.

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.*

72.—LAVA, with crystals of *augite* and *leucite.* Externally coated with crystallized *iron glance (peroxide of iron.)*

73.—Similar specimen to the last.

74.—CRYSTALLINE CALC SPAR enclosing masses of *iron glance;* partly altered to *brown iron ore* (*hydrated perozide.*) *Fossa Grande.*

75.—HAÜYNE (*silicate of soda and alumina, sulphate of lime*) with *felpsar, 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.*

79.—LEUCITE (*silicate of alumina and potash*) *cubical felspar*, 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*. UPPER GALLERY. Table-case in Recess 4.

NEPHELINE, *hexagonal felspar* (*silicate of potash, soda, and alumina*).

$$\dot{R}\,2\,\dddot{Si} + 2\,\dddot{\mathit{Al}}\,\dddot{Si} \quad \dot{R} = (Na\,O\,K\,O).$$

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.

FELSPAR (*silicate of potash and alumina*).

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*.

UPPER GALLERY.

Table-case in Recess 4.

MEIONITE, *Vesuvian Scapolite* (*silicate of lime and alumina*).

$$\dot{C}a^3\dddot{S}i + 2\,\dddot{Al}\,\dddot{S}i.$$

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.

IDOCRASE VESUVIAN (*silicate of alumina of lime*).

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 lime* Fe_2O_3 and M O).

119.—OLIVINE, filling the hollows of a vesicular lava.

120.—GREEN OLIVINE, with granular *green augite*.

121.—VESICULAR LAVA, with acicular *hornblende crystals*.

MICA (*silicate of alumina* Fe_2O_3 *and potash.*)

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 in Recess 4.

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 and144.—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.

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 indicating the country it traverses. The rest of the writing indicates the names, places, and, in some degree, the nature of the different kinds of rock that form a great part of Wales, &c. A careful inspection of the 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 8** 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 contemporaneous Silurian rocks of Wales.

The Upper Silurian rocks are coloured *dark purple*, and lie quite *unconformably* 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 that have been forced in a melted condition from below among the other rocks.*

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. The ashes are truly stratified deposits, and the 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 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, altering the strata with which they are in contact all round. (Section **4,** and specimens 186 to 191.) In the sections (**No. 1 and 4**) four of these masses break up 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 other agencies.

The *greenstones* are coloured *deep crimson,* and appear in all the sections, breaking indiscriminately through the Lower Silurian strata, and sometimes through the associated interbedded igneous rocks. *They are all composed of felspar and hornblende,* sometimes somewhat amorphous or indistinctly crystallized (specimens 152, 164, &c.), at other times

UPPER GALLERY.

Wall-case 4.

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 the 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. If ever, it is only in very rare cases, that they are truly *contemporaneous*, one proof of which is, that the slates or other beds which they pierce are 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 surface over which they flowed, but being cooled, the muddy sediment which fell on the upper surface of the lava remained 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 also 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.

The *contemporaneous igneous rocks* of the district are also of two kinds.

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 shews 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 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 hot and 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 the ordinary Lower Silurian fossils (see the horizontal gallery cases below), and this indicates that the Silurian volcanos of the time in this area were partly submarine, or, at all events, that many beds of lava flowed far into the sea.

UPPER GALLERY. Wall-case 4.

FELSPATHIC AND CALCAREOUS VOLCANIC ASHES 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 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.

Upper Gallery.
Wall-case 4.

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* 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.*

The Snowdon trap lies on highly fossilliferous 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 calcareous and fossilliferous.

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 they 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 mountain and the Cambrian rocks near Y Tryfau. They, therefore, thin out between Moelwyn and Snowdon deep under the surface.

The *eruptive* felspathic and quartz porphyries and syenites (see p. 199) always lie amid rocks deep under the *contemporaneous* felspathic traps and ashes, and it is probable that they indicate parts of the 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.

Though all these rocks are strictly volcanic, *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

UPPER GALLERY. — Wall-case 4.

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, their major portions being buried under thousands of feet of overlying slates and sandstones.—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.

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 direct volcanic origin. 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.*

UPPER GALLERY. — Wall-case 4.

