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ISLAND OF ARRAN

GEOLOGY
OF
CLYDESDALE AND ARRAN;

EMBRACING ALSO

THE MARINE ZOOLOGY

AND

THE FLORA OF ARRAN,

WITH COMPLETE LISTS OF SPECIES ;

NOTES ON THE RARER INSECTS OF ARRAN; AND NOTICES OF
ITS SCENERY AND ANTIQUITIES.

BY

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LONDON AND GLASGOW:
RICHARD GRIFFIN AND COMPANY,

Publishers to the University of Glasgow.

1859.

BELL AND BAIN, PRINTERS, GLASGOW.

PREFACE.

THE first portion of the following work was prepared in the summer of 1855, at the request of the Local Committee of the British Association, then about to assemble in Glasgow. As no connected account of the Geological formations of Clydesdale at that time existed, the Committee was desirous that such an outline should be drawn up as might serve for a guide to the study of the coal series, of the tertiary formations, and evidences of glacial action, for which the neighbourhood of the city is so celebrated. To this request the Author willingly acceded; and to the sketch then printed he appended a notice of some new views regarding the structure of Arran.

At the request of many friends, who deemed that fuller notices of the Clydesdale formations would be useful and acceptable, a new and enlarged edition is now published; and as Mr. Ramsay's excellent *Guide to Arran* has been for some time out of print, an entirely new account of the structure of this interesting island has been added, embodying the observations made during many summer rambles among its romantic glens and mountains. That the work may serve also as a general Guide to Arran, descriptions of the scenery and antiquities have been introduced.

Happily, within the last few years Botany and Marine Zoology have been attracting an increased number of cultivators; and as Arran is a highly interesting field in these departments also, the Author considered that their study would be promoted, and the wants of the student met, by combining an account of the Flora and Marine Fauna of Arran with that of the Geology. At his request the

Rev. Dr. Miles, well known to naturalists for his researches in the Clyde, conducted under the auspices of the British Association, has kindly drawn up a pretty full account of the more remarkable creatures inhabiting the Arran shores. To those engaged in scientific inquiries, the complete list of species which he has added, brought down to the time of his leaving Glasgow for a more important sphere of labour in Malta, will prove welcome and useful. The account of the Flora of Arran has been drawn up by the Author's eldest son. To Professor Balfour, of Edinburgh, his best thanks are due for the permission kindly granted to make use of his catalogue of Arran plants. The list of plants and localities now given has been thus considerably extended.

The Author has also to acknowledge his obligations to H. T. Stainton, Esq. of Mountsfield, near Lewisham, whose high reputation as an entomologist is well known, for the notes which he has most kindly supplied on the rarer insects of Arran.

In examining the lower members of the coal series in the Campsie district, the Author was directed and assisted by Mr. John Young, then of Lennoxton, now of the Hunterian Museum, Glasgow. Two of the illustrative cuts in the early part of the work, and many facts there stated, were supplied by him. Many important facts were also kindly supplied by James King, Esq. of Levernholm, regarding the lower coal series. Through the kindness of the Rev. David Landsborough of Kilmarnock, son of the late distinguished naturalist, the Author was put in communication with John M'Kinlay, Esq. of Bonnington, near Edinburgh; and from this well known archæologist much valuable information has been received. The accompanying map has been reduced by Messrs. W. & A. K. Johnston from the Admiralty Survey of 1846. According to Mr. Paul Cameron, the magnetic variation in the Frith of Clyde at present amounts to $26^{\circ} 35' W.$, with a decrease of $4'$ to $5'$ per year, westerly.

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NOTICES

OF THE

GEOLOGY OF CLYDESDALE, &c.

Few parts of Scotland present so rich a field of geological inquiry as the district of Clydesdale. In none certainly are the facilities so great for studying the varied phenomena of a large class of formations. Even within the compass of its capital city, monuments exist of many successive revolutions in physical geography and organic life; beneath her streets are entombed the remains of a vast extinct creation; the foundations of her teeming warehouses and crowded quays are laid amid the mouldering works of a Primeval Race; while between these extremes there is interposed a long series of terms indicating a progressive advance towards the existing forms of animal life and aspects of the surface. Of scarcely less interest are the shores of the noble Frith, which present a complete suite of the older formations; while among its islands Arran has long been celebrated as exhibiting a greater variety of geological phenomena than perhaps any other tract of like area on the surface of the globe.

In the following pages a few brief notices are given of the various deposits, their fossil contents, and the best points for studying the relations of the strata, in order to direct the researches of future inquirers, and to aid those who are beginning the study of the science.

I.—HUMAN PERIOD.

1. The city of Glasgow stands on the great coal field of Scotland, about seven miles from its north-west border. Within its bounds the several "measures" of this formation, sandstone, shale, clay, iron-stone and coal, crop out in many places; but the surface is generally covered with newer deposits. The site of the smaller portion on the south side of the river is a level plain, composed of ancient estuary

or fluviatile accumulations. A narrow strip on the north, throughout the whole length of the city, is of the same character. North of this, the ground rises with considerable rapidity in a series of elliptic-shaped hills, from 100 to 250 feet above the plain, their longer axes being parallel to the course of the river, here west-north-west. The principal heights are Garngad hill, 252 feet 6 inches; Necropolis, 225 feet; Garnethill, 176 feet 7 inches; Blythswood hill, 135 feet 3 inches; Woodlands hill, 153 feet; Hillhead, 157 feet; Observatory, 179 feet 5 inches;* Jordanhill, two miles west, 145 feet. Some of these were originally a little higher, the tops having been levelled to afford a broader space for the erection of buildings. The elevations give a pleasing variety to the city, and afford striking views of the distant Highland mountains, and the fine amphitheatre of nearer hills, which close in on all sides, except the east, the undulating and well-wooded basin, intersected by the lower course of the Clyde.

2. Apart from deposits now in progress, the latest formation is that of the estuary and fluviatile accumulations above referred to. These are spread out continuously on both sides of the river, but more widely on the south side, from Rutherglen, three miles above Glasgow, to near Erskine, ten miles below it,—the former being the upward limit of the tide before it was obstructed by works connected with the improvement of the navigation,—the latter the termination of the river in the estuary, and the limit of the ascent of salt water. The deposit consists throughout of laminated beds of sand and loam, with thin courses and streams of gravel and layers of peat. Marine

(a a) Carboniferous beds; (b b) Till and lower sand beds; (c) river Clyde; (d d) post-pleistocene, or raised beaches; (e f) estuary deposits of the human period.

shells have been found sparingly in its middle and lower parts, and a few fresh water species in the upper beds; but no collection has been formed of these interesting objects, so that we cannot describe the fossil contents more minutely. The deposit has been tranquilly formed throughout, long periods of repose having been but rarely interrupted by floods. Ancient rude canoes have been found in various parts of it, deeply embedded in the sand and loam, one at

* These heights are given on the authority of Mr. Thomas Kyle, Civil Engineer

either end of the area, and a great many on the banks of the river at Glasgow; some at heights 10 or 12 feet above the highest level reached by the greatest floods on record in the Clyde. Respecting these, the following particulars have been kindly furnished by John Buchanan, Esq., the well-known archæologist of this city, who carefully noted at the time the circumstances attending the discovery of those more recently found:—

“Within the last eighty years, no less than sixteen of these interesting remains of aboriginal workmanship have been found in and near Glasgow. They are all, with one exception, formed of single oak trees, in some instances by the action of fire, in others by tools evidently blunt, probably of stone, and therefore referable to a period so remote as to have preceded the knowledge of the use of iron. The first known instance was in 1780. The canoe lay under the foundations of the old St. Enoch’s church, at a depth of 25 feet from the surface—that is about the level of low water in the river below Argyle Street—and within it was a stone hatchet of polished greenstone, in good preservation. It is now in the possession of C. Wilsone Broune, Esq., of Wemyss Bay. The second, in 1781, while excavating the foundations of the Tontine, at the Cross, the surface being here 22 feet above high water. A third, in 1824, in Stockwell Street, in a deep cutting opposite the mouth of Jackson Street. The fourth was found, in 1825, in the cuttings for a sewer in London Street, on the site of the ‘Old Trades’ Land:’ the canoe was vertical, the prow uppermost, and a number of shells were inside. The next discovery was made in 1846, when the improvements in the river began to be actively carried out. Eleven canoes were discovered in a short period. Of these, five were found on the lands of Springfield, opposite the lower portion of the harbour; five more on the property of Clydehaugh, west of Springfield; and one in the grounds of Bankton, adjoining Clydehaugh. The ten were in groups together, 19 feet below the surface, and above 100 yards south from the *old* river bank, which was then where the middle of the stream now is. The twelfth canoe was brought up by the dredging machine, on the north side of the river, a few yards west from the Point House, where the Kelvin enters. The Erskine specimen was found in 1854. It was taken out by Mr. Taylor, who has charge of the ferry, nearly entire. To test its capabilities, he had it partially supported on a raft, and floated in it across the stream.

“A collection of these canoes is now preserved in a building in the College grounds; and single specimens may be seen in Stirling’s Library, Miller Street; the Andersonian Museum, George Street; ferry house, Erskine ferry, ten miles below Glasgow; and in the hall of the Society of Antiquaries, Edinburgh.”*

* Mr. Buchanan has since published a very full and interesting account of these curious remains in *Glasgow Past and Present*, vol. iii.

3. The conclusion is forced upon us by these facts that the entire area was at a remote time covered by an estuary, connected with the sea by a narrow strait near Erskine, where the hills on either side press close upon the stream; whose limits reached inland almost as far as Johnstone and Paisley, narrowed upward by the projecting Ibrox and Pollokshields ridges, but again widening out, so as to wash the base of the Cathkin and Cathcart Hills, and sweeping round north-east in a wide bay, so as to cover the space now occupied by the Glasgow Green and suburbs of Bridgeton. The river then entered about Bothwell or Rutherglen; and the northern shore was formed by the lower slopes of the hills already alluded to, and their continuations north-west by Partick, Jordanhill, and Yoker to the vicinity of Erskine. At even higher levels within the city Mr. Robert Chambers has traced well-marked terraces, which he considers the beaches of a former sea; and as far up as near the summit level of Sauchiehall Street, about 25 paces west of the Wellington Arcade, a marine deposit with shells was discovered in 1850, and described by Mr. William Ferguson.* The beds were, sand 2 feet; peat 1 foot, and sand again not passed through; whole depth, 9 feet. In the inferior sand bed there were marine shells, but specimens of *trochus ziziphinus* only were preserved. The height above high water is here 94 feet 8 inches, and is the greatest at which recent marine deposits are known to exist within the city. Whether this bed is a remnant of the extensive estuary deposit above noticed it is impossible to say, nor is it of much importance to inquire, as recent shelly deposits exist in the basin of the Clyde at like and even much greater elevations, in situations which we cannot suppose to have been continuously occupied by the estuary in question, and whose origin is certainly very different, far removed from the human period to which the canoe beds are referable. Even this era—the “stone period” of Scottish archæologists—lies far back in pre-historic time—how far we have no means of knowing. Nearly 2,000 years ago the Roman wall was constructed between the Forth and Clyde—from Bowling to Grangemouth; and, as Mr. Smith of Jordanhill has happily pointed out, no oscillation in level has taken place since that time. This singular work had precise reference even to the present tide levels. How remote, then, must be the time when the quiet waters of the estuary laved the hill sides, now covered by busy thoroughfares; and a race whose other memorials are lost navigated in these rude canoes the broader waters of the river, whose narrowed

* Transactions of the Philosophical Society of Glasgow, vol. iii., p. 147.

stream now floats the largest ships, and brings to our doors the choicest products of the globe.

Mr. Robert Chambers, in his interesting and prettily illustrated work on "Ancient Sea Margins," has some judicious observations on the connection of these deposits with those of other parts of Scotland, especially in the estuaries of the Forth and Tay, pp. 206-208.

II.—TERTIARY PERIOD.

4. The beds just described overlies towards their margin another series, occupying a peculiar place, and presenting a marked organic sequence, which links on the tertiary age to the existing order of things, and affords another amid the now oft-recurring examples of passages from group to group, which almost defy classification, and show us how past creations shade off into the present, continuously, without a chasm. The deposits in question are well known to geologists as the Clyde Beds, the discovery of which, with an interesting account of their natural history, we owe to Mr. Smith of Jordanhill. According to his classification, they are as follows, in descending order :—

1. Post-Pleiocene, or Raised Beaches.
2. Pleistocene, Newer Pleiocene, the Till, or Boulder clay of the glacial period.
3. Sands, gravels, and clays, resting on the Carboniferous formations or on the overlying trap rocks.

Post-Pleiocene, or Raised Beaches.

5. When we pass from the river Clyde into the frith at Dumbarton, both shores are seen to be marked by a well defined terrace, 10 to 20 feet above the present tide level, and bounded inland by a steep cliff. The Greenock railway, from the Bishopton tunnel to Greenock, runs along this terrace; and it is equally well defined upon the Cardross side, from the Leven mouth by Helensburgh to Gareloch-head. The watering places of Gourrock, Kempoch, and Ashton, and on the opposite side that of Kilcreggan, stand upon it. In Roseneath peninsula it is extremely well defined and traceable round the whole shore. Everywhere, indeed, upon the shores of the Frith and its islands the same terrace is clearly marked; nor less so on the west coast, from the Crinan canal, by Oban, up the shores of Loch Linnhe, on Loch Fyne, &c., and along it in most parts of these shores the coast road is carried. The cliff, which bounds it inland at a distance varying from a few yards,

as on the north shore of Arran, to a quarter of a mile, and even half a mile, as in parts of the Roseneath and Renfrewshire shores, is everywhere sea-worn, and hollowed out into caves; the terrace is covered with shingle greatly sea-worn; it is flat and difficult to drain; the elevation seldom passes 40 feet; usually it is considerably less. Mr. Smith was the first to point out that at the level which the land then had—for it is the *land that has been raised*, and not as Mr. Chambers would explain the appearances, the sea that has subsided—it must have stood for a much longer period than that which has elapsed (2,000 years) since the Roman works in this country were constructed. The great length of the caves, of which Professor James Nichol has given a remarkable instance on Davar island at Campbelton*—as well as other cases of wearing, such as the projection of the harder veins in the rocks, the overhanging of the cliffs, &c., clearly prove this. In these caves and on the terrace, sea-shells of species now existing in the adjoining sea, occur abundantly and in many places. An interesting case at Rothesay was published in the *Witness*, July 1855, by Dr. Hugh Miller. One of the most remarkable as regards elevation which has come under the notice of the writer of these memoranda is the steep terrace at Roseneath house, a seat of the Duke of Argyll, which is shown in the annexed cut. The heights were kindly furnished by Mr. Lorne Campbell of Roseneath.

(a) Upper slopes, on which the offices stand; (b) Sea-worn cliff of old red sandstone, called *Wallace's loop*;
(c) Terrace of former beach, on which Roseneath house stands; (d) Sea level.

The upper terrace is 79 feet high, the lower north portico of Roseneath house 42 feet; shells broken and mixed with sea-weed are found on both terraces, 2 or 3 feet below the surface; on the upper terrace in hollows 68 feet above high water. The bed in Sauchiehall Street, Glasgow, is probably of this age, though somewhat higher (Art. 3). At Johnstone, near Paisley, a case is mentioned by Mr. Smith, in which sea-shells, bones of fishes and sea-birds, claws of crabs, and sea-weed were found at about 80 feet elevation, resting on Till beds 70 feet thick. The brickfields about Glasgow and Paisley abound in these shells; in the neighbourhood of Jordanhill the beds are 80 feet above the river, the shells being almost always at a considerable

* *Jour. Geol. Soc.*, vol. viii., 1852.

depth;—30 feet in some cases mentioned by Mr. Smith. The Paisley fields are to the north-west of the railway station; they yield a good many species. At Dalmuir, north of Erskine, a shelly deposit described by Dr. Thomas Thomson* has yielded 70 species. Beds on the east shore of Lochlomond, two miles north-west of the mouth of the Endrick, and 10 feet above the highest level of the lake; also beds at the south-east angle of the lake, and on the summit of Inch Lonach island opposite Luss, gave to Mr. Adamson about 12 species.† Captain Laskey found 22 species four miles from Glasgow, in cuttings of the Paisley Canal, 40 feet above the level of the Clyde.‡ The age of these beds has not been accurately determined; it must depend upon the proportion of Arctic species; but they seem referable to the upper or post-pleiocene division. Space does not permit an enumeration of other cases, of which several might be mentioned at much greater altitudes, though not in the vicinity of Glasgow. The shells are generally of a littoral character, much worn and broken, and about 160 species have been noticed. Of the same age and connected with these are many sand, gravel, and clay beds without shells.

The Boulder Clay.

6. This remarkable deposit, whose original mode of formation has excited such active discussion among geologists, was long since noticed by Col. Imrie, Mr. Bald, and other writers, as the old alluvial cover spread out over the surface of the coal fields and trap rocks of Scotland.§ But it is to Mr. Smith we owe its establishment as a definite group, with peculiar organic contents.|| It may, perhaps, be best divided into three subordinate groups: 1st, upper Till, with finer and smaller boulders than those of group No. 3, of lighter colours, and unstratified; 2d, stratified beds, in which chiefly the shells and other remains occur; and, 3d, the lower Till, resting frequently on the carboniferous rocks, and consisting of stiff blue or red clay, confusedly mixed with boulders, and unstratified. In the Till proper, shells are rare, and when found, fragmentary; but the stratified beds have yielded a great number of species, and of these from 10 to 15 per cent. are either extinct or not now known in the British seas. Those which are recent, but not found in the British seas, occur in the Arctic regions, and indicate therefore the existence of a colder climate than that of the present period, and colder also than that under which

* *Rec. Gen. Science*, i., 131.

† *Wern. Mem.*, iv., part ii., 334.

‡ *Wern. Mem.*, iv., part ii., p. 568.

§ *Ibid*, several vols.

|| *Ibid*, viii. *Proceed. Geol. Soc.*, ii., 427; and iii., 118, 149. *Trans. Geol. Soc.*, vi., 2d series, p. 153. *Jour. Geol. Soc.*, ii., 33; v., 17.

the post-pleiocene, or raised-beach formations were accumulated. The shells are generally entire, even delicate specimens being in good preservation.

The deposit may be studied in almost any deep cutting; and shells occur in many localities. One of the richest lies along the south shore of the Kyles of Bute, opposite the Burnt Isles. Here a stream on the Bute side has cut into the deposit, and exposed the shells. *Mya udevallensis*, a boring shell, is in its natural upright position; 25 species were found. Another rich locality was a bed on the side of the railway between Port-Glasgow and Greenock, 50 feet above the sea level. The shells were in a series of thin beds of sand, gravel, and clay, resting on the lower boulder Till of unknown thickness. Here Mr. Smith found 33 species. Over the shell bed were, sand 10 feet; coarse gravel 2 feet; and vegetable soil.

7. The following is a list of the shells of the boulder clay *not found* in a recent state in the British seas, kindly supplied by Mr. Smith. The entire number he estimates at 151 :—

Tellina proxima : Arctic seas.

Astarte multicostata.

—— *Propinqua*.

—— *Withami* : Bridlington : Arctic seas.

—— *Borealis* : Upper Crag : Arctic seas.

Mya udevallensis : Arctic seas.

Pecten islandicus.

Leda oblonga.

—— *antiqua*.

Cytherea lævagita.

Mactra striata.

Natica clausa.

—— *Smithii* (Bulbus, Brown).

—— *fragilis*.

—— *glaucinoïdes*.

Nassa Monensis.

Buccinum striatum.

—— *granulatum*.

Trochus inflatus (*Margarita undulata*, Sowerby?) : Arctic seas.

Littorina expansa : Arctic seas.

Velutina undata : Arctic seas.

Fusus peruvianus : (*Murex*, Sowerby) : Crag, Udevalla ; Arctic seas.

Fusus imbricatus : Arctic seas.

—— *curtus*.

Saxicava sulcata, Udevalla.

Balanus udevallensis, Udevalla.

8. These are not the only remains, however, yielded by the beds in question. Those of mammalia now extinct in these islands have also been found. Mr. Bald found an elephant's tusk in the excavation of the Union Canal, 28 miles from Glasgow, in the west park of the

Clifton hall estate.* Elephants' bones and tusks were found near Kilmarnock and at Kilmaurs, in Ayrshire, in strata which Professor William Couper and Dr. Scouler examined and pronounced to be the Till. At Kilmaurs a few sea-shells were associated. At Chapel Hall, near Airdrie, the late Mr. John Craig discovered elephants' remains in the upper Till, at an elevation of 350 feet above the sea. These interesting specimens are preserved in the Hunterian and Andersonian Museums, at Eglinton Castle, and in the Museum of the Royal Society of Edinburgh. In the spring of 1855, Dr. A. Beveridge, of Glasgow, found in a deposit of this age, near Bishopbriggs, a portion of an elephant's tooth, which is preserved in the Hunterian Museum.

Beds below the Till.

9. The sands, gravels, and clays (No. 3) below the Till occur rarely; the Till generally resting on the carboniferous rocks. The only locality in which they have yielded shells is that described by Mr. Smith;† it is the highest in Scotland at which shells have been as yet discovered, namely, the surface 524 feet and the shell bed 510 feet. The locality is near the Monkland Iron Works, 14 miles south-east of Glasgow. The few shells found were of the same Arctic character as those in the Till.

III.—GLACIAL PHENOMENA.

Scratched Boulders.

10. The boulders from which this deposit receives one of its designations are distributed largely through its entire mass, but generally of greater size in the lower portions of the beds. They consist of rocks which are found only to the north-west and west of Glasgow; and the same holds true with respect to the loose surface boulders which are found over Clydesdale. These have thus travelled *up the river basin* in a direction contrary to that of the present drainage, or action of that force which might in some cases be conceived adequate to the transport of at least the smaller ones. They cover all rock formations alike, being found along the summits of the trap ranges of Lennox and Cathcart, on both sides of the basin, as well as over its interior and less elevated districts. When we pass westwards of the coal tracts, into the district where Devonian and primary rocks prevail, we find that the transport has not been mutual; that region has received no boulders from the basin of the Clyde, though the limestones, sandstones, and

* *Wer. Mem.*, iv., 58.

† *Jour. Geol. Soc.*, vi., 386, 1850.

other "measures," with the trap rocks overlying, are sufficiently hard and coherent to have withstood the attrition of a lengthened journey. So numerous and varied are the contents of the boulder or Till beds, that within the limits of Glasgow, from the cuttings in the hill sides for the foundations of the houses, nearly a complete collection of Scottish rocks may be made;—granite, gneiss, mica, clay and chlorite slates, quartz rock, porphyries, old red sandstone and conglomerate, coal sandstone, ironstone, limestone, and a vast variety of traps are all turned out from the same cutting. The recent excavations on Woodlands' hill for the roads and buildings of the new park have exposed such assemblages; a noted locality, which excited great interest during the meeting of the British Association in 1840, and has been often since referred to, is Bell's park, near the Caledonian Railway station, north side of the city. The great majority of these boulders are rounded and smooth, but many of them are striated and grooved; and when the covering of Till is removed, the rocky bed on which it rested has also been found in several cases to present the same scratched and grooved surface. A good example occurred in Bell's park; but the rock has been quarried. In the neighbourhood of the Town's Hospital some of these striated blocks may still be seen. Many were turned out from the cuttings for the roads and buildings of the new park.

11. Grooved and scratched rocks were observed near Glasgow by Colonel Imrie in 1812 (*Wer. Mem.*, ii., 36), and ascribed by him, and by subsequent observers, to the action of the rocks on one another during transport by currents of water sweeping the surface; and were classed under the head of Diluvial phenomena, being supposed to have been produced by the Deluge, or several successive floods in different periods. About 1840, however, they began to be referred to the action of glaciers, or the agency of floating masses of ice, which carried the boulders, grinding them down and marking the surfaces across which they passed. Mr. Smith's remarkable discovery of Arctic species in the Clyde shelly deposits associated with Till and boulders is strongly corroborative of this latter view, and indicates a prevalent low temperature immediately preceding that condition of things during which the British seas were furnished with their existing testacea. To this view the opinions of geologists now chiefly lean; but the subject is yet beset with difficulties. Several considerations must be carefully attended to;—the impression of the surface markings must have been posterior to the rounding process—the far transported masses are the most rounded, and there seem evidently several periods in the Till deposit, as already noticed. May it not hence be sup-

posed that great undulations in the waters under which the coal strata were deposited produced by earthquakes or other elevating forces, which gradually converted the area into dry land, were of such energy and long continuance as to tear up and re-arrange the rocky materials on the bottom—to sweep off great bodies of strata, forming such valleys of denudation as that of Campsie and Lennox-town—on opposite sides of which the strata exactly correspond—and that the deposits so formed were subsequently modified by the action of floating ice, or the surface moulded by glaciers after the whole area was converted into dry land? Icebergs we know are only formed along the sea borders of land covered with glaciers. Such ice-covered land must therefore have existed along the north-west of Scotland, presenting a bold coast towards the south-east, whence the bergs floating off through a deep sea, deposited their rocky load as they melted below and were capsized, or as they stranded on the tops of sunken ridges. Thus huge masses of mica slate were left on the summits of the Pentlands and Lennox hills, and the whole basin of the Clyde strewed with the spoils of the Grampians, to whose eastern flanks, as an old sea border, we are thus enabled to track back the course of the floating bergs. The blocks are often so remarkably grouped that we can almost mark the spots where successive icebergs were stranded. The writer of these notices has seen in many of the glens descending upon Loch Long from the west and north-west successive assemblages of granite blocks, as many as 200 within a circular area of 30 yards diameter, with long intervening spaces almost destitute of them. The masses increase in magnitude as the granite nucleus whence they emanated is approached; and as the glens become narrower and the hill sides steeper, the crowd of blocks is so great as almost to fill the valley, while the rocky sides exhibit grooved and polished surfaces and *roches moutonnées* in great perfection. In the same district are many striking examples of perched blocks. At heights varying from 1,200 to 1,800 and perhaps 2,000 feet, and on the slopes of mica schist mountains so steep that one cannot descend but by a zig-zag course, granite blocks are lodged but slightly in the thin soil, on narrow ledges or terraces in considerable numbers, and of all sizes up to those whose weight was carefully estimated at $1\frac{1}{2}$ tons. Towards the bottom of the valleys some were estimated at 13 to 15 tons. Across the deep hollow occupied by Loch Long, up the sides of the hills on the east side, and across the rugged and high ridge dividing it from Loch Lomond, *trainées* of such blocks may be followed. Near Arrochar, east side of Loch Long, they are abundant and of great magnitude. These facts indicate a vast amount of submergence

during the drift period. Cases still more striking as regards elevation have been lately noticed by Professor Ramsay. He finds drift with shells on the mountains of Snowdonia at heights of 1,800 to 2,300 feet.*

The shores of Loch Lomond present many isolated boulders of granite, but few are of such enormous size as above stated. These phenomena, however, come under a large class, belonging to general geology, and need not be further referred to. It may merely be remarked with reference to the remains of the extinct quadrupeds (Art. 8), that they seem to point to the existence of a warmer climate than the present, and to present evidence of a kind opposite to that afforded by the Arctic testacea. The state of the remains of the extinct quadrupeds shows that, though associated with rounded gravel and far transported blocks, they belong to animals which must have lived not far from the places where the remains are found; and that their destruction may have been caused by a sudden submergence, and a sweeping of the surface by diluvial currents. But that the climate was warmer does not necessarily follow; since elephantoid remains occur abundantly in North Siberia and Arctic America, in such a perfect state of preservation as to show that the creatures were fitted for a cold climate, and as everywhere in the British isles these remains occur in association with existing quadrupeds and testaceous species.

Striated Rocks—Roches Moutonnées.

12. Local examples of scratched and polished rocks may be noticed here in connection with the scratched boulders of the Till. Perhaps the finest instance to be seen within a short distance from Glasgow is the summit level of the pass between the Gare Loch and Loch Long, 600 feet high, and about two miles from the village of Gareloch-head, fully described by Mr. M'Laren; *Ed. Phil. Jour.*, xl. to xlii. Mica slate rocks are here finely striated in a direction nearly from N.W. to S.E. The rocks on the roadside in several places, from this point to Gareloch-head, exhibit the same markings. They may be seen also at the landing-place at Row, and at several points on both shores of the Loch, where they extend under the sea. But at none of these points are there any striking examples of polishing, nor of that peculiar "Moutonnée" (rounded and bossy) character which is elsewhere exhibited, as at Parson's Green, near Edinburgh, described by Mr. R. Chambers, and Jacob's Wood, near Stavelo, Westmoreland, described by the

* *Jour. Geol. Soc.*, vol. viii.

author of these memoranda; and a case at Ulverston, noticed by Professor Phillips, but not yet described by him; all of which were *under a drift covering*, and as perfect and finely shown as any case yet noticed in Switzerland.* The shores of Loch Lomond, however, exhibit tolerable examples. At Rowerdennan Inn, between the house and shore, there is a good example of striation and rounded rocks. The surfaces are remarkably worn, rounded and polished; and the striation about parallel to the axis of the lake. Other cases of striation occur in many places along the shores. Mr. James Thomson, civil engineer, now of Belfast, lately noticed a good case on sandstone rocks, about three miles from Glasgow, south-east of the road between Auldhouse and Thornliebank, Pollokshaws, and due south of the manse near Auldhouse; the direction was here oblique to the road, or running nearly west. Captain Brickenden has described† striations on the rock of Dumbarton Castle, 150 feet above the river, in the fissure intersecting the rock from north to south. The surface of the sandstones on Craigmaddie moor is striated in many places, the direction being nearly E. and W.; and the trap rocks forming the high ridge between Strathblane and Milngavie are similarly marked, in a direction declining a little S. of E.; while they exhibit also rounded and bossy surfaces in great perfection. Fine examples may be seen in Corrie Glen, about one mile west of Kilsyth. Here a vast accumulation of detrital matter with travelled boulders is exhibited in a natural section on the banks of the West burn, as shown in the annexed cut.

(a a) River bank of detritus, with travelled and striated boulders; (b b) great intruded coulee of basaltic rock, enclosing (c) a shale bed, altered to the state of a coarse opal.

The south bank rises to the height of about 80 feet, and is entirely composed of detritus, partly local and partly derived from rocks existing only *in situ* to the westward. The most remarkable

* *Phil. Mag.*, Dec. 1850; and *Brit. Assoc. Rep.*, 1850.

† *Journ. Geol. Soc.*, vol. xi. (1855).

blocks which we noticed were two of large size and rhomboidal form,—one of the Campsie “main limestone,” and another of greenstone,—showing deep striation and grooving on one side, that on which they must have rested while borne along upon a hard surface. We shall have occasion to refer again to this interesting section.

Moraines.

13. On entering the Argyllshire Highlands from Glasgow, at almost any point, rivers of detritus are met with, filling the glens, obstructing their entrance, and backing up against the hill sides in flat terraces, with steep fronts towards the river. The glacialists early fixed on these, and all such accumulations in the Highlands, as moraines of the various orders, terminal, medial, and lateral; and not a few have been so described. Mr. Charles M'Laren has published an account of a remarkable one in Glen Messan, a glen entering the valley of the Holy Loch from the west, which he considers a true case of an ancient moraine, such being, according to his view, comparatively rare in Scotland.* Mr. Robert Chambers, who is somewhat sceptical on the subject of ice as viewed by Mr. M'Laren, coincides with him in regarding this glen as a true seat of moraines. Another case given by Mr. M'Laren is one mile south of Strachur on Loch Fine. One may be seen at Coruisk, near the mouth of the main glen; another about three miles farther up at Stronlonaig, on a glen entering from the south. The shingle bed at Row Ferry, Roseneath, is fixed upon by Mr. M'Laren as the terminal moraine of a glacier which he supposes to have once filled the Gareloch, crossing from the Loch Goil mountains by the col or summit level, where the scratches are seen. To us this appears a true shingle bank formed by the sea, owing to the peculiar movements of the tide at this part. The material is completely sea worn; and the outlet being narrow, and the extent of water inside great, the tide flows with a powerful current, there being a stream on the west side both at ebb and flood, and an eddy on the eastern. The fact pointed out to me by Mr. Smith of Jordanhill, that the shingle bed *rests upon* the old boulder clay or supposed glacial deposit, and must therefore be of later date than the rock striation and boulder transport, seems decisive as to the nature of this bank. Other cases of moraines will be found noticed in a recent paper by Mr. Chambers.†

* *Edin. New Phil. Jour.*, vol. i., new series, p. 189, 1855, and vols. xl. and xlii., 1846, 1847.

