A

DESCRIPTIVE CATALOGUE

OF THE

ROCK SPECIMENS

IN THE

MUSEUM OF PRACTICAL GEOLOGY,

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

BY

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AND

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NOTICE TO THE FIRST EDITION.

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

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

RODERICK I. MURCHISON,
Director-General.

Museum of Practical Geology,
April 16, 1859.

[7286—1000—10/62.]

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INTRODUCTION.

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

1st. Lithological, illustrative of the nature of 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, as originally arranged, the first was 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, lava, volcanic tufa or ash, and, indeed, all the varieties of stony substances that are of common occurrence. Of late, however, the specimens have so much increased in number that it has been deemed better to arrange the rocks in stratigraphical succession, so as to give a clear idea of the lithological structure of all the British rocks in that order. A table of the order of superposition of the different Formations precedes the list of specimens.

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 and volcanic rocks; the Old Red Sandstone and Devonian rocks, chiefly of red marl, sandstone, conglomerate, slaty rocks, and gneiss; and the Silurian and Cambrian rocks in great part of mudstones, grits, and slaty rocks, with occasional shales, limestones, and beds of conglomerate, sandstone, and grit, and various igneous rocks, many of which are truly volcanic. This is the Welsh and English type, but in Scotland the Lower Silurian strata are to a great extent metamorphic. Such is the general nature of the rocks in Britain; but in other parts of the world there are local peculiarities. Thus the Secondary limestones of the Alps are often crystalline, and the shales are cleaved and slaty, or even changed into gneiss. This can be easily understood in reading special works after the student has studied the rocks of his own region.

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

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

In the other CASES in the galleries of the Museum devoted to the collection of fossils, the student will frequently find illustrative specimens of rocks. These of themselves give some idea of the nature of the different formations, and may be regarded as a kind of stratigraphical collection of rocks, and what is of more importance, in these CASES he will also find suites of fossils illustrative of their order of succession in the British formations. *See* pp. 287 to end.

The collections of ores and other minerals on the principal floor show the economic substances afforded by the rocks. Together they form a kind of handbook to British geology.

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

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

The arrangement of the rocks described in this catalogue was planned and the whole superintended by myself. I also described all the Palæozoic and some of the Lower Secondary rocks, with the exception of the Laurentian, Silurian, and Carboniferous rocks of Scotland, which are by Mr. Geikie. The glacial specimens are also described by myself. The Secondary and Tertiary rocks were chiefly arranged and described by Mr. Bristow, who also described most of the volcanic products. The CASE of Vesuvian specimens was arranged by Mr. Bauerman.

ANDREW C. RAMSAY,
Director of the Geological Survey of Great Britain.

**Museum of Practical Geology,
May 1, 1862.**

The following Table shows the Succession of the British Formations, beginning with the newest Strata.

Table of British Formations.				Wall-case.	Shelf.	Number.
Cainozoic or Tertiary, and Recent.	Recent and Post-Tertiary.		Blown Sand of various ages	7	6	164
			Alluvium "			
			Peat "			
			Raised Beaches "	7	2	120 to 129
			Cave Deposits "	6	7	97 to 111
			Valley-, or Low-level Gravel	6		112 to 119
			Brick Earth "			
	Pliocene. Newer Pliocene.		High-level Gravel and Glacial Drift (Till and Boulder Clay) of various ages			
	Pliocene. Older Pliocene.		Cave Deposits	6	7	97 to 111
			Mammaliferous Crag (Norwich Crag)	6		
			Red Crag	6	7	92 to 94
			Coralline Crag	6	7	89 to 91
	Miocene.		Leaf Bed of Mull*			
			Lignite of Antrim			
			Bovey Beds	6	7	84
	Eocene. Upper Eocene.	Hempstead Beds.	Corbula Beds; Upper Freshwater and Estuary Marls; Middle " "; Lower " " (Fluvio-Marine)	6	7	83
		Bembridge Beds.	Bembridge Marls; " Limestone (Fluvio-Marine)	6	7	82
	Eocene. Middle Eocene.	Osborne Beds.	St. Helen's Sands; Nettlestone Grits (Fluvio-Marine)	6	7	81
		Headon Beds	Upper Headon Beds; Middle " "; Lower " " (Fluvio-Marine)	6	7	76 to 80
		Bagshot Beds	Upper Bagshot Sand	6	7	75
			Middle " { Barton Clay; Bracklesham Beds }		6 & 7	59 to 70
			Lower " Sand and Pipeclay		6	52 to 58
	Eocene. Lower Eocene.		London Clay and Bognor Beds	6	5 & 6	32 to 51
			Woolwich and Reading Beds (Plastic Clay)		1 & 5	14 to 31
			Thanet Sands		5	13

* Lower Gallery, Wall-case 11, Shelf 4.

Era	System	Series	Group	Formation	Beds	Wall Case.	Shelf.	Number.
MESOZOIC OR SECONDARY.	CRETACEOUS.	Upper Cretaceous.		Chalk	Upper Chalk	6	5	114 to 130
					Lower „			
					Chalk Marl			113
					Chloritic Marl			112
					Upper Greensand	6	4	98 to 111
					Gault	6	4	86 to 97
		Lower Cretaceous.		Lower Greensand.	Folkestone Beds	6	3	55 to 85
					Sandgate Beds			
					Hythe Beds (Kentish Rag)			
					Atherfield Clay			
			Wealden.		Weald Clay	6	3	43 to 54
				Hastings Sand.	Upper Tunbridge Wells Sand	6	2 & 3	1 to 42
					Grinstead Clay			
					Lower Tunbridge Wells Sand			
					Wadhurst Clay			
					Ashdown Sands			
					Ashburnham Beds			
	OOLITE.	Upper Oolite.		Purbeck	Upper Purbeck Beds	5	1 to 7	34 to 39
					Middle „ „			16 to 33
					Lower „ „			1 to 15
				Portland	Portland Stone	46	7	75 to 85
					„ Sand		7	73 & 74
					Kimeridge Clay		6 & 7	67 to 72
		Middle Oolite.		Coralline Oolite.	Upper Calcareous Grit	46	5 & 6	50 to 66
					Coral Rag			
					Lower Calcareous Grit			
				Oxford Clay	Oxford Clay and	46	5	55
					Kellaways Rock			53 & 54
		Lower Oolite.		Forest Marble	Cornbrash	46	4 & 5	51 & 52
					Forest Marble and			36 to 50
					Bradford Clay			
				Great Oolite	Great or Bath Oolite	46	1 & 3	30 to 35
					Stonesfield and Collyweston Slate and			
					Northampton Sands			20 to 29
				Fullers Earth	Upper Fullers Earth	46	3	15 to 19
					Fullers Earth Rock			
					Lower Fullers Earth			
				Inferior Oolite.	Ragstone and Clypeus Bed	46	1 & 2	1 to 14
					Upper Freestone			
					Oolite Marl			
					Lower Freestone			
					Pea Grit			
			LIAS.	Upper Lias	Lias Sands	45	7	37 to 42
					„ Clay and Shale			34 to 36
				Middle „	Marlstone	45	7	19 to 3 31
				Lower „	Lias Clay, Shale and Limestone	45	5 & 6	1 to 7

						Wall-case.	Shelf.	Number.
MESOZOIC OR SECONDARY—*cont.*	TRIAS.	Upper Trias.	Koessen Beds	White Limestone or Westbury Beds -		45		61 to 67
				Bone Bed - - - - -				48 to 57
			Keuper -	Red Marl and Upper Keuper Sandstone		45	2 & 3	18 to 34
				Lower Keuper Sandstone and Marl (Waterstones) - - -				8 to 17
		-	-	*Muschelkalk, absent in Britain* - -				
				St. Cassian Beds, ,, - -				
				Dolomitic Conglomerate (of Keuper or Bunter age, Somerset and Gloucester) - - - - -		45	3 & 4	35 to 47
		Lower Trias.	Bunter	Upper Red and Mottled Sandstone -		45	2	absent
				Pebble Beds - - - - -				4 to 6
				Lower Red and Mottled Sandstone -				1 to 3
PALÆOZOIC OR PRIMARY.			Permian	Upper Red Marl - - - -		-	-	
				Upper Magnesian Limestone, Lower Red Marl - -, Lower Magnesian Limestone } Zechstein.		44	1 to 7	22 to 36
				Red Marl, Sandstone, Breccia, and Conglomerate (Röthe-liegende) -		44 S. side	1 to 5	1 to 21
	CARBONIFEROUS SERIES.*			ENGLAND.	SCOTLAND.			
			Coal Measures.	Upper Coal Measures -	- -	43 & 44 N. side	1 to 7 North side	130 to 233
				Middle ,, Pennant Grit. Lower Coal Measures	Upper Coal-Measures			
				Gannister Beds -	- -			
				Millstone Grit (Farewell Rock)	Moor Rock	43 & 44	6	130 to 132
			Carboniferous Limestone.	Upper Limestone Shale (Yoredale Rocks.) Carboniferous Limestone.	Upper Limestones, Edge Coals Series, Lower Limestones			
				Lower Limestone Shale.	Sandstones, Shales, and Burdie House Limestone.			
	OLD RED SANDSTONE† AND DEVONIAN.		Devonian -	Upper Devonian and Petherwin Limestone - - -		43	3 to 5	1 to 98
				Middle Devonian Limestone and Cornstones - - - -				
				Lower Devonian - - -				
	SILURIAN.	Upper Silurian.		Tilestone - - - - -			3	517 to 523
			Ludlow -	Upper Ludlow - - - -		43	3	506 to 523
				Aymestry Limestone - - - -				
				Lower Ludlow - - - -				
			Wenlock -	Wenlock Limestone - - -		43	4	498 to 505
				Wenlock Shale, Sandstone, and Flags				491 to 497
				Woolhope Limestone - - -			2	488 to 490
				Denbighshire Grits, Shales, Slates, and Flags - - - - -			2	480 to 483
				Tarannon Shale (Pale Slates) -		42		468 to 480
				Upper Llandovery Rock - -				
				(May Hill Sandstone) - -				
				(Pentamerus Beds) - -				

* A collection of specimens representing the Carboniferous Formation of Scotland, arranged in Table-cases D and E, and described at p. 82.

† The Old Red Sandstone of Scotland is represented by the specimens in Table-case D, and described at p. 75.

					Wall-case.	Shelf.	Number.
PALÆOZOIC OR PRIMARY—*cont.*	SILURIAN—*cont.*	Lower Silurian.*		Lower Llandovery Rock - -	42	5 & 6	458 to 467
				Caradoc or Bala Beds - -	41 & 42		344 to 436
			Llandeilo -	Upper Llandeilo Flags and Limestone, &c. - - - - -	1 and 42	2 to 6	210 to 342
				Tremadoc Slates - - -			206 to 209
				Lingula Beds - - - -	41	2	195 to 205
		Cambrian.†	Cambrian -	Harlech Grits, &c. - - -	40	1	23
				Purple Slates and Grits (St. David's) -		6	92 to 106
				Llanberis Grits and Slates - -		1 to 3	24 to 56
				Longmynd Rocks - - -		6	107 to 114
				Red Sandstone and Conglomerate (Scotland).		1	19 to 22
		Laurentian.	- - -	Gneiss of the Lewis, &c. - -	40	1 & 2	1 to 18

* All the specimens in Wall-cases 41 and 42, numbered from 139 to 467, are Lower Silurian.
† The Cambrian rocks are contained in Wall-cases 40 and 41, and comprise all the specimens numbered 1 to 138 inclusive.

DESCRIPTIVE CATALOGUE.

METAMORPHISM OF ROCKS,

By A. C. Ramsay, F.R.S.

The oldest known rocks in Britain are metamorphic, consisting of the crystalline gneiss of Lewis and the N.W. of Scotland, considered to be the equivalents of the Laurentian gneiss of Sir William Logan in Canada. The geological horizon of these rocks was first definitely established by Sir R. Murchison. It is necessary to give some account of the phenomena of metamorphism in this place, and the following remarks may be looked on as in general equally applicable to the Laurentian gneiss, the gneissic rocks in Anglesey, the Lower Silurian gneiss, mica-schist, &c., of the north of Scotland, and to part of the Devonian rocks of Devonshire.

The specimens which illustrate the Scotch *gneissic* series are necessarily imperfect, the Geological Survey not having yet been much engaged on these districts. The influences which altered these rocks are different from those produced by the mere contact of small masses of igneous with stratified rocks. It will be observed that *mica-schist*, *gneiss*, &c., possess a *laminar* structure, in which various minerals are arranged, frequently in wavy lines, more or less distinct. This structure is called foliation. Typical *gneiss* consists of irregular alternating layers of *quartz*, *felspar*, and *mica*, these being also the constituents that form granite. Perfect and gradual passages may often be traced from common *shales*, *slates*, and *grits*, into true *mica-schist* and *gneiss*, and *gneiss* sometimes passes imperceptibly into *granite*. The evidence may therefore be considered as perfect, that gneissic rocks have been *metamorphosed*, or in other words, that they have assumed different mineral characters from what they possessed as original sediments. This has been understood and believed by most geologists since the days of Hutton,* but the causes that produced these changes are as yet only imperfectly explained.

For long the laminar structure of gneissic rocks was a mystery. They frequently lie in wavy layers (No. 190), or else in small and rapid contortions (Nos. 60 and 446). 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 with granite, was made from the waste of that rock, and 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 known that gneissic rocks and granites are of every geological age.

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* "Theory of the Earth."

The subject involves much discussion, but it may be briefly stated that enough is known to make it certain, that, when under metamorphic action, distinct minerals are developed that do not appear in the unmetamorphosed strata; it is not that new substances are created there, but as a rule simply that the rocks themselves originally contained certain constituents, which chemically re-arranged themselves according to their affinities, probably in all cases under the influence of slow and long applied heat and moisture. The only cases in which new substances could appear, would be by the occasional infusion of gases and moisture, containing new ingredients, and it is probable that the development of minerals in metamorphic rocks has sometimes been in this manner modified. It would be easy to find unaltered shale, slate, a piece of gneiss, and a piece of granite, of which the ultimate chemical constituents would agree as nearly as they would in two distinct pieces of shale or of gneiss. Gneiss is composed of free silica or quartz; felspar, which is essentially a silicate of alumina, soda, potash, or lime; and of mica, the chief ingredients of which are silica, alumina, potash or magnesia, and peroxide of iron. In any shale or slaty rock most of these ingredients will occur, and in ordinary metamorphic rocks they are merely re-arranged and modified under peculiar chemical and physical influences.

I must now refer to the phenomena of cleavage. (See Nos. 35 to 55.), Mr. Charles Darwin in his 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 is incorrect, and it has been shown by Sir R. Murchison that the foliation of the Silurian rocks of Scotland coincides with the planes of stratification, and that the great anticlinal and synclinal lines actually represent the curvatures of the strata; or, in other words, that the foliated masses of the Highlands lie in great planes of stratification, like those of the Laurentine hills in Canada. Professor Henslow observed, in 1821, that the foliation of the rocks of Anglesey bears a general relation to the planes of bedding. This I can verify from personal knowledge to a great extent. The same is the case in the Island of Arran. The rocks of North Wales are in general highly cleaved, but the metamorphism of the Anglesey rocks preceded the disturbances that produced cleavage. There is, therefore, no necessary connection between cleavage and foliation; and it may perhaps be considered a near approach to the truth, "that if rocks be uncleaved when meta-" morphism 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 granite to gneissic rocks, and of their frequent passage into each other, is obvious, and, from their frequent occurrence together, it may be considered that they are intimately related, the gneissic structure being in some manner connected with the fusion of associated granite. All geological evidence tends to prove that, as a rule, large masses of granite cooled and consolidated slowly, and deep beneath the surface. One result of this on any view would be, that neighbouring rocks, sometimes fused, or on the verge of fusion, would, on cooling, pass gradually into granite ; but the more correct view is that, in many cases, granite and granitic rocks are the actual result of the complete fusion, with presence of water, and subsequent crystallization of the very same strata, that, less altered, have been changed into gneiss. This conclusion is favoured by the circumstance that the presence of granite, syenite, and their allies, often seems due, not to the intrusion of a mass thrust through opposing strata, but rather to the eating away by fusion of a portion of the strata themselves. Under any circumstance, both the granite and the adjoining rocks would for a long time remain in a heated condition; and, further off, if, under the influence of heat and moisture, chemical action in the softened rock occurred, then its constituents more or less re-arranged themselves according to their affinities, in layers, wherever circumstances would allow, most likely showing a tendency to form in the direction of pre-existing lines of stratification when these formed the principal planes, or of cleavage, when in homogenous masses, it had been so strongly superinduced that the rock would split in the cleavage-planes in preference to those of stratification.

Wall-case 40.

LAURENTIAN ROCKS.

Arranged and described by ARCHIBALD GEIKIE, F.R.S.E.

ALONG the western shores of Sutherland and Ross, and forming also the singularly indented chain of the outer Hebrides, there is a gneissose rock of a highly crystalline character, which, both in its general lithological features and in its geological relations, differs from every other gneiss in Britain. Its rugged and contorted laminæ are arranged in a direction from N.W. to S.E., that is, at a nearly right angle to the prevalent strike of the country. It is sometimes a granitic gneiss of the usual composition, sometimes it passes into a hornblendic rock, or it seems to shade into granite. It contains in the Isle of Lewis some large masses of granite, and veins of granite and of a red quartziferous porphyry are abundant both in the Hebrides and on the mainland. Parallel with the general strike of its foliation, there are here and there some intercalated bands of limestone, as along both shores of Loch Maree. No fossils have yet been found in these beds. The gneiss is covered unconformably by Cambrian and Lower Silurian rocks, and is thus the oldest rock in the British Islands. From this geological position it has been classed with a similar set of rocks forming the Laurentian group of Canada.

The following eighteen specimens from this fundamental or Laurentian gneiss of Scotland show some of the more ordinary characters of the rock, as these may be gathered from hand specimens.

Specimens 1 to 10 inclusive illustrate the general character of the Laurentian gneiss of the Island of Lewis. Those from 11 to 17 inclusive are from the formation as developed on the mainland.

1. Gneiss.
Stornoway.
Composed of quartz, felspar, and brown mica, arranged in distinct wavy laminæ.

2. Gneiss.
Stornoway.
In this specimen only two of the ingredients of true typical gneiss are present, hornblende and quartz, disposed, as in the previous instance, in a distinctly lamellar arrangement.

3. Gneiss.
Morsgail, Lewis.
A binary compound of the same minerals as in No. 2. The quartz and hornblende are more distinctly crystalline, the latter mineral being visible in well marked crystals interspersed through the quartz. The laminated structure is distinct.

4. Gneiss.
Morsgail.
This rock is almost a hornblende rock. It contains a slight admixture of felspar in addition to the hornblende and quartz, is finely crystalline, and retains the laminated structure as shown by the irregular veinings of quartz.

5. Hornblende Rock.
Loch of Morsgail.
An aggregate of fine hornblende crystals, arranged in a schistose manner. The quartz and felspar being absent, the rock takes the name of the mineral of which it is composed.

6. Hornblende Rock.
Loch of Morsgail.
An aggregate of hornblende crystals, with a little felspar, but without any trace of lamination. The characteristic bronze lustre of the hornblende is well shown on some of the partially weathered surfaces, and close to the outer crust the small white crystals of felspar are exposed by their partial decomposition.

7. Hornblende Rock.
Stornoway.
A crystalline compound of hornblende and quartz, the former being in excess. Along with the hornblende a little epidote occurs, giving a leek-green tint to parts of the specimen.

8. Hornblende Rock.
Morsgail.
A granitic compound of black hornblende and pale quartz.

9. Granitic Gneiss.
Dalbeg, West Coast of Lewis.
A highly crystalline aggregate of felspar and hornblende, with a little quartz. The hornblende is drawn out in parallel layers, giving a foliated structure to the specimen. This rock, which is itself almost a granite, passes into No. 10.

10. Granite.
Dalbeg.
Composed chiefly of felspar, with a little hornblende and quartz, and a few scattered scales of mica. In this specimen it will be seen that the foliated structure is not wholly absent, the hornblende being still faintly arranged as in No. 9, along more or less determinate planes.

11. Hornblendic Gneiss.
Rhiconich, head of Loch Inchard, Sutherlandshire.
The foliated arrangement of the felspar, hornblende, and quartz in this specimen is distinctly perceptible, traversed obliquely by a vein of felspar which contains a little quartz.

12. Gneiss.
Loch Inver, Sutherlandshire.
Hornblende and quartz, with a little felspar and a few minute specks of iron pyrites, shewing an irregularly laminated arrangement.

13. Hornblende Rock.
Letterewe, N.E. side of Loch Maree, Rosshire.
An aggregate of fine hornblende crystals arranged in a faintly schistose manner.

14. Limestone.
From a bed in the gneiss at *Letterewe*, striking N.W. and S.E. along the N.E. bank of Loch Maree, Rosshire.

15. Talcose Limestone.
Letterewe.

16. Actinolite in the Limestone of Letterewe.

17. Limestone.
Letterewe.
This specimen shows the appearance of the rock on a weathered surface.

18. LIMESTONE.
Island of Tiree.
The island of Tiree consists almost entirely of gneiss, containing masses of limestone. One of these is an irregular rock of flesh-coloured limestone, about a hundred feet in diameter, lying amongst the gneiss without stratification or continuity. The limestone is of a reddish hue, varying from a high flesh-colour through pink to nearly white, and from a muddy crimson to a dull purple, and often also with a greyish aspect bordering on blue. It contains occasionally large concretions of black, shining hornblende, of two inches or more in length, but is most distinguished by the quantity of augite dispersed through it in the form of sahlite, presenting large distinct imbedded crystals, an inch in length, of a dark green or nearly black colour. Its most common appearance, in which it is generally known as forming a constituent part of the limestone, is in the form of coccolite, consisting of small irregular grains, sparingly dispersed or accumulated in larger or smaller groups.

The fine grain and close texture of this stone render it well suited for ornamental purposes. A polished block is placed over the fire-place in the library, as a support to the bust of Sir H. T. De la Beche. A polished cube (No. 376) of this marble is also placed in Table-Case III. in the Lower Hall.—(*See* M'Culloch's Description of the Western Islands of Scotland, vol. i., p. 48.)—H. W. BRISTOW.

ARCHD. GEIKIE.

Wall-case 40.—*continued.*

CAMBRIAN ROCKS.

Arranged and described by A. C. RAMSAY, F.R.S.

The specimens of Cambrian rocks in the Cases are from the following districts: the north-west Highlands of Scotland; Merionethshire, near Harlech; Caernarvonshire, near the Menai Straits; Anglesey; North Pembrokeshire, near St. David's; the Longmynd in Shropshire; and Charnwood Forest in Leicestershire.

SCOTLAND.

Nos. 19 to 22 are from the Highlands of Scotland. It is by no means certain that the rocks from whence they were taken are the equivalents of the English and Welsh Cambrian strata, which everywhere seem to pass *conformably* under the Lower Silurian beds. In Scotland on the contrary they are quite unconformable.

The classification of the older Scottish strata north of the Grampians was first established by Sir Roderick Murchison in the year 1858, thus entirely revolutionizing previous ideas of the geology of the north of Scotland. The Cambrian rocks lie unconformably on the Laurentian gneiss, and the Lower Silurian strata unconformably on both.

The specimens are as follows:—

19. FINE CONGLOMERATE.
The Gwalin, Stornoway.
Well-rounded pebbles and grains of quartz and felspar in a pinkish felspathic base.

20. CONGLOMERATE.
W. side of Brood Bay, Stornoway.
Pebbles of gneiss in a matrix of carbonate of lime, and partly coated with hæmatite. Some of the gneiss blocks in this conglomerate are 3 feet long.

21. CONGLOMERATE.
From lower beds at the Gwalin, Stornoway.
Well-rounded pebbles of grey and pinkish quartz in a sandy felspathic base.

22. PEBBLY GRIT.
From the base of Beinn Sleugach, head of Loch Maree, Rosshire.
It consists of rounded grains of white quartz cemented in a matrix of pinkish felspar, which on weathered parts disappears, leaving the quartz grains standing out in carious surfaces.

Introductory Remarks on the Cambrian and Lower Silurian Rocks of Wales, &c.

The greater proportion of the specimens in Cases 40, 41, 42, and 43, illustrate the relations of the igneous rocks of Wales to the Cambrian and Lower Silurian strata with which they are associated. The sections at the top of the Cases explain these relations, which are described in this place, for though chiefly relating to the Silurian epoch, the neighbouring Cambrian rocks have also been affected by some of the igneous masses. Each section has a title showing the country it traverses. The rest of the writing indicates the names, places, and, in some degree, the nature of the different kinds of rocks that form a great part of Wales, &c. A careful inspection of these sections, with a little knowledge and thought, will show the order of superposition of the different stratified masses that compose the country.

The *Cambrian rocks lie at the base of all*, and are coloured *grey*. (Sections 1, 4, and 8 at and near their left ends, and 4 and 5 on the extreme right.)

The *Lower Silurian rocks* succeed these, and consist at the base of Lingula and Tremadoc beds, above which lie the Llandeilo Flags, and these are succeeded by the Caradoc or Bala beds, and Lower Llandovery rocks. 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 those volcanic rocks which are interbedded or contemporaneous with the Lower Silurian rocks of Wales.

The *Upper Silurian* (Cases 42 and 43) 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*. The term *eruptive* is often ambiguous, and in this instance, for want of a better word, I mean all *those bosses, dykes, &c., not surface lavas, that lie among the other rocks, and may even in some cases consist of parts of the strata amid which they lie, that have themselves been melted*. The word *contemporaneous*, applied to igneous rocks, is here used to signify that *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. Some of the so called irruptive masses may, however, be of the same age. Volcanic ashes or tuffas are truly stratified deposits, and lava-flows may also in a measure be spoken of as strata, in the sense that they are *inter-bedded*.

The *eruptive rocks* of the Cases and sections are of two chief kinds :—

1st. FELSPATHIC AND QUARTZ PORPHYRIES AND SYENITE.

2nd. GREENSTONES, many of which are largely crystalline.

The first are coloured deep scarlet (Sections 1, 4, and 8). Their nature will be seen by referring to the specimens in the Cases. *Numbers corresponding to those on the specimens are written on the sections above the masses of rock from which the specimens were derived.*

No. 224.—*Syenite.* See Section 4.

24.—*Quartz Porphyry.* See Sections 1 and 4.

These and others of like nature occur in large masses, the strata adjoining them being altered. (Section 4, and specimens 25 to 31.) In the sections (Nos. 1 and 4) four of these masses lie among the Cambrian, and three among the Lower Silurian rocks. Many others occur in Wales not crossed by any of the sections. Their structure, mode of occurrence, and the effects they produce, show that those parts of them we now see, being melted, *cooled and consolidated deep beneath the surface;* that is to say, that *the surfaces now exposed were originally covered up by great and thick masses of overlying rocks, which have since been removed by denudation*, or, in other words, by the gradual stripping away of such overlying masses by atmospheric and various watery agencies.

The *Greenstones* are coloured *deep crimson*, and appear in all the sections, cutting 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 271, 307, &c.) at other times well crystallized, as in 230, 328, 333, &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 lie more or less between the beds* of stratified rocks.—(See *Moel Siabod*, section 1; section 2, near Builth; *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 abruptly, across it. It is more than doubtful if they are ever truly *contemporaneous*, one proof of which is, that the slates or other beds which they pierce, are found to be 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 surfaces over which they flowed, but being cooled, the muddy sediments, which fell on the upper surfaces of the lavas, would remain unaltered. This is the case with all the truly bedded felspathic lavas, afterwards to be mentioned. Another proof of the intrusive character of the greenstones is that they frequently branch. They are often columnar, the columns lying at right angles to the dip of the rock. In the district under review they never penetrate the Upper Silurian strata, and as they generally partake of the curves or contortions that affect all the rocks of Wales, it is inferred that they were injected amid the beds before the deposition of the Upper Silurian rocks, and consequently before the disturbances took place that produced the sweeping undulations of the strata. (See sections named above.)

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

1st. Felspathic Porphyries or Lava Beds.

2nd. Felspathic and Calcareous Volcanic Ashes.

The first are coloured light vermilion. The specimens from Nos.

233 to 239 and 374 to 377 are characteristic of this class of rocks, especially from 374 to 377. In 237 the *porphyritic* character is well exhibited, small crystals of yellow felspar being set in a dark blue base. 238 shows the *scoriaceous surface* of an old lava bed, and 374 and 375 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 Y Glyder-fawr, on Snowdon and Moel-wyn, and on Y Dduallt and Aran Mowddwy. They lie perfectly interbedded among the slaty and gritty strata, and partake of all their curves, showing that long after the formation of sedimentary and igneous rocks they have been disturbed together. (See section No. 1, Y Garw and Y Glyder-fawr, and No. 4, Snowdon and Moel-wyn.) *Under* each bed of *felstone the slate or grit is altered,* that is to say, it is hardened, and, as it were porcelainized or baked, and *above* each lava-bed the stratum is in its ordinary condition, proving that the lava flowed over the under stratum in a melted condition, and that after, or during the process of cooling, the upper sediments were deposited upon it. The strata amid which these felspathic porphyries lie are charged with ordinary Lower Silurian fossils (see the horizontal cases in the gallery below), and this indicates that the Silurian volcanos of the time in this area were partly submarine, or, at all events, that, being volcanic islands rising in the midst of the ocean, many beds of lava flowed far into the sea.

FELSPATHIC AND CALCAREOUS VOLCANIC ASHES OR TUFAS are associated with the other rocks. They are coloured vermilion in the sections, of a paler hue than the felspathic porphyries, and when calcareous, or when they contain much ordinary sediment, they are streaked with blue and light purple. The specimens Nos. 243 to 260, 283 to 306, and 389 to 400, will give an idea of their structure. Nos. 243, 245, 260, 292, 389, 393 to 396, and 400, are eminently typical kinds.

243 and 245, show the *bedded character.*
244 shows the *porphyritic character.*
260 shows *porphyritic and conglomeratic character.*
292 shows the *brecciated* nature of the rock.
389 is formed of agglomerated *lapilli.*
393 to 396 are consolidated *peperinos.*
400 shows a *scoriaceous* character somewhat *conglomeratic.*

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 porphyry that forms the summit of Aran Mowddwy; in No. 8, on the left of Cader Idris, and in No. 9 on Arenig-fawr. It will be seen that *they are marked as stratified. Rarely they contain fossils.* Under the felstones 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 spread in Silurian seas. On *Aran Mowddwy* and *Cader*

Idris they are about 2,500 feet thick, the accumulated result of many eruptions. Passing northward they thin entirely away. On the left side of Arenig-fawr (section 9) the rock marked 238 is the equivalent of that marked 235 to 238 on the Aran Mowddwy and Y Dduallt section (7). There is no ash *under* 238; it has thinned out; but there are other ashes 251, of later date *above* 238 forming the summit of the mountain.

The porphyritic felstones, ashes, and conglomerates of Moelwyn (section 4) are the general equivalents of those of the Aran Mowddwy and Y Dduallt (section 7). 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 (Nos. 374 and 375) 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 felspathic lavas lie on highly fossiliferous grits, and the solid mass that forms the base of Snowdon (section 4) splits into several large divisions as it passes northward to Y Glyder-fawr (section 1). The Snowdon mass is, therefore, the result of several eruptions. On the top of the mountain are ashes, sometimes very solid and felspathic, at other places mixed with calcareous impurities, and fossiliferous.

As a whole, *the North Wales rocks show two principal epochs of eruption, the first indicated by the rocks of Aran Mowddwy* (*section* 7), *Cader Idris* (*section* 8), *Arenig* (*section* 9), *and Moelwyn; the second by Snowdon* (*section* 4) *and Y Glyder-fawr* (*section* 1). In No. 4 both sets occur in the same section, showing a clear order of superposition. It is worthy of remark, that the interbedded felspathic igneous rocks of Moelwyn, dipping under the rocks of Cynicht and Snowdon on the south, do not rise on the north side of the Snowdon synclinal axis (or basin) between the higher part of the mountain and the Cambrian rocks near Y Tryfan. The older interbedded igneous rocks, therefore, thin out between Moelwyn and Snowdon deep under the surface. (See section 4.)

The *eruptive* felspathic and quartz porphyries and syenites (see p. 40) generally lie amid rocks deep under, or of older date than, the *contemporaneous* felspathic lavas and ashes, and it is probable that they indicate parts of great masses of deep-seated melted matter or volcanic centres, that lay far below the craters, but from which the melted rocks and ashes proceeded that were ejected from these vents. As they now stand, these bosses have only been exposed by denudations of vast overlying accumulations of strata, which denudations occurred long after the disturbance of all the rocks of the country.

Though all these rocks are volcanic, or connected with volcanic action, *it is not to be supposed that any volcanic craters in Wales still retain their form.* The whole country has been so much disturbed by subsequent contortion of that part of the crust of the earth, and it has been besides so long and so often subject to denudation, that nothing now remain 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. It is as if Etna were turned on its side and denuded over and over again. The greater part of the lava-streams and beds of ashes are concealed deep beneath thousands of feet of overlying slates and sandstones under which they were buried in Lower Silurian times.

Merionethshire.

The Cambrian rocks of Merionethshire extend from Barmouth to Harlech and the neighbourhood of Ffestiniog, forming a rough mountainous country, bounded on the west by the sea, and on the east and north by the Lingula Flags, which lie conformably above them. They consist chiefly of greenish-grey and purple grits, towards the base interstratified with purple slates. The whole is about 6,000 feet thick, but the base is not reached. Everywhere they are pierced by dykes of greenstone. (Geological Survey Maps 59 N.E., and 75 N.E. and S.E.)

23. Grit, Cambrian.
Hills east of Harlech, Merionethshire.
Grains of clear quartz in a base partly felspathic.

Caernarvonshire.

The *Cambrian rocks* of the north part of Caernarvonshire lie chiefly between the Menai Straits and the Passes of Llanberis and Nant Ffrancon. On the N.W. they are bounded by the sea, and inland they are conformably overlaid by the *Lingula Flags.* As a whole they consist of bluish-purple and purple slates, interstratified with grits and conglomerates. They are most conglomeratic towards the base, and about 1,000 feet of the upper strata consist of greenish-grey and occasionally purplish grits. They are intersected by a few hornblendic greenstone dykes, containing Asbestos in the joints, and at the base of the whole there lies a great mass of quartz-porphyry, about 12 miles in length, extending from the neighbourhood of Llanllyfni to that of the Penrhyn slate-quarries, and crossing Llyn Padarn in its course. A second mass, often granitic in structure, runs from Caernarvon to within a mile of Bangor. Close to these the rocks are much altered, and the specimens in Wall-case 40 are arranged so as to illustrate the series in an ascending order, beginning with the porphyry of Llyn Padarn at the base, and the adjoining altered rocks.

24. Quartz Porphyry.
N.E. side of Llyn Padarn, Llanberis. Map 78, S.E.

Grey compact felspathic base, with interspersed quartz-crystals, and a few crystals of felspar.

Even where good sections exist, it is almost impossible to draw a positive boundary line between this rock and the adjoining altered grits, &c., and in places the passage between them is quite gradual. Occasionally also, even where perfectly porphyritic, the porphyry is traversed by great parallel planes, dipping S.E., and suggestive of bedding. All these circumstances easily suggest the idea that the porphyry is not so much the eruptive cause of the alteration of the adjoining strata, as that it is these very strata themselves melted up. (*See also* pp. 17, 19, 21.)

25. Altered Grit, Cambrian.
N.E. side of Llyn Padarn, Llanberis, Caernarvonshire.

This rock was probably nearly in a state of fusion, and is close to No. 24, into which it almost imperceptibly passes. Like No. 24, it contains granular quartz, which may either be grains of silica in the original grit, or attempts at crystallization of the silica in the altered mass.

26. Talcose and Felspathic Grit, Cambrian.
N.E. side of Llyn Padarn, Llanberis, Caernarvonshire.

Contains numerous granules of quartz similar to those in No. 24, but less crystalline. This rock on the ground is a little further removed than No. 25 from No. 24.

27. Talcose Rock; Altered Grit, Cambrian.
Llyn Padarn, Llanberis, Caernarvonshire. Map 78, S.E.

This rock occurs near the mass of quartz-porphyry, 24.

28. Altered Conglomerate, Cambrian.
N.E. side of Llyn Padarn, Llanberis, Caernarvonshire.

Near No. 24, and a little further removed from it than Nos. 26 and 27. The original pebbles of the conglomerate are indistinctly visible in a greenish-grey felspathic-looking matrix, full of quartz crystalline grains. Pebbles and matrix are alike highly altered, and the approach to fusion has been so near that the pebbles seem to melt into the surrounding matrix.

29. Altered Conglomerate, Cambrian.
N.E. shore of Llyn Padarn, near Llanberis, Caernarvonshire.

This specimen is from a mass very near the quartz-porphyry No. 24. It has originally been a conglomerate, with a felspathic gritty matrix similar to No. 32. The base has been partially fused, and the outlines of some of the pebbles rendered indistinct.

30. Conglomerate, Cambrian.
N.E. side of Llyn Padarn, Llanberis, Caernarvonshire.

A little further removed from No. 24 than No. 29. Base and pebbles both crystalline as above, but the alteration being less than in No. 29, 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. Others 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 in this locality is, however, *at the base* of the series in which the slate-quarries are worked, and the pebbles have therefore been derived from an unknown older territory, similar in structure to the existing Cambrian and Silurian rocks of Caernarvonshire.

31. Conglomerate, Cambrian.
N.E. side of Llyn Padarn, Llanberis, Caernarvonshire.

Further from No. 24, and less altered. The pebbles in their original form are distinctly visible. The base, from alteration, is, however, still porphyritic, and contains numerous imperfect crystals of felspar and granular quartz.

For the general geological position of these rocks *see* Sections above, Nos. 1 and 4, on which the altered rocks are marked Nos. 25 to 31.

32. Felspathic Grit, Cambrian.
Llanberis, Caernarvonshire.

The felspar grains retain their crystalline form.

33. Coarse Talcose Grit, or fine Conglomerate, Cambrian.
N.E. side of Llyn Peris, near Llanberis. Map 78, S.E.

A somewhat talcose rock, containing numerous grains of silica sometimes blue and transparent. Also small pebbles of quartz-rock.

This is the usual form in which the Cambrian grits appear in this neighbourhood, being much less altered when at a distance from the quartz-porphyry.

34. Grit, Cambrian.
Llyn Peris, Caernarvonshire.

Composed of grains of quartz and felspar.

Though excessively hardened, there is no porphyry in the immediate neighbourhood of Nos. 32 to 34. The quantity of alkali in the felspar renders such rocks peculiarly liable to alteration.

The following specimens, Nos. 35 to 57, are illustrative of the phenomena of JOINTS AND SLATY CLEAVAGE.

The jointed rocks in this CASE are not arranged according to any special system. There is so little known about joints, that any systematic arrangement according to definite laws is not yet practicable, although in certain districts systems of joints run in sets of parallel lines, which often cross each other. Their mode of occurrence, and the geometrical forms they give to the rocks they traverse, are obvious in almost every quarry in rocks of all descriptions, and many of these forms are well represented on a small scale in the specimens. The practical use of joints is well understood by quarrymen, both in quarries where the wedge and lever are only used, and in those which are blasted. In both cases they guide the quarrymen as to the method by which masses of rocks may be obtained of the largest size, and with the least expenditure of labour. By using the joints as a guide, large blocks of sandstone, limestone, slate, granite, &c. are detached entire; and in cases where great blasting operations are conducted (as at Holyhead), by running judicious levels and galleries, in accordance with systems of joints, as much as 120,000 tons of quartz rock have been dislodged 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.

35 to 38. Various specimens of CLEAVED PURPLE ROCKS of the Cambrian slaty region of *Llanberis, Caernarvonshire.*

39. GRIT AND SLATE INTERBEDDED, Cambrian.

Cleaved. See description of No. 41.

40. SLATY CONGLOMERATE, Cambrian.

N.E. side of Llyn Padarn, Llanberis, Caernarvonshire. Map 78, S.E.

This remarkable specimen is derived from one of the Cambrian conglomerates that lie lower than the slate of the slate-quarries of Llanberis. The whole country is intensely cleaved. The beds 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 hand-specimens, and even on the ground, *the lines of bedding are exceedingly obscure,* except to the 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,* or at right angles to the direction of the pressure which produced the contortion of the rocks of the country.

41. SLATE AND GRIT, purple and green, Cambrian.

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 slate,* the different beds 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 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 ti joins the coarser gritty band marked ×. *The surface marked B is a cleavage plane.* In the 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 part the cleavage and bedding form an average angle of about 46°. In the coarser grit × the angle is about 16°.

42. Purple Slate, Cambrian.
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 ×.

43. Purple Slate and Grit, Cambrian.
Llyn Padarn.
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.*

44. Banded Slate and fine gritty bands, Cambrian.
Llyn Padarn.
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.

45 to 53. Coarse Purple Slates, Cambrian.
Llyn Padarn.
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 numbers are marked on the cleavage planes.* All the *other planes are joints,* giving various forms to the specimens.

In No. 45, the end joints if prolonged would form a triangle with the others. No. 46 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. 47 to 49 are also rhombs. The joints of 51 and 52 form scalene triangles, the latter imperfect from the interference of a small joint at the base. The joints of 50 originally formed a triangle, but one of the angles has been knocked off at another joint so as to form a four-sided figure. In 46 the planes of the joints if produced would meet at different points, and the same is the case in other specimens.

54. Coarse Green and Purple Slate, Cambrian.
Llyn Padarn, Llanberis.
This specimen shows lines of *stratification* marked green and ash-grey, *traversed by coarse cleavage.*

55. Purple Slate with green spot and ring, Cambrian.
Penrhyn quarries, Caernarvonshire.
Small size.

56. Purple Slate.
Penrhyn, Caernarvonshire.
Imperial size. For want of space, laid in bottom of Case D.

The foregoing specimens, Nos. 35 to 56, illustrate not only the lithological character of the Cambrian rocks of Llanberis, but also in some degree the connexion of joints and cleavage with the manufacture of slates.

In ordinary mechanically stratified deposits, the particles of sediment that form each stratum lie on their flatter sides, that being the position they assume on subsiding from suspension in water. The strata of Wales so deposited, have since been for the most part exceedingly disturbed and contorted. This is common to most mountain regions.

The contortion of the strata must have been produced by great *lateral pressure.* Mere upheaval by a force acting from below would stretch the strata, not crumple them. The intense lateral pressure has produced the cleavage.

Cleavage may be defined to be a re-arrangement of the particles, &c., that enter into the composition of certain rocks so as to produce a fissile structure or a tendency to split in given directions, sometimes accidentally coincident or nearly coincident with planes of stratification, but generally transverse to these at every possible angle. The origin of cleavage has been referred to "electric action" and to "polar" and "crystalline forces." These words, however, convey no definite impression to the mind when viewed in connexion with cleavage, and from the writings of Professor Phillips and Mr. Daniel Sharpe, but especially by the memoirs and experiments of Mr. Sorby and Professor Tyndal, it now begins to be generally understood that *cleavage is the result of pressure induced by those disturbances that have frequently produced contortion of cleaved strata.* It is not the case, however, that all contorted strata are cleaved, although perhaps nearly all cleaved rocks are contorted. Probably all the portions of strata intensely cleaved have been buried deep beneath superincumbent masses when those forces operated that produced cleavage, whereas uncleaved contorted beds were generally so near the surface that they were able more easily to fracture and yield, so that their component particles were not forced by pressure to re-adjust themselves so as to produce cleavage. It is not necessary here to discuss the causes of these disturbances. It is sufficient to recognize the fact that *highly contorted rocks have been subject to pressure* (generally *lateral*) *and that " this force by changing " the dimensions of the rock has so re-arranged the laminar particles " as to cause a very great majority to lie in a plane perpendicular to " it."*—(Sorby.) If these rocks contain water in minute interspaces, these cavities would necessarily be elongated in the same direction.—(Tyndal.) *The whole rocky substance has, therefore, often been compressed into narrower space and stretched in directions* at right angles *to the direction of the pressure*, so that *large bodies*, in many cases, *become visibly compressed, often flattened, and much distorted*, the distortion, for instance, sometimes elongating, and at other times broadening fossils far beyond their ordinary dimensions, and giving unsymmetrical shapes to forms that in their natural state are symmetrical. *The true slaty structure in rocks is always the result of cleavage.* Examples may be seen in innumerable places in Wales, and in none more strikingly than in the well-known slate-quarries of Penrhyn, Llanberis, and Ffestiniog.

In No. 40 we see the effect of the force that produced slaty cleavage on coarse material. In No. 41 the beds are of different degrees of fineness, and the cleavage is wavy and imperfect. From Nos. 41 to 53 joints are shown that traverse contorted strata and divide the rocks into blocks, cubical, rhomboidal, triangular, and of other forms. After blasting, the fallen masses when large are again divided along lines of joint with the wedge and mallet into convenient blocks. These are then split, and cut into slates of various dimensions, according to the shapes and sizes of the various masses, so as to use up the greatest quantity of material. No. 406, Case 42, shows a jointed piece split into three previous to being dressed (the edges cut and squared) into slates. No. 54 shows how cleavage, cutting through beds of various coarseness, makes a rough and imperfect slate. In Nos. 55 and 56, the substance is fine and homogeneous, and the cleavage, therefore, is so perfectly regular that the rock easily splits into smooth slates. This description in great measure also applies to Nos. 55, 56 (Table-case D); and to Nos. 261, 262, 342, 368, and 407, Wall-cases 40 and 41.

Cambrian Rocks of Anglesey.

The Cambrian rocks near Bangor are exceedingly altered, and crossing into Anglesey they assume all the characters of metamorphic strata, consisting in a great degree of mica schist, contorted foliated gneissic rocks, hornblende rock, quartz rock, serpentine, &c., traversed by greenstone and elvan dykes, and associated with bosses and veins of granite. As a whole these are believed to be the equivalents of the Cambrian slates and grits of Llanberis and Nant Ffrancon.

57. Fine Gritty and Slaty Beds, Purple and Grey. Cambrian.

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.*

58. Altered Conglomerate, Cambrian.

Sherries, off the N.W. shore of Anglesey.

The Skerry conglomerate is traversed by dykes, and contains pebbles of altered slate, quartz-rock, granite, &c., and resembles Nos. 30 and 31.

59. Gritty Micaceous Slate, Cambrian.

Llanfechell, Anglesey.

60. Schistose Micaceous Rock, *foliated and contorted,* Metamorphic Cambrian.

Llaneilian, near Amlwch, Anglesey. Map 78, N.W.

From a series of foliated rocks that form great part of the north of Anglesey. Probably most of them are of Cambrian date; but the whole are so metamorphosed that some of the strata may be altered Lower Silurian.

61. Micaceous Slate, *foliated.* Metamorphic Cambrian rock.

Bodwrog, Anglesey. Map 78, N.W.

Composed of foliated *layers of quartz and mica.* Close to a mass of granite 10 miles in length, which extends from near Llanerchymedd to the sea near Llanfaelog.

62. Chloritic Slate. Foliated. Metamorphic Cambrian rock.

Tregaian, Anglesey. Map 78, N.W.

Chloritic matter, with lenticular layers of *quartz.*

63. Altered Rock.

Anglesey.

Occurs in serpentine.

64. Green Serpentine. In metamorphic Cambrian rocks.

Ceryg-moelion, Holyhead Island, Anglesey. Map 78, N.W.

From one of three masses of serpentine on the shores of the straits south of the Holyhead road. The serpentinous rocks of Anglesey and Caernarvonshire are metamorphic. They have a layered (and almost a foliated) look, and are full of small twisted contortions, like the foliated rocks of the country.

65. Green Serpentine.

Ceryg-moelion, Anglesey. Map 78 N.W.

With white *calc spar.*

66. Green Serpentinous Marble.

Ceryg-moelion, Anglesey.

With numerous veins of white *calc spar.*

67. Serpentinous Rock (*marble*).

Ceryg-moelion, Anglesey.

68. Green Serpentine. With *diallage.*

Ceryg-moelion, Anglesey.

69. Diallage Rock.

Ceryg-moelion, Anglesey.

70. Green Serpentinous Rock.

Llanfechell, Anglesey. Map 78, N.W.

With apparently a schistose structure, owing to the presence of minute steatitic veins, in the direction of which the rock is most easily broken.

71. Compact Serpentine Rock.

Llanfechell, Anglesey.

72. GREEN SERPENTINE.
Llanfechell, Anglesey.
With veins of *steatite* and *calc spar.*

73. SERPENTINOUS BRECCIA.
Llanfechell, Anglesey.
Composed of fragments of dark greenish *serpentine* cemented with veins of *steatite.*

74. GREEN SERPENTINE.
Llanfechell, Anglesey.
With apparently a schistose structure.

75. Compact brecciated SERPENTINOUS MARBLE.
Llanfechell, Anglesey.

76. Reddish SERPENTINOUS BRECCIA.
Llanfechell, Anglesey.
Contains fragments of *purple slate* and lines and veins of white *calc spar.*

77. Light green SERPENTINOUS ROCK.
Near Four Mile Bridge, Anglesey.

78. Reddish SERPENTINOUS MARBLE.
Llanfechell, Anglesey.
With fragments of *slate* and veins and lines filled with white *calc spar.*

79 and 80. SERPENTINOUS BRECCIATED MARBLE.
Tre-gela, near Llanfechell, Anglesey.
Compact rock with lines of white *calc spar.*

81. SERPENTINOUS BRECCIA.
Tyddyn-dû, 1 mile south of Amlwch, Anglesey. Map 78, N.E.

82. SERPENTINOUS BRECCIA-MARBLE.
Pen'r allt, Llangefni, Anglesey. Map 78, N.W.

PORTH-DINLLEYN, ABERDARON, &c., CAERNARVONSHIRE.

On the north side of the promontory that divides Cardigan Bay from Caernarvon Bay there is a long strip of metamorphic rock, believed to be of Cambrian age, partly from its position in reference to the adjoining Silurian strata, partly because it nearly resembles the metamorphic Cambrian rocks on the Anglesey shore of Menai Straits.

83. GNEISSIC ROCK, *foliated.*
Aberdaron, Caernarvonshire. Map 76, S.
Composed of foliations of *quartz, silvery mica,* and *calc spar.*

84. GNEISSIC ROCK, foliated.
Aberdaron, Caernarvonshire.
Contains a little hornblende, but no mica.

85. GREEN SERPENTINOUS ROCK.
Porth Dinlleyn, Caernarvonshire.
With a few veins of *calc spar.*

86. GREEN SERPENTINOUS BRECCIA, Cambrian.
Porth Dinlleyn Head, Caernarvonshire. Map 75, N.W.
Traversed by a line of *calc spar.*

87. GREEN SERPENTINOUS ROCK, Cambrian.
Porth Dinlleyn, Caernarvonshire.
With veins of *calc spar* and subangular patches of *red jasper.*

88. RED RIBBONED JASPER.
Porth Dinlleyn Head, Caernarvonshire.
"The rock of Port Dinlleyn Point is a kind of coarse serpentine, with nests of red jasper apparently intruded amid the green quartzose and chloritic schists, which are much contorted on a small scale." (Sir Henry De la Beche.) See similar jasper from Aberdaron, Caernarvonshire. Nos. 83, 84, and 88 are from the series of schistose and gneissic rocks, which stretch along the south side of Caernarvon Bay from Porth Nevin to Bardsey Island. They are associated with serpentine and crystalline limestone, containing much silica.

89. RED JASPER.
Aberdaron, Caernarvonshire.

90. METAMORPHIC LIMESTONE, Cambrian.
Porth-felen, near Aberdaron, Caernarvonshire.
A polished cube of hard, red, compact, siliceous limestone.

91. **Metamorphic Limestone**, Cambrian.

Bardsey Island, Caernarvonshire.

A polished cube of compact limestone, or grey marble, used for making lime.

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

Pembrokeshire.

Near St. David's, Pembrokeshire, the Cambrian rocks rise to the surface in a strip about 10 miles in length, extending from Ramsay Sound on the sea-coast to Llaneithan.

The stratified portion of this district consists chiefly of purple grits and coarse slaty beds, together with talc-schist and altered conglomerates, all intimately associated with masses of felspar porphyry, greenstone, syenitic rocks, &c. As in Caernarvonshire, some of the stratified rocks pass so insensibly into porphyritic masses, that it is impossible to draw a positive line between them. They are therefore in this Case all arranged together to show the nature of the strata and the associated porphyritic and greenstone masses.

92. **Felspar Porphyry.**

Whitechurch, near Solva, St. David's, Pembrokeshire. Map 40.

Greenish-grey and white felspar, the latter crystallized, and a few small hornblendic crystals.

This rock occurs in four bosses north of St. Elvis. They are all of the same character, and very much decomposed on the surface.

93. **Greenstone.**

Solva, St David's, Pembrokeshire.

Light green matrix with white felspar and small dark hornblende crystals; felspar predominates. Intruded in lines.

94. **Amygdaloidal Felspathic Trap.**

Penmaen Melyn, opposite Ramsey Island, 2½ miles S.W. of St. David's, Pembrokeshire.

Green felspathic rock, with kernels and crystals of pinkish felspar; those near the outer surface are browned by oxidation, or entirely removed.

This rock belongs to a mass which, in general character, belongs to the greenstone family; and, as with the neighbouring syenite of Port Lisky, the Cambrian rocks around are so much altered that, on the ground, it is difficult to determine where one ends and the other begins.

95. **Greenstone.**

Penmaen Melyn, St. David's, Pembrokeshire.

Dark blackish-green, compact hornblende and felspar rock.

96. **Cambrian Rock.**

Near Penmaen Melyn, St. David's Pembrokeshire.

Altered near Nos. 94 and 98.

97. **Felstone.**

Between Trewellell and Caerforiog, 3 miles N.E. of St. David's, Pembrokeshire.

Bluish-green compact felspathic rock, with dark green stripes, and small diffused crystals of iron pyrites.

From a mass of syenitic and felspathic rock 7 miles in length, lying among altered Cambrian slates, grits, and conglomerates. It extends from Porth Lisky, 2 miles S.W. of St. David's, to Carnymyl, N.E. of Llanhowel.

98. **Syenitic Rock.**

E. side of Porth Lisky, 2 miles S.W. of St. David's, Pembrokeshire.

Composed of felspar and quartz, with a light green hornblendic mineral.

From the same mass as No. 97.

99. **Claystone Porphyry.**

Porth-bynawyd, south coast, at the N.E. angle of St. Bride's Bay, St. David's. Map 40.

Yellowish-white felspathic rock, with black particles of hornblende and white felspar-crystals. Emits a strongly argillaceous odour.

This rock is in places nearly granitic, and is probably connected with the granite which runs from Brawdy, by Hay's Castle, to the neighbourhood of St. Lawrence.

100. Greenstone.

W. side of Porth Lisky, St. David's, Pembrokeshire.

Compact, dark green rock, composed of felspar and hornblende, and rendered porphyritic by small black hornblende crystals diffused through the mass.

101. Conglomerate, Cambrian.

St. David's, Pembrokeshire. Map 40.

In this specimen the joints cut *through the pebbles.*

102. Porphyritic Conglomerate, Cambrian undecomposed.

Porth Lisky, St. David's, Pembrokeshire.

The alteration of the rocks at Porth Lisky is similar to that illustrated by specimens 25 to 30, p. 11.

103. Felspathic Conglomerate.

Porth Lisky, St. David's, Pembrokeshire.

Decomposing, altered Cambrian rock.

104. Talcose Schist, Cambrian.

Porth Lisky, St. David's, Pembrokeshire.

Near a mass of syenite.

105. Purple Slate.

St. David's, Pembrokeshire.

106. Ancient Roofing Slate, Cambrian.

From Carew Church, Pembrokeshire.

Probably derived from the coarse *Cambrian* slaty beds S. 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.*

The Longmynd, Shropshire.

The Cambrian rocks of Shropshire rise in a hilly region, about 1,700 feet high, between Church Stretton and the Stiper Stones. They are bounded on the west by conformably overlying Lingula Flags, and being much disturbed, heaved on end, and denuded, they, together with the overlying Lingula and Llandeilo beds, have formed an island round which the basement beds of the Upper Silurian strata accumulated.

107. Reddish-Purple Micaceous Grit, Cambrian.

The Longmynd, Shropshire.

108. Reddish-Purple Micaceous Grit, Cambrian.

The Burgs, Shrewsbury.

109. Conglomerate of Water-worn Quartz Pebbles, Cambrian.

The Burgs, Shrewsbury.

110. Pebbles from Conglomerate, Cambrian.

Portway, Longmynd.

Pebbles of waterworn quartz and felstone. Originally derived from an old formation of unknown age.

111. Altered Shale or Slate, Cambrian.

Yearling Hill, Longmynd, near Church Stretton.

This rock weathers brown, but is green when freshly fractured. It is hard, flinty, and porcelanic, and is pierced by greenstone dykes in places. The surfaces, as shown in this specimen, are frequently ripple-marked, and annelide (worm) tracks and burrows are common in them, traces of which are seen in the pitted surface of this specimen.

112. Altered Shale or Slate, Cambrian.

Yearling Hill.

Ripple-marked, the surface of one of the beds is pitted with spots described by Mr. Salter as impressions of scattered rain-drops. These occur in rocks of various ages, and were first described by Buckland. They are common in the New Red Sandstone. They must have been formed probably between high and low water, when the ripple-marked muddy shore was exposed and half dry, and were sometimes accidentally preserved when covered by a deposit of mud. Sir Charles Lyell observed this process in the modern mud of the Bay of Fundy, Nova Scotia.

113. Fine Micaceous Arenaceous Shale, Cambrian.

Longmynd, near Church Stretton.

Finely ripple-marked.

114. Bitumen in Quartz Vein.

Near Pontsbury, Longmynd.

Occurs with sulphate of barytes and sulphide of copper sparingly. These rocks at this point were probably at one time covered by the Coal Measures since denuded away. Possibly the bitumen may have been derived from the slow distillation of overlying coal.

Wall-case 41.

Cambrian Rocks—*continued.*

Charnwood Forest, Leicestershire.

The Cambrian rocks of Charnwood Forest are entirely surrounded by New Red Sandstone and marl. They form a region of low hilly ground, once, probably, entirely covered by the New Red deposits, which having since been removed by denudation, the underlying Cambrian strata are exposed. The latter are intermingled with bosses of syenite, a little granite, greenstone, and quartz-porphyry ; and some of these, probably connected with the Cambrian rocks underground, are entirely surrounded by New Red Marl, the latter being always unaltered. The alteration of the Cambrian beds is, therefore, of old date —older probably than the neighbouring carboniferous formations. No fossils have yet been found in the supposed Cambrian beds, except impressions that seem to have been made by the waving of sea-weeds, and the true date of the beds is, therefore, doubtful. They have been classed, in fact, with the Cambrian rocks simply on account of their lithological characters.

Almost everywhere, and especially in the neighbourhood of the syenites, greenstones, porphyries, &c., the strata are so much altered, that, becoming porphyritic, it is often impossible to trace a boundary line between them and undoubted igneous rock. Between Grace Dieu Wood and Charley Wood there is a tract of country from which Nos. 116 to 131, and 127 and 128, were derived. Some part of it seems, in ordinary terms, to be igneous, as in the case of No. 124. Other parts show every degree of gradation, from a common unaltered slaty character to rocks that seem to be in hand-specimens igneous, but on a large scale on the ground, show traces of stratification and other signs proving them to be of sedimentary origin, but so much altered that they have been partly, and in some cases entirely, fused, *and thus pass into so-called igneous rocks* of the deep-seated kinds. All the metamorphism of the Charnwood Forest rocks is of this nature, nor do they ever assume the character of gneissic rocks. It may be that the heating and cooling of the rocks took place with too much rapidity to allow of that slow chemical separation and reunion of constituents, according to their affinities, in layers (often of stratification or cleavage), which constitutes gneiss, and the igneous rocks themselves seem in great part formed of Cambrian strata actually fused.

115. Greenish-purple coarse Slaty Rock.
Markfield.
Hardened.

116. Greenish-grey Slaty Rock.
Greenhill, Charnwood Forest.
Little altered.

117. Greenish-grey Rock.
Old John Hill.
Porcelainized by heat.

118. Grey, fine and gritty Rock.
Tin Meadow.
More altered than No. 117.

119. Greenish-grey and purple, banded, argillaceous and fine gritty Rock.
Billa Barrow Hill.
Very much *indurated and porcelainized.*

120. Green and Grey, altered, fine Grit, Cambrian.
Old John Hill.
Slightly porphyritic, with a few small imperfect crystals of felspar and hornblende.

121. Altered Grit, Cambrian.
Green Hill.
More felspathic than No. 120.

122. Altered Fine Grit, Cambrian.
Old John Hill.
The *stratification* in this specimen is *nearly obliterated.* Rock chiefly composed of imperfectly crystallized felspar, with indications of a few imperfect crystals of hornblende.
The rock appears to have been so far softened that its constituents were partly at liberty to re-arrange themselves according to their chemical affinities.

123. Grit, Cambrian.
Old John Hill.
This specimen is similar to No. 122, only it contains more hornblende, and the alteration has a little further advanced.

124. Altered Rock, Cambrian.
High Cadman.
Very much altered by heat. Chiefly of felspathic matter, sometimes *imperfectly crystalline,* containing numerous specks of hornblende.

125. Altered Grit, Cambrian.
Green Hill.
Felspathic base, *containing crystals of felspar and a little* hornblende, small slaty fragments and grains of quartz. *Extremely altered.*

126. Altered Conglomerate, Cambrian.
Markfield.
Composed of *pebbles* of hardened purple and grey slate, &c., *in a gritty crystalline* (*porphyritic*) *base,* containing crystals of felspar and grains of quartz.
The base of this is in part like No. 125, but the slaty fragments have resisted even partial fusion.

127. Greenish - Purple Altered Conglomerate, Cambrian.
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.

128. Altered Conglomerate, Cambrian.
Pedlar's Tor.
This is a case of *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.

129. Altered Rock, Cambrian.
Birchwood Plantation.
Porphyritic and slightly talcose.
Felspathic base, with crystals of felspar. Hornblende rudely aggregated in nests. *Extremely altered.*

130. Altered Rock, Cambrian.
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 124 to 130 the specimens are from rocks, all exceedingly altered, in which the amount of alteration gradually increases to a point beyond which further alteration could not take place without entire obliteration of any trace of original structure, such as seems to have taken place in No. 129.

The following specimens, from 132 to 138, are arranged so as to show something like a passage from greenstones and porphyritic greenstones into syenites. These are well crystallized, and are in ordinary terms intrusive igneous rocks ; but from the foregoing remarks (p. 19) it may be surmised that they also are probably only stratified rocks which have been so thoroughly melted that all trace of original structure has disappeared, and on cooling their constituents have fairly arranged themselves according to their chemical affinities and crystallized. In Charnwood Forest it would be easy to arrange a suite of specimens showing a perfect passage from stratified into igneous rocks. This may be seen by an examination of the rocks in this Case. Two explanations may be given for this ; 1st, that the intruded igneous rocks have altered the strata ; 2nd, that the strata having been extremely altered by heat and moisture have partly fairly passed the point of fusion, and have thus been in ordinary terms changed into igneous rocks.

131. Altered Rock, Cambrian.
Charnwood Forest.
Serpentinous, with carbonate of lime and flaky layers of hornblende. Pierced by red crystalline felspathic veins.

132. Purplish-Green Igneous Rock, Cambrian.
Quorndon House, near Barrow-on-Soar.
Composed of red felspar and hornblende. This rock passes imperceptibly into syenite and granite.

133. Syenitic Rock, Cambrian.
Broad Hill.
Greenish rock composed of pink felspar, with a little hornblende and granular quartz.

134. Greenstone, Cambrian.
Bowdon Hill.
Composed of hornblende and pink felspar.

135. Greenstone, Cambrian.
Coptoak Farm.
Similar to No. 134, but more felspathic.

136. Greenstone, Cambrian.
Bowdon Hill.
Composed of felspar and hornblende, the felspar predominating.

137. Greenstone (syenitic), Cambrian.
Grooby.
Pink felspar and hornblende as above.

138. Syenite, Cambrian.
Cliff Hill.
Composed of felspar, quartz, and hornblende.

Wall-case 41—*continued.*

SILURIAN ROCKS, SCOTLAND.

Arranged and described by Archibald Geikie.

The greater part of Scotland consists of Lower Silurian strata, but these present a wide variety of character when traced from one end of the country to the other. Thus the tract of mountainous ground which ranges from St. Abb's Head across the southern counties to the Irish Channel, consists of highly convoluted grits and shales, with occasional bands of limestone, containing in places undoubted Lower Silurian fossils. Along the north-western margin of this long tract the beds dip under the broad belt of Old Red Sandstone and Carboniferous strata which runs diagonally across the island. Emerging from the other border of this belt, lies a range of highly altered and crystalline rocks, which retain the prevalent N.E. and S.W. strike, and sweep northwards so as to form nearly the whole of the rest of the country. Notwithstanding their excessively metamorphosed character, these rocks, consisting of gneiss, mica-schist, quartz rock, micaceous flagstone, chlorite-slate, clay-slate, &c., are really the equivalents of the grits, shales, and limestones of the south of Scotland. That this is their geological position is well shown along the western parts of Sutherland and Ross. Resting on the edges of the Cambrian sandstones, the lowest band is one of white quartz rock, in some places attaining a great thickness, and forming ranges of mountains. A limestone sometimes, as at Durness, containing well marked Lower Silurian fossils, is the next member, and then succeeds a second band of quartz rock. The limestone not being persistent, the two quartz rocks sometimes come together. In their upper parts they assume a flaggy micaceous character; and in some bands, both towards the top and the bottom of the series, tubes of annelids are still traceable. The quartz rocks are overlaid by a second limestone, above which lies an immense series of flaggy gneiss and micaceous flagstone, passing here and there, where the metamorphism has been most intense, into hornblendic and actinolitic schist, and gnarled micaceous gneiss. These rocks are disposed in immense folds, the axis of which runs with tolerable persistence from N.E. to S.W. The amount of curvature is sometimes sufficient to bring to the surface again the lower quartzose band. This is the case along the southern line of the Great Glen, in Breadalbane, Glen Tilt, and along the mountainous region from Ben Muick Dhui to the sea at Portsoy. But besides this curving on the great scale, the rocks are sometimes likewise intensely plicated throughout their laminæ, so that a mere fragment broken from the edge of a crag may show many twistings and contortions, even within the compass of a few inches.

The following specimens are arranged in stratigraphical order, beginning with the lowest. No. 139 is from the lower quartz rock, and shows the annelid burrows. Nos. 140 to 151, inclusive, represent the limestone associated with the quartz rock. Nos. 152 to 170, inclusive, show the character of the upper part of the quartzose series where it begins to assume the flaggy character. Nos. 171 and 172 are from the limestone above the quartz rocks, and at the base of the great gneissose and schistose group, which is represented by the specimens from 171 to 184.

LOWER SILURIAN.

139. Quartz Rock.

Glen Cruchalie, Kinloch-ewe, Ross-shire.

From the lower band of quartz rock. The weathered surface shows the ends of annelid tubes, which are the only traces of life yet found in this rock.

140. Limestone.

Overlying the lower quartz rock of *Glen Cruchalie, Kinloch-ewe.*

This bed is in places invaded by a serpentinous granitoid rock, near which it is much mineralized. No fossils have yet been detected at this locality. (*See* specimens Nos. 156 and 157.)

141. LIMESTONE, with *Murchisonia angustata* (Hall.)
Durness, Sutherland.

142. LIMESTONE, with *Maclurea.*
Durness, Sutherland.

143. SILICEOUS LIMESTONE.
Durness, Sutherland.
The lime has been removed by weathering, and only the hard siliceous portion of the rock remains.

144. LIMESTONE.
Inchnadamff, Sutherland.
This, like the preceding specimens, is taken from the limestone between the lower and upper quartz rocks. It shows the characteristic broken and brecciated surface into which the rock weathers.

145. SERPENTINOUS ROCK.
Associated with the Durness limestone of *Sangoe Bay.*

146. ALTERED ROCK.
Sangoe Bay, Durness, Sutherland.

147. GRAPHITE.
Craig Var, Kinloch, Rannoch.

148. LIMESTONE.
Inverveck, Blair Athol.
Overlying the lower quartz rock, like that of Durness and Kinloch-ewe.

149. TALCOSE LIMESTONE.
With a laminated texture, above the lower quartz rock of Glen Tilt.

150. MICACEOUS FLAGSTONE.
Glen Tilt.
From between the lower and upper quartz rock.

151. ARGILLACEOUS SCHIST.
Banavie Glen, Blair Athol Castle.
From a series of highly altered and contorted strata, between the quartz rocks, and associated with the limestone.

152. GRANULAR MICACEOUS QUARTZ ROCK.
Banavie Glen, Blair Athol Castle.
From the same series of beds as No. 151.

153. FELSPAR, with specks of iron pyrites.
From vein among the contorted strata of *Banavie Glen, Blair Athol.*

154. QUARTZ ROCK, above the limestone.
Glen Brera, Inchnadamff, Sutherland.

155. QUARTZ ROCK.
E. of Eriboll, Sutherland.
Showing lines of deposit, above the lower limestone. From this rock have been obtained the *Serpulites Maccullochii.*

156. GREENSTONE.
Associated with the limestone of *Kinloch-ewe.*
(See specimen No. 140.)

157. FELSPATHIC ROCK.
Associated with limestone of *Kinloch-ewe.*
This and the preceding specimen are from different parts of the rock referred to under specimen 140, as invading and replacing the limestone.

158. MICACEOUS FLAGSTONE, from Upper Quartz Rock Series.
Tummel Bridge, Pitlochrie, Perthshire.

159. MICACEOUS FLAGSTONE, Upper Quartzose Series.
Two miles S.E. of Pitlochrie, Perthshire.

160. MICACEOUS FLAGSTONE.
Pictish Tower, Ben Hope, Sutherland.

161. COMPACT FINE-GRAINED FLAGSTONE, Upper Quartzose Series.
Loch More, Sutherland.

162. MICACEOUS FLAGSTONE.
West side of Far-out Head, opposite Balnakeale, Sutherland.

163. TALCOSE FLAGSTONE, from Upper Quartzose Series.
Signal-post in highest part of Far-out Head, Sutherland.

164. COMPACT BROWN QUARTZ ROCK.
Balmacarra House, Loch Alsh, Rosshire.
This rock is remarkably well bedded when seen in situ. It overlies the lower limestone and shades upward into a great group of schists.

165. QUARTZ ROCK, micaceous and flaggy.

From an upper part of the quartzose series of which the last specimen (No. 164) represents the base. The stratified character of the rock is well shown by this specimen.

166. MICACEOUS SCHIST.

Above the quartz rock and limestones of *Eriboll, Sutherland.*

167. HORNBLENDE ROCK.

Associated at the Whiten Head, Sutherland, with granitic and porphyritic rocks.

168. QUARTZIFEROUS FELSPAR.

Whiten Head, Sutherland.

This specimen shows the general character of the red felspathic veins and bosses that traverse the schists of this headland.

169. HORNBLENDE SCHIST.

North Bank of Loch Tay.

From the great schistose series of Perthshire.

170. BLACK SCHIST.

Spittal of Glenshee, Perthshire.

This specimen shows a remarkable threefold structure:—1st. A distinct separation into lines of deposit. These have been contorted subsequent to deposition. 2nd. An imperfect cleavage at acute angles with the contorted bedding. And 3rd. A structure which puckers up both cleavage and bedding lines. Some parts of this schist lose 15·90 per cent. on ignition, and leave an ash of a dirty white. The dissipated material consists largely of carbon, and the rock gives a distinct streak on paper.

171. CRYSTALLINE LIMESTONE.

Among upper schists of *Loch Duich, Rosshire.*

Speckled and crystalline, containing a little serpentine and talc.

172. GREENISH CRYSTALLINE SERPENTINOUS LIMESTONE.

Loch Duich, Rosshire.

173. GNEISS from the Schistose series.

Opposite Inverinet, Loch Duich, Rosshire.

174. GRANITE, associated with three last specimens, Nos. 171 to 173.

Opposite Inverinet, Loch Duich.

175. ACTINOLITIC SCHIST.

Totig Point, Loch Duich.

176. GNEISS, micaceous, with garnets.

Upper gneissose and schistose series of *Glen Quoich, Invernesshire.*

177. MICA SCHIST, with garnets.

From schistose series between *Borrodale* and *Glen Finnan, Invernesshire.*

178. GNEISS.

From between *Borrodale* and *Glen Finnan, Invernesshire.*

179. FELSPATHIC GNEISS, well laminated.

Bettyhill.

180. HORNBLENDIC GNEISS.

Flanks of Ben Llaoghal, Sutherland.

181. SYENITE associated with gneissose rocks.

Ben Llaoghal, Sutherland.

182. SYENITE.

Ben Stornino, Sutherland.

183. MICA SCHIST, with crystals of hornblende and quartz.

Near East Loch Tarbert, Argyleshire.

184. CLAY SLATE.

Associated with limestone of Birnie Glen, Kincardine.

From 185 to 194 the specimens belong to the great series of metamorphic, gneissic, and mica-schist rocks of Lower Silurian age that form the Grampian Mountains.

185. GREENISH-GREY SILICEOUS GRIT, Metamorphic.

Near *Shandon, Gare Loch, Dumbartonshire.*

186. GREY COARSE 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 and pale blue quartz. The district is penetrated by felspathic dykes, No. 187.

187. **Felstone**, with small crystals of black mica.

Near No. 126. From a dyke. Like some of the Cornish Elvans, (Case No. 4.) *Pierces* No. 186.

188. **Gneissic Mica-Schist.**

Near *Arrochar, Loch Lomond, Argyleshire.*

Rather finely *foliated laminæ of quartz and mica*, with a few quartz grains.

189. **Gneissic Mica-Schist.**

Arrochar, near Loch Long Head, Argyleshire.

More *strongly foliated contorted* granular quartz and mica.

190. **Gneissic Mica-Schist.**

Arrochar, near Loch Long Head, Argyleshire.

191. **Gneiss,** *passing into granite.*

Strontian, Argyleshire.

Felspar, quartz, and black mica faintly laminated, very crystalline.

192. **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.

Nos. 192 and 193 may possibly not represent an actual junction, but be altogether gneissic.

193. **Junction of Granite and Mica Slate.**

Strontian, Argyleshire.

The mica-slate is formed of black mica very metamorphic ; the granite consists of quartz, felspar, and black mica.

From the Great Exhibition of 1851.

194. **Micaceous Schist.**

Strontian, Argyleshire.

Very crystalline with a little felspar. Either pierced by a vein of granite, or else part of the rock in process of metamorphism has contained more of the constituents that became re-constituted as well-crystallized felspar.

Archd. Geikie.

SILURIAN ROCKS, ENGLAND AND WALES.

Arranged and described by A. C. Ramsay.

The Silurian rocks of England and Wales consist of numerous subdivisions, the order of succession of which will be easily understood by reference to the table of stratification at the beginning of this volume, (p. xiii.). As a whole they are most typically developed in Wales and Shropshire. In the maps of the Geological Survey, all the Lower Silurian strata (excepting the igneous rocks) have received one colour ; for though an order of succession can be made out by help of fossils (some of which are peculiar to given beds) from the base of the Lingula flags to the Lower Llandovery rocks, yet practically most of the Lower Silurian formations generally pass so gradually into each other that it is impossible to define their limits on the map in the manner that is done with those of Upper Silurian age.

Lingula Flags.

The Lingula Flags lie at the base, and are especially well developed in Merionethshire, where they attain a thickness of from 5,000 to 7,000 feet, ranging from the mouth of the Barmouth estuary to the N.E., and then circling round the Cambrian grits by Trawsfynydd and Ffestiniog they pass out to sea on the south side of Traeth Bach. Throughout they lie directly on Cambrian grits, and are everywhere in this area pierced by dykes and intrusive bosses of greenstone. For the most part the Lingula flags consist of shales, sometimes flaggy, and slaty beds often altered, interbedded with grits and altered sandstones. They have been termed *Lingula flags* from the great numbers of the fossil shell *Lingulella Davisii* found in these strata. For the organic remains belonging to them see Flat Case No. 1., and Wall-case IV., compartments 12 & 13, in the lower gallery.

195. BLUE SLATY ROCK, CLEAVED. Lingula flags.
Bryn Bras, Dolgelli, Merionethshire.
Shows casts of *Lingulella Davisii* somewhat distorted by cleavage.

196. SHALE, Lingula flags.
With *Linguloe*, much hardened by heat.
Moel-Haford-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.

197. TALCOSE SCHIST WITH IRON PYRITES. Lingula flags.
Dol-frwynog, Merionethshire.
This rock is on the horizon of the Lingula flags. It is associated with intrusive greenstones, and in it the gold lode of Dol-frwynog occurs.

198. QUARTZ WITH TALC.
Gold Lode: Dol-frwynog.

198*a*. QUARTZ WITH TALC.
Dol-frwynog.
Contains specks of gold.

199. LINGULA FLAG, INDURATED.
Portmadoc, Caernarvonshire.
Lingulella Davisii on the surface.

200. LINGULA FLAG.
Tremadoc, Caernarvonshire.
Bluish-grey slaty beds from upper Lingula flags, with the small crustacean *Agnostus princeps.*

201. LINGULA FLAG.
Tremadoc, Caernarvonshire.
Same rock as No. 200, partly decomposed. Contains *Orthis vaticina.*

THE LINGULA BEDS OF SHROPSHIRE lie on the west side and bound the Cambrian strata of the Longmynd. The quartz-rock ridge of the Stiper Stones forms their uppermost stratum, and beneath it lie black and dark-blue slaty beds with *Linguloe.*

202. QUARTZ-ROCK.
Top of Lingula flags, Stiper Stones, Shropshire.
Contains *Arenicolites linearis*, (Worm burrows).

203. SILICEOUS GRIT, Lingula flags.
Stiper Stones, near Bishop's Castle, Shropshire.

204. CONGLOMERATE, Lingula flags.
Stiper Stones, near Bishop's Castle, Shropshire.
Composed of fragments of slate in a quartzose base.

The Lingula flags are succeeded by, and lithologically pass into, the Tremadoc slates, and these into the lower Llandeilo beds of Sir R. Murchison.

205. IRON ORE, Tremadoc slates?
Bettws Garmon, Llanberis, Caernarvonshire.
Locally termed *Pisolitic ironstone.*
These iron ores are not in lodes, but bedded.

206. BLUE AND GREY SLATY BEDS, Upper Tremadoc Slate.
Portmadoc, Caernarvonshire.
Shows alternate layers of blue slaty beds and felspathic sediment.

207. Blue Coarse Slaty Beds, Upper Tremadoc slate.

Garth, Portmadoc.

Shows *Trilobites*, and *Angelina Sedgwicki*, distorted by cleavage ; and worm-burrows.

208. Talcose and Felspathic Slaty Beds.

Half a mile from Pant-yr-onen, 1 mile S. of Dolgelli, Merionethshire, Map 59, N.E.

Dark greenish-grey, with black layers separating the different kinds of sediment.

From the upper part of the Tremadoc slates, composed principally of consolidated fine *felspathic sediment*, interstratified with what were originally *black muddy layers*. The felspathic part is possibly chiefly of volcanic origin, direct or re-arranged. The rock is cleaved nearly at right angles to the planes of bedding. The outer surface is irregularly weathered, the purer felspathic layers having been most easily decomposed.

209. Talcose and Felspathic Slaty Beds.

Near Dolgelli, Merionethshire. Map 59, N.E.

Pale greenish-grey *felspathic matter* irregularly cleaved, with included *concretionary felspathic spheroids.*

From the uppermost part of the Tremadoc slates or base of the Llandeilo beds, underlying the thick ashy strata on the north slope of Cader Idris. Principally formed of consolidated *felspathic dust and talc*, subsequently cleaved.

The Llandeilo Flags come next in the series. They are named from the town of Llandeilo in Caermarthenshire, where there were first described by Sir Roderick Murchison.

The fossils belonging to these beds are contained in Flat Cases 2 & 3 and in Wall-case IV., compartments 12 & 13, in the lower gallery.

210. Talcose Schist, siliceous.

Between Tan-y Grisiau and Cwm Orthin, Ffestiniog, Merionethshire. Map 75, N.E.

See No. 210, section 4 above.

Brownish-grey rock, mottled with black, showing a coarse slaty structure ; bleached and partly decomposed on the outer surface. These rocks sometimes pass into felspathic ashes, and sometimes into fossiliferous sandstones, equivalent to the base of the Llandeilo beds. In places they also assume the appearance of the rock termed Variolite.

210a. The same rock as No. 210, *pounded and fused in a furnace.* It has the general appearance of *obsidian*, but is vesicular and spherulitic.

See No. 30, Wall-case 2, where the same general structure is shown in the obsidian of Ascension.

211. Felspathic and Talcose Beds.

S.E. of Cwm Orthin Lake, Ffestiniog, Merionethshire. Map 75, N.E.

Very *compact bands* of grey, dark green, and black *felspathic sediment*, the surfaces of the bed soft, and coated with talc-slate, showing ripple-marks. It belongs to the same set of rocks as No. 210.

212. Calcareous Flags, Llandeilo Flags.

Pont-ladies, Llandeilo, Caermarthenshire.

Bluish calcareous flaggy rock ; weathers brown. Contains *Ogygia Buchii.*

213. Calcareous Flags.

The same as No. 212 : with *Calymene brevicapitata.*

Burnt for lime.

214. Impure Limestone, Llandeilo Flags.

Llandeilo, Caermarthenshire.

With *Leptæna sericea.*

215. Black Slate, Llandeilo Flags.

Abereiddy Bay, Pembrokeshire.

With *Lingula Ramsayi.*

216. Dark blue Flaggy Rock, Llandeilo Flags.

Pen-y-goylan, Llangadoc, Caermarthenshire.

With *Orthoceras Pomeroense.*

217. Dark Blue Slate, Llandeilo Flags.

Abereiddy Bay, Pembrokeshire.

With *Graptolites, Didymograpsus Murchisonæ.* These and the *Lingula* (No. 215) are very numerous at Abereiddy Bay.

218. DARK BLUE SLATE, ALMOST BLACK, Llandeilo Flags?
Conway, Caernarvonshire.
With *Graptolites, Diplograpsus pristis.* This is common in Llandeilo flags, but the position of these strata at Conway renders their age doubtful.

219. TALCOSE SCHIST (with quartz vein), Llandeilo Beds.
Diffwys Slate Quarry, Ffestiniog, Merionethshire. 75, N.E.
This rock contains iron pyrites, and passes into felspathic ash.

220. QUARTZ ROCK, altered Llandeilo flags.
Moel-y-Golfa, Breidden Hills, Shropshire.

221. GREENSTONE of the *Breidden Hills*, with which the altered rock No. 220 *is in contact.*

222. ALTERED SLATE, (Snake-stone,) Landeilo Flags.
Porth Treuddyn Quarries, near Tremadoc, Merionethshire. Map 75, N.E. *Altered by intrusive greenstone.*

Rocks intruded among and altering the Lower Silurian strata.

223. HORNBLENDE PORPHYRY.
Ridge of Cader Idris, Cyfrwy, S.W. 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. 223,) they are known to be intrusive, as they *break across the strike* on Mynydd Pennant, east of Lyn Cae.

224. SYENITE.
Two miles N.W. 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 Syenite among the Lingula Flags, which are altered all round the points of junction. (See No. 224, section No. 4 above).

225. 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.

226. 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. Same as No. 225.

227. 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.

228. GREENSTONE.
Bwlchau-yr-Figen, 3 miles N.W. of Dinas Mowddwy, Merionethshire. Map 60, N.W.
A finely granular mixture of felspar and dark coloured hornblende.
From one of several lines of greenstone intruded into the felspathic porphyry of the Aran range.

229. GREENSTONE.
Bwlch-y-Hendref.
Dull greenish-black rock, obscurely laminated in structure, made of acicular felspar crystals and plates of hornblende in alternate layers, the former projecting on the weathered surface.

230. GREENSTONE.
Bwlch-yr-Hendref, near Capel Arthog, 6 miles S.W. of Dolgelly, Merionethshire. Map 59, N.E.
Dark green hornblende base, containing crystals of white potash felspar and large crystals of a platy variety of hornblende.
Part of a line of greenstone intruded *between* beds of the Lingula Flags. The rocks are altered both above and below the greenstone, proving its intrusive character.

Felspathic Porphyries, &c.—Lava Streams of Llandeilo Age in North Wales.

Specimens from Felspathic Lava Beds that are associated with the Llandeilo Flags, and chiefly overlie the Volcanic Ashes of Cader Idris, Aran Mowddwy, &c. *The whole lie near the base of the lowest part of the Llandeilo Flags.*

231. Calcareous Amygdaloid.
Ridge of Cader Idris, one mile south of Tyn-y-Nant, S. W. 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, Wall-case 2), the vesicles of which have afterwards been filled by infiltrations of carbonate of lime. On the surface the lime has subsequently been dissolved out, and it has again become vesicular.

232. Amygdaloid.
Buarth Glas, by turnpike road 2½ miles N. W. 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, Nos. 208, 209, and 240 to 250, of Cader Idris, Aran Mowddwy, Moel Offrwm, &c.

233. Amygdaloid Felstone Porphyry.
Same locality as No. 232 *above.*

Felspathic base, with kernels of hornblende. Kernels in part decomposed out of the cavities, which contain iron.

234. Felspar Porphyry.
Top of Aran Mowddwy, Merionethshire. Map 74, S.W., and *horizontal section No.* 28, also section above, No. 7.

Compact greenish-grey felspathic rock, with small crystals; weathers white. Continuation of the same set of rocks as Nos. 232 and 233.

235. Felstone.
Penmaen, Merionethshire, between Dolgelly and Bala, near eighth milestone. Map 64, S.W., and *horizontal section No.* 37, *line* 3; also section above, No. 7.

Compact greenish felspathic rock; weathers brown.

This is the equivalent of the Aran Mowddwy and Carreg Aderyn rocks, Nos. 234 and 236, repeated by a fault at the river Wnion. See section above, No. 7.

236. Decomposing Felstone Porphyry.
Penmaen, Merionethshire.

Similar to No. 235, but bleached and porphyritic. Interspersed yellow felspar crystals, partly decomposed.

237. Felstone Porphyry.
Clogwyn-yr-Eglwys, 7 miles S. W. of Bala, Arenig range, Merionethshire. Map 74, S.W.

Dark bluish-grey, porphyritic, felspathic rock, with interspersed white crystals of felspar; from the same set of rocks as No. 236.

This is a good typical specimen of this set of rocks, when freshly fractured and undecomposed.

238. Felspathic Porphyry.
W. of Llyn Arenig, 6 miles W. of Bala, Merionethshire. Map 74, N.W.

Dark greenish felspathic rock, with interspersed crystals and concretions. Scoriaceous, like surface of a lava stream.

From a continuation of the same rocks as No. 237.

239. Felstone.
¼ mile S. of Moel-y-Menyn; 6 miles W.S.W. of Bala, Merionethshire. Map 74, S.W.

Compact dark bluish-grey felspathic rock. Conchoidal fracture. Weathered white to the depth of a quarter of an inch on the exposed faces.

This is also the equivalent of the Aran and Penmaen felstone in its north range, on the west side of the River Wnion or Bala fault (see section above, No. 7); and in this neighbourhood the thick beds of ashes disappear that further south underlie these felspathic lavas. From Nos. 231 to 239 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 Dolgelly to Tremadoc, including the mountain of Cader Idris, the Arans and Arenigs, the Manods, and Moelwyn Mawr and Moelwyn bach. See Maps 59, N.E., 74, S.W. and N.W., 75, S.E. and N.E., and sections Nos. 4, 7, 8, and 9, above.

Felspathic Ashy Beds, &c., North Wales, of Llandeilo Age.

240. Calcareous, Talcose, and Felspathic Slaty Ashes.

Allt-Llwyd, 4½ miles S. 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 rocks of Cader Idris, Aran Mowddwy, Arenig, &c. It occurs below the junction of the Llandeilo and Caradoc or Bala beds.

241. Felspathic Sandy and Slaty Beds.

Moel Offrwm, near Dolgelly, Merionethshire. Map 75, S.E.

Composed of *black slaty bands*, interstratified with *dark grey felspathic layers*, which are unequally affected by cleavage.

This and the rocks up to No. 243, and No. 252, are from the geological equivalents of the lower part of the thick beds of ashes which underlie the crystalline felspathic rock of Cader Idris. On Moel Offrwm the tuffas are mixed with a large quantity of ordinary slaty and sandy sediment.

242. Highly Indurated Felspathic Grit.

Moel Offrwm, near Dolgelly, Merionethshire.

Dark blackish-green finely granular rock, with a flat conchoidal fracture. Weathers dark brown.

From the same beds as No. 241.

243. Sandy Felspathic and Talcose Layers alternating with purer felspathic bands.

Moel Offrwm, near Dolgelly, Merionethshire.

Fresh fracture grey, but weathers white and pale yellow.

From the same beds as Nos. 241 and 242.

244. Calcareous Felspathic Porphyritic Ashes, talcose.

Llyn Aran, Cader Idris, near Dolgelly, Merionethshire. Map 59, N.E.

Consists principally of entire and broken crystals of *felspar* embedded in a talcose and felspathic base, and including filmy layers of *black slate*, slightly calcareous (from infiltration ?). Weathers dark brown; when newly fractured, colour dark bluish green.

The upper portion of the thick beds of ashes which underlie the porphyries of Cader Idris. Exhibits a mixture of ordinary slaty sediment with felspathic material, which originally consisted of fine volcanic dust and broken crystals of felspar.

The rocks immediately N.W. of the Dolgelly and Bala road are repeated by a great fault at the river Wnion. It is a downthrow on the north-west. See Section No. 7 above. This fault passes from the neighbourhood of Dolgelly by the Bala road through Bala lake, repeating the rocks of the Cader Idris and Aran range in the manner shown in the section.

245. Compact Felspathic Ashes (slightly talcose ?), with cherty layers.

Mynydd Gader, Dolgelly, Merionethshire. Map 59, N. E.

Banded alternations of felspathic and cherty matter; the more purely felspathic layers thin and deeply eroded. Original colour light greenish grey. Covered on the divisional planes with ferruginous stains.

From the lower part of the above (No. 240). *Principally formed of consolidated felspathic ashy dust.*

246. Compact Brecciated Felspathic Ashes, slightly talcose.

Mynydd Gader, Dolgelly, 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. 245.

247. Brecciated Felspathic Ash, slightly talcose.

Mynydd Gader, Dolgelly, Merionethshire. Map 59, N.E.

Similar in composition and colour to No. 246, but finer. The brecciated structure is chiefly shown on weathered surfaces.

From the same strata as Nos. 245 and 246.

248. COMPACT WHITISH-YELLOW FELSPATHIC ASHES, talcose.

Mynydd Gader, Dolgelly, Merionethshire. Map 59, N.E.

Varying from a finely granular to a compact structure.

From the same strata as Nos. 245 to 247.

249. PORPHYRITIC ASHES, calcareous and felspathic.

West of Moel Llyfn-nant, Merionethshire. Map 75, S.E.

Slightly talcose. Fragmentary crystals of *felspar, with slaty particles* included in a felspathic base. Weathers to a dark blackish-brown.

From the same beds as Nos. 245 to 249. The crystals of felspar were probably originally showered out in a broken state, and mixed with felspathic dusty sediment.

250. 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°.

251. 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 preceding specimens.

252. FELSPATHIC AND PORPHYRITIC ASHES.

Y Wenallt, 6 *miles S.W. of Bala, Merionethshire.* Map 74, S.W.

Grey felspathic base, including light grey elongated *felspathic fragments.*

From a bed *overlying* the felspathic porphyry of Y Graig and Arenig. This porphyry is the same bed as that of Aran Mowddwy, but separated from it by the great Bala fault. These ashes do not occur above the felspathic porphyry on the Aran Mowddwy range. They extend from Y Graig, 8 miles south-west of Bala, to the river Machno, near Llyn Conwy, a distance of 13 miles.

253. DECOMPOSING FELSPATHIC ASHES.

Top of Arenig, Merionethshire.

Yellowish felspathic rocks, with cavities produced by the removal of decomposed crystals of *felspar,* which are replaced by ochreous matter. Weathers very irregularly of a light greenish-grey colour. Emits a slight argillaceous odour.

These beds form the top of Arenig-fawr. (See Section No. 9 above.) They are often largely and distinctly bedded, but sometimes much jointed and massive, and also, when undecomposed, so resemble the melted felstones that for spaces they are not easily separated. Frequently they are porphyritic, even where distinctly bedded.

254. DECOMPOSING FELSPATHIC ASH.

E. side of Y Graig, Merionethshire, 8 *miles S.W. of Bala.* Map 74.

Light yellowish grey, with cavities from the decomposition of crystals of *felspar,* which are partly filled with ochreous matter.