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 talcose mud,* which have become 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 LIX., 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.*

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 FELSPAR-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.

UPPER GALLERY.
Wall-case 4.

8.—COMPACT FELSPATHIC ASHES, *talcose.*—Mynydd Gader, Dolgelli, Merionethshire. Map 59, N.E. Varying from finely granular to compact felspathic ashes. 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 of a dark brown colour; 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 and talcose ashy 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.

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 ashy beds 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.

Upper Gallery.
—
Wall-case 4.

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 of ashes *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.

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*,

UPPER GALLERY.

Wall-case 4.

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 ashy dust.*

This and the two following specimens are from parts of the highest beds of this volcanic series.

20.—COMPACT FELSPATHIC ASHES.—East slope of Arenig, Merionethshire. Dark grey, finely laminated felspathic rock. Weathers of a light grey or brownish-black.

This rock forms the top beds of Arenig.

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 of the mass.

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 Llyfnnant, 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 talcose and 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, is exceedingly thin in the neighbourhood of the slate quarries, and thins 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.—TALCOSE AND SILICEOUS FELSPATHIC ASH.—Between Tan-y Grisiau and Cwm Orthin, Ffestiniog, Merionethshire. Map 75, N.E. See 24, section 4. 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 fossilliferous 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 Nos. 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

Upper Gallery

Wall-case 4.

with talcose slate, showing ripple marks. It belongs to the same set of rocks as No. 24.

26.—Calcareous felspathic and talcose ash, 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, the latter somewhat coarser in texture than the former, and 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. Weathers very irregularly.

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 in structure, very 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, giving the outer surface a rough scoriaceous appearance.

Upper Gallery. — Wall-case 4.

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 volcanic ash,* enclosing rough angular, and a few rounded felspathic fragments. Exceedingly 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 crystals of white, brown, or yellow felspar fragmentary and entire, 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 truly and 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 larger fragments of included rock, and numerous broken and entire crystals of felspar; also contains impressions of fossils (*Orthis*), the shells of which have been carried away in solution by the percolation of rain water. The fossils in this specimen,

UPPER GALLERY. — Wall-case 4.

embedded along with felspathic crystals, clearly prove its mechanical origin.

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 ashy rocks that lie on the felspathic traps (lava beds) of Snowdon, as a centre, Moel Hebog, near Beddgelert, and in the valley above Cwm Idwal, between Y Glyder-fawr and Y Garn. As a whole, these rocks 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 lava streams; 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 matter is variously intermingled with ordinary sediment. Their uppermost part, on Snowdon, and in the outlier of Dolwyddelan, is probably the equivalent of the Bala limestone, which, even near Bala, is sometimes ashy in its structure. The ashy beds on Snowdon, &c., contain Bala fossils in places. 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 circumstance 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 district in a state of volcanic activity, which did not extend far to the south. Upper Gallery. — Wall-case 4.

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 Pwlheli, Caernarvonshire. Map 75, S.W. Alternations of fine and coarse volcanic breccia and grit. Greenish, with pebbles of greenish and black chert or jasper.

Ashy Series of the Llandeilo flags, Breidden Hills, Montgomeryshire. Map 60, N.E. and Section No. 3 above.

42.—Compact felspathic porphyritic ash.—Breidden Hills, Montgomeryshire. Map 60, N.E. 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 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. Map 60, N.E. 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.

Upper Gallery. — Wall-case 4.

44.—Felspathic Conglomerate.—Moel-y-Golfa, Breidden Hill, Montgomeryshire. Map 60, N.E. 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. Map 60, N.E. 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 imbedded fragments appear to have been well rounded and water-worn on the sea shore. They have been found crusted with Silurian corals.

46.—Felspathic and pumiceous breccia.—Breidden Hill, Montgomeryshire. Map 60, N.E. 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 and talcose ash.—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.

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.

Upper Gallery. — Wall-case 4.

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 ; weathered surface very slightly changed 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 *prophyritic*, Hyssington, near Bishops Castle, Shropshire. Map 60, S.E. Dark greenish-grey granular felspathic rock, with crystals of felspar and strings of calc spar. This is from beds of ashes equivalent to 51 and 52, near the base of the Llandeilo flags.