† *Ed. Phil. Jour.*, new series, i., 97.

In the island of Arran, the northern portion of which might be expected, from its peculiar structure, to be favourable to the growth and seaward extension of glaciers—if such ever existed in Scotland—we have failed to discover any very decided case. The rocks of the granite nucleus are certainly unfavourable to the preservation of surface markings. At the head of Glen Sannox, however, there are some fine examples of smoothed and polished rocks, and traces of lateral moraines on both sides of the glen. Finely marked gravel terraces occur at the mouth of Glen Iona, in front of the Duke of Hamilton's lodge,—they have flat summits and steep sides, and are elevated far above the action of any existing cause. Similar terraces in Glen Catacol, and mounds at the mouths of Glen Rosie, Clachan Glen, and others, may be deemed moraines by some. They are, perhaps, rather due to the action of currents sweeping these glens, when the area was rising from beneath the sea. The only case of striation noticed was in the south section of the island, near the waterfall in Glen Aisdale, two miles west of Whiting Bay. The rock is a tough close-grained greenstone; and the striation and grooving are in a direction from west-south-west, slightly oblique to the valley, which runs nearly east and west. Nowhere, however, are the phenomena of surface boulders more strikingly exhibited. They occur along the eastern shore in prodigious numbers and of enormous size, somewhat larger in proximity to the granite nucleus; but still of huge proportions at Corrygills, and Whiting Bay, three to eight miles from the parent rock; and over the interior of the island, they strew the surface at all altitudes.

IV.—CARBONIFEROUS ROCKS.

14. The carboniferous system of Scotland, which attains so vast a development in the basin of the Clyde and adjoining tracts, presents some peculiarities and departures from the normal type, as exhibited in England and Ireland. The entire area occupied by the coal measures is, in the geological sense, but a single basin, with the sole exception of a limited area to the extreme south-east, to be presently noticed. Across the broad zone which reaches from St. Andrews and Dunbar on the east, to Ardrossan and the heads of Ayr on the west, the older rocks, on which the coal measures repose, nowhere rise to the surface so as to form “independent basins.” Ridges of trap rocks do indeed intersect the area in various directions, but cannot be said to cut it off into distinct basins. The coal tracts of the Forth are continuous with those of Clydesdale, while the latter are confluent with those of Renfrew and Ayr,—at either

extremity the coal beds rise from beneath the sea. The area is thus a great synclinal trough, filled with an enormous thickness of coal-bearing strata. The permian and triassic rocks are rudimentary, and there is no great body of carboniferous limestone at the base of the series, as in most other countries; and this constitutes a second peculiarity of the Scottish field. The boundaries are formed throughout by Devonian rocks, which attain an enormous development along the north-west border; but on the south-east form a narrow and interrupted zone, so that trap ridges and dikes alone, in many parts, cut off the coal strata from the great southern tract of silurian rocks. Limestone, with all the usual fossils which characterize the carboniferous period, does indeed occur, but not as a well developed and continuous base; nor has the millstone grit of England been hitherto established as a member of the Scottish series. It may yet be found possible to prove its existence within the area; and at a still lower level, certain sandstones and shales on the line of junction with the undoubted old red sandstone, may turn out to be on the true horizon of the lower carboniferous limestone. The Ballagan beds seem to us to be such a peculiar group, though by some they may be regarded as the uppermost portion of the Old Red series.—They occur in fine typical development, in the bed of the Ballagan burn, at the base of the waterfall called the Spout of Ballagan, about three miles N.W. of Lennoxtown. They here present a vertical section of about 100 feet in height, and consist of numerous alternations of blue and red shales, calcareous marl, white and red thin-bedded sandstones, and thin courses of limestone. The lowest bed visible is a coarse dark-coloured sandstone containing sedge-like plants resembling calamites, but without joints; the highest, a thick-bedded yellow sandstone without plants, stretching in below the trap series which extends to the hill tops. The plants must, however, exist in the middle portion of the section, for they occur abundantly in the fallen blocks which strew the river bed throughout. A vein of gypsum, 9 inches wide, and numerous contiguous strings of the same substance, stretch far up the cliff, crossing nearly at right angles the various strata, which have a uniform N.W. dip at an angle of 11° . The only fossils met with in this locality are these sedge-like plants, which seem all to belong to one species, and are insufficient to decide the age of the beds. A group of very similar character occurs on the east side of the Leven valley, near Dumbarton, in the glens N. and N.E. of Dumbuck hill; and here a few fish scales have been found, but in so fragmentary a state as to render the species doubtful. The locality is, however, promising, and a careful search for fossils will probably bring species to light which will decide the question, and

determine the true horizon of the carboniferous formations on this side. The strata are almost an exact counterpart of those at Ballagan, but of greater thickness, and seen in more marked superposition to the old red sandstone which here rises northward, forming the outer part of the Kilpatrick hills. This is the western limit of these beds; from Ballagan they sink rapidly eastward, their upper portions being seen in Finglen and Campsie Glen; beyond which they are overlaid by the sandstone forming the floor of the Campsie valley. About one mile west of Ballagan they are again seen in the bed of a stream above the village of Strathblane; and still farther north, in Spittal Glen, running up N.W. towards the base of Drumgun hill, they are finely exhibited in several sections, graduating imperceptibly into the beds of the true Old Red. Two great faults here traverse both series, and throw down the Ballagan beds quite out of position. At the head of the glen the latter are directly covered by the basaltic rocks forming the hill tops. The old red sandstone, from this point northwards, is continuous with the great band on the Highland frontier. Throughout the entire district of Lennox, from Dumbarton to Stirling, the geological horizon is greatly obscured by the disturbances attendant on a prodigious outburst of igneous rocks, forming all the higher portions of the hills, and descending in some parts in broad streams into the low country at their base. Such a *coulée* of basaltic rock crosses the high ground between Strathblane and Milngavie, cutting right through the coal measures, which are tilted up by it on the west part of Craigmaddie Moor, and separating them from the corresponding measures of the Duntocher district, which reappear in the same relative position as in the Campsie valley, in consequence of an immense fold, or dome-shaped arrangement of the strata. This *coulée* will be intersected by a tunnel nearly three miles in length on the line of the new Glasgow Water Works. In the neighbourhood of Castlecary, Kilsyth, and Croy, similar outbursts and streams of igneous matter occur, altering the coal strata, and in some places bearing them up with it, so that the seams are worked on the hill tops, and in anticlinal beds along their flanks. An elevatory movement due to this cause, producing an anticlinal axis in the centre of the valley below the "spout," has given to the Ballagan beds their actual position; at least, it is only by such a supposition that we can explain their situation and their relations to the strata on the south of the valley, or north-west of Craigmaddie Moor. A conical hill of prismatic trap, called Dunglass, above 200 feet high, rises from the centre of the valley, immediately below the section which has been described above.

15. The annexed cut (N.W. to S.E.), the lower portion of which on either side of the hill (*f*) is partly conjectural, represents the

probable relations of the strata at this highly interesting point. Here (*a a*) represents the trap of the hill tops, (*b b*) yellow sandstones, the highest members of the Ballagan series; (*b' b'*) probable position of the same beds south of Dunglass hill; (*c*) the Ballagan beds; (*d*) a trap dike; (*e e*) probable position of the lower portion of the Ballagan series on either side of the axis; (*f*) Dunglass hill composed of prismatic basalt, and forming the anticlinal axis of the strata and watershed of the valley; (*g h*) coarse gritty sandstones higher in the series than the yellow sandstones (*b b*); (*k*) thick bedded fine grained sandstones, forming the highest parts of Craigmaddie Moor to the west. The beds of this latter dipping S.E. form the floor of the Campsie valley, on the level of the Glazert rivulet.

16. The yellow sandstones (*b b*) at the top of the Ballagan section thin out eastward, and disappear in Campsie Glen, so that the trap here rests directly on the beds (*c*), or true Ballagan series, which is depressed in this direction, and covered by newer deposits, whose elevated edges, as they successively crop out N.W., are overlaid along the side of the north hill by tabular masses of trap. The south hill, forming the opposite side of the valley, is a perfect counterpart of the north, save that the overlying trap is absent. The strata correspond exactly; and this rich and beautiful vale, through its extent of five miles in length by half-a-mile to a mile in width, owes its peculiar features to the action of powerful denuding forces, probably coinciding with the elevation of the area, at the close of the glacial period, as already indicated (Art. 11.) On account of the great interest of this case, and the economic value of the strata, we subjoin a section representing the principal beds on both sides. The less important members of the series and the faults, with minor irregularities, are omitted.

N.E.

SECTION OF THE VALLEY OF CAMPSIE, Looking towards the East, Showing the amount of denudation in the valley.

(a) trap of the Campsie hills; (b) yellow sandstone, underlying the trap and forming the highest part of the South hill; (c) shale, with clay ironstone, and seams of limestone ($16\frac{1}{2}$ fathoms thick); (d) blue shale ($22\frac{1}{2}$ fathoms); (e) main limestone ($4\frac{1}{2}$ feet), alum schist (2 feet), and coal (3 feet 8 inches); (f) white limestone, Kingle, shale, blue limestone, thin coal seams, and fire clay; (g) thick bedded white sandstone, forming the floor of the valley, and rising W. into the western portion of Craigmaddie Moor; (h) river Glazert.

The main limestone (*e*) is of marine origin, and has many remains. The white limestone (*f*) is of fresh-water origin, and almost made up of remains of *cypridæ*, a family of *crustaceans*. The sandstone (*g*) is that represented in the preceding cut as forming the higher parts of Craigmaddie Moor, in consequence of its gradual rise to the west. The alum strata are mentioned farther on.

17. The subdivisions of the Coal series, as given in two papers by the late Mr. John Craig, mining engineer and geologist, one published in the *Transactions of the Highland Society*, vol. xii., or vol. vi., New Series, 1839, the other laid before the British Association in 1840, have not since been disturbed, and are generally received as approximately correct.

The entire series may be divided as follows:—

1. Upper Red Sandstone series.
2. Upper or fresh-water coal series.
3. Upper marine series.
4. Lower coal series.
5. Lower marine limestone series, with intercalated fresh-water beds.
6. The Ballagan series and Old Red Sandstone, at the base of the entire formation.

The first of these divisions has been considered to represent the New Red Sandstone series. It occurs in the higher part of the central district, about Hamilton, Blantyre, &c., and consists of variegated sandstones and marls, with a few thin coal seams, and traces of plants; and hence it seems hardly proper to place these beds in the New Red series; but they have been as yet only partially examined, and it may hereafter appear that the uppermost beds really represent this formation in a rudimentary state.

The upper coal series is of fresh-water or estuary origin. It reaches from Glasgow due east by Garnkirk, north side of New Monkland parish, towards Bathgate. South-west its west boundary runs from the trap hills at Dychmont by Drumpeller, Bellshill, Motherwell, and Larkhall to Stonehouse; thence by Carluke, east and north-east towards Bathgate; thus comprehending all the central fields in the parishes of Camnethan, Shotts, Dalserf, Dalzell, with Old and New Monkland. Limestones are absent, and are represented merely by calcareous sandstones. The entire thickness is about 220 fathoms. The testacea are all of fresh-water or estuary genera, as unio, anodon, mytilus, &c.; fish remains, and the usual coal plants abound. There are nine beds of coal, whose aggregate thickness varies from 24 to 34½ feet, and twenty-five minor seams, rarely passing 14 inches each.

The first workable bed, or Ell coal, is 45 to 50 fathoms below the upper red sandstone of the first division; the fifth bed is a splint coal, and below it the remaining seams are less continuous, and of inferior thickness. There are, besides, numerous beds of common clay ironstone and blackband, a variety which contains enough carbonaceous matter to effect its calcination; and this is usually done at the mouth of the pits. The blackbands vary in thickness from 4 to 22 inches. There are three principal bands; the upper, 14 inches thick, is 24 fathoms above the Ell coal, and is worked in Old Monkland parish. Another, the mussel band, the second in descending order, is very remarkable as being almost entirely made up of fresh-water shells, which are seldom found in the clays above and below this ferrugineous band. It is 14 to 22 inches thick, and is worked near Airdrie. This blackband is 16 fathoms below the splint coal. The lowest bed is of the same quality, but lies much lower in the series. With the other beds similar shells are associated; and in Ayrshire the same fresh-water coal series appears, with rich blackband ironstones. The area occupied in Lanarkshire by this upper coal series is about 20 miles long, and from 6 to 15 broad.

18. Immediately north of the Necropolis hill, Glasgow, and along the line of the Monklands canal, this fresh-water series reposes upon limestones, shales, and sandstones abounding in marine remains, orthoceras, encrinites, bellerophon, euomphalus, nucula, productus, spirifer, &c., and constituting the upper marine group. It contains two seams of coal 12 and 14 inches thick, and irregular beds of ironstone; total thickness, about 600 feet. North of Glasgow, across the high ground between Bishopbriggs and Cumbernauld, the sandstones are of great thickness, and the "measures" are without coal.—Below these beds succeeds the lower coal group without limestone, but with several blackbands, and beds of coal, of which the lowest is a cannel coal, 2 to 3 feet thick. These coals and ironstones are worked north-west of the Kelvin, at North Woodside, Jordanhill, &c. At the bottom of the whole group are nodular clay ironstones, and thin limestones.—The lowest group yet established reaches from this horizon to the Ballagan beds, and contains marine limestones (main limestone $4\frac{1}{2}$ feet thick), alum shale, and sulphureous coal, 4 to 6 feet thick; below which are other limestones and coal beds, alternating and intermixed with tufaceous trap, to the bottom of the series. At Hurler, Duntocher, Campsie, &c., these limestones and shales are well seen. The alum works at Campsie, on the south side of the valley of denudation already alluded to, have been long established in connection with the shale bed. These works embrace

a greater variety of manufactures than any other in Scotland, in this department. The aluminous shale, or "alum till," lies between the sulphureous coal below, and main limestone above, and is no more than from 2 to 3 feet thick. There is first (ascending) an aluminous band containing iron pyrites, and passing in some parts of the mines into an imperfect blackband ironstone. Over this is the "gentle slate," or principal aluminous band, 6 or 7 inches thick. The uppermost band, called the "diamond" bed, from being studded with crystals of pyrites, is much poorer in aluminous matter and is seldom used, except to mix with the first or pyritous band. The main limestone rests on this band in the mines; but westwards on the south hill the aluminous strata thin out, and the limestone then reposes upon the sulphureous coal. On the north hill the shale bed is 15 feet thick; but the lower portion only is aluminous, and much poorer in the "ore." The strata, however, are an exact counterpart of those on the south hill. The upper part of the shale on the north hill is charged with multitudes of marine shells.—The chief difference at Hurlet consists in the more equal distribution of the aluminous matter throughout the whole thickness of the shale; but there is over the limestone a thick stratum, called the dough or duff bed, rather poorer in sulphur than the alum schist. The schist here shows, when effloresced, long brittle crystals of sulphate of magnesia; which are rarely met with in the Campsie ore. After the underlying coal is wrought out, the alum schist decomposes under the action of the air, exfoliates and falls down. Its sulphur, by the action of oxygen, combines with the metallic bases, forming sulphates. When decomposition is complete, the mass has the appearance of flock silk. The schist in this state is taken from the coal wastes and lixiviated in stone cisterns. The liquid is then evaporated to the proper density, and receives the portion of muriate or sulphate of potash necessary to its formation into the state of a crystallizable salt. This forms the sulphate of alumina, or alum of commerce. Of late years this salt has been developed by slow combustion in long ridges, coated with the exhausted ore; which is found a quicker process.

The extraordinary mass of coal at Quarrelton, near Johnstone, which attains a maximum thickness of 90 feet, but is generally 50 to 60 feet, seems to belong to these lower divisions. It lies in a basin-shaped cavity, less than 1 mile in diameter, and consists of 5 distinct seams, separated by thin layers of shale, sandstone, or ironstone. Over the coal is a stratum of sandstone, 24 feet thick, and this is covered by blue basalt, 100 feet thick. This prodigious mass of coal, perhaps the thickest ever found, seems to have originated

either in vast quantities of vegetable matter, swept into some sheltered hollow in the original estuary, or in a horizontal displacement, which has thrown several contiguous beds over one another.* The strata are displaced by two faults, one throwing the beds down 30 feet, and the other 50, in a direction nearly vertical.

19. The inferior marine groups appear to the south, south-east and south-west of the fresh-water series, and descend in the usual alternations to contact with the old red sandstone along the borders in that direction. To the south-east of this border, in Lesmahagow parish and adjoining tracts, a small coal field occupies an isolated position, cut off on the one hand from the Clyde basin, and on the other from the Ayrshire fields, by ridges of Devonian rocks, amid which igneous products are variously intercalated. The strata of the Glenbuck field rise up over a ridge of 1,000 to 1,200 feet high, pass down into the basin of the Douglas, a tributary of the Clyde, and rest on a narrow band of old red sandstone, which cuts them off from the Lesmahagow field; the latter is separated from the Clyde fields by a similar band to the north-east of the village of Lesmahagow, and stretches out east to near the base of Tinto. The strata are extremely well exhibited in natural sections, and contain a complete suite of fossils of true carboniferous types. "The coal shales, sandstones and ironstones, afford similar remains in abundance; and there can be therefore no doubt that the coal of this field is of the same age as that of the Clyde basins. It is worthy of remark, that several species of Trilobites occur in the shales and limestones, far up in the series; that a white grit, resting on one of the lower limestones, contains a prodigious quantity of fish remains, and corresponds apparently with the great 'fish bed' of some English fields; and that from one of the middle shales a fossil has been obtained agreeing exactly with the *Serpulites longissimus* of the *Silurian System*, pl. v., fig. 1. The field contains fifteen seams of coal, whose thickness varies from 2 feet to 15 feet, the aggregate amounting to about 65 feet of workable coal. There are black band and clay band ironstones, the principal seam of the former averaging 11 inches; but neither these nor the coal beds have yet been worked to any considerable extent, owing to the greater accessibility of the fields farther down the Clyde."† Here, as in other districts, the alternations of limestone and the other measures already noticed descend to the horizon of the Old Red, on which the whole series reposes, without the inter-

* See Nicoll's *Geology of Scotland*, p. 99, for an illustrative cut, copied from Williams' *Mineral Kingdom*, vol. ii., p. 319.

† See Brit. Assoc. Rep., 1850, p. 77.

vention of any large body of limestone—a peculiarity worthy of notice in all the coal fields of central Scotland. The entire phenomena of this field are highly instructive.

20. The varied phenomena of these interesting fields may be studied to advantage in many natural sections. The Lesmahagow field through its whole area, and along its borders, is completely opened up by glens and deep water channels, which exhibit the succession of the strata and many remarkable faults. The banks of the Nethan, Calder, and other streams which pursue rapid courses from the high uplands into the profound synclinal trough traversed by the Clyde downwards from the Falls, and the banks of the Clyde itself, present many instructive sections and most favourable localities for collecting fossils. The fresh-water series, across the central area, is less completely exposed, and is best known from interior workings and boring journals. The marine series is laid more fully open. It reaches out on either side to the base of the hill ranges bounding the area; and these, composed of igneous rocks, erupted through the coal formation, or along its outer margin, bear up the various “measures” on their flanks, and bring them to day in deep glens and the banks of mountain burns. In the Lennox range we have already mentioned the Auchinreach and Spittal glens, opening respectively into the Leven and Strathblane valleys; the Ballagan, Finn, and Clachan glens, descending into the vale of Campsie, near Lennox-town; these expose the subjacent Old Red, the intermediate Ballagan beds, and the lower members of the coal formation. Farther east there is an interesting section of beds somewhat higher in the series—one of the most instructive in the whole Clydesdale basin, and to which the attention of the student cannot be too emphatically directed. We refer to the succession of beds laid open in the middle portion of Corrie glen, one mile west of Kilsyth, as shown in the following cut.

The strata here exposed lie between two streams descending from the high trap ranges to the N.W., and uniting farther down before entering the valley of the Kelvin. Of these the West Burn, the upper portion of which is represented in the sketch of Art. 12, cuts most deeply into the soft shales and sandstones which are finely shown in a nearly vertical section. Workings on the economic strata farther favour the researches of the student.

The strata belong to the lower marine series. The yellow sandstone (*n*) at the base is higher than that of the Campsie valley, and the two limestones (*g*) and (*l*), respectively 3 and 5 feet thick, are also superior to the Campsie main limestone. The shale beds (*h*)

are from 52 to 60 feet thick. The section is from N.W. to S.E. ; and the general dip is S.E. at a small angle. Organic remains abound throughout the whole series of beds, and are readily obtained even from the limestones. The principal are many beautiful corallines, some very rare ; many species of productus, spirifer, terebratula, orthoceras, bellerophon, goniatites, &c. The shales contain large mityli, nuculæ, &c. The remarkable effects of igneous action in this glen will be noticed farther on.

(a) Shale with ironstone layers; (b) shale with encrinites; (c) thin bedded yellow sandstone; (d e f) thick beds of calcareous shale with limestone bands; (g) main limestone; (h) shale with nodular limestone; (i) coal bed; (j) shale; (k) shale with marine shells and corals; (l) coralline limestone; (m) shale with ironstone bands; (n) thick bedded yellow sandstone; (o) thick shale beds with ironstone bands; (p) boulder clay—see p. 13.

21. We subjoin several journals of borings in these lower marine beds, in order to show the general correspondence at remote points, as well as the local variations of the deposits. No. 1 gives the strata on the South hill, bounding Campsie valley in that direction ; No. 2 the beds lying in the valley, to be regarded as a continuation of No. 1. They are not presented in any natural section, and seem to lie between the Ballagan beds and the strata of No. 1 ; the sandstone on the floor of the valley forms the passage from the one series to the other. A portion of the beds in No. 1 is well seen in Craigen glen, opening southwards towards the village of Torrance ; and these abound in organic remains, among which, in addition to the genera above mentioned, are lingulæ, and many fish teeth and scales. The boring No. 3 is taken from a pit sunk at the E. end of the South hill, and on the S.E. side of a great greenstone dyke which crosses the district from N.E. to S.W., and throws down the beds on the side of Campsie valley, to a considerable depth. They are higher in the series than any in the Campsie district. In the language of the miners, “blaes” denotes all pure shales; “fakes,” laminated sandy shales; “kingle,” hard siliceous bands; “doggar” beds are bands of shale with nodular clay ironstone.

NO. 1. SECTION OF STRATA PASSED THROUGH IN SINKING A PIT NEAR THE SUMMIT LEVEL OF THE SOUTH HILL, 450 FEET ABOVE THE LEVEL OF THE RIVER GLAZERT.

	Fath.	Ft.	Inch.		Fath.	Ft.	Inch.
Sandstone, thickness not known.				White limestone (fresh-water),	0	4	6
Blue shale,	11	1	0	Kingle,	0	4	6
Ironstone band,	0	0	7	Shale,	1	1	4
Blue shale,	3	2	2	Limestone (marine),	0	0	10
Black limestone,	1	0	0	Fakes,	0	0	10
Shale, with 4 bands iron-stone,	1	0	0	Alum schist,	0	0	9
Blue shale,	22	2	0	Parrot coal,	0	0	4
Limestone (marine),	0	4	0	Common coal,	0	0	10
Alum schist,	0	2	0	Fire clay, in two beds, parted by kingle,	1	2	6
Coal,	0	3	8				
Under clay,	0	0	7		46	2	5

NO. 2. JOURNAL OF BORE PUT DOWN AT BURNHOUSE, NEAR THE LEVEL OF THE GLAZERT.

	Fath.	Ft.	Inch.		Fath.	Ft.	Inch.
Surface earth,	1	0	7	Hard shale,	0	3	6 $\frac{1}{2}$
Sandstone,	1	0	9	White freestone,	0	2	5 $\frac{1}{2}$
Very hard band,	0	1	0	Kingle,	1	0	7
Fire clay,	0	1	8 $\frac{1}{2}$	Gray fakes,	0	1	7
Fakes,	0	1	8	White freestone,	2	1	9 $\frac{1}{2}$
White kingle,	0	4	6	Fire clay,	0	2	9
Hard shale,	1	5	8	Light fakes,	0	2	0 $\frac{1}{2}$
Fakes,	0	1	6	Kingle,	0	1	5
Fire clay,	0	0	11	Fakes,	0	1	0
Impure limestone,	0	3	9	White kingle,	2	4	6
Shale, with stripes of fakes,	1	4	6	White marble band,	1	1	11 $\frac{1}{2}$
Blue shale,	0	1	7 $\frac{1}{2}$	Fire clay,	0	1	5 $\frac{1}{2}$
Ironstone,	0	0	3	Blue shale,	0	0	2 $\frac{1}{2}$
Shale,	0	0	7	Light shale,	0	1	3 $\frac{1}{2}$
Coal,	0	0	11	Shale, with stripes of fakes,	0	1	6
Fire clay,	0	1	2 $\frac{1}{2}$	Kingle,	0	1	7 $\frac{1}{2}$
Fakes,	1	0	6 $\frac{1}{2}$	Fakes,	0	0	6
Kingle,	0	0	7	Shale,	1	0	0
Limestone,	0	0	8 $\frac{1}{2}$	Shale, with stripes of fakes,	0	0	9
Shale, with stripes of fakes,	1	4	10 $\frac{1}{2}$	Rock not known,	0	0	9
Shale,	0	1	1	Limestone,	0	1	8
Blue fakes,	0	0	7 $\frac{1}{2}$	White freestone,	0	1	5
Shale,	0	1	1 $\frac{1}{2}$	Light fakes,	0	1	5
Ironstone,	0	0	3	Kingle,	0	0	4
Shale,	0	0	4	Light fakes,	0	0	9 $\frac{1}{2}$
Coal,	0	1	2	Kingle,	1	4	9 $\frac{1}{2}$
Fire clay,	0	2	1 $\frac{1}{2}$	Light fakes,	0	1	6
Fakes,	1	0	10 $\frac{1}{2}$	Light kingle,	0	3	9 $\frac{1}{2}$
Impure limestone,	0	1	10 $\frac{1}{2}$				
Shale,	1	5	5	Depth of this bore below the level of the valley,	33	0	0
White kingle,	0	2	10 $\frac{1}{2}$				

NO. 3. JOURNAL OF STRATA PASSED THROUGH IN SINKING A PIT FOR COAL ON THE GROUNDS OF BALQUAIRIAGE, NEAR CAMPSIE.

	Feet.		Feet.
Surface earth, with clay and boulders,	7	Shale, with ironstone nodules,	2
Blue shale, with marine shells,	42	Dark soft shale,	1
Shale, with encrinites and trilobites,	3	Black shale, with doggars,	1 $\frac{1}{2}$
Shale passing into limestone,	1	Bituminous shale,	0 $\frac{1}{2}$
Culmy limestone, in two beds,	8	Coal, not very good,	5
Calcareous shale,	1	Dark sandy shale, full of coal measure plants,	3
Bituminous shale,	2		
Dark blue shale,	2		

NO. 4. ECONOMIC STRATA OF LANARKSHIRE, COPIED FROM
SECTION MADE OUT BY DR. RANKINE, AND MR. JOHN
KERR OF CASTLEHILL.

	Fathoms under New Red Sandstone.	
Upper or fresh-water series.	32	Upper coal.
	41	Cone in cone limestone.
	52	Ell coal.
	56 $\frac{1}{2}$	Fresh-water limestone.
	63	Pyotshaw coal.
	64 $\frac{1}{2}$	Main coal.
	78	Splint coal, with band of clay ironstone above it.
	86	Mussel band ironstone.
	88	Sour milk coal.
	93 $\frac{1}{2}$	1st Black band ironstone.
	108	Virtue-Well coal.
	114	2d Black band ironstone.
	118	Mussel band ironstone.
	124	Castle hill 1st coal.
	133	Castle hill 2d coal and ironstone.
	144	Kiltongue coal.
	164 $\frac{1}{2}$	Drumgray coal.
	177	Coal (<i>no name given in section.</i>)
	190	Crofthead coal and ironstone.
	200	Slaty ironstone.
	220	Thomson's ball and gin ironstone.
	235	Curdley ironstone.
	254	Gare limestone.
Lower or marine series.	282	Belstone limestone.
	308	Climpey limestone.
	325	Carluke 1st coal.
	326 $\frac{3}{4}$	Carluke 2d coal.
	335 $\frac{1}{2}$	Tower coal.
	342	Four bands clay ironstone.
	347	Gas coal and black-band ironstone.
	370	Lingula ironstone.
	380	Lingula limestone
	381 $\frac{1}{2}$	1st Kinshaw limestone.
	384 $\frac{1}{2}$	2d Kinshaw limestone.
	390	1st Culmy limestone.
	393 to 397	Rae's gill ironstone, 11 bands.
	399	Hosie's limestone.
	415	2d Culmy limestone.
	418	Main limestone, under a band of clay ironstone.
	419	Coal under main limestone.
	424	Limestone.
	434	Shelly limestone.
	440	Oyster limestone.
	450	Scabricula ironstone.
	465	Old red sandstone.

The preceding section, No. 4, contains the economic strata only of the upper portion of Lanarkshire. It was prepared for the meeting of the British Association in 1855 by Dr. Rankine of

Carluké, long well known for his profound and accurate acquaintance with these strata and their fossils. The first 235 fathoms give the fresh-water series; below this, from the Gare limestone down to the oyster limestone, inclusive, there are 13 beds of marine limestone: and among these, the beds 418 and 419 are the equivalents of the Campsie main limestone and coal; and the Campsie strata generally are represented by the beds from the Kinshaw limestone ($381\frac{1}{2}$), inclusive, downwards to the old red sandstone. In the Campsie district, all the beds above the Kinshaw limestone are wanting; and the Ballagan beds have no representatives in the Carluké district. The Ballagan series does, however, occur in the S.E. coal field on the Merse of Berwick, as we are informed by Mr. Stevenson, and indications of them have also been noticed on the borders of the East-Lothian field.

22. Sections very similar to the preceding are obtained around the borders of the district, amid the series of lower strata; but it is impossible to identify the beds except in a very general way, as great analogous groups of limestones, shales, ironstones, and coals; and viewed in this way the Carluké series, so carefully made out by Dr. Rankine, is typical of the entire lower deposits. The lower coals are generally of inferior quality, but good ironstones descend to the very base; while limestones, usually marine, occur in oft-repeated alternations with the other measures. A general resemblance exists, but the local exceptions are remarkable. The Campsie, Duntocher, Carluké, and Hurlet series have been referred to already as illustrating this similarity. At Whiteinch near Partick, a little above the level of the Clyde, a bore of nearly 300 feet gave 11 beds of limestone, varying in thickness from 8 inches to 8 feet, aggregate about 30 feet; eight bands of ironstone, in all about 5 feet, but no coal seams. At Maxwelton near Paisley, a bore of 200 feet gave neither limestone nor ironstone, but several good coal seams, aggregate thickness about 14 feet. At Goldilee near Houston, on the outer margin of the Renfrewshire fields, where they come against the trap associated with the old red sandstone of the Coast Range, among the strata passed through in a shaft of 110 feet deep were two limestones 8 feet apart, and respectively 7 and 4 feet thick, and four coal seams about 6 feet in all, but no ironstone. At Kaimshill on the same border, a little south of Lochwinnoch, the limestones and coals are similar, but good ironstone bands are associated. At Howwood near Castle Semple, 125 feet of shales and rich ironstones overlie a bed of limestone 10 feet thick; and three miles S.E., at Braidstane near Beith, there occurs the largest body of lime-

stone in the West of Scotland. The following section shows the order and thickness of the strata :—

	Feet.		Feet.
1. Surface soil,	1	6. Coal,	1
2. Limestone, full of marine fossils, .	14	7. Slate clay,	6
3. Fire clay,	4	8. Limestone, with few fossils, .	18
4. Limestone,	1	9. Coal,	1½
5. Clay indurated,	1	10. Slate clay, not passed through, .	?

The strata are traceable for a mile in the line of bearing, but the breadth is limited in the direction of the dip. They crop out towards the north in the direction of the great outburst of trap, already noticed as forming a mineral axis in this region, in connection with the old red sandstone, through which it has been erupted.