255. FELSPATHIC AND TALCOSE ASHES.

Moel-y-Menyn, 2 *miles S.S.E. of Arenig, Merionethshire.*

Light grey rock, with imperfect cleavage. Weathers to a light brown colour on the joints. Emits a strong argillaceous odour.

256. PORPHYRITIC FELSPATHIC ASHES (decomposing).

Mynydd Nodol, 5 *miles W.N.W. of Bala, Merionethshire.*

Grey felspathic rock, with white specks and patches of *decomposing felspar.* Weathers light brown. Emits a strong argillaceous odour.

This specimen is from the same set of thick ashy beds that form the Arenig, &c.

257. THIN BEDDED, COMPACT, GREENISH-GREY ASHES, slightly

porphyritic; weathering light brown.

E. side of Y Graig, about 8 miles S.W. of Bala, Merionethshire.

Consolidated fine felspathic dust.

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

258. COMPACT FELSPATHIC ASHES.

Top beds, E. slope of Arenig, Merionethshire.

Dark grey, finely laminated felspathic rock. Shows faint lines of stratification.

259. BEDDED FELSPATHIC PORPHYRY.

Llyn Arenig, Merionethshire.

Compact, dark greenish-grey rock, with small imbedded crystals of *felspar* and grey *felspathic and cherty fragments.* Weathers unequally, the included fragments projecting from the surface.

In hand specimens, this rock might be mistaken for a porphyry that had been melted. On the spot its bedded character tells its origin.

260. CALCAREOUS FELSPATHIC ASH, TALCOSE, imperfectly PORPHYRITIC.

S.E. 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.

261. ROOFING SLATE.

Ffestiniog Slate Quarries, Caernarvonshire. Map 75.

The *red lines* show the direction of the *beds.* *The surfaces* (like all true slates) show *the planes of cleavage.* (See p. 13.)

262. ROOFING SLATE (Countess), 20 in. × 10 in.

This and the preceding specimen are from the dark bluish-black slaty beds of Llandeilo age, associated with the felstones and ashes near Ffestiniog.

INTRUSIVE ROCKS of LOWER SILURIAN (LLANDEILO) AGE, BREIDDEN HILLS, and of the Hills between the STIPER STONES and CHIRBURY, MONTGOMERYSHIRE, and SHROPSHIRE.

263. GREENSTONE.

Breidden Hills, Shropshire. Map 60, N.E.

Black hornblende, and white and greenish felspar in small indistinct crystals; contains calc spar.

From a mass of greenstone intruded among Llandeilo Flags that underlie the volcanic ashes, Nos. 265 to 270.

264. FELSPAR PORPHYRY.

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.

265. GREENSTONE.

Cefn.

Dark grey or greenish felspar, with small black hornblende crystals. Slightly calcareous; seams of calc spar traverse it.

From a small intrusive mass of greenstone by the turnpike road, 3 miles N.E. of Welshpool, Montgomeryshire. Map 60, N.E.

ASHY SERIES, &c. of the LLANDEILO FLAGS, BREIDDEN HILLS, MONTGOMERYSHIRE. MAP 60, N.E., SECTION No. 3 above.

266. COMPACT FELSPATHIC PORPHYRITIC ASH.

Breidden Hills, Montgomeryshire.

Dark and greenish-grey granular felspathic rock, with small brilliant felspar crystals interspersed.

These bedded igneous rocks lie in the Llandeilo Flag series, and are probably the general equivalents of some of the higher igneous rocks that lie between the Stiper Stones and Chirbury, from 4 to 6 miles east of Montgomery.

267. FELSPATHIC ASH.

Moel-y-Golfa, Breidden Hills, Montgomeryshire.

White compact felspathic rock, with green chloritic particles interspersed; weathers to white earth (Kaolin); gives a strong argillaceous odour. From the same set of rocks as No. 266.

268. FELSPATHIC CONGLOMERATE.

Moel-y-Golfa, Breidden Hills, Montgomeryshire.

Greenish-grey felspathic sediment, with rounded felspathic porphyritic fragments, and crystals of glassy felspar.

This specimen very much resembles the ashy rocks (No. 302) 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.

269. ASHY BRECCIA AND CONGLOMERATE.

Breidden Hills, Montgomeryshire.

Large, angular, and rounded fragments of porphyritic and other rocks in an argillaceous and highly calcareous cement. Gives out a strong argillaceous odour.

Some of the embedded fragments appear to have been well rounded and water-worn. They have sometimes been found crusted with Silurian corals.

270. FELSPATHIC AND PUMICEOUS BRECCIA.

Breidden Hills, Montgomeryshire.

Dark blackish-grey, with white angular felspathic fragments and pumiceous fragments included. Odour slightly argillaceous.

Some of the fragments in this neighbourhood appear as if they had been ejected in the form of pumice stone.

271. GREENSTONE.

Simmond's Castle, near Bishops Castle, Montgomeryshire. Map 60, S.E.

Dark green hornblendic rock, with a few indistinct crystals of felspar and black hornblende.

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.

INTRUSIVE and ALTERED ROCKS in LLANDEILO FLAGS, West of the STIPER STONES, MONTGOMERYSHIRE and SHROPSHIRE.

272. GREENSTONE.

Cross Roads, 1 mile S.W. of Hyssington, Montgomeryshire. Map 60, S.E.

Dark compact felspathic rocks, with a few small hornblende crystals and kernels of calc spar.

273. GREENSTONE AMYGDALOID.

Lower Ridge, 2 miles E. of Chirbury, Shropshire. Map 60, S.E.

Dark grey felspar and small black hornblende crystals, with a few large kernels of calc spar; the rock slightly calcareous.

In a line similar to No. 278.

274. 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. 271

275. GREENSTONE.

Corndon, 3 miles S.E. of Chirbury, Montgomeryshire. Map 60, S.E.

Green hornblendic base, with light greenish felspar crystals.

Boss of greenstone, forming a bold round hill in the Llandeilo Flag region, north of Bishops Castle.

276. ALTERED LLANDEILO FLAGS.

Pant-Prinog, Montgomeryshire, 3 miles S.E. of Chirbury.

Altered by neighbouring greenstone. See 271. Map 60, S.E.

277. ALTERED SLATE, Llandeilo Flags.

A species of imperfect gritty snakestone, *altered by the Corndon greenstone, Montgomeryshire.* Map 60, S.E. See No. 275.

278. GREENSTONE PORPHYRY.

Cefn Gwynnlle, near Bishop's Castle, Shropshire. Map 60, S.E.

White imperfect felspar crystals and kernels of calc spar in a light green matrix; also strings of calc spar.

A very felspathic greenstone running in a narrow line in the Llandeilo Flags, among which it has been injected between the lines of bedding.

279. GREENSTONE.

S.E. of Radley, and 2 miles E. of Churchstoke, near Chirbury, Shropshire. Map 60, S.E.

White and greenish felspar and black hornblende. Somewhat calcareous.

From a small boss in the Llandeilo Flags.

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.

280. FELSPATHIC BRECCIA.
Heath Mynd, 3 miles N of Bishop's Castle, Shropshire. Map 60, S.E.
Dark greenish-grey compact felspathic rock, with crystals of felspar and cherty fragments included.

281. COMPACT VOLCANIC ASHY PORPHYRY.
Pitchels, 2½ miles N. of Bishop's Castle.
Brownish-black compact sandy rock, with small fragments and crystals of felspar; surface weathers to a light brown crust.

282. FELSPATHIC GRIT. Llandeilo beds.
Dysgwylfa Hill, near Bishop's Castle, Shropshire.
Very felspathic.

280 to 292, as a whole, are specimens of ashy beds which were spread contemporaneously amid the Lower Silurian rocks of the Llandeilo Flag series. The slates interstratified with them contain the ordinary Llandeilo Flag fossils, and some of the ashy beds are also fossiliferous. They are partly arranged so as to show the passage of fine felspathic ashes into coarse breccias.

Nos. 280 and 281, and 283 to 292 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. 295 to 305 are from higher bands of ash in the same series near Marrington Dingle, Chirbury. These last, in their line of strike, pass gradually from sandstones worked for building purposes, into coarse brecciated and conglomeratic volcanic ashes. The Marrington beds are the equivalents of the eastern ashy igneous ridge of the Breidden Hills. See sections above, No. 3, 266 to 270, and No. 5, 276 and 295 to 305.

283. TALCOSE FELSPATHIC ASH.
Disgwylfa Hill, 3 miles N. of Bishop's Castle, Shropshire. Map 60, S.E.
Greenish-grey slaty rock, with talc, and calcareous particles giving it an amygdaloidal appearance.

284. COMPACT SANDY FELSPATHIC ASH.
Disgwylfa Hill, near Bishop's Castle, Shropshire.
Dark greenish-grey felspathic sediment, close-grained, with a few broken crystals and grains of silica.

285. FINE FELSPATHIC TUFA.
Disgwylfa near Bishop's Castle, Shropshire. Map 60, S.E.
Soft brownish-grey felspathic and argillaceous sediment, with yellow-brown patches of decomposing felspar crystals; outer surface very earthy.

286. FELSPATHIC ASH.
Disgwylfa Hill, near Bishop's Castle, Shropshire.
Felspathic rock, compact, made of fine sediment; lines of concentric weathering.
This rock is composed of fine consolidated felspathic volcanic dust.

287. COMPACT FELSPATHIC ASH.
Yr Ynys, 4 miles N. of Bishop's Castle, Shropshire. Map 60, S.E.
A slightly porphyritic greenish-grey rock, with specks and films of black slaty matter, and a few scattered crystals of felspar, very calcareous; weathers light brown.

288. FINELY BRECCIATED ROCK, *felspathic* and *porphyritic*.
Hyssington, near Bishop's Castle, Shropshire. Map 60, S.E.

Dark greenish-grey granular felspathic rock, with crystals of felspar and strings of calc spar. From beds of ashes equivalent to 281 and 287, near the base of the Llandeilo Flags.

289. PORPHYRITIC FELSPATHIC ASH.

Brook House, 5 miles N. of Bishop's Castle, Shropshire. Map 60, S.E.

Dark greenish-brown and black, 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 281 and 287.

290. FELSPATHIC BRECCIATED ASH.

Hyssington, Bishop's Castle, Shropshire. Map 60, S.E.

Dark bluish-grey rock, with grey felspathic fragments, altered black slate, and iron pyrites. Contains a good deal of lime. From the same bed as 288.

291. FELSPATHIC BRECCIA.

N. of Maes-isaf Green, near Hyssington, Shropshire. 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.

The rocks from 280 to 291 lie in bedded lines, very near the base of the Llandeilo Flags, west of the Stiper Stones.

292. FELSPATHIC BRECCIA.

Hope Common, between Chirbury and Minsterly, 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.

293. FELSPATHIC ASHY ROCK.

Hope Common, between Chirbury and Minsterley, Shropshire. Map 60, N.E.

294. FELSPATHIC BRECCIA.

Rountain Mountain, Montgomeryshire.

295. FINE CONGLOMERATE.

Hagley, 1 mile E.S.E. of Chirbury, Shropshire. Map 60, S.E.

Dark brownish-grey rock made of small fragments of felspathic porphyry, and entire and broken crystals of felspar imbedded in a felspathic matrix. Somewhat calcareous.

Same beds as No. 299, &c.

296. FELSPATHIC BRECCIA.

The Ridge, 2 miles N.E. of Chirbury, Shropshire. Map 60, N.E.

Decomposing felspathic rock with slaty fragments included, and numerous crystals of felspar.

297. FELSPATHIC BRECCIA.

The Ridge, 2 miles N.E. of Chirbury, Shropshire. Map 60, N.E.

Contains fragments of black slate, green felspar-porphyry, and large grey felspar fragments set in a dark greenish-grey felspathic base.

298. FELSPATHO - SILICEOUS SANDY ASH.

The Ridge, Marrington Dingle, 1 mile E. of Chirbury, Shropshire. Map 60, S.E.

Green granular rock, felspathic and siliceous, with small fragments of black slate, and angular fragments and crystals of felspar. Slightly calcareous. From the higher Llandeilo Flag beds west of the Stiper Stones.

299. SANDY FELSPATHIC ASH.

The Ridge, 2 miles N.E. of Chirbury, Shropshire. Map 60, N.E.

Light yellowish-brown granular sandstone, with fragments of crystallized felspar and impressions of fossils.

300. FELSPATHIC BRECCIATED CONGLOMERATE.

The Ridge, Marrington Dingle, S.E. of Chirbury, Shropshire.

Felspathic sandstone like the preceding, and containing small angular and subangular fragments of felspathic and porphyritic rocks.

301. FELSPATHIC SANDY ASH.

The Ridge, Marrington Dingle, S.E. 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 No. 298.

302. SANDY FELSPATHIC ASH.

The Ridge, Marrington Dingle, as above.

Light greenish rock, consisting of felspathic grains and broken crystals, similar to those of No. 304, but coarser in texture.

303. FELSPATHIC SANDSTONE.

Marrington Dingle, S.E. of Chirbury, Shropshire. Map 60, S.E.

Variegated light and dark greenish-grey fine grained felspathic sandstone. Same beds as No. 301.

304. FELSPATHIC SANDY ASH.

Marrington Dingle, as above.

Rock contains fragmentary films of slate, irregularly dispersed in a matrix, similar to Nos. 303 and 305.

305. BRECCIATED FELSPATHIC PORPHYRY.

Rocky bank, 1½ *miles N.E. of Chirbury, Shropshire.* Map 60, N.E.

Light greenish-grey rock. Contains angular felspathic fragments, set in a granular felspathic base containing numerous broken and perfect crystals of felspar.

306. PORPHYRITIC FELSPATHIC ASH.

Moat by Nant Cribba Hall 2½ *miles N.W. of Chirbury, Montgomeryshire.* Map 60, N.E.

Greenish-grey rock. Dark green felspathic base, containing light green and grey fragments of felspar porphyry, and crystals of felspar.

This rock is very similar to, and may be the equivalent of, the volcanic beds of Marrington Dingle, but it is not connected with them above ground. It occurs in a small boss, separated from the Chirbury rocks by an intervening tract of Wenlock shale. This last rests on the Llandeilo beds unconformably, and in Wales never contains volcanic ashes or lava.

SPECIMENS OF THE LLANDEILO FLAGS, AND THE ASSOCIATED IGNEOUS ROCKS FROM THE CARNEDDAU AND ITS NEIGHBOURHOOD, RADNORSHIRE; NEAR BUILTH, BRECONSHIRE.

The Llandeilo Flags near Builth rise in a boss in the midst of the Upper Silurian rocks, which,—with Upper Llandovery rocks at their base,—lie unconformably upon them. Their general arrangement will be easily understood by reference to Section No. 6 at the top of the Case.

All the igneous rocks of this area belong to the age of the Llandeilo Flags, and consist of intrusive bosses and dykes, with felspathic lavas and ashes which are interbedded with the black slaty and sandy strata, and were, therefore, ejected from volcanic vents during the deposition of the common strata. These volcanic eruptions took place long before the deposition of the Upper Llandovery rocks, which rest very unconformably and quite unaltered on the upturned and denuded edges of the Lower Silurian rocks whether slaty or volcanic.

INTRUSIVE ROCKS, AND ALTERED STRATA IN CONTACT WITH THEM.

307. GREENSTONE.

Gaer Einon, Carneddau, 1½ *miles N.E. 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.

308. AMYGDALOIDAL GREENSTONE.

Wellfield, 1½ *miles N.W. of Builth, Brecon.* Map 56, S.W.

Fine grained green rock, with small white crystals of felspar and cavities filled with calc spar. Some of the outer ones, from which the calc spar has been decomposed, are lined with brown iron ore.

From an intrusive branching mass about 1½ miles in length. The porcellaneous alteration it produces on the Llandeilo Flags is well seen on the banks of the river Wye, N.W. of Builth. *Unaltered* Upper Llandovery or May Hill Sandstone rests on its S.E. 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 Flat Case No. 14, Lower Gallery.

309. CONCRETIONARY NODULES of iron pyrites in felspathic rock.

Gwernyfid Rocks, Wye, near Builth, Breconshire.

310. 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. 314.

311. ALTERED LLANDEILO FLAGS.

Carneddau, Radnorshire; near Builth, Breconshire.

Porcelainized by contact with Greenstone.

312. ALTERED LLANDEILO FLAGS.

Carneddau, Radnorshire, near Builth.

313. ALTERED LLANDEILO FLAGS.

Banks of the Wye, Radnorshire, near Builth.

Altered fossiliferous pyritous black slate. In immediate proximity to Greenstone.

314. GREENSTONE.

Garth, N. end of the Carneddau, Radnorshire; near Builth, Brecon. Map 69, S.W.

Crystalline mixture of felspar and light and dark green hornblende. Felspar predominates.

From a mass 3 miles in length between Llanelwedd and the north end of the Carneddau. It is intruded among slates and felspathic ashes of the Llandeilo Flags, but principally overlies them. See section above, No. 6, rocks Nos. 314 and 315.

315. GREENSTONE.

S.W. of Bwlch-Llyn-fawr, near Llandegley, Radnorshire. Map 56, S.E.

Dark blackish-grey rock, hornblende and felspar mixed, not distinctly crystalline except near the outer surface, where the felspar crystals become apparent from decomposition.

From a line of greenstone 2½ miles in length intruded between beds of slate. See *Horizontal Sections, Sheet* No. 6.

316. FELSTONE PORPHYRY.

Craig Quarry, near Llandegley, Radnorshire,

Light green granular felspathic rock, with patches of white felspar and a few small hornblende crystals: quarried for building-stone.

From the north end of the same rocks as No. 317, near which they are overlaid by unaltered Wenlock Shale.

317. VESICULAR FELSTONE.

The Rocks, Llandegley, Radnorshire. Map 56, S.E.

Yellowish-grey felspathic rock, with felspar crystals decomposing of a dark brown.

From an intrusive mass forming a bold hill called the Rocks. It seems like a bed of lava, but has been intruded *between* the beds of slate, which have been altered both at its under and *upper* surface. Were it a lava-bed the rocks in contact with its upper surface would be unaltered.

FELSPATHIC SANDSTONES AND ASHES FROM THE LLANDEILO FLAGS, RADNORSHIRE, NEAR BUILTH. Map 56, S.W. and S.E., and Section No. 2, above.

318. DECOMPOSING FELSPATHIC SANDSTONE.

S.E. of Llansaintffraid Church, Radnorshire. Map 56, S.E.

Dark brown porous rock, made of broken felspar crystals loosely cemented. Contains fragments of fossils.

Nos. 318 and 319 are more properly sandstones made from volcanic material, than true ashes. Such rocks, however, in this neighbourhood pass gradually into true felspathic ashes.

319. SANDY FELSPATHIC ROCK.
Carneddau, Radnorshire; near Builth, Breconshire. Map 56, S.W.
Yellowish-brown granular hard felspathic rock, with hard siliceous or cherty bands.

320. FINE FELSPATHIC BRECCIATED ASH.
Range of the Carneddau, Radnorshire; near Builth, Breconshire. Map 56, S.W.
Light brownish-grey felspathic rock, enclosing angular fragments similar in colour and texture to the matrix; the specimen is apparently bleached.

321. VOLCANIC CONGLOMERATE.
Carneddau, Radnorshire, near Builth. Map 56, S.W.
Dark brownish-black felspathic rock, chiefly formed of angular fragmentary crystals of felspar, enclosing rounded pebbles, and angular felspathic fragments which project from the weathered surface.

322. FELSPATHIC BRECCIA.
N. end of the Carneddau, near Builth; as above.
Very hard rock, full of white hard felspathic angular fragments set in a black base.

323. FELSPATHIC, ASHY, FINE, BRECCIATED ROCK.
Llandegley Mountain, W. of "the Rocks," Llandegley, Radnorshire. Map 56, S.E.
Brownish-grey rock, with fragments of felspathic and slaty rocks included, and crystals of felspar. Contains 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.

S.W. of the Carneddau the igneous rocks next appear among the Llandeilo Flags in an anticlinal at Llanwrtyd, but from these rocks we have no specimens. They again show from 1 to 2 miles S.W. and S. of Llangadoc consisting of brecciated ashy beds interstratified with slates, grits, and thin bands of limestone. These ashy beds are not purely ashy, but contain many slaty fragments and fossils.

324. BRECCIATED FELSPATHIC ASH.
Blaendyffryn, Langadock, Caermarthenshire, South Wales. Map 41.
Brown brecciated rock, containing large decomposing felspathic fragments in a yellowish-brown felspathic base, with fragments of felspar crystals.

325. BRECCIATED FELSPATHIC ASH.
Blaendyffryn.

PEMBROKESHIRE.

The greater part of the igneous rocks of Pembrokeshire lie between Ramsey Island, near St. David's, and the country S. and S.E. of Newport. Those associated with the Cambrian rocks have been already described, (p. 17). The rest consist of greenstones, felstones, and felspathic ashy beds, and lie chiefly among the black slaty rocks of the Llandeilo series. Most of the felstones that run in lines are believed to be contemporaneous, and perhaps also some of the greenstones, but many of the latter, even though they run in the strike of the strata, are truly intrusive, the slaty beds being altered alike on both sides of the line of greenstone.

INTRUSIVE IGNEOUS SERIES, ST. DAVID'S. Map No. 40.

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.

326. Greenstone.
Pen Berry, 3 miles N.E. of St. David's.
Bluish-grey crystalline rock; white felspar and small dark hornblende crystals in about equal quantities.

327. Greenstone.
S. side of Porth Melgan near St. David's Head.
Dull bluish mass, fine grained hornblende and felspar, with large crystals and strings of greenish felspar.

328. Greenstone.
W. end of Carn Llidi, St. David's.
Light green felspathic base, with very small black hornblende crystals.

329. Greenstone.
Carn Llwyd, 2 miles N. of St. David's.
Finely crystalline white and dark greenish felspar with much hornblende in small black crystals.

330 to 334. Greenstone *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.
Rocks largely crystalline are presumed, generally, to have cooled more slowly than those more finely crystallized.

335. Greenstone Amygdaloid.
Tremynydd range, from 3 to 4 miles N.E. of St. David's.
Dull green felspathic base, with large black hornblende crystals and kernels of calc spar.
A line of greenstone about 2 miles in length, intruded between beds of Llandeilo slate.

336. Altered Llandeilo Flags.
Near Llanwnda, Fishguard, Pembrokeshire.
Banded fine siliceous rock, partly porcelainized by great intrusive masses of greenstone. Pen Caer, Strumble Head, Map 40.

337. Altered Llandeilo Flags, more weathered than No. 336.

338. Altered Llandeilo Flags, completely porcelainized.

339. Altered Llandeilo Flags, *more completely metamorphosed*, the silica having begun to crystallize in nests.

340. Brecciated Felspathic Rock.
Strumble Head, Goodwick, near Fishguard, Pembrokeshire. Map 40.
Interstratified in thick beds with slates of the Llandeilo Flag series.

341. Fragment of No. 340.
Strumble Head.

342. Slate.
Barry Island, North Pembrokeshire.

Specimens from North Wales, chiefly illustrative of the Volcanic Series associated with the Bala or Caradoc Strata.

In Caernarvonshire and Anglesey there are many bosses and lines of greenstone, quartz-porphyry, syenite, hæmatite, and granite associated with the Cambrian and Lower Silurian strata. In the same or closely neighbouring regions are found those interbedded felspathic lavas and ashes that alternate with the common strata lying at and about the horizon of the Bala limestone. It therefore seems not unlikely that some of the bosses were deep-seated melted nuclei connected with the volcanic eruptions, and from which proceeded some of the very beds of lava and ashes that we now find interstratified with the Bala beds of Snowdon, Carnedd Dafyd, &c., and all the country between Conway and Moel Hebog. (*See* Sections Nos. 1 and 4 in this Case.)

The following description of the specimens has therefore been generally followed. 1st. Deep-seated or erupted igneous rocks. 2nd. Lavas and ashes and the common strata associated with them. The collections were originally made chiefly with reference to the igneous rocks, which present great variety, and in these Lower Silurian cases they therefore far outnumber the specimens of slate, shale, sandstone, &c., with which they are interbedded on the ground.

INTRUSIVE ROCKS, CAERNARVONSHIRE.

344. GREENSTONE.
Llanfaglan, 1½ *miles S.W. of Caernarvon.*
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.

345. GREENSTONE.
Pen-ar-fynydd, 3 *miles E. of Aberdaron.*
Large plates or scales of hornblende, with a very few small felspar crystals.

346. GREENSTONE.
Pen-ar-fynydd, 3 *miles E. of Aberdaron.* Map 76, S.
Large black hornblende crystals irregularly scattered through a white or brownish felspathic base.

347. FELSPATHIC GREENSTONE.
Pen-ar-fynydd, 3 *miles E. of Aberdaron.* Map 76, S.
Greenish-grey felspar base (somewhat decomposed), with black hornblende and white felspar crystals. Largely crystalline.

Nos. 345 to 347 are from the same mass.

348. GREENSTONE.
Half a mile S.W. of Clynog-fawr. Map 75, N.W.
Dark greenish-grey felspathic base, with a few white felspar and large platy black hornblende crystals.
Small boss on the coast.

349. GREENSTONE.
4½ *miles S.W. of Clynog-fawr.* Map 75, N.W.
Finely granular mixture of pink and transparent white felspar crystals, and small crystalline particles of hornblende.

350. FELSPAR PORPHYRY.
Bwlch-mawr, 1½ *miles S.E. of Clynog-fawr.*
Composed of a black hornblendic base, with a few imperfect crystals of hornblende; simple and geniculated felspar crystals scattered through it.
This rock is continuous with rock No. 359, and forms a good example of the change in general character which the same mass exhibits.

351. GREENSTONE.
Gymblet Rock or Carreg-y-rhimbill, Pwllheli. Map 75, S.W.
Blackish-green finely granular rock, composed of dark-green hornblende and some white felspar crystals.

352. PORPHYRITIC GREENSTONE.
Carn Fadryn, 6 *miles W. of Pwllheli.*
Dark green granular hornblendic base, containing crystals of felspar.
From a continuation of the same mass as Nos. 357, 360, and 361, showing variations of character in the same mass.

353. GREENSTONE PORPHYRY.
Tan-y-Graig, 1½ *miles N.E. of Pwllheli.*
Imperfect crystals of light green felspar in a black hornblendic base.
From a mass, 4½ miles in length, among the Caradoc or Bala beds, between Pwllheli and Plas-dû.

354. FELSPATHIC GREENSTONE.
Yr Eifl, or the Rivals.
Pink felspar with crystals of white felspar and hornblende. Hornblende more abundant than in No. 355.

355. FELSPATHIC GREENSTONE.
Yr Eifl, or the Rivals. Map 75, N.W.
Grey and white crystallized felspar, with small hornblende crystals diffused through the mass.

356. Reddish-brown Felspathic Rocks.
Craig Dda (Black Crag), 5 *miles S.W. of Clynog-fawr.* Map 75, N.W.
Compact or finely granular, with transparent quartz crystals filling the cracks and cavities, and dendritic infiltrations of *oxide of manganese.*
From a high cliff which rises from the sea, and forms part of the intrusive masses of the Rivals, or Yr Eifl.

357. Felspathic Porphyry.
Carn Neddol, 5 *miles W.S.W. of Pwllheli.*
Dark grey felspathic base, including white felspar crystals, and a little hornblende.
From the same mass as 360 and 361.

358. Syenite.
Cefn Amwlch, 8 *miles W. of Pwllheli.* Map 76, S.
Felspar and quartz, and a few specks of hornblende. Felspar sometimes well crystallized. Quartz imperfectly crystalline.
Part of a boss of Syenite in Lower Silurian slates, about three-quarters of a mile wide.

359. Syenite.
Gyrn Goch, 1½ *miles S. of Clynog-fawr.* Map 75, N.W.
Reddish-brown finely granular mixture of quartz and felspar crystals, with a few small hornblende crystals.
Part of a mass 3 miles long, forming the hills of Bwlch-mawr, Y Gyrn-Goch, Y Gyrn-ddu, and Moel Penllechog.

360. Felspathic Porphyry.
Mynydd-tir-y-cwmmwd, 4 *miles S.W. of Pwllheli.* 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.

361. Felspathic Rock.
Mynydd-tir-y-cwmmwd, 4 *miles S.W. of Pwllheli.*
Green felspathic base, with a few hornblende and white felspar crystals.
From the same mass as No. 360.

362. Quartz Porphyry.
Llyn Padarn. Map 78, S.E.
Decomposing felspar, full of granular quartz crystals, mostly stained brown or yellow. Strings of quartz traverse the mass. It is an altered condition of No. 24, Wall-case 40.
Part of a large mass extending from Llanllyfni (Map 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 rocks, which, near the points of junction, are much altered.—See section No. 4 above, and specimens Nos. 25 to 31.

363. Hornblendic Porphyry.
Mynydd Mawr, Llyn Cwellyn. Map 75 N.E. & N.W.
Light pink felspar base, with small specks of hornblende.
Among the Lower Silurian slates, which are altered, and hard and porcellaneous at the junction. About 2 miles wide, and forms the circular mountain of Mynydd-mawr (Great Mountain).

364. Felspathic Greenstone.
Penmaen-mawr, between Conway and Bangor. Map 78, S.E.
Intimate mixture of felspar and hornblende, the felspar predominating.

365. Pitching Stone.
Same as No. 364.
Used in Liverpool, London, Berwick, &c. A very tough rock.

366. Ancient Celt, *unfinished,* found in Anglesey, probably formed from one of the felspathic porphyries of this district; possibly from the rock of Penmaen Mawr.

Specimens illustrative of the Volcanic Series of the Age of the Caradoc or Bala Beds, North Wales, and the associated ordinary Strata.

Caernarvonshire and Merionethshire.

From 367 to 409 the specimens are in great part from the volcanic felspathic ashes, and associated greenstones and common sedimentary strata of Snowdon and the other mountains of the district. The ash beds on the top of Snowdon, &c., &c., are the representatives of the BALA LIMESTONE. The old lava-beds extend from Moel Hebog on the South to Conway on the North. South of Snowdon they form one chief mass. On Snowdon and Y Glyder-fawr the felspathic trap splits into three or four separate beds. See Section No. 1 above, and Maps 75, S.E. and 78 N.E. The ashy beds near Bettws-y-Coed, and on Moel Hebog, &c., are the equivalents of those of Snowdon.

367. BRECCIATED VOLCANIC CONGLOMERATE AND GRIT.

Three quarters of a mile W. by S. of Pwllheli, Caernarvonshire. Map 75, S.W.

Alterations of fine and coarse volcanic breccia and grit. Greenish, with pebbles of greenish and black chert and jasper.

368. Three specimens of roofing SLATE.

Slate quarries, Cwm Eigia. Map 78, S.E.

The slates from some parts of this quarry contain cubes of iron pyrites disseminated through them, which do not decompose on exposure to the atmosphere, as is proved by the circumstance that the slates forming a roof which has been built for 26 years, still retain their original brightness. They are from the Bala beds above the felstone porphyries of the Glyders and Ffynnon Llugwy.

369. ARENACEOUS SLATY ROCK.

Bala, Merionethshire.

Micaceous. Contains *Asaphus Powisii.* Roughly cleaved, the trilobite having been shortened and otherwise distorted by lateral pressure. (See p. 14)

370. GRIT (Caradoc or Bala beds).

Pass of Llanberis, Caernarvonshire. Map 78, S.E.

Imperfectly cleaved. The beds dip at angles of about 60° to 70°. The *cleavage and bedding in this specimen form an angle of about* 10° (cleavage, 70° to 80°.)

371. SLATY FELSPATHIC ROCK, concretionary.

W. 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. *The concretions flattened in the planes of cleavage.*

372. SHALE OR SLATE, altered and hardened.

Near 12th milestone, Pass of Llanberis, Caernarvonshire. Map 75, N.E.

From a thin band in the felstone of Snowdon. Both have been *pierced by greenstone*, which here, and near Pen-y-gwryd, alters the slate in contact with it into hone-stone.

373. GREENSTONE.

Pont-y-Gromlech, Llanberis, Caernarvonshire. Map 75, N.E.

From a mass of greenstone which pierces the felspathic trap, Nos. 374 and 375 that underlies the calcareous ashes of Snowdon. (Section No. 4, above.)

374. Banded FELSTONE.

Clogwyn du'r Arddu, Snowdon, Caernarvonshire. Map 75, N.E.

Compact greenish-grey felspathic rock, with irregular white felspathic bands. The latter resist weathering, and project from the weathered surfaces. These lines probably originated in the same cause that produced the lamination in the lava from Ascension. Nos. 26 and 50, Wall-case 2.

Clogwyn du'r Arddu forms a lofty cliff about a mile N.W. of the peak of Snowdon, in which the felstones (lava beds) are faulted against the calcareous ashy beds that form the top of Snowdon. See section No. 4, above.

375. FELSTONE.

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.

From the same set of lava beds as No. 374.

376. FELSTONE.

Esgair-felen Y Glyder-fawr, Llanberis, Caernarvonshire. Map. 78, S.E.

Grey compact felspathic rock, with patches of pink felspar. Shows 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 felstone that form the cliff of Clogwyn du'r Arddu.

377. 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 felstone north of Pen-y-Gwryd, between the top of the Pass of Llanberis and Capel Curig. Equivalent to a high part of the Snowdon felstone of Clogwyn du'r Arddu, &c.

378. GREENSTONE.

Llyn Cwm-y-ffynon, near the top of the Pass of Llanberis, Caernarvonshire. Map 75, N.E.

Light green hornblende and white felspar. Largely crystalline.

From a line of Greenstone about a mile in length. Alters the slaty rocks in contact with it into hone-stone.

379. GREENSTONE.

Llyn-Pen-Craig, 1½ miles N. of Bettws-y-Coed, Caernarvonshire. Map 78, S.E.

Consists of felspar and hornblende distinctly crystallized, with slender crystals of felspar often traversing the other minerals. Felspar predominates.

From a line of Greenstone injected between beds of slate and felspathic ashes, equivalents of the calcareous ashes that form the top of Snowdon.

The Greenstone rocks of Merionethshire and Caernarvonshire chiefly run in lines, which, in many cases, have been 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 district, but their nature is easily inferred 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 unchanged. (See p.28, No. 230, and sections above.)

Wall-case 42.—North Side.

380. FELSPATHIC VESICULAR ROCK.

Castell Caer Seion, Conway, Caernarvonshire. Map 78, N.E.

North end of the felstones of Snowdon, Y Glyder-fawr, Carnedd Dafydd, and Carnedd Llewelyn.

381. COMPACT FELSTONE.

Digoed, 3½ miles S. of Bettws-y-Coed, Caernarvonshire. Map 75, N.E.

Light greenish-grey felspathic rock, with inclosed chalcedonic or cherty concretions.

382. SILICEOUS AND FELSPATHIC CONCRETIONARY ROCK.

Digoed.

Light grey felspathic rock and bluish chalcedonic spheroids.

383 & 384. SIMILAR SPECIMENS to No. 382.

Digoed.

Specimens 381 to 384 are from bosses of felspathic trap that lie in horizons not far beneath the Bala limestone, and are therefore, probably, approximately equivalent to the felspathic rocks under the calcareous ashes of Snowdon, which are partly the equivalents of the Bala Limestone.

385. CONCRETIONARY FELSPATHIC ASH.

Pen-y-rhiw, three quarters of a mile N.W. of Bala, Merionethshire. Map 74, N.W.

Felspathic layers, much decomposed, and containing ochrey particles, alternating with felspathic concretions.

386. CONCRETIONS IN TRAPPEAN ASH; as above.

Tyn-y-bryn, N.W. of Bala, Merionethshire.

387. FELSTONE PORPHYRY.

Yspytty Evan, Caernarvonshire. Map 74, N.W.

Light bluish-grey compact felspathic rock, containing a few felspar crystals.

388. **Felspathic Ashy Breccia.**
Castell Cader Dinmael, 3 miles S.E. of Cerrig-y-Druidion, Merionethshire. Map 74, N.W.
Roughly bedded dark-grey rock, with small included grey felspathic fragments.

389. **Felspathic Breccia.**
Castell Cader Dinmael.
Light grey rock, made up of angular felspathic porphyritic fragments, imbedded in a felspathic base, containing crystals of *felspar*. Bleached and weathered surface irregularly eroded, and covered with ferruginous stains.

390. **Felspathic Sediment.**
Castell Cader Dinmael.
Dark greenish-grey, with fragments of black sandy slate, and fragmentary and entire crystals of white, brown, or yellow felspar, some much decomposed. Has a coarse slaty structure, and gives a strong argillaceus odour.
The mechanical origin of this rock is apparent, the crystals being mechanically imbedded in felspathic and slaty sediment, containing a few grains of quartz.

391. **Sandy Felspathic Ash.**
Castell Cader Dinmael.
Similar to No. 390, but of a lighter colour, with large fragments of included rock, and numerous broken and entire crystals of felspar; also contains impressions of fossils (*Orthis*), the lime of which has been carried away in solution by the percolation of carbonated rain water. The fossils in this specimen, embedded along with felspar crystals, prove the mechanical origin of the rock.

392. **Brecciated Felspathic Ash.**
Clogwyn du'r Arddu, Snowdon, Caernarvonshire. Map 75, N.E.
Greenish-grey felspathic sediment, with angular fragments, which project from the weathered surface.

393. **Calcareous Ash.**
N.E. 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 removal of lime. Slightly laminated, hard, and brittle.

394. **Scoriaceous Felspathic and Calcareous Ash.**
Crib Goch, Snowdon, Llanberis, Caernarvonshire. Map 75, N.E.
Bluish-grey felspathic sediment, with a little calcareous cement; weathers unequally, exhibiting a rough scoriaceous surface.

395. **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.

396. **Sandy Volcanic Ash.**
N. 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 brown; shows a coarse slaty cleavage.

397. **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. From same beds as No. 396.

398. **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.*

399. **Fine Sandy Rock,** *calcareous and felspathic.* More fossiliferous, than No. 398.
This and the preceding specimen are not truly ashy, but the same beds pass into true felspathic and scoriaceous ashes in the district.

400. **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. Hard and brittle.

The specimens from Nos. 392 to 400 are all from one set of rocks, viz., the ashy rocks that lie on the felspathic lavas of Snowdon, Moel Hebog, near Beddgelert, in the valley above Cwm Idwal between Y Glyder-fawr and Y Garn, and in the valley of Dolwyddelan. 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 the close equivalent of the Bala Limestone, which, even near Bala, is sometimes ashy in structure. The ashy beds on Snowdon, &c., contain fossils in places. They are about 1,000 feet thick on Snowdon, (see section above, No. 4;) but ranging east to Dolwyddelan, and from thence by Cerrig-y-Druidion to the neighbourhood of Bala, and on the north and west flanks of the Berwyn hills, they gradually thin out, and, with the rest of the Snowdon igneous rocks, they finally disappear a few miles south of Bala lake. The meaning of this is, that in the middle of the period when the Bala beds were formed, the area of what is now Caernarvonshire was the centre of a district in a state of volcanic activity, which did not extend far to the south.

The fossils of the Caradoc or Bala beds will be found in the Lower Gallery, in Flat Cases 4 to 12, and in Wall-case V., compartments 14 to 16.

401. BALA LIMESTONE.

Yr Hwylfa, Yspytty Evan, Merionethshire.

Very impure compact limestone, exhibiting a weathered surface.

402. BALA LIMESTONE.

Y Gelli Grin, near Bala.

With *Orthis vespertilio* and *O. Actoniæ.*

403. BALA LIMESTONE.

Two miles N.E. of Bala, Merionethshire.

Impure compact grey limestone.

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.

404. BALA LIMESTONE.

Near Bala, Merionethshire.

Impure compact limestone.

405. BALA LIMESTONE, very impure limestone, with numerous casts of *Orthis Actoniæ.*

½ mile S. of Pont Rhiwaedog, Bala, Merionethshire.

This limestone is about 20 or 30 feet thick. It is always fossiliferous, and is made in great part of fragments of shells and other organic bodies. It is in general very impure, owing to the mixture of ordinary sediment with the lime.

406. UNFINISHED BLACK SLATES.

Dolwyddelan, Caernarvonshire. Map 75, N.E.

From the Caradoc and Bala beds, showing joints and cleavage. The top, bottom, and sides are joints, and the planes in which it is split are cleavage planes.

This specimen forms part of a small block bounded by joints, and suitable for splitting for the manufacture of slates. It has been split into three pieces, but would have admitted of finer division. The value of slaty rocks much depends on the number and arrangement of joints. The fewer the joints the larger are the slabs and slates that may be manufactured from the blocks extracted from the quarries.

407. FINISHED SLATE.

From the quarries in the Caradoc or Bala rocks of *Dolywddelan.*

This slaty band lies among the volcanic rocks.

408. Brecciated Felspathic Trap.

Crib Goch, Snowdon, Caernarvonshire. Map 75, N.E.

Dark bluish-grey felspathic rock formed of angular fragments.

409. Calcareous Amygdaloid.

Moel-yr-Ogof, Beddgelert, Caernarvonshire. Map 75, N.E.

Green felspathic rock, full of cavities, the lime having been dissolved out, and containing *calc spar* on the surface.

From an outlying patch of No. 408, lying on the ashy beds of Moel Hebog.

Nos. 408 and 409 belong to one of 8 isolated patches of compact felstone that *overlie* the ashy rocks of Snowdon and Moel Hebog. No. 408 is generally columnar, and they originally formed a large continuous sheet of lava, the greater part of which has been destroyed by denudation.

Nos. 410 and 411 are from a short band of limestone in the Bala series, much above (and of later date than) the Bala Limestone and the igneous rocks described above.

410. Hirnant Limestone.

Hirnant, Merionethshire.

Dark blue, oolitic, fossiliferous limestone.

411. Hirnant Limestone.

Pen-y-Dall-gwm, 4 miles S.E. of Bala, Merionethshire.

Showing a weathered and oolitic surface.

Greenstone Dykes, piercing intrusive and igneous rocks of Llyn Padarn, and the Cambrian slates and grits above it.

These dykes, Nos. 412 to 416, run in lines, piercing the quartz porphyries and Cambrian and Silurian rocks of Llanberis. They are, however, probably of much later date than the large masses of porphyry and the Lower Silurian lavas and ashes. Containing occasionally *cleaved* fragments of Cambrian slate at Penrhyn quarries, they have perhaps been intruded after those disturbances which contorted the rocks of the country, and during which the cleavage was produced by mechanical pressure.

412. Greenstone.

Llyn Padarn, S.W. side, near Llanberis, Caernarvonshire.

Dark green, finely crystallized, hornblende and felspar, with nests of radiated epidote.

413. Greenstone.

S.W. side of Llyn Padarn, Llanberis, Caernarvonshire.

Dark green rock; felspar and hornblende finely crystallized, with interspersed patches of felspar.

414. Greenstone.

S.W. side of Llyn Padarn, near Llanberis, Caernarvonshire.

Light green felspathic base, with *hornblende* crystals and veins of fibrous hornblende (*asbestos*).

415. Greenstone.

S.W. side of Llyn Peris, Llanberis, Caernarvonshire.

Fine-grained, dark-green rock, composed of *hornblende* and *felspar*, with kernels of *calc spar*.

Nos. 412, 413, and 414 pierce the Cambrian rock No. 185.

416. Greenstone.

N.E. side of Llyn Padarn, below slate quarries, Llanberis.

Compact dark green rock with large stripes of *epidote* and *quartz.*

Montgomeryshire.

Between Bala and the Berwyn Hills there is a synclinal trough, the highest beds of which are the Denbighshire grits (Upper Silurian). On the west the Bala beds dip under these and rise again on the east to form the Berwyn mountains. These mountains are formed of slaty beds and grits, Bala limestone, and volcanic and other igneous rocks, the general equivalents of those of Merionethshire and Caernarvonshire.

417. WHITE FELSPATHIC ROCK.
Craig Rhiwarth, near Llangynnog, Montgomeryshire. Map 74, S.W.

The cavities filled with crystallized carbonate of lime.

418. BLUE FELSPATHIC ROCK, with a few cavities.
Craig Rhiwarth, near Llangynnog, Montgomeryshire. Map 74, S.W.

419. COMPACT FELSPATHIC ROCK.
Y Garn, 3 miles W.N.W., near Llanrhaidr-yn-Mochnant, Montgomeryshire. Map 74, S.E.

With a few interspersed crystals of felspar, some of them brown from decomposition,

It is uncertain whether Nos. 418 and 419 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.

420. FELSPATHIC ASH.
Craig Gwel, Montgomeryshire; 3 miles S.E. of Bala. Map 74, S.W.

Greenish-grey felspathic sediment, with black slaty specks and particles. Weathers greyish-white.

421. PORPHYRITIC FELSPATHIC GRIT.
Llechrydau, 5 miles S. of Llangollen, Montgomeryshire. Map 74, S.E.

Yellowish-brown, 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 underlie 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.

422. PORPHYRITIC FELSPATHIC GRIT, No. 241; fused in a common air-furnace.

Wall-case 42.—South Side.

ANGLESEY.

Much of the Silurian rocks of Anglesey are metamorphic, and most of them are probably of Caradoc or Bala age, (See p. 39.)

423. SHELLY MICACEOUS SANDSTONE, Lower Silurian.
Anglesey.

Lower Silurian, with numerous casts of *Orthis calligramma.*

424. GRIT. Altered Lower Silurian Sandstone.
Pen Ferfyn S. of Llanerchymedd.

From near the edge of granite.

425. SLATY SILURIAN ROCK, porcelainized.
Careg-winllan, E. end of Mona Copper Mine, Anglesey. Map 78, N.W.

In the neighbourhood of *granites*, &c.

426. GNEISS.
One mile N.E. of Ceirchiog, Anglesey. 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.

SHROPSHIRE, MONTGOMERYSHIRE, AND CAERNARVONSHIRE.

The Lower Silurian rocks east of Church Stretton, Shropshire, consist entirely of Caradoc Sandstone. This is mostly a true sandstone with a few beds of shale. They are comparatively undisturbed, and are quite unlike their gritty and cleaved equivalents in North Wales. Neither are there any interbedded volcanic lavas and ashes among these rocks in Shropshire. In the neighbourhood of certain intrusive bosses, however, such as that of Caer Caradoc, the Caradoc sandstone is altered into *Quartz-rock.*

427. CARADOC SANDSTONE.
Church Stretton, Shropshire.
Exhibits lines of stratification.

428. CARADOC SANDSTONE.
Gretton, Cardington, Shropshire.
Fine grained yellow freestone, fossiliferous. Casts of *Modiolopsis orbicularis,* and *Orthis.*

429. CARADOC LIMESTONE.
Near Church Stretton, Shropshire.
Compact, grey limestone, with numerous fossil shells. From a thin band of limestone in the Caradoc Sandstone.

430. CARADOC SANDSTONE.
Bwlch-y-Cebau, Llanfyllin, Montgomeryshire.
Fine grained fossiliferous sandstone, unaltered. Full of casts of *Strophomena expansa, Orthis elegantula, Leptæna sericea.*

431. CARADOC SANDSTONE.
Bodvan, Caernarvonshire.
Unaltered fine grained sandstone with casts of *Orthis flabellulum.*

The next specimen is from the igneous boss of Caer Caradoc, and is inserted here because the Caradoc sandstone in contact with it is altered. Of this we have no specimens, but it quite resembles Nos. 433 and 434.

432. AMYGDALOID, composed of nests of *epidote* in a base of greenstone.
Caer Caradoc, Church Stretton, Shropshire. Map 61, S.W.

The next three specimens show the altered Caradoc sandstone, and the greenstone of Charlton Hill and Hope Bowdler. A large tract of sandstone in this neighbourhood has been altered into quartz-rock, and here and there in the midst of it greenstones protrude.

433. SILICEOUS GRIT, (altered Caradoc Sandstone).
Charlton Hill, Shropshire.

434. CARADOC CONGLOMERATE, (altered).
Hope Bowdler Hill, Church Stretton, Shropshire.
Contains small pebbles of slate, quartz rock, felspar, &c., bedded in a crystalline felspathic base, the result of *alteration.*

435. GREENSTONE.
Charlton, Shropshire.
Hornblende, with a little felspar.

436. ALTERED CARADOC CONGLOMERATE, as above.
The Wrekin, Shropshire.
The centre of the Wrekin is partly 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.

THE MALVERN HILLS.

The stratified rocks of the Malvern hills range from the Lower to the top of the Upper Silurian rocks. The former are in places altered, being associated with gneissic rocks, granites, and syenites. Frequently the intermixture of gneiss and granitic or syenitic rock is so intimate that it is impossible to draw any absolute line between them.

437. GNEISSIC ROCK.
A little N. of the Wych, Malvern, Worcestershire. Map 55, S.E.
Composed of silvery mica, felspar, and a little chlorite.

438. GNEISSIC ROCK, similar to No. 437.
A little N. of the Wych, Malvern.

439. SYENITE.
This specimen, when a fresh fracture of the interior is obtained, shows a kind of rude gneissic foliation.

440. QUARTZ and FELSPAR, coated with serpentinous matter.
Nos. 439 and 440 are from rocks close to the eastern boundary fault of the Malvern hills. The ground seems much broken, and the fragments are coated with soft serpentinous matter, marked by "*slickenside*" polish. (See "Memoirs of the Geological Survey of Great Britain," Phillips, vol. ii., p. 44.)

441. SYENITE; hornblende, felspar, and blue translucent quartz or siderite.
A little N. of the Wych, near Malvern. Map 55, S.E.
This rock is associated with gneissic rocks, as above.

442. GNEISS, very crystalline.
North Hill, Great Malvern Worcestershire. Map 55, S.E.
Exhibits strong foliations of felspar and quartz, interlaminated with mica.

443. SYENITE, very felspathic.
North Hill, Great Malvern, Worcestershire. Map 55, S.E.
Felspar, quartz, and hornblende.
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 are partly composed.

METAMORPHIC ROCKS FROM IRELAND.

The specimens Nos. 444 to 450 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.

444. CLAY SLATE.
Dunlaven, County Wicklow, Ireland.
Nearly unaltered.

445. CLAY SLATE, altered.
Near Hollywood, County Wicklow.
Near junction of slate and granite.
Seems somewhat micaceous, with small imperfect crystals, perhaps of staurolite.

446. TALCOSE SLATE, with contorted laminæ, slightly foliated with quartz.
Croghan Kinshela Mountain, County Wicklow, Ireland.
Near contact with granitic porphyry.

447. MICACEOUS SLATE (near Granite).
Hollywood Glen, County Wicklow.
Possesses a wavy structure, probably induced by the development of imperfect crystals of *staurolite.*

448. MICACEOUS SLATE, near junction of Slate and Granite.
Near Hollywood, County Wicklow.
Slightly foliated and gneissic in structure. Contains crystals of *staurolite.*

449. MICA SLATE, close upon Granite.
County Wicklow.
From a foliated rock containing much mica, with small garnets and large crystals of staurolite.

450. SLATY ROCK, highly metamorphosed.
Near Hollywood, County Wicklow.
At junction of slate and Granite.
The slate has here been changed into a crystalline mass of felspar, quartz, and mica, and has *probably almost undergone absolute fusion.*

Silurian Shales with Porphyritic Rocks, from Lammermuir Hills, Berwickshire.

Arranged and described by Archibald Geikie.

The shales and grits of the Lammermuir Hills are as a whole but little metamorphosed, though in places, where associated with various syenites and felspathic rocks, they are intensely so. The shales are but rarely cleaved, and for the most part are easily split along their laminæ of deposit. Fossils are very scarce in this region ; graptolites, however, have been found at one or two localities, indicating that the chain of the Lammermuirs consists of Lower Silurian rocks.

451. Shale (Lower Silurian).
Banks of Dyewater, above Longformacus, Berwickshire.

452. Shale (Lower Silurian).
Banks of Dyewater, above Longformacus.

453. Grit (Lower Silurian).
Banks of Dyewater, above Longformacus.
A hard quartzose rock with scattered specks of mica.

454. Grit (Lower Silurian).
Banks of Dyewater, above Longformacus.
In texture and composition it resembles the last, but is somewhat more granular, and has a red colour from decomposition.

455. Porphyritic Felstone, (Lower Silurian).
Banks of Dyewater, above Longformacus.
A compact cream-coloured rock, with numerous crystals of hornblende, which have decomposed into brown iron-ore ; also a smaller number of granules of quartz. It occurs intrusively among the shales and grits.

456. Felstone (Lower Silurian).
Banks of Dyewater, above Longformacus.
In this specimen the paste is much less porphyritic, but it still shows a good many small granules of transparent quartz.

457. Syenitic Granite (Lower Silurian).
Priestlaw, Fassney Water, Lammermuir Hills.
A mixture of well crystallized felspar, crystals of black mica, some hornblende, and a little quartz. This rock was the subject of much discussion during the days of Hutton and Playfair, and the locality was frequently visited by them.

Lower Llandovery Rocks.

Arranged and described by Andrew C. Ramsay.

The Lower Llandovery beds form the uppermost part of the Lower Silurian rocks. They consist mostly of slaty shales, grits, and conglomerates, which occasionally are very fossiliferous. They seem to lie conformably on the Bala beds, but the great prevalence of sandstones and conglomerates in the Lower Llandovery beds would seem to indicate oscillations of level and the commencement of a new set of conditions. Most of the fossils are found in the Bala beds, but some are peculiar, and some run into the overlying Upper Silurian strata.

They are contained in Flat Case 13 and in Wall-case VI., compartments 17 to 19, in the Lower Gallery.

458. Fine Compact Grit (Lower Llandovery).
Rhayader, Radnorshire.
Used for building.

459. Fossiliferous Conglomerate (Lower Llandovery).
5 miles N. of Caermarthen.
Nos. 459 and 460 are composed chiefly of small pebbles of quartz and a few subangular fragments of grey slate in a siliceous base. *Encrinites.*
From the range of sandstones and conglomerates on the hills.

460. Fossiliferous Conglomerate. Lower Llandovery.
5 miles N. of Caermarthen.

461. Felspathic Conglomerate (Lower Llandovery).
Cardigan.
Made apparently from the waste of the volcanic rocks of Lower Silurian age in Wales. *Encrinites.*

462. Conglomerate (Lower Llandovery).
Abbey-cwm-hir, near Pen-y-bont, Radnorshire.
Rounded, and a few subangular pebbles of quartz, with occasional fragments of black slate in a siliceous base.

463. Sandy Slate, cleaved.
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.

464. Lower Llandovery Rock, with peculiar surface marks.
Aberystwith, Cardiganshire.

465. Lower Llandovery Rock, with fucoidal markings.
Aberystwith, Cardiganshire.

466. Flattened Elliptical Sandy Concretion (Lower Llandovery).
Aberystwith, Cardiganshire.
Exhibits "*cone-in-cone.*"

467. Concretion.
Cliff above Wallog, N. of Aberystwith.
Imperfect crystallization, termed "*cone in-cone.*"
Presented by the Rev. Henry R. Lloyd.

UPPER SILURIAN SERIES.

Arranged and described by Andrew C. Ramsay.

Upper Llandovery Rocks.

The Upper Llandovery rocks (well seen near Llandovery, Caermarthenshire) form the base of the Upper Silurian strata, being so classed because they always lie quite unconformably on the Lower Silurian rocks, and, except that they are here and there quietly overlapped, there is no marked discordance between the Upper Llandovery rocks and the overlying Wenlock series. The total unconformity mentioned above is well seen in the Longmynd and Stiper Stone country, Montgomeryshire and Shropshire, where Upper Llandovery rocks full of *Pentamerus oblongus* lie on the nearly vertical edges of Cambrian grits and Llandeilo slates. A similar unconformity exists near Builth, and, in general, wherever the Upper Llandovery and Lower Silurian strata are seen in contact. They have often been called the *Pentamerus* beds, from the prevalence of P. oblongus, and, by Sedgwick, May Hill sandstone, from May Hill in Gloucestershire, where they are well developed.

For the fossils of the Upper Llandovery beds, see Lower Gallery, Flat Cases 14 and 15, and Wall-case VI., compartments 17 to 19.

468. FOSSILIFEROUS SANDSTONE (Upper Llandovery or May Hill Sandstone).

Norbury, Shropshire.

Contains numerous casts of fossils; *Pentamerus oblongus*, &c.

469. CALCAREOUS SANDSTONE (Upper Llandovery or Pentamerus Beds).

Hope Quarry, Bishop's Castle, Shropshire.

This belongs to the same set of beds as Nos. 468 and 471. They show how, in a few miles, the same rock may change in character.

470. BRECCIATED CONGLOMERATE (Upper Llandovery or Pentamerus Beds).

Hope Quarry, Shropshire.

Subangular pebbles of slate and shells in a sandy calcareous base.

471. BRECCIATED CONGLOMERATE (Upper Llandovery or Pentamerus Beds).

Longmynd, Little Stretton, Shropshire.

Fragments of slate and a few pebbles of quartz, in a calcareous base, inclosing fossils. This rock once formed part of an ancient beach, or sea-bottom in shallow water, close to the island of the Longmynd. (See "Geological Journal," vol. iv., p. 296. Ramsay.)

472. QUARTZ ROCK and GREENSTONE in contact (Upper Llandovery or May Hill Sandstone).

Old Radnor Hill, Radnorshire.

The quartz rock, in its unaltered state, was probably the equivalent of the fossiliferous sandstone of Presteign.

473. ALTERED SANDSTONE, crystalline and calcareous.

Old Radnor Hill, Radnorshire.

This hill occurs on a line of great disturbance and fracture, along which syenitic and greenstone rocks here and there protrude. On Old Radnor Hill the rock is so highly altered and so intimately intermixed with matter that has apparently been in a state of fusion. that in mapping it is impossible to separate the one from the other. This specimen gives a good example of the intense alteration of the sandstone, and its intimate intermixture with crystalline matter.

474. Crucible containing some of the SANDSTONE of Old Radnor Hill (No. 473), which has been melted in a common air-furnace.

475. SANDSTONE, containing Fossils (Upper Llandovery Rock or Mayhill Sandstone).

Malvern Hills.

Occurs in contact with and containing pebbles of granite, on the Worcestershire Beacon.

476. CONGLOMERATE (Upper Llandovery Rock), with *Petraia*.

Malvern, Worcestershire. Map 43, N.E.

Presented by Miss Phillips.

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

The metamorphism, therefore, of the Lower Silurian rocks of the Malvern Hills, and their disturbance and elevation, is of older date than the deposition of the Upper Llandovery beds.

477. CONGLOMERATE (Upper Llandovery).

Malvern.

Similar to No. 476.

478. GRANULAR QUARTZ ROCK (Caradoc Sandstone), commonly called "LICKEY QUARTZ," with grains of felspar.

Rubury Hill, Worcestershire.

There is no igneous rock intruded into this mass, which, notwithstanding, has an altered character.

479. SANDSTONE (Upper Llandovery).

Near Shustoke Edge, 2 miles E. of Walsall, Staffordshire.

480. SILURIAN SLATE. Age uncertain.

Westmoreland.

Exhibits well-marked *ribboned lines of wavy stratification* in various shades of ashy grey.

These beds are *traversed by seven small faults,* in which it is remarkable that the downthrow is on the opposite side from that which is usually the case in nature on a large scale. In most cases the downthrow is in the direction of the slope or "hade" of the dislocation. The polished front surface is a cleavage-plane.

Wall-case 43.

Denbighshire Grit and Shale.

The Denbighshire grits and flagstones form part of and lie at the base of the Wenlock series. In the typical Wenlock country (Shropshire) they have no representatives; but in Wales, from Conway to Bedd Ugre, near Pen-y-bont, Radnorshire, the western edge of the Wenlock beds consists of a broad band of these gritty beds, of great thickness, and occasionally containing Wenlock fossils.

For the fossils of this formation see Lower Gallery.

480. Denbighshire Grit.
Pont Cletwr, Yspytty Evan, Merionethshire.

481. 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.

482. Quartzose Grit, (Denbighshire sandstone).
Garn Brys, near Yspytty Evan, Merionethshire.
Contains many grains and broken crystals of felspar.

483. Conglomerate, (Denbighshire sandstone.)
Garn Brys, near Yspytty Evan Merionethshire.
Pebbles of white quartz and slaty rocks in a siliceous base, showing a weathered surface.

Woolhope Limestone, Wenlock Shale, and Wenlock Limestone.

The Woolhope Limestone, in the Woolhope country, Herefordshire, near May Hill, Gloucestershire, and near Malvern, lies at the base of the Wenlock shale, with which it may be said to be interstratified in numerous thin bands.

At Old Radnor, at Yat Hill, and near Presteign, at Nash Scar, this limestone is highly crystalline. It here lies in the same general line of disturbed country in which rise the syenite of Hanter Hill, and the chloritic greenstone of Stanner rocks.

For the fossils of this formation see Lower Gallery; Flat Cases 16 to 21, and Wall-case VI., compartments 17 to 23.

488. Woolhope Limestone.
Yat Hill, near Old Radnor, Radnorshire. Map 56, S.E.
Containing fragments of trap rock, and sub-crystalline. In the neighbourhood of a mass of intrusive trap. Used in considerable quantities for making lime.

489. Woolhope Limestone.
Yat Hill, near Old Radnor.
Fossiliferous and crystalline.

490. Fuller's Earth (Walker's Earth) from Woolhope Limestone.
Malvern, Worcestershire.

Wenlock Shale.

For the fossils of this formation see Lower Gallery, Wall-cases 20 to 22, and Flat-cases 17 to 21.

491. Calcareous Shale (Wenlock).
Rock Farm, near Longhope, Gloucestershire.
This rock is in Gloucestershire and Shropshire occasionally so soft, that it is used for brickmaking; and near Llangollen, &c., where it has been subjected to greater pressure, it forms slabs and cleaved slates. See No. 495.

492. WENLOCK SHALE, partially porcelainized.

Upper Heblands, Bishop's Castle, Shropshire.

In contact with Greenstone.

493. WENLOCK SHALE, altered.

Upper Heblands, near Bishop's Castle, Shropshire.

This rock is very calcareous, *and is pierced and much broken by a small dyke of Greenstone.*

494. POLISHED CUBE (Wenlock Shale).

Upper Heblands, Shropshire.

495. FLAGSTONE (Wenlock Shale).

Nant Gwyn, Denbighshire.

Black slaty flagstone, with *Actinocrinus pulcher.*

These rocks easily split into great flags, and in such cases the cleavage and bedding are often coincident.

496. NODULE OF ARGILLACEOUS LIMESTONE, in Wenlock Shale.

Seven miles N.E. of Cerrig-y-druidion, Merionethshire.

Part of the surrounding Wenlock Shale is attached here; a black flaggy rock.

497. NODULE OF ARGILLACEOUS LIMESTONE, from Wenlock Shale.

Near Llanfaredd, Builth, Brecon-shire.

See Horizontal Section No. 5.

WENLOCK LIMESTONE.

The Wenlock Limestone takes its name from Wenlock Edge, where it is well developed. It also occurs in force at Woolhope, May Hill, in the Malvern and Abberley range, and at Dudley and Walsal. It is there called Dudley limestone.

For the fossils see Lower Gallery, Wall-cases 20 to 23; Flat Cases 17 to 21.

498. WENLOCK LIMESTONE.

Wenlock Edge, Shropshire.

Fossiliferous limestone, with shells, Encrinites, (*Taxocrinus tesseracontadactylus*), &c.

499. WENLOCK LIMESTONE.

Wood Green, May Hill, Gloucestershire.

Coralline limestone, principally composed of *Halysites catenularius* (or *Catenipora*)—*the Chain-coral.*

Quarried for lime-burning.

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

500. WENLOCK LIMESTONE.

Dormington Wood, Herefordshire.

Coralline limestone, with *Arachnophyllum typus.*

501. WENLOCK LIMESTONE.

Malvern, Worcestershire.

Polished specimen of limestone, locally termed "*Ledbury Marble,*" formed chiefly of large pisolite (Salter), formerly believed to be corals.

Presented by the Rev. Francis Dyson.

502. OOLITIC WENLOCK LIMESTONE, Polished.

Croft Quarry, Malvern, Worcestershire.

Presented by the Rev. Francis Dyson.

503. WENLOCK LIMESTONE, Polished.

Winning's Quarry, near Malvern, Worcestershire.

Specimen of *shelly limestone*. Formed chiefly of *Rhynchonella* and other shells.

Presented by the Rev. Francis Dyson.

504. WENLOCK LIMESTONE or DUDLEY LIMESTONE.

Dudley, Worcestershire.

Compact grey limestone, with *Corals and numerous stems of Crinoids.*

505. WENLOCK or DUDLEY LIMESTONE.

Dudley, Worcestershire.

Rings of *Trilobites, with Tentaculites, Atrypa reticularis, Strophomena depressa,* &c.

LUDLOW ROCKS AND AYMESTRY LIMESTONE.

Lower Ludlow.

The Ludlow rocks are named from the town of Ludlow, in Shropshire, where they are well developed. They consist of brown sandy mudstones, and in the midst, in that country, lies the Aymestry Limestone. The latter is, however, very inconstant, and does not exist among the Ludlow rocks, either in Radnorshire or South Wales.

For the fossils of this formation, see Lower Gallery; Flat Cases 22 to 26, and Wall-case IX., compartments 25, 26, and 27.

506. LOWER LUDLOW.

Leintwardine, Shropshire.

Impressions of small star-fish, *Protaster leptosoma.*

507. LOWER LUDLOW.

Longhope, Gloucestershire.

Brown fine sandy rock, with casts of *Murchisonia Lloydii.*

508. LOWER LUDLOW.

Malvern, Worcestershire.

Bluish-grey, sandy shale, with *Pentamerus rotundus.*

509. FULLER'S EARTH or WALKER'S EARTH (Lower Ludlow).

Hales' End, Malvern, Worcestershire.

510. AYMESTRY LIMESTONE.

View Edge, Shropshire.

Compact, grey limestone, with *Pentamerus Knightii.*

This fossil is exceedingly characteristic of the Aymestry limestone.

511. AYMESTRY LIMESTONE.

Botvyle, Church Stretton.

Fossiliferous. *Orthis elegantula, Strophomena filosa,* &c.

UPPER LUDLOW; Tilestones, Bone Bed, &c.

512. UPPER LUDLOW.

Ludlow, Shropshire.

Brown muddy sandstone with *Serpulites longissimus.*

513. ARENACEOUS SHALE.

Longhope, Gloucestershire.

Slightly calcareous. Shells half dissolved out.

514. UPPER LUDLOW.

Builth, Breconshire.

Grey calcareous mudstone with shells; *Chonetes lata,* &c.

515. UPPER LUDLOW.

South of Llandeilo, Caermarthenshire.

Purple sandstone, with an occasional small pebble of quartz, and numerous casts of fossils, *Orthonota,* &c.

516. SANDY, SLIGHTLY CALCAREOUS SHALE (Upper Ludlow.)

Birkenhead Burn, Lesmahagow.

Shows concretionary action on their surfaces, after the manner of such shales on drying.

In South Wales the Tilestones form the uppermost Silurian strata. They are generally exceedingly micaceous and fissile, and have been used for roofing purposes, but in no instance are they cleaved like the true slaty roofing slates of the Cambrian and Lower Silurian rocks. The "*Bone-bed*" of Ludlow, Malvern, &c., is apparently on the same general horizon, and the Lingula and "Trochus helicites" beds near Builth, Kington, and at the base of the Old Red Sandstone outliers near Clun and Knighton, lie just at the passage of Upper Silurian into the base of the Old Red Sandstone.

For the fossils of these beds see Lower Gallery; Flat Cases 25 & 26, and Wall-case IX., compartments 25 to 27.

517. TILESTONE (Upper Ludlow).
Storm Hill Lodge, Llandeilo, Caermarthenshire.
Thin-bedded, micaceous, concretionary SANDSTONE.

518. UPPER SILURIAN BONE-BED (top of the Upper Ludlow rocks), containing *fish-bones, coprolites*, &c.
Ludlow, Shropshire.

519. TILESTONE (Upper Ludlow).
Kington, Herefordshire.
Micaceous, with *Lingula cornea.*

520. TILESTONE (Upper Ludlow).
Longhope, Gloucestershire.
Laminated sandstone, from the junction of the Old Red Sandstone and Upper Ludlow rocks.

521. TILESTONE (Upper Ludlow).
Bickton, S.W. of Bishop's Castle, Shropshire.
Contains *Platyschisma helicites* and *Cucullella antiqua.*

522. TILESTONE (Upper Ludlow).
Tin Mill, Downton, Ludlow Shropshire.
Fine micaceous sandy flagstone, with seeds of *Lycopodiaceous* plants (*Pachysporangium*).

523. FISH BED (Upper Ludlow.)
North Esk Reservoir, Pentland Hills, Edinburghshire.
Siliceous grit, with small fragments of fish-bones ? as white specks, scattered through the rock. It also contains *Platyschisma simulans*, and many other Ludlow-rock fossils.

DEVONIAN ROCKS AND OLD RED SANDSTONE.

The DEVONIAN ROCKS and OLD RED SANDSTONE succeed the UPPER SILURIAN strata. The Devonian rocks proper are found in Devon and Cornwall, and having been proved to lie below the Carboniferous strata, and above the Lower Silurian beds of South Devon and Cornwall, and also to possess a suite of fossils intermediate in character to those of Silurian and Carboniferous age, the Devonian rocks are thus proved to occupy the same general position as the Old Red Sandstone, and they are thus commonly classed as equivalents, although markedly different in lithological character.

The Old Red Sandstone in England lies chiefly in the Mendip Hills, and in the great tract of country that runs from Pembrokeshire to Coalbrook Dale in Shropshire, including most part of Herefordshire, Monmouthshire, and Worcestershire. It is at least 8,000 feet thick.

In Scotland the Old Red Sandstone lies in three zones. One between the great central coal-field of the basins of the Forth and Clyde; the 2nd crossing Scotland from N.E. to S.W., and lying between the Grampian Mountains and the Ochil Hills, &c.; and the 3rd in patches along the E. and N.E. coast, the Orkney Islands, &c.

In none of the true Old Red Sandstone areas either in England or Scotland are the marine shells, corals, &c. of the Devonian rocks found. Fish remains are, however, frequent, especially in the north of Scotland. The contemporaneous character of Old Red Sandstone and Devonian rocks is therefore in Britain founded on purely stratigraphical grounds, and at all events it is evident that the two sets of strata were formed under different physical conditions in two distinct areas. In Ireland, in the upper part of the Old Red Sandstone, Mr. Jukes discovered ferns and freshwater shells (*Adiantites Hibernicus*, Wall-case XI., compartment 31, and *Anodon Jukesii*, Wall-case X., compartment 30, and Wall-case XI., compartment 31 in lower gallery); and it has been surmised by Mr. Godwin-Austen that the fish of the true Old Red Sandstone may have been fitted to live both in estuaries and in fresh water, like some modern genera.

The fossils of this formation are arranged in the Lower Gallery, in Flat Cases 27 to 33, and Wall-cases X. and XI., compartments 28 to 31.

1. Felspathic Rock (Devonian).

Near Topleundy Hole, Cave on coast near St. Minver, Cornwall. Map 30.

Four joints forming a rhomb. Metamorphic.

2. Sandy Slate (Devonian).

Near Topleundy Hole, cave on coast, St. Minver, Cornwall. Map 30.

The *upper and under sides are surfaces* of a bed. The *sides* are *joints.* Imperfect rhomb.

3. Argillo-arenaceous Slate, Killas (Devonian).

Quarry near Black Head, St. Austell Bay, Cornwall.

Very fine and soft; cleaved.

4. Argillaceous Slate, Killas (Devonian).

St. Austell, Cornwall. Map 31.

Containing corals.

5. Arenaceous Slate, Killas (Lower Devonian).

Looe, S. Cornwall.

Slaty rock, with casts of *Strophomena gigas* much distorted by cleavage.

6. Argillaceous Slate, or Killas (Devonian).

Great Anchor, Perranzabuloe, Cornwall. Map 29.

Blue slaty rock, with imperfect cleavage.

7. Clay Slate, or Killas (Devonian).

Wheal Vor Tin Mine, near Breague. Map 33.

Micaceous, with banded gritty lines. 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.*

8. Banded Micaceous Argillaceous Shale (Devonian).

Penvivian Hill, near Bodmin, Cornwall. Map 30.

Altered slate, imperfectly foliated, near Granite.

9. Argillaceous Slate (Devonian).

Watergate Bay, St. Columb Minor. Map 30.

Very fine grained and talcose.

10. Talcose Clay Slate, or White Killas (Devonian).

Watergate Bay, St. Columb Minor. Map 30.

Very talcose.

11. Clay Slate, or White Killas (Devonian).

Huel Friendly Mine, St. Agnes, Cornwall. Map 31.

Very talcose. See Upper Shelf.

12. Clay Slate, White Killas (Devonian).
Huel Friendly, St. Agnes, Cornwall.

13. Argillaceous Slate, *with mica and talc* (Devonian).
Bossiney, Cornwall. Map 30.
A finely arenaceous, micaceous, and schistose rock, forming the lower part of the calcareo-trappean series.

14. Altered Rock (Devonian).
St. Clement's Island, Mousehole, Cornwall. Map 33.
Slightly foliated, traversed by granite-vein.
The metamorphism of all the rocks of Cornwall and Devon is intimately connected with large masses of Granite, which lie among the Palæozoic strata.

15. Slaty Rock, Talcose (Devonian).
Consols Mine, Redruth, Cornwall. Map 31.
Near Elvan Dyke and *a boss of Granite.*

16. Micaceous Gneissic Rock (Devonian).
Bolt Head, Salcombe, Devonshire. Map 24.
Metamorphic rock, composed of fine contorted *foliated* micaceous and quartzose interlaminated layers.

17. Micaceous Gneissic Rock (Devonian).
Lizard Head, Cornwall. Map 32.
Fine interlaminated layers of mica, talc, and felspathic matter.

18. Talcose and Micaceous Altered Slate (Devonian).
Camelford, Cornwall. Map 30.
Metamorphic rock, containing imperfect *crystals of staurolite,* from near the junction of slate and granite.

19. Altered Felspathic Rock (Devonian).
Withielgoose, near Withiel, Cornwall.

20. Quartzo - Felspathic Rock (Devonian).
Rosevanion, St. Columb Major, Cornwall.
Exhibits obscure traces of lamination.
Probably an altered rock. Furnishes a good road material.

21. Arenaceous Schist, *with much mica* (Devonian).
Breague, Cornwall. Map 33.
Banded and *slightly gneissic* in structure. From junction of slate with granite.

22. Micaceous Schist (Devonian).
Camelford, Cornwall. Map 30.
Metamorphic rock, containing many small *crystals of staurolite:* from near the junction of slate and granite.

23. Altered Sandy Rock (Devonian).
St. Agnes Beacon, Cornwall. Map 31.
Contorted and foliated; some of the bands felspathic.
Near a boss of granite.

24. Schorlaceous Contorted Rock (Devonian).
Castle Andinas, Cornwall. Map 33.
Metamorphic, and banded like gneiss in interlaminations of quartz and schorl. From contact of slate and granite.

25. Hornblende Slate, weathered (Devonian).
Porthousestock, St. Keverne, Cornwall. Map 31.
From *metamorphic rocks* north of Lizard Head.

26. Hornblende Slate (Devonian).
Beast Head, Lizard, Cornwall. Map 32.
Metamorphic rock.

27. Micaceous Rock, *with crystals of staurolite* (Devonian).
Cornwall.
Metamorphic rock.
Exact locality unknown.

28. Micaceous Argillaceous Rock, *with* large *crystals of staurolite* (Devonian).
Salcombe, Devonshire. Map 24.
Metamorphic rock associated with chloritic micaceous and gneissic rocks.

29. Sandy Schist, cleaved. (Middle Devonian).
Barrier Bridge, Devonport.
Interstratified with limestone. Contains coral. *Polypora repisteria.*

30. LIMESTONE, with veins of CALC-SPAR (Middle Devonian).
Brixham, Devon.

31. RED IRON ORE.

32. Stalactitic RED IRON ORE (*hæmatite*), with a fibrous structure.

33. Botryoidal RED IRON ORE (*hæmatite*), with a fibrous structure, and partly invested with lenticular crystals of sulphate of barytes.
Near Brixham, Devonshire. Map 23.
This ore of iron, Nos. 31 to 33, occurs in *Devonian Limestone* with sulphate of barytes, but it is uncertain if they were originally deposited during the Devonian period, or subsequently formed in hollows. It is worked in the cliffs at Sharkham Point, and is sent into Wales to be smelted. The softer portions of the ore, when washed, are made into colour, which is used for painting ships' bottoms.

34. COMPACT LIMESTONE, Middle Devonian. Quarried for marble.
Babbacombe, near Torquay, Devonshire.

35. CORAL LIMESTONE, PLYMOUTH MARBLE, Middle Devonian.
Cyathophyllum cæspitosum in a base of earthy limestone.

36. CORAL LIMESTONE, Middle Devonian.
Newton Bushel.
Much weathered.

37. CORAL LIMESTONE, Middle Devonian.
Tor Abbey, S. Devon.
Red marble, chiefly formed of the coral *Heliolites porosa.*

38. CORAL LIMESTONE, Middle Devonian.
Reddish-white marble.

39. CORAL LIMESTONE, Middle Devonian.
Teignmouth.
Formed of *Stromatopora concentrica, S. polymorpha, Favosites polymorpha, Alveolites suborbicularis, &c.*

40. CRYSTALLINE LIMESTONE, Devonian.
Breakwater, Plymouth.
Bored by *Saxicava rugosa.* See also No. 100.

41. ARGILLACEOUS SLATE, or KILLAS, (Upper Devonian).
Wheal Friendship, Tavistock, Devon. Map 25.
Bedding faintly traversed by cleavage nearly at right angles.

42. QUARTZOSE SLATE. Upper Devonian.
Tintagel, Cornwall.
Spirifer disjunctus flattened and exceedingly distorted by cleavage. The right wing of the Spirifer very much elongated.

43. CLAY SLATE, (Upper Devonian.)
Tintagel, Cornwall. Map 30.
Cleavage and bedding coincident. *Spirifer disjunctus* flattened and very much distorted.

44. SLATE, (Upper Devonian).
Fossiliferous : cleavage coincident with bedding or nearly so. *Spirifer disjunctus* flattened and much distorted.

45. BANDED SLATY ROCK. Probably Upper Devonian, but locality unknown.
Showing lines of bedding, joints, and cleavage. The front and back are cleavage planes. The upper and under surfaces are planes of bedding, and other parallel beds, in narrow bands, lie between. The sides are joints.

46. SLATE, Devonian.
Tintagel, Cornwall.

47. SEPTARIAN NODULE, with iron pyrites filling cracks in the interior.
North Huel Friendship, near Tavistock, Devon.

48. NODULES, forming Septaria, containing iron pyrites.
North Huel Friendship, near Tavistock, Devon.
This and No. 47 were taken from the walls of a copper lode, 30 fathoms from the surface.

49. CRUSHED PEBBLES of quartz rock, Lower Old Red Sandstone.
Nethan Water, Lesmahago.
From the basement beds, conglomerates near the base of the Lower Old Red Sandstone, Lanarkshire. Very near the *Pterygotus* shale at the top of the Upper Silurian strata. The strata in which the pebbles lie are disturbed and faulted. The pebbles have been crushed and fractured, and in some cases the fractured pieces re-cemented. Where they touch each other there are indentations, formed as if by the grinding of the pebbles on each other.

50. LOWER OLD RED SANDSTONE.
Bonnington Fall, Falls of Clyde, Lanarkshire.
Dark purple sandstone.

51. OLD RED SANDSTONE, variegated.
Bell Rock Lighthouse, Scotland.
The precise horizon of these beds is unknown, but they probably belong to the Upper Old Red Sandstone.

52. DEEP RIPPLE MARKS on Old Red Sandstone.
Locality unknown.

53. Small RIPPLE MARKS on Old Red Sandstone.
Locality unknown. See upper shelf.

54. BRECCIA.
Dulas, Anglesey.
From the lowest beds of the Upper Old Red Sandstone. Chiefly made up of fragments of white quartz, with occasional fragments of red jasper, in a siliceous base.
The Old Red Sandstone of Anglesey lies directly on metamorphic Cambrian rocks, from which the pebbles of this fragment have been derived. It passes under the Carboniferous Limestone, and altogether belongs to the Upper Old Red Sandstone series.

55. CORNSTONE, (Old Red Sandstone.)
Longhope, Gloucestershire.
Impure concretionary limestone.
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.

56. CORNSTONE, (Old Red Sandstone.)
Mitcheldean, Gloucestershire.
Impure concretionary limestone.

57. RED MARL (Old Red Marl).
Mitcheldean, Gloucestershire.
From the lower half of the Old Red Sandstone series, where the beds are chiefly marly.

58. SANDY AND MARLY CORNSTONE, from Old Red Marl.
Near Mitcheldean, Gloucestershire.
Very imperfect Cornstone.

59. MICACEOUS SANDSTONE, with fragments of plants,) Old Red Sandstone).
Hope Brook, near Mitcheldean.
Scales of fish in the same beds.

60. WHITE SANDSTONE, with a tinge of red (Old Red Sandstone).
Mitcheldean, Gloucestershire.

61. WHITE SANDSTONE, Old Red Sandstone.
Mitcheldean, Gloucestershire.
With laminæ of mica, which cause it to split into thin layers.

62. DECOMPOSED MICACEOUS SANDSTONE, Old Red Sandstone.
Mitcheldean, Gloucestershire.

63. QUARTZ CONGLOMERATE, Old Red Sandstone.
Mitcheldean, Gloucestershire.

64. YELLOW SANDSTONE, with *lepidodendron*, Old Red Sandstone, just beneath carboniferous limestone strata.
Mitcheldean, Gloucestershire.

The series from 59 to 64 certainly belong to the Upper Old Red Sandstone and to the beds of passage into the carboniferous series. These beds are, in the opinion of some geologists, altogether intimately connected with the carboniferous series, with which they are altogether or nearly altogether conformable. In Ireland their supposed equivalents contain plants and an Anodon, and both in that country and in Scotland they lie quite unconformably on certain beds, which, though conformable to the Upper Silurian strata, it has been customary to regard as forming part of the Old Red Sandstone. Provisionally they may be classed as Lower and Upper Old Red Sandstone.

65. MICACEOUS SANDSTONE, White; Old Red Sandstone.
Spring Gardens, Frome.
From very near the top of the Old Red Sandstone.

66. WHITE SANDSTONE, Old Red Sandstone.
Clee Hills, Shropshire.
Slightly micaceous, and containing fragments of plant-roots.
From top of Old Red Sandstone.

67. OLD RED MARL, ALTERED.
Brockhill, 3 *miles S.W. of Abberley, Worcestershire.* Map 55 N.E.
Pierced by a greenstone dyke.

68. STALACTITIC BROWN IRON ORE, with a fibrous structure.
From Old Red Sandstone.
Brown iron ore consists of peroxide of iron 85·3, and water 14·7, with occasional impurities, as silica, alumina.

69. BOTRYOIDAL BROWN IRON ORE, with a fibrous structure, and coated externally with an iridescent lustre.
From Old Red Sandstone.

70 BLACK OXIDE OF MANGANESE, assuming a botryoidal appearance on the outer surface.
From Old Red Sandstone.
This ore is composed of oxide of manganese 68·0, oxide of iron 6·5, water 17·5, carbon 1·0, baryta 1·0, and silica 8·0.
Nos. 68, 69, and 70 are from the *Brendon Hill Mine, Somerset.* (Map 20.) Presented by Sir Charles E. Trevelyan, K.C.B.

71. HARD SILICEOUS GRIT, Upper Old Red Sandstone.
Kiltorkan, Co. Kilkenny.
With the impression of a large fern, *Adiantites* (*Cyclopteris*) *Hibernicus.* The same strata also contain freshwater shells *Anodon Jukesii,* (see Wall-case No. 30 in lower gallery,) and are considered by Mr. Jukes to form the uppermost part of the Upper Old Red Sandstone.

CARBONIFEROUS SERIES.

THE CARBONIFEROUS SERIES succeeds the Old Red Sandstone.

In the south and middle of England, and in Wales, the divisions of the strata are as arranged in the column, p. xv. Passing northward into Yorkshire and Northumberland, the Carboniferous Limestone gets gradually interstratified with bands of sandstone and shale, occasionally containing beds of coal, and in Scotland a large part of the workable coal of East and Midlothian, lies in the carboniferous limestone series. The limestone there consists of a few comparatively thin bands. The strata are there also largely intermingled with volcanic products. For details, see pp. 82 to 111. In South Wales, Somersetshire, &c., the Carboniferous Limestone attains a thickness of about 2,600 feet.

The specimens in Wall-cases 43 and 44 represent the English series.

The fossils of this formation are arranged in the lower gallery, in Flat Cases 34 to 49, and in Wall-cases XII. to XIV.

MARWOOD BEDS AND THEIR EQUIVALENTS : LOWER CARBONIFEROUS ?

These strata lie just at the junction of the Devonian and Old Red Sandstone with the Carboniferous Limestone series. The fossils are for the most part peculiar, but they seem to be more closely allied to the Carboniferous series than to the underlying Devonian.

For the fossils from these beds see Lower Gallery, Flat cases 34 and 35.

72. FLAGGY MICACEOUS SANDSTONE, Marwood beds.
Braunton, N. Devon.
With track of *annelides* (marine worms). One of the specimens shows the cast, and the other the track in relief.

73. FLAGGY MICACEOUS SANDSTONE, Marwood beds.
Braunton, N. Devon.
With tracks of *annelides.*

74. FLAGGY MICACEOUS SANDSTONE, Marwood beds.
Braunton, N. Devon.
With burrows of a bivalve shell.

75. FOSSILIFEROUS SANDSTONE.
Braunton, N. Devon.
With casts of *Cucullæa trapezium.*

76. SANDSTONE, Marwood beds.
Braunton, N. Devon.
Weathered marly surface, with casts of *Rhynchonella* and *Spirifer.*

77. SILICEOUS GRIT, Marwood beds.
Braunton Down, N. Devon.
Partly calcareous and fossiliferous. Used as a building stone.

78. CALCAREOUS SANDSTONE, Lower Carboniferous.
Croyde, Barnstaple.
With casts of *Strophomena analoga, Orthis interlineata, Fenestella, Encrinites,* &c.

79. BONE BRECCIA, Lower Carboniferous.
Clifton, Bristol.
Bone bed with *coprolites, fish-teeth,* and occasionally *Brachiopoda.*
These strata are at the base of the Lower Carboniferous limestone shales.

80. BONE BRECCIA, Lower Carboniferous.
West Angle Bay, S. Pembrokeshire.
Similar to No. 79.

81. MICACEOUS FLAGGY SANDSTONE, Carboniferous Limestone series.
Alston Moor, Cumberland.
With annelide-burrows.

82. MICACEOUS FLAGGY SANDSTONE, from Carboniferous Limestone series.
Alston Moor, Cumberland.
With annelide-tracks.

CARBONIFEROUS LIMESTONE.

83. COMPACT LIGHT GREY LIMESTONE.
Forest of Dean, Gloucestershire.
Lowest bed of the carboniferous limestone.

84. SANDY LIMESTONE, Carboniferous Limestone.
Caldy Island, S. Pembrokeshire.
With *Orthis resupinata.*

85. CARBONIFEROUS LIMESTONE.
Caldy Island, S. Pembrokeshire.
Chiefly made of *Productus giganteus.*

86. ENCRINITAL LIMESTONE.
Mold, Flintshire.
Carboniferous limestone, chiefly composed of the stems of *Crinoids.*

87. ENCRINITAL LIMESTONE.
Middleton Moor, Derbyshire.
Carboniferous limestone, chiefly composed of *crinoidal* remains.

88. CARBONIFEROUS LIMESTONE.
Melwnly, near Stanwick Hall, Yorkshire.
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.

89. CARBONIFEROUS LIMESTONE.
Near Wellington, Shropshire.
Grey, coralline limestone.

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

91. ARGILLACEOUS LIMESTONE.
Forest of Dean, Gloucestershire.
From the lower beds of Carboniferous Limestone.

92. BROWN IRON ORE.

93. SPARRY IRON ORE.

94. OCHREY BROWN IRON ORE (Hydrous peroxide of iron), from Carboniferous Limestone.

Nos. 92 and 93 occur in the middle division of the Carboniferous Limestone of the Forest of Dean, where iron ore is raised in considerable quantities. By the last returns the number of tons of ore raised, in the above district, was 90,466; the money value of which was 40,710*l.* 4*s.* ("Mineral Statistics for 1860," by R. Hunt, F.R.S. p. 60.)

95. MAGNESIAN LIMESTONE, Carboniferous Limestone.
Locally called "lid-stone," from its lying on the top of the iron ore which occurs in the limestone of the *Forest of Dean in Gloucestershire.*

96. CARBONIFEROUS LIMESTONE.
Forest of Dean, Gloucesnershire.
Part of a large concretion from the lidstone."

97. CARBONIFEROUS LIMESTONE.
White Head, Forest of Dean, Gloucestershire.
Argillaceous limestone, used as a flux for smelting iron ore.

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

99. OOLITIC LIMESTONE, Carboniferous Limestone.
Clee Hills, Shropshire.

100. CARBONIFEROUS LIMESTONE, bored by marine animals, (*Lithodomus*).
Murdercombe Bottom, near Frome, Somerset. Map 19.
(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.

"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 Philips, 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.)

101. CARBONIFEROUS LIMESTONE.
Near Cardiff, Glamorganshire.
Compact limestone, with *Productus.*

102. TRIVIL WHITE LIMESTONE, Carboniferous Limestone.
Sirhowy Iron Works, Monmouthshire.
Compact and crystalline limestone, formed chiefly of fragments of *Encrinites.* Used as a flux in iron smelting.

103. CARBONIFEBOUS LIMESTONE.
Middleton, Derbyshire.
Compact, light grey limestone, with numerous fossil corals, on a weathered surface.

104. CARBONIFEROUS LIMESTONE.
Middleton Moor, Derbyshire.
With *Encrinites* and *Spirifer cuspidatus.*

Toadstone, Derby.

Toadstone is a volcanic rock or lava truly interbedded in the Carboniferous Limestone of Derbyshire, and is of the same general geological age with the volcanic rocks of the Carboniferous Limestone and Lower Carboniferous rocks of some parts of Scotland. Some of the beds are occasionally ashy.

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, Wall-case 2, and the kernels with which they are filled have been formed by the gradual infiltration of lime or other matters into the cavities. Frequently, on the surface, the kernels are re-dissolved out, and the rock then resumes its original structure, or the emptied cells are wholly or partially filled a second time with extraneous matter.

The term is derived from the German *todtstein* (dead-stone), denoting the absence of minerals in the beds with which it is associated.—H. W. Bristow. See also p. 281.

105. Greenstone, (locally termed "Toadstone.")
From a mine near Hartshill Hall, Derbyshire.
An intimate mixture of *felspar* and *hornblende.*

106. Greenstone ("Toadstone.")
Near Fairfield, Buxton, Derbyshire.
A crystalline compound of *felspar* and *hornblende*, weathering brown.

107. Amygdaloidal Greenstone "Toadstone."
Bonsall Dale near Matlock, Derbyshire.
Fine crystalline compound of hornblende and felspar, with a few small cavities filled with crystalline carbonate of lime.

108. Toadstone, containing pebbles of limestone.
From the deep shaft at the High Rake, near Tideswell, Derbyshire.

109. Amygdaloidal Greenstone ("Toadstone").
Alport, Bakewell, Derbyshire. Map 81, S.E.
A greenstone base, containing cavities filled with kernels of calc spar.

110. Vesicular Greenstone ("Toadstone").
Masson Hill, Matlock Bath, Derbyshire. Map 82, S.W.
The air-vesicles, originally formed when the rock was in a fused state, have been filled with kernels of *calc spar*, subsequently removed by the percolation of carbonated water.

Limestones—*continued.*

111. Carboniferous Limestone.
Richmond, Yorkshire.
With *Productus*, &c.

112. Carboniferous Limestone.
Richmond, Yorkshire.
From the upper beds. With *Serpula parallela.*

113. Hydraulic Limestone, Carboniferous Limestone.
Hênblas, near Holywell, Flintshire.
Locally called "Garreg Aberdo." From the upper beds of the Carboniferous Limestone.

114. Granular Magnesian Limestone or Dolomite, Carboniferous Limestone.
Breedon, Leicestershire.

115. Dolomite or Magnesian Limestone, Carboniferous Limestone.
Agasthorpe, Ashby-de-la-Zouch, Leicestershire.

The Carboniferous Limestone is occasionally interstratified with bands of chert. Some of the finest varieties occur near Matlock Bath. They are capable of a very fine polish. Occasionally the silica entirely replaces the lime of the shells, corals, &c., of the formation.