54.—Porphyritic felsphatic 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 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.

Upper Gallery. — Wall-case 4.

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 up 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 preceeding, 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 lx., 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.

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.

Upper Gallery. — Wall-case 4.

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 up of small fragments of dark felspathic porphyry, and entire and broken crystals of felspar embedded 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 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.

UPPER GALLERY.
Wall-case 4.

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 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, into coarse brecciated and conglomeratic volcanic ashes. The Marrington beds are the equivalents of the eastern 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 LX., 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.

72.—SANDY FELSPATHIC ROCK.—Carneddau, Radnorshire; near Builth, Breconshire. Map 56, S.W. Yellowish-

Upper Gallery.

Wall-case 4.

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 up 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 sandy sediment into decided ashes or tufas, and are frequently fossiliferous.

Caermarthenshire.

78.—Brecciated felspathic ash.—Carn Blaendyffryn, Llangadock, Caermarthenshire, South Wales. Map 41.

UPPER GALLERY. — Wall-case 4. 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 afterwasds been filled up 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 2½ miles north-west of Dinas Mowddwy, Merionethshire. Map 60, N.W. Blackish-green felspathic rock, with kernels of quartz interspersed.

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.

UPPER GALLERY.
Wall-case 4.

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 Careg 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.—FFLSPATHIC 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.

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 quarter of an inch on the exposed faces.

Upper Gallery. — Wall-case 4.

This is also the equivalent of the Aran and Penmaen felspathic trap in its north range, on the west side of the River Wnion 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 No. **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 white felspathic substance. The latter resist weathering, and form projecting lines on the weathered surface. The lines probably originated from the same kind of 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**.

From the same set of lava beds as No. 100.

UPPER GALLERY.

Wall-case 4.

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 once overlying the ash, formed a great 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 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.

UPPER GALLERY.
Wall-case 4.

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 felspar 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 underlying 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 3 or 4 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.

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-Mochant, Montgomeryshire. Map 74, S. E. UPPER GALLERY. Wall-case 4.

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 LIX. 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.)

118.—GREENSTONE.—Bwlch-yr-Hendref, near Capel Arthog, 6 miles south-west of Dolgelley, Merionethshire, Map 59, N.E. Dark green hornblende base, containing crystals of white potash felspar and large crystals of a platy variety of hornblende.

UPPER GALLERY.
Wall-case 4.

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 up 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 Mowdwy, 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. UPPER GALLERY. Wall-case 4.

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 porcelanic at the junction. 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.

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

UPPER GALLERY. — Wall-case 4.

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 dispersed through it.

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. More hornblende 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.

From the same mass as No. 128.

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137.—Greenstone.—Half a mile south-west of Clynog Fawr, Caernarvonshire. Map 75, N.W. Dark, greenish-grey felspar 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 black hornblende base, with simple and geniculated felspar crystals scattered through it.

This rock is continuous with No. 129, and is a remarkable example of the change in general character and composition which the same mass of rock exhibits.

140.—Greenstone.—Tan-y-Graig, 1½ mile north north-east of Pwllheli, Caernarvonshire. Porphyry. 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 Pwllhelli, Caernarvonshire. Dark green granular hornblendic base, containing crystals of felspar.

From a continuation of the same mass as Nos. 127, 130, and 131. These rocks show the 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.

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

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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, (Section No. 4, above,) that underlies the calcareous ashes of Snowdon.

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 summit of Snowdon.

The greenstone rocks of Merionethshire and Caernarvonshire chiefly run in lines, which, in many cases, have been 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.

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INTRUSIVE ROCKS OF LOWER SILURIAN AGE, BREIDDEN HILLS, and 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 ; contains 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 traversing 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.

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.

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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 Bishop's 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.

158.—GREENSTONE AMYGDALOID.—Wellfield, $1\frac{1}{2}$ 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. UPPER GALLERY. Wall-case 4.

From an intrusive branching mass, about $1\frac{1}{2}$ mile in length. The porcelainic alteration it produces on the Llandeilo flags is well seen on the banks of the river Wye, northwest of Builth. The *unaltered* Upper Silurian rocks of the Upper Llandovery or May Hill sandstone rest on its southeast 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 the 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 by it both on its under and *upper* surface. Were it a true 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.