23. On the subject of these local variations, and the prevailing similarity among the local groups, Mr. Montgomery of Cloak has the following remarks respecting the fields of Renfrew and North Ayr, in his clear and accurate outline of the geology of these tracts :*—“The different strata alternate in no definite order, while no one of them seems essentially necessary to the formation of a coal field. Even coal itself may be wanting, whilst all the other strata usually found in a coal basin are there. The place usually occupied by freestone or slate clay is occasionally filled by ironstone. Limestone is as capricious in its presence or absence as any other of the measures ; nor is it possible even to define its limits in the district under consideration. It makes its appearance here and there, more particularly upon the edges of the coal fields ; but its continuity from one place to another where it is seen is by no means certain. In various places it has been wrought out, perhaps indicating that the quarries had been opened in masses detached by some convulsion from greater strata. But whatever hypothesis may be adopted regarding this matter, none favourable to the opinion of the limestone strata holding a necessary place in the coal measures of Renfrew and Ayr can be entertained. If the strata of limestone were ever continuous, they certainly are not so now ; and to support the opinion of their former continuity, a much more intimate acquaintance with their numerous organic remains would be necessary, than it is supposed that any one has yet acquired.”

24. We do not know that these remarks, penned twenty years ago, need any modification at the present time, with all the knowledge we have since acquired respecting the organic remains of these beds. They support the opinion already advanced, upon evidence furnished by other districts of our great coal tract, that there is no great persistent body of “carboniferous limestone” separating by a well marked horizon the “upper” from the “lower” coal measures, and

* *Jour. of Agricul. and Trans. of Highland Soc.*, vol. xliii., p. 441, 1839.

that the millstone grit also finds no place in our series. In England and Ireland the development is more complete, and the lines of division more strongly marked. The mountain limestone is an important formation, and widely persistent in both countries; and in England the millstone grit, overlying the limestone, in most cases fully developed. In Ireland it is less universal, and its thickness is much less. In Scotland, on the other hand, the millstone grit has not been identified; and as to the mountain limestone, we may almost say that it is, as it were, split up into numerous bands; and strata of shale, coal, ironstone, and sandstone, intercalated among the separated members. The mineral type differs widely; but the organic remains are identical throughout the two series. They are thus of one age, but formed under different conditions of the terrestrial surface which adjoined. An ancient sea channel filled the space already described (Art. 14) as forming the great synclinal trough in which lie our coal strata. Warm and humid lands stretched far and wide to the N.W. and S.E.; they nourished a luxuriant vegetation of tropical or sub-tropical species, and were drained by large rivers emptying into this common receptacle. Like the tropical rivers of our own era, these were subject to sudden and violent floods, which swept away the exuberant vegetation and spread it widely over the bottom of that ancient frith. Sand and mud, mixed with peaty matter, produced by decomposition in sheltered situations, were the river sediment, in an incalculable disproportion to the trees and plants carried down. The calcareous matter, suspended in small proportion in these turbid waters, formed, by chemical segregation, subcrystalline beds of limestone of trifling thickness and limited horizontal extent. Under peculiar circumstances existing in particular spots, the purity of the water and a lengthened period of repose favoured the growth of a few corals, and the rearing of pigmy coral banks from the bosom of that primæval sea. In the region of the ancient Earth which we now call Ireland, the conditions were widely different: the whole interior, to two-thirds of the present area, was occupied by the waters of an inland sea or gulf, as large as the Aral Lake. Around its shores on all sides rose high ridges of granitic rocks and silurian slates, breached in a few places by narrow straits, uniting it to the ocean outside; and its surface was varied by a few islands of elongated form, less elevated than the bordering land, but formed of rocks of the same old types. The pure and warm waters of this archipelago were tenanted by myriads of rock-building polypi, whose ceaseless toil through long ages reared up from its still depths numerous reefs of coral; while the high temperature of the waters favoured the prolific growth

of other coralline species, and the development of chambered cephalopods (*nautilus*, *orthoceras*,) to an enormous size, bearing to the Scottish species somewhat of the same relation as do the *Tridacnas* of the Eastern seas to the dwarfish bivalves of our northern latitudes. The suspended lime, calcareous sand formed of triturated coral, and the countless myriads of testacea, zoophytes, and other creatures with which the waters teemed, united in forming vast deposits of limestone with a prevailing crystalline structure rarely found in the limestones of this age in Scotland.

Conditions very similar to these prevailed over large tracts in the centre and North of England, where the formation follows the crystalline type, and has less of that mechanical character which marks the Scottish deposits. Yet are the fossils most markedly alike throughout these groups in the three countries, and all are evidently of the same age. We speak, however, rather of the lower groups, the carboniferous limestones of England and Ireland, and the shale and sandstone beds with coal and ironstone seams, in Scotland. The upper portion of the Scottish series is, we have seen, of fresh-water or estuary origin, and formed under different conditions; while the upper portions of the Irish series perhaps differ in age from both the others, and in amount of development are far less complete.

25. For Fifeshire and the Lothians, Mr. Page has recently* given a classification very similar to that set forth by us, but somewhat less minute, and perhaps on that account to be preferred in the present state of our knowledge. Founding his deductions upon his own inquiries and the published reports of Mr. C. M'Laren, Sir D. Milne Home, and Mr. Cunningham, he arranges the strata in the following order:—

“1. True coal measures—consisting of numerous alternations of coal, shales, sandstones, ironstones, and occasional beds of impure limestone, 2,500 ft.

“2. Several strata of crinoidal and productus limestone, with intervening beds of shale, sandstones, and thin seams of coal, 180 ft.

“3. A vast thickness of whitish fine-grained sandstones, bituminous shales, a few thin seams of coal, mussel-bands or shell-limestone, and fresh-water limestones abounding in cyprides, 1,500 ft.

“In this instance there is no development of millstone grit, the whole system resolving itself into upper coal, mountain limestone,

* In his excellent “*Advanced Text-Book of Geology*,” a work remarkable for accurate and clear statement and sober generalization, and adorned by many eloquent passages.

and lower coal. . . . How far these subdivisions may indicate great life-periods, or only portions of one great epoch, has yet to be determined by a more minute and rigorous comparison both of vegetable and animal species,—a task which has hitherto been neglected for the lighter labour of popular description and attractive generalization.”

The second group in this arrangement corresponds to Nos. 3 and 4 in our division (Art. 17); the third corresponds to our fifth, and in it there occur, as with us, intercalated beds of fresh-water origin, consisting chiefly of a mass of cypridæ. Our sixth group, the Ballagan series of beds, finds no representative in the eastern fields, though occurring, as already noticed, in a state of less perfect development in the Merse of Berwick. But to constitute the middle portion into a separate group under the designation of “the mountain limestone,” appears to us only calculated to mislead the student, and to give a false impression to geologists regarding the true characters and great distinctive feature of our lower groups. Thick beds of marine limestone occur at the base, in the middle, and at the top of the series, and contain the same fossils; while at each end of the series, fresh-water strata are intercalated among the prevailing marine groups.* The entire series of beds thus forms one great natural group of strata, uniform throughout in the character of its often repeated alternations of similar bands of rock, and in its organic contents. Its prevailing character is that of a mechanical deposit, the crystalline limestone bearing an incalculably small ratio to the shales, sandstones, and impure earthy limestones. Yet is this entire series the representative of the great crystalline masses at the base of the coal formation in England and Ireland. The whole group seems to us to be in the place of the mountain limestone; but this rock nowhere exists as a base or geological horizon. This view was first, we believe, put forward at the Edinburgh meeting of the British Association in 1850, but met with considerable opposition, and has since been often canvassed. Mr. Miller remarks regarding it as follows:†—

* The marine limestones of the Lennoxtown valley, and white cyprida limestone (*f*), have been already noticed (Art. 16). Mr. John Young of Lennoxtown also finds a fresh-water limestone among the marine beds at Bishopbriggs; and very recently (March, 1857), Mr. John M'Diarmid of Glasgow has found within the city, south side of Parliamentary Road, opposite the Town's Hospital, beds of limestone and calcareous sandstone, with numerous marine fossils of the ordinary genera, and fossil plants, at the very top of the marine series, and closely adjoining the fresh-water series of our second division (Art. 17).

† “*The Fossiliferous Deposits of Scotland*,” being an address to the Royal Physical Society of Edinburgh, delivered November 22d, 1854. Pp. 16, 17.

“There are few finer sections of the coal deposits anywhere in Britain than those laid open along the shores of Granton, Musselburgh, and Prestonpans; and the section of the mountain limestone exposed in the ravine at Dryden, is, as far as I have yet seen, the most extensive in Scotland. By those who hold, as is done by some of the geologists of our Western capital, that this formation is wanting as a base to the Scottish coal field, a visit to this section might be found very instructive. It does not exhibit that great thickness of limestone for which the corresponding formation in England is so remarkable, but presents for several hundred feet together, in its encrinal bands, intercalated amid shales and sandstone, evidence of a marine origin; and its upper calcareous beds, laden with spirifers and producta, and of very considerable thickness, show that a tolerably profound sea must have covered the field shortly ere the formation of our older beds of workable coal.”

These remarks, however, hardly impugn the statements already put forward; this limestone is not at the base; its thickness is not great; and its encrinal bands are intercalated among shales and sandstones, which contain the same fossils. The sea was indeed deep; but it was not a sea of coral reefs, nor of pure chemical deposits; its waters, by means of frequent floods, were widely discoloured by vast irruptions of black mud, and red or white sand, with which calcareous matter was sparingly mixed; and thus the whole deposit is of one age, while the limestone is truly, from its fossils and mineral character, the same as the mountain limestone, though not *en masse* in the same position. *The shales and sandstones, with its separated portions intercalated among them, represent in all particulars the great English formation, underlying the coal.*—What a long series of changes and vast lapse of time are implied in the elaboration of these strata in the bosom of the primæval ocean! Its deep bed was often laid dry, and on the desiccated surface lakes were formed, which became the abode of cyprides and other fresh-water genera. These conditions so long prevailed, and the individuals continued to exist in such countless myriads, that thick and widely continuous beds of limestone were accumulated from their exuvæ. Again the area subsided to a small depth, the sea found an entrance, and a thick coal seam and shale beds with marine remains were deposited. A continued subsidence to an enormous amount succeeded, and a vast series of shales and sandstones, and a few seams of coal and beds of limestone, charged throughout with a prodigious variety of marine fossils, were slowly accumulated. Again, by some mighty internal convulsion, a new

aspect was given to the region, most probably that of a wide archipelago, in whose winding channels and on its little elevated lands, was formed a new series of alternating marine and fresh-water strata, almost a repetition of those far down in the series. To explain the origin of the upper portion of the marine series, the thick body of strata ranging north of Glasgow and across the higher portions of the city, we must again suppose the existence of a sea of considerable depth, receiving an abundant and very mixed sediment, and the waste of a prolific land vegetation of a tropical or sub-tropical character. The close of this period was marked by the elevation of large tracts along the margins of the area, and the formation of a lake or estuary filling the central and depressed portion, now occupied by the upper or fresh-water coal series already described in Art. 17. The climate remained unchanged, and the vegetation then attained its maximum of development, resembling more that of a tropical jungle or river-delta, than anything now seen in our latitudes. Then began that remarkable series of changes in repeated depressions and elevations of the bottom and margins of this lake or estuary, which geologists have often attempted to chronicle, in describing the physical geography of the coal period. These are much the same in Clydesdale as in other coal tracts, and we need not here attempt the description. We may observe, however, that the underclay, or floor of the coal, *generally* exists in our fields, roots being often seen passing down through it; and that ranges of upright trees have been met with at several levels amid our coal measures. These underclays and seats of the trees point out the successive surfaces on which the vegetation flourished, and which, though perhaps slightly depressed, cannot have been far below water; the coal seams are a sort of rude chronometer indicating the time occupied in the deposit, while the interposed sandstones and shales show the amount of depression which took place before the surface was again fitted for the growth of plants. This series of changes was continued through vast periods of time, till at length the rich storehouse was furnished with those materials which were destined, in the providence of the Creator's goodness, to contribute to the wants and happiness of Man, when he should be called into being upon that theatre, already the scene of the creation and extinction of many races which had served their purpose and disappeared.—But the series of revolutions was not yet completed. The entire area, with portions of its borders, was again submerged to a depth probably exceeding 300 fathoms; the strata were fractured and dislocated in all directions, and successive

streams of volcanic matter were poured out from the heated interior. These spread out among the beds in sheets, pierced them through in dikes, and were accumulated over them in great mountain masses. The succeeding revolutions by which the existing aspects were given to the surface have been briefly sketched in the preceding part of these notices.

26. With regard to the distribution of these igneous products it is remarkable that they have been chiefly erupted along the boundary of the Devonian and carboniferous rocks, from Ardrossan to the mouth of the Eden, in the Coast Range, the Lennox, Ochill, and Sidlaw hills, so nearly continuous with one another, as to be separated only by the channels of the Clyde, Forth, and Tay. This line is parallel to the principal axis of the Grampians, which were elevated at an earlier period; and is also in the direction followed by the many earthquake movements recently experienced in Scotland. There is also evidence of elevatory movements in connection with another band of these rocks near the border of the primary Highland tracts.* On the south border of the coal districts there is also an extensive development of these rocks; and they constitute several considerable ranges within the area, as the Fereneze and Cathkin hills separating the Ayrshire fields from those of Lanark and Renfrew, the Bathgate hills, and other lesser ridges. The huge trappean mass of Tinto, and the varied igneous products of the Pentlands seem to belong to an older era. That the trap ranges on the borders, and within the area, were erupted since the deposition of the coal strata is shown by many facts. Along the base of the Cathkin hills, in the glens near Barrhead and Neilston, and in natural sections among the Gleniffer hills, the coal strata may be seen gradually raised to a high dip, set on end, and finally reversed when in contact with the trap. The Coast Range of old red sandstone from Ardrossan to Port-Glasgow, through which the Clyde has forced a passage between Bishopton and Dumbuck is overlaid throughout by trap rocks. These cover also the eastern slopes, and come in contact with the coal strata, which are overtopped by and disappear beneath them. Similar phenomena have been already noticed in describing the Campsie district. The case figured in the cut of Art. 12 is very interesting. The great stream of basaltic matter intruded into the coal strata, encloses a shale bed, *c*, which has been altered through a considerable distance to the state of a coarse opal. The sandstone also in the river bed adjoining contains crystals of galena in close proximity to the trap. The changes

* *Journal Geolog. Soc.*, 1852.

generally throughout the district are similar to those often described in connection with the contact of the trap rocks and the sedimentary strata. Some very peculiar effects will be described farther on.

V.—THE OLD RED SANDSTONE AND ITS LIMESTONES.

27. In addition to what has been already said regarding this rock as a base to the carboniferous formations, we have now only to notice those portions of it which appear upon the shores of the frith. Those on the north are prolongations of the Kilpatrick hills, which, subsiding at the valley of the Leven, rise again to much lower altitudes in a ridge bounding the Clyde on the north as far as the shores of Gareloch. Thence the old red sandstone passes into the peninsula of Roseneath, in which its junction with the underlying old slates is strikingly marked on the features of the landscape.* It crosses nearly through the middle of the remarkable and very picturesque dell, which intersects the peninsula from Campsail Bay to Kilreggan in a direction nearly north-east and south-west. Thus, in external aspect, and in the nature of its rocks, this southern portion is isolated from the rest; it consists of a single hill of a depressed conical form, having a smooth outline, and extending in gentle and fertile slopes to the water's edge on three sides. Here, as in other places, the soil formed by the decomposition of the sandstone contrasts most favourably with that which rests upon the cold retentive clays of the coal formation on the one side, and the old slate rocks on the other. The series exhibits but its lowest members—conglomerates, coarse sandstone—and finely laminated red sand, irregularly disposed. The base of the conglomerate is coarse red sand; and the imbedded fragments are granite, porphyry quartz, and various kinds of slate; the three former are very much rounded, the latter have lost their angularity, and present elliptic forms. The origin of these is to be looked for in some near district of the Grampians, where such varieties exist, and which we know were elevated and exposed to the action of mechanical forces prior to the epoch of the old red sandstone; the quartz and slate pebbles are from the adjoining strata.

The contact of the sandstone and slate is nowhere seen. In the western part of the cliffs at Portkill Bay, the two rocks approach

* "Roseneath" is said by some to mean in the Gaelic language, "the little dell, or dingle;" and that the name was given to the whole from this peculiar feature. See *New Statistical Account* under "Roseneath Parish, Dumbartonshire."

very close, the sandstone dipping at a small angle towards the nearly vertical slate; and in Campsail Bay a considerable space of flat beach intervenes, concealing the contact. The line of junction passes near the Saw-mill, and across the upper part of the fields sloping down from the northern edge of the plantation which crowns the heights on the south side of the great hollow or dingle.

On the southern coast of Portkill the sandstone dips for a short distance toward the south; the dip then changes, and continues in other parts to be between west and south-west, at an angle of about 15° to 20° . About Inellan, and thence to Toward Point, the old red with subordinate beds of limestone occupies the coast, occurring in small patches over the slate, extending, however, no farther inland than the well marked terrace which exists here, whose front shows the slate rock from base to summit. But neither in the sandstone nor limestone have fossils yet been found. Similar limestone bands occur in the old red on the opposite coast at Innerkip; and at the south base of Benlomond they descend to the very bottom beds of the old red, not far from the mica slate. In none of these localities have we ever found any fossils save a few crushed bivalves. The English cornstones (Monmouth and Pembroke) have yielded some ichthyolites (*cephalaspis*). The most considerable body of cornstone in the West of Scotland is at Kilchattan, in Bute, to which reference will again be made.

28. The coast section of Renfrewshire presents only old red sandstone and trap with occasional beds of limestone. The sandstone rises seaward, dipping east and south-east, at a small angle, and everywhere occupies the coast except at Kempoch Point and Cloch Point, where the overlying trap reaches the coast line, and is seen between high and low water, resting upon and altering the sandstone. The great overlying mass of trap sends out innumerable dikes intersecting the sandstone of the coast, and running in very various directions, but with a general tendency to the west and north-west. Into a minute description of these, and the changes produced by them upon the rocks which they intersect, we cannot enter in this place. One instance only will be given, as bearing upon the changes induced on limestone. This rock appears in two places near Innerkip; one bed extends from the bridge on the Greenock road, at the north end of the village, up into the hill on the south-east of the village, rising with the slope of the sandstone beds, and preserving a thickness throughout, of about twelve feet; it has been extensively quarried behind the village, but is now little worked. As it is extremely hard, and contains much chert dis-

seminated in veins and bands, the rock is capable of taking a fine polish, and of being applied to ornamental purposes;—the colour is dark gray. Between the limestone and the sandstone above it, there is interposed a bed of loose materials, consisting of red sand, marked with round gray spots, and enclosing pieces of limestone and sandstone. Hence the bed of lime must have been exposed to considerable decomposition before the sandstone was deposited over it. A lengthened and careful search was not rewarded by the discovery of any fossils. It is, however, obviously in the position of the cornstones of England.

Several beds separated by strata of sandstone occur on the shore at the mouth of the river. The whole series is here traversed by dikes of greenstone, the largest of which is about sixty feet wide, and ranges about N.N.W.; the others are so numerous, and so ramified, as almost to defy description. They pierce through the limestone in every direction, thin veins branching from the greater, and often again uniting, while small portions of the limestone and sandstone are entangled in the trap, and traverse it in disconnected veins. The changes produced upon the limestone are of the most interesting kind; we know of no locality in the West of Scotland where the posterior origin and intrusive character of the trap rocks are so clearly manifested, and would strongly recommend it as a point to be visited by the student of geology. The changes which the limestone has undergone run through every variety of external aspect, from the impure, dark coloured, perfectly opaque state, to that of a pure white marble, translucent on the edges, homogeneous throughout, and devoid of stratification, or visible lines of cleavage. Intermediate between these extremes there are an indurated semi-crystalline limestone, a granular saccharine marble crumbling into fine powder under slight pressure, and phosphorescing when thrown upon a heated surface; a very hard white or blue crystalline marble, having the crystals in distinct plates; the degree of alteration depending on the distance from the sides of the dike. The entangled portions are among those which exhibit the greatest amount of change. The most altered parts of the sandstone resemble quartz rock.

In order to determine whether any and what chemical changes had been induced simultaneously with these alterations of mineral character, and to afford terms of comparison with metamorphic action upon other limestones, Dr. Robert Dundas Thomson most kindly furnished us with analyses of several specimens, made under his own care. These are as follows:—

Specimen No. 1. is the unaltered limestone, as pure a specimen to the eye as could be selected.

No. 2. is a saccharine marble, crumbling readily into powder.

No. 3. is the most altered specimen in this locality, described above as "a pure white marble, translucent on the edges," &c., and which turns out to be table spar.

No. 4. is a carefully picked specimen of the same, free from carbonate of lime.

No. 5. is a calcareous sandstone, altered by contact, scarcely distinguishable from No. 2.

No. 1.

Carbonic acid,.....	42.40
Lime,.....	54.58
Silica,.....	0.70
Magnesia,.....	0.40
Water and loss,.....	1.92
	<hr/>
	100.00

No. 2.

Carbonic acid,.....	42.52
Lime,.....	54.68
Insoluble siliceous matter,.....	1.14
Magnesia,.....	<i>a trace.</i>
	<hr/>
	98.34

No. 3.—Spec. Grav. 2.88

Silica,.....	47.50.....	48.00.....	46.64.....	49.38
Lime,.....	44.90.....	45.40.....	46.27.....	44.59
Protox. of iron } and alumina, }	5.40.....	1.61.....	1.44.....	1.49
		2.01.....		
Water,.....	0.80.....	0.80.....	0.80.....	1.60
Magnesia,.....	0.70.....	0.83.....		1.05
Soda,.....		0.92.....		.94
Carbonic acid and } loss,..... }			4.85.....	.95
	<hr/>	<hr/>	<hr/>	<hr/>
	99.30.....	99.57.....	100.00.....	100.

No. 4.

Silica,.....	49.380	In atoms this is	
Lime,.....	44.596	Silica,.....	24.89..... 1.93
Alumina and protox. of } iron,..... }	1.490	Lime,.....	12.74..... 1
Soda,.....	.936	And the formula is, omitting	
Magnesia,.....	1.050	the impurities—	
Water,.....	1.600	CaO, 2SiO,	
		or Bisilicate of lime.	
	<hr/>		
	99.052		

No. 5.

Carbonate of lime,.....	31.94
Insoluble siliceous matter,.....	68.06
	<hr/>
	100.00

It appears from these analyses, 1. That the cornstones of Innerkip are carbonates of lime and not dolomites.

2. That in this locality igneous action has converted a carbonate of lime into a bisilicate. Now, as it appears from analyses 1 and 2 that there is but a trace of siliceous matter in the limestone, the origin of the silica must be sought in the igneous rock; in fact, a transference of a portion of its silica must have taken place when the basalt was in a state of fusion. Such transfer, indeed, could readily take place under the influence of chemical attractions, when the rocks were in a state of even imperfect fusion. On No. 4, or the table spar, Dr. R. D. Thomson remarks:—

“It is an interesting fact in connection with this mineral, that it gives a yellow colour before the blowpipe when moistened with muriatic acid; and yields crystals of common salt when treated with the same acid. It is thus associated with Wollastonite, or soda table spar, a mineral occurring in the Bishopton tunnel, and in the Kilpatrick Hills.” There is, however, this difference between the two cases, that in the localities last mentioned the mineral has no direct connection with limestone, although calcareous spar occurs abundantly; whereas at Innerkip, it has obviously originated in a change induced upon common limestone.

VI.—THE OLD SLATES.

29. These rocks are portions of the great bands of sedimentary strata which traverse Scotland from sea to sea, in a direction parallel to the principal axis of the Grampians, and to the great Caledonian valley. They first strike the shores of the Clyde a little to the east of Kilcreggan pier in Porthill Bay, where the junction with the old red sandstone is concealed as already mentioned. They deviate very little from their ordinary type, and it is therefore unnecessary to enter into any lengthened descriptions. The usual varieties, depending upon the varying proportions of the constituent minerals, occur abundantly, but in no definite order, and without much continuity. Thus the clay slate series exhibits beds of flinty slate often approaching to quartz rock, of highly bituminous slate, and of coarse grained compact thick bedded slate, mixed up irregularly with the commoner kinds, such as coarse and fine roofing slates, and a semi-crystalline

silky slate, passing into chlorite or talcose schist. All these varieties are well seen on the road-side between Roseneath and Kilcreggan, and on the shore between the latter place and North Ailey. On the same coast thick cotemporaneous beds and also veins of quartz occur, in the cavities of which rock-crystal is often met with. Roofing slate of good quality is obtained from several quarries; but neither in this rock nor in the mica slate which underlies it, have any indications of metallic ores been noticed. Iron pyrites occurs in the slate rocks in many places. Beds of quartz containing rock-crystal occur frequently in the mica slate, and are well seen on the road-side to the west of the village of Gareloch-head. To the east of Tom-na-hary hill crystals of schorl are found in a variety of mica slate, containing very little quartz.

30. On a geological map these two slate rocks would be marked as separated by a definite boundary; but in nature no such distinction exists; the transition is in fact so gradual, that it is impossible to say where the micaceous series terminates, and the argillaceous commences. Towards its outer boundary the mica slate begins to assume the character of chlorite schist, and to contain occasional beds of fine roofing slate, the true mica slate still constituting the greater part of the mass. Farther out, the argillaceous and chlorite slates begin to prevail, so that the micaceous beds may be said to be subordinate to them; and thus through oft repeated alternations, we at last reach the true clay slate series. We can conceive, therefore, of a certain middle line, along which the strata partake equally of both characters; it is this imaginary line which in such a case may fairly represent the boundary. These remarks are equally applicable to the other slate rocks of the district, and indeed to all the rocks of this class in the West of Scotland. In order to explain the mode in which this gradual loss of a marked character, and assumption of one considerably different was brought about, it is necessary to remember that the slate beds were originally deposited from the sea, layer over layer, in a state of silt or fine mud, and afterwards exposed to great heat, combined with pressure. A slight change in the nature of the sediment, or in the amount of heat or pressure, would be sufficient to produce the want of uniformity, and the variations from a definite type, which we now observe. The arrangement usually is, upper green or chlorite slate, middle dark coloured clay slate, and inferior mica slate, in some tracts passing into gneiss, and extending inward to the Grampian granite. The mica slate has a remarkable structural arrangement which distinguishes it from the two others; its crystalline laminæ are simple foliations, and form only one set of divisional

planes; whereas in the other slates the bedding is traversed by a second set of planes, those of slaty cleavage, perpendicular to the bedding or stratification. The general direction of the beds is about north-east and south-west, the dip being to the south-east, at angles varying from 40° to 70° ;—but there are many local exceptions.

The great upward movement attendant on the elevation of the mica slate mass of Benlomond, has thrown the two other slates several miles southward of the line of bearing which they observe to the eastward of the mountain; and in like manner in other tracts along the Highland frontier, horizontal displacements on a great scale appear to have affected the two upper slate bands, so that the middle or dark slate is often seen in direct continuation of the upper chloritic band, or *vice versa*. And thus the appearance of frequent alternation is produced when these bands are traced from point to point on the line of bearing.

Plutonic and Metamorphic Rocks.

31. The slates above described contain subordinate beds and veins, which possess considerable interest.

To the right of the summit level of the road between Gareloch-head and Portincaple Ferry, a remarkable ridge projects from the smooth outline of the hill side, and trends in a straight line towards the base of the mountains. It consists of a highly felspathic rock erupted through the slate. The base is a very compact mixture of quartz and felspar, in which crystals of felspar and mica are imbedded, the latter ingredient being constantly present, the former often wanting. The prevailing colour is yellowish-red, given by the felspar in the base. From the prevalence of felspar, and the mode in which the crystals are disseminated, the rock must be called, according to the present views, a felspar porphyry; though the constant presence of mica as a constituent, and the compound character of the base, seem rather to require that it should be considered a granite.

At the sides of the vein next the slate, the rock is of a more homogeneous character, resembling a compact claystone or flinty slate, but still enclosing crystals of mica. The laminæ of the slate in contact with the sides of the vein have a very close resemblance to this variety: being, in fact, a yellowish-gray fine grained flinty slate, with occasional spangles of mica. It is thus difficult to determine the exact boundary line between the slate and the vein. This assimilation of mineral character has obviously been induced by the cooling of the masses from a state of fusion, at nearly the same rate, but more rapidly than the inner portions of the vein. The

breadth of the vein is various; in some places no more than twelve or fifteen yards, in others as much as twenty-five, and even thirty, and perhaps considerably more, as it cannot in many places be exactly measured. It rises above the surface of the hill side from fifteen to forty feet, and with several undulations runs in a general N.N.E. and S.S.W. direction.

In the northern part of its course it is interposed as a bed between the strata of slate. To the south of the high road, on the side of a little stream, it is seen intersecting the beds at a small angle. A little farther south the ground rises, and the vein does not appear upon the surface; but on the lowering of the ground still farther south, it again emerges from beneath the slate and occupies the surface for some distance. A similar overlapping occurs farther north, near the high road.

The appearance of this plutonic rock, now as a bed interposed among the strata, and again as a vein intersecting them, and the undulating course which it pursues, point out its posterior origin and the nature of the resisting force. This is plainly to be found in the peculiar undulations and twisted forms which everywhere characterize the mica slate, indicating the powerful compressing forces which acted upon it while yet plastic under the influence of heat.

Near the summit of the ridge, and at a curvature in the vein, the outer or salient angle is intersected by a dike of greenstone and basalt, in such a manner that a portion of the felspathic rock is isolated between the whin dike and the mica slate on the west side, and the continuation of the vein lies on the same side of the dike as before the intersection. The annexed sketch, which is a *ground plan*, shows the mode of this intersection, one of the most singular we have ever met with.

The dike is very distinctly traceable for several hundred yards towards the north-east, the surface occupied by it rising into conical hummocks. It is then

- (a a) Vein of felspathic rock.
- (b b) Altered schist.
- (c c) Dike of greenstone and basalt.
- (d d) Mica slate.

lost in marshy ground for a short distance, but is again continued towards the mountains. In the other direction, its course was satisfactorily made out as far as Portincaple Ferry, where it is well seen; and a dike of the same width and bearing, which seems to be a prolongation of this dike, was met with near the top of the mountain on the east side of Loch Eck, traversing mica slate and altering it considerably. The width is about twenty-five yards, and it bears a point S. of W. It is in many places inclined at the same angle as the slate, among the beds of which it seems to have insinuated itself in a serpentine course. The mica slate in some places is slightly changed by the contact, being rendered harder and more massive: the lamination is partially destroyed, and the rock is banded, parallel to the sides of the dike. In one place pieces of the slate are seen enclosed in the dike, and slightly altered. Portions of the wedge-shaped mass of slate (*d*), between the two veins, are entangled in the basaltic dike, and altered in the same manner. The circumstances of this case clearly show the posterior origin of the basalt.

At the edges the dike consists of blue slaty basalt, but the greater part of the mass is a coarse grained greenstone, which at several points exhibits in great perfection that peculiar structural arrangement in concretionary spheroids, which is the most frequent and characteristic form assumed by the trap rocks, and of which the columnar is but the result, when under favourable conditions, they parted more slowly with their heat of fluidity. The best marked of these is in a cliff about sixty feet high, overhanging the marshy ground above mentioned, where the dike has a considerable underlie, the slate being in contact on both sides. It is here divided into *columns of spheroids* perpendicular to the sides of the dike, and separated from one another by imperfect joints. Sometimes each joint is composed of a single spheroid; one was noticed measuring fifteen inches by ten; in other cases numerous small closely packed spheroids make up a joint. Instead of a distinct separation as in basaltic pillars, the columns are connected by narrow seams of decomposed greenstone. The columnar structure is here seen in the act of development. If the heat had parted more gradually, a façade of pillars would have been the result. This spot affords an excellent illustration of the remarkable experiments of Mr. Gregory Watt on fused basalt (*Phil. Trans.*, 1804).

It will appear from the foregoing statements, that the small area we have been describing, is one of considerable interest, exhibiting, as it does, the rare association of many species of erupted rocks in

connection with the primary strata; and affording illustration of some curious questions in theoretical geology.

Limestone.