116. WHITE CHERT, INTERBANDED WITH LIMESTONE, from Carboniferous Limestone.
Matlock Bath, Derbyshire.

117. BLACK 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.*

118. BLACK CHERT, polished: from Carboniferous Limestone.
Middleton Moor, Wirksworth, Derbyshire.

119. MOTTLED CHERT, containing minute crystals of quartz: from Carboniferous Limestone.
Middleton Moor, Derbyshire.

120. BANDED CHERT in Carboniferous Limestone.
Matlock Bath, Derbyshire.

121. BANDED CHERT, polished, from Carboniferous Limestone.
Matlock Bath, Derbyshire.

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

123. CHERT, with silicified *Productus giganteus:* from Carboniferous Limestone.
Middleton Moor, Derbyshire.

124. WHITE CHERT, from Carboniferous Limestone.
Haddon Fields, Bakewell, Derbyshire.
Contains silicified *Terebratulæ, Spirifers,* &c.

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

126. CHERT, in Carboniferous Limestone.
Middleton Moor, Wirksworth, Derbyshire.

127. CHERT, from Carboniferous Limestone, showing a weathered surface.
Cromford, Derbyshire.

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

129. BLACK LIMESTONE, with *Goniatites Listeri:* from Carboniferous Limestone.
Tenby, Pembrokeshire.
This limestone is close upon the junction of the Carboniferous Limestone and Coal Measures on the coast near Tenby.

129*a*. BRECCIA, composed of angular fragments of granite, in limestone.
From the Crumlin Quarries, near Tallaght, Dublin Co., 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."

MILLSTONE GRIT AND COAL MEASURES.

The Carboniferous rocks in this Case were almost all collected during the progress of the Geological Survey in Wales and the coal-fields of the South and Middle of England. The lower coal strata of the limestone series in the North of England is therefore as yet unrepresented.

Only three specimens are from the Culm Measures of Devonshire, which belong to the Lower Carboniferous Shale and Millstone Grit series.

130. Black Shale, with *Posidonia Becheri:* Lower Carboniferous Shale.

Bickington, North Devon.

Cleaved, and the fossils distorted. The Devonshire Culm resembles some of the Lower Carboniferous rocks of Ireland, and it is probable that none of these strata in Devonshire range higher than the Millstone Grit.

They are often much contorted and cleaved.

131. Quartz Rock, altered sandstone ; Culm Measures.

Between Row and Scarey Tor, Dartmoor, North Devon.

132. Altered Rock, Culm Measures.

Between Row and Scarey Tor, Dartmoor, North Devon.

Granular quartz rock, with felspar and a little mica.

These two specimens are from rocks close upon the Dartmoor granite, and locally the rock from which they are derived is called granite. They are, however, simply metamorphosed sandstones of the Culm Measures.

South Wales Coal-Field.

The great South Wales coal-field consists of *Millstone Grit* and *Coal Measures.* Viewed as a whole, it consists of numerous interstratifications of shale, sandstone, and coal. The coal and iron beds are most numerous near the base of the Coal Measures. The following general account of the mode of formation of coal may serve as an introduction to the description of the remainder of the specimens in Wall-cases 43 and 44 :—

On the Mode of the occurrence of Coal, and the Manner in which it was formed.

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

It is easy to trace every possible gradation from common shale into true coal, by the gradual admixture of carbonaceous matter with ordinary muddy sediment ; for coal is a truly bedded rock, and, in its purer states, may be defined as consisting of beds of mineralized vegetable matter. These are interstratified with beds of sandstone, shale, and ironstone. The South Wales coal field affords a good example.

The Carboniferous Limestone underneath the Coal Measures is there, where thickest, about 2,500 feet thick; the overlying Coal Measures about 12,000. In this there are about 100 beds of coal, of varying thickness; and underneath each bed of these is the underclay (often fire clay), containing *Stigmariæ.* (See specimens 148, 156, 158, and 204; also Coal Measure Cases in the Lower Gallery, Nos. 44 to 54). This underclay was the soil on which the plants grew that formed the coal, and the coal itself is the mineralized vegetation formed partly by the decay of the *Sigillariæ*, of which *Stigmariæ* were the roots.* It is not unlikely that after an early stage the decaying vegetable matter that went to form coal, in some respects resembled peat moss, which in a humid and equable climate, accumulated with considerable rapidity.

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

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

* *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*.

An anthracite from Swansea gave :—

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

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

A collection of coal-measure plants is contained in the Lower Gallery. See Wall-cases XVIII. and XIX., compartments 50 to 54.

South Wales.

Millstone Grit, no specimens.

133. Conglomerate, Coal Measures.

Town Hill, Swansea, Glamorganshire.

Formed of pebbles of grit, gneiss, and carbonaceous fragments. The nearest gneiss in place is in Devon or Cornwall. The carbonaceous fragments seem waterworn, and were probably derived from the waste of a lower part of the Coal Measures themselves.

134. Blue Shale, with *Sigillaria elongata:* Coal Measures.

S. Wales.

The external part of the plant has been carbonized and converted into Coal. The woody tissue of the interior has been replaced by mud, now shale. The whole has been flattened by compression. For the roots of *Sigillaria*, see *Stigmaria* Nos. 148 and 204.

135. Blue Argillaceous Shale, with *Sigillaria flexuosa:* Coal Measures.

S. Wales.

As above; see No. 134.

136. Blue Argillaceous Shale, with *Lepidodendron aculeatum:* Coal Measures.

S. Wales.

Carbonaceous matter gone.

137. Argillaceous Shale, with branches of *Lepidodendron, ferns,* &c.; Coal Measures.

S. Wales.

Carbonaceous bark mostly removed.

138. Ironstone, "Big Vein Coal Brass;" Coal Measures.

Sirhowy Ironworks, Monmouthshire. Map 36.

A kind of concretionary iron ore mixed with carbonaceous matter.

Nos. 138 and 139 presented by the proprietors of the Ironworks.

139. 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.*

140. Black-Band Ironstone, Coal Measures.

Glamorganshire, South Wales.

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

A mixture of carbonate of iron with clay and carbonaceous matter. Its high economic value arises from the fact that it is easily calcined.

141. Crystallized Coal, Coal Measures.

Merthyr Tydfil, Glamorganshire.

With a peculiar structure, locally termed "crystalline, or cone-in-cone."

Presented by W. Crawshay.

142. Crystallized Coal, Coal Measures.

Merthyr Tydfil, Glamorganshire.

As above, see No. 141.

143. Coal, Cannel Coal? Coal Measures.

Cyffyn Vein, Swansea Valley.

Shows concentric rings, and breaks with a conchoidal fracture. This bed is 2 feet thick.

144. Anthracite, Coal Measures.

Coalbrooke, between Slannon and Llangyndryn, Caermarthenshire.

Anthracite is so called from ἄνθραξ (charcoal). In general it contains from 80 to 97 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.

145. Anthracite Coal, Coal Measures.

Pont-y-Berein, or Coal Brook, Caermarthenshire.

146. Argillaceous Shale, with ferns, *Pecopteris Serlii:* Coal Measures.

Somersetshire.

147. Pennant Grit; Coal Measure Sandstone, containing micaceous laminæ.

Forest of Dean, Gloucestershire.

The Pennant Grit forms the lower part of the Dean Forest Coal-measures, above the Millstone Grit.

148. Fire Clay, with rootlets of *Stigmaria:* Coal Measures.

Forest of Dean, Gloucestershire.

Locally termed "under clay," from its mode of occurrence immediately *under* the seam of coal.

149. Argillaceous Shale, with plants, *Asterophyllites*, and reed-like impressions; Coal Measures.

Forest of Dean, Gloucestershire.

150. Argillaceous Shale, Coal Measures: with impressions of *ferns* overlying the "Lowery Coal."

Forest of Dean, Gloucestershire.

151. Arenaceous Shale, with plants; Coal Measures.

Forest of Dean, Gloucestershire.

Above the "Lowery Coal."

152. Arenaceous Shale, Coal Measures.

Forest of Dean, Gloucestershire.

Above the "Lowery Vein." Used for brickmaking.

153. Calamites Suckovii, Coal Measures.

Forest of Dean, Gloucestershire.

A plant very common in the Coal-Measures.

154. Fire Clay, Coal Measures: locally termed "over clay," with impressions of *ferns.*

Forest of Dean, Gloucestershire.

Coalbrook Dale.

155. Reddish Mottled Clay, Coal Measures.

Broseley, Shropshire.

From beneath the "sulphur coal," of Coalbrook Dale. Used for making coarse pottery.

156. Sandstone, with *Stigmaria ficoides,* (root of Sigillaria); Coal Measures.

Coalbrook Dale.

157. SANDSTONE, with *Calamites nodosus*; Coal Measures.
Ketley, Coalbrook Dale.

158. SANDSTONE, with *Stigmaria ficoides*, (Sigillaria); Coal Measures.
Ironbridge, Coalbrook Dale.

159. SANDSTONE, with *Calamites pachyderma*; Coal Measures.
Ironbridge, Coalbrook Dale.

160. SANDY UNDERCLAY (Fire-clay); Coal Measures.
Donnington Wood, Coalbrook Dale.
Impression of Stigmaria with rootlets.

161. ARGILLACEOUS OR CLAY IRONSTONE, Coal Measures.
Ironbridge, Shropshire.
From the Crosstone beds.

162. IRONSTONE, Coal Measures.
Ironbridge, Shropshire.
From the Crosstone beds.

163. ARGILLACEOUS IRONSTONE, Coal Measures.
Ironbridge, Coalbrook Dale, Shropshire.
From the Pennystone beds. "*Curl*," or "*cone-in-cone*," containing about 10 per cent. of iron, and used for making Roman cement.
See also Mineral Cases in Upper Hall.

164. IRONSTONE, "Pennystone band;" Coal Measures.
Coalbrook Dale, Shropshire.

165. IRONSTONE, with *Productus*; "Pennystone band;" from Coal Measures.
Coalbrook Dale, Shropshire.

166. IRONSTONE, Flint Coal Bass; Coal Measures.
Donnington, Coalbrook Dale, Shropshire.
Part of the stem of a tree compressed and distorted.

167. CANNEL COAL, Coal Measures.
Iron Bridge, Shropshire.
This bed frequently contains fish-teeth and shells (*Anthracosia*).
Cannel coal is a corruption of the word *candle*, which has been applied to a particular description of coal, from the bright flame, like that of a candle, which it gives out in burning. In Scotland, this coal is called *parrot*, from the loud cracking noise with which it flies to pieces when placed upon the fire. It is bituminous, and is said to have been formed from decomposing vegetable matter in water, in the finest state of division. It differs from 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, snuff-boxes, and other articles.—H.W.B.

168. SHALEY CANNEL COAL, Coal Measures.
Madeley Pit, Coalbrook Dale.
With shells, *Anthracosia*.

169. BRECCIATED CONGLOMERATE, Coal Measures.
Muxton Bridge, Coalbrook Dale.
Composed of flesh-coloured felspathic fragments, and grey and green slate, derived from the Cambrian rocks of the Longmynd and the Silurian country W. of the Stiper Stones, in a base of clay.

170. LIMESTONE, Upper Coal Measures.
Le Botwood, Shropshire.
This limestone used to be called the "freshwater limestone." It contains a small *Serpula*, *Spirorbis carbonarius*.

NORTH WALES.

171. CHERT. Lower part of rocks in *Millstone Grit.*
Pen-ŷr-Hênblas, near Holywell, Flintshire.

172. MILLSTONE GRIT, occurring in the Chert series.
Holloway, near Holywell, Flintshire.

173. DARK GREY ARGILLACEOUS LIMESTONE, Coal Measures.

Grange Quarry, Holywell, Flintshire.

This stone, called Aberdaw stone, lies above the Millstone Grit, and is burnt for lime, and used for setting masonry under water. Several thousand tons of it have been used in the construction of the Liverpool and Birkenhead Docks.

Presented by Sir Pyers Mostyn, Bart.

174. SILICEOUS GRIT, Lower Coal Measures.

Felin-y-nant, between Halkin and Flint, Flintshire.

Containing plant-remains and carbonaceous matter.

175. CARBONACEOUS SHALE, Coal Measures.

Forming the roof of *Englefield Colliery, Holywell, Flintshire.*

"Batt" or "Bass" is a highly bituminous shale, commonly very compact, and splitting into the finest laminæ, almost invariably black, and often interstratified in layers with the coal. It is termed "*black bass*" in Lancashire, and "*black slag*" in Flintshire. See Jukes "On the Geology of South Staffordshire Coal Field," 2nd ed. p. 16.

SOUTH STAFFORDSHIRE.

176. GORNAL SANDSTONE, Coal Measures.

South Staffordshire.

177. 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 imbedded in it. The vitrification was assisted by the presence of numerous felspathic grains, which are mingled with the quartz grains of the unaltered Gornal sandstone.

It is placed here to show the effect of heat on soft sandstone, and for purposes of comparison with quartz rocks. See Nos. 425, 433, &c.

178. FIRE CLAY, Coal Measures.

Stourbridge, Worcestershire.

Used for making fire-bricks.

179. CARBONACEOUS IRONSTONE, "Gubbin Ironstone and Coal;" Coal Measures.

Queen's Cross, Dudley.

180. CLAY IRONSTONE, with *Calamite*, from Coal Measures.

Bumble Hole, Dudley.

181. CLAY IRONSTONE, with *Calamites pachyderma*; Coal Measures.

Twidale, Dudley.

182. CLAY IRONSTONE, Flattened Nodule ("New Mine Ironstone"); from Lower Beds of the Coal Measures.

North of Oldbury, Dudley, Worcestershire.

183. IRONSTONE ("Pennyearth Ironstone"); Coal Measures.

Clavery Hill, Dudley.

184. WHITE STONE IRONSTONE, 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.*

185. SLIGHTLY ARGILLACEOUS SANDSTONE, interstratified with coal.

Baremoor Pit, South Staffordshire.

In the Baremoor pit, a large oval cake of sandstone, 286 yards wide, and upwards of 400 yards long, is interposed in the measures, gradually cutting out bed after bed of the coal. "This mass of sandstone was very fine-grained, rather soft, slightly argillaceous, not at all differing from the usual argillaceous sandstones of the neighbourhood, which pass under the name of 'rock' or 'rock binds.'" It was not only interstratified with the coal *en masse*, but at or near the junction of the two, they each split up into many beds that interlaced with the utmost regularity. Beds of sandstone 2 or 3 feet thick, extended many yards into the coal, gradually thinning out and splitting up, so that hand specimens could be procured of alternations of bright coal and pale sandstone, each little bed not being more than one tenth of an inch in thickness. Similarly did small beds and thin laminæ of coal stretch into the mass of the sandstone; a few separate masses also, a foot or so in thickness, sometimes occurring suddenly, not as detached fragments, but as little independent beds in the sandstone. (See "Records of School of Mines," vol. i., part 2, pp. 183–5. Jukes.)

186. COAL altered by *Porphyritic Greenstone*, and enclosing Nodules of Magneso-calcite.

Near Bilston Furnaces, South Staffordshire.

The igneous rocks mentioned above are probably of the age of the carboniferous rocks. ("Geology of the South Staffordshire Coal Field," by J. B. Jukes, p. 248.) In the South Staffordshire coal-field sheets of greenstone, known in the district as "green-rock," have been ejected among the Coal Measure beds. From these proceed dykes and veins of "white rock," known to be "truly an igneous rock by the way in which it cuts through the coal and other matters, often producing more or less alteration in them at the place of contact." (Ibid. p. 241.)

187. THICK COAL, Coal Measures, altered by the intrusion of "*White Trap Rock.*"

South Staffordshire.

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.)

188. "WHITE ROCK," Coal Measures.

Grace Mary Colliery, Oldbury, S. Staffordshire.

Trap enclosing and altering "Thick Coal."

189. HEATHEN COAL, Coal Measures.

Grace Mary Colliery, Dudley.

190. HEATHEN COAL, Coal Measures.

Dudley.

Rendered anthracitic by contact with white igneous rock, and seamed by threads of calcareous spar.

191. COAL, Upper Coal Measures.

Bullock's Farm Pits, near Spon Lane, West Bromwich, South Staffordshire.

With a laminated structure, and circular concentric concretionary markings.

See Jukes's "Memoirs on South Staffordshire Coal Field," pp 159, 160; also Map 62, and Vertical Sections, sheet 18, No 25.

192. COAL, Upper Coal Measures.

West Bromwich, S. Staffordshire.

The specimens Nos. 191 and 192 were taken from a bed of *Coal*, 10 inches thick, resting on 3 feet 8 inches of fire-clay; "Part of the 10-inch coal is shaly and rotten, but about two inches of it is a beautifully bright coal, highly bituminous, very brittle, with curious circular concentric concretionary markings." (See No. 191.)

TAMWORTH COAL FIELD.

193. QUARTZ ROCK (Altered Millstone Grit), Coal Measures.

Hartshill, Atherstone, Warwickshire.

Pierced by trap dykes, similar to Nos. 195 and 197.

194. QUARTZ ROCK, with Manganese; Coal Measures.

Near Nuneaton, Warwickshire.

Pierced by Nos. 195 and 197, &c.

195. GREENSTONE, Coal Measures.

Hartshill, Atherstone, Warwickshire.

Composed of felspar and hornblende, the former predominating. Part of a dyke *intruded between the beds of quartz rock.*

196. SHALE, Coal Measures.

Two miles south of Atherstone, Warwickshire.

Partially hardened by heat (baked.)

197. GREENSTONE, Coal Measures.

From the eastern line of greenstone, south of Chilvers Coton, near Nuneaton, Warwickshire.

Very hornblendic. *Intruded among Coal Measures, shales, and sandstones, Nos.* 198, 200, *and* 202.

198. SANDSTONE, with iron pyrites; Coal Measures.

Nuneaton, Warwickshire.

Altered by the proximity of Nos. 197 *and* 199, between which it lies.

199. GREENSTONE, Coal Measures.

From the western mass south of Chilvers Coton, Nuneaton.

Intruded like No. 197.

200. ALTERED SHALE, Coal Measures.

Marston Jabet, near Bedworth, Warwickshire.

201. GREENSTONE, Coal Measures; *below No.* 202.

Marston Jabet, near Bedworth, Warwickshire.

202. ALTERED SHALE, Coal Measures.

From another bed in the same quarry as No. 200, about 10 feet thick, *lying between two masses of intrusive greenstone.*

203. GREENSTONE, *above No.* 202.

These greenstones are the cause of the alteration of Nos. 200 and 202, in which the ordinary soft shaly character has disappeared, and the beds have been simply much hardened by the action of heat. In the quarry there are two masses of greenstone, apparently interbedded like old lava-beds; but the shales both above and below them being equally altered, they are known to have been intruded *between the beds.* This is the case with the greenstones generally of the Warwickshire coal-field, which run in long lines between Atherstone and Marston Jabet, the longest being about six miles in length.

204 and 205. FIRE CLAY, Coal Measures.

Glascote Colliery, Tamworth.

Exhibiting part of a root and rootlets of *Stigmaria.*

Vertical Sections, sheet 21, No. 1.

206. CANNEL COAL, Coal Measures.

Glascote Colliery, near Tamworth, Warwickshire.

See Vertical Sections, No. 1, sheet 21.

207. CLAY IRONSTONE, with *Unio;* Coal Measures.

Glascote Colliery, near Tamworth, Warwickshire.

208. COAL, Coal Measures.

Slate-coal Seam, Haunch Wood Colliery, Nuneaton, Warwickshire.

Inclosing galena (sulphide of lead).

209. Part of a SEPTARIAN NODULE of *clay ironstone;* Coal Measures.

Bedworth, Warwickshire.

210. FINE CONGLOMERATE, Coal Measures.

Baxterley, near Atherstone, Warwickshire.

Small quartzose pebbles and fragments of slate in a siliceous base.

211. LIMESTONE, Coal Measures.

Baxterley, near Atherstone, Warwickshire.

Commonly and erroneously called "*Freshwater limestone;*" from the *upper part of the Warwickshire Coal Measures.*

212. COMPACT GREY ARGILLACEOUS LIMESTONE, speckled with *Spirorbis carbonarius;* (Coal Measures).

Bedworth, Warwickshire.

From the same beds as No. 211, but of a different colour.

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 *Spirorbis carbonarius.* It is probably the equivalent of No. 170.

Lancashire.

213. Conglomerate (Millstone Grit.)

Clapham, near Lancaster.

Pebbles of white quartz in a siliceous and felspathic base (used occasionally for millstones for grinding corn).

214. Millstone Grit.

Parbold, Lancashire.

Coarse grit, composed chiefly of quartz and felspar.

215. Carbonaceous Shale, with *Anthracosia robusta*; (Coal Measures).

Wigan.

From the Arley Mine.

216. Shale, with branches of *Lepidodendron*; Coal Measures.

Wigan.

217. Upholland Flag, Lower Coal Measures.

Gannister beds, near Wigan.

Micaceous flagstone, used for tiles. See Upper Shelf.

218. Upholland Flag, Lower Coal Measures.

Gannister beds, Bispham Delf, near Orrell, Lancashire.

Micaceous flagstone. See Upper Shelf.

Derbyshire and Yorkshire.

219. Nodule of granular crystalline quartz; Coal Measures.

Locally termed "boulders," and occasionally occurring in the *Coal seam* at *Alderwasley, Derbyshire.*

220. Spherical Concretion, 18 inches in diameter, from Millstone Grit, near Sheffield.

From below the upper bed of Millstone Grit W. of Sheffield.

Procured in a tunnel made from the valley of Rivilin to that of Loxley.

Presented by H. G. Sorby, Esq., F.R.S. Under Table-case F.

221. Broken Concretion.

As above. See No. 220.

222. Millstone Grit, Coal Measures.

Grassington Lead Mines, Yorkshire.

223. Sandstone with *Calamite*; Coal Measures.

Sheffield.

224. Argillaceous Shale, with ferns; Coal Measures.

Yorkshire.

225. Siliceous Grit, Coal Measures.

Scaffold Hill Quarry, Shire Moor, Tynemouth, Northumberland.

Presented by Sir Charles Grey, Bart.

226. Ferruginous Grit, Coal Measures.

Rhombic mass found in the gritstone or oak-quarrystone overlying *Coal Measures*, on the tops of hills around Barnsley.

Presented by Mr. Wilson.

227. Clay Iron Ore, Coal Measures.

Cross Green Colliery, Yorkshire.

Presented by Captain Edward James Maude.

Analysis.

	Per Cent.
Protoxide of iron (corresponding to 36·13 metallic iron)	46·56
Carbonic acid	30·34
Lime	2·50
Phosphoric acid	0·60
Manganese	trace
Sulphur (as pyrites)	trace
Organic matter	0·77
Insoluble matter (clay, sand, silica)	14·72
Water (expelled at 212°)	1·12
	96·51

228. Clay Iron Ore, Coal Measures.

Cross Green Colliery, Yorkshire.

Presented by Captain Edward James Maude.

Analysis.

	Per Cent.
Protoxide of iron (corresponding to 25·76 metallic iron) -	42·59
Carbonic acid - - -	14·11
Lime - - - -	2·34
Phosphoric acid - - -	0·67
Sulphur (as pyrites) - -	trace
Organic matter - - -	1·44
Insoluble matter (sand, clay, &c.)	32·38
Water (expelled at 212°) -	1·36
	94·89

229. Coal.

Wombwell Main Coal-pit, near Barnsley.

Rootlets of *Sigillaria* filled with iron pyrites.

Presented by D. C. Porter, Esq.

230. Sandstone, Coal Measures.

Wickerly, Rotherham.

Used for grindstones. From the uppermost part of the Coal Measures.

231. Carbonaceous Shale, with *Stigmaria;* Coal Measures.

Felling Colliery, Newcastle.

232. Ironstone, Coal Measures.

Netherton, Northumberland.

The *front* (marked) and *back* are split faces of the *beds*, the other sides are *joints* forming an irregular rhomb.

233. Ironstone, Coal Measures.

Felling Colliery, Newcastle.

Table-case D.—Upper Compartment.

OLD RED SANDSTONE, SCOTLAND.

Arranged and described by Archibald Geikie.

Edinburghshire.

This formation, as developed in the Lothians, consists of a thick series of sandstones and conglomerates resting on the truncated edges of Silurian grits and shales, and passing conformably upward into strata of Carboniferous age. In Edinburghshire or Midlothian it contains a group of contemporaneously ejected igneous rocks, which form the long chain of the Pentland Hills. The following specimens illustrate the general character of the formation of this district.

The Pentlands are a chain of hills from 600 to 1,900 feet high, running in a south-westerly direction from near the town of Edinburgh for about 15 or 16 miles, till they merge into the hills of Peebles and Lanark. They consist fundamentally of vertical shales and grits of Upper Silurian age, above which lies unconformably a series of conglomerates and grits belonging to the Old Red Sandstone. Interstratified with the upper part of these later deposits, and piled over them to a depth of several thousand feet, occurs a great series of felspathic traps, disposed in regular beds. Between them are intercalated ashes and conglomerates, which appear to form the upper part of the Old Red Sandstone formation in this locality, since they dip below a set of calcareous grits and conglomerates which pass upwards into plant-bearing beds of Lower Carboniferous age. This chain of hills rises out of a great plain of Carboniferous rocks that dip away from it on both sides; but it is not a mere anticlinal ridge, for the dip of the surrounding strata has been much influenced by a series of large parallel faults by which the limits of the older rocks of the hills are definitely marked.

Reference to the sketch section which accompanies the specimens in this case will illustrate the structure of the Pentland Hills. On the left or west side, the Lower Carboniferous strata (C) are seen reclining at a high angle upon the fault which has brought them down against the Silurian shales and grits (1). On the truncated edges of these latter beds rests the lowest felspathic trap (4–6a), the intervening conglomerates not occuring at the point where this section crosses. Two overlapping patches of Lower Carboniferous sandstone and shale cover part of this lower felstone as far as a long north-east and south-west fault, which runs along the flanks of the hills. The effect of this fault as shown in the section, is to bring down the lower felstone (4–6a) and its overlying strata against Silurian strata; in short, to repeat the structure observable at Warklaw Hill. From this fault across to the south-eastern flank of the hills the rocks follow each other regularly, dipping S.E. at an average angle of about 25° to 30°. The felstones occur in distinct beds, alternately dark and pale, so that even at some distance their true bedded form can be made out from the difference in colour which the exposed crags present. Each of the felstone beds represents a lava-flow. The ashy layers (22, 28–9, 35–8) which occasionally separate them, mark the dust and lapilli ejected between the successive erruptions of lava, and the conglomerate bands (9a, 19, 22,) point to periods of rest when the waves and submarine currents acted upon the hardened lava streams, breaking off fragments from them, and forming in this way beaches of coarse gravel and shingle, or of finer felspathic mud and sand, which vary in colour and composition with the character of the rocks whence they were derived. The history of the Pentland Hills, accordingly, is briefly as follows:—During the period of the Old Red Sandstone, the site of these hills was marked by a series of low slate islands, which the waves were ever wearing down and covering with sand and coarse shingle, represented now by the great masses of conglomerate and grit, which, at the south end of the chain, are seen to run like a fringe round the exposed hills of slate. When the hollows between the islets had become more or less filled up, and the islets themselves, wasted by the abrading power of the sea, had probably in large measure disappeared, a volcanic vent opened somewhere near the north end of the range, and poured out the sheet of lava (4–6a); subsequently another flow (7–9) of a different kind of rock was thrown out over the surface of the former, and the portion of it left can be traced for upwards of two miles. A pause then ensued, when the ocean recommenced the work of destruction, and formed, partly out of the subjacent lava-flows, and partly out of the sand-banks and islets, not yet covered by igneous rock, a bed of sandstone and conglomerate (9a). Another series of felspathic lavas (12–14), was thereafter erupted, the existing remains of which form a chain of hills about five miles long. The stratum

(19), consisting of felspathic grits and conglomerates, indicates another pause, and a condition of things similar to that of 9a. These sedimentary materials were eventually covered over by a stream of dark crystalline felstone (20), which, after a pause, marked by the felspathic, ashy, and conglomeratic beds (22), was followed by another eruption of a similar lava (23, 4), which runs south to Carlops, a distance of about ten miles. The next eruption was that of the ash (28, 9), and then followed the great stream of light pink felstone (30–4) which now forms the highest peaks of the hills, and can be traced in a south-westerly direction for six or seven miles. The upper part of this bed shows indications at several points of another shower of ashy fragments (35–8), which was succeeded by a series of dark crystalline and vesicular lavas (40–48), forming the last of the eruptions of this Old Red Sandstone volcano. When the igneous materials ceased to be ejected, the appearance of the locality must have been widely different from what it was when they began. The islands of slate had probably been almost entirely covered up either by the accumulation of their own debris, or by the volcanic matter thrown around and over them. A long bank of lava and ashes, scarcely, if at all, raised above the sea-level, occupied their site, and suffered in turn the same abrading effects from the action of the sea. In time a mass of sand and shingle, represented by the grits and conglomerates of the upper Old Red and Lower Carboniferous groups, accumulated on the site of the ancient volcano; the whole area underwent a gradual process of subsidence until several thousand feet of sand, mud, lime, and peaty matter—the sandstones, shales, limestones, and coals of the Carboniferous series—hath gathered over the submerged reef. In long subsequent times a re-elevation took place, denuding agencies again commenced to abrade the rising land, until the whole of the superposed strata, to the depth of 5,000 or 6,000 feet, were worn away, and the ancient lava-flows, and parts of the old slate islands, once more appeared above the waves, to form what we now know as the chain of the Pentland Hills.

1. PURPLE GRIT, Upper Silurian.

Habbie's Howe.

One of the thin gritty beds intercalated among vertical shales, containing *Orthoceras MacLareni*, and *Rhynchonella compressa.*

2. GREEN QUARTZY CONGLOMERATE, Old Red Sandstone.

Side of river Esk, Fairliehope.

The matrix is granular and chiefly quartzy, with a few specks of yellow felspar. The pebbles are here small, well rounded, and derived from the hard green grits of the underlying Silurians.

3. GRIT, Old Red Sandstone.

Bed of Esk, below Fairliehope.

Granular quartzy rock, not distinguishable in hand specimens from some of the vertical grits of the Silurians below. The old red sandstone of the Pentland Hills has nearly always a greenish colour, corresponding to the green tint of the shales and grits from which it has been derived.

4, 5, 6, 6a. From the lowest bed of felstone, Warklaw Hill. It is hardly necessary to repeat here that all the following felstones and ash beds belong to the Upper Old Red Sandstone.

4. Felstone.

Warklaw Hill.

A very compact dark felspathic rock from the under part of the bed.

5. Porphyritic Felstone.

North side of Torduff Reservoir.

This specimen, from a higher part of the bed, shows a granular crystalline texture largely impregnated with carbonate of lime.

6. Porphyritic Amygdaloidal Felstone.

North side of Torduff Reservoir.

From the highest part of the bed, showing the vesicular cavities of the upper layer of a lava stream, once filled with gas or steam, and subsequently filled up with calcedony, quartz, or carbonate of lime, carried in solution by water and deposited round the walls of the vesicles.

6a. Porphyritic Amygdaloidal Felstone.

South-west corner of White Hill Plantation.

This specimen is from the same bed, where it is repeated on the eastern side of the fault.

7–10. From the second felspathic bed in the section forming Torduff Hill on the west side of the fault, and repeated on Harbour Hill on the east side.

7. Felstone.

South side of Torduff Reservoir.

From under part of second bed, where the rock is darker in colour.

8. Felstone.

South side of Torduff Reservoir.

Light flesh-coloured dull felspathic rock with scattered crystals of felspar. Torduff Hill is entirely formed of a felstone of this character, often with a mottled and brecciated appearance.

9. Felstone.

Stream south of Whitehill Plantation.

Earthy, dull, fine-grained felspathic rock; from same bed as last two specimens, but on east side of fault.

10. Porphyritic Felstone.

Ravine west of Green Craig.

Dull, meagre felspathic rock with crystals of felspar; weathers light brown. From upper part of last-named bed.

At the north end of the hills above the two felstone beds just described there is a good deal of confusion, owing to the number of small lenticular patches of different felspathic traps. From the fact of the number, and of the greater thickness of the igneous rocks generally towards this end of the chain, it may be inferred that in this neighbourhood lay the vent from which they proceeded. The felstone (7-10) is followed at the Bonally pond by a thin seam of sandstone and conglomerate, marked 9a in the section.

11. Felstone.

Green Craig.

Dark compact, crystalline felspathic rock, from one of the narrow lenticular patches at the north end of the hills.

12-14.—From felstone bed above the conglomerates 9a.

12. Felstone.

Glen between Belld Hill and Harbour Hill.

Dull, earthy felspathic rock, mottled yellow and yellowish purple, with small black decomposing grains, perhaps of felspar.

13. Felstone.

Glen between Belld Hill and Harbour Hill.

A whiter, more crystalline felspathic rock, without felspar crystals. It decomposes with a white surface, and its bleached fragments strew the hill sides as long grey lines of rubbish.

14. Felstone.
North Black Hill.
A light flesh-coloured felspathic rock, very compact; breaks with a conchoidal fracture. The rock, in mass, is much traversed by joints, two of which are shown on the sides of this specimen.

15. Felstone.
Quarry on north side of Shearer Knowe north end of Pentlands.
Dark blue compact rock; breaks with conchoidal fracture, weathers greenish yellow. This specimen belongs to a higher lenticular patch at the north end of the hills, and, with the following three, passes northwards into the Braid Hills, which are a prolongation of the beds of the Pentland Hills.

16. Felspathic Ash.
Roadside, quarter of a mile north of Swanston.
Felspathic rock made up of angular fragments of different felstones, chiefly of a soft white variety. This ash bed occupies a very limited area among the lenticular felstones.

17. Mottled Felstone.
First Quarry west of Upper Braid.
Compact mottled felspathic rock, one of the lower beds of Braid Hills.

18. Compact Felstone.
Cayiside Quarry, 2 miles south of Edinburgh.
This dark fine-grained rock occurs above the ash No. 16, and appears to pass northwards into the darker felstone of the Braid Hills.

19. Green Felspathic Conglomeratic Grit.
Quarry between Belld Hill and Knightfield Rig.
This rock seems to be made up in great measure of the debris of the felstone bed (12–14) and of the green Silurian grits. The pebbles are partly of yellow felstone, partly of green grit, and all well rounded.

20. Felstone.
North side of north-east corner of Loganlee Reservoir.
Compact crystalline rock veined with carbonate of lime, and sprinkled with hæmatite, from bed overlying No. 19, and running along the north side of the Logan House Valley for upwards of four miles.

21. Felstone.
Mouth of Howlet's House Burn.
Compact pinkish white felspathic rock like No. 14; occurs in thin beds above the dark felstone No. 20.

22. Felspathic Ash.
North-east side of Loganlee Reservoir.
This rock occurs in thin strata, consisting of fragments of different felstones imbedded in a pale yellowish-pink felspathic base. It rests immediately upon the white thin-bedded felstone 21. Further north-east, this intercalated band becomes more conglomeratic until it finally passes, below Castlelaw Hill, into a coarse conglomerate of rounded felstone and grit fragments.

23. Felstone.
South side of south-west corner of Loganlee Reservoir.
Compact crystalline rock lying above the ash beds (22). This bed is one of the most marked of the series; it runs from Carlops to beyond Caerketton Hill, a distance of about 10 miles. In the upper part it becomes highly amygdaloidal (No. 24).

23*a*. Compact Blue Felstone.
Stream on the west side of Castlelaw Hill.
From same bed as the last specimen, but further north.

24. Amygdaloidal Felstone.
East Kipp Hill.
Chocolate coloured felspathic rock, with numerous cavities, some of which are filled up with quartz crystals, others being empty from the decomposition of the enclosed mineral. This specimen forms part of the same beds as 23.

Between this and the next felspathic trap are intercalated thin lenticular patches of grit and conglomerate that appear to have filled up hollows existing on the surface of the underlying lava-flow. The next two specimens (25 and 26) illustrate these sedimentary interstratifications.

25. Grit.
Road side, quarter of a mile north of Carlops.
Dark quartzy felspathic rock, scarcely distinguishable from some of the more granular felstones.

26. FELSPATHIC CONGLOMERATE.
West side of South Black Hill.
Rounded felspathic fragments, imbedded in a granular felspathic paste.

27. FELSTONE.
Above turnpike road, a quarter of a mile N. of Carlops.
Dull, compact, slightly vesicular felspathic rock from lenticular bed among the grits and conglomerates represented by Nos. 25 and 26.

28. FELSPATHIC ASH.
South-west side of Castlelaw Hill.

29. FELSPATHIC ASH.
Quarry between Scald Law and Carnethy.
From the same bed, but further south, where it overlies the grits and conglomerates (25 and 26).

30–34 are from the bed which forms the highest peaks of the chain, and runs from Caerketton Hill 7 miles to Walstone. They are arranged to show the changes of the rock in its course along the hills.

30. BRECCIATED FELSTONE.
Top of Caerketton Hill.
Fragments of hornstone-like felstone imbedded in a looser-grained dull felstone. From the north end of the bed.

31. BRECCIATED FELSTONE.
S. W. side of Castlelaw Hill.
Collected about 1½ miles S.W. of the last specimen.

32. FELSTONE.
Castlelaw Hill.
Very compact, hornstone-like rock from the same locality as 31.

33. FELSTONE.
Quarry between Scald Law and Carnethy.
White dull felspathic rock, with crystals of a black decomposing mineral, possibly augite, 2 miles S.W. of 32.

34. VESICULAR FELSTONE.
Braid Law.
Dull earthy felspathic rock, concentrically mottled; weathers with a rough orange-coloured surface, 1½ miles south of 33.

35–38 illustrate an ashy layer which rests upon the last described bed of felstone (30–34). They are also arranged to show the different changes of the rock from north to south.

35. FELSPATHIC ASH.
Top of Caerketton Hill, north end of range.
Angular fragments of white and pink felstone embedded in a granular felspathic matrix.

36. FELSPATHIC ASH.
From the same locality.
Showing angular and rounded felspathic fragments in a pinkish felspathic paste.

37. FELSPATHIC ASH.
Roadside north of Camp Hill, 5 miles south of 35 and 36.
The fragments here are mostly subangular, the paste being of a pinkish colour and granular texture.

38. FELSPATHIC ASH.
Walstone, 1 mile south of 37.
The beds at this locality are finely stratified, of a light yellow colour, and nearly vertical, against a large fault which skirts the whole of the south-eastern flank of the Pentlands.

39. PORPHYRITIC FELSTONE.
Quarry above Woodhouslee.
White dull felspathic rock with crystals of pink felspar and small rounded granules of dark-coloured quartz.

40–45 are from the dark-coloured felstone that overlies the Scald Law, Carnethy, and Castlelaw bed, and runs from Walstone northwards for about 8 miles, till lost among the upper felstones of the Braid Hills, which are probably on the same horizon. Although referred to here as one bed it is not unlikely that there may be several, so similar however in composition, and so obscured by the herbage and debris of the south-eastern declivities of the hills, that their limits cannot be traced. The specimens are arranged to show the varieties of this felstone from the south end at Walstone to the north end at the Braid Hills.

40. Porphyritic Felstone.
Quarry west of road between Braidwood and Walstone.
Decomposing felspathic rock with numerous crystals of white felspar.

41. Porphyritic Felstone.
North side of Camp Hill.
Dull, meagre felspathic rock, finely vesicular, with small scattered crystals of felspar. Collected about three-quarters of a mile north of 40.

42. Porphyritic Felstone.
Quarry south-east side of Carnethy.
Very compact crystalline rock with small granules of amethyst and large felspar crystals. These crystals have a thin tabular form, sometimes half an inch broad, and are disposed in planes which give a rudely fissile structure to the rock. Collected about a mile and a half north of the last.

43. Felstone.
East end of Hillend Hill.
Red crystalline rock, with disseminated crystals of glassy felspar.

44. Amygdaloidal Felstone.
East end of Hillend Hill.
Red and crystalline like 43, of which it forms an upper part, with numerous kernels of calcedony, quartz, and sometimes green earth.

45. Felstone.
Quarry on roadside south of Hill-end Hill; 4 miles S. of Edinburgh.
An upper part of same bed, showing the same red crystalline texture, all the jointed surfaces being slicken-sided and covered with a thin coating of serpentine. This is the highest bed of the Pentland Hills; the next specimens illustrate what seems to be the same felstone, or one on the same horizon, in the Braid Hills.

46. Felstone.
Blackford Hill Quarry.
Very compact crystalline rock, joints coated with hæmatite and carbonate of lime.

47. Felstone.
Blackford Hill Quarry.
Finer grained than 46, with a trace of the striped character so marked in the rock of Traprain Law, Haddingtonshire. (Table-case F. No. 63.)

48. Felstone.
Quarry west of Liberton Tower, Braid Hills.
Very compact, dull felspathic rock, with crystals and veinings of carbonate of lime.

At Habbie's Howe, and also at Liberton, the felstones of the Pentland Hills are covered by a conformable series of conglomerates and conglomeratic grits belonging apparently to the upper Old Red Sandstone. These graduate upwards into a set of calcareous conglomerates and reddish sandstones, forming here the bottom beds of the Carboniferous rocks.

49. Conglomerate, Upper Old Red Sandstone.
Habbie's Howe, Pentland Hills.
The pebbles are well rounded, consisting of felstones, jaspers, and grits imbedded in a granular quartzy and felspathic paste, the whole being derived from the waste of the Silurian and Old Red grits with their overlying felstones.

50. Calcareous Conglomerate, passage beds between Old Red Sandstone and Lower Carboniferous.
Liberton Hill, Edinburgh.
The basis is a calcareous sand, and the pebbles, generally well rounded, consist partly of a compact cherty limestone, partly of different felstones, and sometimes of various grey micaceous grits.

51. SANDY CONGLOMERATE, Lower Carboniferous.

West side of Harbour Hill, at the point marked × in the section.

The basis here is sandy, micaceous, and considerably felspathic; the pebbles are chiefly well-rounded pieces of yellow and pink felstone, like that of the upper part of Harbour Hill, from which they were probably derived,

52. SANDSTONE, Lower Carboniferous.

From a higher bed at the same locality as 51.

For the character of some of the Upper Old Red conglomerates and sandstones of Haddington and Berwick, see 1-4 in Table-case E.

Table-case D.—Upper Compartment—*continued.*

CARBONIFEROUS FORMATION OF SCOTLAND.

Arranged and described by ARCHIBALD GEIKIE.

This formation, as developed in Scotland, consists of the following members :—

		English Equivalents.
Upper Coal Measures or Flat Coals of Mid-Lothian	=	Coal Measures.
Moor Rock or Roslin Sandstone - - - -	=	Millstone Grit.
Upper Limestones - - - - - - Lower Coal Measures, or Edge Coals of Mid-Lothian Lower Limestones - - - - -	=	Carboniferous Limestone.
Calciferous Sandstones, passing down into Upper Old Red Sandstone - - - -	=	Lower Limestone Shale.

CALCIFEROUS SANDSTONES OF EDINBURGHSHIRE AND LINLITHGOWSHIRE.

At the base of the Scottish Carboniferous formation lies a thick series of white sandstones, blue and black shales, ironstones, thin cherty limestones, with occasional meagre seams of coal. Throughout this series occur beds of stratified volcanic ash, with masses of greenstone and basalt both interbedded and intrusive. The fossils are of the ordinary Lower Carboniferous types, as *Sphenopteris affinis*, *Lepidodendron Veltheimianum*, *Cyprides*, *Edmondia*, *Myalina*, *Schizodus*, *Amblypterus*, *Palæoniscus*, *Megalicthys*, *Rhizodus*, *&c.*

These rocks are well exhibited in the Merse of Berwickshire, in Haddingtonshire, Edinburghshire, Linlithgowshire, and the East of Fife. The following specimens are arranged stratigraphically, and also in districts, to show the succession of beds in West and Mid-Lothian. They commence at the point where the series is dropped in the collection of specimens from the Pentland Hills in the same Case.

The town of Edinburgh stands upon Lower Carboniferous sandstones and shales, higher in position than the sandstone at Harbour Hill (52). They dip eastwards and pass under the igneous rocks of Arthur's Seat and Calton Hill; two hills of which the specimens in this Case, from 53 to 81, are illustrative. The section accompanying the specimens is drawn through the central ridge of the town from a point west of the

Castle rock to the coal-field beyond Portobello, a distance of about five miles. The lowest strata are the sandstones and shales which recline against the fault on the east side of the Castle rock. They continue with an easterly dip to Arthur's Seat, where their higher portions, retaining the same general character, are seen interstratified among different traps. The general contour of Arthur's Seat, as well as the area of some of the rocks described below, is shown on the model in Recess 2.

Arthur's Seat is the name of a hill about 820 feet high, and a square mile in extent, forming the eastern boundary of Edinburgh. It consists of two parts, separated by the deep valley of the Hunter's Bog; that to the west rises from the streets of the town in a steep slope crowned by a semicircular mural escarpment, called Salisbury Craigs, which descends on the other side into the Hunter's Bog. The eastern portion of the hill is formed of successive terraces with dividing valleys, running north and south, their southern terminations being marked off by a confused pile of rock which slopes up from the north and east, and descends precipitously on the other sides. This higher part of the hill, which seen from certain localities looks like a great irregular cake laid down upon the lower ridges, is crowned by a crag of basalt forming the summit, or Arthur's Seat proper. To this peculiar contour the geology of the hill bears special reference. The ridges are all of hard trap; the intervening valleys consist of softer rocks, which have yielded more readily to disintegration; while the higher irregular mass of rock at the south side belongs to a much later age, and is really what it appears to be, a newer group of ridges set down on the tops of the older ones. The hill is thus of two distinct geological ages. The older rocks form part of the Lower Carboniferous series, and are all inclined to the east at an average angle of about 20°. The under or westerly part consists of a set of white, red, green, and mottled sandstones, fine conglomeratic grits, coarse limestones, and red and green shales (53, 56, 57), among which are intercalated intrusive beds of greenstone (54 and 55, and also Nos. 22, 23, and 24 in the lower compartment of this case), that harden and otherwise disturb the strata above and below them. The upper or eastern portion displays a great group of contemporaneous trap-rocks, that is, basalts, greenstones, felstones, and felspathic ashes (Nos. 58 to 69), which were ejected over the sea-bottom after the sandstones and other strata below had been deposited. All these are arranged in beds which follow with great regularity the dip and direction of the underlying sedimentary rocks, and pass under a higher series of sandstones and shales, the whole forming part of the great Calciferous Sandstone group.

The newer rocks of Arthur's Seat belong to a much later period, for they rest upon the upturned denuded edges of the beds below. The older traps had been covered over by several thousand feet of newer deposits; the rocks of the whole country had been bent into troughs and ridges, and then the whole of this superincumbent mass had been worn away from the site of Arthur's Seat, whose trap beds again stood up as ridges, with the sea excavating valleys through the softer rocks between;—all this had elapsed before the rocks of the summit and south side of the hill were ejected. The latter were suspected by the late Professor Edward Forbes to be of so recent a date as even a part of the Tertiary period,—a conjecture which subsequent investigations have strongly tended to confirm. The specimens of these later ejections are therefore in the meantime placed between the Secondary and Tertiary specimens in Wall-case 6.

The igneous rocks of unquestionably contemporaneous age are arranged stratigraphically in the next series of specimens.

53. CONGLOMERATIC SANDSTONE.

At the Hawse, Queen's Drive.

This specimen is from a bed a little way below the intrusive bed of greenstone which forms the precipice of Salisbury Craig. Like a large number of conglomerates in the lower part of this series, it contains a considerable admixture of lime, both as limestone fragments and in the base. (See under 48–50).

54. AUGITIC GREENSTONE.

Salisbury Craig.

Intruded among sandstones, shales, &c. This specimen is inserted here to indicate the nature of the greenstone by which the alteration shown in the next specimen is produced. See also the lower compartment of this Table-case, where the intrusive rocks of this district are illustrated separately.

55. JUNCTION OF GREENSTONE AND SANDSTONE.

From base of Greenstone bed, south side of Salisbury Craig.

Both rocks are much altered; the greenstone has acquired a fine texture and red colour, while the sandstone shows a vitrified aspect like quartz rock. The greenstone is marked *a*, the altered sandstone *b*. (See also 23 and 24 in the lower compartment.)

56. RIPPLED SANDSTONE.

From quarries above the Greenstone of Salisbury Craig.

57. WHITE SANDSTONE.

Quarries above the Greenstone of Salisbury Craig.

Above these sandstones and another intrusive bed of greenstone known as the Dasses (Nos. 41 and 42, lower compartment of this case), the lowest of the truly interbedded igneous rocks of the hill commence.

58. GREENSTONE.

Long Row.

Very black, compact, approaching a basalt, with scattered crystals of augite and amygdaloidal nodules. This bed has a rudely columnar structure, and is the oldest of the contemporaneous traps of Arthur's Seat. It is succeeded by ashy beds, the junction being seen on the south side of the Queen's Drive.

59. AMYGDALOIDAL GREENSTONE.

Below St. Anthony's Chapel.

Contains grains of specular iron, veins of hæmatite, and cavities filled with carbonate of lime, chalcedony, &c. It is covered immediately by 60.

60. ASHY CARBONACEOUS SHALE.

Below St. Anthony's Chapel.

Contains remains of plants, and scales of *Rhizodus*, &c.

61. GREEN FELSPATHIC ASH.

Dry Dam.

Greenish, granular, felspathic rock, well stratified, containing numerous angular fragments of greenstone, altered shale, &c., with irregular fragments of cherty limestone.

62. BASALT.

Lowest bed above ash of Dry Dam.

Compact black rock with granules of serpentine.

63–65. Three specimens, to illustrate the passage of a Basalt, like No. 62, into a porphyritic felstone.

South end of Whinny Hill.

Collected within a space of 15 yards.

66. PORPHYRITIC FELSTONE.

Side of Queen's Drive, east of St. Anthony's Loch.

Dull felspathic rock, with crystals of specular iron and felspar, its vesicular cavities being filled with a brown decomposing mineral. This bed succeeds the basalts and passes into them imperceptibly, as in 63–65. It is followed by other felstone beds, of which the next three specimens are examples.

67. PORPHYRITIC AMYGDALOIDAL FELSTONE.
Queen's Drive, east of St. Anthony's Loch.
Cavities numerous, often large, filled with calc spar, chalcedony, and green-earth; generally lined with green-earth, frequently empty.

68. PORPHYRITIC FELSTONE.
East of St. Anthony's Loch.
Red, compact, with grains of specular iron and crystals of felspar.

69. FELSTONE.
East of Queen's Drive, east end of the hill.
This is the highest visible bed on Arthur's Seat. It is darker, more homogenous and crystalline than most of the rocks below, and has a granular texture, sparingly porphyritic.

To the north-west of Arthur's Seat, from which it is separated by a deep valley, lies the conical rounded eminence called the Calton Hill. It consists of different bedded felstones, with intercalated seams of ash, and corresponds closely with the eastern part of Arthur's Seat, of which, indeed, it forms geologically a part, the two hills being separated by a large fault. The bed marked 62 of Arthur's Seat, answers to the lowest visible bed of Calton Hill (70), and the porphyries which supervene have the same general character on both hills. The ashy beds of the Calton Hill have not indeed been detected on Arthur's Seat, but such beds throughout the Carboniferous rocks of central Scotland, are usually of very limited extent. The Calton Hill beds may be regarded, therefore, as the northward prolongations of Nos. 62–69 of Arthur's Seat, separated by a fault which is a downthrow to the north.

70. GREENSTONE.
Below Regent Bridge, Edinburgh.
Compact fine-grained rock, with granules of green serpentine.
Lowest of Calton Hill Beds.

71. FELSPATHIC ASH.
Below Nelson's Monument.
Greenish stratified felspathic rock, with rounded felstone fragments.

72. PORPHYRITIC FELSTONE.
Below Nelson's Monument.
Dull compact felspathic rock, with crystals of pink felspar and carbonate of lime, from bed interposed between 71 and 73.

73. FELSPATHIC ASH.
Below Nelson's Monument.
Rounded and subangular fragments of different coloured felstones, imbedded in a dull reddish granular felspathic paste. The space between the two flat surfaces of this specimen shows the thickness of a stratum of this ash.

74. PORPHYRITIC FELSTONE.
Below Nelson's Monument.

75–78. STONES from the bed of Ash, No. 73.
East of Nelson's Monument.
75 and 76 show the rounded form of most of the enclosed fragments; 77 and 78 are pieces of larger stones, broken, to show the nature of the rock, which is an amygdaloidal felspathic porphyry, resembling 72.

79. FELSTONE.
East of Nelson's Monument.
This concentrically-stained compact rock forms the highest bed of the hill, and agrees closely with the highest bed of the Arthur's Seat series, as shown in the railway cutting at St. Margaret's.

Craiglockhart Hill, about 3 miles S.W. from Edinburgh, belongs to the same series of traps as Arthur's Seat and Calton Hill. It consists of a bed of light yellowish-green felspathic ash, dipping westward, and capped by a bed of columnar greenstone.

80. **Felspathic Ash.**

Craiglockhart Hill.

Soft yellowish felspathic rock, with scattered felspar crystals.

81. **Amygdaloidal Greenstone.**

Craiglockhart Hill, from thick columnar bed above ash.

This rock may be compared with 62 and 70, with which it is not improbably contemporaneous. The ash (80), too, may be compared with the Arthur's Seat bed (61) underlying a bed of augitic trap, as is the case here.

The foregoing specimens, from 55 to 81, illustrate the character of the volcanic rocks associated with the basement beds of the Carboniferous series in Edinburghshire or Midlothian. The succeeding specimens carry up the ascending series through the calciferous sandstones of the same county westward into Linlithgowshire or West-Lothian, where this lower group of strata is covered conformably by the Carboniferous Limestone.

82. **Brecciated Limestone.**

Cock Burn, near West Brook, 10 miles S.W. of Edinburgh.

This specimen and 100 are illustrative of the numerous thin calcareous bands in the Lower Carboniferous rocks of Edinburghshire, whence this group of strata was named by Mr. Maclaren the "calciferous sandstones."

83. **Limestone.**

Railway at Selms, Kirknewton.

84. **Felspathic Ash.**

Bed of Linhouse Water, at Felspathic dyke, south end of Calder Wood, Edinburghshire.

Sandy felspathic rock with white angular felspathic fragments.

85. **Altered Sandstone.**

Bed of Linhouse Water, below Red Craig.

This rock is traversed by a mass of felspathic trap (65 and 66, lower compartment of this Case) similar to that which occurs with 84.

86. **Black Shale.**

Hanging Craig, Granton.

Plants and coprolitic nodules occur in these beds. Below the Granton and Craigleith sandstones (89, 90) there is a set of black shales, which at Wardie enclose nodules of clay ironstone, containing coprolites and other fish remains. These shales are remarkably persistent, extending southward for several miles until they abut against the fault which flanks the Pentland Hills.

87–88. **Two Nodules of Clay Ironstone.**

From the Wardie Shales, Granton.

Contain coprolitic centres.

89. **White Sandstone.**

Granton Quarry.

This rock, extensively used as a building material, forms part of a great series of white sandstones, which occupy a large part of the western area of Edinburghshire, and the contiguous portion of Linlithgowshire. They overlie the dark shales (86), and graduate upwards into the shales and sandstones that contain the Burdie House Limestone.

90. **White Sandstone.**

Craigleith Quarry.

Out of this famous quarry most of the New Town of Edinburgh has been built. The rock forms part of the same sandstone as that of Granton.

91. **Felspathic Ash.**

Lauriston Cottage, two miles W. of Granton.

Compact sandy felspathic rock, with white felspathic fragments and irregular pieces of hardened shale.

92. **Felstone.**

Railway cutting 1½ miles N.E. of Harburn Station.

Dull compact felspathic rock forming part of the large bed of Corston Hill. The section displayed at the railway shows several intercalations of ash of which 93 is a specimen.

93. Felspathic Ash.
Railway cutting, 1½ miles N.E. of Harburn Station.
Angular and sub-angular fragments of different felstone in a dull yellow felspathic paste. Many of the fragments in these ash-beds resemble parts of the Pentland Hill rocks.

94. Sandstone, with iron-stains.
Bed of Linhouse Water at foot-bridge, half a mile above Camilty Bridge.

95. Quartzy Grit.
Bed of Linhouse Water, 300 yards above Camilty Bridge.

96. Felspathic Ash.
Bed of Crosswood Water, Harbour Hill Works, Edinburghshire.
Calcareous felspathic rock, with large admixture of crystalline carbonate of lime, in a greenish felspathic paste.

97. Felspathic Ash.
South end of Binny Craig, Linlithgowshire.
This specimen is taken from a circular patch of dull brownish black argillaceous ash, occupying the top of an anticlinal dome-shaped ridge. It underlies a set of calcareous shales (Burdie House Limestone), and may be connected with a series of similar patches of ash (as 98) which, by the convolutions of the strata throughout the eastern part of this county, are found on the denuded tops of the anticlinal axes, dipping below similar shales.

98. Felspathic Ash.
Tor Hill, Ecclesmachan, Linlithgowshire.
Dull greenish-grey brecciated felspathic rock, consisting of green angular felspathic fragments which contain rounded grains of quartz, and are imbedded along with rounded pebbles of cherty limestone, in a dull grey felspathic and calcareous paste. The rock in mass frequently shows angular fragments of yellow baked shale and balls of different traps. It underlies a set of shales similar to those near 99. (See 111.)

The next important stratum in ascending order, illustrated by the specimens in this case, is the Burdie House Limestone. That rock, where it occurs typically, at Burdie House, four miles south-east of Edinburgh, attains a thickness of 27 feet. It there has a dull yellowish or bluish-grey colour, and in certain strata has a finely-striped appearance, owing to the greater or less amount of carbonaceous matter in the layers. It is compact, not crystalline, or only sparingly so in certain bands, and contains in some parts thin laminæ of coaly matter, which impart a fissile structure. Fossils are abundant, and consist of *Ferns*, *Sigillariæ*, *Stigmariæ*, *Lepidodendra*, *Lepidostrobi*, *Calamites*, and other Carboniferous plants, along with the cases of minute crustaceous animals called *Cyprides*, and teeth, scales, bones, and coprolites of several genera of *Fishes*. (For these fishes, see Lower Gallery, Wall-case 43.) The position of the limestone at Burdie House is about 800 feet below the Mountain Limestone of Gilmerton, a distance, however, which greatly varies in the districts to the west.

South of Burdie House the limestone ceases to be traceable, owing to the depth of the covering of drift. In several of the streams which descend from the Pentland Hills, however, blocks of it can be seen, indicating its probable continuity southwards ; and at Carlops, ten miles south of Burdie House, it is found among the vertical strata in the river Esk, but as two beds, four and five feet thick respectively. Its prolongation north of Burdie House is wholly uncertain : possibly it is cut out by the great fault which, running by Liberton to Portobello, brings down the Mountain Limestone and overlying Coal Measure almost vertically against the bottom beds of the Carboniferous group. The thickness of the rock at Burdie House may be exceptional, the rock there seeming to have been formed in a hollow or lagoon, which shallowed southwards—a supposition rendered probable from the appearances presented by the rocks of Linlithgowshire.

In that county there occurs, sometimes fully 1,000 feet below the Mountain Limestone, a seam of grey compact stratified limestone, averaging about 9 feet thick. In colour, texture, and fossils it corresponds closely with the rock of Burdie House, of which, indeed, there can be no doubt that it is the equivalent. Along the shore, between Queensferry and Midhope Glen, the beds undergo frequent reversals of dip, and the limestone, with its associated shales and sandstone, can be seen crossing the beach five times. There it has the usual texture (see 105), but as we trace it inland it gradually becombs more argillaceous, splits up into thin layers, and passes finally into calcareous shales (111), with little resemblance to the limestone, except that they contain the same fossils. Still further to the south the rock regains its purity, and has been extensively worked at Dechmont, but to the south-east of that district it again becomes shaly and argillaceous, till it takes the form of fissile grey shales, whose identity with the limestone of Burdie House could hardly at first sight be suspected. Beyond this it re-assumes its typical character, and at Midcalder and Murieston occurs in great basin-shaped cavities 40 to 70 feet deep. At the Mid Calder quarries it exactly resembles some parts of the rock at Burdie House, being full of plants, especially of *Stigmariæ* which spread out their long roots in regular layers, with the rootlets branching freely in all directions, as if, when the limestone existed as soft calcareous mud, the plants grew upon the spot where we now find their remains (104). From these different facts it appears that the Burdie House limestone was formed very slowly, probably in brackish water, across a series of lagoon-like depressions, separated from each other by muddy shoals; that in these hollows cyprides and ganoidal fishes abounded, while even the larger placoids became occasional visitors; and that in some localities there rose up from the muddy bottom a thick growth of marshy plants. The next thirteen specimens (99–111) illustrate the limestone with its shales, as typically developed at Burdie House, and as it varies in its course through the eastern part of Linlithgowshire.

99–102. Limestone.

Burdie House.

Nos. 99 and 100 show the usual compact grey texture of the rock, with its numerous *Cyprides, Coprolites,* and fragmentary plants. In 101 the texture is looser and the colour lighter, as in the upper portions of the rock. No. 102 shows the striped appearance so characteristic of this limestone. The darker shade of some of the layers is owing to the carbonaceous matter they contain. Such a specimen as 102 points to a slow condition of deposit, when drifted macerated plants sank at intervals to the bottom among the calcareous mud, each layer of such vegetable detritus being marked now by a corresponding lamina of darker limestone. In some cases, however, the difference of tint may be owing to occasional inroads of a darker mud over the light calcareous marl at the bottom.

103. Calcareous Shale.

Above limestone, at Burdie House.

This stratum contains, in immense abundance, the cases of the *cyprides*, along with well-preserved plants and numerous coprolites.

104. Limestone.

Raw Camps Quarry, Mid Calder.

This specimen shows the stigmaria roots referred to above. The bed from which it is taken attains a thickness of 40 feet, and lies in two detached basins. It is distant about 11 miles due west of Burdie House, on the other side of the intervening Pentland Hills.

105. LIMESTONE.

Port Edgar Quarry, South Queensferry.

Black compact rock, with crystals of iron pyrites, fish-scales, and plant-remains. This lower part of the rock is much darker and more compact than the upper parts, which closely resemble some bands in the limestone at Burdie House.

106. BLACK SHALE.

Above limestone, at Port Edgar.

107. LIMESTONE NODULE, containing coprolite.

From shales above limestone, Newhalls, South Queensferry.

108. GRIT, slightly calcareous, with crystals of carbonate of lime.

Above shales capping the limestone, Newhalls.

109. COARSE SHALY LIMESTONE.

Cutting of Edinburgh and Glasgow Railway, Priestinch, Linlithgowshire.

110. COARSE LIMESTONE, or "*cement-stone.*"

From same locality.

These two specimens (109 and 110) show the change which the limestone undergoes in its passage from Port Edgar to the south-west. The rock is an impure argillaceous limestone, with a considerable per-centage of iron, and has been burnt for a cement. The fossils in these beds are similar to those at Queensferry and Burdie House.

111. CALCAREOUS SHALE, with scales of *Palæoniscus.*

Ecclesmachan, Linlithgowshire.

The beds from which this specimen is taken lie above the ash (98), and show the Priestinch beds in a still more argillaceous form as these pass southward. Beyond Ecclesmachan, however, they appear to become purer, for where next seen, at Dechmont, they take the typical form of a pure compact limestone.

Above the Burdie House limestone of Linlithgowshire there follows a great series of white sandstones, with intercalated ashes and greenstones. These sandstones are well displayed in the large quarries at Binny, and the group may be distinguished as the Binny Sandstone series. The next eight specimens (112–119) illustrate the features of this series.

112. BRECCIATED ASH.

Railway cutting, Niddry, Linlithgowshire.

Angular and subangular felspathic fragments and pieces of shale, in a dull black argillaceous paste. The felspathic lapilli are of a light grey colour, and contain small quartz granules, with angular specks of what seems to be black shale. The rock in mass contains enormous blocks of shale, with contorted beds of shale and ironstone. (See 43 in lower compartment.)

113. FELSPATHIC ASH.

350 *yards south of Dechmont House, Linlithgowshire.*

White angular felspathic fragments, in a dull bluish-black felspathic paste.

114. FELSPATHIC ASH.

Shore a quarter of mile E. of Society, Hopetown, Linlithgowshire.

Dull, sandy felspathic rock, containing small rounded grains of quartz.

115. FELSPATHIC ASH.

Wood, a quarter of mile S. of West Binny.

Contains subangular white felspathic fragments and grains of quartz, in a dull greenish-brown felspathic paste.

116. SANDSTONE.

Binny Quarry, Linlithgowshire.

Extensively used as a finer kind of building stone.

117. SANDSTONE.

Humbie Quarry, Linlithgowshire.

White compact quartzy rock, largely employed as a building material.

118. GREENSTONE.

Road, 300 *yards S. of Newbigging Tile Works, Linlithgowshire.*

Crystalline compact rock with glassy felspar crystals. This specimen is from a bed near the top of the Binny Sandstone group.

119. GREENSTONE.

Quarry on Peace Knowe, 1¾ *miles S.E. of Linlithgow.*

From a bed corresponding in position to No. 118.

The Binny Sandstone group is covered by a set of thin shaly sandstones and shales, the distinguishing bed of which is a seam of coal, known as the Houston Coal, whence the group of strata may be termed the Houston Coal series. The next thirteen specimens (120–132), illustrate this series.

120. CONCRETIONARY SANDSTONE.
Cutting of Edinburgh and Glasgow Railway, Priestinch, Linlithgowshire.
From bed underlying Houston Coal.

121. COAL ("Houston Coal"), altered by proximity to neck of Greenstone (No. 9 in Lower Compartment).
Railway cutting, Craigton, Linlithgowshire.

122. CLAY IRONSTONE AND CYPRIS SHALE, from beds above Houston Coal.
Old Pit S. of Newbigging Tile Works, Linlithgowshire.

123. GREEN MARLY SHALE.
Above Houston Coal, cutting of railway, Craighton.
This rock assumes sometimes a reddish colour, and is of a crumbling nature. It occurs all over the eastern part of the county, and is always a reliable indication of the position of the Houston Coal.

124. FELSPATHIC ASH.
Wood half a mile S. of Gateside, 3½ miles E. of Linlithgow.
Stratified greenish granular felspathic rock, with angular fragments of black shale and small felspathic lapilli in a light green felspathic paste.

125. FELSPATHIC ASH.
Bank-head, 3 miles S.E. from Linlithgow.
Granular felspathic rock, with subangular fragments of shale and felspathic matter.

126. FELSPATHIC ASH.
Stream a quarter of a mile W. of Wester Ochiltree, Linlithgow.
Coarse conglomerate of rounded nodules, chiefly trappean, imbedded in a dull granular and crumbling felspathic base.

127–129. Three stones from the FELSPATHIC ASH, No. 126; showing the rounded form of its imbedded fragments.

Table-case E.

130. FELSPATHIC ASH.
Binns Hill, Linlithgowshire.
This hill consists of a large sheet of greenish felspathic ash interbedded among the shales and sandstone above the Houston Coal. Its summit is occupied by a circular patch of Basalt (131), filling up the vent from which the ash appears to have been ejected.

131. BASALT.
Top of Binns Hill, Linlithgowshire.
From neck in felspathic ash.

132. GREENSTONE.
From bed above stream, E. of Longmuir Plantation, Linlithgow.

Above the Houston Coal series lies a set of sandstones and shales, to which the name of the Kingscavel sandstones may be applied, since the strata are well seen in the large quarries at that locality. The specimens 133 to 137 illustrate this group.

133. WHITE SANDSTONE.
Kingscavel Quarry, 1 mile E. of Linlithgow.
Extensively quarried as a building stone.

134. WHITE SANDSTONE, with *Stigmaria.*
Kingscavel Quarry.

135. LAMINATED MICACEOUS SANDSTONE.

Overlying Nos. 133 and 134 *in Kingscavel Quarry.*

136. CARBONACEOUS SHALE.

Highest Beds in Kingscavel Quarry.

Highly impregnated with carbonaceous matter, and forming in consequence a coarse kind of coal.

137. GREENSTONE.

Stream below Broomyknowes Farm, 1½ miles S. of Linlithgow.

From thick bed above Kingscavel sandstones.

CARBONIFEROUS LIMESTONE, LINLITHGOWSHIRE.

The Kingscavel Sandstone series is followed by the lower limestones of the Carboniferous Limestone strata. These consist of several beds of limestone intercalated among shales, sandstones, and occasionally thin coals, with numerous beds of felspathic ash, greenstone, and basalt. The whole group is indeed eminently characterized by the number of its igneous rocks, pointing to a period of great volcanic activity, when showers of dust and ashes and streams of lava were thrown out over a sea-bottom swarming with corals and shells. The completest section is that shown at the south end of the Bathgate Hills along the line of Quarries from Petershill to Kirkton. In the suite of specimens (134–180) which follows, an attempt has been made to exhibit the interstratifications of ash, limestone, and greenstone as completely as the space would allow.

138. LIMESTONE.

Mid-Tartraven, 3 *miles S. of Linlithgow.*

Compact grey rock with traces of shells and joints of encrinites. This rock cannot be traced southwards beyond this locality, inasmuch as the whole country is deeply covered with drift, the only rocks observable being greenstone and ash. It is probably, however, on the same horizon with the lower limestones of Kirkton (146–152).

139. BASALT.

Above Limestone (138), *Mid-Tartraven.*

Black, crystalline, with amygdaloidal kernels of carbonate of lime. This and the next four specimens are put along with the limestone for the sake of local connexion, and in order that the Kirkton beds (144–159) may be taken in uninterrupted series.

140. FELSPATHIC ASH.

Carsie Hill, 1 *mile S.E. of Linlithgow.*

Dull yellowish felspathic rock, with yellow sub-angular felspathic fragments.

141. FELSPATHIC ASH.

Pilgrims Hill, Linlithgow.

This ash is a dull granular felspathic rock, without marked stratification, and contains in addition to the usual felspathic lapilli of all sizes, numerous fragments of carbonized coniferous wood. It is a prolongation of No. 140.

142. FELSPATHIC ASH.

350 *Yards W. of Wester-Drumcross, Bathgate.*

Greenish felspathic rock in well-marked beds.

143. WHITE SANDSTONE.

Hill House Quarry, Linlithgow.

This sandstone forms a good building stone, and overlies the ash 140–142.

160–196. Specimens illustrative of the Mountain Limestone strata as developed in the neighbourhood of Bathgate, Linlithgowshire.

144. GREENSTONE.

Kirkton Quarry.

From the top of a great sheet which underlies the lowest limestone of Kirkton.

145. FELSPATHIC ASH.

East Kirkton Quarry,

Loose pulverulent felspathic rock, underlying the lowest limestone of Kirkton, and resting on the greenstone (144).

146. ASHY LIMESTONE.

East Kirkton Quarry.

A mixture of felspathic fragments in a base of grey limestone. A piece of fish-bone is visible at the side, marked *a* on the specimen. This is the character of the limestone immediately above the ashy bed 145.

147, 148. TWO CALCAREOUS NODULES, from ashy bed in Kirkton limestone, a short way above the seam 146.

East Quarry, Kirkton.

The irregular rounded and sub-angular form of the stones is shown by these specimens.

149–151. CHERTY LIMESTONE.

Lower part of Kirkton limestone, East Quarry, Kirkton.

In 149 the cherty matter is interspersed in an irregular brecciated and nodular manner. In 150 and 151 the rock consists of fine laminæ alternately of silica and lime. These laminæ in the former specimen occur in regular horizontal layers (marking the stratification of the rock), with occasional cherty lumps between them. In 151 they have a concentric and contorted arrangement. The origin of this limestone must doubtless be connected with the action of some thermal spring, which, like the geysers of Iceland, rose in what must have been at that period a highly volcanic region, and deposited the silica and lime carried up by it in solution.

152. UPPER PART OF KIRKTON LIMESTONE.

East Quarry, Kirkton.

The rock is finely laminated and fissile, and shows a mammillated surface on some of the laminæ. The bedding often is greatly contorted. Ferns and other common Carboniferous plants occur in this limestone along with occasional coprolites and other fish-remains.

153. ASHY SHALE.

East Quarry, Kirkton.

Contains numerous plants, as *Lepidodendron*, *Sigillaria*, &c.

154. BASALT.

Above limestone, East Quarry, Kirkton.

This rock occurs in a columnar bed resting immediately on the shale 153. This is the highest bed visible in this quarry. From this point west to the next quarry no rock is seen but basalt, so that the whole space may be occupied by this bed. The dip of the rocks is westerly, and the next observed bed in ascending order (155) ocupies the lowest place in the Kirkton West Quarry.

155. FELSPATHIC ASH.

Below limestone, West Quarry, Kirkton.

Fine-grained green felspathic rock in thin layers.

156. LIMESTONE, with fragments of *producti* and encrinal joints.

This bed rests above the greenish ash (155), and becomes very ashy at top.

157. ASHY LIMESTONE, with shells and encrinal joints.

This specimen, taken from the upper surface of bed 156, contains green felspathic matter interposed through a grey crystalline limestone.

158. CALCAREOUS FELSPATHIC ASH, from a thin bed above limestone 156.

Above this bed occur other thin limestones intercalated among seams of ash and ashy shale, the whole being capped by the basalt 159.

159. BASALT.

From columnar bed above ashes and limestones, Kirkton, West Quarry.

Like most of the augitic traps in the district, this rock contains a considerable quantity of magnesia.

From the Kirkton Quarry westward to that of Petershill, where the next limestone bed is seen, no rock appears but basalt; and possibly in this case, as in 154, there may be only one great sheet of basalt intervening between the upper beds of Kirkton and the lower beds of Petershill. The excavations at Petershill form the southern termination of a great chain of quarries extending northward by Sunnyside and Silvermine to Hillend near Linlithgow. They have been opened in a bed of marine limestone varying from between 30 and 40 to 70 or 80 feet in thickness. It rests upon ash (160) covering the basalt 159, and is succeeded by ashy beds (168), sandstones, shales, and thin coals, over which lie enormous sheets of greenstone and basalt (169, 170.)

160. CALCAREOUS FELSPATHIC ASH.

Below limestone, Sunnyside Quarry.

The upper part of this ash immediately below the bottom of the limestone contains *producti* and *encrinal joints.*

161. LIMESTONE.

North Mine Quarry, 3 miles S. of Linlithgow.

Compact grey crystalline limestone with *encrinal joints* and *cyprides* (?). This rock occurs in a massive bed about 70 feet thick, resting on ash (176). With the limestones, sandstones, and shales above and below, it represents the Carboniferous or Mountain Limestone, as that formation is developed in Scotland. The next five specimens (162-166) are from different parts of the same great bed.

162. LIMESTONE.

North Mine Quarry.

Hard compact grey limestone with *Productus giganteus, Cyprides* (?), and *Encrinites.*

163. LIMESTONE, with cubes of galena.

North Mine Quarry.

The crystals here occur in a vein cutting through the limestone at nearly right angles to the plane of bedding. A larger vein containing a considerable admixture of silver was formerly worked here, the name Silvermine being still applied to the quarry.

164. LIMESTONE, consisting of a mass of the coral, *Lithostrotion.*

Sunnyside Quarry, one mile N. of Bathgate.

165. CHERT, filling a *Productus giganteus.*

Sunnyside Quarry.

The limestone contains irregular nodular lumps of chert, sometimes ranged along the lines of bedding or interspersed through the rock. Not unfrequently, as in the present instance, the cherty matter is found filling and enveloping organic remains.

166. LIMESTONE.

Upper part of bed, Hillhouse Quarry, 1½ miles S. of Linlithgow.

167. CALCAREOUS FELSPATHIC SANDSTONE.

From hole in limestone quarry S. of Knock Hill, 2 miles N. of Bathgate.

This specimen is taken from a mass of ashy and sandy matter with large rounded stones filling up a cavity in the limestone, which increases in width as it descends.

168. CALCAREOUS FELSPATHIC ASH.

From hard bed in soft ash, above limestone in North Mine Quarry.

Angular fragments of green and grey felspathic matter in a base of sandy grey limestone.

169. BASALT.

From columnar bed above limestone, Hillhouse Quarry, 1½ miles S. of Linlithgow.

This bed is beautifully columnar, its under surface corresponding with the bedding of the underlying strata till near the south end of the quarry, when it cuts across the beds obliquely, altering them considerably along the line of contact.

170. AMYGDALOIDAL MAGNESIAN GREENSTONE.

Immediately underlying limestone of Wardlaw Quarry.

Between the basalt of Hillhouse (169) and this greenstone no rock is observable except greenstone or basalt. This specimen is from the upper part of a thick bed, and is succeeded by a limestone (171) higher in position than that of Petershill, Sunnyside, North Mine, and Hillhouse (161-166).

171. LIMESTONE, consisting of a mass of corals (*Lithrostrotion irregulare.*)

Wardlaw Quarry.

Lower part of a seam intercalated between greenstone beds.

172. LIMESTONE, containing the coral *Lithrostrotion irregulare;* from hard bed in middle of the limestone.

Wardlaw Quarry.

The limestone is capped by shales, with a thin limestone bed, the whole being surmounted by an amygdaloidal greenstone (173) much broken by joints.

173. Felspathic Greenstone, at junction with shales.

Wardlaw Quarry.

This is a common appearance presented by the greenstones of the district, where they they can be seen infringing upon other rocks, though usually they are then not quite so compact as in this specimen.

174. Greenstone.

Crag east of Witch Craig, 2½ miles S. of Linlithgow.

From a bed forming part of a great sheet that overlies the Wardlaw limestone, and at one locality contains a bed of felspathic ash (175

175. Felspathic Ash.

Preston Burn, ¾ of a mile S. W. of Linlithgow.

Green granular felspathic rock, containing rounded trap fragments in a dull green earthy paste, from stratified seam between beds of greenstone.

176. Greenstone.

Kettleston Quarry, 1 mile S. W. of Linlithgow.

Upper part of bed 174, above the ash 175.

177. Calcareous Grit.

Shore east of Carriden House, Linlithgowshire.

Surface covered with *cauda-galli* markings.

This and the next three specimens (178–180) occur at the top of the lower limestones of Linlithgowshire where these are overlaid by the coal-bearing beds of Borrowstounness.

178. Felspathic Ash.

Below Carriden House.

From bed among the upper members of the lower zone of the Carboniferous Limestone.

179. Micaceous Sandstone.

Carriden House.

Shows the characteristic false bedding of the Carboniferous sandstones.

180. Coarse Limestone, with *Encrinites*.

Carriden House.

This bed is the highest of the lower limestones of Linlithgowshire.

Above these lower limestones of the Bathgate Hills and the Borrowstounness coal-field, lies a great sheet of greenstone (174–176) extending northwards to Linlithgow. It is covered by sandstones, shales, and coals, with interbedded greenstones, the whole forming the middle zone of the Carboniferous Limestone. These strata run northwards from Bathgate, getting gradually thinner in their progress, while the igneous rocks become proportionately thicker, until in the district round Cocklerue the coal-bearing strata appear to have almost died out, their place being occupied by thin sandstones, and ash-beds with great sheets of greenstone and basalt (181–183.) On the side of Bonnytoun Hill, above Linlithgow, the coals reappear, and seem gradually to increase in thickness as they proceed northwards. Hence it appears that a great bank or ridge, formed chiefly of volcanic materials, intervenes between the Bathgate and Borrowstounness coal-fields. It seems probable that after the deposition of the lower limestones this ridge of lava streams and showers of tuff was gradually formed between Bathgate and Linlithgow, that it then went on increasing in extent, and eventually rose above the level of the water as a low island. In the swampy marshes to the north, a luxuriant vegetation sprang up, and its petrified remains now form the Borrowstounness coal seams, while a similar growth to the south resulted in the coal seams of Bathgate. During the accumulation of peaty matter and silt in these two localities, streams of lava were occasionally ejected from the volcanic vent between and flowed northward to form the thick greenstone beds (187–190) interposed in the coal-field of Borrowstounness, and the thinner ones in that of Bathgate. On the surface of these hardened lava-flows, sand

and mud silted up, forming a soil for the accumulation of new morasses, of which the remains exist in the upper coals of the two coal-fields. The whole area throughout this period was undergoing a process of subsidence until the hollows of Bathgate and Borrowstounness were filled up with sand, mud, peat, and volcanic matter, and the bottom of the water was reduced to a nearly level surface. Upon this floor, depressed considerably below the sea-level, a seam of limestone was formed, consisting in large measure of the broken stems of crinoids and pieces of shells (202). Occasional volcanic eruptions succeeded, marked now by the greenstones (203) and ashes (204), and eventually another seam of limestone (206) gathered over the sea-bottom. Sand and mud thereafter settled down upon the corals and shells, and subsequently another lava-stream (208, 209) was ejected. After this last eruption the series of events went on as before, sand, mud, and peaty morasses accumulating over this part of Linlithgowshire, so as to give rise to the upper coals, or true coal measures. This latter group of strata, however, has not yet been examined by the Geological Survey, the only specimens from it being the pieces of the Boghead Coal (210 and 211) in this Case, and Nos. 32 and 33 of the miscellaneous specimens in Table-case F. It will be described in a future edition of this catalogue.

181–183. From the volcanic bank which seems to have separated the coal-swamps of Bathgate from those of Borrowstounness.

181. Sandstone.

Quarry at south end of Cocklerue, 1½ miles S.W. of Linlithgow.

182. Felspathic Sandstone.

Quarry at S. end of Cocklerue.

Contains white felspathic fragments in a greenish white sandy base.

183. Greenstone.

Quarry at S. end of Cocklerue.

From bed overlying 181 and 182.

184. Greenstone.

Carriden Manse, Linlithgowshire.

Earthy, decomposing, magnesian rock, forming a bed above "Smithy Coal." This greenstone is intercalated among the lower coals of the Borrowstounness field.

185. "Parrot" Coal.

Chance Pit, Borrowstounness.

This is the "Cannel" Coal of England, and is used for gas-making. It occurs above the Carriden beds (177–180, 184), and below the thick trap (187–190) which divides the coal field into an upper and under group.

186. "Black Band" Ironstone.

Chance Pit, Borrowstounness.

This ironstone is associated with the parrot coal (185), part of which is seen adhering to the specimen. The distinguishing feature of black-band ironstone, as compared with ordinary clay-ironstone, is the large amount of carbonaceous matter it contains; so large, indeed, as to admit of the ore calcining itself with the addition of little or even no fuel.

The Borrowstounness coal-field occupies the middle portion of the Carboniferous Limestone series, but, as has just been mentioned, it is subdivided into an upper and under set of strata, by two sheets of greenstone, having a united thickness of nearly 400 feet. This mass of rock seems to have flowed from the south, across the swampy morasses in which the lower coals of the district originally grew. It does not affect the quality of the seams, and throughout the coal-field the pits are invariably sunk through the whole or part of it, to reach the coal and ironstone seams below. In the borings at the Snab pit, which were continued to a depth of 1,179 feet, no fewer than eight beds of greenstone were passed through, having a total thickness of 468 feet. Specimens 187–190 are from this series of interbedded traps.

187. GREENSTONE below "Wester Main Coal."

West side of Chance Pit, Borrowstounness.

The Wester Main coal, where fully developed, measures about twelve feet thick, which occurs about the middle of the thick mass of greenstone, subdividing it into two parts; but its thickness is very variable, and at the Snab Pit borings no trace of it could be found, the only rock between the greenstones being some soft carbonaceous shale.

188. GREENSTONE.

Above Wester Main coal, tramway east of Mingle Pit.

Compact, granular, finely amygdaloidal rock.

189. GREENSTONE.

Side of tramway, east of Mingle Pit, Borrowstounness.

Taken from the under part of the intrusive bed 188, where it rests on the upper surface of the Wester Main coal. Soft, earthy, felspathic, finely amygdaloidal rock.

190. BASALT.

Kipps Hill.

This rock is finely amygdaloidal, and may belong to a southward prolongation of the greenstones 187, 188.

Above the thick sheets of greenstone another set of coal-bearing strata supervenes, similar to that below. They contain several seams of coal and one of ironstone (191), regarded as of inferior quality to those of the under group.

191. BLACK-BAND IRONSTONE.

No. 23 Pit, Borrowstounness.

This seam occurs among the upper set of coals, and is about 18 inches thick.

192. CARBONACEOUS SHALE.

No. 23 Pit, Borrowstounness.

From beds with the iron-stone 191.

193. GREENSTONE.

Capie's Point, ¼ of a mile west of Borrowstounness.

From bed 6 to 8 feet thick, among the upper group of coals.

194. COARSE LIMESTONE, with *Producti*, &c.

Capie's Point, ¼ mile W. of Borrowstounness.

Occurs a few feet above the greenstone 193. The occurrence of this limestone and of some similar beds in a higher part of the series suffices to show how completely all the coals of this district belong to the Carboniferous Limestone.

195. HARD FIRECLAY.

Quarry west of Distillery, Kinneil, Borrowstounness.

This bed overlies the limestone (194), and is used for making fire-brick.

196. GRITTY SANDSTONE.

Quarry W. of Distillery, Kinneil, Borrowstounness.

From thick bed overlying the fire-clay 195.

197. GREENSTONE.

Two hundred yards south of Woodcockdale Cottage, river Avon.

This is from a bed running north by Linlithgow Bridge, and underlying the ash 198.

198. FELSPATHIC ASH.

Banks of river Avon, Little Mill, Linlithgow.

Coarse dull felspathic rock, consisting of rounded fragments of greenstone, &c., imbedded in a greenish felspathic paste.

199, 200. Stones from the FELSPATHIC ASH, No. 198.

201. COMPACT SANDY SHALE.

Bed of river Avon, above Woodcockdale Cottage.

The rock in mass contains numerous *Producti*, *Spiriferæ*, *Fenestellæ*, &c.

As stated after 180, the coal-bearing beds of Borrowstounness are overlaid by a series of sandstones and shales, containing two seams of marine limestone. These higher strata are well displayed along the banks of the river Avon, and in the district round Carribber, whence most of the following specimens have been taken. The bed 201 occurs a few yards below the under limestone (202.)

202. COMPACT LIMESTONE, with iron pyrites.

Banks of river Avon, Carribber, three miles S.W. of Linlithgow.

This rock is the under of the two limestones referred to, and contains *encrinites*, &c.

203. GREENSTONE.

300 *yards east of Bowdenhill farm, three miles S.W. of Linlithgow.*

Compact crystalline rock from bed above lower limestone.

204. FELSPATHIC ASH.

Stream between Lochcote and Gormyre Hill, two miles S.W. of Linlithgow.

Calcareous dull greenish felspathic rock, with nodular pieces of limestone and angular felspathic fragments.

205. COARSE QUARTZY SANDSTONE.

Craigenbuck Quarry, two miles W. of Kinneil, Linlithgowshire.

From thick bed underlying upper limestone.

206. LIMESTONE, with iron pyrites and encrinal joints.

Bowden Hill Quarry, three miles S.W. of Linlithgow.

Bowden Hill consists of a sheet of Greenstone (208, 209) overlying the upper limestone (206), which has been excavated in long galleries extending underneath the hill from side to side.

207. LIMESTONE.

Craigenbuck, West of Kinneil.

Same bed as 206, but four miles further north.

208, 209. GREENSTONE, from the bed overlying Upper Limestone.

208 is from the banks of the *Avon at Carribber;* 209 from the side of *Bowden Hill* above the lime quarries.

210 & 211. CANNEL or PARROT COAL.

Boghead, Linlithgowshire.

These two specimens show the average character of this remarkable coal, which lies in the true Coal Measures above the Carboniferous Limestone and the Millstone Grit of Linlithgowshire.

Table-case E.—*continued.*

CALCIFEROUS SANDSTONE OF HADDINGTONSHIRE.

The next series of 103 specimens illustrates the succession of beds from the top of the Upper Old Red Sandstone into the Carboniferous Limestone as these strata are developed in Haddington or East-Lothian. It shows that between the deposition of these two formations, the north-eastern part of that county was the site of a long-continued series of volcanic eruptions, by which loose ashes, stones, and sheets of melted lava were thrown out to a depth of many hundred feet. The series begins with several specimens from the Old Red Sandstone, followed by one or two from the very base of the Carboniferous rocks, above which commences a set of trap-tuffs, with intercalated limestone bands. These are followed by the later lava eruptions of the Garleton

Hills, and lastly by the Carboniferous Limestone, which appears to have been deposited after the volcanic action in this district had ceased.

1. SANDY CONGLOMERATE.
Raven Craig, Cranshaw Parish, Berwickshire.
Composed of rounded pebbles of grit, shale, and porphyry from the surrounding Silurian rocks.

2. RED SANDSTONE, finely laminated ; Old Red Sandstone.
A little east of Dunbar.

3. RED SANDSTONE, variegated with green spots ; Old Red Sandstone.
A little east of Dunbar.
On the origin of such green mottlings see 1st vol., Geol. Surv., Mem. p. 53.

4. GREY SANDSTONE ; Old Red Sandstone.
A little east of Dunbar.
Speckled with iron-stained grains.

5. GREY MICACEOUS SANDSTONE ; Calciferous Sandstones.
150 *yards S.W. of Long Craigs, Dunbar.*

6. RED FERRUGINOUS IRONSTONE ; Calciferous Sandstones.
150 *yards S.W. of Long Craigs, Dunbar.*
Contains fragments of fish-scales.

7. YELLOW MICACEOUS SANDSTONE, with *Lepidodendron.*
South side of Traprain Law, Haddingtonshire.

8. MOTTLED RED SANDSTONE.
Hawkins Wood, 4 miles east of Haddington.
Nos. 5 to 9 are taken from the basement beds of the Carboniferous series of strata.

Immediately to the west of Dunbar the coast is fringed by a range of tall cliffs. They consist of ash, dull-red in colour, and roughened over with enclosed fragments, which protrude from the rock in great numbers. The matrix of the ash is highly felspathic and ferruginous, and varies in texture from a fine paste to a coarse agglomeration of subangular and rounded fragments. The enclosed stones are of all sizes up to masses a foot or more in diameter, the smaller pieces being frequently somewhat angular, while the larger bombs show a rounded outline, sometimes with a vesicular surface, indicating the former melted condition of their exterior. Although the dust and stones, of which the ash has been formed, were deposited at the sea bottom, the stratification can often be seen bnt rudely, and on the large scale only, and in many places it can be made out merely from the lines of rounded stones which mark what was at one time the floor of the sea. The more characteristic features of the ash cannot, however, be exhibited in a collection of detached specimens, but must be studied in the field.

9, 10, 11. FELSPATHIC ASH.
West of Dunbar.
In No. 9 the lapilli, or included fragments, are mostly subangular, and consist of different felspathic rocks, imbedded in a dull-red, granular, felspathic paste. In No. 10 they are more rounded, and smaller in size, while the matrix is likewise more ferruginous. No. 11 shows a dull-red ferruginous paste, with few fragments of larger size than its component grains. This specimen also illustrates the manner in which some of the finer-grained portions of the ash are stratified.

12–29. STONES FROM THE FELSPATHIC ASH, Nos. 9, 10, 11.
West of Dunbar.

12. FRAGMENT OF AMYGDALOIDAL FELSTONE, broken from large irregular mass in ash.
Near Dunbar.

13. PIECE OF SANDSTONE ; Old Red Sandstone.
From ash, west of Dunbar.

14. NODULE OF RED MARL, crusted with carbonate of lime.
West of Dunbar.

15, 16. FRAGMENTS OF LIMESTONE; Burdie House Limestone?
In the ash of Dunbar.

17. FRAGMENT OF LIMESTONE; Burdie House Limestone?

This specimen from the Dunbar ash shows on the one side the original surface of the stone as ejected from the ancient volcano, and on the other, which has been broken across, a confused mass of fish-remains.

18–22. CALCAREOUS NODULES, perhaps pieces of altered limestone.

23. VESICULAR FELSTONE, showing the rounded exterior of the igneous fragments in the ash, with a vesicular lava-like interior.

24, 25, and 26, are unbroken felspathic stones like No. 23.

27. AMYGDALOIDAL FELSTONE, part of a large mass in the ash.

28. NODULE OF CHALCEDONY.

29. NODULE OF JASPER.

30. COLUMNAR FELSTONE.
Below the Battery, Dunbar.

This rock appears to have a bedded form, but its relations are very doubtful. It was regarded by Dr. Macculloch as an altered sandstone.

31. BASALT.
Dunbar Castle.

From intrusive mass in the ash.

32. VESICULAR GREENSTONE.
Dunbar.

From a dyke in the ash on the shore.

The ash of Dunbar, owing to a gentle rise of the lower strata, is succeeded to the west by lower sandstones and shales, of which Nos. 5 and 6 are specimens. These are seen along the low flat shores at the mouth of the Tyne, where the easterly dip, which they have near Dunbar, is gradually reversed, until they are succeeded by another series of ash beds on the same horizon as those of Dunbar. The coast line for about four miles to the east of North Berwick exhibits a magnificent series of sections of ash with inclosed limestone seams and intruded masses of greenstone. The ash in its lower beds has a greenish tint, getting redder in the higher parts till it acquires the same colour that characterizes the rocks at Dunbar. In this upper red zone there occurs at different localities, a thin-bedded fissile grey limestone, answering closely in texture, colour, and mode of stratification to the limestone of Burdie House, with which also it appears to correspond in geological position. No fossils have been detected in it except some which resemble pieces of bone. Throughout the ash, fragments of ejected rock of various kinds are abundant, varying in size up to large masses from one to two yards in diameter. Tortuous veins and dykes, of greenstone and basalt, also occur, traversing and contorting the ash-beds in all directions.