From the north end of the same rocks as No. 160, near which they are overlaid by unaltered Wenlock shale, quarried for building stone.

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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 the 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 crystals of iron pyrites diffused through it.

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, among which it lies. It extends from Porth Lisky, on the coast, 2 miles south-west of St. David's, to Carn-ymyl, north-east of Llanhowel.

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 in structure, and is probably connected underground with the intrusive mass of 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, 2½ 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 Meleyn, 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 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.**

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

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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 to 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.

In rocks largely crystalline it is presumed that generally they 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. UPPER GALLERY. — Wall-case 4.

A line of greenstone, about 2 miles in length, intruded between the beds of Llandeilo slate in their strike.

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 igneous fusion by the close proximity of 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 specimen on the ground is a little further removed than No. 186 from No. 185. Locality as above.

188.—CAMBRIAN CONGLOMERATE, altered by proximity to No. 185, and a little further removed from it than No. 187. The 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

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to melt into the surrounding matrix, which, perhaps, was almost completely 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.

This is the usual manner in which the Cambrian grits appear in this neighbourhood in a comparatively unaltered

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form when removed from igneous intrusive masses. 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 masses 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 occasionally *cleaved* fragments of slate (at Penrhyn quarries), they would appear to have been intruded after those mecha

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nical disturbances which bent and contorted all the rocks of the country, and during which the cleavage was probably produced by mechanical pressure.

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; others are decidedly metamorphic. 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.

[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 *steatite* 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-

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nated 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 *asbestus*.—Tredavoe, Goonhilly Down, Cornwall.

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32.—DIALLAGE ROCK, from a vein traversing greenstone. —Coast near St. Keverne, Cornwall.

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.

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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, 1 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.

Upper Gallery.

Wall-cases 6 and 7.

Wall-cases 6 and 7.

Igneous Rocks of various Kinds.

Preliminary Remarks by A. C. Ramsay.

The rocks in these cases are all usually 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 a largely crystalline kind 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. 224), 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*, are of

UPPER GALLERY. — Wall-cases 6 and 7.

a *granitic* nature. They are generally characterised 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. 97—99).

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. 251.)

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. Austle, 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 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.

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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 shews 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 shews 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 shews a weathering surface of a ferruginous-brown colour, owing to the decomposition of the felspar. Map 31.—Near Tolvorn Passage, Falmouth Estuary, Cornwall.

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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.

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, and *black 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.—Wheal 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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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.)

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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.

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 fossilliferous, 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 towards the west of Chapel Carn Brea. Map 33.—Mayon or Mean, near the Land's End, Cornwall.

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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 north-western 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 above the level of the sea) forms the highest part. The skirts, generally, of this mass of granite from Penvivian Hill,

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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 argillaceons 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, shewing 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.)

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 towards 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.*

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 shews 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.) They 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 Prophyry 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 architectual 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.

UPPER GALLERY.

Wall-cases 6 and 7.

90.—*Part of a* GRANITE DYKE, apparently cutting through the schistose rocks of the district, and is probably the continuation eastward of Nos. 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*.

UPPER GALLERY.
Wall-case 6 and 7.

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.

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.

90.—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. Upper Gallery. — Wall-cases 6 and 7.

This is one of the many granite veins (see Map 30,) which cut through the slates in the neighbourhood of Blisland. 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.

Upper Gallery. — Wall-cases 6 and 7.

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. (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. UPPER GALLERY. Wall-cases 6 and 7.

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.—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 llwyd*"). 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.

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* See "Report on Cornwall," pp. 509 to 513; also Mr. Hunt's Descriptive Guide, pp. 67, 68. Upwards of 60,000 tons of china clay were exported from Cornwall and Devon in 1855: 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. UPPER GALLERY. Wall-cases 6 and 7.

133.—FELSPATHIC TRAP.—Llandegley Rocks, Radnorshire.

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.

137.—Grey thin bedded TRAP.—Y Wenallt, $1\frac{3}{4}$ miles north-west of Llanruochllyn.