32. On the shore of Loch Long, north of Kilcreggan, and about 250 yards south of the landing pier at Cove, a bed of limestone is interstratified with the clay slate. It has been originally six or seven yards wide, and has extended eastwards across the low ground between the shore and the cliff, into the cliff itself, and probably much farther inland; but it cannot be satisfactorily traced. The part next the shore has been almost entirely removed by quarrying; but from portions which are found among the slate—as shown in the annexed sketch, which is a *vertical section*—there can be no doubt of the true position of the bed.

(a a) *Inclined strata of clay slate; (b) Bed of limestone; (c) Bay with accumulations of shingle.*

The limestone is impure, from intermixture with slaty laminæ; the prevailing colour is bluish-gray; it contains much calcareous spar; and, like the slate, is destitute of fossils.

In the new statistical account of the parish of Row adjoining, beds of limestone are stated to occur in the slate rocks of Glenfruin; these are most probably similar to the bed now mentioned.

In a paper by Mr. Daniel Sharpe, F.G.S.,* many limestone beds in various tracts which Dr. MacCulloch and other observers have described as belonging to the primary strata are referred to the old red system; and he expresses a decided opinion with regard to all of them, denying the occurrence of such beds in association with at least the clay slate system. The cases here given clearly disprove this view.

Slates of the Cowal Coast.

33. This coast consists of slates of the chloritic and agrillaceous series, passing westwards into mica slate. The slates near Dunoon are associated with rocks of igneous origin, to whose effect upon the

* *Jour. of Geol. Soc.*, 1852.

slates, and their own peculiar forms, much of the picturesque beauty of this favourite watering-place is due. Thus the ridge lying between the coast and the valley of Hafton lake, owes its elevation and bold outline to an outburst of igneous rocks, which have induced a very decided change upon the slate along the planes of contact. It consists of crystalline greenstone, of a different type from that of the dikes common on the coast, the structure being slaty and the hornblende in excess. It is from 60 to 100 yards wide, and ranges from near Hunter's Quay, across the highest part of the ridge, transversely to its length, appearing along the summit in a series of conical hummocks, with deep hollows between; and thus presenting a bold picturesque outline when viewed from the low grounds in the neighbourhood. It is interrupted by the Hafton valley, but is resumed on its western side, and attains its greatest altitude in Dunloskin hill, which rises prominently above the surrounding slopes, strikingly relieving their monotonous outline. Westwards, for about half a mile, it is seen in other rocky eminences, but its farther extension in this direction was not traced. The ridge is not seen intersecting the coast, which is everywhere occupied by the slate rocks; so that it seems to terminate before reaching the shore. Owing to the metamorphic character which has been impressed upon the adjoining slaty beds, it is difficult to determine the precise limits of the plutonic rock; near the contact the slate breaks under the hammer into very compact four-sided prisms.

In a similar manner, the high ground dividing the East and West Bays, and projecting beyond the general line of coast, has acquired its strikingly picturesque aspect from a great dike of basalt which traverses it. The castle hill consists of this dike, and of slate borne up with it, and adhering to it. By contact with the dike, the slaty structure is effaced; the rock has been fused and reconsolidated into a compact flinty slate, closely resembling basalt; crystals are developed along the boundary, and bands of different colours are disposed parallel to the sides of the dike. The width is about 100 feet, and the bearing W.N.W. The Gantock rocks are exactly in the line of bearing, but were found to consist of very hard slate. On the opposite coast, however, near Ardgowan, a dike of the same width and direction occurs, which may be the continuation.

Near Inellan the slates are covered by patches of old red sandstone and its associated cornstone, as already mentioned.

VII.—THE CLYDE ISLANDS.

BUTE.

34. A pretty full and generally accurate account of the geology of Bute has been given by Dr. MacCulloch in his work on the Western Isles, published in 1819. For thirty years after, no observations, so far as we can learn, were put on record respecting it, except some notices of its remarkable coast terrace and raised shelly deposits by Mr. Smith of Jordanhill. The greater variety of the strata in Arran, and the bearing of the phenomena there exhibited upon questions in theoretical geology actively discussed at the time, drew attention entirely to that island, and Bute, in common with other parts of the West of Scotland, was overlooked. Yet it has many points of great interest; strata occur here to be met with nowhere else in Scotland; and the effects of its trap dikes upon the adjoining strata, are without parallel in the history of theoretical geology. The phenomena to which we allude were not observed by Dr. MacCulloch; and were first made known to geologists in two papers, published in *The Transactions of the Glasgow Philosophical Society* for 1848, and *The London Philosophical Magazine* for August, 1849. We shall first briefly notice the general structure of the island; and then describe at greater length the remarkable changes referred to, and those strata to be seen nowhere else, and therefore more worthy of the student's attention.

35. Three deep depressions or valleys traverse Bute perpendicularly to its longer axis, dividing the island into four portions, and marking the boundaries of as many distinct geological formations. They terminate on either side in bays or indentations of the land, formed here as in most other cases at the points of least resistance, the junctions, namely, of dissimilar strata. Those on the east side are the well known sheltered bays of Kames, Rothesay, and Kilchattan. The low tracts in question show no rock *in situ*, but are filled with shingle and alluvial deposits concealing the junctions, strata of peat, and occasional shell beds. The deposit already referred to (Art. 5), as described by Mr. Miller in *The Witness* of July, 1855, lay in the Rothesay valley; and a similar one with numerous shells has since been found in the valley at Kames bay. These have not yielded any additional species to those found by Mr. Smith, and already given in our list. The elevation above the sea level has been shown by Mr. Robert Chambers in his interesting and beautifully illustrated work on ancient sea margins, nowhere to exceed thirty feet; and as this is also very nearly the height of the terrace already

referred to as encircling the island, it appears that when the sea stood at that ancient level, Bute consisted of four islands separated by narrow channels.

The various strata exhibited in Bute, are the terminal portions of those great bands of rock, sedimentary and igneous, which extend across the country from sea to sea, as already noticed. Mica slate occupies the northern portion between the Kyles on the north, and Kames and Ettrick bays on the south. The rock has its usual character and aspect; and rises into hills of nearly 1,000 feet elevation. The district south of this, bounded by the Rothesay valley, consists of the two upper slates, the common clay and chloritic. Subordinate to these are great beds of quartz rock, the most considerable of which forms the high ridge called Barone hill, with a picturesque old ruin overlooking Rothesay on the west; and also in the vicinity of Kames bay, copper veins very recently discovered and of considerable promise, arrangements for working which are now in progress. The portion extending from Rothesay valley to Kilchattan is occupied by red sandstone; and finally the southern portion with a sub-stratum of red sandstone, consists mainly of various rocks of the trap family, erupted through and overlying the sandstone. The accompanying outline of the island shows the relation of these strata to the valleys or depressions, which are obviously a part of that system of parallel fractures ranging N.E. and S.W. on both sides of the Grampians, and probably due to the upheaval of this chain, and the later igneous eruptions already noted.

(a) Kames bay; (b) Rothesay; (c) Kilchattan; (m) mica slate; (n) clay and chlorite slates; (s) red sandstone; (t) trap; (r) the terrace.

A description of these rocks would be useless, as it would merely be a repetition of facts contained in all elementary works. The great body of sandstone obviously belongs to the old red system; and as well from its position in immediate sequence to the old strata, as from its general mineral character seems to form the lower portion of that system; but hitherto no fossils have been detected in it. Like the corresponding strata on the mainland, at the base of Benlomond, Innerkip and Inellan, it contains subordinate beds of cornstone. These are seen in several places along the shore south of Bogany point; but the beds are thin, and generally contain much siliceous matter, so that the limestone is of

no economical value. The Kilchattan beds are of the same age; they are subordinate to sandstone and without fossils, but being of considerable thickness, they have been extensively quarried.

36. But there are in Bute sandstones and limestones newer than these, which have been till very recently quite overlooked by geologists. There occurs, in fact, hanging on to the flanks of the old red sandstone at Ascog, a small coal formation, a portion of the lower marine series. This was lately discovered and identified by means of its fossils, about the same time, and independently of one another, by Mr. James Frazer of Glasgow and the writer of these notices, and may yet turn out to be of economic value. It is connected with an isolated overlying mass of trap appearing on the shore, and occupying the cliffs near Ascog mill. On the north side of the promontory, south of the mill, several thin courses of nodular limestone traverse beds of brown coloured crumbling shale subordinate to sandstone. The shale is of considerable thickness and rises into banks above the road. The south side of the promontory presents the following section:—

(a) Limestone; (b) shale with thin coal seams; (c) limestone breccia; (d) trap.

The lowest bed (a) is a fine grained, bluish-gray, nodular limestone. Over it is a bed of black bituminous shale (b), containing veins of coal about a quarter of an inch thick; and upon these rests a bed of concretionary limestone (c), the base or paste being a dark coloured limestone, and the concretions rounded lumps of the same rock, often of considerable size. The upper part of the cliff is occupied by trap in various prismatic forms. The base of the concretionary limestone is so much altered by the contact of the trap, that the two rocks can only be distinguished by the action of a strong acid. A like change is produced upon the imbedded lumps

in the upper part of the bed. The limestone, shale, and coal seams extend under high-water mark, and when the tide is very low considerable pieces of coal are often dug out from beneath the sand and mud covering the tide-way. Several sinkings have been made here for the purpose of discovering workable coal seams, but without success. The fossils by which the strata were identified as belonging to the carboniferous system are given in the following list. The species have been determined by Mr. Frazer, from specimens in his collection and our own:—

Plantae.

Sphenopteris bifida, not uncommon in the shales.

———— *affinis*, ditto.

———— *furcata*, ditto.

———— *dilatata* (rare).

Pecopteris nervosa (rare).

Calamites nodosus, abundant in the sandstone and shale.

———— *undulatus*. ditto.

Trigonocarpum olivaeforme (rare).

Brachiopoda.

Producta punctata, not abundant.

———— *sulcata*, ditto.

Spirifer semicircularis, somewhat common.

———— *trigonalis* (rare).

Spirifer duplicostata (rare).

Lingula squamiformis, abundant in the shales.

Orthis radialis (rare).

37. The trap above referred to as overlying these strata is a projection or tongue, running down to the shore from the principal mass above, which occupies a considerable area inland towards Ascog lake, and is upwards of 100 feet thick. It is seen in the summit of the cliffs on either side, the line of junction ascending rapidly as it retires from the shore. These trap rocks at Ascog derive their chief interest from being the repository of beds of lignite; a substance so rare in Scotland, that no well-marked beds occur on the mainland, and but few in the other islands; and these in situations very difficult of access. A careful examination of this carbonaceous deposit was suggested by the statement of Dr. MacCulloch, that some of the beds occurring here were unlike any he had seen in his survey of the Western Islands.

The principal bed is situated in the face of the cliffs above the road,

a little to the south of Ascog mill, as shown in the annexed section giving the various beds:—

(s) Sandstone; (r) terrace and road; (ff) greenstone; (a) trap-tuff; (b) red ochre; (c) lignite bed; (d) pisolitic ochre; (e) porphyritic amygdaloid, the upper portion much altered.

The lowest bed resting on the sandstone is a small-grained rudely columnar greenstone; the junction is, however, concealed. Over this is a trap-tuff with a base of greenstone, and imbedded spherical lumps of the same substance. This is followed by a bed of red ochre of coarse texture, traversed by numerous black iron-seams, which have doubtless been produced from a change in the oxidation of the component iron. Over this is the lignite bed: it is three feet thick, and consists of hard stony coal, interstratified with a yellowish-white shale, both being much intermixed with pyrites. The coal has been so much altered throughout its whole thickness by the contact of the trap rock, that Mr. Rose of Edinburgh, to whose examination the best specimens that could be selected were submitted, in order that he might determine the species of wood, but without any note of the geological situation of the coal, was "unable to obtain a slice in consequence of the structure being altered by the contact of a whin dike." The coal has been worked to some extent by driving an adit inwards on the line of the dip, which is about 20° to the westward; but the workings have been for some time abandoned, and the inner and lower portions are now full of water.

The floor of the coal has been already described. The roof is a peculiar rock. It consists of a base or paste of an ochreous steatite, with imbedded round pieces of the same substance, and may hence be called a pisolitic ochre; it is three and a-half yards thick. The bed above this is of the same character; but the base feels less unctuous, and with the imbedded steatite it contains also imbedded calcareous spar. The base effervesces briskly with an acid; and

hence we may call the rock a calcareous amygdaloid. The upper portion of this bed, to the thickness of a few inches only, is very hard, and has a semivitreous appearance, and thus closely resembles a porphyry. In common with the trap above, and, indeed, all the beds in this locality, it contains much disseminated iron. The rest of the cliff is occupied by greenstone, similar to the lower bed in contact with the sandstone.

Another bed of lignite occurs on the opposite, or north-west side of the trap district, overlooking Ascog lake. The coal dips to the interior of the area, that is, nearly south. It is of about the same thickness, and is accompanied by beds of steatite and red ochre, very similar to those above described; but the nature of the ground is such that a complete section cannot be had, and the precise number, therefore, and order of the beds cannot be exactly stated. The association, however of the lignite with ochres and steatites here also is sufficiently distinct, and it is even probable that these beds are persistent throughout the whole of this district. It is to these ochreous and steatitic beds that Dr. MacCulloch refers when he says that he "has met with no similar substance among the numerous trap rocks examined in the course of the survey of the Western Islands." He has not indeed described any such strata; yet casual mention is made (vol. i., p. 376) of an iron clay and jaspery substance, forming extensive beds in the trap of the cliffs of Talisker in Skye—the same in which the lignite also occurs—and that these are often variegated with red, gray, and purple colours. No further description is given, nor is the precise position of the lignite mentioned, the cliffs being of very difficult access.

But even by such a brief notice the steatitic beds and variegated ochres are easily recognized; and though these characters are not very distinctly marked in the beds we have been describing in Bute, yet they apply exactly to the red and variegated ochres, which occur as members of the trap series of the north-east of Ireland. The trap rocks there cover an area of upwards of 1,000 square miles, and vary in thickness from 300 to 1,200 feet. They repose upon chalk, while the Scottish series rests on the old red sandstone and coal strata. In the Irish series the lignites occur in the middle and upper parts, associated with variegated ochre and basalt. There is, as we have seen, a like association in Bute. The interesting leaf-beds and associated lignites, overlaid by trap in Mull, discovered and described by the Duke of Argyle (*Jour. Geol. Soc.*, 1851), seem to be a deposit precisely analogous to the Antrim and Bute lignites; and from the casual observations of Dr. MacCulloch it

would appear that such beds occur also in Skye and others of the Western Isles. Similar conditions thus appear to have prevailed over a very wide area, the successive eruptions of igneous matter over the sea bottom were very similar, and there were like periods of repose, during which the productions of the adjoining land were swept down to be buried under the next flow of submarine lava.

The wood which has supplied the Antrim and Mull lignites, has been ascertained to be coniferous; but the species have not been determined. Mr. Robert Brown and Professor Lindley referred the former with some hesitation to one of two species—the common fir (*Pinus Abies*) or the Weymouth pine (*P. Strobus*); and Professor Edward Forbes, who reported upon the Mull leaves, at the request of the Duke of Argyle, found that they belonged to a *taxus*, a *platanus*, and several species of *rhamnites*, upon which he did not venture to pronounce positively (*Jour. Geol. Soc.*, vol. vii., p. 103, 1851). The lignites which occur in Mull in a bed under basalt, apparently in direct continuation of the leaf-beds, have been recently submitted by Professors Harkness and Blyth to a microscopical and chemical examination, and their structure compared with that of the Causeway lignites (*Ed. Phil. Jour.*, New Ser., iv., p. 304, 1856). The results show that the variations from the ordinary coniferous structure are the effects of the great pressure to which they were subjected by the accumulation over them of thick beds of igneous matter. We have failed, as already remarked, in determining the nature of the Bute lignite; but it has quite the appearance of being coniferous; and the beds associated with it being exactly the same as accompany the Antrim lignites, there is every probability that both are of the same age. Now, the basaltic series of the north-east of Ireland, as it overlies the chalk formation, clearly belongs to the tertiary era, and was long ago recognized as of this age. But many cases occur in which the same basaltic flow, which alters the chalk to the state of a saccharine marble, spreads out beyond the limits of the chalk, and overlies and alters the new red sandstone and coal measures. Such overlying masses must also belong to the tertiary period. It is therefore not improbable that the basalts forming the lofty cliffs on the west coast of Mull, superimposed upon the lias and oolites, may also be tertiary. The Duke of Argyle is inclined to refer these to an older date; while his Grace, in the able and interesting paper above mentioned, clearly shows that the Ardtun leaf-beds and lignites are of tertiary age. It seems to us, however, to be premature to place these and the Antrim lignites in the miocene group, as his Grace and Sir Charles Lyell

have done, until greater certainty is attained with regard to the species to which the leaves and lignites are to be referred.—It is not then improbable, that our Bute trap formation, with its ochres and lignites, may also be of tertiary age, though overlying the older secondary strata.

The chemical composition of ochre is almost exactly the same as that of basalt; 100 parts consist of—silex 56·40, alumina 3·46, per-ox. iron 24·14, carb. lime 0·90, water 15·10. It is in fact a decomposed basalt, partially refused and reconsolidated by the succeeding flow of igneous matter.

38. The Kilchattan limestone already referred to is the most considerable mass on the island. It is a cornstone subordinate to the old red sandstone; the strata of the two rocks are conformable, and the dip nearly south at a moderate angle. At the summit of the ridge near the picturesque ruins of the ancient castle of Kelspoke the sandstone over the limestone is seen dipping under the trap which bounds the rugged terraced ridges descending towards Garroch-head on the south coast. These ridges have the same inclination southwards as the underlying sandstone strata, and present a succession of bold fronts towards the north. The sandstone appears to have had its present inclination when the submarine lava streams, of which these ridges consist, were poured out over it; the scarped fronts were no doubt formed by the action of currents when the land was rising. The arrangement of the strata at Kilchattan is shown in the annexed cut.* No fossils were found in the limestone.

(a, b) Sandstone; (c) limestone; (d) trap.

39. The dikes of Bute are composed of greenstone, or basalt, and are very numerous, especially on the east coast. They traverse the strata in various directions, and in some cases can be traced for several miles continuously, preserving nearly the same width and direction throughout.† Two or more are sometimes seen to meet and coalesce

* This and the other cuts illustrative of Bute are copied, by permission, from the *Journal of the Glasgow Philosophical Society* for 1848.

† A dike seventy feet wide emerges from the sea at the mineral well near Bogany point, and ranging nearly west is seen in Huntly Place, where it has been largely quarried; interrupted by the bay it rises again, is conspicuous across the high grounds west of the town, and crossing the island, enters the sea at Ettrick bay. Here another dike, two

for some distance, and again to separate;—a narrow dike branches off into several filaments, which unite again—portions of the rock traversed are often found entangled in the dike; and these, as well as the contiguous strata, present the usual metamorphic effects recognized as due to igneous action, besides others of a peculiar and exceptional character, to which we shall now allude.

The Kilchattan limestone is altered in a remarkable manner by a large dike, crossing it nearly in the direction of the dip, and the effects are well seen at the eastern side of the quarry. Along the plane of contact with the dike the limestone is altered to the state of a granular saccharine marble, which on the application of a slight pressure crumbles into a fine powder. This is succeeded by a hard crystalline marble, the crystals appearing in distinct flakes. Between this and the first change, which is one of simple induration, there are many gradations. Similar effects are common at the contact of limestone with plutonic rocks; in some localities they are accompanied by other singular changes of a chemical nature. Magnesia, and sometimes silica and alumina, are introduced into the composition of the limestone, so that simple carbonate of lime becomes a double carbonate of lime and magnesia. The source whence this magnesia has been derived has occasioned much difference of opinion among geologists. Some imagine that it has been transferred from the plutonic rock to the limestone; while others hold that, as fractures and dislocations of the earth's crust accompanied the eruption of these plutonic rocks, gaseous exhalations might find their way from beneath, and introduce carbonate of magnesia and other substances into rocks near the surface. In confirmation of this view Mr. Phillips has shown, in his *Geology of Yorkshire*, that "common limestone is dolomitized by the sides of faults and mineral veins far away from igneous rocks of any kind;" and some distinguished chemists have expressed their belief that carbonate of magnesia may be sublimed by the action of great heat. (*Rep. Brit. Assoc. for 1835*, Trans. Sect., p. 51; Phillips's *Geology*,

or three times the width, enters near it, crossing from Ascog, and visible in several eminences in the interior. The Rothesay mineral water, which has acquired some reputation for efficacy in rheumatic, cutaneous, and glandular complaints, rises in the former of these two dikes, at Bogany point. The gallon of 277-274 cub. inches contains, according to the analysis of Dr. Thomson,—com. salt, 1860·73 grains; sulph. lime, 125·20; sulph. soda, 129·77; mur. magnesia, 32·80; silica, 14·39; sulphuretted hydrogen, 17·4 cub. inches. Both dikes and this mineral water are noticed at some length in *Wilson's Guide to Rothesay and the Island of Bute*, an excellent and neatly illustrated little work, full of interesting historical and antiquarian matter, but unfortunately, extremely meagre on the geology.

in *Cab. Cyclop.*, vol. ii., p. 98). Much doubt, however, still hangs about this subject. Cases occur in which magnesia has been introduced, although the limestone could not have been subject to such a pressure as would confine its carbonic acid when the rock was softened by heat.

In order to elucidate, if possible, this obscure subject, two specimens of the rock were submitted to Mr. John Macadam, lecturer on chemistry, now of the Melbourne Philosophical Institution, for examination with reference to the presence or absence of magnesia. The following is Mr. Macadam's report; the specimen referred to as No. 1 is the saccharine marble from contact with the dike; No. 2 is the unaltered limestone—both were average specimens:—

"I have carefully subjected to chemical analysis the specimen of limestone No. 1, with special reference to the presence or absence of magnesia; and I find from the indications given that carbonate of magnesia constitutes about $2\frac{1}{2}$ per cent. of the whole mass. The mineral is not, therefore, a double carbonate of lime and magnesia. Its other and principal ingredients are carbonic acid and lime, besides which silica is present, as also traces of oxide of iron and alumina.

"In the specimen No. 2, I find magnesia in great abundance, the amount present being equivalent to 33.72 per cent. of carbonate of magnesia. The other constituents present are similar to those reported in No. 1. From the large proportions of carbonate of lime and carbonate of magnesia present in specimen No. 2, it would appear to be a species of dolomite. It may be noticed that the physical characters of No. 2 are very different from those of No. 1; the former is difficult to pulverize, the latter is extremely susceptible of division.

"The action of strong hydrochloric acid on both specimens causes a portion of gelatinous silica to appear, showing the presence of a silicate, which may be that of magnesia, since the quantity of gelatinous silica is about sufficient to combine with the 1.28 per cent. of caustic magnesia existing in the specimen No. 1. There is a less quantity of this gelatinous silica in No. 2. The greater portion, however, of the silica present in both specimens remains undissolved in the gritty or pulverulent condition, and is hence in a state of mere mechanical mixture with the other constituents of the limestone. It would require a minute quantitative analysis to determine whether the 1.28 per cent. of magnesia exists as a carbonate or silicate, or partly as both."

The phenomena are thus of a contrary character to what is usually

found; the unaltered rock is a dolomite, and contains nearly 34 per cent. of carbonate of magnesia, while the altered rock contains less than 3 per cent. What has become of the constituent magnesia? Has it been driven off by the heat to which the limestone was exposed? Most chemists are unwilling to admit that this is possible; and it may reasonably be objected, that if the limestone had been exposed to so high a temperature as to vaporize its magnesia, the silica would not be mechanically present, but would have entered into chemical combination with the lime or the magnesia, and have formed a silicate.

That whin dikes have sometimes been the means of producing such a combination has been shown by an eminent chemist. In a valuable paper by Dr. Apjohn on the Dolomites of Ireland, published in the *Dublin Geological Journal*, vol. i., the details of an analysis of the white chalk of Antrim, altered to the state of a saccharine marble, are given (p. 376); and it is remarked in conclusion, that "the stone under consideration consists of silica, combined with the mixed oxides of calcium, magnesium, and iron (the carbonate of lime being mechanically present), and is therefore a mixture of trisilicates, very analogous in its composition to olivine. We are thus enabled to understand why olivine should be so very frequently found in trap rocks, and to refer its origin to the contact of silex at a high temperature with an excess of the basic oxides; and we have in some degree a demonstration that the dolomites which contain siliceous sand could not have been exposed at any time to a heat sufficiently high to account for the introduction into them of magnesia in the vaporous state; for by such a heat a silicate of lime or magnesia, or of both, would have been produced."

The presence of these silicates in both our specimens is shown by the appearance of the gelatinous silica; yet a greater quantity of silica is present mechanically, which, as already stated, seems inconsistent with the exposure of the rock to intense heat; unless, indeed, we could suppose that the silica has been introduced by infiltration, or the magnesia removed by the solvent power of free carbonic acid at a period subsequent to the consolidation of the dike from a state of igneous fusion.

Careful *quantitative* analyses of the limestones were afterwards obtained through the kindness of Dr. Robert D. Thomson. It is hoped that these will afford definite terms of comparison with other analyses, such as those of Dr. Apjohn already referred to; and that their publication may lead to the formation of clearer views respecting an obscure question in theoretical geology.

The analyses kindly furnished by Dr. Robert D. Thomson are as follows :—

Specimen No. 1 is the saccharine marble from contact with the dike at Kilchattan,—in the highest state of alteration.

No. 2 is the hard crystalline marble, having the crystals in distinct flakes, more remote and less altered than No. 1.

No. 3 is the unaltered limestone from the middle of the quarry, remote from the dike,—an average specimen.

No. 4 is the altered limestone from contact with the overlying trap at Ascog Mill ; it is an impure dark coloured rock of an earthy aspect, and very like the trap which rests upon it.

No. 1.—Spec. grav. 2·710.

		I.	II.
Silica,.....	} 6·91	5·16	5·70
Alumina,.....			
Protoxide of iron,.....	1·68	1·50	1·28
Carbonate of lime,.....	90·65	...	91·08
Carbonate of magnesia,.....	1·00	...	1·17
	<hr/> 100·24		<hr/> 99·23

No. 2.—Spec. grav. 2·570.

		I.	II.
Silica,.....	} 1·94	0·28	0·28
Alumina,.....			
Protoxide of iron,.....	0·52	...	0·56
Carbonate of lime,.....	96·48	98·76	96·58
Carbonate of magnesia,.....	1·23	...	2·24
	<hr/> 100·17		<hr/> 99·66

No. 3.—Spec. grav. 2·679.

		I.	II.
Silica,.....	} 9·70	...	9·08
Alumina,.....			
Protoxide of iron,.....	1·12	...	1·12
Carbonate of lime,.....	67·42	72·12	67·00
Carbonate of magnesia,.....	17·31	...	18·06
Water, coaly matter, and carbonic acid,.....	} 4·45	...	4·74
	<hr/> 100·00		<hr/> 100·00

No. 4.

Silica,.....	} 64·21	64·46
Alumina,.....		
Protoxide of iron,.....	6·42	6·60
Carbonate of lime,.....	24·00	21·20
Carbonate of magnesia,.....	4·62	2·85
Water and carbonic acid,.....	1·75	4·89
	<hr/> 100·00	<hr/> 100·00

The silica present is in a state of mechanical mixture.

These analyses are confirmatory of the main points of the views already stated, and seem clearly to establish the new and remarkable fact, that by the igneous action in these instances the magnesia has been driven off from the limestone. The unaltered rock is a dolomite containing nearly 70 per cent. of carbonate of lime, and nearly 20 per cent. of carbonate of magnesia; while the altered rock contains but from 1 to 2 per cent. of the latter ingredient. To what cause are we to assign the changes that have taken place? Has the magnesia been sublimed by heat? or has it been withdrawn by the solvent power of free carbonic acid? On the nature of these and the other chemical changes that have been induced, it is difficult to express an opinion; and from such limited premises it would be unphilosophical to draw any general conclusions. The subject is one, however, of great interest both to the geologist and chemist, as the facts are directly opposed to the received views;* and as no instance of similar changes on dolomitic rocks has, so far as we are aware, ever been put on record.

40. A remarkable dike intersects the sandstone between Ascog and Kerrycroy, well worthy of attention on account of the striking illustration it affords of the mode of cooling of basaltic rocks from igneous fusion. It runs parallel to the shore for some distance, and then retires from it towards the S.W., and striking the inland cliff

Side view of whin dike between Ascog and Kerrycroy.

already mentioned, whose direction is here the same as that of the dike, it forms the perpendicular face of the cliff in front of the sandstone, rising like a wall to a height of twenty or thirty feet. The direc-

* For the latest and best account of the views of geologists on this subject see the well known work of Dr. Daubeny on *Volcanoes*, new edit.; also an admirable *résumé* in the anniversary address of Prof. Oldham in the *Journal of the Dublin Geological Society*, 1849.

tion of the cliff soon changes, however, and the dike then enters the hill behind, and is lost. The sandstone having been completely worn away from the eastern or seaward face of the dike by the action of the sea, when it covered the present terrace, a very large surface of the side of the dike is laid bare, and thus the structure is exhibited in the most satisfactory manner, as shown in the annexed cut representing the dike as seen on the east side.

These dikes, as already remarked, are prismatic across, not vertically as in the overlying trap. The cause has been alluded to in a former article (Article 31); the imprisoned caloric of the submarine lava-stream passed off perpendicularly to the cooling surfaces, and hence the divisional planes are also perpendicular to these surfaces, or the dike is prismatic across. In this case the prisms are mostly pentagons and hexagons. The dike is composed of greenstone, and is about fifteen feet wide.

THE CUMBRAYS.

41. These islands are composed of old red sandstone similar to that of the mainland adjoining, broken through and overlaid by various traps, chiefly greenstone. The cliffs at the lighthouse on the lesser Cumbray are composed of sheets of prismatic greenstone rising above one another in successive terraces, having a dip N.E. or contrary to that of the sandstone and trap of Garroch head, and hence suggesting the existence here of a great fault in the strata, giving origin to this main entrance into the proper estuary of the Clyde. The chief interest of the islands is in their whin dikes. These alter the strata remarkably: the sandstone has been fused by them, and reconsolidated into a substance closely resembling a dark quartz rock; simple induration is induced at a greater distance from the dike. Many of the dikes also stand out boldly from the adjoining sandstone, which has been worn away on either side as in the case mentioned in the last article, the amount of wearing in the ancient tideway, compared with that in the present, affording a rude measure of the time during which the sea remained at the higher level. Attention was first called to these remarkable dikes by Mr. Smith of Jordanhill. The best example is seen a little to the east of the entrance of Millport harbour, where a large dike rising from the sea level like a huge wall runs far up along the hillside, raised as if by art above the surface of the fields. On the shore of the mainland opposite, another dike, having the same direction and apparently a prolongation of this, stands out in the same manner from the surface of the sandstone. The similarity of the two masses of rock and their

former connection are pointed at in the legend that this strait was once spanned by an enormous bridge, raised by the hand of mighty wizards, of which the only portions that remain are these two ancient abutments.*

ARRAN.

42. The Island of Arran is about twenty miles long from N.N.W. to S.S.E.; about ten miles broad, and, with Holy Isle and Pladda, includes an area of about 100,000 acres. The number of rock formations, sedimentary and plutonic, which are found within this limited space, is truly remarkable; perhaps unparalleled in any tract of like extent on the surface of the globe; while the varied phenomena which they present in their mutual contacts and general relations to one another, are of the highest import in theoretical geology. The variety indeed is so great, and the interest so lively and pleasing, which an examination of the structure of the island and its charming scenery excite, that, as Professor Phillips has remarked, every geologist who visits Arran is tempted to write about it, and finds something to add to what has been already put on record. For the student there cannot be a finer field; the primary azoic rocks, the metamorphic slates, the lower palæozoic strata, the newer erupted rocks, and phenomena of glacial action, may all be examined by him in easy excursions of a few days; and the exposition of the strata is so complete in the rugged mountains, deep, precipitous glens and unbroken sea coast sections, that the island may truly be called a grand museum arranged for his instruction by the hand of nature.

Physical Features.