33. FELSPATHIC ASH.
North Berwick.

Granular, stratified, without enclosed fragments.

34. FELSPATHIC ASH.
North Berwick.

Granular, stratified, with small rounded felspathic fragments.

35. FELSPATHIC ASH.
North Berwick.

Granular, with numerous rounded and subangular felspathic fragments. This and the two preceding specimens are from the lower green zone.

36. STRATIFIED FELSPATHIC ASH.
North Berwick.

Very granular, with numerous rounded and subangular felspathic fragments. This specimen is from the upper red part of the ash.

37. FELSPATHIC ASH.
Amisfields Mains, 2 miles E. of Haddington.
This specimen belongs to the highest part of the ash, and shows numerous scattered crystals of felspar, many of which are broken.

38. COMPACT GREY LIMESTONE.
Rhodes Quarry, 1 mile S.E. of North Berwick.
This limestone occurs among the ash-beds, and attains a thickness at this locality of 30 feet. Similar seams, probably on the same horizon, are also met with further to the east, near Tantallon Castle, and also southward from Tynninghame to Traprain Law. These calcareous bands are believed to represent the Burdie House Limestone of Mid-Lothian.

39. STRIPED LIMESTONE.
From an upper part of Rhodes quarry.
This specimen exhibits exactly the peculiar stratified appearance of the Burdie House limestone, and may be compared with No. 102 in Table-case D, from the Edinburghshire bed.

40. SHALY LIMESTONE.
Also from Rhodes quarry.
The wrinkled appearance of this specimen, and its finely mammillated surface, bear a strong resemblance to some of the depositions of calcareous springs, and possibly such may have been the origin of this bed. Compare Nos. 149–151 in Table-case E.

41. ALTERED LIMESTONE.
The Leithies, between North Berwick and Canty Bay.
Apparently with enclosed igneous matter obtained from bed close to a large mass of greenstone, of which No. 56 is a specimen.

42. ALTERED LIMESTONE.
From junction with the same mass of igneous rock at the Leithies, near North Berwick.

43. ASH with angular fragments of limestone.
North Berwick.

44. Angular fragment of STRIPED LIMESTONE; Burdie House Limestone.
From ash at North Berwick.

Table-case F.

45. Subangular fragment of CRYSTALLINE LIMESTONE.
From ash at North Berwick.

46. FELSPATHIC ASH, with impression of a plant.
From ash at Tantallon Castle.

47. Piece of LIMESTONE fragment.
From ash at North Berwick.

48, 49, 50. Fragments of RED SANDSTONE (Old Red ?)
From ash at North Berwick.

51. IRONSTONE fragment.
From North Berwick ash.

52. Stone from the same ash, showing the common rounded form of the fragments.

53, 54, 55. Fragments of FELSPATHIC TRAP.
North Berwick ash.

56. AMYGDALOIDAL GREENSTONE.
From intrusive mass in ash at the Leithies, E. of North Berwick.

57. ZEOLITIC GREENSTONE.
From intrusive sheet in ash, at Canty Bay, North Berwick.

58. BASALT.
From similar intrusive mass Longskelly rocks, North Berwick.

59. AMYGDALOIDAL GREENSTONE.
From intrusive mass in ash, gas works, North Berwick.

60. GREENSTONE.
From similar intrusive mass; Saddle Rock, Tantallon Castle.

61. BASALT, porphyritic.
From intrusive mass in same ash, Gin Head, Tantallon Castle.

The ash beds of North Berwick extend southwards for nearly three miles, and then sweep round the eastern and southern slopes of the

Garleton Hills, extending as far as the town of Haddington. They are succeeded by a higher group of trappean rocks, consisting of various felspathic and porphyritic lavas, which have a bedded form, and dip below the Mountain Limestone of Aberlady. These old lava streams flowed out over the ash with its accompanying limestones, and had hardened into solid rock previous to the deposition of the Mountain Limestone. The vents from which the ejected materials proceeded may perhaps be represented by the bosses of Traprain and North Berwick.

62. FELSTONE.
Black Cove, Traprain Law.
Compact pinkish felspathic rock, with disseminated specks of augite (?).

63. PORPHYRITIC FELSTONE.
Black Cove, Traprain Law.
Compact grey felspathic rock, with crystals of glassy felspar, and a striped arrangement of the particles similar to that in the Ascension Island lavas (Nos. 49 and 50 in Wall-case 2), and the felstones of Snowdon (Nos. 100 and 101 in Wall-case 4).

Traprain Law, from which the two specimens 64 and 65 were obtained, is an irregularly oval hill, rising abruptly from a set of strata that underlie the ash beds already described. It is undoubtedly an intrusive mass, and resembles an old volcanic neck. Possibly it may have been the vent from which some of the succeeding felstones were ejected.

64. PORPHYRITIC FELSTONE.
Top of North Berwick Law.
Compact crystalline felspathic rock, with scattered crystals of glassy felspar.

65. PORPHYRITIC FELSTONE.
Quarry on north side of North Berwick Law.
A looser-textured, more granular rock than the last. North Berwick Law, like Traprain Law, is a rounded patch of felstone, and rises with a conical form out of the surrounding ash beds, which dip away from it, where seen on the south-west side, at an angle of 30°. It has the same neck-like outline with Traprain, and may perhaps have been another vent from which felspathic matter was ejected during Lower Carboniferous times.

66–68 illustrate the felstones and porphyries of the great trappean region between North Berwick and Haddington, including the Garleton Hills. The beds have a gentle dip to the west, and, as stated above, are intermediate in age between the Carboniferous Limestone above and the Burdie House Limestone below. The eastern or lowest part of the group is more or less augitic in composition, passing up into a set of compact felstones, which are succeeded by a more porphyritic series of similar rocks.

66. FELSTONE.
Longskelly Point, North Berwick.
Compact felspathic rock, with scattered crystals of augite and veins of carbonate of lime.

This and the two following specimens are from the base of the felstone series, resting immediately above the ash beds already described.

67. PORPHYRITIC FELSTONE.
Blaikie Heugh, near Standing-stone, five miles east of Haddington
Dark red felspathic base, with large crystals of augite.

68. AUGITIC FELSTONE.
Chesters Quarry, Whitelaw Hill, 4½ miles S.E. of Haddington.
A compact rock, with numerous small augite crystals disseminated through a pinkish felspathic base.

69–73. AMYGDALOIDAL PORPHYRITIC SANDSTONE.
Cowton Rocks, a quarter of a mile W. of North Berwick.
These specimens are from the Garleton Hill beds, where they thin out towards the sea, and lie probably on the same horizon with those which follow.

74. PORPHYRITIC FELSTONE.
Shore opposite Broadsands, W. of North Berwick.
Red earthy felspathic rock, with disseminated crystals of felspar, and cavities filled with carbonate of lime.

75-77. PORPHYRITIC FELSTONE.
Longskelly Rocks, 2 miles W. of North Berwick.
The Longskelly rocks appear to be a repetition of the Cowton beds, brought up by a fault which skirts their south-eastern edge. No. 77 shows a vesicular structure, the cavities being drawn out in the direction in which the mass moved when in a melted state. Many of these cavities are filled with decomposing carbonate of lime, or lined with green earth.

78. PORPHYRITIC FELSTONE.
Hailes Mill, 4 miles N.E. of Haddington.
Compact dark red felspathic rock, with crystals of glassy felspar.

79. PORPHYRITIC FELSTONE.
Hopeton Monument, Garleton Hills.
Earthy, fine-grained felspathic rock, weathers dark brown ; greenish-yellow on fresh fracture.

80. PORPHYRITIC FELSTONE.
Skid Hill, 2 miles N. of Haddington.
Light blue compact felspathic rock, with crystals of glassy felspar ; weathers light greyish brown.

81. FELSTONE.
Wallace's Cave, Craigy Hill, Garleton Hills.
Light purplish-grey granular felspathic rock, with iron-stained grains and veins of jasper, With this specimen compare No. 30 in this Case, and also No. 82.

82. PORPHYRITIC FELSTONE.
Silver Hill, Garleton Hills.
Crystalline felspathic rock, with concentric rings of iron-stains and crystals of glassy felspar ; weathers with a reddish crust.

83. PORPHYRITIC FELSTONE.
Garleton Hills.
Very compact blue felspathic rock, with crystals of glassy felspar ; weathers with light brown crust.

84. PORPHYRITIC FELSTONE.
Peppercraig Quarry, a quarter of a mile N.W. of Haddington.
Compact felspathic rock, with numerous crystals of glassy felspar ; weathers dull brown.

85. PORPHYRITIC FELSTONE.
Garleton Hills.
Compact blue felspathic rock, with crystals of felspar, in a somewhat dull granular base.

86. PORPHYRITIC FELSTONE.
Dirleton, 2½ miles W. of North Berwick.
Earthy felspathic rock, with large crystals of white and glassy felspar.

87. FELSTONE, slightly porphyritic.
Kea Haughs, Garleton Hills.
Pinkish earthy felspathic rock, with crystals of a yellow decomposing mineral.

88. FELSTONE.
Hopeton Monument, Garleton Hills.
Dull earthy yellow felspathic rock, with cavities probably formed by the decomposition of the felspar crystals.

CARBONIFEROUS LIMESTONE OF HADDINGTONSHIRE.

The felspathic traps of the Garleton Hills form the last of that long series of igneous rocks erupted over the area of Haddingtonshire during the deposition of the Calciferous Sandstones. They are succeeded by sandstones and shales with imbedded plants, above which lies a series of thin limestone beds, the representatives in Scotland of the thick Mountain Limestone of England. Unlike the English formation, their organic remains are not exclusively marine, for between the limestone beds we frequently meet with coal seams resting on fire-clay, that contains the rootlets of the plants which went to form the coal. They are, moreover, interbedded with sandstones and shales, in which similar vegetable remains occur, so that in the group of strata known as the

Mountain Limestone series of Scotland, which may attain a total thickness of perhaps 300 to 400 feet, the amount of limestone is comparatively small. The coast-line of Aberlady and also south-east of Dunbar affords admirable sections of these deposits. The following specimens chiefly illustrate the coast-section at the latter locality.

89. CORAL LIMESTONE, containing a mass of *Lithostrotion irregulare.*
Cat Craig, Dunbar.
Lowest bed of group.

90. FIRE CLAY.
Cat Craig, Dunbar.
Underlies a thin seam of coal among the limestone, and contains numerous stigmaria rootlets.

91. SHALE, containing *Orthis resupinata*, &c.
Cat Craig, Dunbar.
Underlies second limestone (92).

92. CORAL LIMESTONE.
Cat Craig, Dunbar.
Compact crystalline rock, containing *Clisiophyllum* and *Cyathophyllum.* (Second limestone).

93. COMPACT CRYSTALLINE LIMESTONE.
Cat Craig, Dunbar.
Full of *Encrinites.*

94. SHELL LIMESTONE.
Aberlady Bay.
Containing a mass of *Rhynchonella pleurodon* and *Athyris ambigua.*
Equivalent of No. 93.

95. SHALE.
Skateraw, S.E. of Dunbar.
Containing *Spirifer trigonalis,* &c. Under third limestone.

96. COMPACT GREY LIMESTONE.
Cat Craig, Dunbar.
Third limestone.

97. SHALY SANDSTONE, with double annelid-burrows, showing the transference of material by the operation of worms.
Skateraw Bay.
Above third limestone.

98, 99. LIMESTONE.
Aberlady Bay.

100. LIMESTONE.
Cat Craig, Dunbar.
Showing a cellular surface covered with small oolitic grains.

101. SANDSTONE, with worm-tracks.
The Vaults, Dunbar.

102. SANDSTONE, with encrinal rings.
The Vaults, Dunbar.

103. LIMESTONE, showing *Cauda-galli* markings on a weathered surface.

Table-case F.—*continued.*

The following twenty-four specimens from Fife, are chiefly taken from the Calciferous Sandstone series. This thick development of strata differs in some measure from the equivalent series of the Lothians in the fossiliferous character of its limestones. It is well seen along the coast line from Elie to Fife Ness, and thence round the promontory to St. Andrews. With it are associated not a few masses of volcanic ash and basalt, such as those of Elie, St. Monans, the "Rock and Spindle," and other patches in the neighbourhood of St. Andrews.

1. CALCAREOUS BRECCIA, Calciferous Sandstone series.
Balcomie, 2 miles N. of Crail.
This rock consists of an aggregation of sub-angular limestone fragments imbedded in a calcareous matrix.

2. LIMESTONE.
Pitmilly Harbour, 5 miles S.E. of St. Andrews.
This specimen, full of *Myalina,* shows the usual character of the fossiliferous limestones of the calciferous sandstones of Fifeshire.

3. LIMESTONE.
Pitmilly Harbour, 5 miles S.E. of St. Andrews.
Full of *Anthracosia.*

4. LIMESTONE.
¼ mile S.E. of "Rock and Spindle," St. Andrews.
With *Myalina.*

5. LIMESTONE.
"Rock and Spindle," St. Andrews.
Full of *Myalina.*

6. ALTERED COAL.
¼ mile S.E. of "Rock and Spindle," St. Andrews.
This coal is associated with the thin myalina-limestones. It has been actually fused by the passage across it of a basalt dyke, (No. 8), and the vesicles into which it has been blown are now filled with carbonate of lime, and partially coated with iron pyrites. The coal has been turned into a kind of anthracite.

7. FELSPATHIC ASH.
¼ mile S.E. of "Rock and Spindle," St. Andrews.
The rock from which this specimen is taken occurs among the Calciferous Sandstone series exposed along the coast to the south-east of St. Andrews. It is a dull, earthy, decomposing rock, highly felspathic, with fragments of unaltered shale and coaly matter, and broken felspar crystals.

8. BASALT.
¼ mile S.E. of "Rock and Spindle," St. Andrews.
This hard black rock traverses the coal-bed No. 6. It is, of course, a truly intrusive mass.

9. FELSPATHIC ASH.
"Rock and Spindle," St. Andrews.
An aggregation of small sub-angular and rounded lapilli of earthy greenstone, imbedded in a paste of the same material.

10. Box containing 7 specimens of rounded stones.
From the ash of the "Rock and Spindle," St. Andrews.
Six of these stones are of unaltered limestone, containing fragments of crinoid stems, *Lithostrotion*, *Rhynchonella*, and other Carboniferous Limestone fossils. The seventh is a fragment of chert.

11. CYPRIS SHALE.
1 mile east of Crail, Fifeshire.
This bed is full of *Cyprides*, with occasional fish-scales. It contains a considerable admixture of clay ironstone.

12. COARSE ARGILLACEOUS LIMESTONE.
Knock Hill, 1 mile west of Strathkinness, St. Andrews.
This bed is full of well-preserved fossils, such as *Anatyna* and *Archæocidivus.*

13. CALCAREOUS GRIT.
Bed of streamlet, ¼ mile east of Stravithie, St. Andrews.
It contains leaves of *Cyclopteris.*

14. FINE-GRAINED SANDSTONE.
Bed of streamlet, ¼ mile east of Stravithie, St. Andrews.
It also contains *Cyclopteris* leaves.

15. HIGHLY CARBONACEOUS GRIT.
200 yards east of Marsfield, Anstruther, Fife.
This bed is almost a coal. It contains however, a good deal of sandy matter, and weathers with a dark red crust.

16. ARGILLACEOUS LIMESTONE.
Cairn's Den, ½ mile S.W. from St. Andrews.
It contains fragments of crinoidal stems and some decomposing pieces of a branching coral, probably *Lithostrotion.*

17. FELSPATHIC ASH.
St. Monans.
Consists of small angular, sub-angular, and rounded lapilli of various greenstones and limestones, imbedded in a comminuted paste chiefly of greenstone detritus. This mass is well seen on the shore. It lies nearly on the boundary line between the calciferous sandstones and the Carboniferous Limestone.

18. BASALT.
Ardross Castle, St. Monans.
Hard fine-grained rock, weathering with a somewhat vesicular surface. It occurs in a dyke traversing the ash, and probably belonging to the same series of eruptions.

19. BASALT.
Elie, Fifeshire.
This is also from an intrusive mass which traverses the ash near Elie. It is an exceedingly fine-grained compact rock, and contains an admixture of olivine.

20. GREENSTONE.
Elie Harbour.
From an intrusive mass in the ash. It is a crystalline felspathic rock with a considerable proportion of carbonate of lime.

21. ALTERED SANDSTONE.
Elie Harbour.
This rock is much hardened where it is joined by a dyke of basalt. A fragment of felspathic rock occupies one of the corners of the specimen.

22. CYPRIS SHALE.
Fifeshire.
This bed contains a large amount of carbonaceous matter diffused through the mass. The laminæ are distinctly marked by the numerous cypris-valves that cover their surfaces. The tooth of a large fish called *Rhizodus Hibberti*, lies on the upper face of the specimen.

23. COARSE NODULAR LIMESTONE.
Navity Hill, 4 miles north of Lochgelly.
This stratum lies on the back of a great trappean ridge overlooking the valley of Loch Leven. Its exact stratigraphical position is by no means clear.

24. FLINTY LIMESTONE.
Navity Hill, 4 miles north of Lochgelly.
From the same quarries as No. 23.

MISCELLANEOUS SPECIMENS FROM CARBONIFEROUS FORMATION OF SCOTLAND.

25, 26. GYPSUM (2 specimens), Lower Carboniferous series.
Allanbank Mill, Banks of Whitadder, Berwickshire.
This mineral is by no means rare in crystallized seams and veins intercalated between or sometimes crossing the planes of bedding of the sandstones and marls.

27. LIMESTONE, Carboniferous Limestone.
Pier, Berwick-on-Tweed.
Shows the cauda-galli markings on its surface.

28. LIMESTONE, Carboniferous Limestone.
Cumbernauld, Dumbartonshire.
A compact firm-grained rock, containing a little carbonaceous matter.

29. LIMESTONE, Carboniferous Limestone.
Campsie Hills, Stirlingshire.
Compact crystalline rock, full of the stems of small crinoids.

30. CALCAREOUS SHALE, Carboniferous Limestone.
Campsie Hills, Stirlingshire.
Contains valves and spines of *Productus*, with some other fragmentary fossils.

31. ALUM-SHALE, Carboniferous Limestone.
Campsie, Stirlingshire.
This seam is lorgely worked for the manufacture of alum.

32. STUMP OF A SIGILLARIA, Coal Measures.
Torbanehill, Linlithgowshire.
From the well-known cannel or parrot-coal of Boghead or Torbanehill. The tree itself is converted into the same kind of coal.

33. CANNEL or PARROT-COAL, Coal Measures.
Torbanehill, Linlithgowshire.
Having on its upper surface a root of *Stigmaria* with the rootlets attached. From same seam as

34. CANNEL or PARROT-COAL, Coal Measures.
Methil, Fifeshire.

35. CANNEL or PARROT-COAL, Coal Measures.
Methil, Fifeshire.

Table-case D.—Lower Compartment.

Intrusive Igneous Rocks from Linlithgowshire, Edinburghshire, Haddingtonshire, Berwickshire, and Fife.

Among the Old Red Sandstone and Carboniferous rocks of the central valley of Scotland (Illustrated in Table-cases D, E, and F), there occur in addition to the truly interbedded igneous rocks, dykes and irregular masses of greenstone, felstone, and basalt, which have been intruded among the strata in which they occur. The greater number of these masses are associated with the Calciferous Sandstone and Carboniferous Limestone series. They rarely penetrate the coal-measures, and hence it seems reasonable to infer that they were to a considerable extent connected with the volcanic phenomena which marked the earlier half of the Carboniferous period in Scotland. Some of these intrusive masses indeed bear so close a resemblance to true volcanic vents, that it is difficult to account for their origin in any other way than by supposing that they do really occupy the necks from which some of the surrounding greenstones, basalts, and ashes were ejected. At the same there are also numerous dykes which cannot be referred to so early a period, since they traverse all the other igneous rocks and run through the coal measures. I have elsewhere endeavoured to show that these dykes, striking as they do in a general north-west and south-east direction, may with some probability be referred to the same geological period, and that as they traverse liassic and oolitic strata, both towards the north-west in Skye and towards the south-east in Raasay, they ought to be regarded as in all likelihood later than the earlier part of the oolitic period. (See Trans. Roy. Soc. Edin., vol. 22, p. 649.) In assorting the following specimens, care has been taken to separate these long parallel dykes from the other intrusive igneous rocks of the Lothians. The latter are arranged lithologically, to show how insensibly basalt passes into coarse-grained greenstone, and how the latter, by losing its augite, shades into felstone.

Intrusive Igneous Rocks, probably of Lower Carboniferous Age.

1. Basalt.
Castle Rock, Edinburgh.
From intrusive boss in the lower part of the Calciferous Sandstone series of Midlothian.
This neck-like rock has all the appearance of a true volcanic vent; it lies near the interbedded greenstones and ashes of Arthur's Seat, Calton Hill, and Craiglockhart, and may have been the crater from which the rocks of these hills were thrown out. The basalt is a hard flinty rock, almost approaching a clinkstone.

2. Basalt.
Top of West Lomond Hill, Fifeshire.
A black compact heavy rock, containing a little olivine. It forms a capping on the top of the hill, and is columnar in part, but differs from the greenstone which occurs in a lower part of the same hill (No. 29.) A bed of limestone of the Carboniferous Limestone series underlies it.

3. Basalt.
South end of Binny Craig, Linlithgowshire.
From intrusive sheet in Lower Carboniferous shales (Burdie House limestone).
This compact fine-grained rock, when

freshly broken, emits a bituminous odour. Anthracite occurs in cavities, and lining joints in the rock, while in the neighbouring quarry of Binny petroleum is found in shreds and filaments among chinks of the sandstone.

4. BASALT.
Quarry S. of Dalmeny Church.
From intrusive mass in Calciferous Sandstone series.

5. BASALT.
Yellow Craig, North Berwick.
A compact fine-grained rock, containing grains of olivine and crystals of augite and felspar, and occurring as an intrusive mass in the ash of North Berwick. (See 56–61, Table-case F.)

6. PORPHYRITIC BASALT.
Burning Mount, near Traprain Law, Haddingtonshire.
A hard black rock containing distinct crystals of felspar, which give rise to the porphyritic structure.

7. PORPHYRITIC BASALT.
The Liethies, North Berwick.
A flinty rock with felspar crystals, occurring as an intrusive mass in the North Berwick ash.

8. PORPHYRITIC BASALT.
Millstone Neuk, 1¼ miles S.E. of Dunbar.
The texture is granular, approaching that of a greenstone, and contains an admixture of large well-defined felspar crytals and some of augite.

Among Scottish mineralogists the distinction between basalt and greenstone has always been considered one of texture rather than of composition. Basalt is the term applied by them to fine-grained black rocks made up of augite and felspar, while greenstone is the word used when these two minerals occur in distinct crystals.

9. GREENSTONE.
Craigton, Linlithgowshire. (See 121, upper compartment of this Case.)
From intrusive boss, like volcanic neck, in beds of the "Houston Coal" group. It is a fine homogenous mixture of small felspar and augite crystals. In this specimen, as compared with No. 1, the difference between the greenstone and basalt of Scottish mineralogists is well shown.

10. GREENSTONE.
West Broadlaw, Linlithgowshire.
This rock, like that of Binny Craig, near which it occurs, emits a bituminous odour from a fresh fracture. It has been intruded among the shales which in Linlithgowshire represent the Burdie House limestone.

11. GREENSTONE.
Dalmahoy Hill, 8 miles S.W. of Edinburgh.
From an intrusive sheet in the Calciferous Sandstone group.

12. GREENSTONE.
Hallcraigs, 10 miles S.W. of Edinburgh.
From intrusive mass in calciferous sandstones.

13. GREENSTONE.
Fauch Hill, 15 miles S.W. of Edinburgh.
This is a hard crystalline rock, containing distinct crystals of felspar and a few small amygdaloidal kernels of carbonate of lime. It occurs as an intrusive mass in the Calciferous Sandstones of the south-western part of Mid-Lothian.

14. GREENSTONE.
1¼ miles S.E. from Dunbar.
This rock occurs in a dyke in the Calciferous Sandstones, and is a little more amygdaloidal than the last. The amygdaloidal structure depends upon the presence of gas or vapour in the original melted rock, whereby the lava was blown open into vesicles. These cavities became subsequently filled up with mineral matter carried by the infiltration of water. But it not unfrequently happens that where a surface of the rock is exposed to the action of the weather, the mineral that has filled the vesicles is removed, so as to restore the original cavernous aspect of the rock. This is illustrated by the next three specimens.

15. AMYGDALOIDAL GREENSTONE.
350 yards south of Dechmont House, Linlithgowshire.
This specimen is from an intrusive bed among the shales of the Burdie House limestone series. The pale firm-grained part shows the numerous small vesicles filled with carbonate of lime; but on the brown weathered surface the mineral has been dissolved, and the cavities remain as empty as they were originally.

16. AMYGDALOIDAL GREENSTONE.
Roadside, half way between the Knock and Limefield.
The cavities are larger and fewer than in the previous specimen, and they contain a quantity of soft bitumen. No. 28 is another specimen from the same rock, where the texture is much more crystalline, and contains no cavities.

17. VESICULAR GREENSTONE.
Bed of river Esk, below Carlops, Edinburghshire.
Here the numerous cavities have, in the process of weathering, become once more empty, so as to show the appearance of the rock when it cooled from a state of fusion. This rock occurs in the form of a dyke traversing the Burdie House limestone strata, which are here thrown into a highly inclined position against a line of powerful dislocation.

18. GREENSTONE.
Half a mile E. of Round Craig, Gossford Sands, Aberlady.
From intrusive sheet in Carboniferous Limestone strata.
This and the three following specimens show the common character of the greenstones of central Scotland.

19. GREENSTONE.
South end of Glenpuntie Wood, Cramond, Linlithgowshire.
From an intrusive mass among the Calciferous Sandstone series.

20. GREENSTONE.
Plantation north of Balgreen, 3 miles S.E. of Linlithgowshire.
It occurs among the Binny Sandstones, and, like so many of the greenstones and basalts of this district, it emits a marked bituminous odour when newly broken.

21. GREENSTONE.
Dechmont Law, Linlithgowshire.
From intrusive bed in shales below Burdie House limestone. It emits the same odour when first broken.

22. GREENSTONE.
Salisbury Craig, Edinburgh.
An intimate crystalline mixture of augite and felspar. This is one of the best known greenstones in Scotland. It occurs in an intrusive sheet among the lower portions of the Calciferous Sandstone, and forms the mural escarpment on the east side of Edinburgh, known as Salisbury Craig.

23, 24. TWO SPECIMENS, showing junction of Greenstone and Sandstone.
Salisbury Craig, Edinburgh.
The greenstone (*b*) becomes fine-grained and dull in texture towards the base, where it rests on the sandstones and shales (*a*), which are greatly hardened along the line of contact.

25, 26. TWO SPECIMENS, showing junction of sandstone and greenstone.
Raw Camps Quarry, 10 *miles S.W. of Edinburgh.*
The dark veins of greenstone are well shown running through the white sandstone, which is converted into a kind of quartz rock. The quarry in which this dyke of greenstone is visible has been opened in the Burdie House Limestone, which is here about 40 feet thick.

27. GREENSTONE.
Selms Tops, Kirknewton.
From intrusive mass in the Calciferous Sandstone series.

28. GREENSTONE.
Quarry on roadside, half way between Clinkingstone and Drumcross, Bathgate.
This specimen when first broken had a strong bituminous odour. It was taken from the same great intrusive boss as No. 16.

29. GREENSTONE.
Edge Head, West Lomond Hill, Fife.
This beautiful crystalline rock occurs as an intrusive sheet among Carboniferous Limestone strata. See also No. 2, which comes from a basalt bed at the top of the hill.

30, 31. PORPHYRITIC GREENSTONE.
Heriot Mount, Arthur's Seat, Edinburgh.
This is the lowest of the intrusive igneous rocks of the hill. It is surmounted and underlaid by red and white altered sandstones. The usual character of the rock is that of a hard blue greenstone with disseminated crystals of felspar (as in No. 30), but in other parts, particularly where it approaches the sedimentary rocks, it becomes much redder in colour, more compact in texture, and very sparingly porphyritic. (No. 31.)

32. Greenstone.
From dyke, cutting through greenstone of Salisbury Craig, Edinburgh.

This rock contains amydaloidal cavities, filled with carbonate of lime, and differs considerably in texture from the greenstone which forms the general mass of the Craig. (See No. 22.)

33. Greenstone.
Port Edgar, South Queensferry.

From intrusive sheet among the strata below the Burdie House Limestone.

34. Greenstone.
Corstorphine Hill, 3 miles W. of Edinburgh.

This rock is a mixture of felspar and hornblende, and differs in this respect from other greenstones of the district, which are mixtures of felspar and augite. It is an intrusive bed among the calciferous sandstones.

35. Greenstone.
Aberlady, Haddingtonshire.

From intrusive mass in Carboniferous Limestone strata. This is a coarse grained rock, much decomposed; the specimen shows the way in which such greenstones yield to the influence of the weather.

36. Greenstone.
North end of Craigie Hill, 6 miles W. of Edinburgh.

This and the four following specimens are from a group of crystalline greenstones intruded among the calciferous sandstones between Queensferry and Edinburgh. They are very coarse grained, crystals of hornblende sometimes occurring in them of nearly an inch in length.

37. Greenstone.
Ratho Quarry, 8 miles W. of Edinburgh.

This rock is traversed by some veins of a light felspathic greenstone (62), and contains cavities that are often filled with beautiful zeolites.

38. Greenstone.
Side of road at Crossall Hill, Dalmeny, Linlithgowshire.

Highly crystalline rock containing large scattered crystals of hornblende, and of two varieties of felspar, with some minute cubes of iron pyrites.

39. Greenstone.
Lindsay's Craigs, Kirkliston, Linlithgowshire.

This rock is still more hornblendic than the last. Such a rock, however, is but rare in the Lothians, the greenstones being almost always mixtures of augite and felspar, as in that of Salisbury Craig.

40. Greenstone.
Dundas Hill, Dalmeny Parish, Linlithgowshire.

41, 42. Greenstone.
The Dasses, Arthur's Seat, Edinburgh.

A light fine-grained porphyritic rock, with well-defined felspar crystals scattered through the base. This is the highest of the intrusive greenstones of the hill. It forms a low irregular ridge parallel with the Hunter's Bog, and consists of several beds intruded among sandstones and shales. A short slope, probably covering similar sedimentary rocks, intervenes between this and the crag called Long Row, which is the lowest of the contemporaneous or interbedded igneous rocks. The latter are illustrated in the upper compartment of this Case.

43. Greenstone.
100 *yards north of Niddry Castle, Linlithgowshire.*

From intrusive knob in ash (127) above Burdie House Limestone strata.

44. Greenstone.
Carmel Hill, Linlithgowshire.

From an intrusive mass among the calciferous sandstones of West Lothian.

45. Greenstone.
Bell's Mills, Water of Leith, Edinburgh.

This specimen is taken from a dyke or intrusive bed penetrating the Wardie Shales, which form a part of the Calciferous Sandstone series. It was observed by Hutton and the early Scottish geologists, and, along with some other similar dykes in the same locality, it was frequently appealed to as a proof of the igneous origin of "whinstone," as the greenstones and basalts were called.

46. Greenstone.
Western Breakwater, Granton, near Edinburgh.

From a dyke in the calciferous sandstones.

47. Greenstone.
Stream above East Kenleith, 5 miles S.W. of Edinburgh.

From a dyke in the calciferous sandstones, very near their base, where they rest on the Old Red Sandstone rocks of the Pentland Hills.

48. COMPACT GREENSTONE.
Albany Street, Edinburgh.
From a dyke in the calciferous sandstones. The site of the quarry from which this specimen was taken is now covered over with a church, and the dyke is no longer anywhere to be seen.

49. GREENSTONE.
Tombstone, 2 miles W. of Granton.
From a dyke in calciferous sandstones.

50. GREENSTONE.
Gas works, North Berwick.
A compact felspathic rock, slightly amygdaloidal, from a dyke cutting through ash of Lower Carboniferous age. It will be seen that the specimens are now beginning to show an increasing amount of felspar in their composition.

51. GREENSTONE.
Blackness Castle, Linlithgowshire.
From intrusive bed near the bottom of the Carboniferous Limestone series. This rock is still more decidedly felspathic.

52. GREENSTONE.
Quarry W. of Newlands, parish of Kirknewton, Edinburghshire.
From an intrusive sheet among the calciferous sandstones. A dull earthy rock, without any crystalline structure, and emitting a strong argillaceous smell when breathed upon.

53. GREENSTONE.
Banks of Dyewater, 1 mile below Longformacus.
This and the two following specimens are from dykes in the Upper Old Red Conglomerate of the Lammermuir Hills. They show the red colour and dull, faintly crystalline, felspathic texture so characteristic of the dykes in the Old Red Sandstone of this district.

54. GREENSTONE.
Dyewater, 1 mile below Longformacus.
Here the rock had an amygdaloidal structure. The cavities are partially filled with carbonate of lime, partly empty, and they show a remarkable elongation, indicating that the rock, when fluid, was drawn out in the direction of the length of the vesicles after these had been formed.

55. GREENSTONE.
Raven Craig, Banks of Whitadder, near Cranshaws, Berwickshire.
This dyke closely resembles No. 53 from the banks of the Dyewater.

56. GREENSTONE.
Bed of river Esk, Fairliehope, Pentland Hills.
From a narrow dyke in the Old Red Conglomerate. The dykes in this formation in Midlothian, like those of East Lothian and Berwickshire, are generally felspathic, fine-grained, and have a dull reddish-brown colour.

57, 58. GREENSTONE.
East side of Belhaven Bay, Dunbar.
From a dyke in some of the red sandstones which lie towards the base of the Carboniferous series of East Lothian. No. 57 shows a dull felspathic texture, with crystals of a brown decomposing mineral, possibly augite, and small amygdaloidal cavities filled with amethyst. No. 58 is from a more weathered part of the dyke.

59. FELSPATHIC ROCK.
Long Craig, three-quarters of a mile W. of Dunbar.
From a dyke in the same strata as those from which the last two specimens were taken. It is an earthy decomposing rock, highly felspathic, and full also of small amygdaloidal kernels.

60. FELSPATHIC ROCK.
Quarry behind Dalmeny Church, Linlithgowshire.
From a dyke in the calciferous sandstones. A dull, earthy, decomposing rock, very felspathic, and sparingly amygdaloidal. It has yielded so much to the decomposing influences of the atmosphere as to be with difficulty assigned to any mineralogical species. Originally, it was probably a felspathic greenstone, that is, contained a mixture of hornblende or augite in a very felspathic base.

61. FELSPATHIC GREENSTONE.
St. George's Well, Water of Leith, Edinburgh.
This specimen is taken from one of those dykes in the Wardie shales (Calciferous Sandstone series) which attracted attention during the Huttonian and Wernerian discussion in Edinburgh, towards the close of the last and beginning of the present century.

62. FELSPATHIC GREENSTONE.
Ratho Quarry, Edinburgh.
This specimen is taken from a vein traversing the greenstone of the quarry. It is a pale, compact, crystalline rock, consisting of a little augite scattered through a felspathic base.

63. Felspathic Rock.
Shore at Newhalls, South Queensferry.
From a dyke in the Calciferous Sandstone series. A hard, flinty, compact rock, breaking with uneven semi-conchoidal fracture. It consists almost wholly of felspar.

64. Felspathic Rock.
Western Breakwater, Granton.
From one of a series of dykes in the Calciferous Sandstones. It is a pale compact rock, not distinguishable from some varieties of felstone. It weathers with a brownish-yellow crust.

65, 66. Felspathic Trap.
Bed of Linhouse Water, below Red Craig, Edinburghshire. (See 85 in the upper compartment.)
From a dyke in the Calciferous Sandstones. These two specimens are like the last, identical with felstone, and can be parallelled among the interbedded felstones both of the Gurlton and Pentland Hills.

It is proper to observe, in concluding this series, that the specimens of which it consists were not collected with a view to illustrate the lithological varieties of the intrusive rocks. They were formerly arranged according to the stratigraphical position of the formations in which they occur. But in re-assorting them for the present edition of the catalogue, it was found that they might help to explain the gradations of the different trappean rocks into each other. They were accordingly grouped lithologically, the basalts forming one end of the series, and the felstones the other. But, as already explained, it has been deemed expedient to retain separately a suite of specimens from certain parallel dykes which, running in a more or less easterly and westerly direction, traverse all the other igneous rocks, whether intrusive or interbedded, and which not improbably belong to some part of the Oolitic period. They are placed after those just described.

Dykes later than Carboniferous Rocks of the Lothians.

67. Greenstone.
Nancy's Hill Quarry, 1½ mile E. of Linlithgow.
This dyke runs nearly east and west for a distance of more than four miles, cutting through the Calciferous Sandstone, the Carboniferous Limestone, and all its associated igneous rocks. This specimen is taken from its eastern end, where it cuts through the Houston coal-beds. It is a firm, fine-grained, augitic rock, like the ordinary greenstones already described.

68. Basalt.
Quarry at Hiltly Cottage, 1 mile S. of Linlithgow.
From same dyke, where it traverses greenstones interbedded among the Carboniferous Limestone beds. The rock here is fine, compact, and has a distinctly columnar structure, the columns being arranged horizontally above each other.

69. Greenstone.
Avon Aqueduct, Linlithgowshire.
From same dyke, where it cuts the two upper limestones, Nos. 202 and 206 in Table-case E.

70. Greenstone.
Kipps, Linlithgowshire.
From dyke cutting through Carboniferous Limestone and Coal Measures.

71. Greenstone.
Walton, Linlithgow.
From dyke traversing the Carboniferous Limestone series.

72. Greenstone.
Beecraigs, 2 miles S. of Linlithgow.
From dyke in Carboniferous Limestone. This and the four following specimens are taken from a series of parallel dykes which run in an E. and W. direction across the Carboniferous Limestone beds and their associated igneous rocks.

73. GREENSTONE.
The Knock, 2 miles N. of Bathgate.
From dyke in Carboniferous Limestone.

74. GREENSTONE.
Cottage S. of the Knock, Linlithgowshire.

75. GREENSTONE.
Lower Craigmailing, 2½ miles S. of Linlithgow.
From dyke in Carboniferous Limestone.

76. GREENSTONE.
Binny Burn, Linlithgowshire.
From dyke in Calciferous Sandstones.

77. GREENSTONE.
Currie, 5 miles S.W. of Edinburgh.
From a dyke in the lower part of the Calciferous Sandstones.

78. GREENSTONE.
Green Burn, Dalmahoy, Edinburghshire.
From dyke in Calciferous Sandstones.

79. GREENSTONE.
Three-quarters of a mile S. of Longniddry.
From dyke upwards of six miles long, traversing Mountain Limestone and Coal Measure strata.

ARCHD. GEIKIE.

Wall-case 44.

PERMIAN SERIES.

Arranged and described by A. C. RAMSAY.

The Permian rocks of England overlie the Coal Measures unconformably when in contact with them, and in certain districts, such as the valley of the Eden, and the Abberley and Malvern Hills, they lie indifferently on the denuded edges of Carboniferous and Silurian strata. The whole of the Palæozoic rocks, from the Coal Measures downwards, were therefore disturbed and denuded before the deposition of the Permian formations. In the centre of England and on the borders of Wales only the lowest member is present, viz., those red marls, sandstones, and conglomerates of older date than the Magnesian Limestone. These are believed to be the equivalents of the German Roth-liegende. They border the Warwickshire, South and North Staffordshire, Shropshire, Worcestershire, and North Wales coal-fields, and here and there form part of the Malvern range. The same strata overlaid by magnesian limestone and red marl occur in Lancashire, and the whole of the Upper series, viz., the various subdivisions of the Magnesian Limestone are splendidly developed along the eastern flanks of the Carboniferous series, between the neighbourhood of Nottingham and South Shields in Northumberland. The lower sandstone or Roth-liegende is in this last area comparatively thin.

1. CONGLOMERATE, Roth-liegende, Permian.
Wrexham, Shropshire.
Pebbles of red sandstone in a sandy base.

2. CALCAREOUS CONGLOMERATE, Roth-liegende, Permian.
Near Bridgnorth, Staffordshire.
Chiefly made of waterworn rounded pebbles of Carboniferous Limestone, containing fossils.

The following specimens Nos. 3 to 13 are from a remarkable set of Brecciated Conglomerates that form part of this series. The stones that compose it lie in a red marly base, they are all angular, or only have their edges slightly rounded, and they occasionally reach from 2 to 3 feet in diameter. The majority of them also have not been derived from neighbouring rocks, but have come from a distance often of many miles. Many of them have smoothly polished surfaces, and occasionally they are scratched in a manner suggestive of the markings on stones from the Pleistocene drift.

For further details on this subject see description of Table-case C, on the opposite side of the gallery.

3. BRECCIATED CONGLOMERATE, Roth-liegende, Permian.

Howler's Heath, S. end of the Malvern Hills.

This shows 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 imbedded.

4. LOOSE STONES AND MARL, from Brecciated Conglomerate, Roth-liegende, Permian.

Abberley Hill, Worcestershire.

Small angular and subangular fragments. This on a small scale shows the nature of the stones that form the rock.

5. STONES FROM CONGLOMERATE, Roth-liegende, Permian.

Galacre Hall, and Four Ashes, near Enville.

This conglomerate lies below the 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 Encrinites stand in relief on the weathered surfaces of the pebbles.

6. FRAGMENT OF BOULDER OF CAMBRIAN GRIT, from Brecciated Conglomerate, Roth-liegende, Permian.

Near Hundred House, Abberley Hills.

This block when entire was about half a ton in weight. It resembles some of the grits of the Longmynd, and the surface is deeply grooved and scratched, the surface *in the grooves* not being sensibly fresher than the remainder of the surface.

7. SUBANGULAR STONE, grooved; from Brecciated Conglomerate, Roth-liegende, Permian.

Stagbury Hill, Stourport, Worcestershire.

Consists of felspathic grit, probably from the Longmynd.

8. ANGULAR STONE, grooved; from Brecciated Conglomerate, Roth-liegende, Permian.

Stagbury Hill, Stourport.

This stone itself is part of a conglomerate, like some of those of Cambrian age in the Longmynd.

9. ANGULAR STONES, from Brecciated Conglomerate, Roth-liegende, Permian.

Berrow Hill, near Martley, Abberley.

10. CONGLOMERATIC LIMESTONE, Roth-liegende, Permian.

From the lane between Northfield and Bangham Pit, Worcestershire.

The large angular slab from which this was taken was full of *Pentamerus oblongus*, and other shells of the Upper Llandovery or Pentamerus beds. The nearest rock of this kind *in place* is about 45 miles distant, resting on the Longmynd, and on the lower Silurian rocks to the west.

For a continuation of this subject, see p. 202, and Table-case C on the opposite side of the gallery.

11. BRECCIATED CONGLOMERATE, Roth-liegende, Permian.

Rowton, near Shrewsbury.

Chiefly composed of angular pebbles of Carboniferous Limestone, small pebbles of quartz, &c., in a red marly base.

12. BRECCIATED CONGLOMERATE, Roth-liegende, Permian.
Alberbury, near Shrewsbury.
Consisting of angular pebbles of Carboniferous Limestone, embedded in a red marly calcareous base. These rocks and No. 2 consist of a great mass or bank of angular conglomerate, 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.

13. BRECCIATED CONGLOMERATE, Roth-liegende, Permian.
Alberbury, near Shrewsbury.
Pebbles of Carboniferous Limestone.
For continuation of this subject see p. 202.

14. SANDSTONE, Roth-liegende, Permian, exhibiting ripple-marks and sun-cracks.
Alberbury, Shropshire.
Sun-cracks 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.

15. RED SANDSTONE, Roth-liegende, Permian.
Preston Boat, Shrewsbury.
Very micaceous.

16. Variegated SANDSTONE, Roth-liegende, Permian.
The Hollings, near Market Drayton, Shropshire.

17. CONGLOMERATE, Roth-liegende, Permian, with waterworn pebbles of quartz.
The Hollings, near Shrewsbury, Shropshire.

18. CONGLOMERATE, Roth-liegende, Permian.
Coventry, Warwickshire.
Composed of rounded waterworn pebbles of sandstone, quartz, and limestone in a sandstone base.

19. RED SANDSTONE, Roth-liegende, Permian.
Three miles E. of Wickerley, Rotherham, Yorkshire.

20. RED SANDSTONE, Roth-liegende, Permian.
Rotherham.
Nos. 19 and 20 are used for grindstones and building purposes.

21. CALCAREOUS CONGLOMERATE, Roth-liegende, Permian, underlying Magnesian Limestone.
Kirkby Woodhouse, Notts.

22. PERMIAN LIMESTONE.
Kirkby Woodhouse, Notts.
Compact, grey limestone, containing fossils, occurring in the marl of the *Magnesian Limestone*, which overlies the calcareous conglomerate, No. 21.

23. MAGNESIAN LIMESTONE, Permian.
Mansfield.
Yellow limestone, partly used in the construction of the houses of Parliament.

24. MAGNESIAN LIMESTONE, Permian.
Mansfield Woodhouse, Notts.
Exhibits fretted divisional planes, produced by the percolation of water.

25. CRYSTALLINE MAGNESIAN LIMESTONE, Permian.
Durham.

26. CRYSTALLINE MAGNESIAN LIMESTONE, Permian.
Durham.

27. CONCRETIONS OF MAGNESIAN LIMESTONE, Permian.
Durham.

28. CONCRETIONS, MAGNESIAN LIMESTONE, Permian.
Durham.

29. CONCRETIONS, MAGNESIAN LIMESTONE, Permian.
Durham.

30. LAMINATED CONCRETIONS, MAGNESIAN LIMESTONE, Permian.
Durham.

31. MAGNESIAN LIMESTONE, Permian.
Durham.

32. CONCRETIONS, MAGNESIAN LIMESTONE, Permian.
Durham.

33. MAGNESIAN LIMESTONE, (Permian), cementing fragments of Carboniferous Limestone.
Durham.

34. INDURATED MAGNESIAN LIMESTONE, Permian.
Black Hall Rocks, Durham.

From 25 to 34 presented by W. King, Esq.

35. LAMINATED FLEXIBLE MAGNESIAN LIMESTONE, Permian.
Marsden Bay, Durham.
Presented by Daniel Oliver, jun., Esq.

36. CRYSTALLINE MAGNESIAN LIMESTONE, Permian.
Fullwell Hills, Sunderland.
Presented by Mr. John Kirkaldy. (See top shelf.)

A. C. RAMSAY.

Wall-case 45.

SECONDARY OR MESOZOIC ROCKS.

By A. C. Ramsay and H. W. Bristow.

NEW RED SANDSTONE AND MARL (TRIAS).

Sandstone and Conglomerate (Bunter Beds).

The New Red Sandstone lies at the base of the Secondary rocks, and consists of three subdivisions: Lower Variegated Sandstone, Conglomerate or Pebble Beds, and Upper Variegated Sandstone. No fossils have been found in any of these subdivisions in England.

1. Conglomerate, from Lower Variegated Sandstone, New Red Sandstone.

Doblaston, Cheshire.

Pebbles of quartz in a quartzose base, cemented by micaceous oxide of iron. From the basement bed of the New Red Sandstone.

2. Laminated Red Sandstone, Lower Variegated Sandstone, New Red Sandstone.

Bromsgrove, Worcestershire.

3. Soft Red Sandstone, Lower Variegated Sandstone, New Red Sandstone.

Mansfield, Notts.

Fine-grained, micaceous sand, 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

4. Pebbles, from the Conglomerate or Pebble beds, New Red Sandstone.

Whitmore.

The Conglomerate of the New Red Sandstone, near Whitmore and elsewhere in Staffordshire, literally consists of pebble beds, often so loosely aggregated that they are treated like common gravel banks, and dug out with pickaxe and shovel.

The pebbles are always exceedingly waterworn, and have been smoothed like the pebbles of the Chesil bank, or any similar beach, by breakers or some such power rattling them against each other. "Its component stones are often from three to nine inches in diameter, and where they touch in the rock they indent each other at the points of contact; the indentations being, I believe, due to the fact that, while these gravels were still incoherent over great areas, the upper parts of the new red series, the lias, and perhaps other newer strata, were piled upon them, and the vertical pressure consequent on this vast superincumbent pile, induced a lateral pressure in the loose-lying pebbles of the conglomerate; so that being squeezed, not only downwards, but outwards, they ground on each other, and, 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.

5. Conglomerate, New Red Sandstone.

Pebbles of quartz in a partially crystallized quartzose base.

6. CONGLOMERATE, New Red Sandstone.

Bridgenorth, Shropshire. Map 61. S.E.

Formed of pebbles of iron ore in a ferruginous base.

7. UPPER VARIEGATED SANDSTONE, absent in the Case.

The Muschelkalk, which in Germany lies between the Bunter and Keuper formations, is absent in Britain.

NEW RED MARL SERIES (KEUPER BEDS).

In England this series commences with brown and white Sandstones and Conglomerates, often interstratified with marl. A few plants and fish, but no fossil shells, have been found in these beds, which are usually called the Lower Keuper Sandstones or Waterstones. In places the surface of the Bunter beds on which they rest is eroded. It is probable that the latter had been raised above the water during the formation of the Muschelkalk, and being then subjected to atmospheric influences, the Keuper beds were on its re-immersion deposited on a worn surface.

8. STONES MOSTLY SUBANGULAR, from base of Lower Keuper Sandstone.

Near Stourport, Worcestershire.

9. BRECCIATED CONGLOMERATE, from base of Lower Keuper Sandstone.

Astley, near Stourport.

The stones that form this conglomerate are similar to those of the Permian Conglomerates, No. 3, Wall-case 44.

10. FINE WHITE SANDSTONE, Lower Keuper Sandstone.

Dimock, Worcestershire.

11. MICACEOUS WHITE SANDSTONE, with fish-defence; Lower Keuper Sandstone.

Bromsgrove, Worcestershire.

12. MICACEOUS YELLOW SANDSTONE, with plants; Lower Keuper Sandstone.

Bell Broughton, Worcestershire.

13. WHITE SANDSTONE, Lower Keuper Sandstone.

Chatwell, near Newport, Shropshire.

14. WHITE SANDSTONE, with plants, *Voltzia;* Lower Keuper Sandstone.

Ashley Heath, Market Drayton.

15. MICACEOUS WHITE SANDSTONE, Lower Keuper Sandstone.

Cubington, near Leamington, Warwickshire.

Ripple marks on white sandstone.

16. WHITE SANDSTONE, Upper Keuper Sandstone.

Ashby-de-la-Zouch, Leicestershire.

Containing cavities lined with crystals of calc spar.

17. WHITE SANDSTONE SLAB, Lower Keuper Sandstone.

Grinshill, Shropshire.

Shows ripple marks of large size.

The quarry from which this stone comes supplies a great quantity of very fine building-stone.

It is in these beds that Labyrinthodon foot-prints are common.

The NEW RED or KEUPER MARL is about 600 to 800 feet thick, where thickest. Just about its junction with the sandstones described above, it contains, in the Midland Counties, beds of salt, and gypsum is also common in it.

18. VARIEGATED MARL, RED AND GREEN, (Keuper).

Westbury, Gloucestershire. Map 14.

The red marl countries are usually rich in fruit trees, and produce excellent cider and perry.

19. ROCK SALT, from New Red Marl.

Cheshire.

Used for the manufacture of salt.

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

These beds of salt are regularly stratified, and occur about the base of the Keuper Marl. The greater part of the salt 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) may become saturated with salts, after which, the supply continuing, deposition will ensue.

Pure rock salt consists essentially of chloride of sodium:

Chlorine - - -	59·5
Sodium - - -	40·5
	100.0

20. ROCK SALT, New Red Marl.

North of Ireland.

Presented by the Marquis of Downshire.

21. UPPER KEUPER SANDSTONE, from New Red Marl.

Epworth, Island of Axholme, Lincolnshire.

With fine pseudomorphous crystals of rock salt.

22. UPPER KEUPER SANDSTONE.

With pseudomorphous crystals of rock salt.

From New Red Marl.

These beds of Keuper Sandstone lie in the middle of the New Red Marl, and contain fossils, namely, *Batrachian footprints*, *fish-spines*, and a small bivalve 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 argiliaceous 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 sandbanks 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 homogenous stratum immediately above.—(" On Pseudomorphous Crystals of Chloride of Sodium in Keuper Sandstone." H. E. Strickland Esq., F.R.S., F.G.S. Quart. Jour. Geological Society, Dec. 1, 1852.)

23. UPPER KEUPER SANDSTONE.
Newent, Gloucestershire.
From New Red Marl. Exhibiting in relief the cracked markings of a dried surface.

24. UPPER KEUPER SANDSTONE.
High House, near Warwick.
Annelid-tracks and sun-cracks on ripple-marked surface.

25. UPPER KEUPER SANDSTONE.
Newnham, Gloucestershire.
In the middle of the New Red Marl.

26. UPPER KEUPER SANDSTONE.
Rowington, near Warwick.
White sandstone, with fucoid (seaweed) markings.

27. WHITE GYPSUM, in New Red Marl; in thin fibrous laminæ and small irregular concretions.
Syston, Leicestershire.
This specimen on a small scale somewhat represents the manner in which Gypsum occurs on a large one in the mass of the marl. The layers of Gypsum sometimes cross the bedding in strings at various angles, sometimes the Gypsum runs in layers nearly in the lines of stratification, and sometimes it occurs in swelling solid bunches.

28. FIBROUS GYPSUM, from New Red Marl.
Syston, Leicestershire.

29. MASSIVE GYPSUM (ALABASTER), from New Red Marl.
Syston, Leicestershire.

30. FLESH-COLOURED GYPSUM, from the New Red Marl.
Cardiff, Glamorganshire.
Presented by Sir H. T. De la Beche, C.B.

31. WHITE GYPSUM, from the New Red Marl.
Cardiff, Glamorganshire.
See top shelf.

32. FIBROUS GYPSUM, from New Red Marl.
Penarch, Cardiff, Glamorganshire.

33. SULPHATE OF STRONTIAN, in New Red Marl.
Near Yate, Gloucestershire.
Occurs in large quantities, probably replacing sulphate of lime.
See "Memoirs of Geological Survey," vol. i., p. 267.

34. PAPERY MOUNTAIN LEATHER, occurring in fissures of New Red Marl.
Seaton, Devonshire.
Presented by Sir Walter Trevelyan.

The next four specimens are Magnesian Limestone and Conglomerate. These rocks occur at the junction of the New Red beds (chiefly the marls) with any older formation on which they lie unconformably, in S. Glamorganshire and S. Monmouthshire, round the Mendip Hills, near Bristol, &c. They have frequently been confounded with the Magnesian Limestone of Permian age, but are clearly of the same general age with the New Red Marls with which they are associated. The conglomerates are generally made exclusively of the fragments of the older rock on which they lie, and they are partially in wedge-shaped beds, interstratified with the marl. See sections of the Geological Survey, sheets 15 to 17, and De la Beche, Memoirs of the Geological Survey, vol. 1, p. 240.

35. MAGNESIAN LIMESTONE, New Red series.

Sully Island, 5 *miles S. of Cardiff, Glamorganshire.*

36. MAGNESIAN LIMESTONE, New Red series.

Sully Island, near Cardiff.

37. MAGNESIAN CONGLOMERATE, from the New Red series.

Coast of Glamorganshire.

The specimen consists of fragments of Carboniferous Limestone in a base of Magnesian Limestone, and exhibits a weathered surface.

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.

38. MAGNESIAN CONGLOMERATE.

Durdham Down, Bristol.

From the New Red Series or Trias, composed of fragments of Carboniferous Limestone, in a calcareo-magnesian base, with a tooth of *Thecodontosaurus*.

Presented by W. H. Bailey, F.G.S.

39. GEODE, from junction of New Red Marl and Carboniferous Limestone. Locally termed "*potato-stone*," lined with crystals of quartz, and containing acicular crystals of rutile (oxide of titanium).

Chepstow, Monmouthshire.

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

40. GEODE, from junction of New Red Marl and Carboniferous Limestone. Composed of quartz and imperfect red jasper.

Chepstow, Monmouthshire.

The following iron ores have been occasionally worked ever since the time of the Romans. They lie sometimes in joints, sometimes between the beds.

41. BROWN IRON ORE (*brown hæmatite*), from Magnesian Conglomerate.

Mendip Hills, Somerset.

42. BROWN IRON ORE (*brown hæmatite*), from the Magnesian Conglomerate.

Mendip Hills, Somerset.

43. RED IRON ORE (peroxide of iron), commonly known by the name of "*reddle.*"

From Magnesian Conglomerate.

Mendip Hills, Somerset.

44. BROWN IRON ORE (hydrous peroxide of iron), from Magnesian Conglomerate.

Mendip Hills, Somerset.

45. SPARRY IRON ORE, with carbonate of copper; from Magnesian Limestone.

Mendip Hills, Somerset.

46. PYROLUSITE (*grey manganese ore*), from Magnesian Conglomerate.

Mendip Hills, Somerset.

47. PYROLUSITE (*grey ore of manganese*), with carbonate of lead (*white-lead ore*).

WESTBURY BEDS, equivalent to the Koessen beds, Austrian Alps, and partly to the strata commonly known as "White Lias."

The specimens from No. 48 to 67 belong to the series of beds for long known as the "White Lias." An examination of the fish-remains contained in them induced Sir Philip Egerton, in the year 1841, to consider them as more properly forming the uppermost member of the New Red series. (Proc. Geol. Soc., vol. 3, p. 409.) Notwithstanding this conclusion, they have till lately by many persons been retained with the Lias. In 1860, D. Wright showed that they contained a peculiar suite of fossils, distinct from those of the Lias, equivalent to those of the *Koessen beds* of the Austrian Alps, or of the *Upper St. Cassian beds* of Escher and Merian. These have been termed *Upper Trias*. On these grounds they are classed in this catalogue rather with the Trias than the Lias. (See also the Supplement to the 5th edition of Lyell's Elements, 1857, p. 26.) The best sections of these strata in England occur at Westbury on Severn, Aust Cliff, and Penarth, Glamorganshire, and for the "White Lias" Lyme Regis and Little Stoke, &c., near Watchet.

48. CALCAREOUS SANDSTONE, with ripple-marks; Westbury Beds.

Lower Penarth, Glamorganshire.

Contains fragments of fish-bones and scales. Lies directly on the New Red Marl.

49. CALCAREOUS SANDSTONE, with ripple-marks and sun-cracks; Westbury Beds. See upper shelf.

Lower Penarth, 4 miles S. of Cardiff, Glamorganshire.

Lies on New Red Marl.

This specimen consists of two beds, on the surface of which the ripple-marks run transversely to each other.

50. CALCAREOUS SANDSTONE, micaceous, with surface markings; Westbury Beds.

Westbury-on-Severn.

51. CALCAREOUS SANDSTONE, micaceous, with *Pullastra arenicola;* Westbury Beds.

Westbury-on-Severn.

50 and 51 lie below the Bone-bed, and contain *Pullastra arenicola*, *Avicula contorta* and *Cardium Rhæticum.* The equivalents of these strata were first noticed by General Portlock, at Portrush, Antrim. See Wall-case No. 17 in this gallery.

52. BONE BED, with bones, teeth, scales, and coprolites; Westbury Beds.

Westbury-on-Severn.

Very calcareous, and contains a little iron pyrites.

53. BONE BED, with much iron pyrites; Westbury Beds.

Westbury-on-Severn.

Full of bones, teeth, scales of *fish*, spine of *Hybodus*, coprolites, &c.

54. BONE BED, CALCAREOUS CONGLOMERATE, with coprolites and bones of *saurians;* Westbury Beds.

Cliff Wood, opposite Aust, Severn.

55. BONE BED, POLISHED CONGLOMERATE, with bones, coprolites, &c. See top shelf; Westbury Beds.

Aust Cliff, Severn.

Composed of waterworn pebbles of grey calcareous sandstone, &c.

56. RIPPLE-MARKED MICACEOUS SANDSTONE, with *Pullastra arenicola;* Westbury Beds.

Westbury-on-Severn.

57. CALCAREOUS SANDY LAYER, Westbury Beds.

Westbury-on-Severn.

In black shales above the Bone-bed. Contains *Cardium Rhæticum*, *Pullastra arenicola*, and scales of *fish*.

61. GREY LIMESTONE, with casts of shells, Westbury Beds.

Charlton Bay, Lyme Regis.

At the base of the beds commonly called "White Lias." Contains *Myacites*, *Cardium*, *Pullastra*, and *Modiola*.

62. WHITE LIMESTONE, Westbury Beds.

Lyme Regis.

63. TILE OF WHITE LIMESTONE, from Westbury Beds.

Lyme Regis.

"Roofing slate from the ruins of Roman buildings, near Seaton, Devonshire. The same are also found among the ruins of a Roman villa, near Lyme Regis, in which are tessellated pavements, of which the dies are made of Blue and White Lias and red tile."

Presented by Sir W. C. Trevelyan.

64. White Limestone, with shells; Westbury Beds.
Westbury-on-Severn.
Lower portion of the Monotis bed, containing *Myacites musculoides*, *Cardium Rhæticum*, *Modiola minima.*

65. White Limestone, with shells; Westbury Beds.
Westbury-on-Severn.
Monotis bed. Contains *Modiola minima* and *Monotis decussata.*

66. White Limestone, with shells; Westbury Beds.
Westbury-on-Severn.
Upper part of Monotis bed, with *Monotis decussata.*

67. Grey Argillaceous Limestone, Cotham or landscape marble; Westbury Beds.
Bristol.

Andrew C. Ramsay.

Wall-case 45—*continued.*

LOWER OOLITE ROCKS.

LIAS.

Arranged and described by H. W. Bristow.

The Lias Formations consist of a series of clays, argillaceous limestones, marls, and sands.

They comprise, 1st, the Lower Lias, composed in the lower part of bands of blue argillaceous limestone interstratified with beds of shale and clay, and consisting mostly of clay in the upper part; 2nd, the Marlstone, on the whole a sandy deposit, the upper portion made up of thick beds of hard calcareous and ferruginous sandstone, and the lower of sands much resembling those of the Upper Lias, except that they are, in general, more ferruginous, and sometimes more argillaceous and shaly; 3rd, the Upper Lias Clay, with occasional bands of nodular limestone and shale; 4th a mass of sand with layers of large calcareous concretions, which, until recently, were considered to belong to the Inferior Oolite. These last sands appear to constitute a well-marked physical division between the Lias and the Inferior Oolite formation; but the researches of Dr. Wright tend to show that the fossils found in the sands have much greater affinity with those of the underlying Lias than with those of the overlying Inferior Oolite, and they are now, therefore, generally grouped with the former series. The 3rd and 4th divisions are frequently absent.

The prevailing colour of the Lower and Upper Lias Clay is blue. The lower limestones are largely worked for flagstones and for building; and some of the beds, both of these limestones as well as of those in the clays above, when burned are made into a cement, which is in great request where lime and cement are required to possess the property of setting under water. The brown rock or uppermost beds of the Marlstone also furnish a useful and durable building-stone, while some of the beds are so highly charged with hydrous peroxide of iron as to constitute a very valuable ore of that metal.

In an agricultural point of view, the clays and lower limestones form poor and cold soils, which are usually devoted to pasture; but when properly treated they often afford excellent crops. The Marlstone and the more sandy strata are generally converted into arable land, and yield rich crops. The Marlstone is especially favourable to the growth of apples, and some of the best cider in Somersetshire and Gloucestershire is made in districts situated upon this subdivision.

The fossils of the Lias formation are contained in Flat-cases 1 to 6, and in Wall-cases 8 to 13. Wall-case 17 contains fossils from the Lias of Ireland, and 22 to 24, a fine collection of fish from the Lower Shales and Clays of Lyme Regis in Dorsetshire. See, also, on the walls of the staircase leading from the Lower to the Upper Gallery.

1. LIAS LIMESTONE.

Westbury-on-Severn, Gloucestershire.

Argillaceous limestone, in a sandy marl, occurring at the base of the Lias.

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

2. ARGILLACEOUS LIMESTONE, Lower Lias.

Westbury-on-Severn, Gloucestershire.

Contains the *coprolites, teeth, scales,* and *other remains* of *Fish, Ichthyosauri,* &c.

This bed, called the "bone bed," formed an ancient sea-bottom at the base of the Lias, between the latter formation and the New Red Sandstone.

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

(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.)

2a. CONGLOMERATE, Lower Lias.

Craig-yn-cros, near Bridgend, Glamorganshire.

Calcareous pebbles in a base of shelly limestone, forming the bottom bed of the Lias. (See Memoirs of Geological Survey, vol. i., pp. 244–252.)

2b. DOLOMITIC LIMESTONE, Lower Lias.

Parc, 2 miles N.W. of Bridgend, Glamorganshire.

Forms the lowest bed of the Lias.

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

3. ARGILLACEOUS LIMESTONE, Lower Lias.

Two miles E. of Newport, Monmouthshire. Map 36.

Contains *Ostrea.*

The blue Lias limestones generally contain a good deal of clay, and are eminently useful for producing an hydraulic lime, which is said to set better under water than the lime made from most other limestones.

4. BLUE ARGILLACEOUS LIMESTONE, Lower Lias.

Street, Somersetshire.

This limestone is from the *Ostrea liassica* series, containing *Plesiosaurus dolichodeirus* and *P. Etheridgii,* &c. It occurs nearly at the base of the Lias limestone, and is largely quarried in the neighbourhood for flagstones &c. See large specimens on the wall of the staircase leading from the Lower to the Upper Gallery.

5. GREY ARGILLACEOUS LIMESTONE, Lower Lias.

Barrow-on-Soar, N. Leicestershire. Map 63.

Contains *Ammonites Johnstoni.*

6. SEPTARIA, Lower Lias.

Watchet, Somersetshire.

The lower clays of the Lias frequently contain courses of septarian nodules, similar to the specimen. They are concretions of impure calcareous matter, which have, in most cases, formed themselves about shells, wood, or other organic substances. In the shrinking of the mass which has taken place during the process of solidification, the body has become traversed by cracks, which have subsequently filled with calcareous spar. The regular form which these cracks assume is shown on the surface of the specimen, and it is from these pentagonal divisions of calc spar that the name Septaria has been given. The polished surface shows the veined structure produced internally by the cracks which traverse the mass, and also numerous included fragments of crinoidal stems. Septaria are in great request for making the best kinds of Roman cement. They are also used in a polished state for the tops of tables, and other ornamental purposes, for which, from their veined structure, they are well suited.

7. Blue Clay (Lower Lias).
Lyme Regis, Dorsetshire.
The surface covered with spines and bodies of Echini (*Acrosalenia minuta*). This bed appears to be very persistent, in the Lias, over a large area. Many fine specimens of the above Echinoderm were found by the Survey at the Old Railway Station at Cheltenham.

8. Argillaceous Limestone (Lower Lias).
Freathern Cliff, near Newnham, Gloucestershire. Map 35.
With *Lima*, *Ostrea*, and other fossils. Occurs in thin beds or layers interstratified with blue clay.

9. Blue Limestone (Lower Lias).
Jericho Wood, Barkstone.
Argillaceous limestone, chiefly composed of comminuted shells and fragments of encrinite stems. The large shell (*Lima gigantea*) with which the surface is thickly covered, is one of the most common in the Lias formation. From the limestone beds underlying the Lower Lias Clays.
Presented by Thomas Reynolds, Esq.

10. Argillaceous Limestone (Lower Lias).
Four miles S. of Gloucester.
This stone has a very close texture, like a lithographic stone. It contains numerous fossil shells, with their valves united, showing the gaping position in which, after death, the shells lay filled with calcareous mud in the sea-bottom.

11. Blue Clay (Lower Lias).
Stonehouse, Gloucestershire.
Used extensively for making bricks and tiles.
See Edward Hull's Memoir on the Geology of the Country round Cheltenham (Map 44), p. 15.

12. Blue Limestone (Lower Lias).
Lyme Regis, Dorsetshire.
Argillaceous limestone, with a fine grain and close texture, containing *Ammonites Birchii* in calc spar, small crystals of which also line the cavities of the septa.

13. Argillaceous Limestone (Lower Lias).
The cliffs E. of Charmouth consist, for the most part, of blue Lias-shales, and clays underlying the Marlstone. Interstratified with the clays are bands of impure limestone, two of which, situated 50 feet apart, furnish excellent cement-stone. Map 17, Horizontal Section, No. 21.

14, 15. Ammonite Marble (Lower Lias).
Marston Magna, Somersetshire.
A mass of *Ammonites obtusus* and *A. planicosta* in a base of dark-brown argillaceous limestone, polished on one side.
Presented by the Earl of Enniskillen.

16. Ammonite Marble (Lower Lias).
Marston Magna, Somersetshire.
A mass of *Ammonites planicosta* imbedded in a base of dark-brown argillaceous limestone, polished on one side.
Nos. 14, 15, and 16 are Ammonite marbles which occur in thin bands in the upper clays of the Lower Lias. These beds are not persistent, but occur here and there in occasional patches. The dark tint of the calcareous base which cements the shells is caused by the animal matter of the fossils.

17. Blue Sandy and Argillaceous Limestone (Lower Lias).
Lyme Regis, Dorsetshire.
Impure limestone; the surface of the bed thickly covered with *Ammonites Smithii.*

18. Grey Calcareous Concretion (Lower Lias).
Chipping Camden, Gloucestershire.
Thickly covered with *Goniomya literata*, and other fossil shells. From the upper part of the Lower Lias, near the junction with the overlying Marlstone.

MIDDLE LIAS.

MARLSTONE.

The Marlstone forms the base of the Upper Lias. In Gloucestershire, where it is well developed, the greater part consists of soft sandy and shaly beds, surmounted by the sandy calcareous marlstone after which the whole formation was named by William Smith. The uppermost beds of "brown rock" are often ferruginous, and, in general, very fossiliferous. Besides furnishing a good and durable building-stone, the Marlstone is remarkable for the fertility of its soil.

19. MARLSTONE (Middle Lias).
Vineyard Farm, Cheltenham.

Soft, micaceous, sandy, and calcareous. Contains fossils, *Aviculæ*, *Cardiniæ*, &c. The brown colour of the external coating is the result of the peroxidation of the iron consequent on exposure; the core, where the iron, not having been thus affected, remains in a state of protoxide, retains its original blue colour.

20. MARLSTONE (Middle Lias).
Dursley, Gloucestershire.

Locally called "brown rock." Very calcareous, hard, marly sandstone, with fossils, *Rhynchonella tetrahedra*. It is very tough and durable, and has been used for a building-material in many old churches in the Marlstone districts; it is also used for mending roads.

21. MARLSTONE (Middle Lias).
Near Cheltenham, Gloucestershire.

Grey, sandy, calcareous rock, with many fossils.

Presented by Prof. Morris.

22. MARLSTONE (Middle Lias).
Lyme Regis, Dorsetshire.

Grey, sandy, calcareous stone, with *Ammonites margaritatus.*

23. MARLSTONE (Middle Lias).
Westcombe, Somersetshire.

Micaceous, and with casts of fossil shells: *Terebratulæ, Rhynchonellæ, and Belemnites.*

Harder, more calcareous, and less sandy than No. 19.

24. MARLSTONE IRON-ORE (Middle Lias).
Ironstone Pit, Steeple Aston, Oxfordshire. Map 45, S.W.

Contains numerous *Rhynchonella tetrahedra.*

This ore forms a continuous bed, of an average thickness of about six feet, under the area of the Inferior Oolite, between its outcrop in the valleys of the Cherwell and Evenlode. At some depth, where it has been protected from atmospheric influences, the ore is of a deep green colour, and under the lens beautifully oolitic. In this state it is probably a silicate of iron, which, upon exposure, changes into a hydrated peroxide, with a variable percentage of carbonate of lime. Wherever it is most fossiliferous the proportion of lime is greatest, a fact to be observed in working the ore. It has been smelted at Steeple Aston. The iron-ore from the neighbourhood of Fawler, which appears to be little different in quality, has been assayed at the Museum of Practical Geology, by Dr. Percy, with the following results :—

Analysis of average sample obtained by mixing equal weights of nine specimens.

Peroxide of iron	44·67
Protoxide of iron	0·86
Protoxide of manganese	0·44
Lime	9·29
Magnesia	0·66
Alumina	7·85
Phosphoric acid	0·55
Carbonic acid	6·11
Silica (soluble in acid)	0·48
Sulphur	trace
Water	16·31
Residue insoluble in hydrochloric acid:—	
Silica	11·86
Alumina, with a trace of peroxide of iron	1·25
Lime	trace

Metallic iron, per cent., 31·94; when calcined, 41 per cent.

See Ed. Hull's Memoir on the Country around Woodstock, p. 11.

25. MARLSTONE (Middle Lias).
Steeple Aston, Oxfordshire. Map 45, S.W.

This specimen, like No. 24, is from what is locally called the "Rock Bed." The shells with which it is crowded are *Terebratula punctata*, and they are now entirely replaced by a solid deposit of crystalline carbonate of lime. The rock forming the matrix, cementing the shells together, is seen to possess an oolitic structure when viewed through a magnifying glass.

26. Argillaceous Limestone (Marlstone), Middle Lias.
From foundered blocks on the sea-shore between Down Cliff and Thorncombe Beacon, Dorsetshire. Map 17.
Contains shells and the broken stems of *Crinoids*.

27. Crystals of Calcareous Spar lining a cavity, in *Marlstone*.
Bridport, Dorsetshire.

28. Marlstone, Middle Lias.
Uley, Gloucestershire. Map 35.
The brown sandstone forming the upper part of the Marlstone, is used for building-stone in the district where it occurs. In some localities it furnishes a rich ore of iron. The specimen contains several fossils, *Bellemites rugieri*, *Pecten æquivalvis*, *Ostrea*, *Serpula*, &c.
Horizontal Sections, Sheet 14, No 1.

29. Nodule of Clay-Ironstone, Marlstone.
Half a mile from Oakham, on the road to Ashwell.
Partly invested with a coating of micaceous and ferruginous-brown sandy marlstone.

30. Iron-ore (Marlstone).
Road from Oakham to Ashwell.
A thin layer on Marlstone.

31. Iron-ore (Marlstone).
¼ mile S.E. of Fawler, S.E. of Charlbury, Oxfordshire.
With casts of fossils, *Rhynchonella*, &c.

In some localities in Oxfordshire, and especially at Fawler, near Stonesfield, the "Rock bed" of the Marlstone becomes highly ferruginous, and attains a thickness of from five to eight feet. The original colour is deep olive-green, which on exposure to atmospheric influences turns to yellowish ochreous-brown, consequent on the change of the carbonate of iron into peroxide.

See Ed. Hull's Memoir on the Geology of the Country around Woodstock, p. 9.

32. Iron-ore (Marlstone).
Cleveland, Yorkshire.
Contains *Ammonites spinatus*, partly replaced by calc spar.
This is the Cleveland Iron ore, which, extending over an area of some hundreds of square miles, has of late years been largely worked for smelting purposes. It occurs nearly at the top of the Marlstone of Yorkshire, and is the first hard (Dogger) bed which underlies the Upper Lias of that district. The ore is slightly calcareous, and diffused irregularly throughout it are numerous small oolitic concretions, none of which present any indication of organic structure or radiated crystallization under the microscope. These white concretions are composed of carbonate of iron, frequently coated with a thin layer of peroxide. For an analysis of the Iron-ore of Cleveland, see the Iron-ores of Great Britain, in the Memoirs of the Geological Survey, Part 1.

33. Marlstone (Middle Lias).
Lanbryde, near Elgin, Scotland.
Pale greenish-grey, very micaceous sandstone, with fossils.
The precise position of this stone in the series is not known at present.

Upper Lias.

The Upper Lias Clay is, as its name denotes, a deposit of blue clay overlying the Marlstone, and lying between that formation and the sands which form the uppermost strata of the Liassic series. At the base, and resting on the brown rock or Rock-bed of the Marlstone, there are interrupted zones of impure, argillaceous blue limestones (ball-stones), in which *Ammonites serpentinus*, *A annulatus*, &c., make their appearance for the first time. In the neighbourhood of Gloucester this Upper Lias Clay is nearly 200 feet thick, but it gradually thins away in a southerly direction until, near Wotton-under-Edge, it is only about ten feet thick. Beyond that place it is very feebly represented and the Upper Lias Sands often rest directly on the Marlstone.

The remaining portion of the formation consists of sands that were formerly classed with the Inferior Oolite, of which they were considered to be the base, until the researches of Dr. Wright showed that these sands ought to be regarded as essentially connected, by their fossils, with the Upper Lias Clay upon which they repose, rather than with the Inferior Oolite.

34. IMPURE LIMESTONE (Upper Lias).

From an ironstone pit at Steeple Aston, 7 miles N.E. of Woodstock, Oxfordshire.

Occurs in the upper part of the *Marlstone*, and contains *Ammonites serpentinus*, *A. annulatus*, *A. communis*, and *Belemnites*.

35. BLUE CLAY (Upper Lias).

Northleach, Gloucestershire.

36. SEPTARIA.

Crickley Hill, near Cheltenham.

Cement stone occurring in occasional bands in *Upper Lias Clay*.

(See Ed. Hull's Memoir on Map 44, p. 24.)

37. SANDY LIMESTONE (Upper Lias).

Seatown, near Bridport, Dorsetshire.

Pale brown, impure, sandy limestone with numerous *Ammonites bifrons* and *Belemnites*, many of which are in a broken and rolled condition. Clusters of oolitic grains of hydrous oxide of iron, are occasionally disseminated through the mass of the stone, which occurs in clay overlying marlstone. It is the equivalent, probably, of the ball-stones which form the base of the Upper Lias Clay.

38. SAND (Upper Lias).

North of Blackford, Somerset. Map 18.

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 of the age of the latter formation. Other geologists consider them beds of passage.

39. SANDY NODULE (Upper Lias).

Frocester Hill, Gloucestershire.

Nodules and lenticular layers of calcareous sandstone are common especially in the higher parts of the Upper Lias.

40. SAND (Upper Lias).

Frocester Hill, Gloucestershire.

Micaceous, calcareous, and slightly ferruginous.

Contains *Ammonites*.

41. UPPER LIAS SAND.

Seizincote, Stow-on-the-Wold, Gloucestershire.

Slightly micaceous and ferruginous.

See Edward Hull's Memoir on the Geology of the Country around Cheltenham (Map 44), p. 29.

42. CALCAREO-FERRUGINOUS SANDSTONE (Upper Lias).

Frocester Hill, Gloucesteshire. Map 44.

Contains many fragments of *Belemnites*.

This bed is in fact an ore of iron, the stone being almost entirely composed of oolitic grains of hydrated oxide of iron, in a calcareo-siliceous base. It occurs in a thin band at the top of the Upper Lias Sands, and immediately beneath the "pea grit" of the Inferior Oolite of the Cotteswold Hills.

From the numerous specimens of Ammonites, Nautili, and Belemnites contained in this bed it has been called by some the Ammonite bed, and by Dr. Wright and others the Cephalopoda bed. In consequence of the Ammonites having been found by Dr. Wright to be identical in species with those from the Upper Lias shale of Whitby, in Yorkshire, instead of being characteristic of the Inferior Oolite, as had previously been erroneously supposed, all the sands between this stratum and the Upper Lias Clay are now called Upper Lias Sands, and the bed itself is considered to mark the close of the Liassic formation.

See Ed. Hull's Memoir on the Geology of the Country around Cheltenham, p. 25.

Wall-case 46.

OOLITE SERIES.

The name Oolite was applied to the great thickness of strata comprised between the Lias and the Wealden deposits, by Dr. William Smith, in consequence of the structure of many of the limestones included in the group presenting an appearance resembling that of the roe of a fish. The spherical grains of the Oolitic rocks are small concretions of lime, and it frequently happens that in the centre of a concretion or nodule, a grain of sand, a fragment of a shell, or some other body, has served as a nucleus round which the matter forming the concretion has gathered. Small Oolitic concretions may have been produced during the accumulation of the substance of which the rock consists, but many of the larger concretionary bodies, such as Nos. 42 and 46, have been formed in the stratum subsequent to its accumulation, and perhaps during the process of consolidation. Much remains to be learned on this subject, and of some of the forms in this Case no explanation has yet been given.

The Oolite limestones are often *shelly*, as well as *oolitic*, or composed of small rounded concretionary grains cemented together, and sometimes these characters are mixed. The shelly character is well shown in 41, 69, and 72, and the oolitic type in Nos. 58, 59, 60, and 74.

In many cases the limestones of the Oolite formation do not possess an oolitic structure, but are mere amorphous aggregations of calcareous matter, sometimes in part composed of fragments of broken shells.

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. 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.

The limestones are of all thicknesses up to about 100 feet, and on a large scale are interstratified with beds of clay and sand. Some of our chief building-stones are from the Inferior, Great, and Portland Oolite. They are also occasionally burned for lime.

The Oolitic iron ores lie diffused in various members of that series, forming *ferruginous strata*. The Liassic and Oolite formations are both included by continental geologists under the term Jurassic, after the name of the mountainous chain of hills in the Jura where the rocks in question are largely developed.

INFERIOR OOLITE.

The Inferior Oolite is the lowest member of the true Oolite group, and is well developed in Dorsetshire, Somersetshire, and Gloucestershire.

It receives its greatest development in the latter county, where it may be advantageously studied along the escarpments of the Cotteswold

Hills, which present numerous and instructive sections of its beds in the quarries, where it is largely worked for building-stone and for lime.

It consists, in the above locality, of between two and three hundred feet of limestones of various kinds, which have been sub-divided (commencing with the highest), into the Ragstone, Upper Freestone, Oolite Marl, Lower Freestone, and Pisolite or Pea grit.

The fossils belonging to these beds are contained in Flat-cases 7 to 12, and in Wall-cases 11 to 14.

Inferior Oolite.

1. Conglomerate (Inferior Oolite).

Vallis Vale, Frome, Somerset.

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.

2. Oolitic Limestone (Inferior Oolite).

Dorsetshire.

The lower part of the Inferior Oolite in Dorsetshire is represented by ferruginous beds, containing a large per-centage of iron, in the form of oolitic grains. The specimen is composed of oolitic grains of hydrated peroxide of iron in a calcareous cement.

3. Pisolitic Limestone (Inferior Oolite).

Leckhampton Hill, near Cheltenham. Map 44.

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.)

4. Pisolitic Limestone (Inferior Oolite).

Crickley Hill, near Cheltenham. Map 44.

With *Pygaster semisulcatus.*

At Crickley Hill this zone is nearly 40 feet thick. The higher beds of the pea grit of that hill contain many fossils, which in general are denuded of their shells, but the echinodermata are sometimes found with the test in a good state of preservation.

See Ed. Hull's Memoir on Map 44, p. 33.

5. Sandy Limestone (Inferior Oolite).

Frocester Hill, Gloucestershire.

Contains fossils: *Pecten personatus* and other fossils, the shells of which are replaced by calc spar.

The pea grit is very limited in its horizontal range. Where it is absent, as at Frocester Hill, it is represented by beds of ragstone like the specimen, which in that case immediately repose upon oolitic limestone charged with iron, similar to No. 2.

6. Oolitic Limestone (Inferior Oolite).

Leckhampton Hill, near Cheltenham, Gloucestershire.

To a large extent composed of shells, chiefly in a fragmentary state, cemented by oolitic carbonate of lime.

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 Ed. Hull's Memoir on Map 44, p. 35, and plate 2.)

7. Oolitic Limestone (Inferior Oolite).

Leckhampton Hill, near Cheltenham.

From the "Freestone bed," containing fossils.

"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." (See Hull's Memoir on Map 44, p. 39.)

8. Shelly Limestone (Inferior Oolite).

Bourton-on-the-Hill, Gloucestershire.

From the "Freestone Beds."

"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 Edward Hull's Memoir on the Geology of Map 44, p. 39.)

9. Oolitic Limestone (Inferior Oolite).

Selsey Hill, near Stroud, Gloucestershire.

Containing numerous *Rhynchonellæ*, and *Terebratula globata*, &c.

10. Oolitic Limestone (Inferior Oolite).

Nailsworth, Gloucestershire.

The beds beneath the Oolite Marl (Nos. 11 and 12) are frequently pierced by *Lithodomus attenuatus.*

11. Yellowish Marl (Inferior Oolite).

Frocester Hill, Gloucestershire.

This stone forms a well-defined zone, distinguished by its chalky aspect, over almost the whole range of the Cotteswold, from the vale of Moreton to the plain of Gloucester. It varies in thickness from 4 feet near Turkdean to 8 feet at White Hill, south-west of Pitchcomb; *Terebratula fimbria*, *T. carinata*, and many other fossils abound in this sub-division of the Inferior Oolite.

See Ed. Hull's Memoir on Map 44, p. 37.

12. Oolite Marl (Inferior Oolite).

Condicote, near Miserden, Gloucestershire.

Containing a coral (*Cladophyllia*).

The yellow and white marl of this locality yields a great number of fossils.

13. Shelly Limestone (Inferior Oolite).

Painswick Hill, Gloucestershire.

Slightly oolitic and ferruginous limestone from the "Gryphite bed," in the ragstone or upper division of the Inferior Oolite Series.

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

14. Trigonia Grit.

Fullers' Earth.

The Fullers' 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 bands of thin shelly limestone, the thickest of which is called the Fullers' Earth Rock. The substance formerly used in large quantities for "fulling" was dug in the neighbourhood of Bath, and was of two kinds, blue and brown. It occurred immediately at the base of the Great Oolite, and was worked round the escarpment of the hills from beneath the limestone. Its use has been nearly altogether superseded of late years by artificial compositions.

The fossils from the Fullers' Earth are placed in Flat-case 13 and in Wall-case 16.

15. 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.

16. Fullers' Earth Rock.

Cock, near Holton, Somerset. Map 18.

This limestone is well developed in Dorsetshire, and is extensively quarried for lime for agricultural and other purposes. Like the Cornbrash, it is not oolitic, and furnishes a good soil, while the land based upon the clays is generally converted into pasture.

17. Fullers' Earth Rock.

Sapperton Tunnel, 6 miles S. of Stroud, Gloucestershire.

Impure, grey, shelly limestone, formed of *oyster (Ostrea acuminata)* shells, cemented together in a base of argillaceous limestone.

18. Fullers' Earth Rock.

Three miles E. of Cheltenham.

Shelly limestone, formed of *oysters* and other shells.

19. Fullers' Earth Rock.

Cotteswold Hills, near Cheltenham.

Oolitic limestone, with broken shells, and part of the stem of a plant.

Great Oolite.

The Great Oolite is sometimes called Bath Oolite, from its forming the summits of most of the hills on the north, east, and south sides of the city of Bath.

In Gloucestershire it is sub-divided into two zones, the Stonesfield Slate, which occupies the base of the series, and the Great Oolite Limestone.

The former is remarkable for the remains of Marsupial mammals and terrestrial reptiles which have been found in it. It occurs at the base of the upper zone, and is extensively quarried for roofing-slate, for which it is well adapted in consequence of the ease with which it splits up into laminæ suitable for covering houses.

The Great Oolite Limestone, or Bath freestone as it is commonly called, is largely quarried for building-stone in the neighbourhood of that city. It is well adapted for building purposes on account of the large size of the blocks which may be obtained and the quality which it possesses of working freely in all directions. Henry the Seventh's Chapel, attached to Westminster Abbey, is a good example of the way in which Bath Stone may be carved into the most florid ornaments. It is not, however, of a durable nature where, as in the case of the above mentioned building, it is exposed to the smoky atmosphere of a large city.

For the fossils of this formation, see Flat-cases 13 to 17, and Wall-cases 14 to 16.

Stonesfield Slate.

20. Fissile Limestone (Stonesfield Slate).

Stonesfield, Oxfordshire.

Forms the lower beds of the Great Oolite, and quarried for roofing slates. (See Nos. 21 and 22.)

21. Fissile Limestone (Stonesfield Slate).

Benborough, Gloucestershire.

Quarried extensively for roofing-slates.

"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." (See Ed. Hull's Memoir on the Geology of the Country around Cheltenham, p. 53.)

The rock is quarried in summer and exposed to the weather in winter, when it is split by the frost into thin slabs (*generally in the lines of false bedding*), which are capable of being dressed into slates generally of a heavy kind. The manner of the formation of these slates must not be confounded with that produced by slaty cleavage. (See Wall-case 40, and p. 13.) A.C.R.

22. STONESFIELD SLATE.
Similar to No. 21. Placed on upper shelf, for want of room in its proper place.

23. SHELLY LIMESTONE (Stonesfield Slate.

¼ mile N.W. of Maidwell, Oxfordshire.

With casts of *Trigonia Moretonis.*

The beds at the base of the Great Oolite in their extension into Oxfordshire and Northamptonshire lose the distinctive character which they assume in the typical locality at Stonesfield, and no longer possess the property of being split into slates.

24. FERRUGINOUS LIMESTONE (Stonesfield Slate).

Sandford Mill, 6 miles S.W. of Deddington, Oxfordshire.

Coarsely fissile limestone, splitting up irregularly in the direction of the imbedded zones of shells. Contains *Cardium Buckmannii, wood,* &c.

25. OOLITIC IRON-ORE (Stonesfield Slate).

Blisworth, 4 miles S.W. of Northampton.

The Stonesfield Slate is represented in Northamptonshire by ferruginous sands with layers of shelly limestone like Nos. 23 and 24, the whole being based upon a bed of oolitic iron-ore, from 8 to 10 feet thick in places, but sometimes replaced by sands, or by layers like No. 27.

26. OOLITIC IRON-ORE (Stonesfield Slate).

Gayton, 5 miles S.W. of Northampton.

Similar to No. 25.

27. OOLITIC IRON-ORE (Stonesfield Slate).

¼ mile N.W. of Maidwell, Oxfordshire.

These ferruginous beds of calcareous sandstone occur in the Northampton sands, sometimes imbedded in the iron-ore, and at others occupying its place, when it happens to be altogether wanting.

28. IRON NODULE (Oolite Sands).

Upper Worton, Oxfordshire. Map 45, N.W.

Shows concentric layers.

The sands from which the specimen was obtained must not be confounded with those *underlying* the Inferior Oolite, and which have, until lately, been called "Inferior Oolite Sands," their position being *above* the stony beds of the Inferior Oolite, and immediately beneath the Great Oolite of the district. They are, therefore, the equivalent of the Stonesfield Slate.

29. YELLOW SANDSTONE (Oolite Sands, equivalent to the Stonesfield Slate.)

Foxhall Lime Works.

Slightly calcareous, and very sparingly micaceous.

GREAT OOLITE.

30. CONGLOMERATE (Great Oolite).

Stow-in-the-Wold, Gloucestershire.

Composed of rounded fragments of slightly oolitic limestone in a base of calcareous matter.

See Edward Hull's Memoir on Geology of Map 44.

31. WHITE OOLITIC LIMESTONE (Great Oolite).

Hampton Common, near Stroud, Gloucestershire.

Contains fossils, the shells of which are replaced by calc spar.

32. OOLITIC SHELL-LIMESTONE (Great or Bath Oolite).

Box Tunnel, Great Western Railway.

Numerous fossils, with the shells replaced by calc spar.

33. OOLITIC LIMESTONE (Great Oolite).

Near the Bird's Nest Inn, Burford, Oxfordshire.

From the upper zone of the Great Oolite.

See Ed. Hull's Memoir on Map 44, p. 63.

Placed on upper shelf.

34. COMPACT MARLY LIMESTONE.

Wychwood Forest, Oxfordshire.

From the upper zone of the Great Oolite.

"This limestone is generally very

hard, and along the Cheltenham and Oxford road, produces the best available road-material. It weathers to a degree of whiteness scarcely surpassed by the Chalk."

See Ed. Hull's Memoir on Map 44, p. 61.

35. Oolitic Limestone (Great Oolite).

Kemble, 4 miles S.W. of Cirencester, Wiltshire.

This forms the top bed of the Great Oolite, and is thickly bored by *Lithodomus.*

Forest Marble.

The Great Oolite of Gloucestershire passes into the coarse and shelly oolitic limestone to which the name Forest Marble was given by William Smith, in consequence of the large area covered by it in Wychwood Forest.

In other localities it is associated with a blue clayey deposit called Bradford Clay, after the name of the town in Wiltshire, in the neighbourhood of which it occurs.

Altogether it is a somewhat variable deposit, composed of coarse, blue, shelly limestones frequently splitting up into flagstones, sands, clays, and flaggy sandy limestones. The limestones, whether shelly or not, are hard, and abound in ripple- and current-marks and with much oblique lamination. From these characteristics, and from the fragments of drift-wood it frequently contains, as well as from the general appearance of the deposit itself, it must have been formed in a shallow sea, the currents of which were liable to frequent change.