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 1., pp. 31 and 32.)

139.—FELSPATHIC PORPHYRY.—Tinnacarrig Hill, near New Ross.

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.

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 1, pp. 40 and 41.)—Great Malvern, Worcestershire.

150.—Syenite, a compound of *felspar* and *hornblende,* the latter with a tendency to form separate aggregations.—1½ mile north-west of Ffestiniog, Merionethshire.

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. UPPER GALLERY. — Wall-cases 6 and 7.

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.

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 $4\frac{1}{2}$ miles south of Clynnog Fawr, West of Yr Eifl, Caernarvonshire.

160.—LARGE-GRAINED GREENSTONE, forming some remarkable rocky tors near the cliffs. It might be usefully employed for roads and in massive structures.—Tintagel, Cornwall.

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.

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 vescicular.—Davidstow, Cornwall.

163.—PORPHYRITIC GREENSTONE, containing crystals of *felspar* and kernels of *green earth* in a decomposing hornblendic base.—Carneddau, Builth, Breconshire.

164.—PORPHRYRITIC GREENSTONE, containing a vein of *hornblende.*—Boswednan Cliff, Zennor, Cornwall.

165.—PORPHYRITIC GREENSTONE, composed of crystals of *felspar* in a hornblende base. Part of a dyke.—Breiniongeirwen, Anglesea.

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.

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.

168.—PORPHYRITIC GREENSTONE, composed of crystals of *felspar* in a hornblende base.—Beyond Goodrevy Cove, St. Keverne, Cornwall.

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.

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.

Upper Gallery.

Wall-cases. 6 and 7.

171.—Porphyritic greenstone, composed of crystals of *white felspar* in a felspatho-hornblendic base.—Bwlch Mawr, $1\frac{1}{2}$ miles south-east of Clynnog Fawr, Caernarvonshire.

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.

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.

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.

181.—Greenstone. (See "Report on Cornwall," p. 82.) —St. Mewan, Cornwall.

182.—Greenstone.—Trenoweth, Cury, Cornwall.

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.

184.—COMPACT GREENSTONE (weathering brown) in close contact with slate.—Carn Llidi, St. David's, Pembrokeshire.

185.—FINE-GRAINED GREENSTONE (weathering brown), a little removed from contact with slates.—South-east side of Carn Llidi, St. David's, Pembrokeshire.

186.—BASALTIC GREENSTONE.—Clee Hills, near Ludlow, Salop.

187 and 187a.—COMPACT GREENSTONE.—Gurnard's Head, Zennor, Cornwall.

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.

194.—COMPACT GREENSTONE.—Between Lay Point and St. Ives, Cornwall.

195.—COMPACT GREENSTONE, containing a little *iron pyrites.* From a dyke traversing chlorite and mica schist.—The Skerries, Anglesea.

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.

198.—COMPACT GREENSTONE, apparently intruded among argillaceous slates. Employed for roads, for which it is an excellent material.—Egloshayle, Cornwall.

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.

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.

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.

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.

Upper Gallery. — Wall-cases 6 and 7.

204.—Greenstone associated with contemporaneous argillaceous slates.—Near Trereife, Penzance, Cornwall. (See "Report on the Geology of Cornwall," p. 100.)

205.—Compact greenstone, locally termed "*ironstone.*"—Botallack Mine, St. Just, Cornwall.

206.—Compact greenstone, locally termed "*ironstone.*"—Huel Cock, St. Just, Cornwall.

207.—Compact greenstone.—Burncoose, near Gwennap, Cornwall. (See "Report on the Geology of Cornwall," p. 176.)

208.—Greenstone, a finely divided mixture of *felspar* and *hornblende.*—Dranna 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.

210.—Greenstone, composed of *hornblende*, with a small proportion of *felspar.* (See "Report on Cornwall," p. 100.) Guavas Hill, Newlyn, near Penzance, Cornwall.

211.—Basalt.—Little Wenlock, Buildwas, Salop.

212.—Diallage rock, a compound of *felspar*, *hornblende*, and *diallage.* (See "Report on Cornwall," pp. 98 and 99.)—Gilly Cliff, St. Keverne, Cornwall.