43. A line running from the north angle of Brodick bay almost due west to Iorsa waterfoot, divides the island into two nearly equal portions, strikingly different in their geological structure and in their outward features. The northern half consists of a mass of peaked and rugged mountains, intersected by deep and wild glens, which diverge from a common centre and open seaward on a narrow belt of low land. This belt forms the terrace so often noticed already as marking the ancient sea level, and is bounded inland by cliffs pierced with caves and otherwise sea-worn. The road is carried along it from Brodick bay to the mouth of North Sannox water, and again from Loch Ranza to Dugarry at the mouth of Iorsa water, and affords throughout views of surpassing beauty. The mountains are naturally divided into three separate ridges, which

* *Quart. Jour. of Agric. and Trans. of the Highl. Soc.*, No. 43, or vol. ix., p. 430.

may be named after their most conspicuous summits—the Cior-Mhor, Goatfell, and Ben-Varen groups. Of these by far the most considerable is the first, which forms a long irregular, narrow, and jagged ridge, extending from Ben-Ghnuis on the south to Suithi-Fergus on the north-east. Cior-Mhor stands near its centre at a point where a salient angle in the ridge closely approaches to the Goatfell group on the east. Its connection to this group by a cross ridge or col about 1,000 feet in height, which separates the heads of Glen Rosa and Glen Sannox, and its position near the middle of the range, constitute the prominent peak of Cior-Mhor, the geographical centre of the whole north-eastern mass of mountains. Its height is about 2,500 feet; but it is exceeded by Caistael-Abhael, and perhaps another summit. The whole ridge has great persistent altitude, no point descending below 1,600 feet, and there being at least six summits not less than 2,000 feet. Fronting the concavity of this arch-like ridge on the east, is an assemblage of closely connected mountains dependent upon Goatfell. The most northerly summit is the lofty conical peak of Ciod-na-Oich, or the Maiden's Breast, guarding the south-east angle of Glen Sannox; on the south the group terminates in the bold precipice called Glen Shant rock at the entrance of Glen Rosa. Both groups front the interior glens in tremendous precipices, while they descend with less abruptness to Glen Iorsa on one side, and the sea on the other. To the west of the geographical axis of the island lies the Ben-Varen range, with some connected and lower heights east of it, the entire group being separated from the other mountains by Glen Iorsa and Glen Eais-na-Vearraid, running respectively S.S.W. and N.N.W. through the length of this half of the island. These glens have a common watershed in Loch-an-Deavie, a small mountain lake or tarn, which when it stands at a high level, as in winter and in wet summers, discharges its waters at both ends. Another small lake adjoining, at a higher level, likewise discharges, when full of water, north-west into the head of Glen Catacol and south-east into Glen Iorsa; but it is a mistake to suppose that Loch Tanna, the largest lake in the island, has this singular position; the ground rises suddenly north of it, and all the water passes off into the Iorsa. These Arran lakes illustrate an arrangement which occurs on a large scale in Canada and Norway, where lakes extend across the entire watershed between two seas.

The bleak uplands between Ben-Ghnuis and Ben-Varen are finely varied by several heights, of which the most remarkable is the prominent ridge of Sal-Halmidel, an outlier of the latter range. It

divides Glen Iorsa from Glen Scaftigill, and is a conspicuous and picturesque object from all the south-western portions of the island. To complete our sketch of the northern section, it is only necessary to notice the high ridge between the sea on the north, and north Glen Sannox and Glen Chalmidell on the south. In geological formation it differs from the others, but is connected with the main range which we have called the Cior-Mhor group, by means of a ridge at the watershed between the two glens which bound it. This ridge joins on to the eastern flanks of Tornidneon, an abrupt, massive, but not lofty mountain, overlooking Loch Ranza on the south, and forming the termination of a long but not generally high ridge which sweeps round the east side of Glen Eais-na-Vearraid, and runs in upon the north side of Caistael-Abhael near the watershed at Lochan-Deavie. This northern range terminates in bold heights forming the east side of Loch Ranza; its western boundary is formed by the nearly precipitous sides of Meal-Mhor, the most northerly mountain of the Ben-Varen group. Thus at the northern apex of the island, the principal ranges closely approach one another, their terminal portions forming the lofty abrupt framework to the secluded inlet of Loch Ranza, whose many picturesque features excite the admiration of every visitor.

Various estimates have been formed from time to time of the heights of the Arran mountains; all of them, including some of our own made by trigonometrical measurement, pretty near the truth. They have lately been determined, in the conduct of the Ordnance Survey, with that exactness which marks all the operations of the Royal Engineers. The following principal heights have been kindly supplied by the Superintendent of the Survey, Colonel James, R.E.:—Goatfell, 2,875 feet; Caistael-Abhael, 2,801; north top of Goatfell, 2,628; Ben-Varen, south summit, 2,342; north summit, 2,310; Holy Isle, 1,020; highest point of the slate ridge on the north, over the Cock of Arran, 1,097 feet.

The southern half of the island consists of a rolling table land, bleak and unpicturesque inland, but breaking rapidly down seaward into a coast border of great romantic beauty. The general elevation is from 500 to 800 feet; and the irregular ridges which traverse it, most usually in a direction nearly east and west, rise to about 1,100 or 1,400 feet. These separate the various glens and river-courses, whose origins lie near the central line or axis of the island, but often interlace with one another, so that a stream issuing westward has its source nearer the east coast than the west, and *vice versa*. The views of the northern mountains, from these uplands, are

very grand, especially when they are seen in the early summer twilight, their dark jagged peaks projected against a background of sky, still lit up with brilliant hues from the departed sun. Their aspect from one such point of view has been given with noble effect by a living artist. The terrace border, so conspicuous around the estuary of the Clyde, is marked here with less continuity, owing to the nature of the rocks which advance in many parts upon the sea line in mural precipices. Still, however, it is sufficiently distinct in many parts, as about Corriegills, Whiting bay, portions of the south End, and towards King's Cove on the west, where its salient and re-entrant angles, in their bold points and noble sweeps, afford some of the finest scenes of quiet beauty to be met with in Scotland.

General Outline of the Structure.

44. The remarkable geological structure of Arran, and the striking physical features which give such a charm to its scenery, are alike due to a single peculiarity generally overlooked by those who undertake to describe it. This consists in the *abnormal position* of its granite nucleus. The other granite tracts of the north-west of Scotland lie amid primary slates, which are symmetrically disposed on opposite sides of it, the granite ridge forming an anticlinal axis. This is the case throughout the Grampians, where gneiss and mica slate widely encircle the various outbursts of the granitic rocks; the silurian slates of the south of Scotland envelop in the same manner the granitic bosses which rise amid them. But in Arran there is no such symmetrical arrangement; granite does not form a mineral axis in reference to the slate rocks. It has been protruded *close to the outer border* of the two upper slates, so as to come into contact on one side with the newer sedimentary strata. Its position is thus very different from that of the Grampian granite, being far removed from the axis of the old crystalline slates, and associating it with sedimentary strata of a much later age. The newest of the two upper slates noticed in Art. 30 is not found in Arran, and is probably either thrown out westward beyond the line of bearing of the second slate, or is so altered by the near proximity of the granite as to be undistinguishable from the middle or dark coloured slate, through which the granite has been protruded. On the east side of the granite nucleus about Corrie, this slate band is extremely narrow, probably only a few yards thick in many places; on the western side it is much broader, but the underlying mica slate does not appear, and is not found till we pass into the opposite peninsula of Cantire, where we meet with it on arriving at the line of bearing which it preserves,

as already remarked, in crossing the country from north-east to south-west. To this succeed the gneiss tracts, which, as we advance north-west, keep with us till we reach the granite axis of the Grampians. Along this axis, however, it is now known that the granite does not form an unbroken continuous ridge or line of heights. It occurs rather in independent elliptic shaped masses, its place on the axis being often taken by mountains of gneiss, porphyry, or quartz rock.

Such, then, is the singular abnormal position of the Arran granite, which gives to this island all its peculiarities, both as regards its geographical features and its geological structure. The protrusion of so large a body of igneous rock by plutonic fires along the line of junction of the older slates and the secondary formations, and its elevation to a great height in a space so limited, might naturally be expected to produce phenomena of varied interest, such as have been alluded to in the opening paragraph of this section.

45. The granite nucleus occupies by far the greater portion of the northern half of the island. The three mountain groups already described, with the glens and valleys penetrating and dividing them, consist entirely of this rock. It is remarkable, however, that at no point does the granite reach the sea coast. In its elevation from the plutonic depths, it bore up with it a narrow band or framework of clay slate, of the second or dark coloured variety, which completely encircles the nucleus. The structure of this portion of the island is shown in the cut annexed, representing an ideal east and west section

(a) Coarse grained granite; (b) fine grained granite; (c) slate; (d) old red sandstone; (e) carboniferous strata.

from Corrie to White-Farland. From the mouth of the Iorsa water at Dugarry, round the west side of the island by Imochair, Thundergay, and Catacol, to Loch Ranza, this slate occupies the coast, and forms a belt of considerable but varying breadth. Its junction with the granite is seen in almost every stream, and in many points along the western slopes of the lower hills. It extends all round the precipitous sides of the Loch Ranza valley, and to a short distance east of Newton point, which forms the north-east angle of the loch, as far as a small stream called Alt-Mhor. It here retires from the shore, and forms the high northern ridge already mentioned, the coast from this point eastwards, and then southwards, being occupied partly by

old red sandstone and partly by coal sandstones, beds of carboniferous limestone and of coal and coal shale being interposed amid the beds of the latter. The band of slate is of considerable breadth in this northern ridge, but narrows very much on approaching the opening of Glen Sannox; along the hill sides southward, by the base of Ciod-na-Oich, and above Corrie it is extremely narrow, apparently only a few yards in some places. Still farther south, as it sweeps round south-west between Maoldon and the base of Goatfell, it gradually widens—presents bold precipices on both sides of the lower part of Glen Rosa, and along the south border of the granite nucleus between Loch Ghnuis, Dugarry, and Imochair attains its greatest development. Here the thickness of the slate band between the granite and old red sandstone cannot be less than 2,000 or 3,000 feet; whereas above Corrie, in the bed of a stream, we noticed a spot where it is not more than ten feet, so close to the outer margin has the remarkable outburst of granite taken place. It has indeed been asserted by one writer, and repeated by others, that the continuity here is entirely broken, and that the granite is in contact with the old red sandstone. This we consider is decidedly a mistake. In frequent summer rambles along these romantic hill sides, we have examined carefully every open section, and have never seen such a contact. In the spot referred to, the rock is a hard bluish-gray, flinty slate, very like a hard sandstone when taken wet from the burn. The strata here come against the granite end-on, or nearly at right angles. The prevailing dip of the slate over the whole district is the same as that which it maintains in adjoining tracts beyond the limits of Arran, namely, south or south-east at a high angle; it is not arranged in mantle-shaped strata around the granite nucleus, but is inclined towards it in some places, and off from it in others. Thus along the north side of the nucleus from North Sannox to Catacol, the dip is south or towards the granite, at angles varying from 65° to 75° . This is of course unconformable to the granite centre; but a like dip and inclination on the south side give conformability; and here, accordingly, from Maoldon by Glen Rosa and Dugarry, and perhaps even as far as Thundergay, the slate is seen to recline against the sides of the granite mountains in a kind of mantling stratification. In many spots there is great contortion and irregularity, indicating the operation of violent forces, attendant on the upheaval of the granite. Reference will again be made to several of these cases, as well as to local variations in the mineral character of the slate.

46. Within the granite tract, whose limits are defined by the

slate as above described, there occur two distinct varieties of the rock—a coarse and a fine grained, not intermingled with one another, but occupying separate portions of the district. Mr. Ramsay called attention to these marked varieties, and traced approximately the limits of each. We have somewhat extended the bounds of the fine grained variety. It occupies the space between the Ben-Varen and Cior-Mhor ranges, rising high up on the east front of the former, and on the west front of the latter reaching as far up as the passes from Glen Iorsa into Glen Rosa and Glen Sannox. It crosses the watershed at Loch-an-Deavie, and stretches from half a mile to a mile north-east toward the base of the Castles, and down also into Glen Eais-na-Vearraid. The coarse variety covers the rest of the district, and forms the tops of all the mountains. The Goatfell group is composed entirely of it; as are also the whole east front and all the summits of the Cior-Mhor range from Ben-Ghnuis to Suithi-Fergus; along the back of the range the fine grained variety reaches the heights already noticed. Extending hence across the valley of the Iorsa, it rises on Ben-Varen as high as the base of the last steep ascent. The rest of the range is of the coarse variety. The two kinds are very distinct from one another, though the component minerals are the same. Both consist of quartz, felspar, and mica, the two first being in nearly equal proportions, the last in less quantity than either. In neither kind is this mica replaced by hornblende, so as to form the variety called syenite. This rock is indeed found in Arran, but not within the district called the granite nucleus. There are, however, several varieties of both kinds; but these are merely dependent upon slight changes in the colour or size of the constituent crystalline grains. The fine variety of the interior has often an arenaceous aspect and sandy feel, from the minuteness of the grains. The distinctness of these two varieties of granite in their mineral aspect, and the fact that they do not intermingle, but occupy separate tracts, led Mr. Ramsay to conclude that they were of different ages, and that this fine grained variety was the newest rock in the whole island. He rests this conclusion on the non-existence of whin dikes in the fine granite, and on what he seems to state with the confidence of personal observation, namely, that “in cutting through the coarse granite, these dikes frequently approach the borders where it joins the fine variety, and are then invariably cut sharply off by the fine granite, when they approach it in the coarser kind,” (p. 65). We have never noticed any instance in which a dike is thus cut sharply off, nor does Mr. Ramsay refer to any spot where such a case occurs, and it is possible he may refer merely to

the non-existence of dikes in the fine granite, while they are often met with in the coarse. He states his view with some diffidence, and with the qualification that the tract of fine grained granite has not been carefully investigated with respect to these appearances. This examination was made by us last summer; and the result was the discovery of several trap dikes, ranging between north and north-west across the tract of fine grained granite; but the intersection of these with the coarse grained variety could not be observed, nor has such intersection been anywhere noticed by us. It is quite possible, however, that there may be one system of dikes in the coarse granite cut off by the fine, and another system in the fine itself. If the intersection does indeed occur in the manner mentioned in the above quotation, the conclusion will be forced upon us that the fine granite is of later eruption than the coarse, and also later than the dikes in this coarse variety. There would thus be granite of two ages, and trap of two ages, in this central district. We must, however, express our belief, that the discovery of trap dikes traversing the fine granite for considerable distances renders it extremely probable that they are continued both ways into the coarse variety; and that, while the two granites *may be* of different ages, the dikes are of one age and posterior to both granites. We shall have occasion hereafter to refer to the age of these two granites. The veins of fine granite, which are so frequently found traversing the coarse granite of Goatfell, Ben-Ghnuis, and other localities, are certainly cotemporaneous, formed by chemical affinities or electric forces acting in some peculiar way during the consolidation of the rock, and not injected from below at a later date. In many cases indeed they are seen quite isolated in a granite block. Sir Charles Lyell, who "himself examined a great part of Arran in 1836," adopts the view set forth by Mr. Ramsay (*El. of Geol.*, 5th ed., 1855, p. 590). This view he illustrates by a cut (p. 591), which is slightly inaccurate, as the facts above stated will show. The fine granite does not rise into mountains, co-ordinate with those formed of the coarse variety; the fine grained is actually traversed by dikes of common trap through considerable distances; and we contend that evidence is wanting to prove the injection of veins of the fine variety into the coarse. An error in one of Mr. Ramsay's sections, at the points 5, f, is also copied into this cut, to which we shall again refer.

47. The encircling band of clay slate is succeeded on the east and south by a band of old red sandstone, which, like the slate band, is of irregular breadth. It begins to overlie the slate at the Fallen

Rocks on the north-east coast, and occupies the shore thence to the march of Achab farm, half a mile north of Corrie. Here it retires inland, the carboniferous formations taking its place on the shore; is interrupted for a short space, south of Corrie, the newer sandstone then resting on the slate; is again resumed on the west base of Maoldon, and stretches thence continuously westward, around the border of the slate to the mouth of Mauchrie water. Between this point and Dugarry, near Iorsa waterfoot, it attains its greatest breadth. The breadth is also considerable from the Fallen Rocks to a point a little south of the base of Ciod-na-Oich. A line from the north side of Brodick bay to Dugarry very nearly marks out its line of junction with the slate. The structure varies from a fine grained red sandstone to a coarse conglomerate or pudding-stone, in which the fragments are more than a foot in diameter. The coarse and fine strata do not follow any particular order, but alternate throughout the formation, indicating the operation of powerful currents, and intermediate periods of repose. The imbedded fragments in the conglomerate are mica slate from a distant source, the ordinary slate adjoining, and quartz of two varieties, of which one is the common white quartz, forming veins in the slate, and the other a peculiar resinous quartz, of a cinnamon colour, not found in Arran, and of which we know no locality. This latter is rounder and polished, while the other is often angular or slightly rounded. The resinous variety is exactly the same as fragments which occur abundantly and of large size in the conglomerates of the east coast of Antrim, but not found *in situ* anywhere in the north of Ireland. It is difficult to account for the appearance of these in the conglomerates; they may have some distant source among the Grampians. It is remarkable that fragments of granite do not occur in the conglomerate; none of the Arran sandstones have as yet yielded a piece of this rock to any observer. The conclusion to be drawn manifestly is—that when these sandstones and conglomerates were in process of formation by the wearing down of the slate rocks and the transport of the fragments by water, the granite of the interior was not exposed to disintegrating causes, but remained as yet in hypogene depths, protected most probably by the enveloping slate rocks. Facts to be stated farther on will throw light on this curious subject. It may here be merely noticed, that the sandstones of the coast have the edges of the strata turned up towards the central granite, and that north of the mouth of North Sannox water, the dip is towards the north-east and north, while south of this point it is south-east and south. Beds of limestone occur subordinate to the old red sandstone,

at the march of Achab farm, at Glen Laodh on the hill side south of the road from Brodick to Shiskin nearly opposite Moniquail farm, in Clachan glen, and a few other places. They are without fossils, and similar to the cornstones already noticed in Arts. 27, 28, 35, 38. We shall again refer to them in our separate "Excursions."

48. The southern half of the island, southward of the old red sandstone boundary above defined, that is, from the String road and valley of Mauchrie water to the South End, is composed of several members of the carboniferous series, broken through and overlaid by various igneous rocks, chiefly those of the greenstone type. The prevailing rock and substratum of the whole southern plateau is red sandstone, varying from a fine compact structure to that of a coarse conglomerate. A narrow band of this sandstone extends also along the eastern shore northwards to Corrie; and again from the Fallen Rocks north-west to the Scriden at the northern extremity near the entrance of Loch Ranza. Subordinate to this sandstone are beds of limestone, abounding in fossils of true carboniferous types, beds of shale and coal, in which are found fossil plants and shells, such as characterize these strata in the basin of the Clyde. The structure indeed is quite analogous to that of the Clyde basin, the peculiarities of which have been already explained in Art. 24. The limestone does not occur at the base of the system, nor does it occupy any determinate place in it, but is found throughout the whole series of beds in repeated alternations with the sandstone and shales. These alternations are seen in section on the sea shore along the east border, on the hill side between Corrie and Brodick, along the high grounds on both sides of Glen Cloy, in Clachan glen, Glen Scorodale, and other water channels issuing westward; and in the Alaster water above Lamash, they descend almost to the bottom of the glen, where alluvial deposits obscure the old rocks. On this ground we refer the whole of the strata of the southern division of the island to the carboniferous series. The alternations in question are not seen, it is true, on the Corriegills, Whiting bay, or Kildonan shores, nor do they appear among the sandstones of the South End; but such massive strata of red sandstone as appear along the east and south shores, are common in the carboniferous system, and form indeed everywhere its prevailing member. They are conformable to the strata inland, in perfect sequence with them, of the same mineral structure, and without any fossils of New-Red types. We do not therefore hesitate to refer them all to the carboniferous system; and we are persuaded that the distinguished geologists who established such a classification for Arran, will be the first to agree in this view.

The Outlying Granites.

49. Perhaps the most remarkable feature in the geology of Arran, is one made known by its recent explorers, and of which the British Isles offer, we believe, only one other example. We refer to two outbursts of granite amid the sandstones of the southern division of the island, noticed in the last Article. One of these was discovered by Mr. Ramsay in 1837; but the first description of it was published in 1839 by M. Neckar, who named the district Ploverfield. The other was discovered by the writer of these notices in the summer of 1855, and described in the autumn of that year at the Glasgow meeting of the British Association. Both tracts occur on that side of the sandstone district which is nearest to the "granite nucleus;" and the occurrence of the rock here is thus intimately related to the outburst of the central granite, in its abnormal position—close to the outer border of the upper slate, and to the base of the sandstone formations—already pointed out as the great leading peculiarity of Arran. These tracts are represented in the annexed ideal section from east to west between Corriegills and the valley of Mauchrie water, the horizontal extent of the intervening sandstone being much contracted:—

(a) Granite of Ploverfield; (b) new granite tract at Craig-Dhu; (c) old red sandstone of Mauchrie water; (d) sandstone with beds of limestone, the whole of carboniferous age; (e) eruptive rocks of Doir-nan-Each, the highest hill in the west district of the south section of the island, chiefly porphyry and highly hornblendic basalts.

The Ploverfield Granite.

50. The Ploverfield granite occurs amid strata which undoubtedly belong to the carboniferous system. The tract is situated on the west side of Glen Cloy, and that branch of it called Glen Dhu. The hills here are the highest portion of a long ridge running up south-west from the plain of Brodick, and dividing Glen Cloy from Glen Shirag. At the origin of this ridge, are beds of carboniferous limestone with fossils, under the north wall of the enclosure of Brodick church. On the upper slope of the ridge, beds of limestone and shale also occur in the sandstone, not far from the north base of the Windmill hill—a high, elongated, narrow ridge, steeply overhanging

Glen Dhu, and composed of quartziferous porphyry. On its south-west base, the granite first appears, separated, in some places at least, from the porphyry by a narrow band of altered sandstone. Thence, keeping at a high level, it extends along the hill slopes at the head of Glen Dhu, and terminates southwards against a ledge or low cliff of syenitic greenstone, a little west of the top of the Blackhill—a high, bold point running forward between Glen Dhu and the upper part of Glen Cloy. The top and front of this hill toward both glens are composed of altered sandstone, resembling quartz rock, the change of structure being, no doubt, due to the proximity of this syenitic greenstone. The ledge or cliff seems to be the northern front of a large dike ranging between west and north, and cutting off the granite. To the south of it, the hills are composed of sandstone, with occasional knolls of overlying common trap. Westwards, the granite extends across the moorland tracts, which lie between Glen Cloy and a high ridge forming the watershed or axis of the island at this part. It is seen in a few rocky points, but chiefly rising through the sandy substratum of the peat, where this has been worn away, or in the beds of the small streams. As we advance westwards, it becomes gradually intermingled with syenite and porphyry; but the relation of the three rocks cannot be made out, owing to the nature of the ground. They appear to alternate, the granite diminishing in quantity toward the west. On the summit of the highest ridge or watershed, loose pieces of granite strew the surface, mixed with syenite and porphyry. Bosses of the latter rise through the broken-up masses of the sandstone, forming the main body of this ridge. The surface is also strewn with masses of pitchstone, and of the coarse grained granite of the northern mountains. Such must be taken as the hypothetical boundary of the Ploverfield granite on the west. Its south boundary does not reach so far as a line joining the heads of the Clachan glen and Glen Cloy, sandstone being seen continuously between them. On the north side its boundary runs from the west base of the Windmill hill to a point a little west of the summit level of the String road. Here a high ridge on the south side of the glen, and west of the watershed, presents granite in its upper part; the lower portion, on the level of the watershed, is composed of sandstone; but the junction is not seen. These limits mark out an area much larger than that assigned to the granite in Mr. Ramsay's map and descriptions. He states, indeed, his inability clearly to define it. "From the depth of the moss on the flat surface of the hills, the boundaries of this granite have not yet been determined; but by a little labour, properly

bestowed, this object might doubtless be accomplished.”—(*Guide to Arran*, p. 12). The weathered surface of the granite is generally white; but the prevailing colour in a fresh fracture is red. It is fine grained, with little mica in proportion to the quartz and felspar, and is very similar to the fine grained variety of the interior. Drusy cavities often occur, lined with crystals of quartz and felspar. Mr. Ramsay states (p. 12), that “It sends forth veins into the adjacent sandstone; while specimens of the sandstone, much altered by the effects of intense heat, may even be found enclosed in the granite.” We have not noticed these cases of intrusion; nor are the precise spots mentioned, so that we might verify them. We have, however, seen such in connection with the porphyry of Windmill hill, to which the granite succeeds on the west, and also in connection with the new granite tract to be next noticed.

The Craig-Dhu Granite.

51. The other granite tract lies on the south side of the Shiskin road, nearly opposite the farm house of Glaister. Here the hill, whose base is skirted by the road all the way down from the “String,” overhangs the valley of Mauchrie water in a steep cliff called Craigmore, Craig-Dhu, or The Corby’s Rock. This cliff is the outer edge of a small plateau or table land, cut off from the higher ground behind, towards Doir-nan-Each, by a deep hollow which completely isolates it. The summit is 700 to 800 feet above the valley, and is more than a quarter of a mile long, by one to one and a-half furlong broad. It descends steeply towards Shiskin on the south-west, and slopes gradually north-east towards Moniquail. The summit and sides of this plateau are formed of fine grained granite, very similar to that of Ploverfield. The base of the cliff towards Mauchrie water is covered by a long talus of granite blocks and smaller fragments, reaching to within 200 or 300 yards of the road, and appearing even at that distance of very different aspect from fallen masses of sandstone.—See last cut, *b*, *c*.

The granite here seems to rise either through the old red sandstone, or at the junction of this rock with the carboniferous strata. The granite is nowhere seen *in situ* at a low level; the talus before mentioned obscures the rocks along the base of the hill; and the ground by the roadside, and along the valley, is deeply covered with alluvium. At one spot only could we detect any rock *in situ*. Immediately below the bridge, by which the road crosses a small stream, the water runs over a projecting mass, which seems to be either a serpentine, a greenstone with much felspar, or an iron-shot

claystone. But at a high level on the west, south, and east sides of the plateau, the granite is seen to rise through a coarse conglomerate; and numerous contacts are observable. These are highly interesting, and clearly indicate the intrusion of the granite subsequently to the formation of the conglomerate. The base of this conglomerate is a coarse sand, and the imbedded fragments sandstone, quartz, and granite. The base is highly indurated, and assumes a porphyritic structure; the sandstone is rendered crystalline, and the quartz has been fused, and reconsolidated into a substance resembling porcellanite. The fragments of granite are of an elliptic form, less rounded than the quartz, and are exactly like the adjoining mass of granite in structure and component parts. Whence have these granite fragments been derived? From the body of fine granite among the northern mountains, or from the adjoining mass itself? Mineral structure does not enable us to determine—the two rocks are so similar. If from the former source, then we must conclude that the granite of the interior was elevated so as to be exposed to disintegrating causes, while the conglomerate was forming; in which case granite fragments ought to occur abundantly in the sandstone conglomerates; but this is not found anywhere in Arran;—a fact noticed by all observers. Even here the fragments occur only in close proximity to the granite itself. Must we not then rather suppose that pieces of the granite adjoining, when this rock was erupted in a fluid or semi-fluid state, were injected among the outer strata of the conglomerate, also fused by the contact, and so became imbedded in these strata only?

52. Granite, then, occurs in Arran, in three disconnected tracts, amid slates in the northern mountains, in the old red sandstone of Craig-Dhu, or at the junction of this rock with the carboniferous strata, and also amidst these carboniferous strata at Ploverfield. In each of these positions it is clearly posterior to the rock which encircles it; for it is intruded among these sedimentary deposits, and produces a marked alteration upon them along the planes of contact. We have, therefore, now to consider the question of age. Are the three granites of three distinct ages corresponding with those of the strata among which they intrude? or were they erupted simultaneously, so as to pierce through the three formations during one and the same period of disturbance? In other words—and this view narrows the question—since the Ploverfield granite is clearly of later origin than the sandstones of Windmill Hill, and the shell limestones subordinate to them, were the granites of Goatfell and Craig-Dhu erupted at the same time with it? or does their injection

among the strata, and elevation to the day, date back to an earlier period? The close proximity of the Craig-Dhu granite to the border of the carboniferous formations, if it be not actually enclosed in these, evidently points to an identity of age with that of Ploverfield, and renders their simultaneous eruption extremely probable. How then is the Goatfell granite related to the old red and carboniferous formations? It has been long established, and is well known that it everywhere throws powerful veins into the encircling slate-band around the borders of the northern district, greatly altering the slate along the line of junction, and disturbing its stratification. The slate is manifestly heaved up by it; and in some vertical sections, as at Tormidneon, and the hill sides north of Glen Catacol, we have slate above and granite below, with numerous alternations where the two rocks approach. The granite was, therefore, injected in a molten state amid the already formed strata of slate. But, further, it was suggested long ago by Murchison and Sedgwick, in their celebrated paper on Arran (*Geol. Trans.*, vol. iii., second series, 1835), that the bed of limestone on the north point of Maoldon may have once been continuous with the Corrie stratum, and that its actual position is due to an upthrow by a protruding mass of granite advancing from the central mass east of Goatfell. If this be admitted, it would make the intrusion of the granite posterior to the deposition of the carboniferous formations, and so render probable an identity of age between the Ploverfield granite and that of Goatfell. We think, however, that this view is liable to question; we often find exactly similar bands of limestone amid the strata of coal sandstone, without any evidence of former continuity, or such cause of disturbance; and the amount of vertical displacement implied in the supposition could hardly have taken place here without a fracture of the crust, and the appearance of granite on the surface,—so narrow is the band of sedimentary strata superimposed upon the granite. A positive conclusion, then, seems scarcely justifiable from this case. A stronger presumption is derived from the high angle generally assumed by the sandstones, when they approach nearest the granite, on account of the narrowness of the slate band along the Corrie district. An extremely interesting junction in the Sannox burn throws an unexpected light upon this question of relative age. A few hundred yards above the Barytes mill a narrow band of slate crosses the river at right angles, between the granite on one side, and the old red sandstone on the other. The slate is very much altered by the close proximity of the granite; it has, in fact, the structure and aspect of Lydian stone or basalt; and the sandstone also has a highly meta-

morphic structure, firmly adhering to the slate, and intermingling and interlacing with it, as if the slate had been forcibly injected among the strata of conglomerate in a melted state. This interesting junction seems to have escaped notice, till observed by us, in the summer of 1856. Something analogous, though less striking, is seen towards the junction in the burn of the White water, above Corrie, where a gradual passage takes place from slate to sandstone, clearly the effect of metamorphism, by the heat to which both were subjected. The facts clearly show the posteriority of the granite outburst to the deposit of the old conglomerate, and that the entire slate stratum on the east or Corrie side was in a plastic state, under the influence of the intense heat which fused the granite.

Viewing all these facts in connection with the general conformability of the carboniferous strata to the old red sandstone, and the gradual transition from the one series to the other, observed in several places, there seems a great probability that the injection of the granite, in a melted state among the strata, took place after the deposit of the carboniferous formations; and that therefore the granites of the three disconnected tracts may be all of one age, or belong to the same period of disturbance. But as the granite of the nucleus is nowhere seen to alter the carboniferous formations, while it certainly does, as above stated, alter the old red sandstone, it is quite possible that these carboniferous strata may have been deposited upon the old sandstone during a period subsequent to the irruption of the granite. But this irruption took place in hypogene depths, not only prior to the elevation of the island above the waters of the primeval ocean, but while the granite was yet enveloped by the mantling slate rocks, and perhaps also by the later formations. It is obvious, as already pointed out in Art. 47, p. 69, that these secondary strata have not derived the detrital materials of which they are made up from the disintegration of the granite; this rock was yet protected from disintegration by its mantle of slate; and the old red derived its materials from other, and some of them remote sources. An extensive disintegration and denudation may even have gone on for a long period, ere yet the strata were injected by the molten granite; for this injection, we have seen, *alters the conglomerate*, partly made up of slate fragments, through the medium of the fused or semifused slate; and besides, the extreme narrowness of this band on the east renders it very improbable that portions of the injected veins, with adhering slate, should not be found in the conglomerate, if the injection had been prior to the denudation and to the deposit of this latter rock. The elevation of the central granite

mountains to their present height may have been a gradual process, during the continuance of which, in waters constantly becoming shallower, the strata of slate may have been exposed to further extensive denudation, which, joined to various atmospheric influences, afterwards acting, would give their present form and outline to the jagged ridges of the northern mountains. Long before this elevation took place, the granite, under the pressure of the superincumbent slate, and perhaps of the newer formations also, had acquired its crystalline structure by the slow passage of its heat of fusion into the adjoining strata; and most probably it was quite solidified anteriorly to its elevation, so that it was protruded in a solid form.