In Dorsetshire the lower part of the Forest Marble chiefly consists of clay with occasional layers of thin, slaty, and sandy limestone.

The stone is used for building and paving.

For the fossils of the Forest Marble, see Flat-cases 18 & 19, and Wall-cases 14 & 15.

36. Shelly Limestone (Forest Marble).

Well Down, E. of Abbotsbury, Dorsetshire. Map 17.

Contains numerous fossils, *Ostrea Sowerbyi, Rhynchonella obsoleta (farcta), Cidaris (spines), Terebratula maxillata, Apiocrinus rotundus (oscicles).*

37. Fissile Shelly Limestone (Forest Marble).

Chapel Knap, Melksham, Wilts.

Composed partly of *Ostrea, Pecten,* &c.

38. Shelly Limestone (Forest Marble).

Frome, Somerset.

Formed chiefly of oyster shells, replaced by calc spar. Oolitic. A little iron pyrites.

39. Forest Marble.

Frome, Somerset.

Sandy, calcareous flagstone. Finely oolitic.

40. Shelly Limestone (Forest Marble).

Frome, Somerset.

Oolitic.

41. Dark-grey Shelly Limestone (Forest Marble).

Dorset.

Oolitic, and contains *plant-remains (Lithodomus inclusus.)*

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.

42. SHELLY LIMESTONE (Forest Marble).

Frome, Somerset.

Contains pebbles of clay and fragments of drift-wood.

(See Memoirs of Geological Survey, vol. 1., p. 285.)

43. SHELLY LIMESTONE (Forest Marble).

Hilton, near Wincanton, Somerset. Map 18.

Slightly oolitic, and with included pebbles of clay. These beds are quarried for flagstones, &c.

44. SHELLY OOLITE (Forest Marble).

Tetbury Road, Gloucestershire.

Forming a band of impure limestone in *Bradford Clay.*

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

(See Wall-cases 14 & 15, and Flat-case 18.)

45 and 46. Flattened CALCAREOUS CONCRETIONS occurring in Forest Marble Clay at *Graves' Brickyard, near Buckingham.*

Presented by Mr. Stowe.

47. SHELLY LIMESTONE (Forest Marble).

Bibury, Gloucestershire.

Partly oolitic, and containing *Mytilus,* numerous *Ostrea,* &c.

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

48. SHELLY LIMESTONE (Forest Marble).

Westwell, near Burford, Oxon.

Sandy, and contains numerous *Ostrea,* and other fossil shells.

49. SHELLY LIMESTONE (Forest Marble).

Westwell, near Burford, Oxon.

Occurs in the form of thin-bedded flagstones. Oolitic, and with small fragments of carbonized vegetables.

50. SHELL-LIMESTONE (Forest Marble).

Langford Lane, Woodstock, Oxfordshire. Map 45, S.W.

Light-grey thin-bedded limestone, slightly and partially oolitic.

CORNBRASH.

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 overlying Forest Marble when the series is complete, seldom furnishing stone fit for building, but 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.

The fossils belonging to this formation are contained in Flat-cases 20 and 21, and Wall-cases 14 to 16.

51. LIGHT-GREY LIMESTONE (Cornbrash).

Bayford, near Wincanton, Somerset. Map 18.

Quarried for lime-burning.

52. RUBBLY LIMESTONE (Cornbrash).

Chilcombe, Dorset.

With *Terebratula obovata* and *Rhynchonella tetrahedra.*

KELLAWAYS ROCK.

The Kellaways Rock occurs at the base of the Oxford Clay in certain districts. It derives its name from Kellaways Bridge, in Wiltshire, where it was observed by William Smith. It is seldom used for building-stone, and is chiefly remarkable for the beauty and abundance of its peculiar fossils.

The fossils from these beds are shewn in Flat-case 22, and in Wall-cases 14 to 16.

53. CALCAREOUS SANDSTONE (Kellaways Rock).

Ray Bridge, near Melksham, Wiltshire. Map 14.

With *Myacites* and *Avicula.*

54. KELLAWAYS ROCK. From base of the Oxford Clay.

Kellaways, Wiltshire. Map 34.

Contains *Cardium cognatum.*

(See Survey Memoir on Map 34, pp. 18, 19.)

MIDDLE OOLITE.

OXFORD CLAY.

The Oxford Clay is a thick deposit of dark blue or grey tenacious clay reposing on the Kellaways Rock where the latter is present; or in its absence, as in Somersetshire, Glocestershire, and Dorsetshire, upon the Cornbrash. It contains occasional layers of septarian nodules, but besides these it possesses little or no stony matter. The soil of this formation is well adapted for pasture, of which the Vale of Blackmoor in Dorsetshire furnishes a well-known example. The name Oxford Clay is given to the strata in consequence of its forming the valley on which Oxford is built.

For the fossils of the Oxford Clay, see Flat-cases 23 & 24, and Wall-cases 19 to 21.

55. SHALY CLAY (Oxford Clay) with fossil shells.

Near Sherborne, Dorset. Map 18.

Presented by the Marchioness of Westminster.

CORAL RAG.

The series of limestones, clays, sands, and marls overlying the Oxford Clay, have received the name of Coral Rag, from the circumstance of a portion of the lower calcareous beds being chiefly composed of corals, in Oxfordshire and Wiltshire. In many other districts, as in Dorsetshire, corals are of exceedingly rare occurrence in this formation, which may there be subdivided into Upper Calcareous Grit, Coral Rag, and Lower Calcareous Grit.

Some of the oolitic limestones of this formation are quarried for building-stones, and furnish freestones which, when carefully chosen, are excellent not only as regards colour and appearance but for their durability.

The fossils belonging to this formation are placed in Flat-cases 25 and 26, and in Wall-cases 19 to 21.

56. CALCAREOUS GRIT (Coral Rag).

Near the Lamb and Flag Inn, 6 miles E. of Faringdon, Berkshire. Map 13.

The bed from which the specimen was taken is about four feet thick, and forms the lowest bed of the quarry. It rests upon sand: used for building and road-stone.

57. OOLITIC LIMESTONE (Coral Rag).

Quarry near the Lamb and Flag Inn, 6 miles E. of Faringdon, Berkshire. Map 13.

Nos. 56 & 57 are both from the same quarry, but from different beds; one being loose and earthy in texture, while the other is harder and more compact, and of a ferruginous-yellow colour, owing to the presence of iron. Both specimens contains fossil shells.

58. Pisolitic or Large-grained Oolitic Limestone (Coral Rag).
Steeple Ashton, Wiltshire. Map 14.

59. Pisolitic Limestone (Coral Rag).
Buckland, 3 miles E. of Faringdon, Berkshire. Map 13.

60. Oolitic Limestone (Coral Rag).
Woodhouse Cross, near Gillingham, Dorset. Map 18.
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.

61. Coralline Limestone (Coral Rag).
Steeple Ashton, Wiltshire. Map 14.
A fossil coral (*Thamnastrea arachnoides*) converted into limestone.

62. Oolitic Limestone (Coral Rag).
Buckland, 3 miles E. of Faringdon, Berkshire. Map 13.
Shelly limestone, with numerous fossils, *Pecten*, &c.

63. Cluster of Shells (Coral Rag).
Steeple Ashton, Wiltshire. Map 14.
A mass of cemented *Ostrea gregaria*, occurring in soft clay.
Presented by the Earl of Enniskillen.

64. Very Fine Oolitic Limestone (Coral Rag).
Coast near Weymouth, Dorset. Map 17.

65. Iron-ore.
Near the Railway Station, Westbury, Wilts. Map 14.
Oolitic grains of hydrous oxide of iron, cemented by calcareous matter, forming the *upper beds of Coral Rag*, and worked for iron.

66. Calcareous Sandstone (Coral Rag).
Between Dairy House and Abbotsbury Castle, Dorset. Map 17.
With double burrows of sand-worms (*Arenicola*), &c.

UPPER OOLITE.

Kimeridge Clay.

At the hamlet of Kimeridge in the Isle of Purbeck, and for some distance along the coast, the beds consist of a dark brown or grey clay and shale, immediately overlying the Coral Rag. The formation is of considerable thickness. In Dorsetshire it can scarcely be less than from 600 to 800 feet. The bituminous character, which is so remarkable in the Isle of Purbeck, is not developed to the same degree further northward, where the clay assumes an appearance very similar to that of the Oxford Clay. The septaria and layers of septarian limestone found on the coast yield a cement of excellent quality. The soil of the Kimeridge Clay is, for the most part, devoted to grass-land.

The fossils from this formation are contained in Flat-cases 27 and 28, and in Wall-cases 20 & 21.

67. BITUMINOUS SHALE (Kimeridge Clay).

Little Kimeridge Bay, Dorset. Map 16.

Used for manufacturing naphtha, &c.

This clay is strongly impregnated with bitumen, which causes it give out a very disagreeable odour when burnt. It burns very readily, with a yellowish, rather heavy, and smoky flame; but the large quantity of earthy matter it contains, combined with the unpleasant smell evolved during the process of combustion, render it unfit for being employed as fuel. Notwithstanding this objectionable property, however, it was formerly burned instead of coal by the people of the neighbouring district

A manufactory was erected at Wareham a few years ago, for the purpose of extracting the volatile oil or spirit, and grease, &c., which were obtained from the shale by distillation, but the works were ultimately abandoned, in consequence of the disagreeable smell given out by the products in burning, which could not be effectually removed.

The residue, left after the distillation of the shale, formed a porous kind of coke, consisting of alumina and finely-divided carbon, which has been used for manure, and has proved highly beneficial for the growth of turnips.

This shale has been analysed by Dr. Hofmann, who found it to produce 11½ gallons of crude oil, and a tarry residue. The density of the oil was ·895, at a temperature of 49° F. The amount of volatile matter amounted to 19·2 per cent.

The following is Dr. Hofmann's analysis:—

Coke	43·0	23·5	Mineral matter.
		19·5	Carbon.
Oily and solid volatile products.	39·0	2·3	Light oil (naphtha).
		36·7	Heavy oil containing 1·9 per cent. of paraffine.
Gas, water, &c.	18·0	18·0	Gas, water, ammonia, &c.
	100·0	100·0	

Circular pieces of shale, about the size of a penny-piece, 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 of the Isle.

68. LAMINATED CALCAREOUS BAND (Kimeridge Clay).

Freshwater Bay, near Kimeridge, coast of Dorset. Map 16.

69. BITUMINOUS SHALE (Kimeridge Clay).

Little Kimeridge Bay, Dorsetshire.

Thinly laminated, bituminous shale, with numerous impressions of fossil shells. The surface of the joint covered with a thin deposit of calc spar.

70. ARGILLACEOUS LIMESTONE (Kimeridge Clay).

Broad Bench, Dorset. Map 16.

Occurs in tabular beds in the softer strata of Kimeridge Shale, on the coast of Dorset. It has been extensively worked for cement-stone.

Map 16, and Horizontal Sections No. 56.

71. SHALY CLAY (Kimeridge Clay).

Chapman's Pool, Isle of Purbeck, Dorsetshire. Map 16.

From the upper beds; contains fossil shells.

72. KIMERIDGE CLAY.

Seend Bridge, Devizes, Wilts. Map 14.

Contains numerous fossil shells.

PORTLAND SAND.

The Portland Sand consists of ferruginous-brown or yellow sand and layers of calcareous sandstones, situated between the Portland Stone and the Kimeridge Clay. It often contains numerous green grains similar to those in the Upper and Lower Greensands.

For the fossils belonging to the Portland Sand, *see* Flat-case 29.

73. CALCAREOUS CONGLOMERATE (Portland Sand).

Aylesbury, Bucks.

Small pebbles of flint (chiefly black), in a calcareous base, which also contains fossils.

This bed forms the basement of the Portland Sand, and immediately overlies the Kimeridge Clay.

74. PORTLAND SAND.

Tisbury, Wilts. Map 15.

Soft yellow sand, underlying Portland Stone.

PORTLAND STONE.

The Isle of Portland has long been celebrated for the excellent quality of its limestones, and the quarries at the northern extremity of the Island were especially chosen by Sir Christopher Wren to furnish the stone for rebuilding St. Paul's Cathedral. The building-stones are found in the upper part, and are shelly oolitic freestones. When first quarried they are so soft as to be cut with the saw, and sometimes, as in the vale of Wardour, in Wiltshire, they are of a green tint, owing to the presence of minute grains of silicate of iron; but the colour disappears as the quarry-water dries out, and the stone becomes of an agreeable white or cream colour, and at the same time harder and more difficult to work. The lower beds become sandy, and contain layers of large irregularly-shaped flints, which sometimes form the greater part of the strata.

The whole deposit is of marine origin, the remains of ancient terrestrial surfaces, commonly known by the name of Portland dirt-beds, and formerly supposed to belong to that series, being now considered to form a part of the overlying Purbeck formation.

The fossils found in the Portland Stone are contained in Flat-cases 29 to 31, and in Wall-cases 20 and 25.

75. GREY OOLITIC LIMESTONE (Portland Stone).

Swindon, Wiltshire. Map 34.

Used for roads and building.

See Survey Memoir on Map 34, p. 23.

76. PORTLAND STONE.

Swindon, Wiltshire. Map 34.

This specimen is very similar to the roach-bed of Portland Stone in the Isle of Portland. It contains numerous casts of fossils, the shells of which have disappeared, leaving only the empty spaces they once occupied.

See Survey Memoir on Map 34, p. 23.

77. OOLITIC LIMESTONE (Portland Stone).

Tilly Whim, near Swanage, Dorsetshire. Map 16.

The Portland Stone quarried on the mainland, in the Isle of Purbeck, is locally known by the name of "Purbeck Portland," by way of contradistinction to the true or typical stone of the Isle of Portland.

78. SHELL-LIMESTONE (Portland Stone).

Tilly Whim, near Swanage, Dorsetshire. Map 16.

This bed, generally called the "oyster-bed," is eight feet in thickness, and 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.

79. OOLITIC LIMESTONE (Portland Stone).

Portland Isle, Dorset. Map 17.

Bituminous oolitic limestone, containing numerous casts of fossils, from the "roach" bed of Portland Stone.

This bed underlies the "cap" and "dirt" beds, and is the uppermost stone quarried. Its average thickness is from three to four feet. (For further details in reference to Portland Stone, see R. Hunt's "Descriptive Guide, pp. 15 to 17.) The Roach bed is very hard, and is used for foundations of breakwaters, and in works where strength is required, but it will not bear a close even face. See Map 17, and Horizontal Section, No. 20.

80. Oolitic Limestone (Portland Stone).

Oakley Quarry, Tisbury, Wilts. Map 15.

"Fretting bed" of Portland Stone.

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.

81. Calcareous Concretion, from Portland Stone.

Tisbury, Wilts. Map 15.

82. Disintegrated Portland Stone.

Fonthill Giffard, Wilts. Map 15.

Loose oolitic grains of carbonate of lime, from decomposed Portland beds, immediately underlying Gault.

83. Cherty Flint.

Oakley Quarry, Wilts. Map 15.

Occurs in interrupted layers in the upper beds of Portland Stone.

84. Flint from *Portland Stone.*

Tisbury, Wiltshire. Map 15.

In this specimen siliceous matter has replaced the calcareous skeleton of a coral (*Isastræa oblonga*), commonly called the Tisbury coral (after the locality in which it most abundantly occurs), and by so doing converted the whole into a solid mass of flint.

85. Earthy Limestone, Portland Stone.

Oakley Quarry, Tisbury, Wilts. Map 15.

In the Vale of Wardour, the upper beds of Portland Stone, which overlie the oolitic freestone, No. 80, assume the character and appearance of ordinary chalk, with irregularly disseminated flints. They contain numerous and perfect specimens of *Trigonia, Ostrea, Cardium*, &c., and are burned for lime.

H. W. Bristow.

Wall-case 5.

PURBECK SERIES.

This formation takes its name from the Isle of Purbeck in Dorsetshire, the locality where it is best displayed, and most fully developed. As a whole, it may be described as consisting of alternations of limestones, shales, clays, and marls, in a great measure of freshwater, but partly of estuary or marine formation. That the lower beds were formed, to a great extent, subaërially, is inferred not only from their tufaceous character, but also from the dirt-beds or remains of contemporaneous land-surfaces which are met with in them, containing the prostrate trunks of fossilized coniferous trees, and the petrified stools of plants allied to *Zamia* and *Cycas*. (See p. 140.)

The Purbeck strata, also, contain the shells of several air-breathing snails and the remains of mammalian animals. The limestones are extensively quarried for building- and paving-stone. The Purbeck Marble is found in the upper beds. (See Nos. 36 and 37.)

A collection of fossils from the Purbeck formation is contained in Flat-cases 31 to 34, and in Wall-cases 22 to 28.

1. Large Block of Limestone, showing the junction between the Portland and Purbeck formations.

Oakley Quarry near Tisbury, Wilts. Map 15.

(On the floor in recess.)

The junction between the Portland and Purbeck strata is somewhat different in the Vale of Wardour from that in the Isle of Portland or the Isle of Purbeck.

In the quarry from which the specimen was taken, the uppermost bed of Portland Stone is harder than the underlying chalky limestone (No. 88, Case 46) upon which it reposes, and is crowded with marine shells common to the formation, viz., *Trigonia*, *Cardium dissimile*, *Ostrea*, &c. Immediately above this stratum is a bed of hard, grey, bituminous limestone, the upper foot of which is fissile and used for flagstones. In the specimen, as in the quarry, the exact line of junction between the shelly bed and the fissile limestone is scarcely distinguishable to the eye, but when broken by a heavy blow the Portland Stone and the Purbeck split off from each other at the junction, along a smooth and even surface. The line of demarcation between the two strata is crowded with fish of freshwater species, *Lepidotus*, *Ophiopsis*, *Asteracanthus*, *Pleuropholis*, &c., examples of which (from this formation) may be seen in Wall-cases 22 to 24.

From the frequent occurrence of fish-remains in a beautiful state of preservation in this particular horizon the quarrymen call it the fish-bed.

No. 1. is put on the floor on the left hand side of Wall-case 5, in consequence of the weight and size being too great to admit of its insertion in the proper place among the specimens to which it rightly belongs. The natural position of the stone has also been reversed, and the lowest part (the Portland Stone) has been turned uppermost in order to show more clearly the numerous marine fossils which it contains.

2. Cherty Flint (Lower Purbeck).

Oakley Quarry, near Tisbury, Wilts. Map 15.

The lowest bed of Purbeck Limestone at Oakley Quarry is sometimes overlaid by a layer of black, cherty flint, six inches thick, the uneven surface of which is well shown in the specimen.

3. Tufaceous Limestone, Hard Cap-bed, Lower Purbeck.

Lulworth Cove, E. side, Dorset. Map 16. Horizontal Sections, No. 56.

4. Part of the silicified Trunk of a Coniferous Tree.

West Lulworth, Dorset.

Map 16. Horizontal Sections, No. 56. From the "*submarine forest.*"

5. Part of the silicified Trunk of a Coniferous Tree.

Isle of Portland, Dorset. Map 17.

From the "dirt-beds" overlying Portland Stone.

6. Part of the silicified Trunk of a Coniferous Tree.

From Portland Stone Quarries at Newtown, near Tisbury, Wilts. Map 15.

The specimens Nos. 4 to 6 occur in strata called by the quarrymen "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 Dorset and Wilts, is comprised in Maps 16 and 17, and the position of the beds is shown in Horizontal Sections Nos. 20, 22, and 56, and in Vertical Section No. 22.

7. Tufaceous Limestone, Soft Cap of Lower Purbeck.

Cliff E. of Lulworth Cove, Dorset.

The bed from which the specimen was taken, immediately overlies that containing the stools of Cycas.

See Map 16. Horizontal and Vertical Sections, Sheet 56.

8. Tufaceous Limestone, Cap-bed of Portland Stone.

Hospital Quarry, Isle of Portland.

See Map 17, and Vertical Sections No. 22.

At the base of the Lower Purbeck, immediately resting upon the Portland Stone, there are beds of tufaceous limestone, which, from their position relatively to the latter, are called "cap-beds." They contain dirt-beds, and silicified fragments of coniferous trees, together with the stems of plants allied to *Zamia* and *Cycas;* the presence of the latter indicating the existence of a warmer climate than that of the present period. The dirt-beds are the remains of former land-surfaces, that is, of the soil in which the plants grew, while the tufaceous limestones formed over them are, probably, for the most part, of subaërial origin, and deposited from water highly charged with calcareous matter.

9. Marly Limestone (Purbeck).

Swindon, Wiltshire.

Pale cream-coloured limestone, containing casts of freshwater shells (*Bithynia*, small *Planorbis, Valvata, Limnæa, Cypris*).

The Purbeck strata of Swindon are very slightly developed, and of inconsiderable thickness compared with those of Dorsetshire or even of the Vale of Wardour. At Swindon they consist chiefly of white and cream-coloured limestones with ferruginous stains, which also line the cavities left by decomposed shells, whose casts only now remain. The total thickness of these beds does not exceed 10 or 12 feet.

See Memoir on Map 34 ; p. 23.

10. Earthy Freshwater Limestone, Lower Purbeck.

N.E. of Oakley Quarry (in a wood), near Tisbury, Wilts. Map 15.

From the Insect Marls.

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

11. Soft Marly Limestone (Lower Purbeck).

Osmington, Dorsetshire. Map 17.

From the Insect Marls. Contains insect-remains and specks of vegetable matter.

12. Marly Limestone (Lower Purbeck).

Swanage, Dorset. Map 16.

From the Insect Marls. With vegetable and insect-remains.

13. Grey Slaty Limestone (Lower Purbeck).

Cliff E. of Lulworth Cove, Dorset.

Alternating layers of slaty limestone and pale marly clay make up the particular stratum in the Soft Cockle Beds from which the specimen was taken. The bottom of the bed, as is shown in the specimen, contains several small pebbles, and on both sides are pseudomorphous casts of cubical crystals of rock salt. The occasional occurrence of such pseudomorphs had been previously noticed in the Insect Marls of Durlstone Bay, but their prevalence throughout the entire Lower Purbeck series was not known prior to the publication of the section of the strata near Lulworth Cove by Messrs. Bristow & Whitaker. In that section pseudomorphous crystals of salt are shown to extend from the Cypris Freestone, through the Hard Cockle Beds, up to the upper parts of the Soft Cockle Beds. The discovery is interesting, inasmuch as it indicates the conditions under which the beds in question were deposited, and shows them to have been similar to those which prevailed during the Keuper period. These conditions, and the mode of formation of the pseudomorphous crystals of salt, have been already explained at page 118.

Both the upper and under surfaces of the limestones, as well as the casts of crystals, are thickly covered with cypris (*Cypris legumenella*).

See Map 16; also Horizontal and Vertical Sections, Sheet 56.

14. Fibrous Gypsum and Selenite (Lower Purbeck).

Occurs in large masses in Durlstone Bay, in Dorsetshire.

Used for making plaster of Paris.

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

15. Compact Close-grained Limestone (Lower Purbeck).

E. side of Lulworth Cove, Dorsetshire. Map 16 ; Sections, No. 56.

The specimen was taken from the east side of Lulworth Cove, and exhibits the effect of weathering upon such beds, after long exposure. The original colour of the rock was blue, a small patch of which colour is still visible in the interior of the specimen, and the pinkish tint is due to the peroxidation of the included iron, consequent on exposure to atmospheric and other influences, while the outer surfaces of the bed, being still further acted upon, have assumed a cream-coloured or pale ferruginous-yellow tinge. The bed, 2 feet 4 inches in thickness, belongs to the marly freshwater series, or upper division of the Lower Purbeck, and contains scales of freshwater fish (*Lepidotus*), and numerous, small, freshwater univalve shells, *Limnæa*, *Hydrobia*, *Physa*, and *Planorbis*. It is slightly argillaceous.

16. CHERT in limestone (Purbeck) containing freshwater shells, *Valvata*, *Paludina*, *Cypris*, *&c.*

Cliff E. of Lulworth Cove, Dorsetshire. See Map 16, and Sections, Sheet 56.

From limestone beds in the "Cherty Freshwater" series of the Middle Purbeck.

17. COMPACT BITUMINOUS FRESHWATER LIMESTONE (Middle Purbeck).

Swanage, Dorset. Map 16.

Part of the limestone called the "Feather Bed," and formed chiefly of the remains of bivalve shells, *Cyclas* or *Cyrena*.

18. OYSTER BED (Middle Purbeck).

Durlstone Bay, near Swanage, Dorset. Map 16.

(On upper shelf.)

This bed, which is locally termed "*Cinder*," is well displayed in Durlston Bay. In that locality it is purely a marine formation, composed of a mass of oysters (*Ostrea distorta*), twelve feet thick, associated with *Trigonia*, *Cardium*, and other shells. In this bed, the late Professor Edward Forbes found, for the first time, the Echinoderm called by him *Hemicidaris Purbeckensis*.

This specimen is put on the upper shelf, being too large to go in its proper place.

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

19. COMPACT GREY SHELLY LIMESTONE (Middle Purbeck).

Durlstone Bay, Swanage, Dorset.

Contains freshwater shells (*Cyclas*, *&c.*) From the Downs Vein, about 2 feet above the Cinder Bed.

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

20. SHELLY FRESHWATER LIMESTONE (Middle Purbeck).

Swanage Quarries, Dorset. Map 16.

Contains numerous *Cyclas* or *Cyrena*.

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

21. BITUMINOUS LIMESTONE, Middle Purbeck.

Swanage Quarries, Dorset.

From the "Freestone bed."

22. COMPACT BITUMINOUS LIMESTONE (Middle Purbeck).

Swanage Quarries, Dorset. Map 16.

From the "Pink Bed," which forms a part of the Freestone Series.

23. HARD COMPACT BITUMINOUS LIMESTONE (Middle Purbeck).

Gully Quarry, near Swanage, Dorset. Map 16.

"Roach bed," occurring in the Freestone Beds. The surface of the specimen is covered with *Hydrobia*, *Cyrena*, *Ostrea*, *&c.*

24. HARD SHELLY LIMESTONE (Middle Purbeck).

Durlston Bay, coast of Dorset.

Made up of *Cyclas*, with *Paludina*, *&c.*

25. SHELLY LIMESTONE (Middle Purbeck).

Kingston, Dorset. Map 16.

From the Intermarine Beds, and principally composed of casts of *Cyrena*,

In Dorsetshire, immediately resting on the "Cinder Bed," No. 18, occurs a series of beds, partly of freshwater, partly of estuary and marine origin. From this circumstance, they were 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; westward, 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.

26. Impure Limestone (Middle Purbeck).

Durlston Bay, Dorset.

Contains numerous shells, of brackish-water origin. From the Corbula Beds.

(See Map 16; Vertical Sections, Sheet 22.)

27. Irregular Slaty Limestone, (Middle Purbeck).

Limekiln Quarry, Kingston, Dorset. Map 16.

With fucoidal markings, and small univalve shells.

28. Thin-Bedded Shelly Limestone (Middle Purbeck).

Limekiln Quarry, near Kingston, Dorset. Map 16.

Of brackish-water formation. Contains numerous valves of *Cyclas* or *Cyrena*.

29. Shelly Limestone (Middle Purbeck).

Kingston, near Swanage, Dorset.

Brackish-water shells; small *Ostrea, Cyrena, &c.*

No. 29a, on the top shelf, is probably from nearly the same horizon.

30. Hard Green Marl (Middle Purbeck).

Durlston Bay, Dorset.

From the upper part of the Corbula Beds. Contains *Cyrena*.

(See Map 16, and Vertical Section No. 1, Sheet 22.)

31. Fibrous Carbonate of Lime (Middle Purbeck).

Durlston Bay, Dorset.

It occurs in beds or thin laminæ, termed "Beef" by the quarrymen in the Isle of Purbeck, and "Horseflesh" in the Isle of Portland.

(Map 16: See Vertical Section No. 22.)

"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.)

32. Sandy Limestone, with surface-markings (Middle Purbeck).

Upwey, Dorset. Map 17.

From the "Horseflesh" beds near the fifth milestone, on the E. side of the road to Bridport.

33. Impure Limestone (Middle Purbeck).

Swanage, Dorset. Map 16.

Called the "Devil's bed."

34. Hard Blue Limestone (Upper Purbeck).

Peverel Point, Swanage, Dorset.

Chiefly composed of broken freshwater or estuary shells (*Cyclas* or *Cyrena*) with specks of green matter.

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.

35. Compact Limestone (Upper Purbeck).

Peverel Point, Dorset. Map 16.

From the Marble-rag beds.

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.

Purbeck marble is a compact shelly limestone of freshwater origin, containing numerous casts of *Paludina carinifera*.

It was formerly extensively used, and is still occasionally employed in the construction of the 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. The slender shafts and columns in the interior of Salisbury Cathedral are composed of Purbeck Marble. 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 older marble, but has not its fine pink colour. See Map No. 16, and Vertical Section No. 22.

36. Compact Freshwater Limestone (Upper Purbeck).
Peverel Point, Swanage, Dorset.
Occurs in thin bands in the Upper Cypris Shales of the Upper Purbeck beds, and contains numerous *Cyclas* or *Cyrena*, *Paludina carinifera*, *Cypris*, &c.

37. Purbeck Limestone (Upper Purbeck).
Mewps Bay, Isle of Purbeck, Dorset.
From the Upper Cypris Shales. The surface of the bed covered with ripple-marks, *Cypris*, &c. (See Vertical Section, No. 22.)

38. Compact Shelly Limestone, or Purbeck Marble (Upper Purbeck).
Peverel Point, Swanage, Dorset.
Principally composed of *Paludina carinifera*.

39. Purbeck Marble (Upper Purbeck).
Peverel Point, Swanage, Dorset.
(On Upper Shelf.)
Blue limestone; the surface of the bed covered with the shells of *Paludina carinifera*. See No. 38.

The fossils of the Purbeck formation are contained in the Upper Gallery, in Wall-case X, compartments 25 to 27, and Flat-cases 31 to 34.

H. W. Bristow.

LOWER CRETACEOUS.

WEALDEN FORMATION.

Although the Wealden strata may be said to form a continuation of the freshwater and estuary deposits of the Purbeck beds, they are yet usually considered as forming the commencement of the Cretaceous series of rocks. They may be defined to be a series of clays, sands, and sandstones, with subordinate beds of limestone and shale, and zones of iron ore,—the whole characterized by the presence of freshwater shells, the bones of reptiles and fish, and the remains of land-plants.

The principal area occupied by these deposits, and that from which they derive their distinctive name, is the large tract of country in the south-eastern part of England, called the Weald, and extending over a great portion of Surrey, Kent, and Sussex. The Wealden beds are also present in the Isle of Purbeck, and to a yet more limited extent in the Isle of Wight.

A fuller and better acquaintance with the true order of succession of the various members of these deposits, and of their relation to each other, than was previously known, has been gained since the Geological Survey commenced its examination of the district in detail. The results of these labours, chiefly carried on by Mr. Drew, have led to the abandonment of part of the nomenclature hitherto applied to the subdivisions, and the substitution of another series of names, derived from the localities where the various rocks are best developed and may most easily be examined.

These subdivisions, in descending order, are,—

1st. Weald Clay.

2nd. Hastings Sand, comprising—

Upper Tunbridge Wells Sand.	Wadhurst Clay.
Grinstead Clay.	Ashdown Sands.
Lower Tunbridge Wells Sand.	Ashburnham Beds.

The fossils belonging to this formation are contained in Flat-cases 35 and 36, and in Wall-cases 25 to 27.

Wall-case 6.

WEALDEN ROCKS.

Ashburnham Beds.

These beds, the lowest strata displayed in the Weald of Sussex, consist of alternations of clay, shale, sand-rock, calcareous shale, and limestone, the last of which has been extensively worked for agricultural purposes. They also contain a few layers of calcareous sandstone, and a small proportion of clay-ironstone. The whole thickness of beds exposed amounts to about 300 feet.

According to Mr. Gould, the Ashburnham beds occupy a small area of about nine miles in length, and varying from half a mile to a mile in breadth, which extends from Tottingworth farm, near Heathfield, on the west, to Petley Wood, about a mile N. of Battle, on the east.

The beds belonging to this series which make their appearance further eastward, between Hastings, Coghurst Wood, and Straws Castle, are altogether destitute of the limestones, which rendered the other area economically so valuable, and consist entirely of mottled clay.

1. Compact Limestone (Wealden).

Rounden Wood, N. of Brightling, Sussex.

Pale grey limestone with *Ostrea.*

The Ashburnham limestones are divided into two groups, the lowest or "Blues," and the upper or "Greys;" distinctions which appear to be made more particularly with reference to the prevailing colours of the beds. The blues again are subdivided into a series of subordinate beds of limestone separated from one another by short intervals of shale, called "Bastard Blues," and an overlying limestone about 20 inches thick, known by the name of the "Main Blue."

The specimen is from the bottom layer of the uppermost or Main Blue limestone, (See No. 2,) which at Archer Wood is composed of a single homogeneous bed only. At Rounden Wood and Limekiln Wood, however, the "Main Blue," is composed of two distinct layers.

2. Compact Limestone (Wealden).

Rounden Wood, near Brightling, Sussex.

Grey, compact argillaceous limestone from the Main Blue. (See No. 1).

This bed is about twenty inches thick at Archer Wood.

3. Grey Shale (Wealden).

Swift's Farm, Sussex.

Grey argillaceous shales separating the Blues and Greys.

4. Compact Limestone (Wealden).

Rounden Wood, near Brightling, Sussex.

"Eight-foot Grey" bed, occuring eight feet above the Main Blue. Grey, compact, argillaceous limestone with small specks of iron pyrites. Lines of white calc spar, crystals of which also cover a portion of the original surface of the bed. The succeeding beds above this belong to the "Greys."

5. Shelly Limestone (Wealden).

Poundsford, N.E. of Heathfield, Sussex.

Shelly limestone from the "Bottom," a bed about 10 or 12 inches thick, composed of broken shells of *Cyclas.* At Limekiln Wood the "Bottom" and "Middle" are not shelly.

6. Shelly Limestone (Wealden).

Poundsford, Sussex.

Shell-limestone composed of the broken shells of *Cyclas* and containing scales of fish (*Lepidotus*). From the "Middle," a bed about 6 inches thick, which at Limekiln Wood is not shelly. The specimen retains its original grey colour in the interior, owing to the iron remaining in a state of protoxide, while the atmosphere has converted that of the exterior into peroxide.

7. Shelly Limestone (Wealden).

Poundsford, Sussex.

Limestone composed of broken shells of *Cyclas*. The joints covered with a thin coating of calc spar. From the "Top Bottom," which at Limekiln Wood is about 8 or 9 inches thick. At Poundsford the "Top Bottom," "Middle," and "Bottom" with their partings, occupy a thickness of about four feet. The "Top Bottom" and the "Grey," (No. 8) afford the best lime of the district.

8. Shelly Limestone (Wealden).

Poundsford, Sussex.

A thin band of shelly grey limestone with *Cyrena*; being the "Grey" or lowest bed in the "Vein Greys."

The "Grey" and the "Top Bottom" make the best lime. They are divided by 6 or 7 inches of shale.

9. Shelly Limestone (Wealden).

Poundsford, Sussex.

Compact grey limestone with numerous shells of *Cyrena* or *Cyclas*. The outer surface of the bed uneven and coated with a thin film of peroxide of iron.

The "Rotten one," a layer of limestone 6 or 7 inches thick, overlying the "Grey." At Limekiln Wood this bed is 8 or 9 inches thick.

10. Shelly Limestone (Wealden).

Poundsford, Sussex.

Thin-bedded limestone crowded with *Cyrena* or *Cyclas* in a perished state.

From the "Mealy" bed, consisting of shale, clay, and a thin bed of limestone 15 inches thick, separated from the "Rotten one" by the 2-inch "Bottom Vein."

11. Shelly Limestone (Wealden).

Poundsford, Sussex.

Thin-bedded, shelly limestone, chiefly composed of shells of *Cyclas* or *Cyrena* in a perished state.

From the "Fox" or "Upper Mealy." This stratum is principally composed of hard shale, some of which is still adhering to the specimen; but there is a thin bed of limestone in the middle, and another at the bottom.

12. Shelly Limestone (Wealden).

Poundsford, Sussex.

Grey, shelly limestone, with *Cyrena* or *Cyclas*.

"Top Vein," a band of limestone, an inch or an inch and a half thick, overlying the "Fox" or "Upper Mealy" (No. 11), from which it is separated by from 8 to 10 inches of shale.

13. Shelly Limestone (Wealden).

Poundsford, Sussex.

Chiefly composed of perished shells of *Cyclas*.

From the "Paver," a band of limestone 6 inches thick.

14. Shelly Limestone (Wealden).

Poundsford, Sussex.

Blue, shelly limestone, weathering white or slightly ferruginous, and chiefly composed of shells of *Cyclas*. From the "Main Bull," a bed of limestone about 6 inches thick, lying about 40 feet above the "Bottom" (No. 5).

Ashdown Sand.

These beds formerly formed part of the great Wealden group of Hastings Sands, and are the "Tilgate" and "Worth" beds of Dr. Mantell. Mr. Drew, by whom a great part of the Wealden area has lately been worked out, has proposed the more definite name of Ashdown Sands for the Sands at Hastings. This name has been chosen because the lower sands overlying the Ashburnham beds spread over a large area about Ashdown Forest, showing a very great thickness there, and, although low in the series, forming the highest ground of any in the whole formation.

The Ashdown Sand consists of alternating layers of sandstone and loam, with an occasional bed of rock-sand. The entire thickness in the Forest is about 250 feet or more. In the neighbourhood of Hastings the total thickness was estimated by Mr. Charles Gould to be from 150 to 160 feet. In Ashdown Forest clay-ironstone is of frequent occurrence in these beds, and is dug in some places for mending the roads.

The denudation of these beds has given rise to many of the picturesque ravines and valleys in the neighbourhood of Hastings; amongst others those of the Old Roar Waterfall, Fairlight Glen, the Eaglesbourne Valley, &c.

15. SANDSTONE, Wealden.
Hastings, Sussex.
Large slab of soft yellow sandstone, showing ripple-marks; from the grounds of Sir Woodbine Parish. (Placed on the top shelf.)

Ripple-marks are of frequent occurrence in the Wealden beds, and afford satisfactory evidence of the conditions under which they were deposited.

16. SOFT SANDSTONE, Wealden.
Hastings, Sussex.
Soft and imperfectly consolidated, French-grey sandstone, composed of small gains of sharp, white quartz-sand.

The grains are so slightly coherent that a mere touch only is necessary to cause the disintegration of the stone, nevertheless the stone in mass is sufficiently strong to make a good and durable building material. This applies more or less to all the specimens from No. 16 to No. 20.

The greater part of the sand and sand-rock, nearly 150 feet thick, which compose the Castle Cliff at Hastings, belong to the Ashdown Sand. At a short distance in a northerly direction, and eastward towards Fairlight, beds of shale and clay gradually usurp the place of the sand, and give rise to a step-like appearance in the profile of the cliff.

17. SOFT SANDSTONE, Wealden.
Hastings, Sussex.
Ash-grey, soft sandstone, resembling No. 16.

18. LAMINATED SANDSTONE, Wealden.
Hastings, Sussex.
Soft and imperfectly consolidated white and buff-coloured sandstone, showing false laminations.

19. SOFT SANDSTONE, Wealden.
Hastings, Sussex.
Very fine, soft, and imperfectly consolidated sand-rock, with numerous casts of freshwater shells (*Cyclas*).

20. SOFT SANDSTONE, Wealden.
Hastings, Sussex.
Ash-grey, laminated, soft sandstone; the colour, probably, caused by finely divided carbonaceous (vegetable) matter.

21. CLAY IRONSTONE, Wealden.
Hastings, Sussex.
Flattened nodule of clay ironstone, with shells of numerous freshwater fossils (*Cyclas*).

22. CONCRETION OF CLAY-IRONSTONE, Wealden.
Hastings, Sussex.
The core of clay ironstone is traversed with cracks in the interior, and is covered externally with a thin coating of brown iron-ore.

23. CONCRETION OF SANDY CLAY-IRONSTONE Wealden.
Snape Wood, S.W. of Wadhurst, Sussex.
Similar to the preceding specimen No. 22.

24. ROUNDED CONCRETION OF SAND, Wealden.
East Cliff, Hastings, Sussex.
Presented by Dr. Percy, F.R.S.

25. NODULAR CONCRETION OF SAND, Wealden.
East Cliff, Hastings, Sussex.
The sand is stained by ochreous oxide of iron, and incloses in the centre a nodule of clay-ironstone, which is coated externally with a thin layer of brown iron-ore.

26. NODULAR CONCRETION OF SAND, Wealden.
East Cliff, Hastings, Sussex.

27. ROUNDED CONCRETION OF SAND, Wealden.
East Cliff, Hastings, Sussex.
Similar to Nos. 24 to 26. Contains occasional and impersistent thin laminæ of pale pipe-clay.

Wadhurst Clay.

The Wadhurst Clay is a stiff brown clay, or brown or blue shale, separating the Ashdown from the Lower Tunbridge Wells Sands.

It is remarkable for being the source whence much of the clay-ironstone was derived which supplied the furnaces which were formerly so numerous in the Weald district.

The shallow round pits which may still be seen in the woods that are situated on the Wadhurst Clay, mark the sites of the explorations in question where the "iron-mine" or "mine-stone" was extracted. These still go by the name of "mine-pits," and must not be confounded with the "marl-pits," or those other deeper openings (now partially overgrown, filled up, or forming ponds) where the clay was formerly dug up for the purpose of dressing the land.

The ore in the Wealden beds is a fine-grained clay-ironstone occurring in detached nodules, and occasionally in tabular layers which are continuous over short distances. It appears to form a zone near the base of the shales, and is sparingly accompanied by bands of limestone, which were formerly worked at the same time as the ore, and used, together with chalk, in smelting it.

28. Clay-Ironstone, Wealden.
Shoyswell, near Etchingham, Sussex.

Clay-Ironstone, with a thin coating of peroxide, and containing numerous shells of *Cyclas.*

29. Shelly Clay-Ironstone, Wealden.
Sussex.

Clay-Ironstone partially converted into peroxide. Contains numerous shells of *Cyclas.*

30. Iron Ore, Wealden.
Sussex.

A mass of casts of *Paludina* and *Cyrena* or *Cyclas,* the whole converted into peroxide of iron.

This ore is made up of a mass of fresh-water snails (chiefly *Paludina*), which, together with the cementing material, consists entirely of hydrated peroxide of iron.

31. Nodular Clay-Ironstone, Wealden.
Bodyham, East Sussex.

Nodule of fine-grained Clay-Ironstone, the exterior covered with a thin coating of peroxide.

32. Iron Ore, Wealden.
N. of Ore Church, 2½ miles N. of Hastings, Sussex.

33. Iron Ore, Wealden.
N. of Ore Church, 2½ miles N. of Hastings, Sussex.

Peroxide of iron, investing Clay-Ironstone.

In No. 32 only the chambered covering of peroxide is left, the Clay-Ironstone having been removed from the cavities. These beds of iron-ore, four and three inches thick respectively, are divided by five inches of yellow sand, which on exposure to the weather hardens into sandstone.

34. Clay-Ironstone, Wealden.
High Wood, near Netherfield, E. Sussex.

Flattened, lenticular, concretionary nodule of Iron-ore, the centre composed of a core of ordinary Clay-Ironstone, surrounded with thin, concentric layers of peroxide of iron.

The principal horizon of the iron-ore of the Wealden of E. Sussex is in the Wadhurst Clay, a short distance above its junction with the Ashdown Sands. "It occurs both in the form of small nodules and in tabular masses, and is usually invested by a number of thin concentric coatings of exfoliated hydrated peroxide. Specimens from different localities vary much in appearance upon being fractured, but it is usually a smooth stone of light grey colour, and of high specific gravity. The thickness rarely exceeds four inches."

The ironstones of the south-eastern extremity of Sussex have been largely worked in former times, when wood was more abundant than it is now. The rapidly increasing scarcity of wood, and the substitution of coal for smelting purposes, have gradually driven out of the field the Sussex iron-founders, and no iron is smelted in the county now. Numerous traces of old furnaces, forges, and slag-heaps, still indicate the sites of former ironworks.

35. GREY GRITTY LIMESTONE, Wealden.

¼ mile W. of Leonard Green, St. Leonard's-on-Sea, Sussex.

Fissile limestone, occurring in thin beds in Wadhurst Clay.

36. CALCAREOUS GRIT, Wealden.

Benenden, Kent.

Fine, hard, calcareous sandstone, of a pale grey colour, and containing numerous shells of *Cyrena* or *Cyclas.* This stone occurs in thin beds, here and there, in the Wadhurst Clay.

37. CALCAREOUS GRIT, Wealden.

Well, St. Mary Magdalene's School, St. Leonard's, Sussex.

Hard, grey, calcareous sandstone, passing into a conglomerate, which is composed chiefly of small pebbles of white quartz, and containing bones of *Iguanodon.*

Nos. 36 and 37 are the Tilgate Stone of Dr. Mantell. It occurs at irregular intervals throughout the Wadhurst Clay, either in large detached rounded masses, or in continuous layers, and is quarried in several localities on account of its excellence as a road-material.

38. SHELLY LIMESTONE, Wealden.

Near Ticehurst, Sussex.

Thin-bedded, shelly limestone, composed in great part of the remains of *Cyrena.*

39. SHELLY LIMESTONE, Wealden.

East of Dyke's Farm.

Thin-bedded, shelly limestone, with numerous remains of *Cyrena,* which also thickly cover both the surfaces of the stone.

Nos. 38 and 39 are from the thin beds of limestone, composed in great part of the remains of *Cyrenæ* and *Paludinæ,* several of which are associated with the ironstones in the Wadhurst Clay. In many of the localities in the Weald these limestones are known by the name of "mine greys," and were formerly extracted with the ironstone for the purpose of being used as a flux. As they do not occur in any great abundance, they are seldom specially sought for now.

TUNBRIDGE WELLS SAND.

The sandy deposits, the Horsted Sands of Dr. Mantell, but named Tunbridge Wells Sand by Mr. Frederic Drew, (after the name of the town in the neighbourhood of which they occupy a considerable area,) intervene between the Wadhurst and Weald Clays. They consist, for the most part, of sands, which may be described as soft, buff or light brown sandstone, interstratified with beds of loam, thin beds of clay, and occasionally some loose sand. They are subdivided into two groups, an upper and a lower, by a stratum of stiff clay (red in its upper part), which has been named Grinstead Clay by Mr. Drew, from its occurrence on the north side of the town of East Grinstead, in the neighbourhood of which its relation to the lower beds is well seen. The top bed of the uppermost of the two sands is sometimes a bed of rock-sand, which forms a fine line of rocks at Redleaf, Penshurst, Tunbridge Wells, and Rusthall Commons, while in the same manner the top bed of the lower subdivision constitutes bold and picturesque masses called "The Rocks," at West Hoathley and Uckfield.

40. Soft Yellow Sandstone, Wealden.

Goford, near Cranbrook.

A very fine-grained rock-sand, from the Lower Tunbridge Wells Sand, containing occasional very minute specks of silvery mica.

41. Sandstone, Wealden.

High Beach, Hollington, Sussex.

Pale quartzose sandstone, most probably from the rock-bed of the Lower Tunbridge Wells Sand.

This stone is easily worked, takes a sharp edge, and appears to be well adapted for building purposes.

Presented by Mr. Lewis.

42. Siliceous Grit, Wealden.

Polvender, Kent.

Yellow siliceous grit, with an irony coating, showing a kind of concretionary structure.

Weald Clay.

The Weald Clay is the uppermost member of the Wealden Group. It consists almost entirely of stiff brown and blue clay, but sometimes the colours are of various tints, and towards the top the clay becomes shaly and blue, and assumes the character of what are called, from the thinness of their flakes, "paper shales," the laminæ being separated by an accumulation of the cases of Cyprides.

In the neighbourhood of Tunbridge Wells and other places it includes thin bands of Paludina limestone, and some calcareous grit and clay-ironstone.

The thickness of the Weald Clay of Sussex and Kent is not less than 600 feet.

For the fossils see Flat-case 35.

43. Shelly Limestone, Weald Clay.

Railway cutting, 3 miles S. of Redhill, Surrey.

Grey shelly limestone, occuring in thin bands about the middle part of the Weald Clay. It is crowded with the shells of freshwater snails, chiefly *Paludina fluviorum.*

44. Impure Shelly Limestone, Wealden.

Bethersden, Kent.

This limestone occurs in large and irregular tabular masses, which are not continuous for long distances in the direction of the strike of the beds. It is argillaceous, and full of the shells and casts of *Paludina Sussexensis*, a larger species than that contained in No. 43. This stone is locally called Bethersden Marble, after the name of one of the localities where it has been found in large quantities, and obtained for ornamental and other purposes.

45. Impure Shelly Limestone, Wealden.

Earlswood, near Reigate, Surrey.

Argillaceous limestone with casts and shells of *Paludina Sussexensis*, occurring near the top of the Weald Clay. Similar to No. 44.

46. Shelly Limestone, Wealden.

Weald of Sussex.

Impure shelly limestone, crowded with *Paludina Sussexensis.* Casts of that freshwater snail are crowded together on the natural surface of the stone, the other side of which is polished, to show the effect produced by the sections through the shells, which are replaced by calc spar.

This stone occurs in the Weald Clay, in layers varying from a few inches to a foot or 18 inches in thickness, and sometimes sufficiently large for chimney-pieces and other ornamental objects. It takes a high polish, and has long been used, under the names of Bethersden or Sussex marble, for ancient tombs and sepulchral monuments as well as for other ornamental purposes. The darker lines of the pattern in the stone are produced by those portions of the sections of the shells which consist of the substance, composed of carbonaceous matter and phosphate of lime, which has been derived from the decomposition of the soft bodies of the snails, and which has in consequence received the name of "Mollusckite" from Dr. Mantell. (See No. 58). In many cases white crystalline carbonate of lime fills the whole interior of the shell. It bears a strong general resemblance to the Purbeck Marble (see Nos. 1 and 8), but may always be distinguished from it by the greater size of the shells contained in it.

47. Iron Ore, Wealden.
Hythe, Kent.

Part of a concretionary nodule of brown iron-ore, with numerous *Paludina elongata*, showing its freshwater origin.

48 and 49. Silicified Wood, Wealden.
Brixton Bay, Isle of Wight. Map 10, and Horizontal Sections No. 47.

Part of the silicified trunk of a coniferous tree, probably allied to the pine; from the "pine-raft" which covers the shore between high and low-water marks, at *Brook Point.*

"The trees are completely mineralized, being converted into a coal-black stony mass, containing a considerable quantity of iron pyrites. They lie prostrate in all directions, broken up into cylindrical fragments, some as much as two or even three feet in diameter, and (when united) many feet in length. Unlike those in the dirt-beds of the Isle of Portland, the trees are not mineralized by siliceous, but by calcareous matter. Some of the trees still present traces of woody structure, and the annular rings of growth are clearly perceptible; but others are converted into pyrites, or into a black shining substance resembling jet, which breaks with a conchoidal fracture."

See H. W. Bristow's Memoir on Isle of Wight, p. 3 and plate II.

50. Whitish Sandstone, Wealden.
Brook Point, Isle of Wight. Map 10.

Pale grey or whitish sandstone, showing a weathered and irregular surface, and containing iron pyrites. This sandstone, which forms Brook Point, is the lowest bed seen at the base of the cliff, and reposes on the red and green variegated marls underlying the sandstone with the trunks of the trees forming the pine-raft.

See H. W. Bristow's Memoir on the Isle of Wight, p. 4, plate II.; and Horizontal Section No. 47.

51. Conglomerate. Wealden.
Brixton Bay, Isle of Wight.

Composed of calcareous pebbles in a siliceous base.

52. Siliceous Grit, Wealden.
Cowleaze Chine, Isle of Wight.

Overlies red marls and contains casts of freshwater shells; (*Unio.*)

53. Ironstone, Wealden.
E. End of Brixton Bay, Isle of Wight. Map 10.

Peroxide of iron containing numerous casts of freshwater shells (*Paludina*).

54. Green Clay, Wealden.
Haslemere, Sussex. Map 8.

Greenish-grey clay with numerous shells of freshwater forms (*Melanopsis* or *Melania*).

This clay, which forms the very uppermost beds of the Wealden formation, is immediately overlaid by brown clays containing abundant tracks of marine worms, and bivalve shells of the genus *Panopæa* occupying the same upright positions which they held in their old burrows when alive.

LOWER GREENSAND.

The freshwater and estuary formation of the Wealden is immediately succeeded by a purely marine series of deposits, which has received the name of the Lower Greensand. The thickness of the latter strata is very considerable, amounting in the Isle of Wight, where they are well developed, to more than 900 feet. They have been divided on the maps of the Geological Survey into four groups :—1st. Atherfield Clay; 2nd. Hythe Beds; 3rd. Sandgate Beds; and 4th. Folkestone Beds, and named after the localities and towns where good sections of them may be seen.

1st. The Atherfield Clay, or lowest beds of the Lower Greensand, consists of bluish clays, which are well displayed in the cliffs in the neighbourhood of Atherfield Point in the Isle of Wight, where they attain a thickness of more than 60 feet.

2nd. The characters of the Hythe Beds are very variable, but they may be described, generally, as a soft yellowish sandstone often containing green grains, and interstratified with a considerable quantity of sand and a little chert. The average thickness is about 200 feet.

3rd. The Sandgate Beds are of a more clayey nature than those above and below them. In some places they attain a thickness of as much as 20 feet, but sometimes they thin away and only appear as occasional traces of clay. They are remarkable for containing valuable beds of fuller's earth, which are worked at Reigate and elsewhere for that substance.

4. The Folkestone Beds are very constant in character. They are loose white, buff, or brown sands, often containing waving ferruginous streaks and bands of siliceous ironstone, formed of the sand cemented with peroxide of iron. The thickness of this group may be estimated at 150 feet.

The iron-ore of the Lower Greensand is chiefly high up in that formation, and consists generally of reticulating veins crossing in all directions the sandy strata in which they lie.

The fossils found in this formation are placed in Flat-cases 36 to 42, and in Wall-cases 28 to 33.

Surrey, Kent, and Sussex.

55. Lower Greensand, Hythe Beds.

Sandgate, Kent.

With *Ostrea* and other fossil shells.

56. Kentish Rag, Lower Greensand.

Chart, near Ashford, Kent.

Hard, grey, sandy limestone belongto the Hythe Beds.

57. Kentish Rag, Lower Greensand.

Hythe, Kent.

Hard, bluish-grey sandy limestone from the Hythe Beds.

The Kentish Rag consists of about 80 feet of regular alternations of hard, blue limestone (Nos. 56 and 57) and soft sandstone (No. 58) locally called "hassock." The Rag-stone beds are very irregular, and the same stratum sometimes varies from six inches or a foot in thickness to three feet. Some of the beds are composed of chert and black flint, No. 59. Bones of *Iguanodon*, *Plesiosaurus*, *Crocodilus*, and other saurians, have been found in these beds, together with *Pterodactyle*, and *Turtle*. In addition to these numerous *Fuci* occur in nearly all the beds, and *Siphonia*, spiculæ of *sponges*, and waterworn fragments of *wood* in various states of preservation, together with certain shells.

The thicker beds are extensively used as a building material, for which they are well adapted when judiciously chosen, and the thinner ones are burned for lime.

The total quantity of Rag-stone shipped is about 55,000 tons per year.

The following is an analysis by Mr. Richard Phillips, late of the Museum of Practical Geology:—

Carbonate of lime -	- 92·6
Earthy matter -	- 6·5
Oxide of iron -	- 0·5
Carbonaceous matter	- 0·4
	100·0

The weight of a cubic foot is 172·3 lbs.

58. Calcareous Sandstone (Lower Greensand).

Maidstone, Kent.

Pale greenish-white, calcareous sandstone, with numerous dark-green specks of silicate of iron, impressions and shells of fossils, and Molluskite.

This stone comes from the Kentish Rag quarries, where it occurs between the beds of hard limestone Nos. 56 and 57. It is called "Hassock" and "Calkstone" by the workmen.

The term Molluskite was proposed by Dr. Mantell for the dark brown substance which is especially abundant in the Iguanodon Quarry of Kentish Rag, near Maidstone, and which is in every respect identical with the nodular and irregular concretions of coprolitic matter of frequent occurrence in the surrounding sandstone.

The darker portions appear, by an analysis of Mr. Rigg, to contain about 35 per cent. of their weight of carbon in an organized state. This was, probably, derived from the decomposition of the soft bodies of shell-fish or mollusca (whence the name *Molluskite*).

See Proc. Geol. Soc., vol. 4, page 35.

Presented by Dr. G. Mantell.

59. Chert, Lower Greensand.

Iguanodon Quarries, Maidstone, Kent.

From the Ragstone beds, where it occurs in thin zones or lenticular layers. Used for road-material.

60. Calcareous Grit, Lower Greensand.

Godalming, Surrey.

Pale-greyish calcareous grit, consisting of minute rounded grains of translucent quartz, and green silicate of iron, &c., held together by a calcareous cement. From the Hythe Beds of the Lower Greensand.

This stone, which extends through Kent and Surrey, is locally known by the name of "Bargate Stone." It is well seen on the south side of Godalming, where it is extensively quarried for building- and road-stone. It occurs in beds varying from six inches to three feet in thickness, and often terminated abruptly by oblique planes of false lamination. At Holloway Hill, near Godalming, the beds of Bargate Stone attain a thickness of about 40 feet.

61. Blue Calcareous Sandstone, Lower Greensand.

Pulborough, Sussex.

Forms a hard and compact building-stone.

62. Soft Yellowish Sandstone, Lower Greensand.

Pulborough, Sussex.

Nos. 61 and 62 belong to the Hythe Beds. They have been extensively worked at Pulborough for several years, and were used by the Romans for building-stone. Pulborough Church was built of this stone in the 16th century; Arundel Castle and Town Hall, as also the piers at Littlehampton.

63. Dark Sandy Clay, Lower Greensand.

Folkestone, Kent.

From the Sandgate Beds, which consist of about 80 feet of clays and clayey sands. The colour of these in their natural moist state is much darker than that of the specimen, which when wetted becomes of a dark green, and appears to consist of green grains of sand bound together by clayey matter.

64. Greenish Calcareous Grit, Lower Greensand.

Hythe, Kent.

Hard, greenish-grey, and rather coarse calcareous grit, from the Folkestone Beds of the Lower Greensand.

This Folkestone Stone, as it is sometimes locally called, consists of small grains of translucent quartz, small rounded pebbles (some of quartz, jasper, &c.), and green grains of silicate of iron, the whole cemented together with calcareous matter. It occurs in irregular beds about two feet thick, alternating with layers of whitish chert, three or four inches thick, which follow the oblique bedding of the grit.

65. Pebbles, &c., Lower Greensand.

Guildford, Surrey.

Pebbles of quartz, jasper, &c., with fragments of sandy iron-ore from the Folkestone Beds.

Isle of Wight.

66. Atherfield Clay, Lower Greensand.
Atherfield, Isle of Wight. Map 10.
Pale grey clay with *Gervillia solenoides*, forming the lower part of the Lower Greensand.

67. Pale Brownish Sandstone, Lower Greensand.
Atherfield Point, Isle of Wight.
From the "Cracker Beds," overlying the Atherfield Clay, No. 66.
The lower part of this subdivision of the Lower Greensand, from which the specimen was taken, consists of a bed of sandstone from a foot to eighteen inches thick, and composed almost entirely of *Gervillia aviculoides* and other fossils.

68. Pale Ferruginous Sandstone, Lower Greensand.
Atherfield, Isle of Wight. Map 10.
Pale brownish or ferruginous-coloured sandstone from the Exogyra group, and crowded with fossils (*Terebratula sella*), which particular shell occurs more abundantly in those beds than elsewhere in the formation.

69. Pale Greenish Sand, Lower Greensand.
Atherfield Cliff, Isle of Wight. Map 10.
Contains numerous fossil shells, *Ostrea, Rhynchonella Gibbsiana, &c.*
From the Scaphite group.
See H. W. Bristow's Memoir on the Isle of Wight, page 13.

70. Ferruginous Concretion, Lower Greensand.
Blackgang Chine, Isle of Wight.
Ferruginous concretion resembling the stem of a plant. From the dark green sands of the Cliff End group.
See H. W. Bristow's Memoir on the Isle of Wight, p. 13.

71. Fine Conglomerate Grit, Lower Greensand.
Atherfield Cliff, Isle of Wight.
Chiefly composed of quartz-pebbles in a quartzose base, containing spangles of mica and fossils cemented by oxide of iron.
See H. W. Bristow's Memoir on the Isle of Wight, p. 15.

72. Iron Sand, Lower Greensand.
Two miles E. of Freshwater Gate, Isle of Wight. Map 10.
This ore contains 55·6 per cent. of metallic iron. It consists of grains of oxide of iron derived from the destruction of cliffs of Lower Greensand; out of which it is washed by the sea, and afterwards deposited on the shore in considerable quantities, between high and low-water mark. A button of metallic iron, reduced from the ore, is placed with it for illustration.

73. Crystals of Selenite, Lower Greensand.
Atherfield Cliff, Isle of Wight.

Buckinghamshire.

74. Geode, Lower Greensand.
Linslade, near Leighton Buzzard, Buckinghamshire.
Hollow, nodular concretion of Iron-ore (Brown Hæmatite) occurring in zones of ferruginous-brown, yellow, and white sand, worked for Iron-ore.

75. Geode, Lower Greensand.
Linslade, near Leighton Buzzard, Buckinghamshire.
Nodular concretion of Iron-ore (Brown Hæmatite) broken to show the concentric structure, and the hollow interior. Worked for Iron-ore. See Nos. 74 and 76.

76. Geode, Lower Greensand.
Linslade, near Leighton Buzzard, Buckinghamshire.
Nodular concretion of Iron-ore (Brown Hæmatite) broken to show the hollow interior, which is lined with minute crystals of quartz.
Nos. 73, 74, 75, and 76 were presented by H. J. Jones, Esq.

77. Iron-ore, Lower Greensand.
Linslade, near Leighton Buzzard, Buckinghamshire.
Flat septarian nodule of Clay Iron-ore coated with Brown Iron-ore, which becomes ochreous by decomposition.

This band of ore, which is about 2½ inches thick, is called the "yellow ore bed." It occurs immediately overlying the beds containing the Brown Iron-ore, Nos. 74 to 76.

78. LARGE GEODE, Lower Greensand.

Rammermere Farm, Woburn, Buckinghamshire. Map 7.

Portion of a large concretionary nodule of Iron-ore (Brown Hæmatite) apparently concreted round a fragment of wood, which has also itself become mineralized by being converted into Brown Iron-ore, and then subsequently coated with small but brilliant rock crystals.

WILTSHIRE.

79. IRON-ORE, Lower Greensand.

Seend, near Devizes, Wilts. Map 14.

Peroxide of iron, with small included concretions of Clay-Ironstone.

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

In 1860, 32,000 tons of ore were raised at Seend, the value of which was £15,200.

(See Mineral Statistics for 1860, by Robert Hunt.)

80. IRON-ORE, Lower Greensand.

Bromham, Devizes, Wilts. Map 14.

Flat nodular concretion of Clay-Ironstone, invested with a thin coating of ochreous Brown Iron-ore.

OXFORDSHIRE.

81. IRON-ORE, Lower Greensand.

Shotover, near Oxford. Map 13.

Siliceous Ironstone containing numerous casts of freshwater shells.

82. IRON-ORE, Lower Greensand.

Shotover, near Oxford. Map 13.

Brown Iron Ore investing concretions of ochreous Brown Iron-ore.

The beds containing this ore have been referred by various authors to the Hastings Sands or Wealden, and to an estuary condition of the Lower Greensand. They have been coloured provisionally by the Geological Survey, as an exceptional member of the Lower Greensand. On Shotover Hill, where these beds are about 80 feet thick, they consist of a series of fine-grained variegated sands in the lower part, with partings of white clay and beds of ochre. "The upper beds are more ferruginous, with irregular masses of siliceous iron-ore, and the whole is capped (according to Mr. Coneybeare) by beds of highly siliceous grit 6 feet thick. The fossils are preserved only in the iron-beds."

See E. Hull's and W. Whitaker's Memoir on the Geology of parts of Oxfordshire and Berkshire, (Map 13) page 15.

BERKSHIRE.

83. CONGLOMERATE, Lower Greensand.

Faringdon, Berkshire. Map 13.

Conglomerate composed of oolite fossils, small rounded pebbles of quartz, slate, hornstone, &c. imbedded in a ferrugino-calcareous base. This forms the lower part of a remarkable deposit of sands and fossiliferous gravels which occurs in the neighbourhood of the town of Faringdon. When fossils have been found in these deposits they indicate the existence of marine conditions, differing in that respect from the sands of Shotover Hill, which they otherwise greatly resemble. They are generally considered now to be of the age of the Lower Greensand.

See E. Hull's and W. Whitaker's Memoir on Map 13, page 13.

84. Brown Sand, Lower Greensand.
Hartwell, near Aylesbury, Buckinghamshire.
Used for making glass.

85. White Sand, Lower Greensand.
Hartwell, near Aylesbury, Buckinghamshire.
Used for making glass.

Wall-case 6.

UPPER CRETACEOUS ROCKS.

Gault.

The local term Gault is applied in Geology to a stratum of clay filling a depression in the ground between the Lower and Upper Greensand, which occupy higher levels on either side of it. In colour it varies from pale grey to dark blue, and affords a very heavy, tenacious soil, the fertility of which is due to the high per-centage of carbonate of lime which it contains. When not placed under cultivation, the Gault is marked by the presence of rushes and other plants which affect damp situations.

A collection of Gault fossils is placed in Flat-cases 42 and 43, and in Wall-cases 31 to 33.

Wiltshire.

86. Clay, Gault.
Dinton, Wilts. Map 15.
Used for making bricks.

87. Iron-ore, Gault.
St. Bartholomew's Hill, Wiltshire. Map 15.
Concretionary nodules of Brown Iron-ore, from the base of the Gault; which, in the Vale of Wardour, lies unconformably on the oolitic strata.

88. Selenite, Gault.
Dinton, Wiltshire. Map 15.
Crystals of sulphate of lime, or selenite, found in Gault Clay.
These crystals are of frequent occurrence in clay formations, examples of which are shown in Nos.

89. Phosphatic Nodules, Gault.
The Brickyard, Dinton, Wiltshire. Map 15.

90. Phosphatic Nodules, Gault.
The Brickyard, Lidhurst, Wiltshire. Map 15.
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.

91. Phosphatic Nodules, Gault.
Longbridge Deveril, near Warminster, Wilts. Map 14.
The cracks in the interior of the nodule are filled with phosphate of lime, thus converting it into a small septaria.

92. Silicified Fossil Wood, Gault.
Ridge, Wiltshire. Map 15.
The bark pyritized.

Kent and Sussex.

93. Gault Clay.
Folkestone, Kent.
Greenish-grey clay containing numerous *Rostellaria carinata*.
This clay becomes of a blue colour when in a moist state. At Folkestone, where the upper part of the cliffs on the east side of the town, for a considerable distance from their termination at Copt Point, consists of Gault, the latter is called "Folkestone blue marl." It contains numerous fossil shells with their pearly lustre still preserved, crystals of selenite, and (according to Mr. Phillips) 30 per cent. of carbonate of lime.

94. Pale Grey Marl, Gault.
Brighton, Sussex.
Obtained in boring the deep well, for the supply of Brighton with water, at a depth of 1,130 feet from the surface.

95. Grey Marl, Gault.
Brighton, Sussex.
Blue marl obtained at a depth of 1,160 feet from the surface in boring the deep well at Brighton.

96. Fragments of Shells, and Phosphatic Nodules, Gault.
East Wear Bay, Folkestone, Kent.

97. Sandy Clay, Gault.
East Wear Bay, Folkestone, Kent.
Sandy clay containing phosphatic nodules, from the upper beds of Gault, near their junction with the Upper Greensand. *See* No. 96.

Upper Greensand.

This formation reposes on the Gault, and consists for the most part, in the lower portion, of sand and sandstones, with chert in the beds immediately underlying the Chalk. It has received its name partly from the position which it occupies with respect to the other subordinate great mass of sands and sandstones which overlie the Wealden beds, and partly from the almost invariable occurrence of small grains of silicate of iron, which are so plentiful as frequently to give a green tinge to the beds, especially when they are first taken from the quarry. The Upper Greensand furnishes a soil generally remarkable for its fertility. Below the escarpment of the chalk north of London, the Upper Greensand seems to pass gradually into a fine white deposit, scarcely distinguishable from the Lower Chalk itself.

Flat-cases 44 to 48, and Wall-cases 31 to 33 contain the fossils belonging to this formation.

Norfolk.

98. Red Earthy Limestone, Upper Greensand.
Hunstanton, Norfolk.
The Red Chalk of Hunstanton, as it is sometimes called, has been referred, by different authors, indifferently, to the Gault, Upper Greensand, and Chalk. Its proper position in the geological scale, is, most probably, that which has been assigned to it by Sir Roderick Murchison, who, in 1836, stated it to be the equivalent of the Upper Greensand. The truth of this is corroborated not only by its lying immediately beneath the Chalk, which rests conformably upon it, but by the evidence of its fossils, the preponderance of those peculiar to each of the three formations being in favour of the Lower Greensand.

Its red colour is attributed to the peroxidation of the green grains of silicate of iron (or glauconite) with which it is charged. By the late Professor Edward Forbes, the Red Chalk was considered to be the equivalent of the Gault.

99. Earthy Limestone.
Hunstanton, Norfolk.
This deposit was considered by the late Professor Edward Forbes, to be, in all probability, the equivalent of the Upper Greensand of the south of England.

Dorsetshire.

100. Upper Greensand.
Shaftesbury, Dorset. Map 15.
Soft bed, with small green grains, underlying No. 102.

101. Clay, occurring in thin bands in the Upper Greensand, No. 100.
Shaftesbury, Dorset. Map 15.

102. SANDSTONE, Upper Greensand.
Shaftesbury, Dorset. Map 15.
Underlies the "rag bed" (No. 103), and is extensively used as a building-stone, in the district in which it occurs, for churches, &c.

103. SANDSTONE, Upper Greensand.
Shaftesbury, Dorset.
From the "rag" or upper beds of the Upper Greensand; used extensively as a building-stone in the district in which it occurs.

The Upper Greensand in some districts furnishes a useful and durable building-stone, locally called "firestone," which is soft and easily worked when first quarried, but becomes extremely hard on exposure. Many of the old churches in the district where it is found are built of this stone, the durability of which is proved by the presence of the old tool-marks, which, in many cases, remain as perfect at the present day as when they were originally made.

104. CHERT, Upper Greensand, overlies the sandstone beds Nos. 102 and 103.
Shaftesbury, Dorset.
Used for road-material, for which, from its hardness and toughness, it is well adapted.

105. CHERT, Upper Greensand.
Shaftesbury, Dorset. Map 15.

The beds of Chert Nos. 104 and 105 occur in the south of England, in the upper part of the formation, frequently, as in Dorsetshire and the Isle of Wight, alternating with the hard beds of sandstone which constitute the higher portion of the series. The chert furnishes a better road-material than ordinary chalk-flints, owing to its greater toughness.

106. SHELLY SANDSTONE, Upper Greensand.
Three miles N. of Devizes, Wiltshire. Map 14.
Greenish sandstone cementing numerous shells of *Gryphæa conica, Vermetus, &c.*

ISLE OF WIGHT.

107. CHERT, Upper Greensand.
Arreton, Isle of Wight. Map 10.

108. CHERT, Upper Greensand.
One mile N. of Brixton, Isle of Wight.
From the upper calcareous beds.

109. NODULES, Upper Greensand.
One mile N. of Brixton, Isle of Wight. Map 10.
Two specimens of nodular concretions from the upper beds.

110. SOFT SANDSTONE, Upper Greensand.
One mile N. of Brixton, Isle of Wight.
Soft, whitish sandstone, with numerous points and specks of green silicate of iron.

SURREY.

111. SOFT SURREY SANDSTONE, Upper Greensand.
Farnham Surrey.
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.
Presented by J. M. Payne, Esq.

CHALK.

Chloritic Marl.

Intervening between the Chalk and the Upper Greensand, there is, in the south of England, a thin but persistent zone of whitish marl, full of green specks of silicate of iron, to which the name of Chloritic Marl has, in consequence, been given.

Owing to the appearance in this bed, for the first time, of *Scaphites* and numerous other species peculiar to the Chalk formation, the Chloritic Marl has been assigned to the Chalk, of which it is considered to be the base. In Dorsetshire the Chloritic Marl is seldom more than a foot or eighteen inches thick; in the Isle of Wight it varies from one to three feet in thickness.

It is chiefly remarkable for the numerous nodules and broken fragments of shells and bones it contains, which are commonly, but improperly, called coprolites, in consequence of their being sometimes used, like those bodies, for manure. Large quantities are annually raised in the neighbourhood of Cambridge, and (after being ground and treated with sulphuric acid) they are used for agricultural purposes. The large amount of phosphatic matter which they contain, varying from 15 to 28 per cent., renders them particularly valuable to the farmer for applying to the land.

For the fossils of this stratum see Flat-case 49.

112. Phosphatic Nodules, Chloritic Marl.

Near Cambridge.

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.

Chalk.

The Chalk is a marine formation of considerable thickness, occupying a large area in the Isle of Wight, and in the southern and eastern parts of England. It consists of nearly pure carbonate of lime, and may, therefore, be considered to be an *earthy limestone.* In many instances it is almost entirely composed of microscopic shells, either whole or in a comminuted state; but sometimes Chalk may be formed of carbonate of lime precipitated by chemical action, and gradually deposited at the bottom of the sea in the form of an ordinary calcareous sediment or mud. Mr. Sorby, from an examination of thin slices of chalk under a microscope, has demonstrated that it consists of from 90 to 95 per cent. of the cases of *Foraminifera,* and of comminuted shells. The chief difference between the Upper or soft Chalk and the Lower or hard Chalk, is caused by the filling up of the cavities of the shells by calcite or crystalline carbonate of lime,—where it has probably been deposited by infiltrating water, which has carried away some of the lime in percolating through the higher beds. The Chalk formation is divided into Chalk Marl at the base, Lower or hard Chalk without flints, and soft or Upper Chalk with flints,—the whole attaining a thickness, in the Isle of Wight, of at least 1,300 feet. On the mainland, in the south of England, the thickness varies from 600 to 900 feet.

The fossils found in the Chalk are placed in Flat-cases 51 to 53, and in Wall-cases 34 to 39.

Chalk Marl.

113. Chalk Marl, Lower Chalk.

One mile N. of Brixton, Isle of Wight. Map 10.

Forms the base of the Chalk formation. The specimen contains casts of *Ammonites* and *Inoceramus.*

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

114. Chalk-Rock.

N. of Henley-on-Thames, Oxfordshire. Map 13.

Hard blocky chalk, jointed perpendicularly to the plane of bedding; with lines of irregularly shaped, hard, calcareo-phosphatic nodules, which are green outside, but cream-coloured within. The "chalk-rock" breaks with an even fracture, and rings when struck with the hammer. It is of a pale cream-colour, the nodules being darker than the rest of the rock.

This bed occurs in the Chalk-district of Wiltshire, Berkshire, Oxfordshire, Buckinghamshire, &c. About three miles S.S.W. of Marlborough it is 12 feet thick, and contains six lines of nodules; but generally it is only from four to six feet thick, and with two or three lines of nodules. Wherever the "chalk-rock" has been seen, in the above-mentioned country, it forms an exact boundary between the Chalk with flints (Upper Chalk) and the Chalk without flints (Lower Chalk). It never contains flints, nor are any found below it, whilst a bed of them often occurs immediately above it. A general account of this bed is given in the Journal of the Geol. Soc., vol. xvii., p. 166.—See also Memoir illustrating Map 13, p. 20; by W. Whitaker and E. Hull.

115. One of the Nodules from the "Chalk-rock," (see No. 114).

3 miles S.S.W. of Marlborough, Wiltshire. Map 14.

Some of these have been found to contain 10 per cent. of phosphates.

116. White Earthy Limestone, Chalk.

Monckton, near Cranborne, Dorset.

This chalk furnishes an excellent manure.

117. White Earthy Limestone, Chalk.

Monckton, near Cranborne, Dorset.

This chalk, although dug in a pit very near that from which No. 116 was got, affords a very inferior manure.

Isle of Wight.

Map 10. Horizontal Sections, Sheet 47. Vertical Sections, Sheet 25.

118. White Earthy Limestone, Chalk with Flints.

Arreton Down, Isle of Wight.

This specimen gives an idea of the manner in which flints lie bedded in Chalk.

The Chalk of Arreton Down furnishes the best lime in the Island.

119. Iron Pyrites, Chalk.

Compton Bay, Isle of Wight.

Two nodules of iron pyrites.

Concretions and nodules of iron pyrites are found, scattered at rare intervals, throughout the entire thickness of the Chalk. The two specimens show the ordinary appearance and modes of occurrence of such masses, and their cubical crystallization.

120. Flint, Upper Chalk.

Freshwater Bay, Isle of Wight.

Flints are nodular masses of nearly pure silica, of very irregular shape, and of various sizes. They generally occur in layers or zones, chiefly in the upper part of the Chalk, and parallel with the bedding. More rarely they are found in flat tabular layers, but most frequently in separate nodules imbedded in the chalk, but not in contact with each other. The formation of flint has been accounted for by different authors in various ways.

"It has been proved by Dr. 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. Ramsay.

See H. W. Bristow's Memoir on the Isle of Wight, p. 31. See also No. 129.

121. FLINT, Upper Chalk.

Freshwater Bay, Isle of Wight.

See H. W. Bristow's Memoir on the Isle of Wight, p. 31.

122. FLINT, Upper Chalk.

Arreton Down, Isle of Wight.

Broken to show the casts of decomposed sponges about which the flinty matter was deposited.

123. FLINT, Upper Chalk.

Brixton Down, Isle of Wight.

Contains the casts of decomposed sponges.

124. FLINT, Upper Chalk.

Arreton Down, Isle of Wight.

Broken open to show the interior lined with minute crystals of quartz.

125. FLINT, Upper Chalk.

Arreton Down, Isle of Wight.

With a fossil shell (*Plagiostoma spinosa*) attached to its outer surface.

126. FLINT, Upper Chalk.

The locality of this flint, which was presented to the Museum by the late Dr. Buckland, is not known. It is, however, placed in the collection because it is a very characteristic specimen of the forms which chalk-flints not unfrequently assume.

127. FLINT, Upper Chalk.

Broken to show the hollow interior, which is coated with chalcedony.

128. FLINT, Upper Chalk.

Part of a large flint, broken open to show the hollow interior, lined with a deposit of mammillated chalcedony.

129. FLINT, Upper Chalk.

Thorney Wood, near Burnham, Buckinghamshire.

Remarkable for showing a white band in the middle of a tabular zone of black flint.

The flat tabular flints which are coincident with the stratification, are of a different age from the similar layers which are found filling cracks and joints. The former are contemporaneous with the chalk, and the flinty matter was deposited at the same time as the chalky matrix; the latter are, on the contrary, of more recent date, having been formed by the percolation of infiltrating water holding silica in solution into cracks and joints which were formed in the chalk, during or after its solidification.

130. DRESSED FLINT, Upper Chalk.

This flint, presented by the late Rev. Professor Henslow, is placed here to show the characteristic conchoidal, or shell-like fracture, and the manner in which, by exposure to ordinary atmospheric action, the disintegration of such bodies is brought about. The small circular markings under the influence of frost, heat, &c., show where parts of the surface of the flint become detached, leaving pitted hollows, which by a repetition of a similar process may become deepened and extended.

A very beautiful example of the perfect conchoidal fracture sometimes exhibited in flint is shown in the Horse-shoe Case, on the principal floor: See No. 736.

There was formerly a large consumption of flints for the locks of guns, but the all but universal adoption of percussion caps, has almost entirely put a stop to this branch of industry. Examples of dressed gun-flints may be seen in the Horse-shoe Case, Nos. 703 to 714.

H. W. BRISTOW.

CAINOZOIC OR TERTIARY ROCKS.

Arranged and described by H. W. BRISTOW.

The Tertiary strata which come next in the series above the Chalk, consist of all those formations which commence with the Thanet Sand, and range, with many breaks, up to the commencement of the existing order of things.

The Eocene strata lie in two great basins, known respectively as the London and Hampshire basins. As may be expected from their comparatively recent age, and their never having been subjected to the intense pressure under which the older rocks have become solidified, the British rocks of Tertiary age are not of a highly indurated kind, but consist of alternations of clays, marls, sands, sandstones, and limestones.

EOCENE SERIES.

The Eocene is the oldest of the three great groups into which the Tertiary rocks were divided by Sir Charles Lyell, viz., Eocene, Meiocene, and Pleiocene. The name signifies the dawn or commencement of the present state of things, which is indicated by the occurrence, in a fossilized state, of a few shells of species which are still in existence.

LOWER EOCENE.

THANET SAND.

13. THANET SAND (Lower Eocene), slightly calcareous, and containing an included pebble of flint.

From the lower part of the Thanet Sand, *Grays Thurroch, Essex.*

This fine, soft, light-coloured 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, Woolwich, and Epsom. In the eastern portion of the London basin it attains a maximum thickness of 80 to 90 feet, but disappears west of London, where the Woolwich and Reading Beds are based directly on Chalk.

Flint pebbles are very rare in this formation, whilst in the sands of the overlying Woolwich and Reading Beds they are common.

Presented by R. Meeson, F.G.S.

WOOLWICH AND READING BEDS, (PLASTIC CLAY).

In the absence of the Thanet Sand this series forms the lowest member of the Tertiary group. It was formerly called Plastic Clay, from the circumstance of some of the beds consisting of plastic clays, suitable for making pottery. This somewhat vague and indefinite term has now given place to that of "Woolwich and Reading Beds," which was proposed by Mr. Prestwich, in consequence of their development at those two localities. The series is composed of sands, pebble-beds, and clays, the latter very often either bright red or else merely mottled with some shade of that colour.

The fossils belonging to the Woolwich and Reading Beds are contained in Flat-cases 54 and 55.

14. CHALK FLINT.

Large specimen, apparently, from its stained exterior, from Tertiary Beds immediately overlying a denuded surface of Chalk.

15. CHALK FLINT, Woolwich and Reading Beds.

Studland Bay, coast of Dorset. Map 16.

From the bottom bed of the Woolwich

and Reading Beds, immediately overlying the Chalk. Shows the peculiar green stains, frequently characteristic of flints occurring at the junction of Chalk and the Lower Tertiaries. (See also No. 14.)

16. GREEN-COATED FLINT-PEBBLES AND SUB-ANGULAR FLINTS.

Railway-cutting, just W. of Reading, Berkshire. Map 13.

From the "bottom-bed" of the Woolwich and Reading Beds, overlying Chalk. See Memoir on Map 13, p. 40.

17. IRON ORE, Lower Eocene.

Beedon Hill, N. of Newbury, Berkshire.

Sandy peroxide of iron, forming a very thin layer in "the bottom-bed" of the Woolwich and Reading Series, resting on Chalk, at the Brickyard, Beedon Hill, Berkshire.

See Memoir on Map 13, p. 34.

18. RED MOTTLED PLASTIC CLAY.

Crendle Common, near Cranborne, Dorset. Map 15.

From the lower part of the 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 ware to supply the neighbouring districts.

19. CONCRETION OF SAND, Woolwich and Reading Beds.

Near Beedon, Berkshire. Map 13.

Nodular concretion of sand, forming sandstone.

20. GREYWETHER SANDSTONE.

Overton Down, near Avebury, Wiltshire. Map 34.

Scattered blocks of this saccharoid sandstone or grit lie on the surface of the country in Dorsetshire and Wiltshire, sometimes (as in the Valley of Stones, west of Black Down, Map 17, and on the Chalk Downs in the Vale of Pewsey), in such numbers, that a person may almost leap from one stone to another without touching the ground.

The stones are frequently of considerable size, many being four or five yards across, and about four feet thick. In Bride Bottom (the Valley of Stones) they often become conglomeratic, being composed of rounded, sometimes of angular Chalk-flints in a base of white siliceous grit, and, in many instances, the same block furnishes an example of this structure, one portion of it consisting of sandstone, and another of conglomerate, occurring with a well-defined line of separation between them.

In the village of Little Bredy, they may be seen in the brook which flows by the side of the road; and, in many instances, when it has been possible to do so, advantage has been taken of their position to build them into the walls of the houses; partly, perhaps, to avoid the trouble of removing so great a weight, partly to save the labour of breaking up a mass of such hardness and magnitude.

The Trilithons or larger stones forming the outer circle of Stonehenge, as well as the larger stones used in the construction of Avebury, were, probably, procured from immense blocks scattered over the neighbouring downs. Those found, at the present day, on Marlborough Downs are hammer-dressed into rectangular blocks, which are used for paving and building-stone; while near Marlborough and Fyfield, where they are extremely abundant, the roads are mended with them, and the walls by the turnpike road are built of them.

Their original geological position was, probably, in the sands of the Eocene series, out of which they were worn by denudation, and subsequently hardened by exposure to the atmosphere.

On the turnpike road from Dorchester to Broad Maine, blocks of this stone are visible (apparently in place) by the roadside at Little Maine, in sands which rest immediately on the Chalk; while several other blocks of it are scattered over the surface of the adjoining fields.

The name *Greywether*, by which these sandstones are known, has been given to them from their supposed resemblance (when scattered over the ground, and seen from a distance,) to (wether) sheep.

The name *Druid Sandstone* has reference to their employment by the Druids in the erection of their temples.

Sarsen or Sarsden Stone is, probably, a corruption of *Saracen Stone*, originating in the popular belief that the stones had been originally brought over to this country, and placed in their present positions by foreigners. The term Saracen is applied in some parts of England to *any* foreigner, and has probably been in vulgar use since the time of the Crusades. In Cornwall large heaps of refuse from the mines, are, to this day, known by the names of Attle-Saracen, or heaps of rubbish that have been left there by the Saracens.

(See Memoir on the Geology of Map 34. p. 41.)

21. CONCRETIONS OF SANDSTONE, from the Woolwich and Reading Beds.

Langley Park, near Beedon, N. of Newbury, Berks. Map 13.

The specimens show the formation of Greywether-sandstone from the sands of those beds. They were broken from off a large mass of stone "throughout nearly its whole thickness made up of an aggregation of balls of sandstone, from the size of a pea to that of a plum; at the lower part these are comparatively soft and easily broken; they are of a yellow colour, and the spaces between them are filled with the ordinary yellow sand of the Reading Beds; higher up they are harder and of a duller colour, the sand between them is also hardened; near the top they are hardly to be seen, the stone being uniform throughout, and the top surface is exactly like that of an ordinary Greywether."

See Memoir on Map 13, p. 35.

22. SANDSTONE, Woolwich and Reading Beds.

Peppard's Wood, 2 miles E.S.E. of Amersham, Buckinghamshire.

Loose, friable sandstone, forming an irregular bed about 8 inches thick.

23. YELLOW SAND, Woolwich and Reading Beds.

Fareham, Hampshire. Map 11.

Underlies the red-mottled clay of the Plastic Clay Series, No. 24.

Used for making bricks, building, &c.

24. RED MOTTLED PLASTIC CLAY, Woolwich and Reading Beds.

Fareham, Hampshire. Map 11,

Used for making coarse pottery.

See Nos. 18, 23, and 25.

25. PIPE-CLAY, PALE GREY MOTTLED CLAY, with ochreous-coloured stains: Woolwich and Reading Beds.

Chalbery Hill, near Horton, Dorsetshire. Map 15.

26. CONCRETIONS OF IRON, Woolwich and Reading Beds.

Near Wimborne Minster, Dorsetshire. Map 15.

These small concretions occur in mottled clay, and are, probably, derived from iron pyrites, which has become converted into oxide by exposure to atmospheric influences.

27. SANDY PIPE-CLAY, Woolwich and Reading Beds. Contains numerous leaves of trees.

East Bloxworth, Dorsetshire.

Sandy pale-grey pipe-clay, of an ochreous colour in places, with an irregular fracture, and sometimes with the fractured surfaces coated with a ferruginous stain. This bed of pipe-clay is remarkable for containing numerous leaves of plants. It occurs about six feet below the Iron-ore Nos. 31 and 32.

28. CLAYEY LIMESTONE, Woolwich and Reading Beds.

Effra-Branch-Sewer, Peckham.

This limestone is known as the "Paludina, bed" (and by workmen as the "Cockle-bed") from the occurrence in it of great numbers of *Paludina lenta.* The bed is about 6 or 8 inches thick, and sometimes the shells are almost all together in one line in the middle, as in the specimen. The new genus *Pitharella* occurs in this limestone-band.

29. SILICEOUS CONGLOMERATE, Woolwich and Reading Beds.

Whiting Shoal, Limehouse Reach.

Black flint-pebbles in a pale-grey siliceous base.

30. SILICEOUS CONGLOMERATE, Woolwich and Reading Beds.

Bed of River Thames.

(On the upper shelf.)

Small flint-pebbles, mostly black, imbedded in a dark siliceous base, and forming Whiting Shoal in the River Thames.

Presented by the Tidal Harbour Commissioners.

Nos. 29 and 30 are both from the "Pebble-beds" of the Woolwich and Reading Series. The masses of sand and pebbles at the upper part of that formation on the south-eastern side of London are sometimes hardened into a "pudding-stone."

31. SANDSTONE, Woolwich and Reading Beds.

Alum Bay Isle of Wight. Map 10.

(On upper shelf.)

Pale sandstone containing Siphonia-like tubes.

London Clay.

Overlying the beds of the Woolwich and Reading Series, there is a considerable thickness of dark blue or brown clay, containing numerous fossils of marine genera, to which the name London Clay has been assigned, on account of its forming the subsoil over a great part of London and the surrounding country. Septaria are of common occurrence in the clays.

Basement-Bed.

Immediately resting on the Woolwich Beds there is a bed of varying thickness, which has been named by Mr. Prestwich "the basement-bed," from its position relatively to the main mass of the London Clay, which reposes immediately upon it. This bed is generally composed of brown, ferruginous, and somewhat clayey sands, and brown loam, and, in addition to its peculiar fossils, it almost invariably contains rounded pebbles of black flint disseminated in it towards the lower part, sometimes, however, only sparingly. Seams and nodules of iron-ore are frequently found in the basement-bed.

For the fossils found in the London Clay see Flat-cases 56 to 58, and Wall-cases 47 to 51.

32. Iron-Ore, London Clay.
E. Bloxworth, Dorsetshire. Map 16.
Nodular concretions of Clay-ironstone, externally coated with concentric layers of peroxide of iron.

33. Iron-Ore, London Clay.
East Bloxworth, Dorsetshire.
Peroxide of iron, investing Clay-ironstone, and containing rounded pebbles of flint.

At East Bloxworth the iron-ore is from 6 to 8 inches thick, and consists of yellow, sandy clay with a band of concretionary hydrated peroxide of iron investing cores or nodules of Clay-ironstone, like No. 32, which sometimes forms a conglomerate of black flint-pebbles cemented with peroxide of iron, a foot thick. The pebbles are cleaved similarly to No. 34.

34. Flint Pebble, London Clay.
Wickham, near Newbury, Berkshire. Map 13.
From the "basement-bed" of the London Clay. The pebbles in this bed are often of large size, and remarkable for splitting up into fragments with a slight blow.
See Memoirs on Map 13, p. 50, and on Map 12, p. 33.

35. Rounded Flint Pebble, London Clay.
Sherborne St. John, Hampshire.
From the basement-bed.

36. Rounded Flint Pebbles London Clay.
Hurst, E. of Reading, Berkshire. Map 7.
From the basement-bed.

37. Iron-Ore, London Clay.
Dorsetshire.
Flattened nodular concretion of argillaceous hydrated peroxide of iron, resulting, most probably, from the decomposition of Clay-ironstone.

38. Concretionary Iron-Ore, London Clay.
Redlands, Reading, Berkshire.
From the lower part ("basement bed" ?) of the London Clay.
(See Mem. Geol. Surv. Map 13 p. 49.)

39. IRON-ORE, London Clay.
Watford Heath Kiln, Hertfordshire. Map 7.

Slightly conglomeratic iron-ore from the bottom of the "basement-bed," and partly composed of small concretions, with a concentric lamellar structure, forming a kind of bean-ore.

40. CONCRETIONARY SANDSTONE, London Clay.
Lane End, near High Wycombe, Buckinghamshire. Map 7.

From the basement-bed. The surface partly covered with adherent shells of *Ditrupa plana.*

41. CALCAREOUS SANDSTONE, London Clay.
E. of Gravesend, Kent. Map 1. S.E

With casts of *Panopæa intermedia, Pectunculus decussatus,* &c. From the basement bed of the London Clay, by the North Kent Railway, between Chalk and Higham.