213.—Greenstone, composed of veins and laminæ of fibrous *asbestus* in a light green felspathic base.—Conway, North Wales.

214.—Greenstone, with veins of *asbestus.* From a dyke traversing the trap rock of Llyn Peris.—Llanberis, Caernarvonshire.

215.—Hornblende rock.—Greeb Rock, Mount's Bay, Cornwall.

216.—Hornblende schist, an irregular aggregation of hornblende in imperfect crystals. Used for building-stone.—Guernsey.

217.—Hornblende rock.—Llanerchymedd, Anglesea.

218.—Crucible, containing fused portions of the above rock.

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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.

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.)

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 Tintagel. This series is occasionally fossiliferous in its course. —St. Clether, Cornwall.

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 adjacent coast, these masses of trap have been intruded

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Wall-cases 6 and 7.

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.)

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.

225.—Vesicular trappean rock.—Part of a trappean mass, which extends from near Burlarroc 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.

227.—Trappean rock (*greenstone*) in a decomposing state.—Porthleven, near St. Breague, Cornwall.

228.—*Vesicular trappean rock* (greenstone.)—Bellurian Cove, Mullion, Cornwall.

Volcanic trappean rocks, ash-beds, and cinders, *from Brent Tor, Devonshire.* (See "Report on Geology of Devon and Cornwall, pp. 120 and 121.)

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 occurs in (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 probably of the same geological age with the volcanic rocks of the lower Coal measures 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 dissolved lime or other matters into the cavities. Fre-

* *See* also Nos. 188, 190, 191, and 253.

Upper Gallery. — Wall-cases 6 and 7.

quently, on the surface, these 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.

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.

247.—Amygdaloid, composed of nests of *epidote* in a base of greenstone.—Caer Caradoc, Church Stretton, Salop.

248.—Amygdaloid, composed of kernels of decomposing *green earth*, and *compact mesotype*, in a greenstone base.—Caradoc Hill, Church Stretton, Salop.

249.—Amygdaloidal greenstone, the cavities filled with *calc spar*, which have almost entirely been removed.—Gaer Fawr, Carneddau, Builth, Breconshire.

250.—PORPHYRITIC GREENSTONE, composed of imperfect crystals of *felspar*, in a base of compact greenstone.—Opposite Ramsey Sound, St. David's, Pembrokeshire.

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251.—AMYGDALOID, with crystals of *quartz* replacing *calc spar*.—East of Bettws Disserth, Radnorshire.

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.

254.—SERPENTINOUS GREENSTONE.—Damory Bridge, Wotton-under-Edge, Gloucestershire.

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.)—Carn Mere Point, near Nare Head, Cornwall.

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.

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* American rocks, chiefly presented by Sir William 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 Main, 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 shews 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.

Upper Gallery.

Wall-cases 6 and 7.

275.—Napoleonite, or orbicular granite,* 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.

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.—Chambly Canal, Lower Canada.

278.—Syenite, composed of *hornblende*, *flesh-coloured felspar*, and a small quantity of *quartz*.—Australia. Presented by J. B. Jukes, F.G.S.

279.—Basalt, containing crystals of *hornblende* and *analcime*, Australia.—Presented by J. B. Jukes, F.G.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 145.

Upper Gallery. — Wall-cases 6 and 7.

286.—Trap rock, crystals of *analcime* in a hornblendic base.—Longeiul, 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 octahedral 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 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 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.G.S.

10.—TUFA, with fragments of *lava, augite, mica, calc spar,* &c., forming the nucleus of the Capitoline Hill.

Upper Gallery. — Table-case 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.

22 and 23.—Varieties of TUFA from Monte Verdi, used for the ordinary building stones of Rome.—Presented by Warington W. Smyth, F.G.S. UPPER GALLERY. Table-case in Recess 6.

24.—GREY PEPERINO, with *augite*, *calc spar*, *mica*, &c., from the lower portion of the mass.—Albano. Presented by Warington W. Smyth, F.G.S.

25.—GREY PEPERINO, with fragments of *scoriaceous lava*, *augite*, *mica*, and *cabonate 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.