53. The agent in this protrusion may have been a newer granite, produced beneath the former. Let fresh accessions of molten matter—the matter of granite—be slowly and constantly transfused from the nether depths, amid the basement portion of the older granite, already cooled and crystalline above, while fused below by contact with the molten mass,—this latter will expand, and perhaps laterally extend the former, and raise it in a solid form. Thus a great upward movement might be produced, forming the high mountain nucleus of the north, and at the same time elevating and contorting the strata of slate and sandstone resting on the flanks of the older granite, and in some places perhaps even inverting the dip of the slate, as being subject to a greater strain, and more likely to yield *en masse*, without disruption; while the sandstones of the southern plateau, remote from the focus of intensity in the upheaving force, would be elevated from below in more horizontal strata. The newer granite below might likewise impenetrate the older, and so make its appearance in lower situations, when the land was finally raised, and had assumed, in virtue of denudations effected during the process, and by causes afterwards acting, somewhat of the aspect which it now retains. Formed under such conditions, this later granite might be expected to differ in structure, if not also in composition, from the older granite, invaded and displaced by it. Such differences we know do actually exist between granites in the Alps, Andes, and other localities, which can be clearly proved to be of different ages. Now, we have two such granites within the area of the mountain nucleus—the coarse and the fine-grained—whose limits have been already described, and whose mineralogical differences, as originally recognized by MacCulloch, have been pointed out (Art. 46). It is with this latter, or fine grained variety, deficient in mica, that Mr. Ramsay's Ploverfield and our Craig-Dhu granite almost exactly agree (Art. 50, 51). Is it not, then, probable that these

three belong to one period of disturbance—that they were simultaneously injected amid the rocks which now enclose them, at a period subsequent to the deposit of the carboniferous strata? But the evidence for this conclusion is incomplete without a decided example, along the line of junction of the coarse and fine varieties in the interior, of veins from the latter penetrating the former. Such a case has never been seen by us, or recorded by any observer, as already noticed (Art. 46, p. 68). Its discovery would amply repay the trouble of a careful search, and render much more probable the posteriority of the fine variety. Much also depends on the view which may be taken respecting the rounded pieces of fine grained granite enclosed in the conglomerate, close to the Craig-Dhu granite (Art. 51). If our explanation of their occurrence there be deemed unsatisfactory, then will not the above conclusion hold; and it must be admitted that, before the irruption of the Craig-Dhu granite, the fine grained variety of the interior must have been elevated, stripped of its slate covering, and exposed to degradation.

54. What, then, it may be asked, is the conclusion which we favour, and to be finally drawn from these various and somewhat conflicting statements? The discussion may seem tedious and unimportant to many; yet we hope it will not be without its use to the student and future inquirer; and as several of the facts are new, it may have some value in the eyes of the many geologists in this and other countries, who have either written upon the subject or take a lively interest in the physical history of this extraordinary island. The question of relative age is, we hope, much narrowed by these statements, but for the present must remain unsettled. The various possible conclusions may be set forth, by way of recapitulation, as follows:—

1. The oldest rock in the island is the slate.
2. The old red sandstone and the carboniferous sandstones, with their intercalated limestones and coal strata, were formed before the granite was exposed to disintegration, the only fragments of this rock yet found being those in close proximity to the Craig-Dhu mass, of which they are probably injected pieces, and not derived from the disintegration of a granite already exposed.
3. The injection of the granite of the nucleus, that is the coarse grained or Goatfell granite, in a molten state, amid the slate strata, was certainly posterior to the deposit of the old red sandstone, and may have been posterior also to that of the carboniferous strata.
4. If the granite of the nucleus be thus of later age than the carboniferous strata, then may all the three granites be of one age, such

differences of mineral structure, or aggregation of parts, being often seen in granites certainly cotemporaneous.

5. But as the coarse grained granite cannot with certainty be pronounced newer than the carboniferous strata, while the Craig-Dhu and Ploverfield undoubtedly are so, then we may have two ages for these outbursts—one for that of the granite of the nucleus, and another for that of these latter.

6. The constant character of the fine grained granite of the interior, through a considerable area, and its subordinate position to the coarse, point to a later origin than that of the latter; while its almost perfect identity in structure and arrangement of parts with the other two granites render very probable the cotemporaneity of these three, and their posteriority to the coarse grained variety. This conclusion, which is extremely probable, and to which we chiefly incline, would be greatly strengthened by finding decided veins of the fine variety penetrating the coarse, along the line of junction. The mere occurrence of veins of fine grained granite amid the coarse variety is insufficient. Their connection with the inferior masses, and alterations at the line of contact, similar to those at the slate junctions, are the points to be determined. Already, we think, sufficient evidence has been set forth (Art. 46, p. 68), to show that this fine grained granite is not the newest rock in the island, but is older than the traps and porphyries.—To a short history of these we now proceed.

The Trappean Rocks.

55. Arran is extremely rich in rocks of this class; most of the known species occur, and also those numerous varieties by which these graduate into one another. They form great overlying masses, capping the sandstone of the southern plateau, and rising into the highest hills of this division of the island. They are interposed amid the sedimentary deposits, in huge sheets or beds conformable

Relation of the Igneous and Sedimentary Rocks.

to the stratification, and cut through all the rocks alike, from the lowest to the highest, in vertical or slightly inclined dikes, which range continuously across great horizontal distances, in one uniform direction. These dikes are never observed to wedge out downwards; and no doubt they descend into the hypogene depths, where sheets

of molten matter still exist, concentric with the crust—the common source whence they all proceeded, and whose vents or outlets these dikes once formed, in past stages of the earth's history, when the various rocky materials were elaborating beneath the primeval ocean. The pressure of a great depth of that ocean, or of other strata, amid which they were poured out, gave these various igneous products that density and compactness, which constitute almost the sole differences between them and the modern products of fire thrown out under the pressure of the atmosphere only. They differ little in their chemical composition—mainly in that arrangement of component parts which would be given by different rates of cooling from a state of fusion, to which reference has been already made in previous portions of these notices (Art. 31, 37, 40).

56. The trap rocks of Arran may be ranged under three classes,—

The Felspathic, comprising porphyry, claystone, compact felspar, and pitchstone.

The Hornblendic, as basalt, greenstone, clinkstone, and amygdaloid.

The Hornblendo-felspathic, as syenite and trap-porphyry.

These are all intimately connected, one species often passing into another by regular gradations, and they are all found in the same relative positions with respect to the sedimentary strata. Among themselves they do not preserve any order of succession, nor do they occupy separate areas, so that their continuity cannot be reckoned on through a considerable space. Nor can they be indicated on a map by distinct colours, so intimately are they blended with one another. Basalt, greenstone, and trap-porphyry are by far the most abundant, as well in overlying masses as in dikes and interposed beds. Porphyry is next in abundance, and occurs in all these positions; pitchstone alone has not overflowed the surface, and occurs only in dikes and beds. The overlying masses are limited to the southern section of the island, while dikes occur everywhere, not however with the same frequency in all parts. On this subject Professor Phillips was, we believe, the first to offer a good generalization:—"Dikes are most abundant at some distance from the granitic centre. At Corrygills, at Lamdash and Tormore, they are exceedingly abundant in the red sandstone, while in the north-eastern face of the island, where that rock is nearer to the granite, fewer dikes appear; and about Loch Ranza the slate is still less divided by them. Perhaps we may venture to add another generalization,—viz., that these dikes are most abundant beyond the line of violent flexure of the strata from their horizontal position.

After measuring with care the directions and breadths, and noting the characters of forty-four dikes, chiefly of greenstone, between Brodick and Lamash, and also those at Tormore, it did not appear to us that any other dependence of the direction of these dikes upon the local centre of the granitic eruption could be traced.”—(*Man. of Geol.*, 1855, p. 505.)

Rocks of the felspathic types, which are most closely allied to granite, seem to have no more intimate relation to the granitic centre than have those of the hornblendic. The largest body of porphyry on the island is that of Leac-a-breac, on the south-west; the next in extent is that of Dunfion, over the Corrygills shore. A similar rock occupies a small space on the Windmill hill, over Glen-cloy, in close connection with the Ploverfield granite. A different variety forms the bold precipices of Drumadoon, on the west, and the principal mass of Bennanhead, on the south. The largest body of claystone forms the middle and upper portions of Holy Isle, and has a thickness of nearly 900 feet; extensive beds and dikes of the same substance are met with in Lamash river and at Blackwater-foot; lesser veins and beds in many other places. All of these cut through or overlie the carboniferous formations of the southern section of the island; the northern section, the region of granite, slate, and old red sandstone, is almost devoid of these felspathic rocks; a few dikes only are met with; almost all those in this tract being of hornblendic rocks. The pitchstones also, exclusive of those in the granite, are almost all met with in the neighbourhood of Brodick, and towards Mauchrie water on the opposite shore. These various felspathic rocks thus seem to correspond pretty nearly on opposite sides of the island, and to have no relation, in their position, to the granitic nucleus. Neither does there seem to us any good foundation for a generalization put forward by some writers on Arran, that rocks of this type are more abundant on the western than on the eastern side of the island.

Overlying rocks purely hornblendic, as basalt and greenstone, occur chiefly over the central and south-eastern portions of the southern plateau, south of the parallel of Lamash. North of this line too great an extension has been hitherto given to these rocks; they merely cap the sandstone in isolated knolls or narrow bands of inconsiderable thickness. The details regarding these, as well as the felspathic rocks, will be seen upon the map, and will be more fully noticed in the several “Excursions” which follow. Under the same head we shall notice the changes made by the dikes on the adjoining rocks.

In Arran, as elsewhere, almost all the dikes are simple—that is,

composed of one kind of rock ; while a few, of which the most remarkable are those of Tormore, are composed of parallel bands of different substances. By far the greater number, in every part, consist of common trap, that is, some variety of greenstone or basalt.

57. M. Necker, who visited Arran in 1839, carefully measured the direction by the compass of a great number of dikes seen along the eastern shore and in the interior, and laying these directions down upon a map, he identified a great many of them at remote points. Such continuity has been often made out through distances greater than the whole length of Arran ; but we know of few tracts pervaded by dikes, where the same caution is required in drawing such conclusions, on account of the varying directions of the dikes, and the undulations to which the same dike is subject. The prevailing direction is towards the north-west and north-east quarters, and nearly within the limits between which the magnetic needle is known to vary. Yet are there many which range without these limits, and not a few have a direction nearly due east and west. Most of the dikes are vertical ; those which are inclined to the horizon seldom pass an angle of inclination of 20° . M. Necker estimates the number of dikes between Loch Ranza and King's-cross point at 200 ; the number to the south of this, on the east coast, at 144—making a total of 344. The remaining portion of this estimate we give in his own words :—

“ Mais l'évaluation précédente ne comprend que les dykes de la surface d'une moitié environ de l'île ; tout l'intérieur de la partie meridionale n' y est pas compris, non plus que la côte N. O., ni le groupe granitique de Ben Vearan entre cette côte et la rivière Irsa ; et quoiqu' il soit connu que l'intérieur des terres renferme toujours moins de dykes que les côtes, et que la côte N. O. est en général très dépourvue de dykes, quoiqu' enfin cette moitié de l'île soit bien plus petite que cette que j'ai parcourue ; omettant ces circonstances je porterai pour elle un nombre égal à la première—soit 344, formant un total de 688, ou, en nombre rond, de 700 dykes de trap dans la totalité de l'île de Arran. Doublant même encore ce nombre si l'on vouloit, pour y comprendre tous les dykes cachés par les bruyères vastes et étendues dans l'intérieur, par les grèves de sable sur les rivages, ou placés dans des recoins inaccessibles des montagnes, on n'arriveroit pas encore au nombre de 1,500 ; et pourtant en parlant de telle ou telle côte, de telle localité d'Arran, il est souvent échappé à ceux des géologues qui ont décrit Arran, à moi-même peut-être tout le premier, de dire qu' on y voyoit des *innombrables* dykes de trap. Or, je crois avoir maintenant montré que, loin de ne pouvoir

être comptés, on peut à présent concevoir l'esperance de voir chacun des dykes de cette île individuellement étudié, numéroté, décrit et enregistré dans un catalogue descriptif et raisonné, analogue à celui que j'ai aujourd' hui l'honneur de mettre sous les yeux de la Société Royale."*

We are not able to state how far this estimate may be correct. No one has followed out the suggestion made in the last sentence; the labour implied in the inquiry would scarcely be rewarded by the scientific value of such a catalogue.

Mr. James Napier, of Glasgow, has published a short paper on the dikes between the bays of Brodick and Lamlash in the *Edinburgh New Philosophical Journal*, New Series, vol. ii., No. 1, July, 1855, accompanied by a map, on which the dikes are laid down. He reckons altogether fifty-four dikes as visible along the shore, but considers that not a few may have escaped his notice. "Struck," says Mr. Napier, "by the large number of trap dikes cutting through the sandstone, in a direction at right angles to the sea line, it occurred to me that if such dikes continued round the coast to Lamlash, and still at right angles to the sea line, they must in all probability have proceeded from a common centre, lying somewhere between the two bays." To test this idea by observation, he measured and marked down the position of every dike, and the result confirmed his "anticipation, that they proceeded from one, or possibly from two centres." A similar idea would be very likely to occur on examination of M. Necker's map, which certainly Mr. Napier had not seen, else he would have mentioned it. The notion of radiation from a common centre we do not, however, find alluded to in M. Necker's paper. Mr. Napier seems disposed to assign two centres—one for the felspathic dikes, and another for the hornblendic—both lying inland towards the Lamlash road. Prolonging the directions of the two principal felspathic dikes on the shore, he finds that they would meet near the claystone quarry on the Lamlash road, about a mile from Springbank; and here he would place the felspathic centre; the hornblendic he does not so definitely fix.

Now, analogies in support of this view can certainly be drawn from districts of recent volcanic action, where fissures radiating from a vent, or focus of disturbance, are seen to be filled with basaltic lava and other igneous matters; and the same may doubtless have occurred

* Documents sur les Dykes de Trap d'une Partie de l'île d'Arran. *Transactions of the Royal Society*, Edinburgh, vol. xiv., Part 2, 1840, p. 684. Extra copies of this paper and accompanying map were thrown off, and are still to be had. It is a model of patient and generally accurate research.

in the case of the plutonic rocks ; but the evidence for it in Arran we cannot consider sufficient. There are many exceptions to the rectilineal course of dikes here as in other places ; some of the dikes converge towards the Corrygills shore, and the largest runs a long way parallel to it, while one at least re-appears far inland beyond the place of the supposed focus. Besides, so far from "the whole of the hills between Brodick and Lamash being composed of trap," this rock is, in point of fact, confined to a narrow and thin capping along the highest ridge between the two bays ; and Mr. Napier has overlooked the great outburst of porphyry at Dunfion, which has a manifest relation to the felspathic dikes on the shore, as well as the numerous masses of claystone intercalated amongst the sandstone strata along the northern slopes west of Corrygills.

On these grounds we cannot admit that this speculation has any value ; the apparent radiation arises from the circumstance already mentioned, that the vast majority of the dikes range between the points of extreme magnetic declination east and west. Some other suggestions, however, of this paper have great value ; those, namely, of a chemical nature, referring to the different degrees of fusibility and rates of cooling among trappean rocks, which, if carefully followed up, and experimentally illustrated, might lead to the elucidation of many points still obscure in the natural history of the hypogene igneous formations.

Glacial Phenomena.

58. The various accounts which we possess of the geology of Arran, and the separate memoirs upon it, were written before glacial action had been recognized in the production of superficial phenomena ; and we are not aware that any geologist has since turned his attention to the subject. Those phenomena, indeed, had been observed of which the ice theory is now considered to offer the most satisfactory explanation ; but the island has not hitherto been examined with the view to discover the direct evidence of the action of ice, such as striated and polished rocks, and "roches moutonnées." Visiting Arran in 1855, after having spent two months of the previous summer in a district abounding in unequivocal evidences of such action, I felt the greater confidence in undertaking this task. The result may now be briefly stated ; details being reserved for the notices regarding particular tracts, which will be given farther on.

The remarkable peak of Cior-Vor, whose altitude is about 2,500 feet, has been already (Art. 43) pointed out as the geographical centre of the northern group of mountains. From its base the four great

valleys of the island, Sannox, Rosa, Iorsa, and Eis-na-Vearraid, radiate in all directions, their extremities opening on the seaward belt of low land. If glaciers ever existed in Arran, under the subarctic climate to which Scotland was once subjected, these central heights must have been the seat of the snow-fields which fed them, and the radiating valleys the channels down which the viscous mass of glacier ice must have pushed forward to debouch upon the low ground, and melt under a higher temperature. On the sides, then, and towards the openings of these valleys, we should expect the effects of glacial action to be most distinctly traceable in the striation and polishing of the subjacent rocks and transported masses, and in the formation of lateral and terminal moraines. Many broad surfaces of the natural rock are exposed both on the sides and in the bottoms of these valleys, favourably placed for receiving such impressions under the grinding action of a descending mass; yet have we failed in detecting more than a few cases of striation and polishing, or of that "moutonné" character of surface, which is referable to the action of moving ice. A granite surface is, however, very unfavourable for the preservation of such markings, especially the Arran granite, which is generally of such structure as to be subject to rapid disintegration. The slate is better fitted to retain impressions of this kind, its toughness and fine-grained structure rendering it less liable to decomposition; but it is seldom exposed in favourable situations, and is rarely found striated. Granite bosses in the glens, and on many of the lower ridges, have that peculiar rounded character, due to the action of ice, to which the term "roches moutonnées" has been applied; but perhaps none of the cases can be decidedly referred to glacial action, on account of the peculiar spherical structure so often assumed here by granite on the large scale. On the slate ridges, however, beyond the granite border, some well marked cases do occur, as on the plateau to the south-west of Goatfell. We have already in previous articles called the attention of the student to many undoubted instances exhibiting these appearances much better than anything in Arran.

But though these more direct evidences are so rarely met with here, there are others scarcely less satisfactory, and of more frequent occurrence. These are the terraces and mounds of transported materials on the sides and at the openings of the glens, and the dispersed blocks in every part of the island.

The terraces and mounds consist of earth and rounded masses of rock, irregularly mixed without reference to weight, and in such

situations, that they could not have been brought together by existing river action, being much above the level of the streams which now traverse the valleys. They are most probably referable to glacier moraines of two classes—the lateral and terminal—formed by masses of rock descending from the highest peaks, and thrown to either side by the movement of the ice, or deposited at the extremity of the glacier when the ice melted. The former have been much modified by torrents entering from the sides, after the glaciers disappeared, and now present but detached mounds. In some glens, however, as Sannox, terraces yet remain complete, but not of great extent. The terminal moraines are better marked, fine examples being visible at the mouths of Glen Iorsa, Glen Catacol, Glen Rosa, and others. The remarkable terraces at the opening of Glen Catacol skirt the valley on the south-west, at a height much exceeding any level the stream could now reach by the joint effects of floods and high tides, and indeed surpassing that which it could ever have attained even when the sea covered the present maritime belt or terrace. We are therefore inclined to regard these mounds and terraces as terminal moraines, modified in their outlines by floods, tides, and ordinary river action.

Still more remarkable are the lofty terraces at the mouth of the river Iorsa; they are far more striking, indeed, than anything of the kind in Arran. They consist throughout of transported materials, some of the rocky masses being very large; the sides are steep and the summits usually flat; and the height of the highest is sixty or seventy feet above the river, and at least thirty above the ancient sea level just alluded to. Speaking of these (Iorsa and other such mounds) in reference to river action, MacCulloch remarks:—"The origin of such alluvia is very obscure—a few may have been deposited in particular situations by the same waters which are now removing what they formerly laid down; while in other cases it is impossible to assign any mode of action by which this double and opposite effect could have taken place from one agent. . . . The quantity and quality of the materials, their extremely rounded forms, the nature and permanence of the hills above, and the want of a regular gradation of size in the stones from the bottom upwards, seem to show that other causes [than river action] of a transient, and probably of a diluvian nature, have in distant times generated those deposits, which have been subsequently acted on by the stream concentrated on the bottom of the glen by the form of the ground." —(*Western Isles*, ii., 335, 1819.) The difficulties of these cases had thus presented themselves to the mind of this distinguished geologist,

and he offers for their solution a *vera causa*, one certainly capable of producing such appearances. At that time glacial action had not been recognized in these countries ; and he offers the best explanation that could then have been given. The action of ice is, however, more simple, rational, and consistent, not only with these appearances, but with others to be presently mentioned.

Similar mounds occur, but not in the terraced form, at the openings of Glen Sannox and Glen Rosa, much elevated above the river beds. Some way up the latter, also, there are remarkable mounds, in a situation where, from a great bend in the glen, we should expect a moraine to be thrown down. Many other examples might be given ; but it is unnecessary to refer in greater detail to phenomena of this class. A closer examination of the contents of the mounds and terraces, which are limited to the rocks of each particular glen, has led us to modify the view already expressed (Art. 13) regarding their origin. We admit, however, that the few decided cases of striation, such as are so frequently and distinctly marked in the valleys of the lake district of Cumberland, radiating in all directions from Great Gabel as a centre, or, as are already noticed by us regarding the West of Scotland (Arts. 10-13), goes so far against the glacial theory as applicable to Arran, and in favour of the idea that the mounds and terraces in question were formed when currents swept these glens, during the gradual elevation of the land. That such elevation may have been a long continued process we have already seen reason to suppose (Art. 52, 53) ; and the effect must have been a general disturbance in the sea bed, which, joined to the action of tides produced then as now, could not fail to give rise to currents of considerable force. Where these met the sea towards the mouths of the glens, banks and terraces may have been thrown up ; or a sudden elevation of the land of a cataclysmal character may have given origin to long continued currents of sufficient force to transport large blocks, and to throw down a promiscuous deposit, such as we find in the mounds and terraces of the mountain glens. Such sudden elevations of a range or group of mountains are still regarded by many geologists as the true explanation of the " diluvial phenomena ;" and it was such probably that Dr. MacCulloch had in view when he spoke, in the passage above quoted, " of other causes, of a transient and probably of a diluvian nature," as giving origin to the remarkable accumulations at the mouths of the Catacol and Iorsa.

59. The dispersed blocks present phenomena still more curious and of much more difficult explanation. They are almost exclusively

granite, a very few only of slate being found. They are scattered in great numbers over every part of the island, and are often of enormous magnitude. They are most abundant and largest in the vicinity of the granite nucleus, as about Corrie and the shore at Corrygills; and generally less numerous, and of smaller bulk, in the remote southern districts. Occasionally, however, some very large ones occur even there. They are limited to no particular locality, but occur alike in the valleys, on the summits and northern and southern slopes of the hills, in situations to which they must have passed across deep and narrow glens. They are found also isolated on the Holy Isle, which is separated from the mainland by a wide bay, and two deep navigable channels. Blocks of the coarse-grained variety are much more numerous than those of the fine. The latter, indeed, are in a great measure limited to the tracts on which Glen Iorsa, the principal seat of this variety, opens towards the south; and this fact, in connection with the more sparing distribution of the blocks along the northern coast, on which but one glen with a narrow opening debouches, than in other parts of the island, shows that, though the dispersion has been quaquaversal, it has been to a large extent determined by the direction of the valleys. Dr. MacCulloch, who has noted the leading facts regarding the dispersion of the granite blocks with great accuracy, though imperfect in many of his details, closes his account with the following observations:—"None of the blocks have the marks of a distant origin; all have the characters of the granites of the adjoining mountains, characters sufficiently distinct from those of almost all the granites of Scotland. . . . No situation, perhaps, has been pointed out where the origin of the travelled blocks is more obvious, or their new position more difficult to comprehend, without assuming considerable revolutions of the surface of the land over which they have passed. . . . The compact and solitary position of the fixed mass of granite, the identity of the materials of this mass with that of the travelled stones, the gradual diminution of these as they recede from the parent rock, and the insulated position of the whole, render their origin indubitable, and present to the geologist a spot, on the changes of which he may speculate, with the certainty that he has before him a set of incontrovertible data from which to reason."—(*Ut sup.*, p. 341.)

This passage places in a clear light the conditions of the problem, and the difficulties attending it. The author does not, however, propose a solution of the difficulties, nor does he enter into any theoretical discussion. His account of the travelled blocks is the only

one which we have seen ; no other writer on Arran, that we know of, has turned his attention to the subject. It is hoped, therefore, that the notices now given will be the more acceptable.

In Arran, as generally in other districts, the boulders belong to a particular period. The entire system of rocky strata had been formed, and the existing inequalities of the surface established ; but in all probability the last upward movement of the land, to which we have already often referred, had not taken place. The relative age, in fact, seems to have coincided with that of the boulder clay of Scotland, or with the newer pleiocene era. Then, as regards the forces concerned, we know only two natural agents capable of producing the effects. These are currents of water and moving masses of ice. Now, the former are totally inadequate to carry forward masses of the enormous magnitude found here, or even to transport the lesser blocks over all the obstacles which they have surmounted, in their outward course from the parent rock. Besides, they are often found “perched” in situations where it is extremely improbable that currents could have left them, and also crowded together in groups in places quite open, and removed from the influence of eddies. It is true, indeed, that the origin of such currents can be readily accounted for, by movements which we know to have taken place—the elevation, namely, of the mountain nucleus from beneath the sea. We have only to suppose that it was sudden and of considerable amount, and we have at once generated a series of mighty pulses, which would carry the disturbed waters, with their load of torn off materials, along the surface of the lower lands, still submerged. Rocky materials may thus have been swept away, and re-arranged in new situations, valleys scooped out, and extensive denudations effected. But the forces thus brought into play cannot have been adequate to bear along the enormous masses, now far separated from the parent rock ; and therefore we do not hesitate, on this and the other grounds above stated, to conclude that moving masses of ice were the transporting agents. In the passage of glacier ice adown the valleys, and the buoyancy of floating bergs, forces of sufficient energy would be lodged to carry the largest masses ; and this agency we know, as already pointed out (Art. 11), is adequate to produce the various phenomena of transport, grouping, and “perched blocks.”

60. We must conclude, then, that the northern mountains formed a mass of ice-covered land, with glaciers in the valleys reaching the bold shores of the sea of that period. From the extremities of these, rock-bearing masses of ice, of which at least a few must have been considerable bergs, floated away, and stranding or melting, threw

down their load of blocks. Thus the shores of the island, and the southern plateau as yet under water, became encumbered with vast multitudes of granite boulders, chiefly of that coarse-grained variety constituting the highest mountains. The land, previously moulded into its existing outlines by submarine currents, was next permanently raised to that altitude which it retained for a vast period—certainly much more than 2,000 years (Art. 5)—till that final upward movement occurred which is marked by the present inland cliff.

Such is, we think, the only view which the phenomena admit of. Beset with formidable difficulties as regards every region, there are in Arran others of a special kind. As already remarked in the passage quoted from Dr. MacCulloch, the phenomena of Arran must be considered in their isolated aspect, and independent of the mainland. In the Grampians we have ample room in wide open surfaces for the support of snow-fields to serve as feeders of the glaciers (Art. 11). In Arran such spaces are limited to narrow and greatly inclined tracts at the bases of the higher central peaks, and above the cols between the glens, containing an area which seems too small for the support of such a snow-field. Yet we do not see what other hypothesis can be framed. The existing levels of the surface forbid us to suppose that the whole island, elevated as now, in both divisions alike, high above the waters, was wrapped in sheets of ice, across which the granite boulders, as they dropped from the high peaks, were carried onwards in all directions on a slowly descending viscous mass. A continual descent is required to effect such a transport; and this could not exist beyond the limits of the mountain nucleus; the boulders could not thus have passed to the heights of the southern plateau. This portion, therefore, we are constrained to admit, must have been wholly and deeply depressed below the level of the mountain tract of the north, on which the glaciers rested; subsequent elevations, marking probably the close of the drift period, established between the two portions of the island those *relative* levels which still subsist. But the present level of the shores was not yet attained, nor the actual coast outlines as yet carved from the rocky border which broke steeply down all round the island. The sea covered the plains of Brodick and Shiskin, and stretched its winding arms far up the solitary glens. During the slow progress of perhaps forty centuries, the streams from the rugged mountain sides and gentler hill-slopes bore down detritus of granite-sand, slate, and quartz pebbles, and spread them out below the waters of the quiet friths. In sheltered places the tides and waves cut a low

but well marked margin along the highest water line ; while on the open shores the heavier surge wore deeper, the hill-slopes were cut into a steeper and higher cliff, and hollowed out into caves in all the rocks alike. The testacea and other denizens of the present shores already inhabited the waters of that remote period ; but we have no evidence that man had yet appeared. It is most probable, indeed, that the last elevation of the land, to which we have already often alluded, took place before the human period. We are only certain, however, that all the existing levels were established prior to the Roman invasion. Here, as generally in the west of Scotland, this last elevation amounted to twenty or thirty feet, and gave to Arran its present maritime border, and the inland cliff which forms a singularly picturesque feature in its coast scenery.

EXCURSIONS IN ARRAN.

EXCURSION I.

TO THE SUMMIT OF CIOR-MHOR.

61. THIS shall be our first Excursion. It will reveal to us the structure of the granite nucleus, and the relations of the mountain groups. It will show us the basset edges of all the strata as we pass in succession across them to the central granite. We shall see some curious dikes, explore a lonely corrie, climb a high pass, and thread a difficult pathway by the edges of the highest cols. The morning clouds have melted from the peaks; there is neither bank of mist nor cirrous haze to veil the far-off horizon; the day will be calm and bright, and the view from the summit glorious. Cior-Mhor (Kior-Vawr) is that far-off peak, with sharp point and rugged shoulders, rising behind the plateau on the south-west of Goatfell. We shall reach it by a walk longer and more difficult than the ascent of Goatfell, and the more exciting that it is somewhat dangerous. Should a mist happen to surprise the tourist upon certain portions of the route, his situation might be very critical. How promising soever the day may be, let him never enter these mountains without a pocket compass. The mists come down so sudden and so thick in this changeful climate that without it he will be bewildered and lost amid the high cols and peaks, and huge slippery granite sheets. With ordinary caution, and the use of a correct compass, he has nothing to fear. True, he will find neither house nor herd's shieling within the mountain circuit; but directing his steps by the compass, he cannot fail, in a walk of two or three hours at the utmost, to reach the inhabited border, where a frank welcome will meet him at every cottage door. Let it be remembered, however, that the variation of the magnetic needle in the west of Scotland is now about 24° west of true north. To the geologist we would recommend to carry, besides his hammer, indispensable at every step, a good clinometer with which to note the varying dips and

inclinations of the slate and sandstone, and the relations of these to the granite centre and the numerous dikes.—On this and most of our Excursions our departure will be taken from the shores of Brodick bay, the unrivalled grandeur and beauty of which attract the greatest number of summer visitants. For a few days' sojourn new inducements are now afforded by a fine spacious hotel on a beautiful site at Invercloy, on the south side of the bay. Here and at several other points on the east coast steamers call six times in the day during the summer months.