LONDON CLAY.

42. BROWN CLAY, London Clay.
Elson, near Gosport, Hampshire. Map 11.

This specimen shows the nature of the London Clay in the Hampshire Basin, where it is a thick blue clay (when moist) with occasional interrupted zones of Septaria. It has been largely manufactured into bricks for the newly built Fort Elson.

43. SEPTARIAN NODULE, London Clay.
Great Northern Railway.

Cut open and polished to show the calcareous septa.

Presented by Mr. Matthew Wright.

44. BROWN CLAY, London Clay.
London Basin.

45. SEPTARIAN NODULE, London Clay.
Isle of Sheppey.

Contains a fossil shell (*Pyrula Smithii*), and shows the manner in which such concretions are formed; generally round some organic substance, as a nucleus, about which the more stony matter has collected.

46. SEPTARIAN NODULE, London Clay.
Hampstead, Middlesex.

Oblong septarian nodule, cut through in the direction of the longest diameter and polished, to show the cracks filled with calcspar.

In Nos. 43 and 46 the shrinking of the mass has taken place internally, and few, if any, of the cracks have extended to the outer portion of the stone.

47. CALCAREOUS SANDSTONE, London Clay.
Kingston, Surrey.

Contains numerous specimens of *Pectunculus decussatus.*

48. CALCAREOUS SANDSTONE, London Clay.
Alum Bay, Isle of Wight. Map 10.

Contains shells of *Cytherea, Pectunculus,* and other marine genera.

49. ARGILLACEOUS SANDSTONE, London Clay.
Artesian well, Southampton. Map 11.

With *Pectunculus brevirostrum, Natica Hantoniensis,* and other fossil shells of marine genera.

50. BOGNOR ROCK, London Clay.
Bognor, Sussex. Map 9.

Pale grey, calcareous grit.

The Bognor Rocks consist of beds of calcareous grit, which are visible on the shore at low water for a considerable distance out at sea, to the westward of the town of the same name.

Their true position, in the geological scale, is in the middle part of the London Clay.

51. SEPTARIAN NODULE, London Clay.
Strathfieldsaye, Berks. Map 12.

From the upper part of the London Clay, and containing *Pectunculus brevirostrum, P. decussatum, Cytherea obliqua, Cyprina, Cardium, Buccinum* or *Fusus, Natica Hantoniensis,* &c.

MIDDLE EOCENE.

BAGSHOT SERIES.

The Bagshot Beds are divided into Upper, Middle, and Lower. They receive their name from the locality, Bagshot Heath, near London, where they are well displayed, and occupy a large tract of country.

Lower Bagshot Beds.

These consist of a thick deposit of sands and clays, reposing on the London Clay. They are remarkable in Dorsetshire for containing important strata of pipe-clay, which have been extensively worked for many years, and furnish most of the clay used in the potteries for making ordinary earthenware. They are also interesting on account of the remains of the rich flora which they contain, in the shape of the leaves of subtropical land-plants. A collection of leaves from the Lower Bagshot pipe-clays will be found in Wall-case 52 ; see also Wall-case 50, upper shelf.

Isle of Wight.

52. Pipe-clay, Lower Bagshot Beds.

Alum Bay, Isle of Wight.

With bright-red ferruginous laminæ. See Bristow's "Memoir on the Isle of Wight," p. 40.

The clays 52 and 55 contain fossil leaves. See Wall-cases 50 and 52.

53. Coloured Sands, Lower Bagshot.

Alum Bay, Isle of Wight.

Variegated sand of bright colours, used in the Isle of Wight for making sand-pictures and paintings on the inner surfaces of glass-bottles.

Dorsetshire.

54. Pipe-clay, Lower Bagshot.

S. of Corfe Castle, Dorset. Map 16.

Used in the manufacture of china and earthenware.

Presented by the Messrs. Pike, Wareham.

According to Mr. Robert Hunt, 37,087 tons of this clay were shipped from Poole in 1861 ; of these, the finer kinds are used for making earthen- and stone-ware, while the inferior qualities are used in the manufacture of alum.

55. Pipe-clay, Lower Bagshot.

Branksea Island, Dorsetshire. Map 16.

Used for making stone-ware, blacking-jars, &c.

Presented by Colonel Waugh.

56. Pipe-clay, Lower Bagshot.

Branksea Island, Dorsetshire. Map 16.

Used for making bricks, &c.

Presented by Colonel Waugh.

The following analyses of the pipe-clay of Branksea Island, by Professor Way, is extracted from a paper by Joshua 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

57. Concretionary Nodule, Lower Bagshot.

Branksea Island, near Poole. Map 16.

Concretionary nodules of Clay-Ironstone, forming septaria, are of occasional occurrence in the pipe-clay beds of the Lower Bagshot Series, and might be used for making Roman cement with advantage.

Presented by Colonel Waugh.

Hampshire.

58. White Sand, Lower Bagshot.

Stoke Common, near Bishopstoke, Hampshire. Map 11.

Immediately underlying the pebble-bed No. 58.

MIDDLE BAGSHOT.

Bracklesham Beds.

The Bracklesham Beds form the lower part of the Middle Bagshot Series, and are so called after the remarkable sections of fossiliferous strata displayed, at low water, along the shelving shore of Bracklesham Bay, in Sussex. In general these deposits are covered up with a few inches of sea sand, but at certain states of the tides, and after the wind has been blowing for a short time from a particular quarter, the sands are washed away, leaving the underlying beds fully exposed to view, and affording one of the most striking and instructive displays of fossiliferous strata to be seen in the British Islands.

Throughout the remaining portion of the district over which these beds extend in Map 11, they are only locally fossiliferous. When, however, shells occur, they are generally very abundant, as is the case at Stubbington, on the coast, where *Cardita planicosta*, *Cerithium*, and other characteristic shells, are found crowded together like those in No. 63, in a bed about 4 feet thick.

The fossils obtained from the Bracklesham Beds are shown in Flat-cases 58 to 60, and in Wall-cases 49 to 53.

Hampshire.

59. Black Flint-Pebbles, Middle Bagshot.

Stoke Common, near Bishopstoke, Hampshire. Map 11.

Occurring at the base of the Bracklesham beds.

The white sands, No. 57, forming the uppermost of the Lower Bagshot beds in Hampshire, have an uneven and irregular surface, resting upon which is, generally, a deposit of black flint-pebbles. The pebble-bed is very well developed at Stoke Common, where it forms a thick bed of shingle covering the crest of the higher grounds. Very often the commencement of the Bracklesham beds is only denoted by a line, or a very thin zone of black pebbles.

60. Bracklesham Sand, Middle Bagshot.

Bevois Valley, Southampton. Map 11.

Yellow sand, used for building and brick-making.

61. Bracklesham Clay, Middle Bagshot.

Netley, near Southampton. Map 11.

Green clay, used for making bricks.

62. BRACKLESHAM CLAY, Middle Bagshot.

Netley, near Southampton.

Green clay, used for making bricks.

The clay affording brick-earth varies very much in quality. No. 61 is of a very mild description, but on other parts of the ground, at the same depth below the surface, the clay is too stiff for use alone, and requires to be mixed with one-twelfth of its bulk of sand: (No. 60.) The best bricks are made with a mixture of the two clays, Nos. 61 and 62, and 5,000,000 are made annually, and used for the erection of the Military Hospital at Netley.

63. BRACKLESHAM SAND, Middle Bagshot.

Stubbington, Hampshire. Map 11.

Yellow sand, with green specks, cementing together a mass of shells, *Cardita planicosta.* From the Cardita bed.

The beds at this locality, which was discovered by the Rev. Osmond Fisher, are very fossiliferous. The sand in which the shells occur is seen, at intervals, in the cliffs, beneath the drift-gravel which caps the low cliffs west of Brown Down, and also along the shore at low water.

SUSSEX.

64. BRACKLESHAM SAND, Middle Bagshot.

Bracklesham Bay, Sussex.

Green sands, from the Cypræa bed, containing shells of *Cypræa tuberculosa and Cardita acuticostata.*

65. BRACKLESHAM SAND, Middle Bagshot.

Bracklesham Bay, Sussex.

Dark green sand from the Cardita bed, with *Cytherea suberycinoides, Turritella imbricataria, and Cytherea acuticosta.*

66. BRACKLESHAM SANDS, Middle Bagshot.

Bracklesham Bay, Sussex.

Green sand from the Turritella bed, overlying the Cardita bed (No. 65), containing numerous specimens of *Turritella imbricataria* and *T. sulcifera, Cardita planicosta,* and *Ostrea flabellula.*

67. OYSTER BED, Middle Bagshot.

Bracklesham Bay, Sussex.

A mass of oysters (*Ostrea tenera*) cemented together in sand.

Nos. 64 to 67 contain in great abundance small grains of a dark-green substance, which imparts to the whole body of the sand a tint of the same colour. The following is an analysis of the green grains in question, by Professor Liveing, who states that they do not differ materially from the glauconite, or colouring matter of the Upper Greensand of Cambridgeshire, &c.*

Silica - - -	50·11
Alumina - - -	6·12
Protoxide of iron - -	25·04
Magnesia - - -	3·14
Potash - - -	5·17
Water - - -	10·02
	100·00

68. BRACKLESHAM SAND, Middle Bagshot.

Bracklesham Bay, Sussex.

Yellowish-grey sand, from the Nummulite bed, containing *Nummulites lævigatus, Cardium semigranulatum,* &c. Probably from the Park beds on the east side of Selsey Peninsula.

69. SANDY LIMESTONE, Middle Bagshot.

Bracklesham, Sussex.

This limestone forms a ledge of rocks out at sea, called the Mixen, about a mile south of Selsey Bill. It is almost entirely composed of *Foramenifera,* principally *Miliola* and *Alveolina.* Considerable quantities of the stone have been obtained at various times from the shore, and have furnished materials for Selsey church, many of the houses in the village, and between that place and Chichester.

70. IRON-ORE, Middle Bagshot.

Hengistbury Head, Christchurch Bay, Hampshire. Map 16.

Sandy clay-ironstone, with an included pebble of flint.

This ore forms layers of isolated reni-

* See Memoir on the Bracklesham Beds by the Rev. Osmond Fisher, F.G.S., in Quart. Jour. Geol. Soc., No. 70., p. 86.

form masses of large dimensions, in the Bracklesham beds of the Middle Eocene, on the coast of Hampshire. As the coast line has been worn back, the ironstone has been detached from the cliffs and fallen on the shore, where it is found in large quantities. It is also extracted from the cliffs (Map 16), and furnishes an ore of iron, which is not only valuable from the ductility of the metal it yields, but also on account of its tendency to promote the fusion of other ironstone. 5,000 tons were raised and sent to Newport, in South Wales, to be smelted, in 1860.

See Mineral Statistics for 1860, by Robert Hunt, F.R.S.

Barton Clay.

The uppermost subdivision of the Middle Bagshot Series is composed of a dark tenacious clay, for the most part greenish, and frequently sandy in places. It contains great numbers of fossils, some of which are common to the underlying Bracklesham Beds, but more to the London Clay. The formation derives its name from Barton on the coast of Hampshire, the locality where it is best exposed, and may be most conveniently examined, and its beautiful fossils collected. These are placed in Flat-cases 61 to 63.

In the London basin there is no Barton Clay; but the Upper Bagshot Sands rest immediately upon the Bracklesham Beds.

71 to 74. No specimens.

Upper Bagshot Sand.

The Bagshot Series is terminated by a mass of sands of considerable thickness, which have long been celebrated for the valuable sands obtained from Alum Bay, in the Isle of Wight, for glass-house purposes. The only fossils found in these beds are from the upper part, where a few casts of shells of marine genera, and of Barton types, have been procured by the Geological Survey.

75. Glass-house Sand, Upper Bagshot.

Alum Bay, Isle of Wight. Map 10.

This sand is largely worked in the face of the cliffs at Alum Bay. It is of great value to the glass-makers, in consequence of its purity and whiteness, and large quantities of it are supplied to the glass-houses of Bristol and London.

FLUVIO-MARINE SERIES.

The Fluvio-marine Series, as the name indicates, consists of a series of strata partly of freshwater and partly of estuary origin. They present, therefore, a marked contrast to the underlying strata, which, except the Woolwich and Reading Beds, have been deposited under purely marine conditions, as is proved by the fossils that occur towards the top of the Upper Bagshot Sand, all of which are of decided marine forms. The Fluvio-marine formation is most clearly and completely developed in the northern half of the Isle of Wight, where its whole thickness is displayed in unbroken succession, from the lowest Headon beds to those of Hempstead which crown the series. A large area is also occupied by the Fluvio-marine beds in the opposite parts of Hampshire, but, as the strata are not so well exposed there, and the section is less complete than in the Isle of Wight, the names of the various subdivisions have been taken from those of the places in the latter locality where the typical sections are best shown and may be most conveniently examined.

The fossils collected from this series are arranged in Wall-cases 54 to 58.

Headon Beds.

The Headon Series, as a whole, consists of a succession of strata of fresh-water, estuary, and marine origin. As its name indicates, it is called after Headon Hill, where the whole of the beds may be seen in the cliffs in unbroken succession, from the Upper Bagshot Sand upwards. It has been subdivided into Upper, Middle, and Lower. The Lower and Upper consist of fresh- and brackish-water beds, abounding in fossils. The limestones of these subdivisions, which form a conspicuous feature in the cliffs, especially in the upper portion, are altogether of freshwater formation, as is clearly denoted by their fossil contents. The Middle Headon Beds, on the contrary, (the "Upper Marine" of previous authors) appear to have been deposited either under brackish-water conditions, or, as in Colwell Bay, under conditions purely marine.

For the fossils of the Headon Beds, see Wall-cases 56 to 58.

76. Shelly Sand, Fluvio-marine.
Colwell Bay, Isle of Wight.
Map 10.

Green sand, cementing numerous marine fossil shells, from the "Venus bed" of the Middle Headon Series.

See H. W. Bristow's Memoir on the Isle of Wight. p. 60 and plate 4.

77. Green Shelly Sand, Fluvio-marine.
Headon Hill, Isle of Wight.
Map 10.

A soft, sandy, shelly band, containing *Ostrea* and other shells, from the "Venus bed" (another variety of No. 76.)

78. Soft Sandy Bed, Fluvio-marine.
Headon Hill, Isle of Wight.
Map 10.

Green sand, cementing univalve shells.

79. Earthy Limestone, Fluvio-marine.
Headon Hill, Isle of Wight.
Map 10.

Upper Headon limestone, of freshwater origin, with numerous shells of *Planorbis, &c.*

80. Earthy Limestone, Fluvio-marine.
Headon Hill, Isle of Wight.
Map 10.

Earthy, freshwater limestone, with numerous shells of *Limnæa, &c.*

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 H. W. Bristow's Memoir on the Isle of Wight, page 62; and plates 3 and 4. Horizontal Sections No. 47, and Vertical Sections No. 25.

Osborne Beds.

The Osborne Beds were named, by Professor Edward Forbes, after the royal demesne of Osborne; where, at the time of his visit, they were well displayed in the cliffs and grounds. They were also subdivided into St. Helen's Sands and Nettlestone Grits, the two localities in question being those where the sections may be conveniently examined, in the cliffs, and along the shore at low tides. The Osborne Beds vary very much, both in mineral character and in their fossil contents. A full account of them is given in H. W. Bristow's Memoir on Map 10, at page 65, and the nature of the beds, and the order of their succession, are shown in Plate 4.

The fossils may be seen in Wall-cases 56 to 58.

81. SANDY LIMESTONE, Fluvio-marine.

One mile E. of Ryde, Isle of Wight. Map 10.

Contains numerous casts of *Paludina lenta.*

This bed is from the Nettlestone Grit series, that is, from the lower member of the two divisions, into which the Osborne group was divided by Professor Edward Forbes. This last constitutes the upper portion of the Middle Eocene. "At the western extremity of the Isle of Wight, the Osborne Series is represented by marls and clays, for the most part unfossiliferous, which at the eastern extremity of the Island are replaced by grits and sands, with imperfect limestones, clays, and marls. At the west corner of Apley Wood a bed of calcareous sandstone, about four feet thick (full in places of casts of *Paludina*, associated with numerous large *Unio, Limnæa, Planorbis*, and occasional bones of *Turtle*) appears on the shore, beneath the sea-wall, resting on ragstone, similar to that seen at Nettlestone, where it is 10 feet or more in thickness. The shells, which are as much crowded as in Sussex Marble (No. 46 shelf 3), are sometimes filled with a greenish marl, and the rock itself is somewhat ferruginous, and of a pale ochreous colour."

See Vertical Sections No. 25., and Ed. Forbes' Memoir on the Isle of Wight. p. 128.

UPPER EOCENE.

BEMBRIDGE BEDS.

This series, comprising the Bembridge Limestone at the base, and the Bembridge Marls above, is named after Bembridge Point, the locality, in the Isle of Wight, where it is well displayed for examination on the shore and in the cliffs.

The limestone, which is well developed at Sconce, Headon Hill, Binstead, and elsewhere, is of a tufaceous character, apparently of fresh-water or sub-aërial formation, and abounding in casts of freshwater shells and of land snails. The limestone and the overlying marls spread over nearly the whole of that part of the Island which is covered by Tertiary strata, and are the most constant of all the Fluvio-marine deposits both in mineral character and fossil contents. The last are contained in Wall-case 57.

82. BEMBRIDGE LIMESTONE, Fluvio-marine.

Headon Hill, Isle of Wight. Map 10.

Contains the tooth of *Palæotherium crassum.*

The Bembridge Limestone is also known by the name of the Bulimus Limestone, from the frequent occurrence in it of the shell of *Bulimus ellipticus.* It is quarried in several places, and is of considerable importance in an economical point of view, not only on account of the good agricultural soil it affords, but because it has long furnished the best building-stone in the Island.

See Ed. Forbes' Memoir on the Fluvio-marine formation of the Isle of Wight, Plates 9 and 10, and pp. 51 to 58, and 113 to 120 ; H. W. Bristow's Memoir on Map 10, p. 71 ; also Horizontal Sections, No. 47, and Vertical Sections, No. 25.

HEMPSTEAD BEDS.

These constitute the uppermost Eocene strata in the British Isles. They were named by the late Professor Edward Forbes, who was the first to demonstrate that they formed a series of deposits higher in the geological scale than had up to that time been supposed ; and who proved the truth of his observation by the evidence of fossils, and by showing how the mistake originated which had caused the true order of succession of the upper strata of the Isle of Wight to be imperfectly understood by previous observers.

The Hempstead Beds, which only occur on the higher grounds of Hempstead and in Parkhurst Forest, may be divided into Upper, Middle, and Lower Freshwater Marls, and Corbula beds of marine origin, 15 feet thick; the latter constituting the summit of the series, the aggregate thickness of which is 170 feet.

The fossils from the Hempstead strata are contained in Wall-case 58.

83. IRON-ORE, Fluvio-marine.
Hempstead Cliff, Isle of Wight.
Map 10.
Peroxide of iron, cementing freshwater shells.

MEIOCENE.

84. BOVEY COAL, Meiocene.
Bovey-Tracey, Devonshire.

Lignite, or Brown Coal, retaining woody structure, and found associated with sands and beds of clay.

The Bovey deposits consist of sand, clay, and lignite, occupying a depression below the level of the surrounding country, and covering an area of about 10 miles in length by 2½ in breadth. The clays have been worked for potter's and pipe-clay for more than 100 years, and the greater part of the fuel used in an extensive pottery near Bovey-Tracey has been furnished by the accompanying beds of Brown Coal or lignite. The total thickness of these deposits is not known, but it has been proved, by boring, to be not less, in many places, than 130 to 150 feet, and at one spot it has been bored to a depth of 200 feet without meeting rock.

The Bovey beds have been systematically explored very recently, under the superintendence of Mr. Pengelly, and, after a careful examination of the vegetable remains, Professor Heer declares it to be his opinion that the deposits in question are decidedly of Meiocene age.

85. BROWN COAL, Meiocene.
Bruhl, Prussia.

Samples of the Brown Coal of Prussia, collected on the spot by Prof. A. C. Ramsay, and also of Meiocene age, are placed by the side of the Brown Coal of Bovey-Tracey, for the purpose of showing the similarity of these substances, which have been deposited at such a wide geographical distance from each other. The Brown Coal from Bruhl retains the appearance of the original woody matter in a very perfect manner, and might, with propriety, be called a bituminous wood.

In Germany, Belgium, and various parts of the Continent, the Brown Coal formations assume important proportions, and are largely worked near Teplitz, in Bohemia, and elsewhere, for fuel, not only for domestic use, but also for smelting and other purposes.

86. CONGLOMERATE, Meiocene.
St. Agnes Beacon (N. side), Cornwall.

Pebbles of slate, in a base chiefly composed of small quartz-grains, cemented by oxide of iron.

PLEIOCENE.

87. SILICEOUS IRONSTONE, Pleiocene.
Boughton Hill, near Canterbury, Kent.
With crystals of quartz.
Presented by William Harris, Esq.

88. SILICEOUS IRON-ORE, Pleiocene.
Ightham, Kent.
(On upper shelf.)
Part of a pipe of very siliceous Ironstone, found in beds of Iron-Sandstone, and often of considerable size.
Presented by Joseph Barling, Esq.

The age of these siliceous ironstones has been a matter of considerable discussion. By Mr. Prestwich, by whom they were first noticed, as well as by other able geologists, they have been assigned to the Crag period. This has been principally on palæontological grounds, the ironstone not having been observed in situ, but merely as a drifted substance washed out of the beds in which it was originally deposited, and subsequently left on the surface, like any other drift, or forming part of the materials which now fill potholes in the Chalk.

Crag.

The Crag formations consist, in descending order, of Norwich or Mammaliferous Crag, Red Crag, Coralline Crag.

The Coralline Crag consists, for the most part, of soft, calcareous, and marly sands, sometimes passing into a softish building-stone, and distinguished from the overlying Red Crag by its whiteness. It is a deposit of very limited extent, only attaining a thickness of about 20 feet, and occupying an area of about 20 miles long, by three or four broad, between the rivers Stour and Alde, in Suffolk.

The Red Crag seldom exceeds 40 feet in thickness, and is distinguished from the Coralline Crag by the deep ferruginous colour of its contents. When the two are in contact, the Red Crag reposes on an uneven and eroded surface of the underlying group, but when the former only is present it rests on London Clay. In either case it consists of beds of red quartzose sand and gravel, with much diagonal stratification, and occasionally intermingled with rolled, sometimes comminuted, shells.

Both groups have been formed at the bottom of shallow seas, the Coralline Crag in deeper and more tranquil water than the Red Crag, which was deposited at a much later period, after the sea had become shallower, and the climate cooler and more like that of the northern seas at the present time.

The Mammaliferous or Norwich Crag (classed by some as of Pleistocene date), consists, of beds of sand, loam, gravel, &c., containing a mixture of *land-* and *freshwater shells*, with *ichthyolites*, and *bones of mammalia*. These deposits are well exposed in the sea-cliffs at Thorpe, near Aldborough, and at Southwold, in Suffolk, and at several places on both banks of the Yare, near Norwich. In the latter localities they occur in patches of variable thickness, resting on white chalk, and with a thick covering of stratified flint-gravel.

Among the teeth and bones of mammalia which have been found, are those of the *elephant*, *rhinoceros*, *horse*, *deer*, *pig*, and *field-mouse*.

Lyell's "Manual of Elementary Geology," p. 155.

89. Coralline Crag, Pleiocene.
Suffolk.

(On upper shelf.)

A mass chiefly composed of comminuted shells, and full of *Fascicularia aurantium*; showing the surface of the sea-bed at the Coralline Crag period.

Presented by J. B. Alexander, Esq.

90. Coralline Crag, Pleiocene.
Suffolk.

A mass of comminuted *Corals*, *Echini*, and *shells*, containing a specimen of *Echinus Woodwardii*.

91. Coralline Crag, Pleiocene.
Suffolk.

Panopæa Ipsviciensis, filled with the Coralline Crag deposit; and *Terebratula grandis*.

92. Red Crag, Pleiocene.
Suffolk.

Shells, &c., from the Red Crag, consisting of *Trophon antiquum*, *Buccinum Dalei*, *Natica*, *Turritella incrassata*, *Trochus*, *Mactra*, tooth of *Carcharodon* (*Shark*).

93. Iron-ore, Red Crag.
Suffolk.
(On upper shelf.)

Sandy, concretionary layers of hydrated peroxide of iron, occurring in Red Crag.

Presented by the Rev. Professor Henslow, F.R.S.

94. Red Crag, Pleiocene.
Walton-on-the-Naze, *Suffolk.*

95. Specimen to be added.

H. W. Bristow.

Newer Pleiocene or Pleistocene, Drift, Bone Caves, &c.

Described by A. C. Ramsay.

The Newer Pleiocene formations in Britain chiefly consist of unstratified Boulder Clay, or Till, frequently overlaid by stratified Drift; and of moraines and erratic blocks in those mountain regions where the evidence of ancient glaciers is complete. In the limestone regions Bone-caves are also of frequent occurrence, containing bones of extinct and recent species of mammalia, &c.; and in some of these there have been also found flint implements, the work of man. Some of these bones probably found their way into the caves before the deposition of the *Drift*, others during its deposition, and others at later periods down to the present day.

The lower Boulder beds, or Till, occur largely in Scotland and the north of England. This formation is generally unstratified, and on a large scale is apt to partake largely of the nature of the rock on which it rests. Thus in the central part of Scotland, above the coal-fields, it is generally a stiff blue clay (with stones and boulders) derived from the waste of the Coal Measure shales. In other districts it is often more sandy. It very rarely presents any traces of stratification, and the stones and boulders with which it is charged, are scattered through it in an irregular manner, standing sometimes on their ends, or (unlike those of regular strata) lying at every possible angle to the horizon. Except that the masses generally contain an unusual quantity of clay and fine detritus, and also that they are widely spread over great tracts of country, they present, in the mode of accumulation, many of the characters of ordinary moraine-heaps, more especially of those great moraines in the north of Italy formerly shed from the large ancient glaciers of the Alps.

This Boulder Clay was formerly considered to have been deposited from icebergs and other floating ice, and was in some degree confounded with later drifts. But there is no authentic case of marine shells or other organic remains having been found in it, and, indeed, it appears to have been formed by terrestrial glacial action at that period when, like Greenland, the greater part of the country was covered with glacier-ice. A large proportion of the stones and boulders in it are striated and scratched.

For further particulars, see pp. 185 and 191 and Table-case C.

96. SCRATCHED STONES. Boulder Clay.

Balgothrie, Lomonds of Fife, Scotland.

A considerable part of Fife is covered with unstratified Boulder Clay, and among the hills are lakes in true rock-basins formed by the excavating power of glacier ice in motion. See p. 201.

Many of the Bone-caves were partly filled with bones before the deposition of the upper ***stratified drift,*** and examples of these are therefore inserted in this Case between the two.

97. BONE BRECCIA, Bone Cave, 2 specimens.

Cefn, Flintshire.

Sandy clay, with stones, and mammalian bones much decomposed.

Cefn Cave was first explored by the Rev. Edward Stanley (late Bishop of Norwich) in 1832. (See Proc. Geol. Soc. I., p. 402. Phil. Mag. Series 3, I. p. 232. Edin. N. Phil. Jour. xiv., p. 40.) It lies in the Carboniferous Limestone of Denbighshire, near St. Asaph, in the Vale of Cyffredan, on the west side of the Vale of Elwy. It is on the side, and near the top, of a steep escarpment overlooking the river. Most of the bones were probably dragged in by beasts of prey, of which it served as the den, others may have dropped in through cracks in the roof. The following species named by Dr. Falconer have been observed, many of which were in the possession of the late Lieut.-Colonel Watkins Wynne, on whose property the cave lies.

Elephas antiquus.
Rhinoceros hemitœchus.
Rhinoceros tichorinus.
Hippopotamus major.
Bos cervus, &c.

No human remains have been found in it; but human bones have been found at a lower level, in the base of the same escarpment.

In the Vale of Clwyd there is much stratified drift, with ice-scratched boulders and sea-shells, and the cave has clearly been submerged during that period when it has been filled with clay, gravel, and stones, in which Dr. Falconer and myself found fragments of cockles and other marine shells.

The following specimens are from these deposits.

98. SAND AND CLAY, Bone Cave.

Cefn, St. Asaph.

One foot above the natural floor of the cave, and 4 ft. below the present floor.

99. FINE STRATIFIED CLAY, Bone Cave.

Cefn.

3 ft. above natural floor, 2 ft. below present floor.

100. FINE SAND AND CLAY, Bone Cave.

Cefn.

2 ft. above rock, 3 ft. below present surface.

101. SAND AND CLAY, Bone Cave.

Cefn.

3 ft. 6 in. above natural floor, 1 ft. 6 in below present.

102. SAND AND GRAVEL, WITH FRAGMENTS OF SHELLS, Bone Cave.

Cefn.

103. SAND FROM ROOF OF CAVE.

Cefn.

11 ft. above present floor.

104. ICE-SCRATCHED STONE, Stratified Drift.
Bryn Elwy, Vale of Clwyd, Flintshire.

105. ICE-SCRATCHED STONES, Stratified Drift.
Bryn Elwy, Vale of Clwyd.

106. SHELLS FROM THE DRIFT, Stratified Drift.
Bryn Elwy, Vale of Clwyd.

From the same strata as 104 and 105.

These strata in great part cover the Vale of Clwyd, concealing the underlying New Red Sandstone. The drift, of which these deposits form a part, rises 2,300 ft. on the mountains of North Wales. See p. 192.

107. SHELLS from Deposits overlying Glacial Drift.
Quebec, Canada.

The strata in which these shells occur, consist in great part of *remodelled drift*, made during the erosion of terraces while the country was being re-elevated from the sea.

These are placed here for comparison. See p. 201.

108. PEBBLES FROM BONE CAVE.
Brixham, Devonshire.

This cave was opened in the year 1858. It lies in the Devonian Limestone, on the hill-side above the town. A layer of stalagmite covered the *Cave-earth* with stones, and on this stalagmite, and partially imbedded in it, lay the horns of a reindeer (*Cervus tarandus*). In the red cave-earth below were found the bones of bears, *Ursus spelæus*, *Rhinoceros tichorinus*, *Elephas primigenius*, *Hyæna spelæa*, *Lagomis ogotonna*, *Cervus Tarandus*, *C. elephas*, *Capreolus*, *Canis lupus*, *Bos primigenius*, &c.; and, along with these, flint-knives.

In the neighbouring cave of Kent's Hole, near Torquay, many flint-knives were found underneath the stalagmite and apparently along with the bones of extinct mammalia, but at the time no precise record was kept of the mode of their occurrence. Another bone cave, on the southern flanks of the Mendip Hills, at Wookey-Hole in Somersetshire, has been described by Mr. Dawkins in the Quarterly Journal of the Geological Society. (See vol. xviii., p. 115). It also contains flint implements, and others occur in Gower, Glamorganshire, excavated by Major Wood, containing human works along with the bones of extinct species of mammalia.

109. STALAGMITE, Bone Cave.
Brixham, Devonshire.

It was in this stalagmite, forming the floor of the bone-cave, that the reindeer horns were found.

110. STALAGMITE, Bone Cave.
Brixham, Devonshire.

Calcareous deposit on Devonian Limestone; found lying on the floor of a bone cave.

111. STALAGMITIC CONGLOMERATE, Bone Cave.
Gower, near Swansea, Glamorganshire.

Rounded pebbles of Carboniferous Limestone imbedded in stalagmitic carbonate of lime, and forming the floor of a bone cave called Bacon-Hole.

The low country in the east of England, north of the Thames, and all Wales, is more or less covered with drift, but the south of England (Weald), and the country south of the Bristol Channel, is in general destitute of it, except at very low levels, on and near the shore at Brighton, Selsey Bill, &c. See p. 201.

112. DRIFT CLAY.
Hitcham, Suffolk.

Clay containing small rounded fragments of chalk. It forms a part of the *Drift* of Suffolk, and is used for making bricks.

Presented by Captain Ibbetson R.R.E.

113. ICE-SCRATCHED CHALK FLINT.
Hitcham, Suffolk.

Shows scratched surface. Has been fractured previously to the deposition of the drift.

Presented by the Rev. Professor Henslow.

114. FLINT.
Swaffham, Norfolk.

Exhibiting agatiform structure in cracks.

115. Waterworn Flint.
Swaffham, Norfolk.
With white spots, and showing a conchoidal fracture

116. Calcareous Sandstone.
Waterbeach, Sussex.
From fine and regularly stratified sand, with recent shells, overlying Chalk, at Waterbeach sandpit, near the S.E. corner of Goodwood Park. This sand, except that is "recent," it is of unknown date. It contains thin seams of very hard, tabular sandstone, like No. 116, sometimes covered with numerous small, blunt projecting points. The shells are of marine species, and comprise *Mytilus edulis*, *Cardium edule*, *Purpura lapillus*, *Balanus porcatus*, *Echinocyamus pusillus*, with *Foramenifera*, &c.
See Quart. Jour. Geol. Soc. vol. xv. p. 218.

In certain "low level gravels" at Hcxne, in Suffolk ; on the Ouse, near Bedford ; at the Reculvers, Kent, &c. ; teeth of *Elephas primigenius* have been found along with flint-hatchets, similar to those found at Abbeville, Amiens, &c. in France. These have been described by Mons. Boucher de Perthes, Mr. Prestwich, and Mr. John Evans. The gravels are formed of re-modelled Drift, and are of comparatively late date. For specimens of these and similar implements, see Table-case 36, in the floor below, opposite, near the bronze head of Melpomene.—A. C. Ramsay.

Arranged and described by Henry W. Bristow.

117. Conglomerate.
Hertfordshire.
(On upper shelf.)
Polished conglomerate, locally called "Hertfordshire Puddingstone," composed of flint-pebbles in a siliceous base, blocks of which are found scattered over the surface of the chalk district of Hertfordshire, &c.
They are, most probably, the remains of the Lower Eocene strata (Woolwich and Reading Beds) that once spread over that district.
See Prestwich in Quart. Jour. Geol. Soc. vol. x. p. 1.

118. Conglomerate.
Hertfordshire.
(On upper shelf.)
Conglomerate or puddingstone, composed of flint-pebbles in a siliceous base stained with peroxide of iron. Some of the pebbles are cleaved.

119. Conglomerate.
Hordwell, Hampshire.
(On upper shelf.)
Conglomerate or puddingstone, composed of rounded pebbles of chalk-flints in a siliceous base ; from the diluvial gravel-bed on *Hordwell Cliff.*

Wall-case 7.

Raised Beaches, &c.

120. Conglomerate, Pleistocene.
Near New Quay, Cornwall.
Raised beach, composed of rounded pebbles of slate and white quartz in a calcareous base consisting, chiefly, of comminuted sea-shells. Part of a consolidated, raised beach.
(See "Report on the Geology of Cornwall," &c., by Sir H. T. De la Beche, pp. 426, 427, and 431 ; and "Geological Observer," pp. 456, 457.)

121. Fine Conglomerate, Pleistocene.
Bareppa Cove, Falmouth Bay, Cornwall.
Part of a raised beach, composed of pebbles and grains of quartz and slate, cemented by oxide of iron.
(See De la Beche's "Report on the Geology of Cornwall," p. 432.)

122. Recent Conglomerate.

Bill of Portland, Dorset. Map 17.

Part of a raised beach, composed of waterworn siliceous pebbles, and broken stones, &c., (mostly flint,) cemented together by lime, derived from the calcareous beds of the Purbeck and Portland formations. This old beach, which is now raised several feet above the level of the highest tides, extends about a quarter of a mile inland.

Quar. Jour. Geol. Soc. vol. viii. p. 110.

R. Damon's "Handbook to the Geology of Weymouth," page 141.

123. Conglomerate, Pleistocene.

Hopes Nose, N. of Tor Bay, Devonshire. Map 22.

Part of a raised beach, composed of recent shells, and pebbles of limestone, quartz, &c., cemented together into a compact mass by calcareous matter.

124. Conglomerate, Pleistocene.

East Wear Bay, Folkestone, Kent.

Part of a beach composed of rounded pebbles of chalk-flints, cemented together by carbonate of lime.

This conglomerate appears to be formed of the ordinary beach-pebbles between high-water mark and the level of the highest spring tides. The cementing matter is the water which flows from the land into the sea, and deposits the calcareous matter which it had dissolved out of the Lower Chalk Marl.

An artificial conglomerate, made of the same materials, has been employed in the construction of Dover harbour.

125. Part of a Consolidated Recent Beach now in process of formation.

Red Wharf Bay, Anglesea.

The consolidation is a result of the percolation of carbonated water, which dissolves part of the lime of the shells, and evaporating, re-deposits it among the fragments of stone and shell, thus uniting them together with calcareous matter.

Presented by Mr. J. D. T. Niblet.

126. Recent Marine Shells, from a raised beach.

Neighbourhood of St. Andrew's, Scotland.

127. Consolidated Raised Beach, composed of recent marine shells, and cemented by calcareous matter.

This deposit forms a small compact bed, in a horizontal cleft of a rock, 40 feet 10 inches above the present high-water mark, on the eastern shore of the island of *Kerera*, near *Oban, Argyleshire, Scotland.*

128. Part of a Raised Beach.

Island of Kerera, Argyleshire.

Composed of pebbles and recent shells, but for the most part of comminuted shells; the whole cemented together by carbonate of lime.

Nos. 127 and 128 were presented by Commander E. J. Bedford, R.N.

129. Fine Conglomerate, chiefly composed of small pebbles of quartz.

Hemmick Beach, Cornwall.

Loose sand, washed up by the sea, in a small recess close to the Cottages, near the Dead Man Point.

The sand fills a recess in the cliff, and masses of it are cemented together by the water, charged with calcareous matter, which issues from a dripping stream that flows from above.

Presented by Edwd. B. Fitton, Esq.

130. Conglomerate, Low-level Gravel.

Kippernham, near Romsey, Hampshire. Map 11.

Ferruginous and siliceous conglomerate, formed of angular and subangular pebbles of chalk-flint imbedded in a ferruginous base.

The low-level gravel in the neighbourhood of Romsey is of considerable thickness, and is used for making the roads of the district. The specimen furnishes a striking example of the manner in which sand, gravel, and other naturally loose and incoherent materials, become hardened and consolidated into sandstones, grits, conglomerates, &c. by the cementing power of iron, and exposure to the atmosphere. Portions of gravel, owing to the presence of iron, are occasionally converted into masses of hard conglomerate and puddingstone, as may be seen in the road at Kippernham, whence the specimen was procured.

131. Conglomerate.

South Wales.

Composed of large rounded pebbles of sandstone, imbedded in a ferruginous base.

132. Breccia.

Box Hill, Surrey.

Angular fragments of chalk, cemented together by carbonate of lime.

The cementing calcareous matter has been carried away in solution, by infiltrating water, out of beds of chalk situated at a higher level, and deposited on the broken fragments by the evaporation of the water. The specimen was taken from a road-cutting on the S.W. side of Box Hill, and presented by Mr. Grantham, C.E.

133. Rounded Pebbles.

Chesil Beach, midway between Abbotsbury and Burton Bradstock, Dorsetshire. Map 17.

The Chesil Bank, on the coast of Dorsetshire, affords a good example of the driving forward of shingle, in a particular direction, by breakers, produced by the action of prevalent winds. It is nearly 15 miles long, connecting the Isle of Portland with the mainland, and for about eight miles from the island is backed by a narrow belt of tidal water, known as the Fleet. From its position, the heavy swells and seas from the Atlantic often break furiously on this bank, which protects land that would otherwise soon be removed by them.

In this instance, also, we seem to have an example of the Atlantic breakers not having reached the land behind, prior to the formation of the beach, since the relative levels of the sea and land were such as we now find them. A gradual sinking of the coast would appear to afford an explanation of the phenomena observed. (De la Beche's "Geological Observer," 2nd edition, p. 56.)

The pebbles are based, near the Isle of Portland, upon tenacious Kimeridge Clay, which is frequently laid bare after heavy gales from the eastward, when the beach is often swept away in places. It is, however, soon restored, under the piling influence of westerly winds, to its original height, which, opposite Abbotsbury, nearly midway between its two extremities, is about 40 feet. Its breadth, at ordinary low tides, has been computed by Mr. Coode at 170 yards near Abbotsbury, and at Portland at 200 yards.

The pebbles forming the bank are derived from rocks situated to the westward, and gradually increase in size in an easterly direction, that is, towards the Isle of Portland, the reason of which is, that the larger pebbles, presenting a broader surface to the action of the wind and waves, are driven forward more rapidly than the smaller stones. Examples of this action are frequently afforded by very rapid brooks, where the larger stones may be seen to be pushed onwards by the force of the stream, while those of less size remain comparatively quiescent.

The variation in the size of the pebbles forming the Chesil Bank is well known to the people of the adjacent coast. It is said by them, that persons familiar with it can tell the exact position of any part on which they may happen to land on the darkest night, merely by feeling the size of the pebbles forming the beach.

At Abbotsbury the pebbles are only slightly larger than coarse gravel, but towards Portland they are from one to three inches in diameter, with occasionally some of larger dimensions.

(See Damon's Handbook to the Geology of Weymouth, and the Island of Portland, page 154.)

134. Calcareous Concretion.

Ilford, Essex.

These calcareous concretions are termed "Race" by the workmen. They occur in interrupted zones, in the Brick-earth, interstratified with mammalian bones, and land- and freshwater shells.

135. Calcareous Concretion.

Erith, Kent. Map 1, S.W.

Calcareous concretionary matter formed round a bone. It is called "Hard Race" by the workmen.

From the Brick-earth of the Thames Valley, at the large brickyard near Erith.

136. Clay, containing recent shells, *Cardium*, *Natica*, &c.

Outside the Chesil Beach, Weymouth, Dorset. Map 17.

Compare with Nos. 70 and 71, Wall-case 46. Under favourable circumstances the shells of No. 136 might become fossilized like those of Nos. 70 and 71.

Stalactites, Stalagmites, Travertines, Tufas, Aragonite, and other Calcareous Deposits and Incrustations.

Nos. 137 to 158 chiefly consist of specimens illustrating the manner in which depositions of carbonate of lime (limestone) are formed from a bi-carbonate of lime in solution in water. All rain-water contains carbonic acid, which it abstracts from the air. Such part of the water as percolates through rocks containing lime is thus enabled to form a soluble bi-carbonate, and rising in springs or dropping from the roofs of caverns, evaporation takes place, and a portion of this mineral is deposited in the form of *calcareous tufas, stalactites, stalagmites, &c.* A familiar illustration occurs in the stalactitic pendants hanging like icicles from the arches of almost every stone-bridge. In the same manner *stalagmites* are formed by the dropping and evaporation of calcareous water on the floors of caverns, &c., and *calcareous tufas* are frequently formed in the open air by the evaporation of the water which flows over the surface from springs highly charged with lime. The bones of many animals, mostly extinct species, have been preserved in numerous caves in the limestone-rocks of Great Britain, partly through the agency of stalagmitic crusts, which cover up the clays, gravels, &c. in which they lie, and protect them from the air. Nos. 137 to 142 especially illustrate the formation of *stalactites* and *stalagmites.*—A. C. R.

Nos. 137, 138, and 139, are hung in the natural pendent position of a stalactite, and No. 142 is placed flat, to show the manner in which such stalactites and stalagmites are frequently formed, by the evaporation of dropping water containing lime in solution.

The term *Calcareous Tufa* is applied to the loose and friable varieties of carbonate of lime, deposited in and about waters which are charged with lime.

The name *Travertine* is restricted to the harder and more compact kinds of calcareous Tufa, formed by the evaporation of water holding lime in solution, on the sides of rivers, waterfalls, &c. Large deposits of such a nature are formed by some of the rivers and springs of Italy. (See Bristow's Glossary of Mineralogy. Longman.)

Travertines and *Tufas*, being both formed in the open air, frequently incrust mosses, grasses, leaves, stems of plants, land- and freshwater shells, &c., which thus become fossilized before our eyes.

The tufaceous deposits from No. 143 to 150 are all comparatively recent, and inclose plants and shells of living species.

Laminated and crystalline aggregations of various substances are in an analogous manner, frequently formed in the interior of lodes, and other cavities. (See Nos. 172 and 173.)

137. Stalactite.

Stalactitic Carbonate of Lime obtained in 1804, from the "*Blue John Mine,*" *Derbyshire.*

Presented by Richard Phillips, F.R.S.

138. Concretionary Stalactite.

Matlock, Derbyshire.

139. Stalactite.

Forest of Dean, Gloucestershire.

From *Carboniferous Limestone,* and stained of a red colour by iron.

Nos. 137, 138, and 139 are placed in their natural pendant state, in the positions in which they were formed.

140. Long columnar STALACTITE, composed of concentric layers of carbonate of lime.

141. STALACTITE.
Derbyshire.
(On upper shelf.)
Longitudinal polished section of a large stalactite, showing the mode of formation, by the deposit of successive layers of calcareous matter.
Presented by Prof. Tennant, F.G.S.

142. STALAGMITE.
Radiating crystals of *carbonate of lime*, producing a mammillated surface.

143. CALCAREOUS TUFA.
Tolland's Bay, Isle of Wight. Map 10.
Deposited on the Fluvio-marine strata of Tolland's Bay, in the Isle of Wight. Contains concentric concretions of carbonate of lime, together with numerous *land- and freshwater shells* of existing species.
See H. W. Bristow's Memoir on the Isle of Wight, p. 98; and Vertical Sections No. 25.

144. CALCAREOUS TUFA, encasing plants.
Richmond, Yorkshire.

145. CALCAREOUS TUFA.
Near Llangollen, Denbighshire.
Deposited upon *Carboniferous Limestone* by old springs now dried, and containing *stems and leaves of plants* with *land-shells.*

146. CALCAREOUS TUFA.
Near Newbury, Berkshire. Map 12.
A loose, greyish-white, tufaceous deposit, locally called *malm*, and alternating with the peat which occurs in the alluvium of the Kennet, in Berkshire. It rests on low-level gravel, and contains numerous shells of land- and freshwater snails of existing species.
See Bristow and Whitaker's Memoir on Map 12, pp. 47 to 51.

147. BOG WOOD.
Newbury, Berkshire. Map. 12.
From the peat forming the alluvium of the Valley of the Kennet, and taken from a depth of about 7 feet from the surface.
Trunks of trees, sometimes six or eight inches in diameter, are found in the peat, and branches and other remains of oak, alder, willow, fir, birch, and hazel, together with mosses, reeds, and equiseta.
See Memoir on Map 12, pp. 47 to 51.

148. CALCAREOUS TUFA.
Great Northern Railway.
Incrusting stems of plants.
Presented by Thomas Reynolds, Esq.

149. TRAVERTINE OR CALCAREOUS TUFA.
Matlock, Derbyshire.
Contains the impression of a leaf.
See also Table-case in Recess 6, Nos. 206 to 223.

150. TRAVERTINE.
Probably from *Matlock.*
Calcareous incrustations deposited upon the leaves of a tree.

151. TRAVERTINE.
Probably from *Matlock.*
Calcareous deposit on the branches of an oak-tree.

152. MEDALLION.
Springs of San Filippo, near Radicofani, Tuscany.
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 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.

153. CALCAREOUS DEPOSIT.
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.

154. CALCAREOUS DEPOSIT.
Carbonate of lime deposited in the interior of a lead pipe.

155. CALCAREOUS DEPOSIT.
Formed in the interior of an earthenware pipe.

156. CALCAREOUS DEPOSIT.
Formed in the condenser of a steam-engine, and obtained by John Dawes, Esq., Smethwick House, near Birmingham.

157. CALCAREOUS DEPOSIT.
Pen-y-darren, Glamorganshire.
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.
Presented by Mr. M. Moggeridge.

158. CALCAREOUS DEPOSIT.
Frome, Somerset.
Formed on the heads of rivets, in the interior of a boiler, at Mr. Sheppard's cloth factory.

ARAGONITE.

"Aragonite differs from Calcareous Spar in its greater hardness and specific gravity, and in containing generally from ½ to 4 per cent. of carbonate of strontia, a little water, and more rarely from 2 to 4 per cent. of carbonate of lead. Analysis from Aragon, by Stromeyer.

Carbonate of lime - -	94·82
Carbonate of strontia - -	4·08
Water - - -	0·98
	99·88

Flos Ferri, or *Flower of Iron*, is the name given to the branching or coralloid form of Aragonite by the older mineralogists, by whom it was considered to be an ore of iron.

The name *Satin Spar* is given to a fibrous variety of Aragonite, which, when polished, has a satiny lustre, and is, on that account, employed in the manufacture of ornaments. It is found at Dufton, in Cumberland, in thin veins, traversing shale, and generally accompanied by iron pyrites." (Bristow's Glossary of Mineralogy, p. 25. Longman.)

159. CORALLOID ARAGONITE, or *Flos-ferri*, on Clay-slate.
Ilfracombe, Devon.
Presented by T. Richardson.

160. STALACTITIC ARAGONITE, on Clay-slate.
Ilfracombe, Devonshire.
Presented by T. Richardson.

161. FIBROUS ARAGONITE, with veins of Calcareous Spar.
Alston Moor, Cumberland.

162. STALAGMITE, OR STALACTITE.
Aden.
Formed by the deposition of carbonate of lime upon botryoidal Chalcedony.
Presented by the East India Company.

163. ARAGONITE (*polished*).
Ilfracombe, Devonshire.
Presented by Thomas Reynolds.

AËRIAL ACCUMULATIONS.

BLOWN SAND.

Along most low sandy coasts considerable accumulations of drifted sand take place, forming hills, or "dunes," as they are commonly called, which often attain considerable height.

This effect is produced by the action of the wind driving before it, when it blows towards the land, the sand upon the shore, which it piles up into hills, which "have been described as advancing on the low shores of France, in the Bay of Biscay, at the rate of 60 and 70 feet per annum, overwhelming houses and farms in their progress." Jukes' Student's Manual of Geology, 2nd edit. p. 154.

Sometimes the sand is composed largely of fragments of shells and coral, which then (as on the coast of Cornwall, and Western Australia, for instance) become converted by the action of rain-water dissolving some of the carbonate of lime, and re-depositing it on evaporation, into a compact stone, hard enough to be used for building.

164. BLOWN SAND.
Hayling Island, Hampshire. Map 11.
Forms low hills at the south-west corner of the island.

165. GRANITE.
Near the Land's End, Cornwall.
Flat piece of Granite, with the surface worn irregularly into furrows by the action of Blown Sand drifting before the wind, through a deep glen opening into Whitesand Bay.

166. A LOOSE STONE OF GRANITE rounded by the action of drifting sand.
Near Whitesand Bay, Land's End, Cornwall.

AGGLUTINATIONS.

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

168. CONGLOMERATE.
Wall-case 6, upper shelf.
Principally composed of siliceous pebbles, agglutinated by a ferruginous cement round the tire of a wheel.

169. CONGLOMERATE.
East Coast.
Composed of flint pebbles and sand, agglutinated by a ferruginous cement round a wooden pile with an iron head.

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

171. 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. 170 and 171) are placed here to illustrate the rapid destruction of iron by the process of oxidation or rusting, leaving a spongy mass of graphite or impure carbon, No. 171.

Laminated and crystalline aggregations of various substances are in an analogous manner frequently formed in the interior of lodes, and other cavities. (See Nos. 172 and 173.)

172. PART OF A LODE.
(On upper shelf.)
Angular fragments of *limestone*, cemented together and encrusted with crystals of *calcareous spar*.
Presented by Dr. Lyon Playfair, C.B.

173. SAND, *agglutinated by carbonate of copper*, derived from the decomposition of the ores in heaps of refuse.
Huel Leisure, Cornwall.
(On upper shelf.)
In this case the sulphide of copper was partly decomposed, and carried away in solution by water percolating 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.

H. W. BRISTOW.

Table-case C.

ARRANGED AND DESCRIBED BY A. C. RAMSAY, F.R.S.

SPECIMENS ILLUSTRATIVE OF PHENOMENA CONNECTED WITH GLACIERS AND FLOATING ICE.

Specimens No. 1 to 56 were chiefly collected by M. Daniel Dolfuss-Ausset. No. 1 to 39 are illustrative of *existing Alpine glaciers*, and of their former extension.

No. 50 to 56 are derived from the remains of the *newer Pliocene glaciers of the Vosges*, and some of them are from the neighbourhood of Mulhouse, &c., &c.

No. 60 to 85 were collected by Mr. A. C. Ramsay, to illustrate the *newer Pleiocene glaciers* and other points connected with glacial action in *Caernarvonshire and Anglesey*. No. 87, from the drift, was presented by Mr. Thomas Barton; 88 and 89 by the Rev. John Gunn; 90 (3 specimens) by Mr. James Nasmyth; 91 (3 specimens of scratched flints), by the late Rev. Professor Henslow; and 93 to 106 by Colonel Legge. No. 107 (several specimens collected by Mr. A. C. Ramsay) illustrate the ice-drift of the south coast of England; and Nos. 108 to 113 are chiefly from *roches moutonnées*, and other ice-scratched surfaces of rock that underlie the northern drift of Scotland and North America, collected by Mr. Ramsay, except No. 110, from Skye, which was presented by the Rev. S. W. King.

No. 120 to 155 were collected partly by Mr. Ramsay, and Mr. R. 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 are produced by the drainage of this snow, which, in its passage downward, in consequence of the pressure consequent on the accumulation of snow, and partly by alternating thaws and 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 abrupt like a cataract. A large glacier passes down these slopes in a manner that may be compared to a broad and deep river of ice. Accordingly the whole mass bends and accommodates itself to the sinuosities and varying width of the valley, and its rate of progression has been ascertained, when the valley is straight, to be fastest in the middle and slowest at the sides; or, when curved, to be most rapid in a line nearer the convex side of the valley. Without explaining the nature of several theories, now exploded, it may be sufficient to mention that in 1842, Professor Peter Merian of Basel attributes the motion of glaciers to the general pressure of the mass, the wetness of the bottom of the ice facilitating slipping, &c. He, however, objects to the theory that the surface moves faster than the bottom, and in a paragraph on the effect of the unequal slopes over which glaciers flow, he remarks that crevasses are formed in consequence of the "upper ice" (that further up the valley) being retarded or flowing slowly, while the "lower ice" (that at the points of fracture) proceeds without check. "A short distance below the obstacle, however, these fractures are completely closed up again, . . . for this reason, that two pieces of glacier ice unite when pressed together, the glacier again forming an unbroken mass when the cracks have re-closed by pressure." (Bericht über die Verhandlungen der Naturforschenden Geselschaft in Basel 1840–42, p. 156.) Professor J. D. Forbes' theory of glacier motion (Travels in the Alps 1845) is this :—"*A glacier is an imperfect fluid, or a viscuous body, which is urged down slopes of a certain inclination by the mutual pressure of its parts.*" It has again lately been maintained by Professor Tyndall, who was unaware of Professor Merian's paper, that the progressive motion of glaciers is not due to a viscous movement in the strict sense of the term, but to numerous and repeated fractures of the entire mass, and to rapid regelation by pressure, by which means the general continuity of the glacier is maintained. The entire body of a glacier a short distance below the surface all the year round maintains a temperature of about 32° Fahr.: and in summer, on the surface of a glacier there is much waste by thawing. At the lower extremity it is finally dissolved by the heat. This waste is replenished by the fall of snow on the high grounds, and thus 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 margins of glaciers from the mountains and from solid rocky masses that project above the ice, and as it progresses, these are carried, as it were, floating on the surface in long, regular, and often broad lines, termed moraines. Where the ice of two valleys coalesces, two of these side moraines unite, and generally form one central moraine, which passes down the mid-surface of the glacier. Where glaciers finally melt at their lower extremities curved *terminal moraines* are formed by the stones and finer substances, that find their way so far, and are there shed by the glaciers.

The surfaces of glaciers are seamed by *crevasses*, or small and large cracks caused by tension, which is in places due to the passage of the ice over the unequal floors of the valleys, so that parts of the mass are torn asunder during the onward progress of the whole. Into these, stones from the surface frequently fall, and mud and other fine sediments are washed into them by running water, that, during the heats of summer, often forms actual brooks upon the ice. These substances often find their way to the bottom of the ice, and the finer siliceous and other materials, acting like emery powder between the moving mass 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 ends of the glaciers. In Switzerland, the Himalaya, &c., *roches moutonnées* and *moraines* are found for immense distances beyond the limits of existing glaciers, and all the *signs of glaciers* often force themselves on the notice in mountain regions where they have altogether disappeared, probably since the newer Pliocene or glacial epoch. These signs are *roches moutonnées*, often covered with *ice-borne boulders* ("*blocs perchés*"), *scratched*, *striated*, and *grooved surfaces*, and numerous *moraines*, sometimes as perfect as those that fringe the sides and ends of existing Alpine glaciers. Appearances of the kind adverted to are frequent in the mountains of the Jura, the Vosges, the Black Forest, Ireland, the Highlands of Scotland, and Wales. Specimens from the moraines of the Alps, the Vosges, and Wales, are deposited in this Case.

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

1. FINE MORAINE CLAY, *in place.*

Near the Lower Glacier of the Aar.

Derived from the Finster Aar Horn, in a heap on a rock 9,100 feet above the sea, near the *lower glacier of Trift*. This glacier is nearly two miles east of the "Pavilion," 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.

Lower Glacier of the Aar.

Derived from the Finster Aar Horn? in little heaps on the surface of the glacier, below the Pavilion.

3. DARK MORAINE CLAY.

In heaps of many cwts. in motion on the Lower Glacier of the Aar.

As in No. 2, west of the Pavilion.

4. QUARTZOSE SAND AND FINE GRAVEL.

Lower Aar Glacier.

Derived from the Finster Aar Horn? left by a block of ice upset on the left bank of the glacier, below the Pavilion.

5. SANDY GRAVEL, covering a large gravelly cone on the glacier *of the Lower Aar*, 1½ miles from its terminal declivity.

These cones of ice are generally regular in form, steep on the sides, and often 5 to 10 feet in height. They originate in any stone or heap of earth or stones placed on the ice, so as to protect it from the heat of the sun. From the same cause moraines on the ice are convex. The cones are sometimes formed as follows:—Into slight hollows in the ice, mud, sand, and gravel are washed; this in sunny weather absorbs heat, and aids in melting the ice, so as to increase the depth 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 dissolving, the inverted cone becomes by degrees converted into an erect one, protected for a time from external heat by a covering of mud, sand, and fine gravel.

6. VERY FINE SILICEOUS SAND.

Lower Aar Glacier.

Derived from the *Finster Aar Horn*? lying on a rock in place, touching the ice on the left bank of the glacier, below the Pavilion.

Illustrations of the former longitudinal 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. FINEST SAND, separated by suspension in water (derived as in No. 7).

From a moraine on the left bank of the *Aarboden*, 1,625 feet beyond the present terminal slope of the glacier.

9. FINE SAND, separated by the sieve.
From moraine, as in No. 7.

10. SAND, separated by the sieve.
From moraine, as in No. 7.

11. FINE ANGULAR GRAVEL.
As in No. 7.

12. FINE ANGULAR GRAVEL, separated by the sieve.
From moraine, as in No. 7.

13. FINE YELLOW MORAINE SAND.
Between the Grimsel and the glacier, 5,850 feet above the sea; at the bridge, on the right and left banks, at the efflux of the Aar from the stony plain, 30 to 50 feet above the Aar.

More ancient extension of the Aar and Rhone glaciers.

14. MORAINE MUD, SAND, AND FINE ANGULAR GRAVEL, in place.
Roderichsboden between the *Grimsel* and *Handeck*, 33 feet above the level of the torrent, left bank.

15. MORAINE MUD, SAND, AND FINE ANGULAR GRAVEL.
Chalets of Handeck, Oberhasli, on the Grimsel road, 4,616 feet above the sea.

16. MORAINE MUD AND ANGULAR GRAVEL, containing very large erratic blocks.
Kirchet, near Meyringen, Oberhasli.

17. FINE MORAINE CLAY.
From a moraine containing blocks and rounded and angular pebbles, scratched and polished, *on a roche moutonnée. Left bank of the Aar, at the Tiefenau bridge, on the road to Berne.*

18. MORAINE CLAY.
About $\frac{3}{4}$ of a mile N. of Solothurn.
Containing scratched Alpine pebbles, and covering ice-polished limestone in a quarry. About 40 English miles from the nearest glaciers of the Bernese Alps. Deposited by the ancient glacier of the Rhone.

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

19. BLOWN SEA SAND.
Dunes of Bayonne, France.

20. SEA SAND.
Mediterranean, Barcelona, Spain.

21. FINE SEA GRAVEL.
Mediterranean, 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.—Glaciers of the Aar.

22. GRANITIC GNEISS.
At the Pavilion, 263 feet above the *Lower Aar Glacier*.
Polished and striated, in place.

23. QUARTZ.
Upper Aar Glacier, 547 yards from its lower end.
Polished, in place.

24. GRANITIC GNEISS.
Polished by the isolated glacier of the *Helle-Platte, Handeck, Oberhasli.*

25. QUARTZ.
"*Lac des Morts*," *The Grimsel.*
Polished and striated, from a rock in place.

26. SERPENTINE, POLISHED AND STRIATED.

Gorner Glacier, near the *Riffelberg, Zermatt*.

Presented by Dr. Sibson.

27. LIMESTONE ROCK.

Polished and striated, in place, at the quarry of *Baumann*, about three-quarters of a mile from *Solothurn*.

Moraine matter from the Alps covers this rock, containing polished and striated pebbles of Alpine limestone, touching the "*roche moutonnée*." This moraine was deposited by the great old glacier of the Rhone, which at its largest overspread great part of the lowlands of Switzerland, and abutted on the Jura.

28. CONGLOMERATE.

In place; *Hill of Chardonne, near Vevey*, 547 *yards above Torgni*.

Polished and striated by the Old Rhone Glacier, and covered by 4 feet 8 inches of moraine matter.

NOS. 29 to 39 show the appearance of some of the stones in motion on the surface, and under the ice of the glaciers or that have been, or are inferred to have been transported by glaciers.

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

Many of the smaller blocks, stones, and gravels in the moraines of the great old glaciers, such as those of the Rhone glacier at Monthey, on the Jura, and in the great moraine near Ivrea, are rounded and waterworn, and in places parts of the moraine are rudely and sometimes well stratified for short distances. Frequently at the sides and on the larger moraines of existing glaciers, pools and small lakes are formed, and stratified matter is deposited in them, which may afterwards be buried under ordinary moraine heaps.

30. PARTLY ROUNDED AND SUBANGULAR STONES OF GRANITIC GNEISS.

In motion on moraine of the lower Glacier of the Aar.

31. PART OF A PEBBLE OF WATERWORN LIMESTONE.

Taken from under *the Glacier of Rosenlaui*.

32. ANGULAR STONES WITH NATURAL FRACTURES.

From moraine in motion near the junction of the *Finster Aar and Lower Aar Glaciers*.

Presented by A. C. Ramsay.

33. ANGULAR STONES, like No. 32.

Upper Grindelwald Glacier.

34. GRANITE PEBBLE, rounded and waterworn.

One of many rounded and angular stones in motion; on the *side-moraine, Upper Grindelwald Glacier*.

Presented by A. C. Ramsay.

These specimens (32 and 33) are intended to illustrate the angularity of the majority of moraine stones on the surfaces of glaciers, most of which are, in the first instance, detached by the effects of frost from the solid rocks of the mountain sides, or from smaller bosses that project through the ice like islands. They are of all sizes, from grains of sand up to blocks, occasionally 20 yards in diameter, and the majority of them never having been *under* the ice are not scratched like Nos. 38 and 42. Rounded pebbles like 34 occur occasionally among them, especially in the lower part of the glacier, owing to the circumstance that stones that have been rounded by attrition in mountain brooks, sometimes find their way to the surface of a glacier.

35. ANGULAR SCRATCHED LIMESTONE PEBBLE.

Terminal moraine, *Upper Glacier of Grindelwald.*

Presented by A. C. Ramsay.

36. ANGULAR SCRATCHED LIMESTONE PEBBLE, from under the ice.

Lower Glacier of Grindelwald.

This specimen, like the other loose scratched stones, has been scratched by being imprisoned between the massive ice and its rocky floor during the downward passage of the glacier. It was found, among other stones and glacier mud, by Mr. Ramsay, while creeping up an ice-cavern at the end of the glacier.

37. ANGULAR SCRATCHED LIMESTONE PEBBLE, from under the ice.

Terminal moraine, *Lower Grindelwald Glacier.*

Presented by A. C. Ramsay.

38. PEBBLE OF SCRATCHED LIMESTONE.

From the terminal moraine, touching the *Lower Glacier of Grindelwald.*

39. SCRATCHED GRIT STONE.

In motion, on the side moraine, *Great Aletsch Glacier*, close above the tributary *Middle Aletsch Glacier.*

Presented by A. C. Ramsay.

This stone was probably marked by one of the higher tributary glaciers, in its passage to form part of the side moraine.

40. ANGULAR STONES AND SMALL MORAINE DEBRIS.

Part of an old terminal moraine at the outlet of the *Merjelen See, Great Aletsch Glacier.*

Presented by A. C. Ramsay.

The Merjelen See is a lake below the Eggischhorn, on the east side of the Aletsch glacier, which forms a cliff of ice above the upper end of the lake, in places about 60 feet high. The total thickness of the ice (by soundings) is about 107 feet. The continuation of this ice once filled the area now occupied by the lake, and descending into the Valley of Viesch, united the Aletsch and Viesch glaciers. Both glaciers have since decreased in size from climatal changes, and at the outlet and on the banks of the Merjelen See there are still left striations and moraine heaps, marking the gradual recession of the glacier. (See text at page 186, and note to page 189.)

41. POLISHED AND SCRATCHED PEBBLE OF BLACK LIMESTONE.

Moraine of St. Theodule Pass, Zermatt.

42. SCRATCHED LIMESTONE.

From old moraine, on the road from the Rhone valley to the *Gemmi, above Leuk.*

Presented by Professor Huxley.

43. FRAGMENTS OF GNEISS AND GRANITE.

From the *Blocks of Monthey, valley of the Rhone*, opposite Bex.

Presented by A. C. Ramsay.

44. SUBANGULAR, but chiefly ROUNDED STONES.

From waterworn roughly stratified gravel, on and in which the Blocks of Monthey lie.

Presented by A. C. Ramsay.

Erratic pebbles transported by ice, and others.

45. PEBBLES OF SCRATCHED BLACK LIMESTONE.

Torgni, Hill of Chardonne, near *Vevey*, Lake of Geneva.

Deposited by ancient glacier of the Rhone.

46. ANGULAR AND ROUNDED SCRATCHED STONES, &c.

From the *Moraine of Ivrea.*

This moraine was shed from a glacier that descended from the regions of Mont Blanc, Monte Rosa, &c., through the valley of Aosta and Chatillon, to the plain of Piedmont beyond Ivrea. This immense glacier, where it protruded into the plain, shed a vast semicircular moraine at its sides and end, which forms a series of mounds arranged concentrically one within another, the highest rising about 1,500 feet above the plain.

The low hills around Ivrea are all *mountounée*, and small lakes in rock-basins lie amid them.

47. PEBBLES.

From the wells at *Dornach*, stated to be from an ancient moraine.

48. ROUNDED WATERWORN PEBBLES.

From the *Rhine*, contrasting with the *angular* and *subangular* pebbles from *glaciers.*

49. SLATY ROCK, POLISHED AND STRIATED.

In place, in the valley of Asto, about two miles from the plain of Asto, Pyrenees, France.

Specimens illustrative of ancient glaciers of the Vosges, &c., similar to those of North Wales, &c. See p. 197.

50. SLATY ROCK, POLISHED AND STRIATED, in place at *Wesserling* (Glattstein).

The Vosges, France.

51. SCRATCHED MORAINE STONE.

Wesserling, The Vosges.

52. MORAINE SAND.

In place in *the moraine of Rupt.*

Containing erratic blocks and covering polished rocks.

Specimens collected by M. Dolfuss-Ausset, from the neighbourhood of Mulhouse, "Haut Rhin," and the Black Forest.

53. FINE SANDY CLAY.

In place *at Rudisheim, about* 2 *miles E. of Mulhouse (Upper Rhine).*

Forms a hill, 32 feet in height, above a "moraine" formed of Alpine pebbles.

54. SAND.

In place at *Rixhein, about* 5½ *miles E. of Mulhouse.*

This sand has been washed by the streams from a moraine.

55. SAND.

Same as 54.

56. VERY FINE SAND.

Forming a mound 32 feet high, at *Schliengen, Duchy of Baden,* 1¼ *miles from the right bank of the Rhine.*

In the interior of the Black Forest, Duchy of Baden, the valleys show all the signs of glacier action. The rocks are moutounnée (though weathered), sometimes well striated in the direction of the flow of the ancient glaciers, and the valleys are, here and there, crossed by moraines, as for instance in the Menzenschwandenalb, near the Feldberg. Some of the lakes are dammed by old moraines (the Feldsee) and others are true rock basins.

NEWER PLEIOCENE GLACIERS AND DRIFT-ICE OF BRITAIN.

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

OLD GLACIERS OF WALES, &c.

There is distinct evidence of the former existence of glaciers where none are now found, in Britain, and in several other countries. The greater part also of the north of Europe and North America has been covered by ice and by Newer Pliocene icy seas. These subjects have attracted much attention among observers; but long after the transporting power of glaciers, and the ice-borne character of Alpine boulders that rest on the Jura had been indicated, there was a powerful reaction among geologists; the true doctrine fell into discredit, and most writers adhered to the dogma that the heterogeneous mixtures that cover 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 at length prevailed; and there are now few geologists who have studied the effects of ice, but will readily recognize its familiar indications, and more especially those of glacier action in the Highlands of Scotland, in Cumberland, Wales, Ireland, and the mountains of the Black Forest and the Vosges.

It is generally allowed that greater contours of mountain ranges, of plains, and of those broad valleys between mountain systems, which are not mere valleys of denudation, were in the continents of the old and new world approximately the same as now, previous to the glacial epoch. It was long ago stated by Agassiz that after the commencement of the glacial epoch, a great part of the northern and southern continents were covered by glacier-ice on an immense scale, and though this theory at the time met with much opposition, of late the opinions of many experienced observers lean strongly to this view, for over great part of the North of Europe and in North America, wherever the superficial detritus is removed, the underlying rocks are found to be smoothed, mammilated, and striated, precisely in the same manner as the rocks that have been polished by the former extension of the glaciers of the Alps. By this means the surface of the country was modified by erosion to a great extent, and in the opinion of the writer, the thousands of lake-hollows that lie in true rock-basins (eminently characteristic of all glaciated countries) were formed. At this period the North of Europe and America must have resembled in glacial phenomena the interior and north of Greenland of the present day. Much of the oldest boulder clay is moraine-like, and seems to have been the result of this universal glaciation. The land was then slowly depressed beneath the sea; and as it sank, its minor features were again 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 again modified the rocky surfaces over which they passed, and deposited, in the course of many ages, clay, gravel, and numerous boulders over wide areas that had once been land. The transported boulders and probably many of 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 birthplace 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 either at their present elevation, or when perhaps by upheaval of the land, they attained a still greater height; for it is certain that in Wales marine *drift* rises on the mountains to the height of more than 2,300 feet, in Derbyshire at least to 1,500 feet, and as high, or perhaps higher, in many parts of Scotland; and all between these elevations and the present sea level, the signs of ancient drift-ice are unmistakeable. Thus, for instance, in Pembrokeshire, north of St. Bride's Bay, the low country is covered with 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 special glaciers, and therefore the large boulders derived from them were probably floated and scattered by coast-ice that 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* now lying in stratified deposits have been borne many miles to the south. The whole of the central counties of England are more or less dotted with boulders of limestone, granite, greenstone, &c., some of them transported from Cumberland, and perhaps from Scotland; and the drift of our eastern shores contains boulders borne from Scandinavia.

While much of this drift was probably transported from low ice-packed coasts, it is, however, equally certain that great part of it originated in true moraine matter that reached the sea by means of glaciers, which, when the country was at various elevations, descended to the sea-level; and their ends, floating up and breaking off as icebergs, bore away large freights of moraine—earth, stones, and boulders,—to be dropped to the bottom of the sea wherever the bergs chanced to melt. This is evident in North Wales, from whence the moraine specimens of this Case are derived, and the same kind of evidence is equally strong in other areas.

In Wales (as in Italy and Switzerland at the present day) *terminal moraines* sometimes form in part the confining barriers of mountain lakes and tarns.* Llyn Idwal, in Nant Francon, and Llyn Llydaw on Snowdon, among others, form examples of this phenomenon; although it is not to be supposed that the depth of these moraines is necessarily equal to the profoundest depth of the lakes.

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 outside. In the meanwhile the space at 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 filled 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

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

Caernarvonshire, are the lakes of Llyn Dulyn, Melynllyn, Ffynnon Llugwy, Marchlyn-mawr, and Marchlyn-bach. Judging by the present average elevation of these Welsh lakes, when the moraines that confined them were formed, the highest parts of the mountains of Caernarvonshire (*the snow drainage of which gave birth to the glaciers*) could not have been more than 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 Ffrancon, 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 produced a decided amelioration of climate.

This amelioration did not, however, completely take place till after the re-elevation of the land, and after the upheaval, in the greater valleys large glaciers were formed, which in Wales ploughed the drift out of the Passes of Nant Ffrancon and Llanberis, and left untouched the marine drift-deposits that cover the broad spreading table-lands that lie on either side of these valleys at their mouths. Though comparatively large, these glaciers were necessarily much smaller than the great original glaciers that covered and moulded the surface of the country before its submergence.

Another proof of the former existence of glaciers is to be found in the small lakes and tarns (*entirely surrounded by rock*) that lie in old glacier valleys or in the hollows of high passes, like the *Lac des Morts* between the Grimsel and the Valley of the Rhone; or again, on high surfaces, like the tarns on some of the rough table-lands between Ffestiniog, Nant Gwynant, and the river Conwy. The producing cause of these peculiar hollows was probably an immense weight of glacier ice eroding the surface unequally, or in the rough table-lands of superincumbent ice pressing and grinding downwards and outwards, over high, flat, and sometimes broad watersheds, during that period of intensest cold, that produced the glaciers of Wales and the great original extension of the glaciers of Switzerland. The same reasoning applies to the great lakes of Switzerland and North Italy, all of which lie in the courses of the glaciers that crossed the plains when the ancient glaciers attained their greatest size. (See "Geological Journal," vol. xviii. p. 185.—RAMSAY.)

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

When by degrees the glaciers diminished in size, then the minor 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, 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. By degrees these results were clearly produced by amelioration of climate, for in Wales there is perfect evidence of a gradual decline of the glaciers in the retreating moraines concentrically arranged one within another,—as, for instance, in three or four perfect moraine mounds on the west side of Cwm Idwal, or in the moraine of Cwm Llafar, below Carnedd Llewelyn,—in which a long narrow channel has been ploughed clean out of the terraced boulder-drifts * by the glacier, the remains of a small moraine crossing near its upper end—or in the upper part of Cwm Brwynog, and in Cwm Glas, on the sides of Snowdon. Near the mouth of the last, not far above the bottom of the Pass of Llanberis, there are three concentric elliptical moraine heaps, touching each other; and further up the valley, beyond the great *roche moutonnée*, that lies half a mile south of Blaen-y-Pennant, there is a perfect terminal moraine, forming across the valley a long curved ridge of clay, sand, and moraine stones and boulders, some of them well scratched, and so regular is the mound in form that an uninitiated eye might fancy it to be an artificial earthwork. Other cases could be cited, showing a gradual retreat of the glaciers, till at length we find only the last symptoms of the ice in the relics of tiny moraines far up amid the innermost recesses of the mountains.

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

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

In the Alps, when glacier ice is freshly removed, the rock underneath, whether of limestone, gneiss, granite, or even quartz, though striated, often possesses almost the polish of a sheet of glass. In our own country, both in mountain regions and in the lowlands, when the impervious covering of till has been taken away, the surfaces, though grooved and striated, are often beautifully smooth. In other cases, as in some parts of Wales, when the turf and glacier debris is lifted, the underlying surfaces of cleaved slate still retain a perfect polish, marked sometimes by flutings, and sometimes by numerous scratches almost as fine as if made by the point of a diamond. After long exposure, these finer markings disappear, and, though the general rounded form remains,

* These terraces in the drift have been made by denudation during pauses in the elevation of the country after its submersion to a depth of more than 2,000 feet. See p. 192.

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

Specimens illustrative of the ancient Glaciers of North Wales, and of the Glacial Drift (Newer Pleiocene or Pleistocene). Collected by A. C. Ramsay.

60. MORAINE MUD in its native state.

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 18.

61. MORAINE MUD, as in No. 60, containing small angular stones in native proportion.

Cwm-y-llan, Snowdon.

62. MORAINE MUD, with small angular and scratched stones.

Cwm-y-llan, Snowdon.

Partly separated from larger material.

63. MORAINE MUD, similar to No. 62.

Cwm-y-llan, Snowdon.

64. ANGULAR QUARTZ AND SLATY AND FELSPATHIC STONES, partly *scratched*.

From moraine of Cwm-y-llan, Snowdon.

* For details on this subject see "The Old Glaciers of North Wales," Ramsay, Longman and Co. 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.

65. ANGULAR SLATY STONE, well *scratched*.

From moraine of Cwm-y-llan, Snowdon.

66. 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 (which is a true rock-basin), at its efflux. The *roches moutonnées* above alluded to, are covered with erratic blocks (*blocs perchés*), transported from higher levels by the glacier.

67. MORAINE MUD, WITH SMALL ANGULAR STONES.

Llyn Llydaw, Snowdon.

68. ANGULAR STONE, IMPERFECTLY SMOOTHED AND SCRATCHED.

Moraine, Llyn Llydaw, Snowdon.

69. SANDY MUD, WITH ANGULAR STONES (unsifted).

Glaslyn, Snowdon.

This lake is at a higher level than Llyn Llydaw, and 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 ice that helped to feed the great glacier of Llyn Gwynant.

70. MORAINE MUD AND SMALL ANGULAR, FELSPATHIC, SLATY STONES, in native proportion.

From inner moraine, south of the large roche moutonnée, Blaen-y-Pennant, Cwm Glas, Pass of Llanberis, Snowdon.

71. ANGULAR AND PARTLY SCRATCHED, FELSPATHIC SLATY PEBBLES.

Moraine as above, Cwm Glas, Pass of Llanberis, Snowdon.

This moraine is perhaps the most entire and regular of any in Caernarvonshire. Its precise position is as follows: —In the Pass of Llanberis, immediately above the 11th mile-stone, 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 porphyry, partly weathered. The moraine lies less than a quarter of a mile S.W. of the top of the rock, and stretches across the hollow between two brooks, looking almost like an artificial mound, so perfect is its form. Many other traces of moraines occur higher in this valley, especially in the neighbourhood of the little lakes (rock-basins) in the uppermost recesses of Cwm Glas.

72. MORAINE MUD AND SMALL ANGULAR STONES, in native proportion.

Outer moraine, N.W. of the roche moutonnée, Blaen-y-Pennant, Cwm Glas, Pass of Llanberis.

73. FELSPATHIC AND SLATY, SCRATCHED ANGULAR STONES.

From the same moraine as 72.

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

Moraine drift.—On the mountains of Caernarvonshire, and in North Wales generally, the surface is, over large areas, more or less covered by GLACIAL DRIFT. This drift rises from underneath the present sea level to a height of about 2,300 feet on some of the mountains. Near the shore it has often been re-arranged and waterworn by the sea during terrestrial oscillations of level, but in the higher grounds it is generally in its native state, consisting of clay, angular stones, gravel, and boulders, sometimes, as in Cwm Llafar below Carnedd Llewellyn, arranged in terraces marking pauses in the elevation of the country (see p. 195). Shells were found by Mr. Trimmer, on Moel Tryfan, 1,300 feet above the sea, in gravel, and others were found by myself in stratified boulder clay at about the same height, less than two miles west of the peak of Snowdon. It has been already stated that some of the Welch glaciers shed their moraines in the sea, while drift was being deposited on adjacent sea-bottoms. Much of this, though stratified drift, precisely resembles ordinary moraine matter in the quality of its mud, and the angularity, scratched surfaces, and sizes of its stones. At a time when glaciers descended to the sea, the very highest mountains rose as islands of not more than about 2,000 feet high, and yet gave birth to distinct glaciers. It is therefore not improbable that in other portions of the same islands not possessed of the form requisite to originate massive glaciers, snow and glacier-ice may yet have covered nearly their entire surfaces, for unless the cold were sufficient to produce such a result, it is difficult to understand how on other parts of these small islands good-sized glaciers, such as then certainly filled the valleys, could have been produced. If this covering did exist, it is very intelligible how the drift on the sides of the mountains is generally composed of stones from the hills close above, and also is more or less moraine-like in its character. It is not till we reach the comparatively distant lower ground of Caernarvonshire, near the sea, and the plains of Anglesey, that far-travelled fragments begin to occur in ordinary drift deposits.

74. FINE SIFTED MORAINE MUD.

Ceunant-Mawr, near the top of Cwm-Gwynant, between Llyn-Gwynant and Pen-y-gwryd.

75. MORAINE MUD AND ANGULAR STONES, in native proportion.

Ceunant-Mawr.

76. SMALL ANGULAR AND SUB-ANGULAR STONES, separated from the mud.

Ceunant-Mawr.

77. SCRATCHED SLATY STONE.

Ceunant-Mawr.

78. FINE MORAINE MUD, WITH SMALL ANGULAR GRAVEL.

Between Llyn-y-Gader and Yr Aran,

Partly sifted, from thick banks of drift matter, full of local fragments.

79. FINE MORAINE MUD, with angular stones.

Between Llyn-y-Gader and Yr Aran.

80. SLATY PEBBLES, scratched.

Between Llyn-y-Gader and Yr Aran.

81. FINELY POLISHED SCRATCHED SLATY STONE.

Between Llyn-y-Gader and Yr Aran.

In this specimen the majority of the scratches run in the direction of the length of the stone.

82. DRIFT MORAINE MATTER? with angular and rounded stones.

N. 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.

83. RECENT LAKE GRAVEL.

Llyn Padarn, Llanberis, Caernarvonshire.

To contrast the waterworn shape of the stones with the angularity of most of the moraine and drift stones in the Case.

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

84. SUBANGULAR SMOOTHED AND SCRATCHED SLATY STONE.
From sea-cliff of boulder drift, Yr Henborth, Llanfairynghornwy, Anglesey.

85. SUBANGULAR SMOOTHED AND SCRATCHED STONE.
From Anglesey; underlying bed containing tooth of a *horse* (*Equus fossilis*).

86. ROUNDED WATERWORN STONE, OF QUARTZ ROCK.
Anglesey.

Similar to the pebbles of the New Red conglomerate, and perhaps derived from it. This stone, though well waterworn, shows traces of *glacial scratching*, in this respect being unlike the pebbles of the New Red Sandstone *in place*.

87. PART OF A BOULDER OF CALC GRIT.
Threxton, near Watton, West Norfolk.

Presented by Thomas Barton Esq.

From a boulder weighing about one ton. There is a similar one interbedded in the clay at Merton, the adjoining parish, computed to weigh 18 or 20 tons. See lower compartment of this Case.

88. ANGULAR BOULDER OF STRIATED GRIT.
From the lower drift boulder clay of Happisburgh, Norfolk.

Presented by the Rev. John Gunn. (Lower compartment of Case.)

89. FRAGMENT OF LARGE SCRATCHED AND STRIATED SEPTARIAN, of the *Kimeridge Clay.*
Upper drift boulder clay, near Burgh Castle, Suffolk.

Presented by the Rev. John Gunn. (Lower compartment of Case.)

90. ROUNDED AND ANGULAR STRIATED GRIT STONES.
Drift, Patricroft, Lancashire.

Presented by Jas. Nasmyth Esq.

The striations of these stones mostly run in the direction of their length. (Lower compartment.)

91. CHALK PEBBLE AND TWO FLINTS, ICE-SCRATCHED.
Boulder clay, Hitcham, Suffolk.

Three specimens, one in the lower compartment of the Case.

Presented by the Rev. J. S. Henslow.

92. CARBONIFEROUS LIMESTONE PEBBLE ICE-SCRATCHED.
Boulder sand, at base of Drift, Heath and Reach, near Leighton Buzzard, Bedfordshire.

Stones showing in part the composition of the drift, Shropshire. Presented by COLONEL LEGGE.

93. SCORIACEOUS FELSPATHIC ROCK.

94. FELSPATHIC PORPHYRY.

95. BRECCIATED FELSPATHIC PEBBLE.

96. FELSPAR PORPHYRY.

97. FELSPATHIC AND SILICEOUS ROCK.

98. FELSPATHIC PEBBLE.

99. RED JASPER.

100. JASPIDEOUS QUARTZ.

93 to 100 are like many of the Lower Silurian rocks of Shropshire and North Wales.

101. LIMESTONE.
Like a piece of Cornstone.

102. RED GRANITE.

103. VEINED JASPIDEOUS QUARTZ.

104. BASALT.

105. GNEISSIC ROCK.

106. ALTERED SHALE.

107. FLINTS AND PEBBLES FROM THE DRIFT.
Pagham Harbour, Sussex. Map 9.

Flints, pebbles of granite, and parts of boulders of greenstone.

The S.E. coast is more or less strewn with transported boulders, some of them, near Selsey and Brighton, of great size. They are supposed by Mr. Godwin-Austen to have been transported by ice from the coast of France, the Channel Islands, or other islands that formerly existed in the Channel, but are now submerged. The higher ground of the S. of England was not submerged during this period.

GLACIATED ROCKS *in place*, SCOTLAND.

108. GREENSTONE WITH GLACIAL STRIATIONS.

Part of the rock on which North Berwick pier is built.

109. CARBONIFEROUS LIMESTONE SHOWING GLACIAL GROOVES AND SCRATCHES.

North Berwick.

110. GLACIER-WORN AND STRIATED HYPERSTHENE ROCK.

From the outlet into Loch Scavaig of the great glacier-basin of the Cuchullin Hills, now Loch Cormick, Skye.

Presented by the Rev. S. W. King.

The specimens 108 and 109 are from the low shores of the south coast of the Firth of Forth. On both sides of the valley of the Firth, and inland over the whole of Scotland, there are numerous indications of glacial action, both in the older boulder-clay, gravel, and later boulder-clay and gravels that more or less cover the country, and in the frequent striation of the rocks visible where the drift has been freshly cleared. By the Firth I have observed that these striations run roughly east and west in the main line of the valley ; and north of the Grampian Mountains they generally follow the great slopes of the country on the east and west sides of the chief watershed (Jamieson). These striations were probably formed at a time when the whole country was cased in ice, like the north of Greenland at the present day, when, probably, the older boulder-clay was formed. It was afterwards submerged when the younger drift was deposited, and on re-emergence a second set of glaciers of smaller size filled many of the valleys.

111. SCRATCHED STONE, from a terrace scooped in the northern drift.

Montreal, Canada.

112. STRIATED NIAGARA LIMESTONE.

A loose stone from a terrace of northern drift, near the railroad above Clifton House, *Niagara, Canada.*

113. STRIATED NIAGARA LIMESTONE.

Top of the gorge of the river, near Clifton House, *Niagara, Canada.* (Lower compartment.)

The specimens from 111 to 113 are placed for comparison, and to show the universality of glacial action in the northern hemisphere.

From the great Lawrentian chain to the banks of the Ohio the Central plains of North America are more or less covered by boulder-clay and drift, often several hundred feet in thickness. When removed, the rocks on which they rest are found to be very generally grooved and striated, the striations chiefly running more or less from north to south. Examples are so common that they scarcely need enumeration. They may be well seen down the road from Clifton House, near the Falls of Niagara. On the shores of the Hudson, and the eastern flanks of the Catskill mountains near Catskill, they are also frequent, running along the side of the escarpment from north to south, till we reach the high minor gorge that traverses the range from east to west, and there by Mountain House, nearly 3,000 feet above the sea, the striations bend round and cross the watershed, as if, when the land was submerged to a certain level, the ice, previously grating along the side of the escarpment, had found a passage to the west, through what is now an upland valley.

Permian Ice-drift.

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

The following specimens belong to the Permian series, but they are placed in this Case for convenience of comparison with the glaciated stones of Wales and Switzerland.

On the Abberley Hills at Woodbury, and behind Hundred House, at Stagbury Hill, Warshill, and near Enville, *brecciated conglomerates* of the same age form 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 paste, and in all cases they contain few or no 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 igneous rocks of the same distant area, together with certain *Pentamerus or upper Llandovery limestones and conglomerates*, which rest upon the Longmynd rocks and contain peculiar green pebbles derived from Longmynd strata. These Pentamerus beds when in place lie unconformably on the Longmynd Cambrian rocks and the Llandeilo flags, between the Stiper Stones and Chirbury. The pebbles and blocks therefore of the breccia chiefly consist of felstone porphyry, greenstone porphyry, greenstone amygdaloid, altered ribboned slate, black and green slate, felspathic ash, quartz rock, quartz conglomerate, purple and green Cambrian slate and coarse conglomerate, grey grit, and sandy *Pentamerus limestone*, all characteristic rocks of the Longmynd area or its neigbourhood. The Pentamerus limestone often occurs in the Breccia (as at Northfield) in large angular slabs, full of the peculiar assemblage of fossils that mark that ancient Upper Silurian beach in the Longmynd country, and the inference is that they were transported from thence. Along with these "a well-rounded waterworn pebble is of rare occurrence. The surfaces of a great majority of the pebbles are much flattened, numbers are highly polished, and, when searched for, some of them are found to be distinctly grooved and finely striated. The striæ in some are clear and sharp, and run parallel to each other or cross at various angles; while in others, though you see their traces, 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 pasty clay in which they lie, present such strong resemblances to much of the "Drift," that, except for difference in hardness, 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 Roth-todte-liegende of Thuringia, is identical with the coarse angular conglomerates of that formation in general appearance, and I believe that they both had the same origin. (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.

120. BRECCIATED CONGLOMERATE.

Woodbury Rock, Knightsford Bridge, Abberley Hills.

This shows, 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.

121. ANGULAR PEBBLES.

Berrow Hill, near Martley, Abberley Hills, Worcestershire.

122. ANGULAR PEBBLES.

Clent, N. of Bromsgrove.

123. ANGULAR PEBBLES.

Wars Hill, near Bewdley.

124. ANGULAR PEBBLES.

Romsley, near the Day House, Bromsgrove Lickey. Map 54.

These specimens were dug from the quarries, and loosened to show the angularity of the smaller fragments.

125. 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. 38, from the glacier of the Grindelwald; 51, from the Vosges; 65, 73, from the moraines of Caernarvonshire; 77, 80, and 81, from the moraine drift; and 84, from the ordinary marine glacial drift of Anglesey.

126. SUBANGULAR STONE (Cambrian grit), *scratched;* the scratches covered with a thin ferruginous coating.

From the outlier of Church Hill, Bayton.

This small outlier helps to mark the original wide extension of the brecciated conglomerate before denudation. It is surrounded by Coal-Measures, which lie on Old Red Sandstone, and the blocks that form the breccia are not derived from the strata around. The nearest spot where grit like this stone occurs in place is the Longmynd. The scratches at × show a tendency to pass round the curved edge, as in 93 and 107.

127. PART OF A GROOVED SMALL BOULDER (of altered Cambrian grit) dug out of a quarry.
Berrow Hill, near Martley, Worcestershire.
The rubbing and grinding of the stone goes partly round the edge marked ×, in this respect resembling the sides of some of the stones from the glacial drift.

128. PART OF A SUBANGULAR STONE (Cambrian grit?), *scratched.*
Berrow Hill, Abberley Hills, near Martley, Worcestershire.

129. FLAT ANGULAR STONE (Cambrian grit), *faintly striated.*
Romsley, near Day House, Bromsgrove Lickey, Worcestershire.

130. PART OF STRIATED STONE, well marked on the edge marked ×.
Berrow Hill, Abberley Hills.
The remainder of the sides show rough fractures. The stone consists of fine-banded conglomerate and grit.

131. FLAT, SUBANGULAR, SCRATCHED STONE (greyish-red Cambrian grit?).
Abberley Hill, behind Hundred House, Worcestershire.

132. SUBANGULAR STONES, *smoothed and finely scratched.*
Stagbury Hill, near Stourport.
The altered slaty fragment marked × is as finely striated as the specimen No. 38, from the moraine in the *Pass of St. Theodule.*

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

134. SUBANGULAR STONE, with *scratched* surface.
Clent Hill, near Clent. Map 54.
Banded (Cambrian ?) grit.

135. SCRATCHED GRITSTONE, from the Drift.
Railway cutting, Wigan.
Placed for comparison with No. 134. Both have been naturally scratched by the agency of ice, and both have received accidental scratches by the pickaxe or shovel.