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* These are used, when mixed with lime, for making the cement called Pozzuolana.

UPPER GALLERY.
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Table-case 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, $3\frac{1}{2}$ miles from Rome.

38.—*VOLCANIC CINDERS, composed of pieces of *scoriæ, earthy leucite.*—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.

* These are used, when mixed with lime, for making the cement called Pozzuolana.

52.—SEMI-VITRIFIED SCORIACEOUS LAVA.—From the most ancient summit of Monte Artemisio, near Velletri.

UPPER GALLERY.

Table-case in Recess 6.

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 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 Cave 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.

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 (*amphigene*, *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 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.

134.—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.

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* Nos. 107 to 109 attract the magnetic needle.

UPPER GALLERY.

Table-case 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.*

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* 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 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 *nepheline, 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 decompased 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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* No. 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.

150.—HAÜYNE, with scales of *green mica.*—Occurring in hollows in the peperino at the base of Monte Cavo, above Albano. Table-case in Recess 6.

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 *or* 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 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.

185.—ALUMSTONE* which has been roasted.

186.—ALUMSTONE* which has been roasted and macerated in water. Table-case in Recess 6.

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, inside Rome.

197.—FETID LIMESTONE (*stinkstone*).—From the peperino of Monte Albano.

198.—WHITE MARBLE (*metamorphic limestone*).—From the Peperino of Monte Albano.

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* Nos. 184 to 187 are from the neighbourhood of the Alum Works at Tolfa, near Civita Vecchia.

UPPER GALLERY.

Table-case in Recess 6.

199.—SELENITE.—From the Great Altar, near Tolfa.

200.—WHITE GYPSUM (*alabaster*).—Tolfa.

201.—ARAGONITE.—Monte Cappuccini, 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.

UPPER GALLERY.

Table-case in Recess 6.

218.—STALAGMITE (*commonly called "travertine of Tivoli"*), and found in hollows of large masses at the limestone cavern, near Lake Tartarus.

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.

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* "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 travertin, from four to five hundred feet in thickness."—*Lyell's Principles of Geology*, p. 241.

Upper Gallery. — Table-case 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 Fonte Salaro, 3 miles from Rome.

Lavas and other Products of Eruption from Etna.

Etna.—"After Vesuvius (see p. 161) 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 1100 feet, from which sulphureous vapours are continually evolved. The most grand and original

Upper Gallery.

Table-case in Recess 6.

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.

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 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 orginal forms. But there is no weight in this objection, for the older hills are covered with trees and herbage,

UPPER GALLERY.

Table-case in Recess 6.

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. * * * *

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.

UPPER GALLERY. — Table-case in Recess 6.

243.—EARTHY SCORIACEOUS LAVA, *with small crystals of specular iron.*

244.—LAVA, exhibiting partial fusion, with *augite, mica,* &c.

245.—MICA, *with olivine and augite.*

246.—VESICULAR SCORIACEOUS LAVA. (Eruption of 1819.)

247.—TWISTED LAVA AND SCORIÆ, from the great crater. (Eruption of 1805.)

248.—BASALTIC LAVA *with olivine,* and crystals of *glassy felspar.* (Eruption of 1836.)

249.—SCORIACEOUS LAVA, with minute crystals of *specular iron,* from Monte Rossi. (Eruption of 1669.)

250.—LAVA, partially vesicular; from the desert region. "The desert region is a kind of plain covered with black lava and scoriæ, from which springs the cone of eruption to a height of about 1100 feet."

251.—VESICULAR SCORIACEOUS LAVA, with crystals of *glassy felspar.*

252.—SCORIACEOUS LAVA, from the Grotto Longo.

253.—SCORIACEOUS LAVA, thrown from the great crater in 1802.

254.—VESICULAR LAVA, in contact with augitic lava, from the desert region.

255.—Four specimens of SCORIACEOUS LAVA. (Eruption of 1669.)

256.—BASALTIC LAVA, with *augite and olivine,* from Licatia, above Catania.

257.—*Fragments of* VOLCANIC BOMBS, ejected from the great crater in 1805.