62. The rock on the shore at Invercloy is a conglomerate of the age of the coal—a member, in fact, of the coal formation. Murchison, Sedgwick, and Ramsay have classed it as a lower member of the new red; but, as already stated (Art. 48), on evidence which we think inconclusive. The inland cliff marking the old coast line is well seen on the Invercloy shore, and extends far up both sides of Glencloy. The lower part of the glen, much of the plain of Brodick, and the marshy grounds at the head of the bay, are but an expansion of the terrace which formed the sea bottom, when the tides and waves were carving out the cliff. The alluvium and rolled stones form, however, but a thin covering to the subjacent sandstone, which appears in the river bed a little way up the glen. On the north-west the sandstone is quarried upon the line of cliff, and forms a tolerable building stone. The dip is nearly south, at about 25° . By the side of Brodick wood, adjoining the handsome new school house lately erected by the Duke of Hamilton, a vein of pitchstone occurs in the sandstone. The contact is not seen at either surface, so that the thickness cannot be ascertained; a portion only of the front appears by the side of a lane, showing a prismatic structure in the rock, and an underlie in the vein towards the west. In large blocks lying loose upon the surface in the course of the vein, which here seems stript of the sandstone through a considerable breadth, a similar structure is seen. The colour is bottle-green, and specks of red felspar disseminated in the base give the rock a porphyritic texture, approaching that of pitchstone porphyry. The direction is nearly south-east and north-west; but the vein cannot be traced either way beyond the limited portion here exhibited. It is probably a continuation of one of the many beds or veins of the Corrygills shore, which we shall notice in another Excursion. A dike of disintegrating ironshot greenstone, forming a bank behind the school house, has an angular course with respect to the vein; but the nature of the ground does not permit their connection to be observed. In the opposite direction the dike intersects the inclined strata of sandstone,

but no marked change is produced. It is in excellent taste that the striking geological features of this spot have been left untouched in carrying out the improvements connected with the erection of the school house.

By the wayside here, where a sweep of the road gradually opens to us one of the finest views in Arran, there stands a huge upright stone, marking, perhaps, the spot where a chief was interred, or where a leader fell in the old days of feud and warfare; or mayhap the scene of some decisive battle with the old Norse invaders. Many such stones are found in the island, but their purpose and date of erection are wholly matters of conjecture. There are several in this immediate neighbourhood; on the high ground south of Invercloy, and on the plain of Glenshant, between the mouth of Glen Rosa and the site of the old village of Brodick. A complete circle of such stones formerly existed at the mouth of Glenshirag; it is briefly noticed in Mr. Headrick's book; but not a vestige now remains; in 1813 the stones were broken up and removed, to make way for the operations of the plough. In 1836 a farmer, not less gothic in his ideas, removed a double circle of such stones from the farm of South Sannox, and used the materials in the erection of a stone fence. A single pillar still remains in front of South Sannox house. In most places where we examined these stones, we found them to be coarse sandstone of the old red formation. As this does not exist in many of the localities where the stones now stand, we must conclude that mechanical appliances of great power were brought to bear in their transport; and therefore it is not wonderful that, in a rude age, their erection was ascribed to the hands of giants. In all ages the illiterate observe facts and phenomena with tolerable accuracy; but their explanations always introduce the marvellous or the supernatural. The subject will be again referred to in our notice of Tormore.

63. There are two paths to the entrance of Glen Rosa; we take that which passes Brodick chapel, and crosses the opening of Glen-

shirag. The chapel stands on a platform, bounded northwards by a low cliff of sandstone, and overlooking one of the most varied and pleasing views in Arran. In this sandstone, underneath the north wall of the chapel enclosure, there is a bed of carboniferous limestone in a vertical position. It has been largely quarried, and a small portion only is now visible. It contains fossils, of which the most characteristic is the *producta gigantea*, completely identifying this bed with the limestones of Corrie, the Salt Pans, Bein Lyster glen, &c., and enabling us, therefore, to assign the sandstone also, without hesitation, to the age of the coal formation. A little farther on, above a rustic bridge, where the Shirag burn, rushing out from a winding rocky gorge overhung with trees, forms a scene strikingly picturesque, another bed of limestone occurs in the sandstone. Thence to the entrance of Glen Rosa, we pass across the lower beds of the carboniferous formation, which, however, are nowhere seen except in spots in the bed of the Rosa burn. The succession of the strata is shown in the annexed cut.

(a a) Sandstone and conglomerate; (b) *producta* limestone; (c) old red sandstone; (d) schist; (e) granite.

We now reach the outer edge of the band of old red sandstone, which, ranging from the Corrie shore diagonally by the flank of Goatfell, crosses the opening of the glen. It is seen on rocky prominences by the side of the path, but no junction is visible. The beds here exposed consist of a dark-coloured, close-grained sandstone, with specks of mica, bits of quartz, and small clay-galls, and are very characteristic of the upper portions of the formation. The lower portions are seen farther up the glen, but at some height on either side, in the wood and moor on the left, and the hill-side on the right. They are very coarsely conglomerate. Specimens of both varieties may be seen in the stone fence by the side of the wood.

The alluvial mound at the entrance of the glen has been noticed already, as most probably the terminal moraine of a glacier which once filled the valley. It is precisely in the position where such a moraine would have been thrown down, and consists of such materials as the ice would have borne forward; and its height, fully thirty feet from the bottom of the glen, places it far above any existing river action. Not knowing its height above the sea level, we are unable to say whether its accumulation may not have been

due to combined sea and river action before the last elevation of the land took place. It seems to us, however, to be higher than any level the waters could then have reached. It appears to have extended, at some former period, entirely across the opening of the valley, backing against the hill side on the south, as it now does in the opposite direction, and forming the barrier which confined a lake, occupying at that period the lower portion of the glen. The bursting of such barriers, and their subsequent modification by floods in the river, are common phenomena in mountainous districts. Traces of a lateral moraine are seen on both sides; and farther up the glen, where it turns northwards, two other mounds, rising high above the stream, are in the position where a terminal moraine would be thrown down, after the ice had retreated from the lower part of the valley.

The discovery of an anchor in Glen Rosa, similar to those now used by the herring smacks which visit Brodick bay, has often been referred to as proving that, since the island was inhabited by a people far advanced in civilization, the sea filled the valley, and afforded a "trustworthy station for ships." That an anchor was really found, brought to the smithy at Invereloy, and worked up into various articles, we think there cannot be a doubt, from the accounts given by several persons still living, who saw it and handled it. All agree, however, in fixing the locality in which it was found at a place where peat is cut, at a considerable height on the southern hill side, and therefore far above the level at which the waters of the sea stood before that last elevation of the land to which we have so often alluded already. If the discovery, then, be admitted as a fact by the archæologist, it is entirely without that geological significance which attaches to the Clyde canoes. With the archæologist the explanation may be left.

64. The contact of the lower old conglomerate with the clay slate is not seen in Glen Rosa. The latter rock first appears in the bed of the stream, at the sharp turn where it begins to flow eastwards; but the junction must be farther down the burn. The slate rises high into the hills on both sides, forming on the north the principal mass of Glenshant rock, called also the Pillar, from a large isolated sheet or prism, standing out detached from the front of the bold cliff. The precipice is about 1,000 feet above the river, and forms one of the finest features of this noble glen.

We now approach the base of the series, where the central granite rises from beneath the enveloping slate rocks; and here a celebrated junction occurs in the bed of the stream. The hill sides show the contrast of the two rocks from a great distance, in the bare stony

character and loose gray blocks on one part, and the grassy or heath-covered slopes, with dark terraced ledges, on the other; and the geologist is therefore prepared to find a junction somewhere here in such a natural section as the river affords. It occurs about two or three dozen yards below the point where the Rosa burn receives from the west side its only tributary—the Garbh-Alt or Rough burn, which drains the whole eastern side of the Ben-Ghnuis range, and comes down into the glen, bounding headlong across the huge granite sheets in a series of striking falls. The junction has not been so well shown these few years (1855-58) as it was formerly, in consequence of the accumulation of loose masses of granite; still it is sufficiently well seen to make the place interesting and instructive in a high degree, and some future floods in the river may again open it better up. The slate is greatly altered for a considerable distance down the stream, and pervaded by small veins and strings of quartz, and granite in which quartz predominates. The colour of the slate is changed, having more of blue than is usual to it; the structure is altered also, the laminæ are contorted and present thin bands of different colours, chiefly blue and gray; the latter being purely siliceous, that is, flinty slate or quartzite without the colouring matter, iron or manganese, which exists in the former. The slate on this side of the mountains is generally a dark-coloured coarse siliceous rock, showing shining crystalline flakes in fresh fractures; in some places assuming that arenaceous semi-conglomerate structure which used to be designated as greywacke. Both structures are obliterated on approaching the granite; the colour is bluish, or blue and gray in alternate bands, the structure is extremely fine-grained, and the hardness and toughness are both excessive. These changes, the contortion of the laminæ, or the total disappearance of all stratification, coupled with other modifications not seen here, but to be again noticed, clearly indicate that the schist to a considerable distance from the granite was subjected to intense heat, and remained in such a state of at least semi-fusion as to permit, under the action of chemical forces, a new arrangement of parts, and the permeation and interlacing of veins from the molten rock below. The granite veins are less numerous, smaller, and of varieties differing from the ordinary type of this rock more than is usual in most other junctions with the slate; such might perhaps be seen in the interval of several yards here obscured before the granite itself is reached. The great extent of the altered slate seems to indicate that the strata near the junction are of inconsiderable thickness, and that the granite exists beneath at a small depth, as shown in the

illustrative cut at *e*. The slate is here traversed by a basaltic dike, still further modifying its altered structure. The dike intersects the bed of the stream at a small angle, but is seen only on the east bank ; it ranges about magnetic north and south, and has a breadth of ten or fifteen feet. We shall meet with it farther up the glen on another Excursion. Rising from the bed of the stream in great rhomboidal masses, divided by partings here inclined towards the slate, the granite extends in a slanting direction up the hill towards Goatfell, and on the opposite side by the Garbh-Alt burn, so that the line of junction almost coincides with the southern margin of the stream. The remaining part of our walk is entirely on the granite.

65. Our path now lies up the steep slope forming the western side of the glen, a little to the north of the Garbh-Alt, which we keep on our left hand. Having reached the summit level we are on the southern slope of the high rugged ridge called Ben-Talshan, which forms the western boundary of Glen Rosa. In the hollow between it and the lower swells of the Ben-Ghnuis range, the Garbh-Alt pursues its rapid course from north to south, along a granite bed, down a pretty fall, and then between perpendicular walls of granite about twelve feet in height, till, escaping from this rocky barrier, it sweeps round the south end of the ridge, and plunges headlong into the depths of Glen Rosa. The gorge has been excavated along the line of a basaltic dike, which occupies the bottom of the stream throughout, and retires from it at the base of the fall. These dikes, as already remarked (Art. 40), are prismatic across; and this structure renders their disintegration much more easy than that of the granite. The amount of wearing in this case is measured by the depth of the chasm, and the distance to which the fall has receded. The stream ran at first on the level of the top of the granite walls, and the fall must have been at the southern extremity of the chasm; the recession would cease, or become extremely slow, when the present situation of the fall was reached, as the dike here retires from the stream. The dike is ten to fifteen feet wide, and ranges nearly due north and south. The rocks adhere firmly at the junction, but the alteration on the granite is not remarkable. Similar cases of the excavation of river channels along the line of dikes are frequent in Arran. As a general rule, fractures or faults determine the course of streams in the first instance ; along such lines the excavation is much more rapidly effected.

The steep brow on the eastern side of the wide hollow where we now are, exhibits many rounded masses of granite, presenting the "moutonnée" character of surface, as if moulded by the action of

ice: but as no striæ were observed, we can hardly ascribe them to the action of glaciers, as the forms may be due to the effects of disintegration on the concentric structure upon the large scale, so often seen in granite. The bed of the stream, as we pass up, is strewn with many loose rounded masses of pitchstone and trap, indicating the existence of dikes or beds of these rocks among the lofty precipices on the west. Mounting this steep brow, to reach the corrie under the north front of Ben-Ghnuis, we meet with a dike of spheroidal trap in the bed of one of the streams; it is about seven feet wide, and ranges 35° W. of N. The rounded masses of granite here may have received their forms from the long continued action of water trickling over them, and torrents occasionally sweeping along gravel and large stones. Arrived at this corrie, we are in the midst of a scene wild, lonely, and picturesque. The bare and rugged precipices of Ben-Ghnuis rise high into middle air on the south, with their immense sheets and rhombic masses of granite, from six to twelve feet in the side, piled up, block on block, in massive courses, like the huge rough masonry of giants. The topmost row, broken by clefts and deep gashes, due to irregular disintegration, shows grandly in its perfect definition against the clear sky. Along the front, which sweeps round to form one side of the corrie, there stand out here and there enormous pillars of the rock, detached from the cliff behind, resting on a basis which is rapidly giving way under the active agents of waste in this changeful climate, and threatening a speedy descent into the valley of the Garbh-Alt. The rugged outlines of the Goatfell group bound our view on the east, the distant landscape being shut out by the intervening ridges; and the eye from this point does not take in a single human dwelling, or other sign of the abode of man. No sound reaches the ear but that of the crystal rills trickling from the clefts of the granite, the hum of insects on the wing, or the twitter of the solitary stone-chat, as it flits from rock to rock. The solitude is complete, the silence solemn and impressive. Our perfect isolation amid such a scene,—the vast dimensions of the objects around us, and their expression of power, are true elements of the sublime, and awaken the most pleasing and elevating emotions. There is a delightful consciousness of a new activity in the fancy, and an increased buoyancy and intensity in the feelings. To the geologist there is another source of the sublime in contemplating the effects of the mighty forces which have rent the crust of the earth, raised these mountain masses from the fiery depths beneath, and scooped the glens and corries out of the solid rock.

66. The cliff on the north side of the corrie shows some interesting dikes. One of these is of green pitchstone, and cuts the granite sheer through in a N. and S. direction from bottom to top of the cliff. It is four feet wide, prismatic across, and owing to the more rapid disintegration, depressed below the level of the granite. The contact does not present any peculiar change in either rock, such as invariably marks the planes of contact of pitchstone and the sedimentary strata. The pitchstone is decomposed into a thin white film in many places along the outer edge of the dike, next the granite, in consequence, probably, of the oxidation and removal of the iron which enters into its composition. The dike is in some parts of its course obscured by debris, but upon the whole is, perhaps, the best defined dike of this rock occurring anywhere in the granite of Arran. But phenomena of much greater interest will be again noticed in connection with other pitchstones.

Two basaltic dikes occur close together, about 100 yards east of the dike we have been describing; they traverse the granite precipice in the same manner, but in a different direction, their course being about 28° W. of N., subject, however, to undulations. These dikes are from 18 inches to 2 feet broad, and are separated by a granite band 8 or 10 feet in breadth; elliptic masses of granite, of which the largest we observed was about 18 inches by 9, are enclosed in the trap, but very little altered. The alteration, indeed, is nowhere remarkable, the granite being in some places coarse, in others fine-grained, along the planes of contact. Specimens may be obtained of both rocks firmly adhering.

Some pretty plants occur here in shady spots on the granite ledges, where a little soil has accumulated; they will reward the young botanist for his long walk to their secluded habitat. The *Sedum rhodiola*, *Oxyria reniformis*, *Saxifraga stellaris*, *Alchemilla alpina*, and several others, rejoice in the temperature and humidity which these heights supply.

To reach the head of the valley, and the first ascent of the Pass into Glen Iorsa, we now direct our steps along the base of the precipice, where the grassy tufts and granite debris afford a safe footing on the steep slope, keeping as high a level as possible, in order to shorten the ascent by which the summit is reached. As we pass along we notice several dikes of pitchstone and basalt, ranging north-westwards up the precipices on our left towards the summit of the ridge, and doubtless crossing down on the other side into Glen Iorsa; but we may not now delay to trace them. The Ben-Talshan ridge on our right, and that along which we have passed, coalesce at

the head of the valley, and their union is marked by a very steep grassy slope, encumbered with granite blocks projecting from the soil *in situ*, or deeply imbedded in it, but free from the huge flat and smooth sheets along which it is difficult and dangerous to cross. This depression or break is in the direction of the head of the valley, and owes its origin to a basaltic dike, which appears at the beginning of the ascent, and is seen to enclose masses of granite as in the case already mentioned. Its range is magnetic north and south, and width about twelve feet. The situation of the Pass to which we are now to mount, and which is fully 1,000 feet above us, is indicated by a bold rocky point, a little in advance of Beilach-an-id-bho, the last high summit of the Ben-Ghnuis range. Marking its position by the compass, and then pressing up the steep, we gain a wide and grand prospect from the summit of the Pass. Clambering to the top of the rocky point, we look down from a height of fully 2,000 feet into a nook or recess of Glen Rosa on one side, and into Glen Iorsa on the other. The descent towards the latter is easy; towards the former, it should not be attempted; for, if practicable, it is highly dangerous. From the Garbh-Alt valley, in fact, the only access to Glen Rosa is by the way we have come up.

67. We are now at the southern extremity of the Ceims (Kyims) which link on Cior-Mhor to the Ben-Ghnuis range. This is the ridge whose sharp and rugged outline, seen from the shores of Brodick bay, is well known as bearing a striking resemblance to the profile of a distinguished living statesman and writer. The ridge is formed by the edges of vast tabular masses or sheets of granite, inclined towards Glen Iorsa at a considerable angle, and cut sharply down on the side next Glen Rosa, so as to present towards it a continued precipice, formed of successive tiers of granite sheets and rhombic blocks. The jagged outline is due in part to the irregular wearing of the coarse-grained granite, but still more to the intersection of the ridge by a series of whin dikes. The horizontally prismatic structure of these subjects them to a more rapid decay than even the friable coarse granite; and hence most of the deep notches of this jagged ridge mark the situations of whin dikes. The fact is curious and interesting, and has not been before noticed. Ranging up the front of the precipice from Glen Rosa these dikes cut right through the crest of the ridge, and pass downwards into the fine-grained granite, which occupies most of the Iorsa valley, and rises up on the back of the Ben-Ghnuis range and the Ceims, as far as the level of many of the cols, that is, the lowest parts of the ridges between the glens. Here, then, we have a decided case of a system of

dikes common to both granites, and newer than either of them ; and a confirmation of the view already stated (Art. 46), that trap, and not the fine-grained granite, is the newest rock in the island. It seems highly probable, from the direction in which these and the other dikes already mentioned range, that they are the same as those which were found crossing the fine-grained granite tract on the west side of the Iorsa valley (Art. 46, p. 68).

68. The jagged and notched character of the ridge makes it impossible for us to pass along it on our way to Cior-Mhor ; neither can we safely cross the huge granite slabs at the back of the ridge, as they are smooth, slippery, and considerably inclined. But below these a safe, though rough and irregular pathway, will be found ; and from this we can occasionally pass upwards towards the ridge, along the clefts in which the dikes lie, to have a peep down into Glen Rosa, or to scan the frowning cliffs on the north side of Ben-Talshan. For the latter purpose a telescope will be useful. We must be careful, however, to return by the cleft by which we came up, till we reach the path. The granite sheets must not be attempted, as a single false step upon them might hurl the tourist with fearful velocity into the valley at their base, filled with blocks and debris. The range, width, and structure of the dikes are well seen as we pass along ; the width is various, in some 5 or 6 feet only, in others 10 to 12, and 15 to 18 feet. The broadest, being of this latter width, is one on the south side of the col, between Glen Rosa and Glen Iorsa. It consists of a crumbling greenstone, and ranges 29° W. of N. The others have various ranges between W. and N. Many small shining flakes of crystalline oxide of iron occur in the trap of these dikes. The ridge of the Ceims is composed of the coarse-grained granite ; but the path at its west base, along which we have come, is partly on the fine-grained variety. This appears generally at the height of about 1,600 feet on the cols, and on the west side of the ridge, but is not seen in Glen Rosa nor on Goatfell. It disappears on the ascent of Cior-Mhor, and is succeeded by the coarse-grained variety. The contrast is remarkable. The rock has quite a different aspect, a different feel under the hammer, and a peculiar style of disintegration, giving smooth outlines, and an entire absence of the aiguille-like highly picturesque forms, into which the coarse variety is resolved by the action of the atmosphere. The decomposition of both rocks conceals the contact, and we were not so fortunate as to discover anywhere the actual junction of the two varieties.—But the day is waning, and we have yet to scale the lofty peak of Cior-Mhor, shooting

grandly up 900 feet above the ridge on which we stand. Though right to the summit "we might press, and not a sigh our toil confess," we must pause now and again to mark the ever-changing features of the magnificent scene gradually opening towards the west and north, and the new aspects in which the rugged crest of the Ben-Ghnuis range now appears. We must note, too, the change in the rocky floor over which we are passing. We leave the fine-grained granite on gaining the foot of the steep ascent: thence to the summit the mountain is composed wholly of the coarser kind. It is disposed in irregular tabular masses, split up into rhombic or cuboidal forms by fissures, independent of disintegration, and coeval with the solidification of the rock. The thinner masses we have called sheets; in both the divisional planes separating mass from mass, and the fissures perpendicular to them, are alike the result of crystallization on the large scale, and bear no analogy to stratification, which is the result of sedimentary deposit. The disintegration of granite, porphyry, and other igneous rocks, is mainly determined by these lines of separation; in some granites, but more remarkably in porphyry and trap rocks, by the concretionary structure, already referred to in the case of the latter (Art. 31); and which has resulted from the mode in which the crystalline centres of affinity develop themselves at the first parting of the heat of fusion, in a melted mass beginning to solidify. The schistose and prismatic forms, under which granite often appears, are but slight modifications of the forms already noticed, depending on the relative position of the divisional planes. The schistose form has often been described as a true stratification; but this structure is not continuous in one direction as strata are, nor does it exhibit the fracture or incurvation of beds; it is in truth but a local modification of the rhombic or cuboid form, under which granite more frequently appears.

69. The summit of Cior-Mhor, narrowed by distance into the form of an alpine aiguille, we found to be an irregular elongated plateau, large enough to accommodate a small pic-nic party. The rugged shoulders flanking the peak are huge rifted masses of bare rock, separated by clefts which descend far into the heart of the mountain. On three sides are inaccessible precipices; the ascent is possible from the west side only. Thrown forward on a salient angle of the western ridge, and little more than 300 feet lower than Goatfell, Cior-Mhor affords a commanding view of the ridges and dividing valleys, the peaks and precipices of this singular mountain group. Its situation as the geographical centre of the tract has been noticed already, and the relations of the various ridges pointed

out (Art. 43). Viewed from the summit where we now stand, the scene is very wild and grand. The ridges swell up steeply and nobly in front of us, from the very depths of the glens, in their majestic forms of "peril and pride," and stretch away on either hand, shooting up here and there into the highest peaks, and cut, in lower parts between, into spiry fantastic crests. The craggy precipices and long steep fronts of naked rock have an imposing expression of sternness and power. Crowning the ridge of which they form the lateral supports, Goatfell presents on this side its grandest aspect. The eye, from its elevation, takes in under a large visual angle the entire western steep from the summit of the mountain to the bottom of the glens. On the north side of Glen Sannox the ridge of the Castles and Suithi-Fergus starts up with little less of suddenness and grandeur. Lying deep down at the foot of these lofty ridges, and closed in on the south-west by the high mountain on which we stand, Glen Sannox has an air of singular loneliness and solemnity. The same breadth of form and grand scale of parts are found nowhere else in Arran;—the very simplicity of the composition is one of the greatest charms of the glen. The silver thread of its river, meandering far out eastwards, leads to the world of life without; and the gentle murmur of waters, stealing up from its sombre depths, breaks pleasingly the awful stillness of the summer day on these high peaks.

We have attempted in preceding paragraphs (pp. 69, 76, 77), to indicate the successive steps of the process by which the mountain nucleus acquired its actual conformation. From our present commanding position we are better able to estimate the amount of elevatory force required to raise the high peaks and massive ridges around, and the length of time and intensity of erosive agents which the formation of the long and deep chasm dividing the ranges demands. Fill up this chasm and the other glens with solid granite masses, to the level of the peaks and ridges, over all throw a mantle of slate, continuous with the present circular boundary around the nucleus, depress the area full three thousand feet below the waters of the ocean, and some measure will be obtained both of the force and the time through which the present aspects were assumed.

The sunbeam is the joy of this mountain wilderness. It lights up the solemn old rocks till they laugh into beauty under its bright spell. Though devoid of vegetation which might throw bright tints around the rugged surfaces—for the saxifrage and alchemilla, the cryptogramma and other ferns, the club moss and juniper, nestle in shady clefts, and small patches of grass occur only here

and there among the blocks—yet are not these bare rocky masses without a certain natural adaptation to produce warm harmonious colouring. The three ingredients of granite have peculiar shades and different reflective powers; oxide of iron, always present as a constituent, passes in decomposing through various rich tints, and the rocky surfaces themselves, smooth or rough, dry or moist, are often dotted with small lichens. The result is a sober but pleasing tint in keeping with the general expression of the mountain scenery; it runs through various shades of gray, purple, and a tempered red or orange. The effects seen from Cior-Mhor are finest in the afternoon. Marvellous contrasts now lie athwart the stony ridges and deep glens, adding a wondrous charm to the scenery. The sun has gone down an hour since in the depths of Glen Rosa, and a deep gloom has settled on the dark recesses of Glen Sannox. Sharp shadows of the western ridge, showing a perfect profile of its jagged crest, are slowly creeping up the western front of Goatfell, whose summit is bathed in a glorious flood of orange light. Thrown back from rock to rock in mellowed and harmonious tints, it maintains a bright twilight along the base of the western ridge, by which we must descend, and throughout the upper part of Glen Rosa, along which our after path will lie. Taking a last survey of the surrounding peaks in their gorgeous evening tints, and contrasting the bold rocky foregrounds, now flooded with light, with the smoother and fading outlines of the lower hills, we must hasten downwards. The far off landscape we shall see better another day from the summit of Goatfell.

The low ridge or col connecting the base of Cior-Mhor with the next height to the south, breaks down steeply, but without precipices, towards Glen Rosa. We can descend easily at almost any part of it. A few minutes will bring us to the junction of the two burns, over the most rough and toilsome part of the long walk yet before us. Farther our way lies nearly by the side of the Rosa burn, through the moss and heather, till we reach the Garbh-Alt, where our ascent began in the morning. The smooth carpet of the glen is now beneath our feet, and we dismiss all fears of adders in the path, which troubled us a little in the uncertain light of the last hour. Emerging from the glen, and crossing the pretty burn by the rustic bridge, we gain the Brodick side and Glenshant lane. In twenty minutes more we are at the door of our comfortable inn, and are soon seated at the welcome evening meal. It is pleasant to talk over the incidents of our long walk; they will awaken joyful memories on wintry nights, years to come.

EXCURSION II.

THE CORRIEGILLS SHORE.

70. To-day we shall stroll leisurely by the sea-side, and study the eruptive rocks which break through the Corriegills sandstone. The botany of the shore is rich, and the pools in the tide-way teem with marine life. We shall notice in this place the geological phenomena only. A group of whin dikes marks the first emergence of rock from beneath the Brodick sands; and from this point eastwards the rocky platform exhibits a complete network of interlacing veins and beds of igneous products, traversing the sandstone strata. Between the end of the sandy beach and the landing-pier at Spring-bank there are several cases of bifurcation of dikes, and of a singular crumpling of the sandstone strata. The bed of the burn within the pretty grounds connected with the hotel shows several greenstone dikes, and the beds of sandstone are well seen in the banks and rocky ledges over which the water tumbles. On the shore fine sandstone and conglomerate are irregularly intermixed, indicating periods of sudden and gradual deposit, and varying forces in the transporting currents. The sandy strata are red, yellow, and white, and, as we advance eastwards, predominate over those of conglomerate structure. The fragments in the conglomerate are mica slate, like that of Cantire, slate similar to that of the nucleus, white quartz, and quartz of that peculiar resinous variety (Art. 47), for which we know no locality in Arran or elsewhere. Pieces of porphyry also occur, but no fragments of granite. The whole series dips nearly south, at angles varying from 15° to 20° . The upper surface of the sandy beds is worn in a singular way, portions more quartzose, or with a calcareous cement, standing out in thin, sharp, irregular ridges, while the parts around are worn away, being softer or more ironshot. The rock has thus a honeycomb structure, like what one often sees in the worn coralines of the mountain limestone. Numerous bowl-shaped cavities also occur, due, probably, to the removal of imbedded quartz balls, or the grinding action of these, by the movements of the waves, when once loosened from their bed in the sandstone.

Some general remarks have been already made (Art. 57) on the dikes of this coast, and we shall now only notice the individual cases of most interest. The whole number is about sixty, and the direction generally between N.W. and N.E., a few running nearly E. and W.

Most of them alter the strata of sandstone more or less. The great majority are depressed below the level of the sandstone, owing to the more rapid disintegration depending on their structure, as already often noticed. They are of all widths, from eight inches to forty feet, and the sides are generally parallel, and the course rectilinear or slightly undulating. Most of them traverse quite across the rocky platform, and are continued into the cliffs, up whose front they are seen to range, either level with the surface, forming deep gashes, or projecting like walls. These cliffs are the old sea margin, and are hollowed into caves along their bases, and otherwise sea-worn to a considerable height. The gashes in the cliffs were doubtless formed when the sea stood higher; the process being now completely arrested in such situations. But dikes placed under circumstances exactly alike do not waste with the same rapidity. Though the prismatic structure is the same (Arts. 31, 40), the chemical composition varies, as does also the internal texture, while the adjoining sandstone varies also in its capability to resist decay. When the alteration produced by the dike is great, the sandstone will resist disintegration; if the contrary is the case, the sandstone may wear rapidly, and the dike project. "From some experiments made several years ago," says Mr. James Napier (paper quoted in Art. 57), "on the decay of trap boulders, I found that certain varieties of that rock are rapidly changed by the action of water; lime and magnesia being dissolved out, the iron converted into a peroxide, and a crust formed on their surface, which is brittle and easily abraded." Mechanical and chemical differences have thus both to be considered, as well as the *relative* powers of resistance of the dike and the containing rock.

A remarkable group of dikes occurs under the east end of the high cliffs, near the point where the shore bends southwards. One of these is the broadest dike of greenstone on this coast. Its general breadth is twenty-five feet, but it widens at one place to forty feet. The sandstone is rendered very hard and quartzose to the distance of several feet. The range is 47° W. of N., and the inclination east at a small angle. A deep fissure marks the course of the dike up the front of the cliff. This dike is noticed by Playfair, in his *Illustrations of the Huttonian Theory* (*Works*, vol. i., Art. 266), as producing a marked change on the sandstone, and as indicating the relative durability of the two rocks. A little east of this dike is another, nine to twelve feet wide, inclined to the west, and ranging 18° E. of N. It offers no remarkable appearances; but the next dike east of it, though but seven feet wide, alters the sandstone more than any other of the

whole series. This is probably owing to the nature of the rock, which, being a highly crystalline greenstone, must have passed slowly from a state of fusion. The stratification of the sandstone is obliterated through a space of seven or eight feet, and this rock assumes the structure of a claystone. The case is strongly in favour of the view often advanced, that the Arran claystones are merely metamorphic sandstones. Intersecting this dike is another, ten or twelve feet wide, ranging 37° W. of N., dipping E.N.E., and consisting of compact fine-grained greenstone. It is sunk below the level of the sandstone; and, on this worn, depressed surface, there rests a boulder of coarse-grained granite, estimated at about thirty tons weight. Now, no force of surging waves, surged they ever so fiercely, is adequate to shift the position of such a mass as this; and we must, therefore, conclude that the huge boulder now rests where it was originally thrown down by the floating berg which bore it from the granite nucleus. Perhaps, however, it is not necessary to suppose that the dike was then excavated to its present level. It is quite conceivable that as the parts of the dike around the boulder were worn away, its support may have been loosened, and so its position may have shifted a little at long intervals.

71. In the sandstone of the cliffs overlooking this point we were so fortunate as to discover a very interesting fossil, on our last excursion, after the pages containing Art. 62 had been printed off. We refer to a specimen of *orthoceras communis*, a true carboniferous fossil, the occurrence of which in this locality is strongly in favour of the view we have advanced (Arts. 48, 62), regarding the age of these sandstones. It may, indeed, be urged that carboniferous fossils pass upwards into the lower portion of the Permian (lower new red) system. But we submit that *orthoceras* is not a genus of which this can be said; a very few cephalopods, allied to *nautilus*, being the only animals of this order yet found in the lower Permian system.

Still advancing eastwards, we meet with several other dikes—one of these is depressed ten feet in the tideway, is on a level with the sandstone along the grassy surface at the base of the cliffs, and in the front of the cliff is again worn, forming a deep chasm, which is bounded eastwards by a bold projecting edge of the cliff, crowned with wood. The dike on the beach, and fissure aloft, are about fourteen feet wide each, but not exactly in the same direction, the dike sustaining here a considerable undulation.