136. POLISHED AND SCRATCHED SUBANGULAR STONE; scratches partly covered by a very thin ferruginous crust.
From the lane between Northfield and Bangham Pit, on the E. side of the S. end of the South Staffordshire coal-field, 7 miles S.W. of Birmingham.
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.

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

138. WATERWORN, GREENISH-PURPLE PEBBLE (Cambrian ?), polished and *faintly scratched.*
Berrow Hills, Abberley Hills.

139. SUBANGULAR FRAGMENT of a *boulder* of felspathic greenstone.
Abberley Hill, near Hundred House.

140. SMOOTHED ANGULAR CONGLOMERATE.
Woodbury Hill, near Hundred House, Worcestershire.
Like some of the Cambrian conglomerates.

141. SUBANGULAR STONE, felspar porphyry.
Stagbury Hill, Stourport, Worcestershire. Map 55.

142. SUBANGULAR FRAGMENT, greenstone.
Clent Hills. Map 54.

143. Part of a SUBANGULAR STONE of altered (porcelainized Lower Silurian) slate.
Clent Hills. Map 54.

144. SMOOTHED ANGULAR STONES.

From Lane between Northfield and Bangham Pit, Worcestershire.

The large one is felspathic porphyry; the others are of banded fine altered grits.

145. ANGULAR STONES, grit and fine felspar porphyry.

Abberley Hills, Worcestershire.

146. Part of a SUBANGULAR STONE, *of quartz rock.*

Romsley, near the Day House, Bromsgrove Lickey.

147. ANGULAR STONE of *felspathic trap,* like that of the *Lower* Silurian rocks.

Shropshire.

148 to 151 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.

148. SILURIAN LIMESTONE, PENTAMERUS OR UPPER LLANDOVERY BEDS.

Lane between Northfield and Bangham Pit, E. side of the S. end of the South Staffordshire coal-field.

149. FOSSILIFEROUS LIMESTONE, UPPER PENTAMERUS OR UPPER LLANDOVERY BEDS.

From Woodbury Rock, Knightsford Bridge, Worcestershire.

The specimen is like the rock 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* is identified, before the slates were transported by floating ice to the position in which they now lie. Broken with the hammer to show the fossils.

150. FRAGMENTS OF UPPER PENTAMERUS LIMESTONE.

From the Lane between Northfield and Bangham Pit, Worcestershire. Map 54.

Full of *Pentamerus oblongus,* &c. These were derived from very large angular slabs. The nearest known rock of this kind in place is about 45 miles distant, resting on the Lower Silurian rocks west of the Longmynd.

151. UPPER SILURIAN FOSSILIFEROUS LIMESTONE.

From Permian brecciated conglomerate of Abberley Hill, Hundred House.

152. UPPER SILURIAN LIMESTONE.

From the outlier of Church Hill, Bayton.

Both Nos. 151 and 152 were probably originally transported from the Wenlock Edge country.

Specimens to illustrate the difference between Waterworn Stones in Conglomerates and Angular aqueous Breccias.

153. PERMIAN CONGLOMERATE, AND WATERWORN STONES from Conglomerate.

Four Ashes, near Enville, Shropshire.

154. CONGLOMERATE OF WATERWORN PEBBLES.

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 Encrinites stand in relief on the weathered surfaces of the pebbles.

155. Calcareous Conglomerate.

From the Permian rocks near Bedworth, Warwickshire.

Like 153 and 154.

156. Pebbles from the Conglomerate of the New Red Sandstone (Bunter).

These are also placed in the Case to contrast with the angular stones Nos. 120 to 147. No scratches appear on them, but they are exceedingly waterworn, and have been smoothed like the pebbles of the Chesil bank, or any similar beach, by breakers or some such movement rattling them against each other. "Its component stones are often from three to nine inches in diameter, but unlike those in the breccias, they are all beautifully rounded, and where they touch in the rock they are not scratched, but indent each other at the points of contact; the indentations being, I believe, due to the fact that, while these gravels were still incoherent, over great areas, the upper parts of the New Red Series, the Lias, and perhaps other newer strata, were piled upon them, and the vertical pressure consequent on this vast superincumbent pile induced a lateral pressure in the loose-lying pebbles of the conglomerate; so that being squeezed, not only downwards, but outwards, they ground on each other, and perhaps partly by the aid of intervening grains of sand, circular indentations were formed sometimes an inch in diameter." (Ramsay, Geological Journal, Feb. 1855, p. 200.) Some of them are fractured and recemented. The fractures were produced by pressure, generally close to faults.

A. C. Ramsay.

Wall-cases 1 & 2.

IGNEOUS ROCKS.

Arranged and described by H. W. Bristow.

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 and 5.

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 40. 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.*

Nos. 148 to 154 are from the volcanic district of *Auvergne,* in central France.

Case 2 is principally occupied by a series of specimens of lava and 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.

A model of Arthur's Seat, geologically coloured by Mr. Archibald Geikie, is placed in the recess between Wall-cases 1 and 3.

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 1860.

The remaining portion of the contents of this Case consists of volcanic specimens from Iceland, and some specimens of Rowley Rag to show the effect produced by different rates of cooling upon that rock, after it has been melted. No. 177 is especially interesting on account of its being a model of Graham's Island, made of the ashes and lapilli of the volcano, which has now, together with the island itself, altogether disappeared.

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.

Wall-case 1.

Arranged and described by H. W. Bristow.

Specimens of *lava, pumice, sulphur*, &c. (Nos. 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.

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. Nos. 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 (No. 12), and the more opaque substance Pitchstone.

The lighter Lava or Pumice (Nos. 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 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, inclose and fossilize shelly and other organic bodies (Case 2, No. 66).

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 Nos. 21 to 25, 27, 31, and 35.

A variety of this scoriaceous lava, No, 35, is partially coated with small crystals of specular iron, which have been deposited on its surface probably by the decomposition of sublimed chloride of iron.

Other specimens, Nos. 36 to 41, *contain included crystals of augite and olivine.* The presence of these minerals is, probably, generally due to the separation of the substances of which they are composed, from the including mass, during the process of slow cooling, and, possibly, is sometimes the result of the remelting of older Lavas, into the composition of which they entered ; in such cases, if less fusible than the more modern Lava, they would be caught up by it and retained, undergoing but little change themselves.

Nos. 42 and 42*a* are specimens of *native sulphur*, a mineral frequently found sublimed in and around the craters of volcanos. The sulphur from the Sandwich Islands is chiefly remarkable for containing an admixture of *Selenium*, to which it owes the red colour that is more especially to be observed on No. 42*a*.

Shelf 4 *and part of shelf* 5 (Nos. 43 to 93) *contain specimens of the Trachytes and associated volcanic rocks of the mining district of Schemnitz, in Hungary.*—Of these, Nos. 44 to 47 are basaltic rocks. Nos. 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. Nos. 57 to 68 are varieties of Greenstone ; the first contains spherical concretions, and Nos. 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.

Nos. 94 to 101 are from the Bannat and Croatia, principally to illustrate the rocks, associated with the ores, which are worked at Drey König Mine. Of these, Nos. 94 to 96 are *volcanic*, Nos. 97 and 98 are the rocks associated with and containing the ores.

Nos. 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 (Nos. 122 to 130) from the *extinct tertiary volcanos of the Eifel.*

Nos. 131 to 137 are principally varieties of highly crystalline *porphyritic Greenstones from the volcanic mountain of St. Vincent.*

No. 138 is a curious variety of concretionary *Greenstone from Corsica.*

Specimens of *Lava*, *Pumice*, *Sulphur*, &c. (Nos. 140 to 147) *from the Peak of Teneriffe*, are placed on the upper shelf, together with (No. 139) a specimen of *stalactitic Lava from Etna*, which is too large to accompany the collection to which it more properly belongs.—

Nos. 148 to 154, placed on the lower shelf, are from the extinct volcanos of Auvergne, in central France.

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 5½ miles long by 2¼ to 3½ 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.

1. Basalt traversing the volcanic rocks *in dykes.*

2. Grey massive Basalt, very slightly vesicular, and with a few small crystals of *glassy felspar.*

3. Grey Vesicular Lava, with the cells elongated in the direction in which the stream flowed. These became afterwards filled with a white mineral, which has subsequently, in most cases, decomposed, leaving the cells empty.

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 *mamillated 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, wit streaks and laminations of other colours.

A familiar example of similar appearances may be noticed in the slags of iron-furnaces, which are artificial lavas, composed of silicates of alumina and lime, with a little iron and other minor constituents. A.C.R.

13. Light-green transparent OBSIDIAN, or VOLCANIC GLASS upon *Lava*.

14. PUMICE, with crystals of *gypsum* (*sulphate of lime*).

15. PUMICE, with a fibrous silky structure.

16. VESICULAR PUMICE, coated with *sulphate of lime*.

17. VOLCANIC ROCK traversing *Pumice* in dykes.

18. VOLCANIC BRECCIA passing into *Basalt*.

19. VOLCANIC BRECCIA with much *sulphur*, and a thin band of reddish-brown compact Felspathic Trap.

Specimens of volcanic rocks and minerals from Kilauea and Hawaii, in the Sandwich Islands; collected and presented by Count Strzelecki, C.B.

The three principal volcanic mountains in Hawaii are Mauna Loa, Mauna Kea, and Hualalai. Of these, the former is supposed to be 13,760 feet above the level of the sea, and the second 13,950. There are great numbers of minor craters scattered over their slopes, one of which, Kilauea (Lua Pélé), is situated on the flank of Mauna Loa, at a distance of nearly 20 miles from the summit; its height has been variously estimated by different observers—by Count Strzelecki at 4,101 feet. This last crater is described by Ellis, in his "Tour in Hawaii," as situated on a lofty elevated plain, bounded by precipices, and apparently sunk from 200 to 400 feet below its original level. "The surface of this plain was uneven, and strewed over with loose stones and volcanic rock, and in the centre was the great crater. Immediately before us yawned an immense gulf in the form of a crescent, about two miles in length, from N.E. to S.W., nearly a mile in width, and apparently 800 feet deep. The bottom was covered with lava, and the S.W. and northern parts of it were one vast flood of burning matter in a state of terrific ebullition, rolling to and fro its fiery surges and flaming billows. Fifty-one conical islands, of varied form and size, containing so many craters, rose either round the edge or from the surface of the burning lake; 22 constantly emitted columns of grey smoke, or pyramids of brilliant flame; and several of these at the same time vomited from their ignited mouths streams of lava, which rolled in blazing torrents down their black indented sides into the boiling mass below. The side of the gulf before us, though composed of different strata of ancient lava, were perpendicular for about 400 feet, and rose from a wide horizontal ledge of solid black lava of irregular breadth; but, extending completely round beneath this ledge, the sides sloped gradually towards the burning lake, which was, as nearly as we could judge, 300 or 400 feet lower. It was evident that the large crater had been recently filled with liquid lava up to this black ledge."

The Lavas of Hawaii appear to have been in a very fluid state, as will be seen on reference to specimen No. 20, &c.

They have also been poured out in enormous quantities; a stream of basaltic Lava, two miles broad and 25 miles long, proceeded from an opening in Mauna Loa, 13,000 feet above the level of the sea.—(Lyell's "Principles of Geology," p. 383.)

In June 1840 a stream of melted lava continued to flow for three weeks into the sea, in coming in contact with which it became shivered like melted glass poured into water, and heated it so much as to cause the shores to be strewed with dead fish for a distance of 20 miles. The area covered by the lava was calculated at about 15 square miles, with an average depth of 12 feet, and the lower pit of Kilauea, which was calculated to have held 15,400,000,000 cubic feet of molten matter, was emptied by the discharge of the Lava through the fissures by which it was discharged at intervals.

The ejection of cinders and ashes appears to be comparatively of rare occurrence; they are, however, occasionally thrown out. Thus, in 1789, a large volume of cinders and sand is said to have been thrown to a great height, and to have fallen in a destructive shower for many miles around. Some men, belonging to an army then on its march, are described by Dana to have been killed by this shower of cinders, &c., while others perished from an emanation of heated vapour or gas.

The modern Lava and Volcanic Glass of Kilauea are composed of silica, protoxide of iron, alumina, soda, potash, and lime, but these vary much in their relative proportions. They contain a large amount of oxide of iron. Professor Silliman, jun., asserts that soda is present to the exclusion of potash, but this is not borne out by Mr. Peabody's analysis of Pélé's Hair (No. 20), in which both potash and soda are given.

20. Filamentous or Capillary Lava (*Pélé's Hair*).
Kilauea, Island of Hawaii.

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.

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.)

20a. Filamentous or Capillary Lava (*Pélé's Hair*).

Obtained from near the bottom of the great crater of *Kilauea*, by a party from H.M.S. "Vixen," February 1, 1858.

21. Vesicular Scoriaceous Lava, showing on one side a

smooth surface on which the melted Lava flowed.

22. VERY VESICULAR SCORIACEOUS LAVA.

23. VESICULAR SCORIACEOUS LAVA from the outer portion of the stream.
Kilauea, Hawaii.

24. Finely vesicular reddish-brown SCORIACEOUS LAVA.

25 & 26. VERY VESICULAR LAVA.

27. SCORIACEOUS LAVA, or *volcanic slag; very vesicular.*

28. CELLULAR BASALTIC LAVA.
Hawaii.

29. VESICULAR VOLCANIC SLAG, or *Cellular Obsidian.*

30. VERY VESICULAR LAVA, or *Cellular Obsidian.*

31. SCORIACEOUS LAVA, inclosing 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. BALSATIC 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, octahedral 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, Hawaii.

42a. NATIVE SULPHUR, sublimed round the twigs of plants.
Kilauea, Hawaii.
The presence of Selenium in the sulphur from Kilauea has been determined by the analysis of Professor Silliman.

42b. Crystals of NATIVE SULPHUR, with a hot, soft, and greasy earth.
Obtained at a bank N.E. of the great crater of *Kilauea,* February 1, 1858, by a party from H.M.S. "Vixen."

42c. Crystals of NATIVE SULPHUR.
Obtained from the mouths of hot-air holes in a bank N.E. of and above the great crater of *Kilauea,* by a party from H.M.S. "Vixen." February 1, 1858.

42d. CONDENSED VAPOURS, from heated air passing through fissures in the rock.
In the N.E. bank above the great crater of *Kilauea:* obtained February 1, 1858, by a party from H.M.S. "Vixen."

Specimens of the Igneous Rocks of the mining districts of Schemnitz in Hungary, the Bannat, Croatia, and Transylvania.

Presented by WARINGTON W. SMYTH, M.A., F.R.S.

"The Hungarian lavas are chiefly felspathic, consisting of different varieties of trachyte; many are cellular, and used as millstones; some so porous, and even scoriform, as to resemble those which have issued in the open air. Pumice occurs in great quantity; and there are conglomerates, or rather breccias, wherein fragments of trachyte are bound together by pumiceous tuff, or sometimes by silex.

" It is probable that these rocks were permeated by the waters of hot springs, impregnated, like the Geysers, with silica; or, in some instances, perhaps, by aqueous vapours, which, like those of Lancerote, may have precipitated hydrate of silica.

"It appears from the species of shells collected principally by M. Boué, and examined by M. Deshayes, that the fossil remains imbedded in the volcanic tuffs, and in strata alternating with them in Hungary, are of the Miocene type, and not identical, as was formerly supposed, with the fossils of the Paris basin."—(Lyell's "Elements of Geology.")

43. GRANITE, composed of *felspar*, *quartz*, and *mica*.
From the Trachytes of the *Glashütte, Schemnitz.*

44. BASALT.
Top of Kalvarienberg.

45. BASALT, containing a very small quantity of *olivine*.
Giesshübl.

46. AMYGDALOIDAL BASALT.
The kernels filled with *zeolites* and *calc spar*.

47. BASALT, inclosing fragments of *Trachyte* and a *zeolitic mineral.*
From the west edge of the basaltic mass of *Giesshübl.*

48. COMPACT PEARLSTONE.
Western extremity of the *Vale of Hlinik.*

49. Grey PORPHYRITIC PEARLSTONE.
From the conglomerate in the *Vale of Hlinik.*
Composed of crystals of *quartz*, *glassy felspar*, and *black mica*, in a pearlstone base.

50. PORPHYRITIC PEARLSTONE; A variety of No. 49.

51. PORPHYRITIC PEARLSTONE.
Two miles W. of Glashütte.

52. PEARLSTONE, with *sphærulite.*
Two miles W. of Glashütte.

53. PEARLSTONE, with *sphærulite* and specks of black *mica*, some in crystals.
Near the mouth of the Vale of Hlinik.

54. PEARLSTONE, "PERLITE RÉTINIQUE" of Beudant, with a few small specks and laminæ of black *mica*.
Vale of Hlinik.

55. PEARLSTONE ("*Perlite-lithoide*" of Beudant).
Two miles W. 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.
W. slope of Schobobnerberg.

62 and 63. ALTERED GREENSTONE, with a small quantity of *iron pyrites.*
From the hanging wall of a branch of the Theres gang (Theresa vein) N. of Georg Stolln.

64. PORPHYRITIC GREENSTONE.
Summit of Paradeisberg.

65. PORPHYRITIC GREENSTONE.
E. slope of Paradeisberg.

66. GREENSTONE PORPHYRY.
Georg Stolln.
Several varieties of this rock occur near the mouth of the Ferdinand Adit, being the first rock pierced by it.

67. EARTHY GREENSTONE PORPHYRY.
100 *yards W. of Tepla.*
Composed of crystals of *Albite* (*soda felspar*) and prismatic crystals of black *mica*, with some *hornblende* in a felspatho-hornblendic base.

68. EARTHY DIORITIC PORPHYRY.
400 *yards W. of Tepla.*
Composed of crystals of *Albite* (*soda felspar*) in a hornblendic base.

69. AUGITIC PORPHYRY.
From the Trachytes, E. of Mount Szitna,

70 and 70a. EARTHY TRACHYTE.
From the Conglomerates, W. of Prinzendorf, and S. of Mount Szitna.
Sent to Vienna, and used as porcelain-earth.

71. PORPHYRITIC TRACHYTE, with *augite* and *glassy felspar*.
Summit of Mount Szitna.

71a. PORPHYRITIC TRACHYTE, with crystals of *mica*, *augite*, &c.
S. of the Basalt of Giesshübl.

72. SCORIACEOUS TRACHYTE.
From a block near the rocks at the "Teich," or reservoir, half a mile S.E. of Kremnitz.

73. SCORIACEOUS TRACHYTE.
From a block near the rocks at the reservoir, half a mile S.E. of Kremnitz.

74. TRACHYTE.
W. of Calvarienberg, near the aqueduct.
Composed of crystals of black *mica*, *hornblende*, and *glassy felspar*, in a pinkish trachytic base.

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.
A mile W. of Glashütte.

79. TRACHYTIC PORPHYRY.
From the slope above the cliffs of Glashütte.
Composed of crystals of *hornblende*, *mica*, and *glassy felspar*, in a white trachytic base.

80. SPHÆRULITIC MILLSTONE TRACHYTE.
Hlinik.

81. TRACHYTE with *mica* and *hornblende*.
W. of road between Bleyhütte and Antal.

82. TRACHYTE (another variety).
W. of road between Bleyhütte and Antal.

83. From the junction of *Trachyte* and *Greenstone*.
W. of Calvarienberg, near the aqueduct.

84. TRACHYTIC CONGLOMERATE.
N. slope of Mount Vepor.
Composed of fragments of decomposing crystals of *glassy felspar* in a base of Trachyte, containing minute specks of black *mica*.

85. TRACHYTIC CONGLOMERATE.
Wissegrad.
Used as a material for building the Cathedral at Gran.

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.
W. of Mount Szitna, between Antal and Prinzendorf.

89. FELSPATHIC ROCK, with crystals of *glassy felspar*.
From junction of Trachyte and Greenstone, W. of Calvarienberg, Schemnitz, near the aqueduct.

90. FELSPATHIC ROCK, with a few crystals of *glassy felspar*.
From the Trachyte E. 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*).
Andreas Shaft; Schemnitz.
Occurs in *Greenstone*, 70 fathoms from the surface.

93. GARNETS.
Sajba, near Libethen, Hungary.
Washed by the rain from the *trachytic beds.*

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*.
It is succeeded, firstly, by grey-limestone, and then by granular limestone.

97. CALCAREOUS SPAR AND GARNET ROCK.
Drey König Mine.
Occurs between *Syenite and limestone*, as matrix to the ore.

97a. COMPACT GREY LIMESTONE.
From the upper adit of the Drey König Mine.
Occurs between *granular limestone and Syenite.*

98. GRANULAR LIMESTONE, containing ores of copper.
Drey König Mine.

99. WHITE CRYSTALLINE LIMESTONE.
Ruszkberg in the Bannat.

100. FLESH-COLOURED CRYSTALLINE LIMESTONE.
Ruszkberg in the Bannat.

101. MARL, with nodules of Bitterkalk.
Radoboj, Croatia.

102. DIORITE (or GREENSTONE).
Nagy Banya.

103. DIORITIC PORPHYRY, with *calc spar.*
Vale of Fernezely, Nagy Banya.

104. GREENSTONE PORPHYRY, with metalliferous threads.
Nagyag, Transylvania.

105. NON-METALLIFEROUS PORPHYRY forming the peaks of the mountains around *Nagyag.*

106. AUGITIC (?) PORPHYRY.
Almas, between Zalathna and Nagyag.

107. QUARTZOSE PORPHRY.
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.
Piatra Dorni.
Occurring among trachytic rocks.

112. CONGLOMERATIC ROCK.
Probably in connection with the Trachyte of Tihutza on the border of the Bukovina.

113 GRANITE, with green *epidote.*
Magurka, near Unter Franz Stollen, Northern Hungary.

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

115. ALTERED SANDSTONE with *specular iron.*
Magurka.

Specimens of Rocks 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.

W. of the Serai, at Argana Maden.

119. ALTERED MARLY SHALE, capping hills of Serpentine at *Argana Maden.*

119a. REDDISH-BROWN LIMESTONE, altered by the intrusion of Serpentine (?).

Argana Maden.

120. Reddish-brown ALTERED MARLY SLATE, capping hills of Serpentine at *Argana Maden.*

121. LIMESTONE, altered by Serpentine.

Argana Maden.

Volcanic specimens from the extinct Volcanos of the Eifel, on the Lower Rhine.

Presented by G. POULETT SCROPE, M.P., F.R.S.

NEWER VOLCANOS OF THE EIFEL.—The volcanos of the Eifel are of a date coeval with that of the "*brown coal*" of the Germans, which has been variously referred to the close of the Eocene, or to the commencement of the Miocene epochs.

"The fundamental rocks of the district are grey and red sandstones and shales, with some associated limestones, replete with fossils of the Devonian or Old Red Sandstone group. The volcanos broke out in the midst of these inclined strata, and when the present systems of hills and valleys had already been formed. The eruptions occurred sometimes at the bottom of deep valleys, sometimes on the summit of hills, and frequently on intervening platforms. In travelling through this district we often fall upon them most unexpectedly, and may find ourselves on the very edge of a crater before we had been led to suspect that we were approaching the site of any igneous outburst. For this we have been prepared by the occurrence of scoriæ scattered over the surface of the soil. But on examining the walls of the crater we find precipices of sandstone and shale which exhibit no signs of the action of heat; and we look in vain for those beds of lava and scoriæ, dipping in opposite directions on every side, which we have been accustomed to consider as characteristic of volcanic vents. As we proceed, however, we find a considerable quantity of scoriæ and some lava, and see the whole surface of the soil sparkling with volcanic sand, and strewed with ejected fragments of half-fused shale, which preserves its laminated texture in the interior, while it has a vitrified or scoriform coating.

"The most striking peculiarity of a great many of the craters, is the absence of any signs of alteration or torrefaction in their walls, where these are composed of regular strata of ancient sandstone and shale. . . . There is, indeed, no feature in the Eifel volcanos more worthy of note than the proofs they afford of very copious aëriform discharges, unaccompanied by the pouring out of melted matter, except here and there, in very insignificant volume. I know of no other extinct volcanos where gaseous explosions of such magnitude have been attended by the emission of so small a quantity of lava.

"In the Lower Eifel, eruptions of trachytic lava preceded the emission of currents of basalt, and immense quantities of pumice were thrown out wherever trachyte issued. The tufaceous alluvium called *trass*, which has covered large areas in this region, and choked up some valleys now partially re-excavated, is unstratified. Its base consists almost entirely of pumice, in which are included fragments of basalt and other lavas, pieces of burnt shale, slate and sandstone, and numerous trunks and branches of trees."—(Lyell's "Manual of Elementary Geology," 5th edition, pp. 545–548.)

122. VESICULAR LAVA.
Siebengebirge, on the Rhine.

123. SCORIACEOUS BASALTIC LAVA.
Laacher-see.
Remarkably hard and containing fine crystals of *augite*, with a few crystals of reddish-coloured *felspar*.
(See Hibbert "On the Extinct Volcanos of the Rhine," p. 148.)

124. VESICULAR BASALTIC LAVA, with crystals of *augite*.
Bertrich.

125. SLIGHTLY VESICULAR BASALTIC LAVA, with crystals of *augite* and *olivine*.
Norenberg.

126. SLIGHTLY VESICULAR BASALTIC LAVA.
Mayen.
Contains a few crystals of *augite*, *glassy felspar*, and *quartz*, small specks of *Haüyne*, and entangled fragments of laminated *felspatho-hornblendic rock*.
(See Hibbert "On Extinct Volcanos of the Rhine," p. 116.)

127. SCORIACEOUS BASALTIC LAVA.
Weinfeld.

128. SLIGHTLY VESICULAR BASALTIC LAVA.
Banks of the Weinfelder Maar, near Daun, Vorder Eifel.
Composed almost entirely of crystals of *augite*, with a crystalline structure and partly scoriaceous; occurring in numerous large ejected blocks.

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*.

133. HIGHLY CRYSTALLINE PORPHYRITIC GREENSTONE, composed of crystals of *glassy felspar* and *hornblende*.

134 & 135. HIGHLY CRYSTALLINE PORPHYRITIC GREENSTONE with *olivine* and included fragments of *scoriaceous lava*; the augite has undergone partial fusion.

136. FINE GRAINED PORPHYRITIC GREENSTONE (another variety of Nos. 134 and 135), with decomposing *olivine*.

137. JASPIDEOUS ROCK.

138. NAPOLEONITE, or ORBICULAR GREENSTONE.

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 cavernons opening, where a lava-stream first commences to flow out at the side of a volcano.

Presented by W. W. Smyth, F.R.S.

Volcanic products from the Peak of Teneriffe.

(On Upper Shelf.)

Presented by Professor C. Piazzi Smyth, F.R.S.

TENERIFFE.—The island of Teneriffe, off the west coast of Africa, is the largest of the Canary Islands, being 36 miles long, with an area of 1,000 square miles. The Peak is situated at its N.E. end, and rises to a height of 12,158 feet above the level of the sea. The upper portion is a rugged conical eminence, 852 feet high, difficult of ascent on account of the loose ashes by which it is covered, and so narrow on the top as scarcely to afford standing room. A steep wall on the summit would prevent access to the crater, 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.

140. LAVA, from the outer surface of the stream, of a twisted form, showing the result of a viscous flow.

141. LAVA, with a wrinkled surface, the result of flowing while in a viscous state.

From the Ice Cavern.

142. BLACK LAVA, overlying the Pumice at *Alta Vista*; showing the smooth planes of joints, and a tendency to assume spheroidal forms.

143. PUMICE.

Alta Vista.

144. PITCHSTONE 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.

Volcanic rocks, &c. from Auvergne, in Central France.

Presented by Hilary Bauerman.

(On Lower Shelf.)

148. PORTION OF A GRANITE PEBBLE.

Bed of River Allier, Pont du Château.

149. GNEISS.

Bed of River Allier, Pont du Château.

Nos. 148 and 149 are from the granitic ridges bounding the hollows in which the Eocene fresh-water beds are deposited. The volcanic rocks are principally assignable to a later period.

150. Volcanic Ashes (consolidated).
Pont du Château.

151. Pumiceous Volcanic Conglomerate.
Monts Dome.

152. Domite or Earthy Trachytic Porphyry.
Puy de Dome.

153. Basalt.
Puy de Dome.

154. Trachytic Tuff.
Gergovia, near Clermont Ferrand. Contains olivine.

H. W. Bristow.

Wall-case 2.

Arranged and described by H. W. Bristow.

Nos. 1 *to* 105, *from the Island of Ascension, were collected by Mr. Charles Darwin, F.R.S., and Captain Ord, R.E.*

The Island of Ascension, situated between the coasts of Africa and Brazil, is nine miles long by six in breadth. Its entire surface, which is broken into mountains, hills, and ravines, is covered with ashes, cinders, pumice, and lava. Its general appearance is that of a mass of smooth, bright-red conical hills, with truncated summits, rising from a plain of black, sterile lava. The highest point on the island, Green Hill, is 2,870 feet above the sea-level.

Nos. 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. *

Nos. 14 to 14e, as well as No. 106, from Chatham Island, Galapagos Archipelago, from the superficial parts of a lava-stream, are especially remarkable for their singular forms. They are described as being scattered over the surface of the ground, presenting the appearance of logs and branches of trees.

Nos. 15 to 26 represent varieties of laminated beds, which alternate with and pass into Obsidian.

The great number of these are composed of Pearlstone and Pitchstone, with occasional nodules of Obsidian, alternating with felspathic layers.

Nos. 18, 22, and 23 are sphærulitic, while 16, 19 to 21, 24 and 25 contain included crystals of glassy felspar, lying lengthways, or with their longest axes parallel with the laminæ in which they are included; an arrangement which is due to the motion of the mass while in a heated state.

Nos. 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. See page 244.

* See also No. 275, Case 6, p. 259.

Nos. 31 to 31c are varieties of volcanic slag, exhibiting different degrees of fusion.

Nos. 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. Nos. 57 to 58 are augitic lavas, with included crystals of glassy felspar.

Nos. 63 and 64 are pumiceous. 65 to 67 volcanic ashes and sand, or the more finely divided products of eruption.

No. 68 to 73 are varieties of softer Tufa, and 105 are concretions which occasionally occur in it.

Nos. 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. Nos. 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 Nos. 95 to 99. It occurs in the altered Trachytes either in the form of irregular masses or in seams. The formation of these, as well as of the thin plate-like veins No. 93, has been produced by the segregation or infiltration of siliceous matter.

In the same manner the Jasper, (Nos. 100 to 102,) which also forms large irregular masses in the altered Trachyte, was probably produced by a process (as suggested by Mr. Darwin) analogous to that by which wood becomes gradually silicified ; that is, by the gradual removal, particle by particle, of the original rock, (in this case a basaltic rock,) accompanied by the simultaneous substitution of siliceous matter and iron.

Nos. 106 to 109 are varieties of scoriaceous Lava from Chatham Island, Galapagos Archipelago ; while 110 to 113 are cellular basaltic Lavas, the latter containing crystals of Olivine.

Nos. 116 to 117 are from the Cape de Verde Islands.

Various kinds of Lava from New Zealand (White Island) are represented by Nos. 121 to 126. 127 and 128 are specimens of siliceous sinter. 129 and 130, gypsum ; 131 and 132, native sulphur ; and 133, the ashes with which the country around Auckland is covered.

Nos. 134 and 135 are from volcanic springs at Kertch, in the Crimea.

Volcanic rocks from the Island of Ascension.

Presented by Charles Darwin, F.R.S., and Captain Ord, R.E.

1 & 2. Volcanic Slag or Cinder.

3. Red Scoriaceous Lava, partly vesicular.
From the outer portion of the stream.

4 & 5. Cellular or Vesicular Basaltic Lava.

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

7. Vesicular Basaltic Lava, showing the elongation of the vesicles in the direction of the current.

8. Slightly vesicular Basaltic Lava, the vesicles elongated in the direction of the flow.

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 parts of a Basaltic Lava Current, presenting singularly twisted and convoluted forms, and exhibiting lines formed by the flowing of the stream while in a viscous or slightly fluid state.
(See Darwin "On Volcanic Islands," p. 35.)

Laminated beds alternating with and passing into Obsidian.

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.)

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: (allied to No. 18.)

24. Irregular nodules of OBSIDIAN, united into thin layers, which alternate with other thin felspathic layers, containing crystals of *glassy felspar*.

25. Irregular layers of PEARLSTONE, with crystals of *glassy felspar*, and passing into *Pitchstone*, alternating with irregular dull red-coloured trachytic layers.

26. Irregular layers of PITCHSTONE and greenish-grey *felspathic layers*.

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

28. GREEN PITCHSTONE, OR OBSIDIAN.

29, 29a to 29g. BLACK OBSIDIAN or VOLCANIC GLASS, with a conchoidal fracture and sharp, cutting edges.

30. BLACK OBSIDIAN, full of minute globular vesicles, which become gradually less perfectly defined until the whole passes into compact Obsidian.

The vesicular structure is owing to the expansion of included gases or aqueous vapour which were not entirely driven off during the fusion of the melted mass.

31. OBSIDIAN, passing into vesicular, scoriaceous Lava, and presenting an appearance of perfect fusion.

31a. VOLCANIC SLAG, SCORIA, or CINDER, presenting an appearance of partial fusion, and converted in some places, into layers of Obsidian.

31b. VOLCANIC SLAG, SCORIA, or CINDER, presenting an appearance of imperfect fusion.

31c. VOLCANIC SLAG, SCORIA, or CINDER, presenting an appearance of imperfect fusion and covered, superficially, in some places, with an iridescent lustre.

The specimen contains a few small fragments of scoriaceous Lava, which have become entangled with and taken up by the partially fused slag.

Trachytic series of rocks occupying the more elevated and central, and likewise the south-eastern, parts of the Island of Ascension.

32. Somewhat friable WHITE TRACHYTE, appearing when viewed in mass, like a sedimentary Trachytic Tufa.

The specimen is earthy and in a decomposing state, passing into china-clay. It also contains some cavities, with crystals of *glassy felspar*.

33. Pale greenish-grey, decomposing TRACHYTIC 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. Slighly laminated, pale-grey, TRACHYTE.

36. Pale grey LAMINATED TRACHYTE.

From the base of Garden Hill.

The specimen contains a few crystals of *glassy felspar*, and has a weathered surface

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* variety of No. 40, having some of the cavities filled with a white powder.

42. GREENISH TRACHYTE, with imbedded 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. LIGHT GREY TRACHYTE (*another variety*), 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*).

(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. Reddish-brown AUGITIC LAVA (*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 imbedded in the earthy Trachyte.

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, inclosing a *Pecten.*

67. VOLCANIC SAND (in a bottle).

68. SOFT WHITE PUMICEOUS TUFA.

69, 70, 71, & 72. Varieties of TRACHYTIC TUFA (in bottles).

73. Bright-red VESICULAR TUFA.

74. Fine-grained, partially consolidated TUFA or PEPERINO, with coarser loose scoriæ.

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

77. BLACK TRACHYTIC TUFA OR PEPERINO, from the bottom of the volcano.

St. Vincent.

78. SCORIACEOUS LAVA or *Pozzolana.*

Sheepwalk.

79 & 80. SCORIACEOUS LAVA or *Pozzolana.*

High Peak.

81. VOLCANIC SCORIA AND ASHES.

82, 83, & 84. VOLCANIC SCORIA, CINDERS, AND SLAGS.

VOLCANIC BOMBS.

85. VOLCANIC BOMB OF OBSIDIAN.

"The specimen was found, in its present state, on a great sandy plain between the rivers Darling and Murray, in Australia, and at the distance of several hundred miles from any known volcanic region. The external saucer consists of compact obsidian, of a bottle-green colour, and is filled with finely cellular lava, much less transparent and glassy than the obsidian. The external surface is marked with four or five not quite perfect ridges. The lip of the saucer is slightly concave, 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." (See Darwin "On Volcanic Islands," pp. 38 and 39.)

86. Fragment of a spherical VOLCANIC BOMB, with the interior parts coarsely cellular, coated with a concentric layer of compact Lava, and this again with 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." (See Darwin "On Volcanic Islands," pp. 36 and 37.)

87. Part of a VOLCANIC BOMB of a similar description to No. 86, and showing the internal structure.

88. Portion of a VOLCANIC BOMB, composed of coarse and finer cellular rock, of an irregularly

scoriaceous structure; probably the central portion of the bomb.

89. EJECTED GRANITIC FRAGMENT, consisting of a brick-red mass of felspar, quartz, and small dark patches of a fused mineral, ascertained by its cleavage to be hornblende.

(See Darwin "On Volcanic Islands," p. 40.)

90. EJECTED GRANITIC FRAGMENT (*Syenite*), streaked and mottled with red, and composed of white *potash-felspar*, numerous grains of *quartz*, and small crystals of *hornblende*.

91. EJECTED FRAGMENT (*white granitic rock*), composed of confusedly crystallized white *felspar*, with little nests of a dark-coloured mineral, often carious, externally rounded, and with no distinct cleavage, probably *fused hornblende*. This rock was ejected amongst cinders from one of the more recent volcanos.

(See Darwin "On Volcanic Islands," p. 41.)

92. EJECTED FRAGMENT, *Greenstone*, composed of crystals of *Labrador Felspar*, a little *altered hornblende*, and scales of black *mica*, with white granular *felspar*, filling the interstices.

(See Darwin "On Volcanic Islands," p. 41.)

93. EJECTED FRAGMENT, portions of hard SILICEOUS PLATE-LIKE VEINS, of varying thickness, intersecting the earthy trachytic masses on the flanks of the "crater of the old volcano."

(See Darwin "On Volcanic Islands," pp. 44 and 45.)

94. Seams of compact OXIDE OF IRON, occurring conformably in the lower parts of a stratified mass of ashes and fragments.

"This seam of compact stone, by intercepting the little rainwater which falls on the island, gives rise to a small dripping spring, first discovered by Dampier. It is the only fresh water on the island, so that the possibility of its being inhabited has entirely depended on the occurrence of this ferruginous layer." (See 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. JASPER (*another variety*), inclosing irregular angular patches of *red jasper*, with their edges blending into the surrounding mass.

102. SCORIACEOUS ROCK, occurring near veins of siliceous sinter (Nos. 96, 97, and 98), having the cells lined and filled with fine concentric layers of *white chalcedony*, which are coated and studded with bright-red *oxide of iron*.

103. SILICEOUS CONGLOMERATE, with small prismatic crystals of *tourmaline* and crystals of *quartz*, and coated with a thin layer of *siliceous sinter*.

104. ROCK RESEMBLING SYENITIC GNEISS, probably from one of the laminated beds alternating with and passing into Obsidian, noticed in Darwin "On Volcanic Islands," pp. 56 and 57.

105. CONCRETIONS *from pumiceous tufa,* composed of a very tough, compact, pale-brown stone, with a smooth and even fracture, and containing a small proportion of carbonate of lime.

Some of the larger concretions are described as mere shells filled with slightly consolidated ashes. (See Darwin "On Volcanic Islands," p. 47.)

On the lower shelf of this Case several other specimens of Obsidian, Sulphur, Cinders, Ashes, Sand, &c., from Ascension, are placed temporarily. These will be more particularly described in the next edition of the Catalogue.

Volcanic Specimens from the Galapagos Archipelago, Chatham Island.

(Collected and presented by CHARLES DARWIN, F.R.S.)

The Galapagos Archipelago consists of ten islands, situated under the equator, 500 or 600 miles westward of the coast of America. They are all formed of volcanic rocks, and are chiefly remarkable for the immense number of craters with which they are covered. These are formed either of lava and scoriæ, or of tufa; in the latter case they present beautifully symmetrical forms, which appears to be owing to their having been formed while standing out at sea, by the eruptions of volcanic mud, without any lava.

Chatham Island is the largest of three islands, intersected by the parallel of 43° 45″ S., and by the meridian of 176° 40′ W. It contains 477 square miles. The rocks are chiefly volcanic, and the island itself presents a rugged, arid appearance; the dark basaltic lava, of which the surface is composed, being covered by a dwarfed and parched brushwood.—H. W. BRISTOW.

106. BASALTIC LAVA from the surface of the stream, slightly scoriaceous, and twisted and convoluted by flowing while in a viscous state.

From the road near Dead Man's Cove.

107. VESICULAR AND SCORIACEOUS LAVA.

Dead Man's Cove.

108. SCORIACEOUS LAVA.

Evans' Well.

109. VOLCANIC SLAG or CINDER, mixed with fine-grained, friable, brown-coloured *Tufa* or *Peperino.*

From the mouth of the crater.

110. CELLULAR BASALT, containing *olivine* and *calc spar.*

North Hill.

111. BASALTIC LAVA, with numerous small vesicles.

Road from First Well, Charles' Island.

112. CELLULAR BASALT, with *olivine,* and minute crystals of *calc spar.*

Salt Lake, Chatham Island.

113. CELLULAR BASALT.

Bottom of the well near Quebrada.

Some of the cells contain *olivine,* and others crystals of *calc spar.*

114. TRACHYTIC LAVA.

Evans' Well.

115. COMPACT GREENSTONE.

Dalrymple Rock.

116. Porphyritic Greenstone.
Near the summit of Pico d'Estacia, Boã Vista, Cape de Verde Islands.*
Composed of crystals of *hornblende* and flesh-coloured *felspar*, and weathered crystals of *glassy felspar* in a felspathic base.

117. Green Pitchstone.
Mayo Island, Cape de Verde group.

117a. Cellular Basaltic Lava.
St. Jago, Cape de Verde Islands.
Some of the cells are elongated, and partly filled with earthy *carbonate of lime*.
(See Darwin "On Volcanic Islands," p. 10.)

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*, showing by transmitted light an olive-green colour, on the thin, cutting edges.
Mexico.

120. Basalt, with *Greenstone*.
Kattewar, East Indies.

Volcanic Products from White Island, New Zealand.

Presented by the Lords of the Admiralty.

White Island, or Puhia-i-Wakari, is situated in the Bay of Plenty, in the south-east district of New Zealand. It is six miles in circumference. It contains an active volcano, and yields considerable quantities of sulphur. The flames issuing from its crater are visible at dusk, while its position is marked during the day-time by a white cloud, which rests upon its summit.—H. W. B.

121. Volcanic Bomb, composed of *basaltic lava*, with numerous crystals of *glassy felspar*.

122. Scoriaceous Basaltic Lava, with crystals of *augite* and *glassy felspar*.
Upper Waipa, from the summit of Kokibako, an extinct volcano.

123. Vesicular Basaltic Lava.
From the central part of White Island.
Some of the vesicles partly filled with *calc spar*.

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.

* 1260·5 feet above the level of the sea.

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.

CRIMEA.

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.

Case in Recess 2.

GEOLOGICAL MODEL OF ARTHUR'S SEAT,

BY MR. ROBISON WRIGHT.

Re-coloured from the Map of the Geological Survey ;

BY ARCHIRALD GEIKIE, F.R.S.E.

Arthur's Seat is the name of a hill about 820 feet high, and a square mile in extent, forming the eastern boundary of Edinburgh. It consists of two parts, separated by the deep valley of the Hunter's Bog ; that to the west rises from the streets of the town in a steep slope crowned by a semicircular mural escarpment, called Salisbury Craigs, which descends on the other side into the Hunter's Bog. The eastern portion of the hill is formed of successive terraces, with dividing valleys running north and south, their southern terminations being marked off by a confused pile of rock which slopes up from the north and east, and descends precipitously on the other sides. This higher part of the hill, which, seen from certain localities, looks like a great irregular cake laid down upon the lower ridges, is crowned by a crag of basalt forming the summit, or Arthur's Seat proper. To this peculiar contour the geology of the hill bears special reference. The ridges are all of hard trap ; the intervening valleys consist of softer rocks, which have yielded more readily to disintegration ; while the higher irregular mass of rock at the south side belongs to a much later age, and is really what it appears to be, a newer group of ridges set down on the tops of the older ones. The hill is thus of two distinct geological ages. The older rocks form part of the Lower Carboniferous Series, and are all inclined to the east at an average angle of about 20°. The under or westerly part consists of a set of white, red, green, and mottled sandstones, fine conglomeratic grits, coarse limestones, and red and green shales, among which are intercalated intrusive beds of greenstone, that harden and otherwise disturb the strata above and below them. The upper or eastern portion displays a great group of contemporaneous trap rocks, that is, basalts, greenstones, felstones, and felspathic ashes, which were ejected over the sea-bottom after the sandstones, and other strata below had been deposited. All these are arranged in beds, which follow with great regularity the dip and direction of the underlying sedimentary rocks, and pass under a higher series of sandstones and shales, the whole forming part of the great Lower Carboniferous group.

The newer rocks of Arthur's Seat belong to a much later period, for they rest upon the upturned denuded edges of the beds below. The older traps have been covered over by several thousand feet of newer deposits; the rocks of the whole country had been bent into troughs and ridges, and then the whole of this superincumbent mass had been worn away from the site of Arthur's Seat, whose trap beds again stood up as ridges, with the sea excavating valleys through the softer rocks between; all this had elapsed before the rocks of the summit and south side of the hill were ejected.

Thus, then, it would seem that Arthur's Seat has been the scene of, at least, two distinct volcanos, one of which was in activity during the Lower Carboniferous period, and the other long subsequently, after an entire change had taken place in the physical appearance of the country, and a new vent had been established through the deposits formed by the pre-existing volcano.

Wall-cases 2 & 3.

On the outside of Case 3 is a

Model of the Isle of Bourbon.

By Mon. Ls. Maillard.

Presented by Mons. Dufrénoy, Director of the Ecole des Mines, Paris.

The Isle of Bourbon, or Mascarenhas (as it has been called after its discoverer), is situated in the Indian Ocean, in S. lat. 21°, and E. long. 55°, about 90 miles W.S.W. of Mauritius, and 370 miles east of Madagascar. It is elliptical in shape, about 90 miles in circumference, and 45 miles across in its widest part, in a N.W. and S.E. direction. From a distance it appears to rise gradually from the sea to a high central peak—the Piton des Neiges—9,450 feet high. The island is composed of two volcanic mountains, the Gros-morne or Salazes, 7,200 feet in height, and the volcano. Of these, the former, which is the largest, and situated towards the centre of the island, has long ceased to be in activity, but that it was so formerly is fully proved by the aspect assumed by the features of the surrounding country. During the long interval which has elapsed since it has been in repose, the action of the atmosphere has disintegrated its former bleak surface, and converted it into a fertile soil, which is now in a state of high cultivation.

Towards the S.E. of the island the country is, on the other hand, scorched and barren, owing to the scarcity of water and the neighbourhood of the volcano, and the Pays brûlé, as the district is called, is a continuous desert, the barren dreary aspect of which forms a frightful picture of desolation. Since 1785 the volcano has vomited lava at least twice every year, which in nine instances flowed to the sea.

The rivers are not supplied by springs, but are derived from the rain which falls on the mountains, and the snow and mists upon their summits. In consequence of this, they all partake, more or less, of the nature of mountain torrents rather than of ordinary rivers, and rush through deep gullies, which have been worn by them in the sides of the mountains, during a long succession of ages. These torrents sometimes rush with such impetuosity, as to carry down vast fragments of rock, which, by accumulating at the mouths of the rivers, block them up with lofty and impassable barriers. "The isle of Bourbon is surrounded by coral reefs, only broken through at the embouchures of the rivers, and opposite the chief ravines. The channels or passages through the reefs are kept open by the streams of fresh water passing outward through them, without which they would be otherwise soon filled up; as it is, they are considered to have decreased in size in consequence of a diminished quantity of rain having, of late years, fallen on the Isle of Bourbon."—De la Beche's Geological Observer, (2nd edition, p. 179).

H. W. BRISTOW.

(UPPER SHELVES.)

MODELS OF ROCKS *by M. Bardin.*

From the Paris Exposition of 1855.

No. 1 is a model of part of the limestone rocks near Sablé (Sarthe). The beds are inclined at an angle of about 52°, and are somewhat jointed.

No. 2 is a model of part of the (Permian ?) sandstones of the Vosges (Grès des Vosges). They form tabular hills, the strata lying nearly horizontally. They are much jointed, and it will be observed that there are caverns in the main cliff, and in front of it there are many outstanding fragments and pinnacles, like the Needles of the Isle of Wight or of Studland Bay, giving evidence that, like these chalk cliffs, this sandstone, when it stood at a different level, was formed into cliffs by the same kind of marine denudation that now forms the cliffs of the chalk.

Nos. 3 & 4 are models of inclined limestone rocks in the neighbourhood of Sablé (Sarthe).

Nos. 5 & 6 are models of parts of a country formed of Gneiss. In No. 5 the numerous vertical and highly-inclined joints are remarkable, especially the curved form they assume on the side next the printed title. (Gneiss rocks at the entrance of the Bay of Morlaix). The great irregularity of the coast line is evidently partly due to the multitude of joints, parts of the rocks having offered less resistance than others to the denuding force of the waves.

A. C. RAMSAY.

Wall-case 3.

NORTH SIDE, SHELF 2.

NEWER PLIOCENE LAVAS AND VOLCANIC ASHES, of the age of the Loess of the Rhine.

Roderberg, near Mehlem.

PLIOCENE TERTIARY LAVAS, PUMICE, TUFA, &c.

Laacher See, Eifel, Prussia.

PLIOCENE TERTIARY LAVAS AND VOLCANIC ASHES.

Eifel, Prussia.

Shelf 5. MIOCENE (?) IGNEOUS ROCKS AND TRACHYTIC CONGLOMERATE.

Siebengebirge, Rhine.

The above series of specimens were presented by Professor A. C. Ramsay, F.R.S.

VOLCANIC AND ASSOCIATED ROCKS.

From the Island of Madeira.

The great mass of the volcanic rocks of Madeira are probably of subaërial origin. " Some of the earlier igneous formations were submarine, and are associated at San Vincente, in the northern part of the island, with deposits containing corals and sea-shells. These marine strata are elevated at least 1,200 feet above the sea.

" A long and complicated series of volcanic eruptions, for the most part subsequent in date to the above, and which took place in the open air, built up the island. They have given rise to a mountain chain about 30 miles in length, running east and west. This chain in its middle and loftiest portion rises to the height of 5,000, and in some peaks to more than 6,000 feet. Its composition is displayed in the precipitous sides of valleys more than 3,000 feet deep, and is seen to consist entirely of scoriæ, lapilli, breccias with angular fragments of volcanic rocks, tuff, scoriaceous lava, and some beds of solid lava ; the whole being traversed by dikes. None of the fragments of stone in the breccias of the central region have been rounded by water, and no marine remains have been found in them ; hence, had there never been any upheaval, Madeira would have acquired a height of between 4,000 and 5,000 feet by the simple reiteration of volcanic eruptions above the sea-level, or by the heaping up of ejected materials, which have been fissured, and injected by lavas in the form of dikes. Large portions of these mountains, constituting the axis of the island, are amorphous and unstratified ; but a series of basaltic lavas, separated by tufaceous partings (many of which have probably been ancient soil), are seen to dip away in all directions from the central axis, chiefly towards the north and south, where the island is only 12 miles in diameter, but also towards the east and west, where the chain is highest and most dome-shaped. Under about 1,200 feet of these lavas, Sir Charles Lyell and Mr. Hartung discovered, in the ravine of San Jorge, a leaf-bed, or argillaceous layer full of fossil leaves, both of ferns and dicotyledonous plants. The leaf-bed occurs at the height of 1,000 feet above the level of the sea, and is overlaid by superimposed basalts and scoriæ, 1,100 feet thick, implying the existence of an ancient terrestrial vegetation long before a large part of Madeira had been built up. The nature of the tuffs accompanying the lignite, together with some agglomerates in the vicinity, entitles us to presume that near this spot a series of eruptions once broke out. Nor is it improbable that there may have been here the crater of some lateral cone in which the lignite and leaf-bed accumulated.

"As a general rule, the lavas of Madeira, whether vesicular or compact, do not constitute continuous sheets parallel to each other. When viewed in the sea-cliffs in sections transverse to the direction in which they flowed, they vary greatly in thickness, even if followed for a few hundred feet or yards, and they usually thin out entirely in less than a quarter of a mile. In the ravines which radiate from the centre of the island, the beds are more persistent, but even here they usually are seen to terminate, if followed for a few miles; their thickness also being very variable, and sometimes increasing suddenly from a few feet to many yards."—Quar. Jour. Geol. Soc. vol. x. p. 325.

Lyell, Manual of Elementary Geology, 5th ed., p. 515.

Shelf 3. Various kinds of LAVA, PUMICE, TUFA, &c.

Shelf 4. CALCAREOUS CONCRETIONS, formed by the infiltration of carbonate of lime through volcanic ashes.

Shelf 5. PUMICE, SANDS, &c. LIMESTONE, with gypsum, &c.

Shelf 6. LAVA AND VOLCANIC ROCKS from *Vesuvius*.

Presented by Dr. Strange.

Shelf 7. A SERIES OF ROCK SPECIMENS from *Skomer Island, Pembrokeshire*, to be inserted in their proper places in the next edition of the Catalogue.

Shelf 7. SPECIMENS ILLUSTRATIVE OF THE EFFECTS OF HEAT AND INTRUDED MELTED ROCKS ON SLATES.

Exhibiting the action of fire on slate. From the premises of Messrs. Scott Russell and Co., burnt 10th September 1853.

Presented by the late Superintendent Braidwood.

At the top is a piece of the slate scarcely altered, and showing its original thickness. Lower down the same fragment swells out and becomes spongy. This is still more obvious below. The slates have become spongy by the escape of watery vapour, air, or gases, and, being softened by heat, they have been bent. Similar rocks, altered by contact with igneous rocks under great pressure, *do not assume this vesicular structure.* For instances of strata altered by contact with melted rocks, see WALL-CASE 41, No. 220; WALL-CASE 44, Nos. 193, 194, 198, 200, 202, &c.

Specimens broken from a VITRIFIED FORT at *Knock-farrel, Strath-Peffer, Scotland.*

Presented by Professor A. C. Ramsay, F.R.S.

H. W. BRISTOW.

VESUVIUS.

Table-case A. in Recess 4.

Topographical and Geological Model of Vesuvius, and Specimens illustrative of Vesuvius and its Neighbourhood.

In the model, constructed by M. Dufrénoy in 1838, the horizontal and vertical scales correspond. The order of age, or superposition, of the different rocky masses, seems to be as follows, beginning with the oldest:—

1st. Trachyte spreading from Portici to Pompeii on the coast, and up to the base of Somma.

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.

"From the first colonization of Southern Italy by the Greeks, Vesuvius afforded no other indications of its volcanic character than such as the naturalist might infer, from the analogy of its structure to other volcanos. The ancient cone (of which Somma forms a part) was of a very regular form, with a flattish summit, where the remains of an ancient crater, nearly filled up, had left a slight depression, covered in its interior by wild vines, and with a sterile plain at the bottom. On the exterior, the flanks of the mountains were clothed with fertile fields richly cultivated, and at its base were the populous cities of Herculaneum and Pompeii. But the scene of repose was at length doomed to cease, and the volcanic fire was recalled to the main channel, which, at some former unknown period, had given passage to repeated streams of melted lava, sand, and scoriæ.

"The first symptom of the revival of the energies of this volcano was the occurrence of an earthquake in the year 63 after Christ, which did considerable injury to the cities in its vicinity. From that time to the year 79, slight shocks were frequent; and in the month of August of that year they became more numerous and violent, till they ended at length in an eruption. The elder Pliny, who commanded the Roman fleet, was then stationed at Misenum; and in his anxiety to obtain a near view of the phenomena he lost his life, being suffocated by sulphureous vapours. His nephew, the younger Pliny, remained at Misenum, and has given us, in his "Letters," a lively description of the awful scene. A dense column of vapour was first seen rising vertically from Vesuvius, and then spreading itself out laterally, so that its upper portion resembled the head and its lower the trunk of the pine, which characterizes the Italian landscape. This black cloud was pierced occasionally by flashes of fire as vivid as lightning, succeeded by darkness more profound than night. Ashes fell even upon the ships at Misenum, and caused a shoal in one part of the sea—the ground rocked, and the sea receded from the shores, so that many marine animals were seen on the dry sand. The appearances above described agree perfectly with those witnessed in more recent eruptions, especially those of Monte Nuovo in 1538, and of Vesuvius in 1822." (Lyell's "Principles of Geology," 1847, p. 351.)

"It does not appear that in the year 79 any lava flowed from Vesuvius; the ejected substances, perhaps, consisted entirely of lapilli, sand, and fragments of older lava," and it was in these that the cities of Herculaneum and Pompeii were buried.

The first recorded stream of lava, after the year 79, flowed in 1036, and after that period eruptions took place in 1049, and 1138 or 1139; "after which a great pause ensued for 168 years," when an eruption took place in 1306, another in 1500, another at Monte Nuovo in 1538, when a new hill was formed 440 feet in height." For nearly a century after the birth of Monte Nuovo, Vesuvius continued in a state of tranquillity. There had been no violent eruption for 492 years. Bracini, who visited Vesuvius not long before the eruption of 1631, gives the following interesting description of the interior:—

"The crater was five miles in circumference and about a thousand paces deep: its sides were covered with brush-wood, and at the bottom there was a plain on which cattle grazed. In the woody part wild boars frequently harboured In one part of the plain, covered with ashes, were three small pools, one filled with hot and bitter water, another salter than the sea, and a third hot but tasteless. But at length these forests and grassy plains were consumed, being suddenly blown into the air, and their ashes scattered to the winds. In December 1631, seven streams of lava poured at once from the crater, and overflowed several villages on the flanks and at the foot of the mountain. Resina, partly built over the ancient site of Herculaneum, was consumed by the fiery torrent. Great floods of mud were as destructive as the lava itself—no uncommon occurrence during these catastrophes; for such is the violence of rains produced by the evolutions of aqueous vapour, that torrents of water descend the cone, and becoming charged with impalpable volcanic dust, and rolling along loose ashes, acquire sufficient consistency to deserve their ordinary appellation of 'aqueous lavas.' A brief period of repose ensued, which lasted only until the year 1666, from which time to the present there has been a constant series of eruptions, with rarely an interval of rest exceeding ten years." —Lyell's "Principles of Geology," 1847, pp. 358, 359.

The analyses given of the simple minerals represent their average per-centage composition; the formulæ give the usual mineralogical notation.

A. C. Ramsay.

LIST OF SPECIMENS OF VESUVIAN ROCKS AND MINERALS ARRANGED AND DESCRIBED BY H. BAUERMAN.

1. ASHES.
Bocco Tre Case. Eruption of 1760.

2. VOLCANIC SAND, (rounded *fragments and crystals* of *augite and idocrase)* from the eruption of 1794.

3. Similar to No. 2; locality, &c., not stated.

4. VOLCANIC CONGLOMERATE, fragments of decomposing and incrusted lava cemented.
Found on the Piano del Cinestro. Eruption of 1794.

5. YELLOW TUFA, with *felspar crystals.*
Eruption of 1794. Locality not stated.

6. LAPILLI, small fragments of scoriaceous Lava from the eruption of 1813.
Found at Resina.

7. FINE RED, FERRUGINOUS ASHES, from the eruption of 1822.
Resina.

8. LAMINATED FELSPATHIC ASHES.
Monte Nuovo.

9. *White pumiceous Lava,* with a few transparent *white felspar crystals.*
Real Capo di Guoglio. Date of eruption not stated.

10. GREY PUMICE.
Fossa Grande. Date not stated.

11. VESICULAR LAVA (externally weathered brick-red).
Fossa Grande. Date of eruption not stated.

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.
La Scala. Date of eruption not stated.

14. COMPACT GREY LAVA, with crystals of *olivine* and *sodalite;* externally coated with *atacamite* (*oxychloride of copper*).
La Scala. Eruption of 79.

15. GREY LAVA, covered with crystals of *sodalite:* externally, coloured red.
La Scala. Eruption of 79.

16. LAVA, containing *sodalite,* which flowed when Pompeii was destroyed.
La Scala. Eruption of 79.

17. LAVA, with crystals of *augite.*
La Scala. Eruption of 79.

18. BLACK SCORIACEOUS LAVA, with crystals of *augite.*
La Scala. Eruption of 79.

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*).
Fortino di Calastro. Eruption of 1429.

21. BASALTIC LAVA, with crystals of *leucite* and *augite.*
Bosco Reale. Eruption of 1440.

22. LAVA, with small crystals of *augite* and *leucite.*
Santa Maria di Pagliano. Eruption of 1533.

23. LAVA, with *augite* crystals.
Granatello di Portici. Eruption of 1551.

24. LAVA, with crystals of *leucite* and *black augite.*
Bocco Tre Case. Eruption of 1554.

25. LAVA, with crystals of *augite,* externally crusted with *calc spar.*
Fortino di Calorto. Eruption of 1631.

26. VESICULAR LAVA, crusted with *calc spar.*
Portico del Granatello Portici. Eruption of 1655.

27. LAVA, with crystals of *augite* and *olivine.*
Locality not stated. Eruption of 1659.

28. LAVA, with small crystals of *meionite.*
Santa Masiello. Eruption of 1760.

29. LAVA, with crystals of *augite.*
Fossa Grande. Eruption of 1767.

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.
Atrio del Cavallo. Eruption of 1779.

32. Similar rock to No. 31.
Fossa del Vetraro. Eruption of 1786.

33. BLACK SCORIACEOUS LAVA.
Crater of Pagliatone, Atrio del Cavallo. Eruption of 1786.

34. LAVA, with crystals of *augite* and *olivine.*
Torre del Greco. Eruption of 1794.

35. VESICULAR LAVA, externally coated with crystals of *iron glance.*
Camandoli delli Torre del Greco. Eruption of 1803.

36. BASALTIC LAVA, with crystals of *augite.*
Camandoli. Eruption of 1803.

37. SCORIACEOUS LAVA, with *obsidian.*
Camandoli. Eruption of 1804.

38. LAVA, with small crystals of *mica.*
Camandoli. Eruption of 1804.

39. SCORIACEOUS LAVA, with crystals of *felspar.*
Camandoli. Eruption of 1806.

40. LAVA, with crystals of *augite.*
Camandoli. Eruption of 1809.

41. LAVA, with crystals of *leucite, augite,* and *mica.*
Piano del Cinestro. Eruption of 1810.

42. LAVA, with crystals of *mica* and *augite.*
Piano del Cinestro. Eruption of 1810.

43. DARK SCORIACEOUS LAVA, weathered, brownish-red with a few *augite* crystals.
Giesovito. Eruption of 1811.

44. BLACK VESICULAR LAVA, with a few crystals of *felspar* and *augite.*
Vicilo del Vesuvio. Eruption of 1812.

45. FELSPATRIC LAVA, with *augite* crystals.
Locality not stated. Eruption of 1814.

46. Red laminated FELSPATHIC LAVA, with interspersed *felspar*-crystals; apparently part of an ejected fragment.
Eruption of 1815.

47. LAVA, with crystals of *augite.*
Croce di Croris. Eruption of 1815.

48. Granular white FELSPATHIC LAVA, with interspersed, black, scoriaceous fragments.
Grotto del Mauro. Eruption of 1817.

49. SCORIACEOUS LAVA, coated with a crust of *sylvine* (*chloride of potassium*).
Found at Grotto del Mauro. Eruption of 1817.

50. BASALTIC LAVA, with crystals of *augite.*
Foot of Vesuvius, towards Monte Somma. Eruption of 1818.

51. SCORIACEOUS LAVA, with crystals of *augite* and *olivine.*
Locality not stated. Eruption of 1818.

52. Vesicular Black Lava.
Locality not stated. Eruption of 1819.

53. Basaltic Lava, with small crystals of *augite*.
Piano del Cinestro. Eruption of 1819.

54. Lava, with large black *augite* and decomposing *leucite* crystals, in a reddish base.
Eruption of 1820.

55. Vesicular Lava, with decomposing crystals of *leucite*, coated with a yellow crust.
Eruption of 1820.

56. Grey Lava, with crystals of *sodalite*.
Mauro. Eruption of 1821.

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 crystals of *augite* and *leucite*.
Eruption of February 1822.

60. Lava, with crystals of *leucite* and fibrous crystals of *hornblende*.
Mauro. Eruption of 1822.

61. Vesicular Lava, with crystals of *augite*, *leucite*, and *olivine*.
Cone of Vesuvius. Eruption of 1822.

62. Black Scoriaceous Lava, containing a *coin* imbedded in it while the lava was in a fluid state.
Eruption of 1842.

63. Black Scoriaceous Lava, similar to No. 62.

64. Scoriaceous Black Lava, externally weathered yellow.
Eruption of 1855.

65. Stalactitic Lava, showing lines of viscous flowing, cooled close to the mouth of a crater.

65a. Lava.
Atrio del Cavallo. Eruption of 1858.
Presented by Dr. Strange.

Simple Minerals.

Spinel (*aluminate of magnesia*).

$\dot{\mathrm{Mg}}\,\dddot{\mathrm{Al}}$ = Magnesia 21; Alumina 72.

66. Black Spinel, *mica*, and *idocrase*, with *meionite* in limestone.
Monte Somma.

67. Black Spinel, with *green augite* and *mica*, partly clouded and decomposed.
Vesuvius.

68. Black Spinel, with *green augite* and *mica*.
Coestani, Vesuvius,

69. Black Spinel, with *augite*, *epidote*, and *mica*.

70. Spinel, *mica*, and *green augite*.

71. Spinel and Meionite, in *green granular augite*.

Specular Iron Ore (*peroxide of iron*), or $\dddot{\mathrm{Fe}}$.

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

73. Similar specimen to No. 72.

74. Crystalline Calc Spar, inclosing masses of *iron glance*; partly altered to *brown iron ore* (*hydrated peroxide*).

HAÜYNE (*silicate of soda and alumina with sulphate of lime*).

75. HAÜYNE with *felspar, mica, augite*, and *spinel.*

76. HAÜYNE *in felspatho-augitic lava*, similar to No. 75.

77. HAÜYNE with *mica* in felspathic lava.
Mauro.

78. MEIONITE AND HAÜYNE in limestone.
Monte Somma.

LEUCITE ; *cubical felspar* (*silicate of potash and alumina*).

Silica, 55 ; Potash, 22 ; Alumina, 23.

79. LEUCITE, a large trapezohedral crystal in *lava.*
Monte Somma.

80. LAVA with *leucite* crystals.
Capo di Sobotoniello.

81. VESICULAR RED LAVA with crystals of *leucite.*

The material of which part of Pompeii is built.

82. BASALTIC LAVA with crystals of *augite* and *leucite.*
Monte Somma.

83. VESICULAR LAVA, with crystals of *leucite* and *bronzite-augite.*

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

$$\dot{R}\ 2\ \dddot{Si} + 2\ \dddot{Al}\ \dddot{Si}, \text{ in which } R = (Na, K).$$

$$(\dot{Na}, \dot{K})^2\ \dddot{Si} + 2\ \dddot{Al}\ \dddot{Si}.$$

Silica, 44 ; Soda, 17 ; Potash, 5 ; Alumina, 34.

84. NEPHELINE AND AUGITE. Eroded and rounded crystals in limestone.

85. NEPHELINE, with *mica* and *augite.*

86. NEPHELINE, with *granular augite.*

87. NEPHELINE. Transparent crystals in *augitic lava*, with *augite* and *idocrase.*

88. NEPHELINE. Large crystals, with transparent crystals of *green augite* in limestone.

FELSPAR (*silicate of potash and alumina*).

$$\dot{K}\ \dddot{Si} + \dddot{Al}\ \dddot{Si}^3.$$

Silica, 65 ; Potash, 17 ; Alumina, 18.

89. ICE SPAR (*glassy felspar*), with *green augite* and *mica.*

90. LAVA, with crystals of *glassy felspar.*
Fossa Grande.

91. LAVA, with crystals of *augite* and *leucite*, and small sphærulitic masses of *obsidian* (*impure felspar or volcanic glass*).

92. LAVA, with crystals of *felspar, mica, augite*, and *olivine.*

93. AUGITIC LAVA, with *felspar, mica*, and *epidote.*

94. LAVA, with *felspar, black mica*, and *augite.*

95. AUGITIC LAVA, with *black mica* and *felspar.*

96. AUGITIC LAVA, with crystals of *black mica* and *meionite.*
S. Anastasia di Somma.

97. AUGITE, *idocrase* and *mica.*

98. AUGITIC LAVA, with *black mica* and *felspar.*

99. GREEN AUGITE, with *mica*-crystals.
Monte Somma.

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

$$\dot{Ca}^3\,\dddot{Si} + 2\,\dddot{\bar{Al}}\,\dddot{Si}.$$

Silica, 42; Alumina, 32; Lime, 26.

100 to 111. Various specimens of MEIONITE in limestone, from Monte Somma. The clouded and rounded masses form the variety "NUTALLITE" of Brooke, which is distinguished by its inferior hardness.

IDOCRASE; *Vesuvian* (*silicate of alumina and lime*).

$$\dot{R}^3\,\dddot{Si} + \dddot{\bar{R}}\,\dddot{Si} \text{ where } \dot{R} = (\dot{Fe}, \dot{Ca}, \dot{Mg}, \dot{Mn})\ \&$$

$$\dddot{\bar{R}} = \dddot{\bar{Al}}\,\dddot{\bar{Fe}}$$

Silica, 39; Alumina, 23; Lime, 29 to 36; Protoxide of Iron, 0·30.

112. BROWN IDOCRASE, with *augite* and *mica.*

113. IDOCRASE, with *felspar, augite*, and *mica.*

114. REDDISH-YELLOW IDOCRASE, with *felspar.*

115. YELLOW IDOCRASE, with *felspar, mica*, and *augite.*

116. IDOCRASE, with *augite* and *nepheline* in limestone.

117. IDOCRASE in rounded crystals, with *mica* and *meionite.*

118. MEIONITE and *idocrase* on limestone.
Monte Somma.

OLIVINE (*silicate of magnesia, and protoxide of iron, with variable quantities of lime and protoxide of manganese*).

$$\dot{R}^3\,\dddot{Si}.$$

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

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

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

MICA ; *Biotite* (*silicate of magnesia, potash, peroxide of iron, and alumina*).

$$\dot{R}^3\,\dddot{Si} + \dddot{\bar{R}}\,\dddot{Si}$$

122. Crystals of *greenish-black mica* much eroded.

123. Small *mica crystals*, with *augite* in limestone.

124. MICA CRYSTALS, with *chondrodite* (*silicate of magnesia*) in limestone.

125. LAVA, with *augite* crystals and a little *chondrodite*.
Capo di Guoglio.

126. *Similar specimen to* No. 125.
Capo di Guoglio.

ZEOLITIC MINERALS.

(*Hydrous silicates not containing magnesia*).

127. VESICULAR LAVA, with crystals of *Phillipsite* (*hydrous silicate of lime, potash, and alumina*).

128. AMYGDALOIDAL LAVA, the vesicles mostly empty, some containing a little *Phillipsite.*

129. PHILLIPSITE. Cruciform macled crystals in *amygdaloid.*

130. VESICULAR LAVA, with crystals of *analcime* (*hydrous silicate of soda and alumina*).
S. Anastasia di Somma.

131. LAVA, with crystals of *laumonite* (*hydrous silicate of lime and alumina*) *and mica.*

132. VESICULAR LAVA, with crystals of *aragonite* (*prismatic carbonate of lime*).

133. CALCAREOUS BRECCIA, with fragments of green *altered limestone.*
Monte di Ottajano.

134. VOLCANIC ASHES, with included fragments of limestone.
Monte Somma.

135. SOFT GRANULAR WHITE LIMESTONE.
Fossa Grande.

136. WHITE LIMESTONE, similar to No. 135, but harder.

137. WHITE LIMESTONE, like 136.

138. CHRYSOPRASE (*light-green amorphous quartz*).

139. FIBROUS GYPSUM, coating *lava.*

140. Similar specimens to No. 138.

141. TRACHYTIC LAVA, with crystals of *felspar* (*ryacolite*).
Solfatara, near Naples.

142. SOFT SILICEOUS SINTER.
Solfatara, near Naples.

143 and 144. PITCHSTONE PORPHYRY ; *Obsidian* with imbedded crystals of *glassy felspar.*
Island of Ischia.

145. GRANITE, composed of *quartz*, white and red *felspar*, and black *mica.*
Montagna di Castellamare, near Naples.

H. BAUERMAN.

Arranged and described by H. W. BRISTOW.

146. SAL-AMMONIAC or Muriate of ammonia on Scoriaceous Lava.
From the eruption of February 1850.

147. DIMORPHINE.
(Sulphur 24·55, Arsenic 75·45.)
From a fumarole of the Solfatara, Phlegræan fields, near Naples.

148. 32 polished specimens of volcanic rocks from *Vesuvius.*

149. VESICULAR SCORIACEOUS LAVA.
Vesuvius.
Eruption of March 1860.
Presented by Dr. Strange.
Compare with No. 65a.

150 and 151. GLASERITE (sulphate of potash).
Vesuvius.
Eruption of February 1850.

152. HORNBLENDE, with *idocrase, meionite, mica,* &c., on limestone.
Vesuvius.

153. SYLVINE (chloride of potassium) on vesicular, scoriaceous lava.
Vesuvius.
Eruption of February 1850.

154. SOLFATARITE (soda-alum).
Solfatara, near Naples.

155. PERICLINE, with *calc spar.*
Somma.

156. COQUIMBITE (hydrous sulphate of iron) with *realgar* and *sal-ammoniac.*
Solfatara, near Naples.

157. COTUNNITE (chloride of lead) on scoriaceous lava.
Crater of Vesuvius.

158 and 159. COTUNNITE.
Vesuvius.
Found in the autumn of 1857 on the still warm scoriaceous lava of 1855.

160, 161, and 162. COTUNNITE.
From the eruption of 1855. Found on *Vesuvius* in 1858, on scoriaceous lava.
Presented by J. B. Pentland, Esq.

163. SCORIACEOUS LAVA, enveloping a pebble.
The neighbourhood of Bonn.
Presented by Sir Roderick I. Murchison, G.C.S.S.

Nos. 160 and 161 present a very different appearance from the three specimens Nos. 160 to 162, the mineral in the latter being of an opaque yellow instead of colourless, and in rounded amorphous coatings instead of in clusters of minute, delicate crystals. This change of appearance has been produced by the melting of the crystals, after their deposition on the lava.

No. 157 affords examples of the mineral in both conditions.

VOLCANIC SPECIMENS FROM HECLA, ICELAND.

Collected and presented by J. W. Bushby, Esq.

Hecla is a volcanic mountain 6,131 feet in height, situated on the S.W. part of Iceland, in lat. 63° 59′ N., long. 19° 42′ W.

The volcanos of Iceland are known to have been in activity as early as the ninth century. Since 1004 or 1005 no less than 23 marked eruptions have taken place; no interval exceeding 40 years, and seldom one of 20 years, having elapsed without the occurrence of either an eruption or a great earthquake.

Some of the eruptions have been of great violence, and have lasted six years without ceasing. During the eruption of 1766, smoke and clouds of ashes obscured the sunbeams to such an extent, that in Glaumbär, about 100 miles distant, men could only find their way by groping.

Again in 1783, Skaptar-jökull, which had remained dormant as far as any human records of the land extend, suddenly burst into activity, and did not again become quiescent for two years.

Immense quantities of volcanic matter were thrown out during this period. Two of the lava-streams, 40 and 50 miles in length, flowed in opposite directions, attaining a width of seven miles and from 12 to 15 miles respectively; while the height of both currents, which was ordinarily 100 feet, became as much as 600 feet in narrow defiles.

During this eruption many villages were inundated by water, 20 were destroyed, and more than 9,000 human beings perished, together with immense numbers of cattle, while the coasts were deserted by fish.

On the 2nd September 1845, a Danish vessel was covered with ashes, during an eruption, near the Orkney islands, 537 miles from the volcano.

In the intervals between eruptions, inumerable hot springs burst forth, and solfataras discharge copious streams of inflammable matter.

The most remarkable of the intermittent springs or geysers, are situated in the south-western part of Iceland, more than 30 miles distant from Hecla. They rise through a thick bed of lava, in such numbers, that nearly a hundred of them may be counted in a circumference of two miles.

"Few of them play more than five or six minutes at a time, and the intervals between each eruption are very irregular.

"The Great Geyser rises out of a spacious basin at the summit of a circular mound composed of siliceous incrustations deposited from the spray of its waters. The diameter of this basin, in one direction, is fifty-six feet, and forty-six feet in another."

(Lyell's "Principles of Geology," 7th edit. pp. 406–530.)

(De la Beche's "Geological Observer," 2d edit. p. 343.)

164. SCORIACEOUS LAVA.
Hecla.

165. SCORIACEOUS LAVA.
From the extinct Volcano at Svinahraun.

166. VOLCANIC BOMB.
From the sulphur banks of Yousavatn.

167. SILICEOUS SINTER, with impressions of leaves.
Little Geyser.

168. SULPHATE OF LIME now being formed at *Krusivik.*

169. NATIVE SULPHUR.
From banks or mines at Mount Hengill.

170. NATIVE SULPHUR.
Krusivik.

ROWLEY RAG (BASALT).

"The *Rowley Rag* is a basalt; a hard, heavy, black, close-grained rock, weathering brown outside, having a tendency to form spheroids, that envelope with several concentric coats a solid ball in the middle, and consequently often assuming a columnar structure, that in some instances becomes nearly as regular as that of the Giant's Causeway. This is the stone of the Rowley Hill, Barrow Hill, at Pensnet; Park Hill, at Bentley, and other spots. It is 200 or 300 feet thick, resting here upon the Coal Measures."—(On the Geology of the South Staffordshire Coal Field. J. Beete Jukes, F.R.S., page 241.)

These specimens are placed here to show the manner in which certain igneous rocks, when melted, assume different appearances, according to their more or less rapid rate of cooling from a state of fusion. In this instance about 31 cwt. of the basalt having been melted, in a large double reverberatory furnace, at the Eagle Foundry, Birmingham, was broken up, after cooling slowly during thirteen days. It was then found that the outer portions of the fused rock, that is, those portions which had cooled the most rapidly from their contact with the air, had assumed the appearance and structure of obsidian, while those from the bottom and middle, which had cooled more gradually, bore a resemblance to pitchstone. Some of the more glassy portions near the top were sphærulitic and vesicular, and may be compared with actual volcanic products of a similar nature in Wall-case 1. See also Case VII. in the Hall.

171. Rowley Rag in its natural state. See Wall-case 4, No. 280.

172. From the bottom of the cooled mass of Rowley Rag.

173. From the middle of the cooled mass of Rowley Rag.

174. Artificial Obsidian, or *Volcanic glass*, from near the top of the cooled mass of Rowley Rag. See Wall-case 2, Nos. 29 to 31.

175. Artificial Obsidian, vesicular and sphærulitic. See Wall-case 2, Nos. 30, 119.

176. Artificial Obsidian showing the effect of rapid cooling, produced by pouring the melted rock into water. See Wall-case 1; Nos. 20, 29, 30, 36.

Nos. 171 to 176 were presented by William Hawkes, Esq.

Model of Graham's Island.

Constructed by M. Constant Prevost.

Presented by Dr. Fitton, F.R.S.

This island has been variously called Nerita, Ferdinanda, Hotham, Graham, Corrião, Sciacca, and Julia, but the name most generally adopted is that of Graham's Island which was given to it by Captain Senhouse, R.N., the first person who succeeded in effecting a landing upon it.

It was situated in lat. 37° 11′ N., long. 12° 44′ E., 33 miles N.E. of Pantillaria, and 31 S.W. of Sciaca in Sicily.

The island was first actually seen by the captain of a Sicilian vessel, on the 18th July 1831, when it appeared as a small island 12 feet high, throwing out volcanic matter and immense columns of vapour from a central crater.

The eruption continued with great violence till the end of the month, when the island was from 50 to 90 feet high, and $\frac{3}{4}$ of a mile in circumference.

By the 4th of August it had attained a height of 200 feet and a circumference of three miles. After the latter date it grew less under the action of the waves, until on the 25th of August it was only two miles round; on the 3rd of September it was still further reduced to $\frac{3}{5}$ths of a mile in circumference, and 107 feet in height, and on the 29th of the same month it was only 700 feet in circumference.

On the latter day it was visited by M. Constant Prevost, by whom the model in the Case was constructed out of the ashes and lapilli thrown out by the volcano. The island was found by M. Prevost to be entirely composed of scoriæ, pumice, and other incoherent ejected matter, few of the stones thrown out exceeding a foot in diameter. By the end of October no trace of the crater remained, and the island was nearly level with the water's edge.

At the commencement of 1833 there was merely a shoal and discoloured water to mark the spot, and at the end of 1833 a dangerous reef existed about $\frac{3}{5}$ths of a mile in extent, and of an oval shape.

Thus little more than three months intervened between the first appearance of the island and its final destruction; during which period there is no reason to suppose that the original bed of the sea was subjected to any elevatory movement.

Sir Charles Lyell conjectures that the cone must have been as large as one of the lateral volcanos on the flank of Etna, and about half the height of Jorullo in Mexico, which was formed in nine months. He also supposes that a hill at least 800 feet high was formed by a submarine volcanic vent, of which the upper part only (about 200 feet high) emerged above the sea to form the island. The lava ejected contained augite, and the only gas evolved in any considerable quantity was carbonic acid. (Lyell's Principles of Geology, 7th edit p. 414.)

H. W. Bristow.

Table-case B in Recess 6.

Collection of Lavas, Ashes, Simple Minerals, &c., from the district of the Extinct Volcanos of the Papal States.

Arranged and described by H. W. Bristow.

The date of the extinct volcanos of the Roman States has been satisfactorily determined by the researches of Sir Roderick Murchison and Sir Charles Lyell, by both of whom it has been referred to the Coralline Crag period of the older Pliocene. The earlier volcanic rocks of this district rest conformably on, and are interstratified with, the shelly marls of the Subappenine Hills, the fossils of which have a specific agreement with those of the Suffolk Crag of this country.

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 Subappenine 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.*
Forms erratic blocks scattered over the *Aventine and Esquiline Mounts, inside Rome.*

6. Brick-red Tufa, with fragments of *grey lava, leucite, augite*, and *calc spar ;* forming a great deposit *beyond Sta. Agnese.*

7. Grey Tufa, composed of minute fragments of *lava, leucite, augite*, and *mica ;* forming a great deposit on the *Capitoline Mount, inside Rome.*

8. Tufa, composed of fragments of *augite, mica*, and *earthy leucite*, with *lava, decomposed pumice*, &c.; from the prolongation of Monte Esquilino, *beyond Porto San Giovanni*, 3 *miles from Rome.*

9. Brick-red Tufa, from the *Aventine Mount.*
Presented by Warington W. Smyth, F.R.S.

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

11. Tufa.
Composed of decomposing *glassy felspar*, small fragments of *grey lava, augite*, and specks of *silvery mica.*
Basin of Lake Baccano, on the road to Monte Rossi.

12. Brown Cellular Tufa.
Monte Pincio, inside Rome.
Some of the cells are filled with yellow *pumiceous remains*, with *earthy leucite, augite*, a little *mica*, &c.

13. Compact Tufa, with earthy *leucite*, fragments of *pumice, mica*, and *augite.*
Olive Grove of Valdo Ambrini.

14. Brick-red Tufa, with fragments of *lava, pumice, earthy leucite, augite, mica*, and *metamorphic marble.*
Monte Verdi, 2 miles from Rome.

15. Spongy Tufa, full of yellow *pumice*, partly stained with oxide of iron and fragments of *glassy felspar.*
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.
Summit of the Quirinal, 5 feet below the roadway in front of the Palazzo della Consulta, Rome.

17. Granular Tufa.
Monte Pincio, inside Rome.
Composed of pieces of *pumice, augite*, and *leucite*, overlying No. 12.

18. Reddish-brown Tufa, with fragments of *grey lava, mica*, and much *earthy leucite.*
Summit of the Quirinal, inside Rome.

19. Grey Tufa, with *leucite*, &c.
Near the gate of Santo Spirito, inside Rome.

20. Stony Tufa.
The Vatican at Rome ; found in 1818 in digging the foundations of the Chiaramonti Museum.
Composed of pieces of *lava, pumice*, and *ashes*, with *augite, mica*, and *earthy leucite.*

21. Tufa, with included fragments of *pumiceous lava*, with *earthy leucite*, crystals of *glassy felspar*, &c.
Occurs at the surface *near the first gate beyond Tor Di Quinto.*

22 and 23. Varieties of TUFA, used for the ordinary building-stones of Rome.
Monte Verdi.
Presented by Warington W. Smyth, F.R.S.

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

25. GREY PEPERINO, with fragments of *scoriaceous lava, augite, mica,* and *carbonate of lime.*
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.*
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.*
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.
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.*
Tempesta, in the basin of Lake Albano.

34. BRICK-RED ASHES, with fragments of *augite* and *leucite.*
Capo di Bove: forming the bed of the basaltic lava-stream.

35. GREYISH-WHITE ASHES.
Monte Artemisio, near Velletri.

36. GREY ASHES.
Monte Albano and Monte Artemisio, near Velletri.

37. RED ASHES.
From the lava on the hills *near San Paolo, 3½ miles from Rome.*

38. VOLCANIC CINDERS.
Lake Nemi.
Composed of pieces of *scoriæ, earthy leucite,* &c.

39. Fragments of VOLCANIC CINDERS.
Monte Cavo, above Albano.

40. CINDERS.
Forming a part of *Monte Cappuccini, near Velletri.*

41. CINDERS.
Monte Cimino, between Velletri and Gensano.
Nos. 35 to 41 are used, when mixed with lime, for making the cement called Pozzuolana.

42. PUMICE.
Caprasola, E. of Monte Cimino.

43. YELLOWISH PUMICE.

44. PUMICEOUS LAVA.
Neighbourhood of Ronciglione.
Contains included fragments of grey *scoriaceous lava,* similar to the lava of the Phlegræan Fields, near Naples.

45. SCORIACEOUS LAVA (approaching to *pumiceous*), with included crystals of *decomposed felspar.*
Braccianesse.

46. SCORIACEOUS LAVA, SLIGHTLY POROUS.
Capo di Bove, near Rome; forming the base of the basaltic lava-stream.

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.*
Summit of Monte Malchio, near Velletri.

50. Reddish-brown Vesicular Scoriaceous Lava.
Monte Cappuccini, near Velletri.

51. Greyish Lava.
Lake Albano.

52. Semi-vitrified Scoriaceous Lava.
From the oldest summit of *Monte Artemisio, near Velletri.*

53. Brown Vesicular Scoriaceous Lava.
Monte Porfio, and the Tusculan hills above Frascati.

54. Scoriaceous Lava.
Monte Cappuccini.
The interior is finely vesicular, and some of the cavities are filled with *leucite.*

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*).
Summit of Tusculum, above Frascati.

57. Trachytic Lava.
E.S.E. of Viterbo.
Contains *glassy felspar*, angular fragments of black and grey vesicular *scoriaceous lava*, and decomposed fragments of *felspar* in a felspathic base.

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.*
Ascent to Cignanello, E. of Monte Cimino.
From volcanic conglomerate.

61. Trachytic Lava.
N. of Monte Cimino.
Composed of crystals of *glassy felspar* and *mica* in a felspathic base.

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.
Madonna del Poggio, between Bassano and Bomasto.
Contains crystals of *glassy felspar, mica*, and small fragments of *augite.*

65. Trachytic Lava, with crystals of *augite* and *glassy felspar.*
Hills near Vignanello, S.E. of Monte Cimino.

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, E.S.E. of Monte Cimino.

68. Trachytic Lava, with crystals of *glassy felspar, mica*, and small fragments of *augite.*
Bomargo, E.N.E. of Monte Cimino.

69. Trachytic Lava, with crystals of *glassy felspar, mica*, and *augitic fragments.*
Near Bagnaja, E. of Monte Cimino.

70. Decomposed Earthy Trachyte.
San Leonardo, near Fabbrica, E. of Monte Cimino.

71. COMPACT PORPHYRITIC ROCK.
The alum works near Tolfa; forming the upper portion of Monte della Cava Grande.

72. PORPHYRITIC ROCK, with *decomposed felspar.*
Forming the second stratum which alternates with the alum rocks at *Monte della Cava Grande.*

73. SILICEOUS AND FELSPATHIC ROCK.
Forming the upper stratum at the *Great Cavern near Tolfa.*

74. GREY LAVA, with crystals of *glassy felspar.*
Monte Fogliano, above Vitralla.

75. SCORIACEOUS LAVA (approaching to pumiceous), with crystals of *glassy felspar.*
Civita Castellana.

76. LAVA, with crystals of *glassy felspar.*
Neighbourhood of Bracciano.

77. LAVA, with *glassy felspar,* &c.
Capo le Grotti, near Bassano nella Teverone:

78. LAVA, with crystals of *glassy felspar* and small black *augite.*
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, E.S.E. of Viterbo.

80. BASALTIC LAVA, with *felspar* and brown *calc spar.*
Capo di Bove, near Rome.

81. LAVA, with *augite* and *calc spar*, and cracks filled with *ochreous iron ore* (*graphic lava*).
Border of Lake Nemi, near the Mills.

82. LAVA, with crystals of *glassy felspar, leucite, black mica,* and *augite.*
Fountain near Bassano, E. of Monte Cimino.

83. LEUCITE (*Amphigène, white garnet*), in detached trapezohedral crystals.
Neighbourhood of the Tusculan and Alban Hills.

84. LAVA, with crystals of *altered leucite.*
Borghetto, 3 *leagues from Civita Castellana.*

85. LAVA, with numerous crystals of *leucite.*
Monte Cavo, above Albano.

86. POROUS LAVA, with crystals of *leucite.*
Monte Cimino; From the hollow under Canapino.

87. LAVA, with large crystals of *leucite*, and a little *Haüyne* and *augite.*
Rock of Travignano, Lake Bracciano.

88. BASALTIC LAVA, with *leucite*, a little *Haüyne* and *Breislackite* (*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.*
Monte Albano.
In cavities in Pozzuolana (volcanic ashes).

93. LAVA, with large crystals of *leucite* and *augite, Haüyne,* &c.
Near Osteria, on the road to Albano.
In volcanic conglomerate.

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.

96. Lava, with crystals of *altered leucite.*
Vignanello, Monte Cimino; in cavities in friable Tufa.

97. Finely Vesicular Grey Lava, approaching to pumice, with lines of ashy laminæ, and a few crystals of *leucite.*
In large masses *N.E. of Monte Cimino.*

98. Grey Lava.
From the rock, *halfway up Monte Maschio, near Velletri.*
Finely vesicular in places, and containing crystals of *leucite* and a crystal of *garnet.*

99. Brown Scoriaceous and Finely Vesicular Lava.
Monte Cavo.
Contains trapezohedral crystals of *leucite,* and disseminated scales of *black mica.*

100. Basaltic Lava, with *leucite, augite, &c.*
Strada di Bracciano.

101. Detached Crystals of Augite.
Tusculan and Alban Hills.

102. Augite and Leucite.
Found in the ashes on the *plains of Monte Albano.*

103. Basaltic Lava, with *Breislackite (white-augite), leucite, &c.*
Capo di Bove.

104. Basaltic Lava, with crystals of *leucite* and *augite.*
Capo di Bove.

105. Lava, with *leucite, augite,* and *Haüyne.*
Near Osteria, on the road to Albano.
Forming masses in a bed of volcanic conglomerate.

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.

Nos. 107 to 109 attract the magnetic needle.

110. Pitchstone Lava, with crystals of *glassy felspar.*
From the mass on the plain of Galli, near the Alum-works at Tolfa.

111 and 112. Obsidian.
East of Monte Cimino.
Occurs in large masses, with sphærulitic pearlstone.

113. Obsidian (*Volcanic glass*), showing a conchoidal fracture and sharp cutting-edges.
From an isolated mass found on the Tusculan Hills above Frascati.
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 Breislackite, 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.

Nos. 115 to 127 are from *Capo di Bove,* and Nos. 115, 116, 117, 119, 120, 124 attract the magnetic needle.

128 and 129. BASALTIC LAVA, *with nepheline, mellilite, apatite, and Breislackite.*

130. BASALTIC LAVA, *with Breislackite and apatite.*

Nos. 128 to 130, from *Capo di Bove,* attract the magnetic needle.

131. BASALTIC LAVA, *with Breislackite* (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, Breislackite, nepheline, and apatite.*

136. BASALTIC LAVA, *with mesotype.*

Nos. 128 to 136, from *Capo di Bove,* attract the magnetic needle.

137. IDOCRASE, with small scales of *mica,* and pale grey decomposed *nepheline.*

From the decomposed ashes of Monte Albano.

138. GRANULAR ICESPAR, iridescent *augite, melanite,* and scales of *black mica.*

Round the sides of Lake Albano, lining cavities in Peperino.

139. ICESPAR, with rhombic dodecahedrons of *melanite.*

From the Peperino in the neighbourhood of Albano.

140. DETACHED PRISMATIC CRYSTALS OF MICA.

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.*

The borders of Monte Cavo.

144. HEXAGONAL PRISMS OF MICA, *with augite, Haüyne, olivine,* &c.

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.*
Monte Albano.