258 and 259.—Two specimens of VOLCANIC BOMBS, from the side of the great cone. (Eruption of 1838.) Presented by Warington W. Smyth, F.G.S.

260.—VESICULAR LAVA, from the neighbourhood of Monte Mompeloso.

261.—SCORIACEOUS LAVA, of the kind which overwhelmed Malpesso in 1669.

262.—LAVA from a "*bocca*," shewing 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 in Recess 6.

LIST OF SPECIMENS

IN

Wall-cases 4 and 40 to 46,

Classed according to the Order of Superposition of the Rocks, chiefly British.

BY A. C. RAMSAY AND H. W. BRISTOW.

TABLE OF STRATA.

Recent and Tertiary or Cainozoic.

RECENT.

Stalactites, **Case 40,** Nos. 1, 3, 4, 5, 7, 10, Page **31.**

Stalagmites, **Case 40,** Nos. 11, 16, Page **31, 32.**

Calcareous Tufa and Travertine, **Case 40,** Nos. 25, 26, 27, 28, 29, 30, 31. Pages **33, 34.**

Clay with shells, **Case 41,** No. 144, Page **54.**

Specimens from existing Alpine Glaciers and their (probably) recent extension, Table-case in **Recess 41,** Nos. 1 to 6, Page **4** ; 7 to 15, Page **5** ; 24 to 26, Page **6** ; and 30 to 36, Page **8.**

PLIOCENE.

NEWER PLIOCENE.

Conglomerate, **Case 41,** No. 27, Page **43.**

„ **Case 41,** No. 9, 14, 15, 21, 28, Pages **41, 42, 43.**

Stalagmitic Conglomerate, **Case 41,** No. 32, Page **44.**

Specimens from the ancient extension of existing Alpine Glaciers, &c., **Recess 41,** Nos. 16 to 19, Pages **5** and **6** ; 28 and 29, Page **7** ; and 37 to 39, Page **8.**

Drift and Glacier specimens of Britain and the Vosges, **Recess 41,** Nos. 50 to 58, and 60 to 96, Pages **8** to **22.**

Norwich Crag, **Case 52.**

Older Pliocene.

Red Crag.
Coralline Crag.

MIOCENE.

Tertiary clays of Mull ?
Bovey lignite ?

EOCENE.

Upper Eocene.

Hempstead beds. Iron ore from Hempstead clay, **Case 43,** No. 162, Page **90.**

Bembridge limestone, **Case 43,** No. 95, Page **83.**

Middle Eocene.

Osborne beds. Limestone. **Case 43,** No. 91, Page **81.**

Headon beds. Sand. **Case 41,** Nos. 109, 110, 111, Page **50.**

Ditto. Limestone. **Case 43,** Nos. 92, 93, Page **82.**

Upper Bagshot. (Sands.)

Middle Bagshot.

Barton clay.
Bracklesham sands.

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Lower Bagshot Sands.

Pipeclay, **Case 41,** Nos. 135, 135a, 135b, 136, Page **53.**
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Lower Eocene.

London Clay.

Sand, **Case 41,** No. 106, Page **50.**
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Plastic Clay.

Clay, **Case 41,** Nos. 139, 145, Page **54.**
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Thanet Sand.

Sand, **Case 41,** No. 119, Page **51.**

Secondary or Mesozoic.

CRETACEOUS.

UPPER CRETACEOUS.

Chalk.

Chalk, **Case 43,** Nos. 99, 100, 101, Page **83.**
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With Mr Ramsay's Compliments

A

DESCRIPTIVE CATALOGUE

OF THE

ROCK SPECIMENS

IN THE

MUSEUM OF PRACTICAL GEOLOGY,

WITH EXPLANATORY NOTICES OF THEIR NATURE AND MODE OF OCCURRENCE, AND OF THE PLACES WHERE THEY ARE FOUND.

BY

ANDREW C. RAMSAY, F.R.S.,
LOCAL DIRECTOR,

HENRY W. BRISTOW, F.G.S., AND HILARY BAUERMAN,
GEOLOGIST, ASSISTANT GEOLOGIST,

OF THE SURVEY OF GREAT BRITAIN.

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