147. LEUCITE, *with idocrase and mica.*
The neighbourhood of Lake Albano.

148. MICA, *augite*, and crystals of *melanite.*
Monte Albano.

149. GREEN MICA WITH HAÜYNE.
Found in grey Peperino round the basin of Lake Albano.

150. HAÜYNE, WITH SCALES OF GREEN MICA.
Occurs in hollows in Peperino at the base of Monte Cavo, above Albano.

151. HAÜYNE, MICA, OLIVINE, &c.
Monte Cavo.

152. MASS OF CRYSTALS OF AUGITE, with black *mica.*
In red ashes on the plains of Monte Cimino.

153. DETACHED DODECAHEDRAL CRYSTALS OF MELANITE (*black garnets of Frascati*).

154. GREEN MICA and octahedral 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 octahedral crystals*).
From decomposed Ashes on the plains of the Tusculan and Alban Hills.

156. WAD OR EARTHY MANGANESE.
The mountains near Civita Vecchia.

157. TITANIFEROUS IRON, with *quartz.*
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.*
Lake Albano.

160. SAND, composed of small grains of *titaniferous iron,* fragments of *augite, glassy felspar, olivine, scoriaceous lava,* and *pumice.*
The Lake of Bossena.

161. IRON PYRITES (*sulphide of iron*).
Monte di Salisano.

162. SPATHIC IRON (*carbonate of iron*).
Monte Ernici, in the Campagna.

163. PEROXIDE OF IRON.
Guercino, in the Campagna.

164. NODULE OF CLAY IRONSTONE.
Umbrian Hills.

165. NODULE OF CLAY IRONSTONE.
Magnano, N. of Monte Cimino.

166. GREY SULPHIDE OF ANTIMONY.
From the hills near the Alum-works on Mount Tolfa.

167. BITUMEN, *with white limestone.*
Castro, in the Campagna.

168. BITUMEN (ASPHALT).
From the hill under the lighthouse of Sabina.

169. SULPHUR on PEPERINO, decomposed by sulphuric 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 sulphuric 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 octahedral crystals of *alumstone.*
Found in hollows of the rock, and 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, Tolfa.

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.

184. ALUMINOUS ROCK.
From the Old Cavern.

185. ALUMSTONE which has been roasted.

186. ALUMSTONE which has been roasted and macerated in water.

187. PURIFIED ALUM (*the alum of commerce*), obtained from *alumstone* by roasting and macerating in water, from which it has been deposited in crystals.

Nos. 173 to 187 are from the neighbourhood of the Alum-works at Tolfa, near Civita Vecchia.

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.*
The Chian Hills, N. 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 is probably discoloured by organic matter, accompanying the *brown iron-ore* (No. 162).

195. CLAY.
From the decomposed Trachyte of Monte Cimino.

196. GREY CALCAREOUS PIPE-CLAY, used for making pottery.
Vatican Hill, S. of St. Peter's, inside Rome.

197. FETID LIMESTONE (STINK-STONE).
From the Peperino of Monte Albano.

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

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

200. WHITE GYPSUM (*Alabaster*).
Tolfa.

201. ARAGONITE.
Monte Capuccini, near Orta.

202. BOLE.
Found in crevices of Tufa near the church of San Lorenzo, outside the walls of Rome.

203. BOLE.
Outside the Porto San Giovanni, 4 miles from Rome.
From a large hollow in decomposed Peperino.

204. BOLE.
Capo di Bove; in crevices of the basaltic lava-stream.

205. FINE CLAY.
The Great Cavern at Tolfa, in veins of Alum-rock.

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.
Below Tivoli: from the spring near the lake of the floating island.

209. TRAVERTINE.
Occurring in volcanic Tufa at the descent from Porto Solaro, 2 miles from Rome.
Calcareous deposit, inclosing the *shells of snails.*

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, inclosing a fossil *bivalve shell.*
Monte Mario.

213 and 214. METAMORPHIC LIMESTONE.
Apennine chain of the Roman States.

215. STALACTITIC CARBONATE OF LIME.
Grotto of Collepardo, on Monte Ernici, in the Campagna.

216. STALACTITIC CARBONATE OF LIME.
The Cascade below the Temple of the Sibyl, at Tivoli.

217. STALACTITIC CARBONATE OF LIME.
Subiaco, in the Campagna.

218. STALAGMITE (*commonly called " Travertine of Tivoli."*)
Near Lake Tartarus.
In hollows of large masses at the limestone-cavern.

219. CALCAREOUS TUFA OR TRAVERTINE.
*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 the Aventine Mount, inside 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 travertine, from four to five hundred feet in thickness."—*Lyell's Principles of Geology*, p. 241.

224. CONGLOMERATE (*Pudding-stone*).

Bridge of St. Onofrio, near Monte Mario.

Composed of calcareous and siliceous pebbles in a hard calcareo-arenaceous base.

225. CONGLOMERATE.

Near Ponte Salaro, 3 *miles from Rome.*

Forming Monte Sacro, and overlying the elephant-gravel.

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 siliceo-calcareous base.

Forms a portion of *Monte Mario, near Rome.*

228. COMPACT CALCAREOUS CONGLOMERATE.

The Vatican Hill, outside Rome.

229. CALCAREOUS BRECCIA, *composed of fragments of metamorphic limestone.*

Found in crevices of the limestone forming the *Apennine chain of mountains.*

230. PUMICEOUS CONGLOMERATE.

Sta. Agnese, 3 *miles from Rome.*

Overlies beds of calcareous breccia, and associated with beds of volcanic Tufa.

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.

Interior of Monte Sacro, near Ponte Salaro, 3 *miles from Rome.*

H. W. BRISTOW.

LAVAS AND OTHER PRODUCTS OF ERUPTION FROM ETNA.

Arranged and described by H. W. BRISTOW.

ETNA.—"After Vesuvius (see p. 234) our most authentic records relate to Etna, which rises near the sea in solitary grandeur to the height of nearly 11,000 feet. The base of the cone is almost circular, and 87 English miles in circumference; but, if we include the whole district over which its lavas extend, the circuit is probably twice that extent.

"The cone is divided by nature into three distinct zones, called the *fertile*, the *woody*, and the *desert* regions. The first of these, comprising the delightful country around the skirts of the mountain, is well cultivated, thickly inhabited, and covered with olives, vines, corn, fruit-trees, and aromatic herbs. Higher up the woody region encircles the mountain, an extensive forest six or seven miles in width, affording pasture for numerous flocks. The trees are of various species, the chestnut, oak, and pine being most luxuriant; while in some tracts are groves of cork and beech. Above the forest is the desert region, a waste of black lava and scoriæ, where, on a kind of plain, rises the cone to the height of about 1,100 feet, from which sulphureous vapours are continually evolved. The most grand and original feature in the physiognomy of Etna is the multitude of minor cones which are distributed over its flanks, and which are most abundant in the woody region. These, although they appear but trifling irregularities, when viewed from a distance, as subordinate parts of so imposing and colossal a mountain, would, nevertheless, be deemed hills of considerable altitude in almost any other region."—Lyell's "Principles of Geology," 7th edition, chap. xxv.

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 2342 years, the earliest authenticated eruption having taken 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 1,000 to 3,000 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 2,000 years. Of the 80 most conspicuous minor cones which adorn its flanks, only one of the largest, Monte Rossi, has been produced within the times of authentic history. Even this hill, thrown up in the year 1669, although 450 feet in height, only ranks as a cone of second magnitude. Monte Minardo rises even now to the height of 750 feet, although its base has been elevated by more modern lavas and ejections. * * * * * *

"To some, perhaps, it may appear that hills of such incoherent materials, as the loose sand and scoriæ of which the lateral cones of Etna are composed, cannot be of very great antiquity, because the mere action of the atmosphere must, in the course of several thousand years, have obliterated their original forms. But there is no weight in this objection, for the older hills are covered with trees and herbage, which protect them from waste; and in regard to the newer ones, such is the porosity of their component materials, that the rain which falls upon them is instantly absorbed; and for the same reason that the rivers on Etna have a subterranean course, there are none descending the sides of the minor cones. * * * * * *

"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.

233. TRACHYTE, with crystals of *augite*.
The neighbourhood of Milo.

234. TITANIFEROUS IRON-SAND.
The crater of 1819.

235. LAVA, with minute crystals of *specular iron.*
Monte Calvano.

236. BASALTIC LAVA, *with mellilite and Thomsonite.*

237. SPECULAR IRON, crystallized on scoriaceous lava.
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.*
Hill of Paterno.

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. BALSATIC LAVA, *with olivine,* and crystals of *glassy felspar.*
Eruption of 1836.

249. SCORIACEOUS LAVA, with minute crystals of *specular iron.*
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 1,100 feet."—Lyell.

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*.
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.R.S.

260. VESICULAR LAVA.
Neighbourhood of Monte Mompeloso.

261. SCORIACEOUS LAVA, of a similar kind to that which overwhelmed Malpesso in 1669.

262. LAVA from a "*bocca*," showing the manner in which, when the head of a lava-stream has been forced through a narrow aperture, it assumes a stalactitic form in cooling during its descent.

H. W. BRISTOW.

Wall-case 4.

IGNEOUS ROCKS OF VARIOUS KINDS.

Preliminary Remarks by A. C. RAMSAY.

The rocks in these cases are in common geological nomenclature all considered IGNEOUS. *They are arranged lithologically, or according to their structure and composition*, and without reference to their geological ages. As near as possible, *they follow each other so as to show the manner in which igneous rocks merge, or show a tendency to merge into each other.*

Nos. 1 to 5 show familiar examples of the minerals of which GRANITE is composed, viz., *quartz*, *felspar*, and *mica*.

Nos. 6 to 33 exhibit different varieties of GRANITE, a ternary (or triple) compound of the above minerals. The specimens from 6 to 13 are *grey Granites*, and show a passage from largely crystalline to the finer grained varieties. Nos. 14 to 29 are (with the exception of No. 24) *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. 30 to 33 are other ordinary varieties. Nos. 34 to 42 are from the outer portions or margins of certain granitic masses, and contain a fourth mineral, viz., *schorl* (see p. 262), which also enters into the composition of many of the granitic porphyries and other specimens. From 43 to 65 all the specimens are *schorlaceous*, and exhibit the gradual increase of that mineral, till, from 66 to 72, it predominates, and they are termed *Schorl Rock*. 73 and 74 are pure *schorl*, and 75 shows the manner of its occurrence in *a vein* in *Granite*.

Nos. 76 to 83 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. 86 to 132, 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 a *granitic* nature. They are generally characterized by an *absence of mica*. Many of them are porphyritic. Being dykes, from the smallness of their masses, they probably cooled with comparative rapidity, radiating heat into the rocks which they traversed. Hence their component substances have not had time to crystallize out separately in the manner of those in true Granites, although their general composition is the same.

Nos. 133 to 136 are specimens of *granitic veins*, traversing other larger-grained Granites, and *Slates* which are invariably *altered* at the points of junction. (See pp. 10, 19, 38, 49 and 233. Also No. 51, p. 264.)

Nos. 138 to 143 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.)

Nos. 144 to 159 are *felspathic traps* of various kinds. Most of them are uncrystalline, as, for instance, 145; others are slightly porphyritic (156 and 157). Some are exceedingly felspathic, like 146; and others contain much associated silica, like 145.

Nos. 162 and 163, and 165 to 171 are *Syenitic Granites*, that is to say, they contain a little *hornblende*, in addition to the other minerals.

No. 164 is a *Schorlaceous* Syenite, and 172 to 176 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. 180 to 199 show these minerals distinctly crystallized in the rock. From 201 to 242 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. 243 to 245 are *hornblende rocks*, being formed entirely of hornblende.

Nos. 247 to 262 from Devonshire and Cornwall are 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 WALL-CASES 1 and 2.

Nos. 263 to 279 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.

The remainder of the specimens on the lower shelf of this Case are chiefly *Canadian*. The upper shelf contains a few specimens too large to go in their proper places below.

A. C. RAMSAY.

Wall-case 4.

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. Map 75.

3. FELSPAR (*silicate of alumina and potash*), a large tabular crystal on Granite.

Huel Damsel, Gwennap, Cornwall. Map 31.

4. FELSPAR.

Roche, Cornwall. Map 30.

From a vein in Granite. Used for making glaze for earthenware.

5. MICA, *in foliated plates.*

St. Dennis Consols, near St. Austell, Cornwall. Map 31.

Forms a dyke 12 feet wide traversing granite.

Presented by Robert 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.

6. LARGE-GRAINED GRANITE.
Lundy Island. Map 28.
A ternary compound, made up of large crystals of *white felspar, translucent quartz* (*free silica*), and *black* and *silvery mica*, the latter comparatively rare.

7. GRANITE.
Bars Oban, Argyleshire.
Composed of two varieties of *felspar* (white and flesh-coloured), the former with a tendency to form separate crystals: *black mica* (some in good crystals) and *quartz.*
Presented by the Marquis of Breadalbane.

8. PORPHYRITIC GRANITE.
Oban, Argyleshire.
A polished cube of High Rock Granite, composed of two kinds of *felspar* (white and light pink, the former with a tendency to form separate crystals), *translucent quartz* (also attempting to crystallize separately), and *dark green mica.*
(On upper shelf.)
Presented by the Marquis of Breadalbane.

9. GREY GRANITE.
Dalkey, Dublin.
Composed of *translucent quartz,* crystals of *white felspar,* and *black* and *silvery mica.*

10. GREY GRANITE.
Strontian, Argyleshire.
Composed of crystals of *white felspar* (*orthoclase*), much *black mica and quartz.*

11. GRANITE.
Ardshiel, Scotland.
A small cube of grey Granite, polished on one side. Composed of an intimate mixture of *white felspar, quartz,* and *black mica,* in nearly equal proportions.

12. GREY GRANITE.
Aberdeen, Scotland.
A ternary compound in nearly equal proportions of *orthoclase* (*white potash-felspar*), *black mica and quartz.*

12a. GRANITE.
Aberdeen, Scotland.
A fine-grained grey Granite composed of *white felspar* (some in crystals), with *translucent quartz,* and large flakes of *black mica,* sometimes with a tendency to form separate crystals,

13. COARSE GRANITE.
Grey Granite Quarries, Rubislaw, 3 miles from Aberdeen.
A coarse aggregation of pink *felspar,* large plates of silvery *mica,* and translucent French-grey *quartz.*

14. GRANITE.
Corennie, Aberdeenshire.
Pale pink Granite composed of flesh-coloured *felspar* (*orthoclase*), translucent *quartz,* and an occasional small speck of black *mica.*
(On upper shelf.)
From the property of Colonel Gordon, of Cluny.

15. 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.

16. RED GRANITE.
Peterhead, Aberdeenshire.
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.

17. RED GRANITE.
Blackhill, Stirlingshire.
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.

18. GRANITE.
Strontian, Argyleshire.
Composed of *quartz,* large crystals of *felspar* and much *silvery mica,* with numerous crystals of garnet.
From the summit of Ben Resipole, 3,000 feet in height.
(On upper shelf.)

19. LARGE-GRAINED GRANITE.
Bl , Cornwall.
Composed of translucent *quartz* and crystals of white *felspar* in nearly equal proportions, with much silvery and black *mica.*
(On upper shelf.)

20. GRANITE.
Rough Tor, near Camelford, Cornwall.
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 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.

21. GRANITE.
St. Mary's Isle, Scilly Islands.
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*.

22. GRANITE.
Near Oliver Cromwell's Monument, Trescoe, Scilly Isles.
Composed of two varieties of *felspar* (*white and light brown*), the former with a tendency to crystallize separately--*quartz* and *dark-coloured and silvery mica*.
The specimen shows a weathered surface of quartz and white felspar, from the decomposition of the mica and brown felspar.

23. GRANITE.
Camelford, Cornwall. Map 30.
Composed of *quartz*, *felspar*, and two varieties of *mica* (*black and white*).
It belongs to the mass of Granite noticed, No. 20. Used for building.

24. GRANITE.
Isle of Arran.
Vein of fine-grained Granite traversing coarser-grained Granite, composed of *felspar* (*orthoclase*), some in crystals, *translucent quartz*, *hornblende*, and *black mica*.
Presented by Dr. Percy, F.R.S.

25. FINE-GRAINED GRANITE.
Guernsey.
Composed of *quartz*, *flesh-coloured felspar*, and *black mica*. Used for building.

26. FINE-GRAINED GRANITE.
Bryers, Scilly Isles.
Composed of *quartz*, *felspar*, and *black mica*.
The specimen shows a weathered surface, and is apparently decomposing throughout.

27. SMALL-GRAINED GRANITE.
St. Mary's (north end), Scilly Isles.
Quartz, *flesh-coloured felspar*, and *mica*, both *black* and *silvery*.

28. FINE-GRAINED GRANITE.
Poltesco, Lizard, Cornwall. Map 32.
Part of a vein traversing Serpentine. ("Report on Devon and Cornwall, p. 173.)

29. FINE-GRAINED GRANITE (very micaceous).
Near Tolvorn Passage, Falmouth Estuary, Cornwall. Map 31.
This specimen shows a weathering surface of a ferruginous-brown colour, owing to the decomposition of the felspar.

30. FINE-GRAINED GRANITE.
Strontian, Argyleshire.
Composed of *quartz*, *felspar*, and *black* and *silvery mica*.

31. FINE-GRAINED GRANITE.
Strontian, Argyleshire.
Quartz, *felspar*, and *black mica*.

32. FINE-GRAINED GRANITE.
Strontian, Argyleshire.
Quartz, *felspar* (sometimes with a tendency to form larger separate crystals), and much *black mica*.

33. FINE-GRAINED GRANITIC ROCK.
Pains Bridge, near Warleggon, Cornwall. Map 30.
Composed of *felspar*, *quartz*, and *silvery mica*.
Forms a projecting Granite-point, apparently thrust in amongst the adjacent Slates. Might be usefully employed for architectural purposes.

34. GRANITE.
Near Giant's Punch Bowl, St. Agnes, Scilly Isles.
A quaternary compound, composed of *felspar* (two varieties), *light brown and white*; *quartz*, *mica* (two varieties) *black and white*, and a small quantity of *schorl*.

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.

35. GRANITE.
Tregender, near Ludgvan, Cornwall. Map 33.

Composed of much *silvery mica, quartz, felspar, and schorl.*

36. SMALL-GRAINED GRANITE.
Castle an Dinas, Cornwall. Map 33.

Composed of *quartz, felspar, mica, and schorl.*

37. GRANITE.
Near St. Hilary, Cornwall. Map 33.

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*. (See "Report on Geology of Cornwall," p. 175.)

38. GRANITE on the side of a tin lode.
Beam Mine, Cornwall. Map 31.

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*.

39. GRANITE.
St. Dennis Hill, Cornwall. Map 30.

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.

40. GRANITE.
Penvivian Hill, near Bodmin, Cornwall. Map 30.

Composed of *quartz, white felspar* (*forming large separate crystals*), *black mica* and a little *silvery mica*, with a small quantity of *schorl*.

This forms the main mass of the rock, the skirts of which, adjoining the slate district, is schorlaceous.

41. GRANITE.
Huel Damsel, Gwennap, Cornwall. Map 31.

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*.

42. FINE-GRAINED GRANITE.
Burthy Quarry, near St. Stephens, Cornwall. Map 31.

Composed of *quartz, felspar*, and a green *steatitic mineral*, with a small quantity of *schorl*. (See "Report on Cornwall," p. 185.)

43. GRANITE (GRANITIC PORPHYRY).
Near Lower Woodley, Lanivet, Cornwall. Map 30.

Composed of crystals of *quartz, schorl*, and *mica*, in a quartzo-felspathic base. 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.

44. PORPHYRITIC GRANITE.
Bossullow Down, Morvah, Cornwall. Map 33.

Large crystals of *light flesh-coloured felspar*, in a quartzo-felspathic base, with a small quantity of *schorl*.

45. GRANITE.
Rosemodris, St. Buryan, Cornwall. Map 33.

Composed of *felspar*, with a tendency to form separate crystals, *quartz, schorl*, and *mica*.

46. GRANITE.
Knill's Monument, St. Ives, Cornwall. Map 33.

Composed of two varieties of *felspar* (*white and light brown*), *quartz, schorl*, and *mica* (the latter scarce and small).

47. GRANITE.
Cligga Point, Cornwall. Map 31.

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.)

48. FINE-GRAINED GRANITE.
Belovely Beacon, Cornwall. Map 30.

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 Down to Higher Rosewastes, near St. Columb Major. (See Map 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.

49. GRANITE.
St. Dennis Down, St. Dennis, Cornwall. Map 30.

Composed of *white felspar* (some in large crystals), *translucent quartz, schorl,* and *black mica.* Forms a portion of the Hensbarrow mass of Granite. (See "Report on Geology of Cornwall," p. 160.)

50. GRANITE.
Near Penzance, Cornwall. Map 33.

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.

51. GRANITE.
Belovely Beacon, near Roche, Cornwall. Map 30.

Composed of *quartz, white* and *flesh-coloured felspar,* and *silvery mica.*

This Granite forms a mass which rises through a system of slate beds, having an east and west strike, and seen to be fossiliferous, near New Quay. The Slates are much altered around this Granite, which is schorlaceous along its northern boundary. This rock might be advantageously employed for purposes in which Granite is used; large blocks of it are scattered over the northern flank of Belovely Beacon. Passes into No. 72.

52. FINE-GRAINED GRANITE.
Dartmoor, Devonshire. Map 25.

Composed of *quartz, schorl,* and much *silvery mica.*

53. GRANITE.
W. side of St. Agnes Beacon, Cornwall. Map 31.

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.)

54. LARGE-GRAINED GRANITE.
Trink Hill, near St. Ives, Cornwall. Map 33.

Composed of highly crystalline *pink felspar,* with *white felspar* (also in crystals), *schorl, quartz,* and a little *black mica.*

55. PORPHYRITIC SCHORLACEOUS GRANITE.
W. side of St. Agnes Beacon, Cornwall. Map 31.

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.)

56. SCHORLACEOUS GRANITE.
Mayon or Mean, near the Land's End, Cornwall. Map 33.

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.

57. SCHORLACEOUS GRANITE.
Penvivian Hill, near Bodmin, Cornwall. Map 30.

Composed of *felspar, quartz, silvery mica,* and *schorl.*

58. SCHORLACEOUS GRANITE.
Penvivian Hill, near Bodmin, Cornwall. Map 30.

Composed of *black 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.

59. GRANITE.
Caryquoita Rock, near St. Enoder, Cornwall. Map 31.

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.

60. GRANITE.
St. Brelade's quarry, Jersey.

Composed of *schorl, flesh-coloured felspar* (some in large crystals), *quartz*, and *black mica.*

61. GRANITE.
Above St. Martin's Bay, St. Martin's, Scilly Islands.

Composed of *schorl, quartz*, and *felspar*, and much *silvery mica.*

62. PORPHYRITIC GRANITE.
From the skirt of the Carmarth Granite, near St. Day, Cornwall. Map 31.

Composed of imperfect crystals of light flesh-coloured *felspar*, in a quartzo-schorlaceous base, with a few minute spots of *silvery mica.*

63. PORPHYRITIC SCHORL-ROCK.
From the skirts of the granitic mass close to Trevalgan, near St. Ives, Cornwall. Map 33.

Composed of *quartz* and *schorl.*

64. SCHORL-ROCK.
Trevalgan, near St. Ives, Cornwall.

Occurs associated with No. 63.

The rock from which Nos. 63 and 64 are taken contains large crystals of felspar. In some parts of it, as is the case in No. 64, 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.)

65. SCHORLACEOUS GRANITE.
Mayon or Mean, near the Land's End, Cornwall. Map. 33.

Part of the same Elvan-dyke, as No. 64; but contains a larger quantity of schorl.

66. SCHORL-ROCK.
Mayon or Mean, near the Land's End, Cornwall. Map 33.

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.)

67. SCHORL-ROCK.
Small Money, Belovely Beacon, Cornwall. Map 30.

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.

68. SCHORL-ROCK.
Penvivian Hill, near Bodmin, Cornwall. Map 30.

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. 69.

69. SCHORL-ROCK.
Roche Rock, Roche, Cornwall. Map 30.

Composed of *schorl* and *quartz* in nearly equal proportions.

70. SCHORL-ROCK.
Roche Rock, Roche, Cornwall.

Schorl and quartz in nearly equal proportions.

Roche 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, round by the Indian Queen Inn (Map 30), are schorlaceous. It is remarkable, also, that the granitic veins and dykes (Elvan-courses) of the neighbouring country, and which may readily be supposed to be connected, at various depths, with the main mass of Granite, are frequently schorlaceous.

This schorlaceous Granite generally appears to prevail when a peculiar kind of argillaceous Slate is brought into contact with the granitic mass, such Slates when near the latter having also a schorlaceous character. There would seem to have been a reciprocal and chemical action along the line of junction, when the whole was in a heated state.

Roche Rock forms a conspicuous object in the country, rising abruptly from an undulating surface of elevated land, constituting a portion of a mass of Schorl-rock, which has an east and west direction.

Although this portion of the Schorl-rock rises abruptly above the surface of the adjoining land, it is by no means so hard a substance as might at first sight be supposed; hence, when employed as a building-stone, however ornamental its appearance, it would not, probably, be attended with the success that might be otherwise anticipated.

71. SCHORL-ROCK.
Laity, near Lelant, Cornwall. Map 33.

Composed of *schorl* and *quartz* in nearly equal proportions.

72. SCHORL-ROCK.
N. end of Belovely Beacon, Cornwall. Map 30.

Composed of small grains of *schorl* and *quartz*, with occasional included fragments of the latter. The Granite of Belovely Beacon (No. 51) passes into this rock.

73. SCHORL.
Botallack Mine, St. Just, Cornwall. Map 33.

Showing a tendency to form prismatic crystals in places. From a mass in Schorl-Rock.

74. SCHORL.
Rosemergy, near Morvah, Cornwall. Map 33.

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. (See "Report on Cornwall," p. 161.)

75. SCHORL VEIN, *traversing Granite.*
Morvah, Cornwall. Map 33.

Illustrative of the mode of occurrence of such veins in Cornwall.

76. FINE-GRAINED SCHORLACEOUS GRANITE.
Flagstaff, Cadgwith, Cornwall. Map 32.

Composed of *felspar*, *schorl*, and *quartz*.

From a vein of Granite cutting Serpentine.

77. FINE-GRAINED SCHORLACEOUS GRANITE.
Rosemodris, St. Buryan, Cornwall. Map 33.

Composed of *quartz*, *felspar*, a little *schorl*, and small occasional specks of *silvery mica*. From a Granite-vein cutting coarser-grained Granite (See "Report on Cornwall," p. 172.)

78. PORTION OF A GRANITE VEIN.
Poltreath, Lizard Town, Cornwall. Map 32.

The specimen is composed of *pink felspar*, with a few small specks of *schorl*,

79. GRANITE VEIN.

Helligan, near Helland, Cornwall.

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 Map 30) extending from the main mass of Granite eastward toward St. Mabyn. It has been employed for building and for roads; the more compact parts of the dyke afford a good material for the latter purpose. (See "Report on Geology of Cornwall," p. 180.)

80. GRANITIC DYKE.

Tregreenwell, near St. Teath, Cornwall. Map 30.

Light-coloured felspar, *quartz*, and *mica*, containing disseminated crystals of light-coloured *felspar*. It forms a portion of the granitic dyke noticed No. 99.

Employed for roads, for which it is an excellent material, and for building.

81. GRANITIC DYKE.

Near St. Columb Minor, Cornwall. Map 30.

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 Maps 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 Mitchel.

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.

82. FINE-GRAINED SCHORLACEOUS GRANITE.

Kynance Cove, Cornwall. Map 32.

Composed of *pink felspar*, *quartz*, and *schorl*.

It forms a vein traversing Serpentine. (See "Report on Cornwall," p. 172.)

83. GRANITIC PORPHYRY.

Seveock Water, between Redruth and Truro, Cornwall. Map 31.

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. (See "Report on Cornwall," p. 177.)

84. CUBE OF FELSPAR PORPHYRY.

Tremore, Bodmin, Cornwall.

Part of an Elvan-dyke.

Composed of well-developed crystals of *white* and *flesh-coloured felspar*, *translucent quartz* (some attempting to form separate crystals), and large specks of *schorl*, in a pale pink base.

85. FELSPATHIC PORPHYRY.

Banks of Lochfine, Scotland.

Composed of white, occasionally *translucent felspar*, and *black mica*, sometimes with a tendency to form separate crystals; in a base of compact, pale chocolate-coloured felspar.

Compare with the felspar-porphyries or Elvans from Cornwall.

(On upper shelf.)

86. FELSPAR PORPHYRY.

Near St. Hilary, Cornwall. Map 33.

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.

87. FELSPAR PORPHYRY.

Piran Sands, Cornwall. Map 31.

Composed of a quartzo-felspathic base, containing crystals of *felspar*, *quartz*, and *schorl*.

The specimen shows the composition of the inner parts of a dyke which juts out on the coast from beneath that great mass of calcareous sandhills known as Piran Sands, which extend from Piran Porth on the south to Penhale on the north.

This dyke is seen to cut through Argillaceous Slates on the south side, on the north its junction was concealed by the sands from view in 1835. Included fragments of the adjoining Slate are seen among the mass of Porphyry, and have, for the most part been somewhat altered in their character, though they have not lost their schistose structure.

88. FELSPAR PORPHYRY, (*Elvan-dyke, near a lode*).

Consols Mines (west end), Cornwall. Map 31.

Composed of crystals of *quartz* and *felspar*, and nests of *schorl*.

89. Felspar Porphyry.
Endellyon, Cornwall. Map 30.

Composed of a grey felspathic base, containing disseminated *hornblende*, and vesicles filled with calcareous matter. Forms part of one of several elongated trappean masses which occur near Endellyon. (See Map 30.) These vary in mineral structure, even at short distances, in the same mass. Judging from the phenomena observable on the adja- coast, these masses of trap-rock have been intruded among the slates of the district, which slates are fossiliferous.

90. Felspar Porphyry.
Tregurtha Mine, near St. Hilary, Cornwall. Map 33.

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.)

91. Granitic Rock.
Treburget, near St. Teath, Cornwall.

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 30) extending through St. Kew, towards Padstow Harbour.

92. Felspathic Porphyry (*part of an Elvan-dyke*).
Tremore, near Bodmin, Cornwall. Map 30.

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. 103; it would be a beautiful ornamental stone. (See also No. 95.)

93. Felspathic Porphyry.
Cliff, S. of Penhale, Crantock, Cornwall. Map 31.

Forms part of the same dyke as No. 100, where it abuts against the Slates among which it has been intruded. The variations in the structure of the different parts of the dyke may be explained as at No. 108.

94. Felspathic Porphyry.
Roseangrouz, near St. Erth, Cornwall. Map 33.

Composed of crystals of *schorl* in a felspatho-quartzose base.

95. Felspathic Porphyry.
Near St. Wenn, Cornwall. Map 30.

Composed of crystals of *quartz* and *flesh-coloured crystals* of *felspar* in a *lighter coloured base*. This forms the continuation westward of the Tremore Porphyry No. 92. It might be employed for ornamental purposes.

96. Felspathic Porphyry.
Near Dolcoath Mine, Cornwall. Map 30.

Composed of crystals of *felspar, quartz*, and *schorl* in a felspathic base. From the junction of Granite and Slate.

97. Granitic Porphyry.
Creegbroaz Quarries, near Chacewater, Cornwall. Map 31.

Composed of crystals of *felspar* and spots of *schorl*, in a roseate felspathic base. It forms part of an Elvan-dyke.

98. Felspathic Porphyry.
Croft Michel, near Crowan, Cornwall. Map 31.

Composed of crystals of *light-coloured felspar, quartz*, and *schorl* in a quartzo-felspathic base.

It forms an Elvan-dyke traversing Granite.

99. Porphyritic Granite.
Trecligoe, near Camelford, Cornwall. Map 30.

Composed of a light-grey felspathic base, containing crystals of *quartz, flesh-coloured felspar*, and plates of *mica*.

Forms part of a granitic dyke, extending from Greylake, near Camelford, by Trecligoe and Helstone to Treforda, and varies much in its mineral character; it clearly cuts the lodes. This (as well as Nos. 105, 109, &c.) is one of the rocks named *Elvans* by the Cornish miners, several varieties of which have been and still are employed for architectural purposes, for which in general they are well suited. At present they are employed for the corners of houses, for rough buildings, walls, and for roads.

100. Granitic Porphyry.
Penhale Cliffs (S. side), Cornwall. Map 31.

From the central parts of a dyke, and composed of *quartz*, a small proportion of *mica* and *felspar* and *schorl*, some in crystals.

Quarried for building-stone.

101. *Part of a* GRANITE DYKE.
St. Cubert, Cornwall. Map 31.

This dyke apparently cuts through the schistose rocks of the district, and is probably the continuation eastward of No. 100. It is quarried for building-stone and road-material.

102. FELSPATHIC PORPHYRY.
Penstruthal Mine, Cornwall. Map 31.

Composed of disseminated crystals of *schorl*, in a fine-grained felspathic base. It forms part of an Elvan-dyke traversing Granite. (See No. 119.)

103. GRANITIC PORPHYRY.
Tremore, near Bodmin, Cornwall. Map 30.

Composed of a roseate-red felspathic base, containing imperfect crystals of *white felspar*, *quartz*, and plates of *brown mica*. (See No. 115.)

104. GRANITIC ROCK.
Hill on the S. side of Endellyon, Cornwall. Map 30.

Crystals of *flesh-coloured felspar* and *quartz* in a felspathic and hornblendic base. It forms part of the granitic rock noticed at No. 91, and is employed for roads.

105. GRANITIC PORPHYRY.
Near Camelford, Cornwall. Map 30.

Composed of crystals of *quartz* and specks of *mica* in a greyish-white quartzo-felspathic base.

It forms part of the same granitic dyke noticed at Nos. 80 and 89. It is used for roads and buildings, for both of which it is a good material.

106. GRANITIC DYKE.
Watergate Bay, Cornwall. Map 30.

The northern portion, as far as is visible above the level of the sea, of the dyke noticed at No. 108. It is a mixture of *quartz*, *felspar*, and *mica*.

Used as a building material under the name of "*freestone*."

107. GRANITIC ROCK.
St. Kew Hills, St. Kew, Cornwall. Map 30.

Disseminated *quartz* and imperfect crystals of *felspar*, in a felspathic base.

Forms part of a line of granitic rock extending from Treburget, near St. Teath, nearly to Padstow Harbour.

It cuts through a series of variegated Slates.

Employed for building and for roads. Large quarries are opened on the St. Kew Hills.

108. OUTER PORTION OF A GRANITIC DYKE.
Near St. Columb Minor, Cornwall. Map 30.

This specimen shows a porphyritic arrangement of the same substances as in No. 106, and beautifully illustrates 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 those least easily 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.

109. PORPHYRITIC ROCK.
Helstone, near Camelford, Cornwall. Map 30.

Composed of a greyish-white quartzo-felspathic base, containing imperfect crystals of *white felspar* and plates of *brown mica*.

110. FELSPAR PORPHYRY.
Pentuan, St. Austell, Cornwall. Map 31.

A fine-grained compound of *felspar* and *quartz* with crystals of *mica*. It forms part of an Elvan-dyke, known as the Pentuan Elvan or *Pentuan Stone*. (See "Report on Cornwall," pp. 182 and 183.)

111. GRANITIC PORPHYRY.
Creegbroaz Quarries, near Chacewater, Cornwall. Map 31.

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.

(See "Report on Cornwall," p. 177.)

112. FELSPAR PORPHYRY.
London Inn, near Cardinham, Cornwall. Map 31.

Part of a granitic vein, proceeding from the main body of Granite to the eastward of this locality (see Map 30), and composed of a *quartz* and *felspar* base, in which plates of *black mica* and crystals of *white felspar* are included.

This is one of the many granite-veins (see **Map** 30) which cut through the Slates in the neighbourhood of Blisland. It is employed for the roads, for which it is a good material.

113. Felspar Porphyry.
Tremore, near Bodmin, Cornwall. Map 30.

Flesh-coloured *felspathic base*, containing crystals of *white felspar* and *quartz*. (See No. 115.) Part of an Elvan-dyke.

This stone would form a very beautiful material for ornamental purposes; there are also some grey varieties that would be by no means inferior.

114. Granitic Rock.
Treburget, near St. Teath, Cornwall. Map 30.

Composed of a grey base of *felspar* and *hornblende*, containing imperfect crystals of *light-coloured felspar* and *quartz*.

A variety of No. 94.

115. Felspar Porphyry.
St. Wenn, Cornwall.

Reddish-pink crystals of *felspar*, mixed with others of *quartz*, and with a greenish substance not very determinable, in a flesh-coloured *felspathic base*. 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.

116. Granitic Porphyry.
Marazion Mines, Cornwall. Map 33.

Composed of crystals of *flesh-coloured felspar* and *translucent quartz*, with a few spots of *schorl* in a light-grey *felspatho-quartzose base*, and containing cracks filled with translucent quartz and schorl.

It forms a dyke which can be traced for 12 miles from Huel Darlington, near Marazion, into the Carnbrea Granite, cutting into the latter on the west of Camborne Beacon. (See "Report on Cornwall," p. 174.)

117. Porphyritic Rock.
Marazion Mines, Cornwall. Map 33.

Composed of crystals of *felspar* and *quartz*, in a felspatho-quartzose base. From an Elvan-dyke adjoining the copper and tin lodes.

118. Felspathic Porphyry.
Enys, Cornwall. Map 31.

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.

119. Part of an Elvan-dyke.
Newham Quarry, near Truro, Cornwall. Map 31.

A whitish rock composed of a fine-grained compound of *quartz* and *felspar*; a continuation of the Penstruthal Elvan, No. 102.

120. A variety of the Elvan-dyke No. 119.

(See "Report on Cornwall," p. 177.)

121. Granite.
Gunnis Lake Quarries, Calstock, Cornwall. Map 25.

Composed of *translucent quartz*, crystals of *white felspar*, and specks of *black* and *silvery mica*.

This specimen is extremely interesting in consequence of an angular fragment of hornblende-schist being imbedded in it. The schist presents no appearance of alteration, the angles of the fragment retain their sharpness, and the surrounding Granite is in close contact with it on all sides The Granite has acquired a slight ferruginous stain for a few inches around the schist.

(On upper shelf.)

122. Granite.
Honey Bag Tor, N. of Ashburton, Devonshire. Map 25.

A mass of Granite containing a concretionary nodule of Greenstone.

(On upper shelf.)

The Granite contains large and well-developed crystals of pale flesh-coloured felspar (orthoclase), with quartz and mica. The imbedded nodule is composed of a fine-grained Greenstone, with a small quantity of black mica. The concretionary structure is well shown on the fractured surface of the nodule; as is, also, the partial decomposition it has undergone in the outer portion, and the consequent peroxidation of the iron.

Presented by the Rev. J. H. Mason.

123. FELSPATHIC PORPHYRY.
Pentuan, St. Austell, Cornwall. Map 31.
Contains prismatic crystals of *schorl*, and fragments of *quartz* in a quartzo-felspathic base.

124. FELSPATHIC PORPHYRY.
Pentuan, St. Austell, Cornwall. Map 31.
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 No. 110. (See also "Report on Cornwall," p. 182.)

125. FELSPATHIC PORPHYRY.
Pentuan, St. Austell, Cornwall.
Another variety of the Pentuan Elvan, containing included *fragments of Slate.* See Nos. 110, 124, and 126.

126. FELSPATHIC PORPHYRY.
Pentuan, St. Austell, Cornwall.
Another variety of the Pentuan Elvan, from the *outer* portions of the dyke, containing an included fragment of the adjoining rock. (See Nos. 110, 124, and 125.)

127. FELSPATHIC PORPHYRY.
Corbus Quarry, near St. Erth, Cornwall. Map 33.
Composed of crystals of *flesh-coloured felspar*, and *translucent quartz*, with spots of *schorl*, in a light-grey felspatho-quartzose base.

128. FELSPATHIC PORPHYRY.
Herland Mine, Gwinnear, Cornwall. Map 33.
Another variety of the above Elvan-dyke, No. 127.

129. FELSPATHIC PORPHYRY.
St. Mary's (near the Telegraph), *Scilly Islands.*
Part of an Elvan-dyke, cutting through Granite.

130. FELSPAR PORPHYRY.
Carrick Fells, Cumberland.
Large crystals of pale green *felspar* in a base of darker green compact *felspar*.

131. ELVAN.
Opposite Cant Hill, Padstow Harbour, Cornwall. Map 30.
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.

132. FINE-GRAINED ELVAN.
Carn Marth, near Redruth, Cornwall.
A vein traversing grey Granite, forming a crystalline compound of opaque-white *felspar* (*orthoclase*), translucent *quartz*, and black, with some silvery *mica*.

133. GRANITIC VEIN, traversing altered Slates.
St. Michael's Mount, Cornwall. Map 33.

134. SCHORLACEOUS GRANITE.
Mousehole, Cornwall. Map 33.
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.)

135. SCHORLACEOUS GRANITE.
Round Rock Point, St. Martin's Bay, Scilly Islands.
Composed of *quartz*, *white felspar*, *schorl*, and varieties of *mica*, with a vein of fine-grained Granite. (See "Report on Cornwall," p. 161.)

136. GRANITE VEIN, traversing altered Slates.
St. Michael's Mount, Cornwall. Map 33.

137. BRECCIA.
South side of Dinas Hill, near Padstow, Cornwall. Map 30.
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 ot lime. (See "Report on Cornwall," p. 89.) Employed for roads and rough building-purposes.

DECOMPOSED GRANITES.*

138. DECOMPOSED GRANITE.
Dartmoor, Devonshire. Map 25.
A hard variety from the Morley Clay-works.
(On upper shelf.)

139. DECOMPOSED GRANITE.
Dartmoor, Devon. Map 25.
A hard variety from the Morley Clay-works.

140. DECOMPOSED GRANITE.
Morley Clay Works, Dartmoor, Devon. Map 25.
A white variety, with much quartz, and white felspar, and silvery mica.

141 and 142. DECOMPOSED GRANITE.
Morley Clay Works, Dartmoor, Devon. Map 25.
A white variety, with much silvery mica.
See De la Beche's "Report on Cornwall," pp. 163, 164.

143. DECOMPOSING FELSPATHIC TRAP.
Porth Hagog, Ramsey Island, St. David's, Pembrokeshire. Map 40.

144. FELSPATHIC PORPHYRY (*Elvan*).
South of Hafod-onen, near Amlwch, Anglesey. Map 78, N.W.

145. FELSPATHIC PORPHYRY ("*Elvan*") ("*Carreg lwyd*").
Llanfechell, Anglesey. Map 78.

146. PINK FELSPATHIC TRAP.
Near Lanark, Scotland.

147. FELSPATHIC TRAP.
Dysgwylfa Hill, near Bishop's Castle, Shropshire. Map 60, S.E.

148. COLUMNAR FELSPATHIC TRAP.
Owlbury, near Bishop's Castle, Shropshire. Map 60, S.E.

149. LIGHT-GREEN FELSPATHIC TRAP.
Tinnacarrig Hill, near New Ross, Ireland.
Showing a white weathered surface.

150. FELSPATHIC TRAP.
Clegyr Bridge, St. David's, Pembrokeshire. Map 4

151. PORPHYRITIC ROCK.
Cawsand, Plymouth, Devonshire. Map 24.
Traversing red sandstone and slates. (See "Report on Cornwall," p. 65.)

152. VESICULAR FELSPATHIC TRAP.
Llandegley Rocks, Radnorshire. Map 56, S.E.
Used for building.

153. FELSPATHIC TRAP.
Llandegley Rocks, Radnorshire. Map 56, S.E.

154. CONCRETIONARY FELSPATHIC TRAP.
Hafnant, 3 miles S.W. of Yspytty Evan, Merionethshire. Map 74.

155. FELSPATHIC TRAP.
Clogwyn-du'r-Arddu, Llanberis, Caernarvonshire. Map 75, N.E.
Forming the base of the Snowdon rocks; showing an unevenly weathered and laminated surface.

156. COMPACT FELSPATHIC TRAP.
Quarter of a mile S. of Moel-y-menin, Arenig range, Merionethshire. Map 74, S.W.
Light-grey, with the surface and joints weathered white.

157. GREY, THIN-BEDDED TRAP.
Y Wenallt, $1\frac{3}{4}$ *miles N.W. of Llanuwchllyn, Merionethshire.* Map 74, S.W.

* See "Report on Cornwall," pp. 509 to 513; also Mr. Hunt's Descriptive Guide, pp. 78 to 80. 81,078 tons of china clay were exported from Cornwall and Devon in 1857; of these the best quality is used for making porcelain, while the inferior description is used by calico- and paper-makers.

158. **Felspar Trap.**
Winds Point, Little Malvern, Worcestershire. Map 43, N.E.
Compact, greenish trap rock with occasional thin lines and veins of red *felspar* and *calc spar*.
(See "Survey Memoirs," vol ii., part I., pp. 31 and 32.)

159. **Felspathic Porphyry.**
Tinnacarrig Hill, near New Ross, Ireland.

160. **Greenish Felspathic Porphyry.**
Carrick-a-daggan, near New Ross, Ireland.
Weathering white.

160a. **Crucible**, containing some of the felspathic porphyry from Carrick-a-daggan (No. 160) fused in an ordinary air-furnace.
For comparison with igneous rocks contained in Wall-cases 1 & 2.

161. A kind of **Trappean Rock.**
Opposite Cant Hill, Padstow Harbour, Cornwall. Map 30.
This rock has a semi-mechanical origin, and is associated with a conglomerate of the Slate series. It is quarried for building-stone at the cliff, close to the river.

Syenite.

162. **Syenitic Granite.**
Syning Gill, Cumberland.
Granite composed of *felspar, quartz*, and much *black mica*, with a small quantity of *hornblende*, in contact with hornblendic Gneiss.
The specimen is taken from the N.W. side of Saddleback, where the junction between the Granite and Gneiss may be seen. Near this locality the musical stones, exhibited at Keswick, are obtained. They are made of the Gneiss or Hornblende Rocks of the district. The rock from which the specimen was taken is very sonorous.
Presented by Mr. C. Wood.

163. **Syenitic Granite.**
Strontian, Argyleshire.
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.

164. **Syenite.**
Luxulyan, 3½ miles S.W. of Lostwithiel, Cornwall. Map 30–1.
Composed of large crystals of *pink felspar*, with *quartz* (occasionally in prismatic crystals), and some *schorl* in a base of *hornblende*.
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 of the late Duke of Wellington is formed of a single block of this stone. (See "Descriptive Guide," p. 26.)

165. **Syenitic Greenstone.**
Markfield, Charnwood Forest, Leicestershire. Map 63.
Composed of *hornblende*, and *pink felspar* well crystallized. The felspar rather predominates.

166. **Syenitic Granite.**
St. Brelade's Quarry, Jersey.
Composed of *quartz, flesh-coloured felspar, black mica*, and a small proportion of *hornblende*.

166a. **Syenitic Granite.**
Roche des Guets, Guernsey.
A somewhat finely granular and porphyritic compound of pale, *flesh-coloured felspar* (some in crystals), white *translucent quartz*, small grains of *hornblende*, and scales of *black mica*.
(On upper shelf of Wall-case 5.)
Presented by Mr. Luxmore.

166b. **Grey Syenitic Granite.**
Lancrisse, Guernsey.
A compound of white, *translucent quartz, white felspar, dark green* and *black mica*, and small grains of *hornblende*.
(On upper shelf of Wall-case 5.)
Presented by Mr. Luxmore.

167. **Syenitic Granite.**
Strontian, Argyleshire.
Composed of two varieties of *felspar* (*white and light flesh-coloured*), a small quantity of *quartz* and *hornblende*, and a little *black mica*.

168. SYENITIC GRANITE.
Fassney Water, Lammermuirs, Scotland.
A fine-grained compound of pale *pink felspar, translucent quartz*, and *hornblende* in nearly equal proportions; with *black mica.*
From a mass of Granite traversing Silurian rocks.

169. SYENITIC AND PORPHYRITIC GRANITE.
Strontian, Argyleshire.
Composed of large crystals of white and light-pinkish *felspar* in a base of *translucent quartz, hornblende,* and black *mica.*

170. SYENITE.
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, a picturesque island, in the Firth of Clyde, situated at nearly an equal distance from the shores of Ayr and Argyll. Ailsa Craig consists of a single rock of greyish compact felspar, with small grains of quartz and very minute particles of hornblende, rising abruptly out of the water to the height of 1,100 feet.
(On upper shelf.)
Presented by the Royal Commissioners of the Great Exhibition of 1851.

171. GREY SYENITIC GRANITE.
Guernsey.
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 for building-stone.

172. SYENITE.
Mynydd Cefn-amwlch, 9 *miles W. of Pwllheli, Caernarvonshire.* Map 76, S.
Composed of *milk-white quartz* in a felspathic base, with lines and specks of *hornblende.*

173. Red felspathic SYENITE.
Great Malvern, Worcestershire. Map 55, S.E.
Chiefly composed of *reddish felspar,* with *hornblende* and a little *quartz.*
This rock may be regarded as the fundamental rock of the chain of the Malvern Hills. (See "Memoirs of the Geological Survey," vol. ii., part I., pp. 40 and 41.)

174. SYENITE.
$1\frac{1}{2}$ *miles N.W. of Ffestiniog, Merionethshire.* Map 75, N.E.
A compound of *felspar* and *hornblende,* the latter with a tendency to form separate aggregations.

175. SYENITE.
Guernsey.
Composed of *quartz,* white *felspar* (some in crystals), and *hornblende,* with a very few minute specks of *iron pyrites.*
Used for building-stone.

176. SYENITE.
Strontian, Argyleshire.
Chiefly composed of *pink felspar* with *hornblende* and a small proportion of *quartz.*

176a. GREENSTONE.
Parish of Leslie, 28 *miles N.W. of Aberdeen.*
A crystalline composed of *felspar,* some in crystals, and *hornblende.*

177. SYENITIC GREENSTONE.
Grooby, Charnwood Forest, Leicestershire. Map 63; N.W.
Pink felspar and *hornblende,* well crystallized, with a few small granules of *quartz.*

178. GREY SYENITE or, SYENITIC PORPHYRY.
Guernsey.
Composed of prismatic crystals of *hornblende,* with *white felspar* and *quartz,* and a few specks of *iron pyrites.*
Used for building-stone.

179. GRANITIC ROCK, fine-grained, reddish-grey.
Great Brin, near Roche, Cornwall. Map 30.
Containing imperfect crystals of a *lighter-coloured felspar.*
This rock forms part of a Granite dyke which extends from the western end of Penvivian Hill towards Belovely Beacon.

180. PORPHYRITIC GREENSTONE.
Pen-ar-fynydd, 3 *miles E. of Aberdaron, Caenarvonshire.* Map 76, S.
Chiefly composed of prismatic crystals of *hornblende,* with *felspar,* a little *translucent quartz,* and a few occasional spangles of *mica.*

Greenstone, Hornblende Rock, Toadstone, Amygdaloid, &c.

181. Greenstone.
Hanter Hill, Kington, Herefordshire. Map 56.
Variety Hypersthene Rock.
Composed of *hypersthene* and *felspar.*

182. Greenstone.
Hanter Hill, Kington, Herefordshire. Map 56.
Variety Hypersthene Rock.
Composed of *hypersthene* and *felspar.*

182a. Greenstone.
Hanter Hill, Herefordshire.
Variety Hypersthene Rock.
See Wall-case 5, upper shelf.

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. 206. Map 56, S.E., and Horizontal Sections, Sheet No. 27.

A crucible containing some of this rock, melted in an ordinary air-furnace, is placed by the side of Nos. 181 and 182, for comparison with specimens of lavas contained in Wall-cases 1 and 2.

A large specimen of the Greenstone (No. 182a) is placed on the upper shelf of Wall-case 5, for want of space by the side of Nos. 181 and 182.

183. Fine-grained Greenstone.
Sea-coast, 4½ miles S. of Clynnog-fawr, W. of Yr Eifl, Caernarvonshire. Map 75, N.W.
Composed of *brownish felspar* and *hornblende,* in nearly equal proportions.

184. Large-grained Greenstone.
Tintagell, Cornwall. Map 30.
This rock forms some remarkable rocky tors near the cliffs. It might be usefully employed for roads and in massive structures.

185. Porphyritic Green stone.
Davidstow, Cornwall. Map 30.
Forming part of a long line of trappean rocks extending to and beyond St. Clether, and which are for the most part schistose in that direction and occasionally vesicular.

186. Porphyritic Greenstone.
Boswednan Cliff, Zennor, Cornwall. Map 33.
Contains a vein of *hornblende.*

187. Porphyritic Greenstone.
Bryniangeirwen, Anglesey. Map 77, N.
Composed of crystals of *felspar* in a *hornblende* base. Part of a dyke.

188. Large-grained Porphyritic Greenstone.
St. Minver, Cornwall. Map 30.
Forms 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 those purposes.

189. Porphyritic Greenstone.
Gaer-fawr, Carneddau, near Builth, Breconshire. Map 56.

190. Porphyritic Greenstone.
Carneddau, Builth, Breconshire. Map 56.
Contains crystals of *felspar* and kernels of *green-earth* in a decomposing hornblendic base.

191. Fine-grained Greenstone.
Broom Close Bay, Veryan, Cornwall. Map 31.
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.

192. Porphyritic Greenstone.
Beyond Goodrevy Cove, St. Keverne, Cornwall. Map 31.
Composed of crystals of *felspar* in a hornblende base.

193. Porphyritic Greenstone.
Bank of river Barrow Dungans-town, near New Ross, Ireland.
A crystalline compound of *felspar* and *hornblende,* containing a small quantity of iron pyrites.

194. Porphyritic Greenstone.
Grange Hill, near Chair of Kildare, County Kildare, Ireland. Map 119.
Composed of crystals of *felspar*, a small quantity of *quartz*, and a few minute specks of *iron pyrites* in a base of *hornblende.*

195. Porphyritic Greenstone.
Llanfechell, Anglesey. Map 78, N.W.
Var: "*Porfido Verd'antico;*" "*Carreg Eiarn*" (Anglesey).
Composed of a few crystals of *white felspar* disseminated in a base of *compact greenstone.*

196. Porphyritic Greenstone.
Tan-y-graig, 1¼ *miles N.N.E. of Pwllheli, Caernarvonshire.* Map 75, S.W.
Composed of crystals of *light green felspar* in a base of *hornblende.*

197. Porphyritic Greenstone.
Bwlch Mawr, 1½ *miles S.E. of Clynnog-fawr, Caernarvonshire.* Map 75, N.W.
Composed of crystals of *white felspar* in a felspatho-hornblendic base.

198. Porphyritic Greenstone.
Dun, Coast of Ayrshire, Scotland.
In a decomposing state: composed of crystals of *white felspar* in a hornblende base.

199. Felspathic Greenstone.
Careg-y-rimbill ("Gimblet Rock"), *Pwllheli, Caernarvonshire.* Map 75, S.W.
Composed of *felspar* and *hornblende* in nearly equal quantities. Furnishes a good building-stone.

200. Greenstone.
Quarry in Nant Radlas, 6 *miles from Pwllheli, Caernarvonshire.*
A mixture of *hornblende* and *white felspar* in nearly equal proportions.
(On upper shelf.)
Presented by Lloyd Edwards, Esq.

201. Felspathic Greenstone (part of a dyke).
West Pentire, Crantock, Cornwall. Map 30.
Contains crystals of *iron pyrites.*
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.

202. Greenstone.
Salisbury Crags, Edinburgh.
Composed of *felspar* and *augite* in nearly equal proportions.

203. Small-grained Greenstone.
Campsie Hills, Stirlingshire, Scotland.
Composed of an intimate mixture of *felspar* and *hornblende* (?), and weathering ferruginous-brown.

204. Concretionary Greenstone.
2 *miles S. of Atherstone, Warwickshire.* Map 63, S.W.
Weathering into ferruginous-brown concentric concretions (from Coal Measures).

205. Greenstone.
Clee Hill, near Ludlow, Shropshire. Map 55.
A crystalline rock, chiefly composed of *hornblende* with a little *pink felspar.*

206. Greenstone.
Stanner Rocks, near Kington, Herefordshire. Map 56, S.E.
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.

207. Compact Greenstone.
Baily Lighthouse, Howth, County Dublin.
From a dyke traversing Cambrian Rocks.

208. Greenstone.
Michaelstow Beacon, Cornwall. Map 30.
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.

209. Compact Greenstone.
Between Lay Point and St. Ives, Cornwall. Map 33.

210. Greenstone.
St. Mewan, Cornwall. Map 31.
(See "Report on Cornwall," p. 82.)

211. COMPACT GREENSTONE (weathering brown).
Carn Llidi, St. David's, Pembrokeshire. Map 40.
In close contact with Slate.

212. GREENSTONE.
Trenoweth, Cury, Cornwall. Map 31.

213. FINE-GRAINED GREENSTONE.
S.E. side of Carn Llidi, St. David's, Pembrokeshire. Map 40.
(Weathering brown).
A little removed from contact with Slates.

214. BASALTIC GREENSTONE.
Clee Hills, near Ludlow, Shropshire. Map 55.

215 & 216. COMPACT GREENSTONE.
Gurnard's Head, Zennor, Cornwall. Map 33.

217. COMPACT GREENSTONE.
N. of Strathaven, Lanarkshire, Scotland.
Composed of an intimate mixture of *felspar* and *hornblende*, in nearly equal proportions.
Weathers ferruginous-brown.

218. GREENSTONE (*"Toadstone"*).
Allport, Bakewell, Derbyshire.
In contact with a vein of *aragonite.*

219. COMPACT GREENSTONE.
Black Head, St. Austell, Cornwall. Map 31.
Associated with Slates and Grits. (See "Report on Cornwall," p. 82.)

220. GREENSTONE.
Longmynd, Shropshire.
From a dyke cutting through Cambrian Rocks.

221. COMPACT GREENSTONE.
Between Lay Point and St. Ives, Cornwall. Map 33.

222. COMPACT GREENSTONE.
The Skerries, Anglesey. Map 78, N.W.
Containing a little *iron pyrites.*
From a dyke traversing chlorite and Mica Schist.

223. GREENSTONE.
Bardon Hill, Charnwood Forest, Leicestershire. Map 63, N.W.
Imperfect Greenstone, consisting of imperfectly crystallized *hornblende* and *felspar*, with a few grains of *quartz.*

224. COMPACT GREENSTONE.
Rhos-mynach, Anglesey.
With a weathered surface.

225. DIALLAGE ROCK.
Penvose, Landewednack, Cornwall. Map 32.
Apparently cutting through Serpentine. (See "Report on Cornwall," p. 98.)

226. COMPACT GREENSTONE.
Egloshayle, Cornwall. Map 33.
Apparently intruded among Argillaceous Slates.
Employed for roads, for which it is an excellent material.

227. GREENSTONE.
Bryn Fuches, Anglesey.

228. FINE-GRAINED GREENSTONE.
Dinas Hill, near Padstow, Cornwall. Map 30.
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.

229. A kind of TRAPPEAN ROCK.
Opposite Cant Hill, Padstow Harbour, Cornwall. Map 30.
This rock has a semi-mechanical origin, and is associated with a conglomerate (No. 119) of the Slate Series. It is quarried, for building-stone, at the cliff close to the river.

230. GREENSTONE.
Park Head, St. Eval, Cornwall. Map 30.
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.

231. Greenstone.
E. side of Trevose Head, Cornwall. Map 30.
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 extends eastward into Polventon Bay. The Greenstone has evidently been intruded among the adjacent schistose rocks.

232. Greenstone.
Near Trereiffe, Penzance, Cornwall. Map 33.
Associated with contemporaneous Argillaceous Slates.
(See "Report on the Geology of Cornwall," p. 100.)

233. Compact Greenstone.
Huel Cock, St. Just, Cornwall. Map 33.
Locally termed "*ironstone.*"

234. Compact Greenstone.
Botallack Mine, St. Just, Cornwall. Map 33.
Locally termed "*ironstone.*"

235. Compact Greenstone.
Burncoose, near Gwennap, Cornwall. Map 31.
(See "Report on the Geology of Cornwall," p. 176.)

236. Greenstone.
Drana Point, St. Keverne, Cornwall.
A finely divided mixture of *felspar* and *hornblende.*

237. Greenstone, *somewhat hypersthenic.*
Hill, W. from Dinham, Padstow River, Cornwall. Map 30.
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.

238. Greenstone.
Gwavas Hill, Newlyn, near Penzance, Cornwall. Map 33.
Composed of *hornblende,* with a small proportion of *felspar.* (See "Report on Cornwall," p. 100.)

239. Basalt.
Little Wenlock, Buildwas, Shropshire. Map 61, N.W.

240. Diallage Rock.
Gilly Cliff, St. Keverne, Cornwall. Map 32.
A compound of *felspar, hornblende,* and *diallage.* (See "Report on Cornwall," pp. 98 and 99.)

241. Greenstone.
Conway, North Wales. Map 78, N.E.
Composed of veins and laminæ of fibrous *asbestos* in a light green felspathic base.

242. Greenstone, with veins of *asbestos.*
Llanberis, Caernarvonshire. Map 78, S.E.
From a dyke traversing the Trap Rock of Llyn Peris.

243. Hornblende Rock.
Greeb Rock, Mount's Bay, Cornwall. Map 33.

244. Hornblende Schist.
Guernsey.
An irregular aggregation of *hornblende* in imperfect crystals.
Used for building-stone.

245. Hornblende Rock.
Llanerchymedd, Anglesey. Map 78, N.W.

245a. Crucible, containing fused portions of the Hornblende Rock, No. 245, fused in an ordinary air-furnace.
For comparison with the volcanic rocks in Wall-cases 1 & 2.

246. Trappean Rock.
Higher Fenternadle, near Camelford, Cornwall. Map 30.
This rock has a hypersthenic character, and is apparently a Greenstone altered, together with the Slates with which it is associated, by the intrusion of the neighbouring Granite.

247. Greenstone.
Grylls, near Camelford, Cornwall. Map 30.
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. (See "Report on Geology of Cornwall, &c.," pp. 57 and 58.)

248. VESICULAR TRAPPEAN ROCK.

St. Clether, Cornwall. Map 30.

Part of a Trappean Rock that extends west-north-westward to Davidstow, and east-south-eastward to St. Clether. It is associated with Argillaceous Slate, and with a line of rocks which frequently contain calcareous matter, and even limestones.

The calcareo-trappean series sweeps round the north of Dartmoor, and, after making a southern curve towards Callington, again sweeps round the Brown Willy and Rough Tor Granites, which appear to have forced it out by Tintagell. This series is occasionally fossiliferous in its course.

249. FINE-GRAINED GREENSTONE, *partly vesicular.*

Endellyon, Cornwall. Map 30.

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 among the fossiliferous Slates of the district.

250. VESICULAR TRAPPEAN ROCK.

Endellyon, Cornwall. Map 30.

Another variety of Greenstone.

These varieties are often employed for building-stones. (See "Report on Geology of Cornwall," p. 88.)

251. VESICULAR TRAPPEAN ROCK.

Tintagell, Cornwall. Map 30.

This mass of Greenstone crosses the village in a north-east and south-west line. It becomes schistose towards the north-east, and is traversed by veins of quartz in some places.

252. VESICULAR TRAPPEAN ROCK.

Near St. Mabyn, Cornwall.

Part of a trappean mass, which extends from near Burlarroe to Lower Croan. The northern parts of the mass are vesicular, and the southern more compact. In the coppice (see Map 30) the rock is quarried for road-stone. It is the same kind of rock as that which is so much prized and so well known to the South Devon farmers by the name of *Honeycombe Dun.*

253. VESICULAR TRAPPEAN ROCK.

Pentire Point, Padstow Harbour, Cornwall. Map 30.

This 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.

254. TRAPPEAN ROCK (GREENSTONE) in a decomposing state.

Porthleven, near St. Breague, Cornwall. Map 33.

255. VESICULAR TRAPPEAN ROCK (GREENSTONE).

Polurian Cove, Mullion, Cornwall. Map 32.

VOLCANIC TRAPPEAN ROCKS, ASH-BEDS, AND CINDERS, *from Brent Tor, Devonshire.* Map 25. (See "Report on Geology of Devon and Cornwall," pp. 120 and 121.)

"Although there are many good localities where the intermixture of the igneous rocks with the continuation of the Petherwin group and the carbonaceous series, as also with the passage-beds between them, may be studied, the volcanic character of the igneous rocks themselves is seldom better exhibited than at Brent Tor. This tor, which is a remarkable object in the county (1,100 feet above the sea), presents us with a mixture of trap rocks, ash, and a conglomerate containing vesicular portions of igneous rocks, which approach the condition of pumice when the contents of the vesicles, the results of infiltration being often siliceous, are weathered out. These rocks are associated in a manner such as is often seen in volcanic countries, and the tor may be regarded as a sectional portion of such igneous accumulations, mingled with some more common detritus of a date corresponding with the lower carbonaceous accumulations of North Devon." (Sir H. T. De la Beche, Memoirs of the Geol. Survey of Great Britain, vol. i. p. 137.) For a section through Brent Tor, and the mode in which its rocks are associated with the lower part of the carbonaceous series, see Report, &c., plate iv. fig. 4.

Devonshire.

256. Compact Trappean Rock (*with ash*).
Brent Tor, Devonshire.
(See "Report on Geology of Cornwall," p. 121.)

257. Vesicular Trappean Rock (Greenstone), with *green-earth* and *calc spar*.
Brent Tor, Devonshire.

258. Schistose Vesicular Volcanic Ash.
Tavistock, Devonshire.
Some of the vesicles are filled with *calc spar*.

259. Schistose Vesicular Volcanic Ash, showing the bedding, joints, and cleavage-planes.
Tavistock, Devonshire.

260. Very Vesicular Volcanic Cinder.

261. Vesicular Volcanic Cinder.
Brent Tor, Devonshire.
Some of the vesicles are filled with *calc spar*, while other and more solid portions are probably of contemporaneous Lavas. Upon the whole the specimen resembles a substance composed of finely comminuted volcanic matter consolidated.

262. Scoriaceous Lava (volcanic cinder).
Brent Tor, Devonshire.

Somersetshire.

262a. Greenstone Ash.
Wrington, Somersetshire. Map 19.
With an amygdaloidal structure. The vesicles filled with *green-earth*.

262b. Amygdaloidal Greenstone.
Wrington, Somersetshire. Map 19.
Contains *green-earth* and a kernel of *calc spar*.

No. 262a & 262b form part of the small masses of Greenstone-ash which occur close together on Broadfield Down, in the Mendip Hills. Both specimens were presented by Robert H. Valpy, F.G.S.

Toadstone and Amygdaloid.

The name Toadstone is applied to the Greenstone which is interstratified with the Carboniferous Limestone of Derbyshire and the north of England.

It is a volcanic rock or Lava truly interbedded in the Carboniferous Limestone of Derbyshire, and is of the same general geological age with the volcanic rocks of the Carboniferous Limestone and Lower Carboniferous rocks of some parts of Scotland.

It frequently assumes a cellular structure. Sometimes the cells are empty, while at others they are filled with calc spar, green-earth, and other minerals, and in the latter form they are termed Amygdaloids.

The vesicles have originally been formed by the escape of gases, as in modern lavas (see Nos. 4 and 5 CASE 2), and the kernels with which they are filled have been produced by the gradual infiltration of lime or other matters into the cavities. Frequently, on the surface, the kernels are re-dissolved out, and the rock then resumes its original structure, or the emptied cells are wholly or partially filled a second time with extraneous matter. See also p. 64.

The term is derived from the German *todstein* (deadstone), denoting the absence of minerals in the beds with which it is associated.

263. AMYGDALOIDAL GREENSTONE ("TOADSTONE").
Mine near Hartshill Hall, Derbyshire.
Composed of Greenstone containing cavities and cracks filled with kernels and veins of *calc spar*.

264. AMYGDALOIDAL GREENSTONE ("TOADSTONE").
Alport, Bakewell, Derbyshire. Map 81, S.E.
A Greenstone base, containing cavities filled with kernels of *calc spar*.

265. AMYGDALOID.
N. of Colzean Castle, Ayrshire, Scotland.
Composed of a base of *Greenstone*, containing numerous cavities filled with kernels of *calc spar*, some of which have been subsequently removed by infiltration.

266. LARGE KERNEL OF CALC SPAR, detached from the above *Amygdaloid*.

267. AMYGDALOID.
N. of Colzean, Ayrshire, Scotland.
Contains a portion of a large kernel of *quartz*.

268. AMYGDALOID.
Cliff, near Colzean, Ayrshire, Scotland.
Contains cavities lined with kernels of *calc spar* and others lined with crystals of *quartz*.

269. AMYGDALOID.
Sea-cliff, N. of Colzean, Ayrshire, Scotland.
Contains cavities filled with kernels of *calc spar*, *quartz*, and *chlorite*.

270. AMYGDALOID.
Sea-cliff, N. of Colzean, Ayrshire, Scotland.
Incloses kernels of *calc spar* and a few of *quartz*.

271. AMYGDALOID.
Charfield Green, Gloucestershire. Map 35.
Composed of kernels of *calc spar* in a Greenstone base.

272. AMYGDALOID.
Caradoc Hill, Church Stretton, Shropshire. Map 61, S.W.
Composed of kernels of decomposing *green-earth*, and *compact mesotype*, in a Greenstone base.

273. AMYGDALOIDAL GREENSTONE.
Damory Bridge, Tortworth, Gloucestershire. Map 35.
Greenstone, containing kernels of calc spar, from a mass erupted through Upper Llandovery Rocks.

274. AMYGDALOIDAL GREENSTONE.
Gaer fawr, Carneddau, Builth, Breconshire. Map 56, S.W.
The cavities are filled with *calc spar*, which has been almost entirely removed.

275. PORPHYRITIC GREENSTONE.
Opposite Ramsay Sound, St. David's, Pembrokeshire. Map 40.
Composed of imperfect crystals of *felspar*, in a base of compact Greenstone.

276. AMYGDALOID, with crystals of *quartz* replacing *calc spar*.
E. of Bettws Disserth, Radnorshire. Map 56, S.E.

277. AMYGDALOID.
Lower Ridge, 1½ miles E. of Chirbury, Shropshire. Map 60, S.E.
Contains a large kernel of *calc spar*.

278. SERPENTINOUS GREENSTONE.
Damory Bridge, Wotton-under-Edge, Gloucestershire. Map 35.

279. TRAPPEAN CONGLOMERATE.

Carne Mere Point, near Nare Head, Cornwall. Map 31.

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.)

280. BASALT (Rowley Rag).

Staffordshire. Map 62, S.W.

A hard, fine-grained, crystalline compound of *augite* and *felspar*, forming Rowley Hill in the Dudley coal-field.

It is used for mending roads. It has, also, recently been cast by the Messrs. Chance of Birmingham into blocks and ornamental mouldings for architectural purposes.

See Table-case A in recess 4, page 244.

CANADIAN SPECIMENS, &c.

Chiefly presented by Sir WILLIAM E. LOGAN, F.R.S.

281. FELSITE PORPHYRY (*Euritique*, &c.)

Near Montreal, Lower Canada.

Part of a boulder.

282. GNEISSOID ROCK, *containing garnets.*

La Prairie, near Montreal, Lower Canada.

283. QUARTZ (from a veinstone).

Banks of the St. Lawrence, Montreal, Lower Canada.

Contains crystals of *garnet.*

Part of a boulder.

284. Part of a GRANITE BOULDER.

Banks of the St. Lawrence, Montreal, Lower Canada.

Contains numerous *garnets.*

285. GRANITE.

Mount Johnstone, St. John's, River Richelieu, Lower Canada.

Composed of *felspar* (some in fine crystals), *quartz*, and *black mica.*

286 & 287. GRANULITE, LEPTYNITE, or FELSPATHIC GRANITE.

Near Montreal, Lower Canada.

A compound of *roseate felspar* and *quartz.*

From a boulder.

288. SYENITE.

Maskmenga, St. Lawrence, Lower Canada.

Composed of large fragments of *hornblende*, with flesh-coloured *felspar* and *quartz.*

From a dyke occurring in a range of syenitic hills.

289. SYENITIC GRANITE.

Saddleback Mountain, State of Maine, United States.

Contains *garnets*, and composed of crystals of *white felspar, quartz, hornblende*, and *silvery mica.*

290. SYENITE.

Near Montreal, Lower Canada.

Composed of *light flesh-coloured felspar* (some in crystals), with *quartz* and *hornblende.*

291. SYENITE.

Near Montreal, Lower Canada.

Composed of *flesh-coloured felspar, quartz*, and *hornblende.*

Part of a boulder.

292. SYENITE.

Near Montreal, Lower Canada.

Composed of *flesh-coloured felspar, quartz*, and a small proportion of *hornblende.*

Part of a boulder.

293. GREENSTONE.

Beleiul Mountain, near Chambley River, Lower Canada.

Composed of, for the most part, imperfect crystals of *white felspar* in a base of *hornblende.*

The specimen shows a weathered surface, with decomposing felspar.

294. SYENITE.

Bytown Canal, Johnson Falls, Upper Canada.

An irregular mixture of *pink felspar, quartz*, and *hornblende.*

295. SYENITE.

Montreal Mountain, Lower Canada.

Composed of *hornblende* in a felspatho-quartzose base.

Part of a dyke

296. SYENITE.
Near Montreal, Lower Canada.
Composed chiefly of *labradorite* with *hornblende*, and a small quantity of *translucent quartz*.
Part of a boulder.

297. NAPOLEÓNITE, or ORBICULAR GREENSTONE.
Corsica.
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.
See also No. 138, Wall-case 1, page 219.

298. SYENITE.
Montreal Mountain, Lower Canada.
Composed of *felspar*, *hornblende*, and *quartz*, in contact with a basalt dyke.

299. FELSPAR PORPHYRY.
Chambley Canal, Lower Canada.
Composed of crystals of *felspar* in a felspathic base, with small cavities, containing minute cubes of *purple fluor spar*.
Part of a dyke.

300. SYENITE.
Australia.
Composed of *hornblende*, *flesh-coloured felspar*, and a small quantity of *quartz*.
Presented by J. B. Jukes, F.R.S.

301. BASALT.
Australia.
Containing crystals of *hornblende*, *felspar* (*albite*), and *olivine*.
Presented by J. B. Jukes, F.R.S.

302. COMPACT GREENSTONE.
Berthier, St. Lawrence, Lower Canada.
Composed chiefly of *hornblende*, with a small quantity of *felspar*. The specimen has an irregularly weathered surface.
Part of a boulder.

303. BASALT.
Montreal, Lower Canada.
Shows a weathered surface, and contains large crystals of *hornblende*.

304. AMYGDALOID TRAP.
Hostis Bluff, Nova Scotia.
The kernels filled with crystals of *stilbite* (coated with *green-earth*), which are sometimes replaced by *quartz* (*rock crystal*).
Part of a boulder.

305. AMYGDALOID.
Mountain of Montreal, Lower Canada.
With decomposing kernels of *green-earth*.

306 & 307. HORNBLENDE ROCK.
Longeuil, near Montreal, Lower Canada.
Composed of crystals of *hornblende* and *analcime*, in a hornblende base.

308. TRAP ROCK.
Longeuil, near Montreal, Lower Canada.
Crystals of *analcime* in a hornblendic base.

309. TRAP ROCK.
Montreal Mountain, Lower Canada.
Composed of crystals of *augite*, and *analcime* in a hornblende base.

310. LABRADORITE.
Montreal, Lower Canada.
Part of a boulder.

311. SERPENTINOUS ROCK.
Brompton Pond, Canada West.
With small octahedral crystals of *chromate of iron* on a weathered surface.

312. SLATY TOURMALINE.
Levant Mine, St. Just, Cornwall.

313. MICA ROCK.
Near Montreal, Lower Canada.
Principally composed of laminæ of *black mica*.
Part of a boulder.

314. BRECCIA.
Near Montreal, Lower Canada.
Composed of fragments of *quartz-grit*, cemented with *black chert*.
Part of a boulder.

315. ACTYNOLITE.

316. BASALTIC DYKE.
Toulinquet, N. coast of Newfoundland.
This dyke cuts through Slates, and contains crystals of *hornblende*, *black mica*, and kernels of *calc spar*.
Presented by J. B. Jukes, F.R.S.

H. W. BRISTOW.

Wall-case 5.

Arranged and described by H. W. Bristow.

Upper Shelf: See Nos. 166a, 166b, and 181; Wall-case 4.

1. BASALT.
Giant's Causeway, Ireland.
A pentagonal prism of columnar basalt. Composed of a fine-grained mixture of *augite* and *felspar.*

2 & 3. ALTERED LIMESTONE (Lias).
Portrush, Co. Antrim, Ireland.
The Lias of this district occurs of various degrees of induration, altered by contact with Trap-rock.
No. 2 contains a *pecten*, and No. 3 shows the impression of an *ammonite.*

4. VOLCANIC ASH.
Headland, W. of Chimney Head, near the Giant's Causeway, Ireland.
This is the Ochre bed, occurring between beds of columnar Basalt along the coast of Antrim.

5. FERRUGINOUS CONCRETIONS.
Headland, near the Giant's Causeway.
Contains crystals of *augite.*
Occurs in masses in the Ochre bed No. 4.

6. COMPACT CLAYEY ASH.
Foot of the Hill, by Stocanus, Giant's Causeway.

7. SANDSTONE.
Cave Hill, near Belfast.
Altered Upper Greensand.
This rock is usually a soft and incoherent sand of a very dark green colour, called Mulatto-stone. Where it has been in contact with dykes of Basalt it has become hardened and reddened.

8. GREY, COMPACT LIMESTONE.
Cave Hill, near Belfast.

9 & 10. ANGULAR FLINTS, &c.
Shore, a little W. of Ballycastle Harbour.
An old sea-bottom, composed of angular flints, derived from the waste of Chalk, and subsequently overflowed by Basalt and baked.

11. ALTERED FLINTS.
Cave Hill, near Belfast.
Altered by Basalt.
From the little clay-bed, between the Chalk No. 8 and the Basalt, which seems to be nearly always present.

POLISHED GRANITE.

NOS. 12 to 20, nine specimens of POLISHED GRANITE, &c.

Presented by Mr. McDonald of Aberdeen.

12 to 16. PINK GRANITES.

17 & 18. GREENSTONES.

19 & 20. FELSPATHIC PORPHYRIES.

SERPENTINE, DIALLAGE, &c.

Serpentine is a silicate of magnesia combined with water, with the addition of a minor proportion of oxide of iron.

Some Serpentines are said to be intrusive igneous rocks. The Serpentine of the Lizard district in Cornwall reposes on Hornblende-Slates and Rock, and is said to have been erupted previously to the Granite of the same district, the former being traversed by veins of the latter.

Serpentines are, however, often true metamorphic rocks, good examples of which occur in Anglesey, 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. 15.

(For details of the Serpentine and associated rocks of Cornwall, see "Report on the Geology of Cornwall," De la Beche, pp. 98 to 100, and 473 to 500.)

21. GREEN SERPENTINE.
Penare Barn, Veryan, Cornwall. Map 31.

22 & 23. RED AND GREEN SERPENTINE.
Kynance Cove, Lizard, Cornwall. Map 32.

24. Red and green STRIPED SERPENTINE.
Cadgwith, Lizard, Cornwall. Map 32.
Contains a few minute cracks filled with *steatite.*

25. Dark green and red SERPENTINE.
Carnhalla, Porthalla, St. Keverne, Cornwall. Map 31.
Shows a weathered surface.

26. POLISHED RED SERPENTINE.
Ruan Minor, Lizard, Cornwall. Map 32.
Contains a few disseminated crystals of *diallage.*

27. RED AND GREEN SERPENTINE.
Near Ruan Minor Church, Lizard, Cornwall. Map 32.
Contains steatitic lines and disseminated crystals of *diallage.*

28. OLIVE-GREEN SERPENTINE.
Flagstaff, Cadgwith, Lizard, Cornwall. Map 32.
This variety is marked with red veins, and contains occasional crystals of *diallage.*

29. RED AND GREEN SERPENTINE.
Flagstaff, Cadgwith, Cornwall. Map 32.
Contains a small quantity of *diallage* in disseminated crystals.
From a vein in Serpentine.

30. Olive-green and red SERPENTINE.
Flagstaff, Cadywith, Cornwall. Map 32.
Contains a few crystals of *diallage* and veins of *steatite.*

31 & 32. GREEN AND RED SERPENTINE.
Flagstaff, Cadgwith, Cornwall. Map 32.
Traversed by veins of *steatite,* and contains a small quantity of *diallage.*

33. GREEN AND RED SERPENTINE.
Treraboe, Goonhilly Downs, Lizard, Cornwall. Map 31.
Exhibits a vein of *steatite.*

34. DARK GREEN AND RED SERPENTINE.
Trezoddern, Ruan Minor, Lizard, Cornwall. Map 32.
With disseminated crystals of *diallage,* and a few veins of *steatite.*

35. DARK REDDISH-BROWN SERPENTINE.
Maen Midgee, Kernick Sands, Lizard, Cornwall. Map 32.
Contains a few small crystals of *diallage.* The specimen exhibits a weathered surface.

36. DARK GREEN AND RED SERPENTINE.
Black Head, Lizard, Cornwall. Map 32.
Contains disseminated crystals of *diallage.* The specimen exhibits a weathered surface.

37. GREEN AND RED SERPENTINE.
N. of Poltreath, Lizard, Cornwall.
With a few crystals of *diallage,* and a weathered surface.

38. GREEN SERPENTINE.
Karakclews Point, St. Keverne, Cornwall.
Contains a few crystals of *diallage.*

39 & 40. DARK GREEN SERPENTINE.
Porthalla, St. Keverne, Cornwall. Map 31.
Exhibits a few minute cracks filled with *steatite.* This Serpentine rises through Hornblende-slate, and Greenstone.

41. LIGHT-GREEN SERPENTINOUS ROCK.
Porthalla, St. Keverne, Cornwall. Map 31.
Shows a weathered surface, and contains small cracks filled with *steatite*. From the outer portion of the mass.

42. REDDISH-BROWN SERPENTINE.
Downas Cliff, St. Keverne, Cornwall.
Contains a few crystals of *diallage* and veins of *steatite.*

43. SERPENTINOUS ROCK.
Treraboe, Goonhilly Downs, Cornwall. Map 31.
Exhibits a schistose structure.

44. DARK REDDISH-BROWN SERPENTINE.
Treraboe, Goonhilly Downs, Cornwall. Map 31.
Shows a schistose structure.

45. DARK RED AND GREEN SERPENTINE.
Downas Cliff, St. Keverne, Cornwall.
Contains disseminated crystals of *diallage* and veins of *steatite.*

46. PART OF A VEIN OF STEATITE.
Lizard, Cornwall. Map 32.
Polished, and contains large angular fragments of *green Serpentine.*
Presented by Lieut. Brewer, R.N.

47. SERPENTINE.
Tredavoe, Goonhilly Downs, Cornwall.
Contains veins of *asbestos.*

DIALLAGE ROCK is a mixture of *Diallage* and *Felspar.* The former mineral is a foliated variety of augite, of a green, grey, and reddish-brown colour, remarkable for the metallic-pearly lustre which it reflects, more especially from one of its two planes of cleavage. This character is well displayed by the large specimen No. 51, on the upper shelf of Wall-case 4. (See Bristow's Glossary of Mineralogy, p. 108, Longman.)

Most probably the Diallage Rock of the Lizard district was produced after the Serpentine, inasmuch as the veins of Diallage Rock appear to cut through the Serpentine at the junction of the two rocks at Coverack Cove and near Landewednack. (De la Beche.)

48. DIALLAGE ROCK.
Coast near St. Keverne, Cornwall.
From a vein traversing Greenstone.

49. DIALLAGE ROCK.
Coverack, Lizard, Cornwall. Map 32.

50. DIALLAGE ROCK.
Cadgwith, Cornwall. Map 32.
Composed of crystals of *diallage* disseminated in a base of Serpentine.
Used for ornamental purposes, chimney-pieces, &c. (See "Report on Cornwall," p. 499.)

51. DIALLAGE ROCK.
Cadgwith, Cornwall. Map 32.
A large specimen similar to No. 50, is placed in Wall-case 4, upper shelf; in consequence of the want of room in this Case, where it ought properly to be inserted.

52. ELVAN (*felspathic trap*).
Serpentine Quarry, Llanfechell, Anglesey.
Contains fragments of *Serpentine*, with included crystals of *diallage* and a few *steatitic lines.*

H. W. BRISTOW.

CONTENTS OF THE FLAT- AND WALL-CASES IN THE LOWER AND UPPER GALLERIES.

Lower Gallery.

FLAT-CASES.

Flat-case 1. Cambrian and Lingula Flags. Annelida, Crustacea.
„ 2. Llandeilo Flags. Brachiopoda, Crustacea.
„ 3. Llandeilo Flags. Crustacea, Brachiopoda, Lamellibranchiata.
„ 4. Caradoc. Crustacea.
„ 5. „ „
„ 6. „ „
„ 7. „ „
„ 8. „ Brachiopoda.
„ 9. „ „
„ 10. „ Lamellibranchiata.
„ 11. „ Gasteropoda, Pteropoda.
„ 12. „ „
„ 13. Llandovery. Crustacea, Brachiopoda, Lamellibranchiata, Gasteropoda, Pteropoda.
„ 14. Llandovery. Crustacea, Brachiopoda.
„ 15. „ Lamellibranchiata, Gasteropoda.
„ 16. Woolhope. Crustacea, Brachiopoda, Gasteropoda.
„ 17. Wenlock. Crustacea.
„ 18. „ Brachiopoda.
„ 19. „ „
„ 20. „ Lamellibranchiata.
„ 21. „ Gasteropoda, Pteropoda.
„ 22. Ludlow. Crustacea, Brachiopoda, Lamellibranchiata.
„ 23. Ludlow and Aymestry. Lamellibranchiata, Gasteropoda, Pteropoda, Crustacea, Brachiopoda.
„ 24. Ludlow. Crustacea, Brachiopoda, Lamellibranchiata.
„ 25. „ Lamellibranchiata, Gasteropoda, Pteropoda.
„ 26. Ludlow and Passage beds.
„ 27. Devonian. Crustacea, Brachiopoda.
„ 28. „ Brachiopoda, Lamellibranchiata, Gasteropoda.
„ 29. Middle Devonian, Crustacea, Brachiopoda.

Flat-case 30. Middle Devonian, Brachiopoda.
„ 31. „ „ Lamellibranchiata, Gasteropoda.
„ 32. „ „ Gasteropoda.
„ 33. Upper Devonian. Crustacea, Brachiopoda, Lamellibranchiata, Gasteropoda.
„ 34. Pilton and Marwood Beds. Crustacea, Brachiopoda Lamellibranchiata.
„ 35. Marwood Beds. Lamellibranchiata, Gasteropoda.
„ 36. Lower Carboniferous. Crustacea, Brachiopoda.
„ 37. „ „ Lamellibranchiata, Gasteropoda.
„ 38. Carboniferous. Crustacea.
„ 39. „ Brachiopoda.
„ 40. „ „
„ 41. „ „
„ 42. „ „
„ 43. „ Brachiopoda, Lamellibranchiata.
„ 44. „ Lamellibranchiata.
„ 45. „ Lamellibranchiata, Gasteropoda.
„ 46. „ Gasteropoda.
„ 47. Carboniferous and Millstone Grit. Gasteropoda, Pteropoda, Brachiopoda, Lamellibranchiata.
„ 48. Coal-measures. Crustacea, Brachiopoda, Lamellibranchiata.
„ 49. Coal-measures. Lamellibranchiata, Gasteropoda, and Pteropoda.
„ 50. Magnesian Limestone. Brachiopoda, Lamellibranchiata.
„ 51. „ „ (Permian). Lamellibranchiata, Gasteropoda.

Lower Gallery.

Wall-cases.

Wall-case I. Recent Dredgings, &c. Compartments 1, 2.
„ II. Pleistocene, Marine and Fresh Water deposits. Compartments 3 to 6.
„ III. Red, Corraline and Mammaliferous Crag. Compartments 7 to 11.
„ IV. Cambrian. Lingula Flags. Llandeilo Flags. Compartments 12 and 13.
„ V. Caradoc. Compartments 14, 15, and 16.
„ VI. Llandovery Rocks. Woolhope Limestone. Compartments 17, 18, 19.
„ VII. Wenlock Shale and Limestone. Compartments 20, 21, and 22.
„ VIII. Wenlock Shale and Limestone. Compartments 23 and 24.
„ IX. Ludlow. Downton Sandstone. Compartments 25, 26, and 27.

Wall-case	X.	Old Red Sandstone. Devonian. Pilton Beds. Compartments 28, 29, 30.
„	XI.	Marwood Beds. Old Red Sandstone. Devonian. Compartment 31.
„	XII.	Marwood Beds. Lower Carboniferous. Culm Measures. Compartment 32.
„	XIII.	Carboniferous Limestone. Compartments 33, 34, and 35.
„	XIV.	Carboniferous Limestone and Millstone Grit. Compartments 36, 37, 38.
„	XV.	Palæozoic Crustacea. Compartments 39, 40, and 41. Fish.
„	XVI.	Palæozoic Fish. Compartments 42, 43.
„	XVII.	Palæozoic Fish. Compartments 44 to 48.
„	XVIII.	Coal Measure Plants. Compartments 50 to 52.
„	XIX.	Coal Measure Plants. Compartments 53, 54.

Upper Gallery.

Wall-cases.

Case	IV.	Lower Lias. Compartments 8, 9, 10.
„	V.	Marlstone. Upper Lias. Inferior Oolite. Compartments 11, 12, 13.
„	VI.	Inferior Ooolite, Fullers' Earth, Great Oolite, Bradford Clay, Forest Marble, Cornbrash, Kellaways Rock. Compartments 14, 15, 16.
„	VII.	
„	VIII.	Oxford Clay, Coral Rag, Calcareous Grit, Kimeridge Clay. Compartments 19, 20, 21.
„	IX.	Mesozoic Vertebrata. Compartments 22, 23, 24.
„	X.	Portland Oolite, Purbeck Beds, Hastings Sand. Wealden. Compartments 25, 26, 27.
„	XI.	Lower Greensand, Speeton Clay. Compartments 28, 29, 30.
„	XII.	Lower Greensand and Gault, Upper Greensand, Chloritic Marl. Compartments 31, 32, 33.
„	XIII.	Chloritic Marl, Lower Chalk, Upper Chalk. Compartments 34, 35, 36.
„	XIV.	Upper Chalk. Compartment 37. Cretaceous Fish. Compartments 38, 39.
„	XV.	Lower Eocene. Compartment 47.
„	XVI.	„ „ „ 48.
„	XVII.	Lower and Middle Eocene. Compartments 49, 50, 51.
„	XVIII.	Lower and Middle Eocene. Compartment 52.
„	XIX.	Middle Eocene. Compartment 53.
„	XX.	„ „ Compartments 54, 55, 56.
„	XXI.	Upper Eocene. Compartment 57.
„	XXII.	„ „ „ 58.

Upper Gallery.

Flat-cases.

Case 1. Lower Lias.
„ 2. „ „
„ 3. „ „ and Marlstone.
„ 4. Marlstone.
„ 5. „
„ 6. Upper Lias.
„ 7. Inferior Oolite.
„ 8. „ „
„ 9. „ „
„ 10. „ „
„ 11. „ „
„ 12. „ „
„ 13. Fullers' Earth and Great Oolite.
„ 14. Great Oolite.
„ 15. „ „
„ 16. „ „
„ 17. „ „
„ 18. Bradford Clay and Forest Marble
„ 19. Forest Marble.
„ 20. Cornbrash.
„ 21. „
„ 22. Kellaways Rock.
„ 23. Oxford Clay.
„ 24. „ „
„ 25. Coral Rag.
„ 26. „ „
„ 27. „ „ and Kimeridge Clay.
„ 28. Kimeridge Clay.
„ 29. Portland Oolite.
„ 30. „ „
„ 31. „ „
„ 31. „ „ and Purbeck Beds.
„ 32. Purbeck Beds.
„ 33. „
„ 34. „
„ 35. Wealden and Hastings Sand.
„ 36. Hastings Sand and Lower Greensand.
„ 37. Lower Greensand.
„ 38. „ „
„ 39. „ „
„ 40. „ „ and Speeton Clay.
„ 41. Speeton Clay and Gault.
„ 42. Gault.
„ 43. „
„ 44. Upper Greensand.
„ 45. „ „
„ 46. „ „
„ 47. „ „
„ 48. „ „

Case 49. Chloritic Marl.
" 50. " "
" 51. Lower Chalk.
" 52. Upper Chalk.
" 53. " "
" 54. Lower Eocene.
" 55. " "
" 56. " "
" 57. " "
" 58. Lower and Middle Eocene.
" 59. Middle Eocene.
" 60. " "
" 61. " "
" 62. " "
" 63. " "

THE END.

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