72. We now reach the great bed of claystone, the largest upon this coast, and presenting many interesting appearances. It forms a

vein rather than a bed, as it is placed at an angle of about 15° with the sandstone strata. The sandstone dips 12° E. of S. at about 15° , while the claystone vein is inclined in the same direction at an angle of about 30° . The rock is divided irregularly into prisms by joints perpendicular to the lower surface of the vein, so that the prisms lean back towards the south, giving the appearance, when viewed casually, of a bedding directed northwards. The structure at the upper surface is often schistose at right angles to the joints, or in the direction of the vein. The base is of a uniform texture, of felspathic substance, with quartz pieces imbedded. The structure varies from a uniform claystone, or clinkstone, to a small-grained porphyry. The colour is pale yellow, or yellowish-white; and at the first view the rock might be taken for a sandstone: it has indeed been described, when seen in its continuation in the adjoining cliff, as a white columnar sandstone (Headrick's *Arran*, p. 66). The rock on which it rests is a conglomerate; that beneath which it plunges southwards is fine-grained sandstone. The upper surface of the vein is very rough and jagged, with no resemblance to the style of decomposition among sandstones. The breadth exposed upon the shore is between thirty and forty yards. Along the level shore, where the vein rises to the north, its lower surface is exposed in a wide fissure hollowed out of the sandstone by the action of the sea. It is here seen to rest upon a vein of trap, three or four feet thick, and having the same inclination as the claystone. The line of contact is irregular, and in two or three places thin bands of conglomerate are interposed between the trap and the claystone. The lower portions of the claystone, next the trap, are harder, or converted into hornstone, the conglomerate is much indurated, and assumes the dark colour of the trap; while the latter becomes a fine basalt, and is intermixed with the sandstone below, or dispersed through it in lumps. The posterior origin of the trap vein is thus clearly indicated. The appearances are correctly described by Dr. MacCulloch (*West. Isles*, vol. ii., p. 403), and an illustrative drawing given (vol. iii., plate xxiv., fig. 1). The sandstone overlying the claystone along the south side of the vein is very slightly altered.

Several dikes traverse the sandstone platform between the claystone vein and the great boulder, some running nearly N. and S., and others nearly E. and W. The former seem to shift the latter, producing a change in the direction of more than 20° . The dip of the sandstone is also affected by these dikes, being thrown round about 25° towards the west. One of the dikes, sunk more than two feet below the sandstone, and eight inches broad, is lost on entering

the claystone: it may be connected with the underlying trap vein. Another, close to the boulder, $6\frac{1}{2}$ feet broad, consists in the centre of blue-coloured rapidly decaying greenstone, and at the sides of a hard crystalline variety of the same rock, standing above the level of the central parts and of the adjoining sandstone.

73. The celebrated Corriegills boulder, under whose shadow we are now resting, is of imposing dimensions, and a conspicuous object from all parts of this coast. A few on the Corrie shore exceed it in size; but they are close on the edge of the granite nucleus, and we may suppose it quite possible that if Goatfell "shook his giant sides" under some earthquake throe, they might have been hurled headlong from the summit to the sea level. Other causes must be sought for the transport of this enormous mass from the parent mountains; and of others still farther removed, though of lesser magnitude. We have already considered the only possible causes, and attempted to estimate the evidence in favour of each (Arts. 59, 60). That to which we chiefly lean receives support from the case before us. A crowd of lesser blocks surrounds the huge boulder of which we speak—an association much more likely to occur in the case of floating ice, than of currents emanating from a centre so remote. The cubical contents, and consequently the weight, are very difficult to estimate on account of the irregular form. The dimensions at the base are 21 feet by 12, and the height 15 feet. If rectangular, it would weigh 315 tons, as 12 cubic feet of granite make a ton; but if we deduct one-third for the conical form, which is a large allowance, we shall have a weight of 210 tons.

74. South of the boat station under the farm-house of Corriegills, the dikes traverse the sandstone in every possible way; intersecting one another at various angles, bifurcating, lesser ones lost in larger, &c. One of them is exposed through a longer course than any other dike on the coast. It runs a long way parallel to the line of the shore, or almost due N. and S., till lost under the sea near Clachland Point. It is fourteen feet wide, sunk under the sandstone in the tideway, and sends off a branch towards the N.W., a tongue of altered sandstone being at the bifurcation.

Two pitchstone veins, one of claystone, and one of quartziferous porphyry, are found on this part of the shore. The lesser pitchstone vein traverses the level shore obliquely about half-way between the boat station and the base of Dun-fion. Within the tideway it ranges about 72° W. of N.; then bends about 20° towards the S., *i. e.*, runs about due W., and bends again into the former course before it enters the sandstone cliff. Under high-water mark it is

about three feet wide, in other parts five or six feet. Seaward it is placed conformably among the sandstone strata, and is irregular in direction and breadth. A dike of greenstone here cuts it nearly at right angles, but the appearances are noway remarkable. This vein, or bed, has been overlooked by MacCulloch and succeeding observers. The greater pitchstone vein is conspicuous, forming a broad band in the front of the sandstone cliff farther S., and has been noticed by every one. It occupies a slanting position in the cliff, parallel to the sandstone strata, dipping with them towards the S.S.W. at nearly 30° , and rising towards the N.W. In the opposite direction, or towards the S.E., it seems to plunge beneath the sea; but the debris here obscures it, so that its course cannot be traced to the water's edge. Climbing up the cliff to examine it more closely, we find it to be 13 feet $5\frac{1}{2}$ inches in thickness; of lamellar structure and dark bottle-green colour. There is no remarkable change on the sandstone—a slight induration merely, but the lower portion of the pitchstone is changed into a blue-coloured porous slag-like matter, like a pumiceous lava: this, however, is probably the mere result of decomposition. Its exact position among the sandstone strata is not easily determined: if parallel to them we must call it a bed, if intersecting them, a vein. Fallen masses of the pitchstone strew the beach; and among these, where the path comes close on the water, there is a dike of red quartziferous porphyry, nearly perpendicular to the shore, twelve or fourteen feet broad seawards, but narrowing inland to five or six feet.

A granite boulder, about one-third of the size of the one at Corriegills farm-house, rests here in the tideway; and great numbers strew the shore all along.

75. Between the two veins of pitchstone which we have just described, there occurs upon the flat shore another large vein of claystone remarkable for a peculiar structure. This is developed in those parts only which are near the junction with the sandstone, along the south side of the vein. The appearances are fully and accurately described by Dr. MacCulloch (vol. ii., p. 405). The structure referred to “is concretionary globular, or striated; the latter being either found separate, or united with the globular in the same specimen. The former puts on sometimes the appearance of spots, circular or elliptic, resembling Siberian jasper. The spots, as well as the stripes, are attended with corresponding differences of hardness, the former arising from the globular structure, the latter from a schistose or laminar one. The spots being often elliptical, compressed or elongated, occasionally become laminæ in the progress of

elongation, passing into them by insensible degrees. The vein next the sandstone varies much in hardness, but it cannot be said that this induration bears any relation to its proximity to the sandstone. The concretionary structure is seen both in the hard and soft varieties, it is radiated fibrous, the radii sometimes diverging from a point, and sometimes from a solid nucleus, which is further, in some instances, surrounded by a white earthy crust. In the progress of induration the rock at length loses its character entirely, appearing to pass into a substance of an indefinable nature, of a horny aspect and dark dull green colour—partaking of the character both of calcedony and pitchstone. It has been described as globular pitchstone; but it is far removed from this rock by its extreme toughness, want of lustre, and by the form of its fracture.” Mineralogists have long regarded this curious rock with much interest, and various opinions have been held respecting its true relations, some considering it as allied to claystone, and others to pitchstone. A comparison of the appearances observed here with those seen at Tormore, and in Moneymore glen, has led us to conclude, that “the substance of an indefinable nature” is hornstone; and a transitional state of these earthy matters, between claystone and pitchstone; the globules being due to the formation, within the fluid mass, of crystalline centres of radiation, in the manner described in Mr. Gregory Watt’s *Experiments* (Art. 31). The radiations are of pure quartz, while the base is of the same substance, but mixed with colouring matter, iron or manganese, and other trifling impurities. We shall again notice similar varieties in other places.

76. Near the pitchstone vein the high ridge of Dun-fion reaches the coast; and the trap which forms its summit appears in section in the cliffs, overlying the sandstone. It presents a façade of imperfect columns, and contrasts strongly with the stratified sandstone. Both sink rapidly southward in the direction of the dip; the sandstone is depressed below the sea-level, and the trap then occupies the coast, forming the low point at the entrance of Lamlash bay, and the small island in the channel. Near the point where the sandstone disappears, some remarkable effects of trap dikes are exhibited. On the west side of the point the sandstone suddenly emerges again, and extends to Lamlash. The whole bay, indeed, has been excavated in this red rock, which forms the base of the cone of Holy Isle, as well as the coast on the mainland. But we turn here meanwhile, and direct our steps to Brodick, by the summit of the ridge, which divides the two bays. Its southern side forms a long grassy slope of gentle inclination towards Lamlash

bay ; towards the north it falls suddenly in steep cliffs and terraces. As we pass up the easy ascent striking views open southwards. Starting suddenly from the water's edge to the height of 1,020 feet, Holy Isle, with its encircling sea line, fills the foreground grandly. The bay, with its fine double sweep to King's Cross point, its wooded banks, debouching glens, and background of dark hills, forms the right of the picture ; to the left the glassy sea sleeps in the sunlight, dotted with small white moving specks, and bounded by the winding line of the Ayrshire coast, with promontory, creek, and bay, along which the eye may range from Ardrossan heights to the Mull of Galloway. The scene is singularly sweet and picturesque ; without Holy Isle as an integrant part it would want character : this stamps upon it peculiar features. The northern mountains, so essential and expressive in most Arran landscapes, are here hidden from us ; but when we gain the highest edge of the ridge, they burst upon us with startling suddenness in an aspect quite new. They are grouped in a way not seen from any other point, and their jagged profiles are thrown into lines of singular boldness. Not less new and striking is the aspect of the lovely bay, with its noble castle and hanging woods, of the glens into whose far depths the eye can reach, and of the "cottage homes" nestling amid groups of trees, in shelter of the hills and sloping banks which enclose the smiling fields of Brodick plain. Often as we have come to the edge of this ridge by the same route, we have always felt the same delightful surprise when the scene first burst upon us.

77. This ridge consists chiefly of sandstone. Trap rocks form a thin capping along its highest part ; they extend a little way down the southern slope, thickening as they descend, but along the highest ridge are so thin that sandstone occupies in some places depressions in the ridge ; and the trap occurs only on the isolated tabular knolls into which the ridge is cut up, especially towards the west. The trap consists of felspar and augite mainly, with imbedded zeolites. MacCulloch designates it augite rock ; but hornblende and iron also occur. The sandstone close to its junction with the greenstone of the summit is highly metamorphic, resembling a quartz rock. Along the steep northern front also, west of Dun-Dhu, beds of clinkstone crop out in various places, at different heights. These are either of truly igneous origin, or are metamorphic sandstones, altered by whin dikes, of which there are several, or by the near proximity of the great igneous masses—greenstones, porphyries, and pitchstone—which pervade the sandstone in this quarter. The asso-

ciation of these various products affords one of the most interesting sections to be met with in Arran. It is best exhibited a little to the west of the path which leads down from Dun-fion to the farm-houses. Dun-fion, or Fingal's Fort, is the highest point on this portion of the ridge, right over Corriegills shore, and 500 to 600 feet in height. Traces of old walls, the remains of a fortification, are seen round the summit, but nothing whatever is known of its history. Dun-Dhu is a prominent hill, nearly as high, a little farther west, and standing out in front of the cliffs, to whose base it is joined below. This hill is composed of columnar felspar porphyry; and between it and the path descending from Dun-fion the beds represented in the annexed diagram occur in a well marked vertical section; two veins of pitchstone and one of porphyry, with sandstone intervening, surmounted by augitic trap.

(a a a) Sandstone; (b) felspar porphyry; (c c) pitchstone; (d) overlying trap.

The upper pitchstone vein, *d*, is about thirteen feet thick, and dips S.W., at a small angle, probably 10° or 15° , and may, therefore, be conformable to the sandstone, which is seen in the quarry near the footpath to dip about S.W. at 10° . The rock is of a dark green colour, without felspar spots, divided into beds from eight inches to three feet in thickness; and these beds consist of closely aggregated prisms, or laminæ splitting into prisms. The bed is very high on the cliff, coming close up to the prismatic greenstone, but apparently separated everywhere by altered sandstone. Its upper surface is on a level with some of the depressions in the edge of the trap ridge; and, as we had repeatedly noticed a large block of pitchstone imbedded in the soil on the southern slope, at the back of Dun-fion, whose location there we were unable to account for, not having then discovered this pitchstone vein, it appeared probable that the vein might pass over the ridge. This, however, we satisfied ourselves is not the case; in searching for it a block of the Dun-Dhu porphyry was found resting in a hollow of the ridge, and we conclude, there-

fore, that the pitchstone mass, like the porphyry, is a transported block, borne upwards from the beds below, and deposited here in shelter of the ridge. Along the southern slopes of the ridge we found many granite blocks strewing the surface.

The lower pitchstone vein, *c*, is fourteen feet thick, and of the same colour and structure as the other. The vein of porphyry occupies a ledge about fifty yards lower down: this ledge being on the level of the front of Dun-Dhu, from which the porphyry extends. The sandstone strata are not well seen on the ledges *a a a*, between the veins, in the line of section; but come out distinctly enough on their continuations east and west.

Neither of the pitchstone veins has any connection with those upon the shore, which are far below the level of the base of our section. Mr. Headrick, in his work on Arran, says (p. 78):—"Pitchstone is seen jutting through the soil in various places to the N. and N.W. of Dun-Dhu. In one place near a small burn it rests on red sandstone, and makes the same angle with it." We did not visit this spot; but it cannot be a continuation of our veins, as these are cut off by the Dun-Dhu porphyry.

The northern front of Dun-Dhu consists of fine columns of porphyry, divided at irregular intervals by flat joints. On the N.W. side the columns are very perfect, and have a singular diverging fan-shaped arrangement. We ascend the hill easily from the south side, and find the summit composed of huge prismatic masses of porphyry, lying closely side by side almost in a horizontal position, and in a direction from N.E. to S.W., so that their ends, cut uniformly off, form a wall towards the west, ten to fifteen feet in height. Some of these columns are twenty feet in length, apparently without joints: in general, however, there is an indication of a flat jointing, at distances of four to seven feet. Most of the prisms are four and five-sided. The rock has a gray felspar base, occasionally ironshot throughout, or merely streaked with iron; and the imbedded crystals are of glassy felspar. Bits of quartz are also disseminated through the base; apparently minute crystals with their angles rounded off, as if by attrition.

No granite blocks were noticed on this detached summit; but many of considerable size, as much as from six to fourteen tons, were observed close to the cliffs on the west side. They are found in great numbers, and of large size, over all parts of the open plateau between the base of this ridge and the shores of Brodick bay.—Across this plateau our path homeward is by the tortuous lane which enters on the Lamash road immediately below the Free

Church. The road in itself has no object of interest ; but there is much to beguile the way. The evening tints of rich purple-gray on the northern mountains, beyond which the sun is now going down, and the profile of the rugged peaks against the golden sky behind, are glorious to look upon—the light is strong yet on the peaks of Ben-Yim and the Cobbler, on Benlomond and the mountains of Aberfoyle ; the broad shadow of Maoldon falls dark athwart the sea ; but beyond this a flood of light comes streaming down the northern channel, and brings out strongly the gray rocks of Garroch head and the Cumbrays, and the lovely glades amid the woods of Fairlie. The turrets of Brodick Castle are yet gilded by the sunlight which falls in broad sheets across the lovely bay, whose glassy expanse is crowded with fishing parties. Before we can reach our stately but pleasant inn, the steamer has rounded Merkland point, disappeared in the shadow of the hills, emerged again into the “lanes of light,” and threaded her way through the fleet of boats.—Already the fair throng has left the landing-place, scattered now in gleeful groups along the various roads.

EXCURSION III.

TO THE SUMMIT OF GOATFELL.

78. GOATFELL is an unmeaning corruption of the native name of this mountain. Gaoth (gāō) is the Gaelic word for wind ; this may be the origin of the first part of the name ; with the animal indicated the mountain has no sort of connection. Then, Fell is not a Scottish word ; it belongs to the North of England, and to Scandinavia in its form of fjeld or field, applied appropriately to the wide flat mountain plateaus of South Norway. Bein, or with the aspirate Bhein (ban, or ben, ven), is a mountain. Pen is the English form, as in Penyghent, Pendle hill, and hence the Latin term Pennine for a principal range. Thus the name would be Gaoth-bhein, or Bein-gaoth—the hill of the winds—not very expressive or special as regards this hill more than others standing prominent. But those who gave the name perhaps knew no higher hill ; and there is a peculiar effect often seen here to which the name may perhaps have reference. The Ben-Ghnuis or western ridge first arrests the vapours ascending from the western sea, and condenses them into a dark

sinuous bank, from whose shattered edge masses float away when the breeze gets up, and, dashing against the flat side of the ridge of Goatfell, are driven in rapid eddies round its south end or over its upper edge. To one looking up from the quiet depths below, this would suggest the existence of a furious gale upon the summit. As the weather thickens and the clouds accumulate, the cone gets completely hidden, and the rolling vapours pass even lower than the mill-dam, veiling the edge of the great waterfall, which then seems to issue directly from the clouds.

But such a day as this will not suit for our walk; we must wait for bright skies and still air—few walks in Arran will then please us more. Every lover of mountains has a keen desire to climb the highest summit within his reach, and many will choose this walk for their first excursion.

79. The woods which stretch westwards from the castle are crossed by two roads, by either of which we may pass upwards into the moors. A path lies near the east bank of the Cnocan burn, as far as the mill-dam, where this stream is gathered from many heads. Beyond this a track is marked out among the granite blocks to the east shoulder of the mountain; thence, along the edge of the ridge, a rugged path conducts us to the summit, over huge masses of rock, and along the edge of Cyclopean walls. But the geologist has much to see on the ascent which this route will not show him, and we must conduct him by another way.

Beds of fossiliferous limestone occur in the woods N.W. of Brodick castle; they belong, of course, to the carboniferous system, and are higher in the series than the sandstones, which appear in the bed and banks of the burn before it enters the wood. They are regarded by Murchison and Sedgwick as an upthrow of the Corrie beds, a theory to which we do not object; but the facts may be explained otherwise (Art. 52). These sandstones are succeeded by the old red as we ascend the burn above the wood, the junction being somewhere about the place where the wall enclosing the new plantation abuts against the bank of the stream. But the contact is not seen, nor is there any gradation visible. The old red is here a hard quartzose slaty sandstone, with many thin brown laminae, and elliptic blue or white claygalls: the dip is back against the slate of the mountain, contrary to that of the overlying carboniferous beds, at angles varying from 55° to 70° W. of magnetic N. As we advance the strata become much obscured by debris; and a little above the point where the west burn enters the main stream the dip is reversed or toward S.S.E., at about 65° to 70° . The rock

is here coarser, and contains imbedded masses of resinous quartz and dark blue slate; farther on it is darker and finer, with claygalls, and the dip again appears to be toward the slate, but the stratification is obscure. In front of the first waterfall, amid a group of birch trees, a mass of quartziferous hornstone porphyry lies across the bed of the stream, but seems to terminate against the bank on the west side; on the east side its extension cannot be traced, so that most probably it is not a dike. It is a beautiful rock, and if readily obtained in quantity might be used for ornamental purposes. The base is a dark reddish hornstone, containing crystals of glassy felspar, and round bits of quartz. There are beds of conglomerate here; and the strata lean toward the slate, but less "end on;" the dip being about 30° W. of magnetic N.

We are now approaching the junction of the old red sandstone with the slate; but as this is not well seen in the bed of the main stream, it will be more instructive to diverge to the left, up the course of the west branch, as far as the dark brow of slate, where the hill suddenly rises. Passing up the bed of this west-burn, we find the common red rock and conglomerate succeeded by flinty or quartzose sandstone, obviously metamorphic. The cause of this change is soon discovered. At a waterfall on the burn there is an outburst of a peculiar granite amid the sandstone strata. This is an intimate mixture of quartz and felspar, without mica; in fact, the *Eurite* or *Weisstein* of mineralogists. It extends many yards in the bed and banks—how far cannot be determined. Between it and the rocky brow, which is formed of the common dark slate, there are various metamorphic beds, conducting us by insensible gradations into the true slate. Some of these are white and gray flinty slates, others fine-grained hard sandstones. It is thus difficult to decide to which series the beds ought to be referred. The strata have been assimilated by the metamorphic action to which both series have been alike subjected. A similar case occurs on the White Water, as already noticed (Art. 52, p. 76).

Returning now to the bed of the main stream, and entering it some way above the waterfall at which we turned off, we find similar white and gray quartzites about fifty yards in front of a deep chasm, with a waterfall, cut out of the slate rock. The sandstone is not seen in close proximity; but the junction must be near, as this is the first point at which the slate appears in the bed or banks. Two dikes of greenstone, from opposite sides of the pool, unite at the edge of the fall, twice bifurcate, and twice unite again, enclosing two long elliptic masses of altered slate, and then continue as

one dike right up the chasm. The branches are three to four feet wide; and the joint breadth, as one dike, eight or ten. The dike undulates in its course from 30° to 40° , conforming to the course of the chasm. The chasm is, in fact, due to the dike; an original depression, produced by a fault or the irruption of the dike, determined the channel for the stream, and along the course of the dike the water met with least resistance in its work of disintegration. The chasm is nearly half a mile in length, with perpendicular walls ten to fifteen in height, above which the banks rise very steeply on both sides. It runs in against the great sheets of slate, forming the waterfall below the mill-dam. At the base of these sheets the dike is seen again, interrupted or broken off in one place by the slate, from beneath which it again emerges, and appears upon the high brows above in the bed of a small stream entering from the N.E.

80. We are now at the famous junction of granite and slate close to the mill-dam. The appearances have been often described; we shall quote the very clear account given by Professor Ramsay (*Arran*, p. 4):—"The absolute junction of the two rocks is not here visible; but that it is in the immediate neighbourhood, probably in the bed of the dam, is clearly shown by the appearance of a granite vein, about one foot broad, which penetrates the strata, and crosses the bed of the stream about ten yards below the artificial wall which confines the water of the dam; thus indicating its intrusion, while in a state of fusion, into the stratified deposit with which it came in contact. The granite is of a yellowish colour, fine-grained and compact in texture, and consists principally of felspar. The slate is exceedingly tortuous; and the strata are intermingled with numerous veins of quartz of varying sizes, and which generally alternate with the slaty strata in regular minute laminae." This description is correct and well stated; but an important fact has escaped notice altogether. It has not, indeed, been alluded to by any one of the many observers who have visited this locality, owing probably to the state of the water in the river at the time when this junction was examined. We refer to a dike of greenstone which crosses the river diagonally, ranging about 20° E. of N., and about thirty feet wide. It enters the east bank of the stream under the mound or wall of the dam, and is seen again on the surface, a little way toward the N.E., but is soon lost under the heaps of granite blocks. The strata of slate range 65° E. of N., or almost E. and W. by the compass, dipping 25° E. of S., at an angle of 70° . Thus the direction of the dike makes an angle of 40° with that of the slate. Now, there are granite veins in this dike; and these cross out into the slate on the

east side of the dike, continuously without a change of direction. There is no mistaking the rocks, both the greenstone and slate are perfectly well marked; a portion of the former, traversed by the veins, has distinct acicular crystals of white felspar, and that concentric structure so peculiar to this rock. The state is quite homogeneous—a dark blue hard quartzite, in some specimens resembling Lydian stone—but the alteration from its ordinary state is not remarkable. The principal granite vein is several inches (six to eight) wide, and is traceable in the greenstone through a space of fifteen or twenty yards; and runs right on into the slate. Several smaller veins ramify through the greenstone, dividing and then uniting again. These have the structure so well described in the above extract. We conclude that the slate was first injected by the greenstone dike; and that the irruption of the granite, at a subsequent period, pierced through both of these rocks. The case is very interesting, being the only one in Arran, that we know of, in which greenstone is proved to have been erupted anterior to the injection of the granite amid the strata of slate.

81. We recommend the geologist, who is not deterred by the prospect of “a pretty stiff pull,” to mount at once by the southern shoulder of Goatfell, avoiding the common pathway, already pointed out, which presents much less to interest him. He will thus have an opportunity of examining those huge natural ramparts of granite blocks, piled mass on mass to a great height, like the Cyclopean walls of Tadmor or Heliopolis, and of studying the structure of a granite mountain, the varieties of the rock, and its peculiar style of decomposition. We especially recommend this course, if he has not accompanied us on our First Excursion.

We have now reached the south summit of Goatfell, the highest point in the island, elevated 2,875 feet above half-tide level. The north summit is 247 feet lower. There is not, perhaps, in Scotland, another mountain peak which looks abroad upon a scene combining the same variety of grand features. Many afford wider and finer mountain views; here the eye ranges over a vast extent of broken coast, the whole expanse of the noble frith, and its many narrow branches winding far in amid mountain solitudes. How grand from this commanding height are the surrounding peaks and rugged ridges, and the profound dividing glens! what lovely pictures in their glassy frames are these sister islands! how stirring the rapid movements of life all day on the inner frith! what a world of human interest in that great ocean steamer starting on her outward voyage! The “sweep of the circling horizon” embraces a magnificent amphi-

theatre—reaching from the mountains of Donegal and Londonderry, on the S.W., to Ben-Lomond and Benledi on the N.E.; from Ben-Cruachan and the mountains of Mull, on the N. and N.W., to the ranges of the South Highlands and the Mull of Galloway in the opposite direction.*

As the day verges into evening the Western Isles stand grandly up in a sea of molten gold, which, rising far out westwards, blends with masses of gorgeous clouds, “set on fire with redness.”—Later still,

————— “ the sun descending
Leaves upon the level water
One long track and trail of splendour.”

There is not much of mere geological interest on the summit of Goatfell. A claystone vein occupies a fissure to the N.W. of the cairn, and there are traces of a greenstone dike. Many veins of fine granite, which we regard as cotemporaneous, and not injected, intersect the coarse-grained variety of which the whole mountain consists. Dr. MacCulloch long ago pointed out a magnetic property in the granite here, which he afterwards confirmed by observations made on other mountains in Scotland. (*West. Isles*, ii., 451, and *Geol. Trans.*, 1st Series, vol. ii., p. 430, and vol. iv., p. 124.)

82. There are various routes by which we may descend. Those into Glen Rosa and by the Rosa col must be carefully selected, as they are very dangerous in some places. There are two more instructive than the rest for the geologist. One is by the plateau S.W. of the mill-dam, along the boundary of the granite and slate, where some fine junctions, granite veins and contorted schist, may be studied. A good example of a “*roche moutonnée*” may be seen on the edge of the plateau a quarter of a mile S.W. of the mill-dam. The exposed horizontal surface is fourteen or fifteen yards in extent, rounded nicely off diagonally to the laminæ; the N.W. front or vertical face is also ground off, but the opposite face, turned towards the S.E., retains its original form. This indicates the direction of the abrading force.—The other route is eastwards, by Maoldon and the White Water. Crossing to Maoldon from the eastern ridge of Goatfell, we pass the slate and old red sandstone bands, and come upon the carboniferous sandstone; but no junctions are visible on this line. The top of Maoldon, about 1,000 feet high, is composed of soft red sandstone, dipping 25° E. of S., at

* We have never decidedly identified Ben-Nevis, but believe that it may be seen from Goatfell. The mountains in the Isle of Man are probably visible in very favourable weather;—in that direction Ailsa Craig is a fine object.

15° to 20°, and thus the strata are “end on” to the granite. It is strewn with granite blocks of moderate size. The N. and N.E. fronts are very precipitous; the western part of the precipice is intersected by a greenstone dike about fifteen feet broad, ranging 25° W. of N., and inclined towards the E. at an angle of about 15°. It forms a deep chasm in the cliff, over which the sandstone rises in a lofty wall. The amount of wearing here is prodigious, and we cannot conceive how it can have been effected without the action of the sea. Yet the place is many hundred feet higher than the ancient level, indicated by the raised beach so often mentioned already. We must, therefore, call in the agency of the sea, during the elevation of the land at an earlier period.—Through a narrow passage between the dike and the sandstone wall, we can descend to the base of the cliffs. A remarkable alteration is produced in the sandstone by this great dike.

In the broken ground in front of the cliffs a great bed of limestone occurs; it is similar to that at Corrie, with the same number of integrant strata, each of which is, however, thinner than at Corrie, —and with the same assemblage of fossils. It has been already noticed (Art. 52, p. 75), as probably an upthrow of the Corrie beds; those in the woods N.W. of Brodick Castle may have the same origin; there being thus, in all, four upthrows of this stratum, separated by four great faults. Our reasons for doubting this view have been stated already (Art. 52).

There is little else worthy of notice here; it is a wild bosky place, encumbered with huge fallen masses of sandstone, and with granite blocks, among which many pretty ferns and flowering plants find suitable habitats. Before passing down to the high road, on his way homeward, the geologist will do well to visit the interesting junction in the bed of the White Water, near the fall at which the burn issues from a wild corrie. The metamorphism here is very remarkable; the granite becomes a blue compact felspar or eurite; the narrow belt of slate is streaked with white veins, and contains crystals of felspar; while from the slate to the sandstone there is a similar passage, analogous to that which has been described already as occurring in the west branch of the Cnocan burn. The student must be prepared to encounter many difficulties in his ascent of the channel; and to submit, now and again, with the best grace he may, to a shower-bath from the dashing spray as the water bounds from ledge to ledge of the long fall.

83. The largest boulder in the island is well deserving of a visit before we pass down to the highway. It rests on the edge of the

ancient seaciff, a short distance N. of the White Water. It is a true boulder,—granite reposing upon sandstone. We estimated the weight at more than 2,000 tons. What force could have hurled a mass so enormous from the mountain-side? Not gravity urging its descent; unless, perhaps, the first impulse was given by an earthquake, for the slope of the hill-side is gradual, and the mass itself ill adapted for easy rolling. But if we admit the agency of ice, we have a force adequate to the transport. This transport took place before the present level of land and water was established; the cliff was not yet cut out from the sloping hill-side; the bed on which the boulder now reposes was the sea bottom, and in the glacial period it may have glided down upon icy sheets descending from the corries, or been borne off by a berg which deposited here the heaviest portion of its load. A sister block rests upon the same cliff, on the south side of the burn; but its dimensions are much less. The shore is strewn with multitudes of similar masses of all sizes.

84. In passing along the road towards Brodick, we are upon sandstones of the carboniferous system, dipping south at small angles, but often disturbed by the numerous dikes which cross the strata in various directions. On our right is the picturesque cliff, the old sea-margin, hollowed into caves, and bearing other marks of the former action of the waves. From these caves, from the summit of the cliffs, and from the low terrace along which the road is carried, once the sea bottom, many marine shells have been obtained. The great proportion are the same as those now inhabiting the shores of the Clyde; but with them are associated a few of those arctic species which we have already given (Art. 7), in the list kindly furnished by Mr. Smith, of Jordanhill; thus indicating the prevalence of the same conditions which obtained during the era of the boulder clay.

Between Brodick pier and the fine picturesque group of ash trees near the beach, there are some remarkable dikes which disturb the stratification of the sandstone, and are obviously connected here, as at the other extremity of the beach (Art. 70), with the appearance of the rock from beneath the sands. The ridge of gravel and sand dividing the beach from the marsh behind is the joint work of the sea and the two streams. The Cloy burn formerly entered the bay at Invercloy, as the name of the village implies; the course was changed by a bar cast up in a storm, and it has now for a long period followed the winding course which unites it with the Rosa burn before reaching the sea.

EXCURSION IV.

THE WAYSIDE MUSEUM.

85. THE student of geology will make little progress in this delightful science without a thorough practical acquaintance with the mineralogical distinctions of rocks. He must first know a few of the common simple minerals; quartz and its varieties, amethyst, smoke quartz, hornstone, jasper, &c.; felspar, and its varieties, as glassy and compact felspar, and albite; mica, talc, chlorite, hornblende, augite, hypersthene, olivine, and calcspar. Of these, quartz, felspar, mica, hornblende, and augite are the components of almost all the mountain rocks of the globe. Knowing these, he will easily make out the composition of most rocks. With every term a definite idea will then be connected, and the study of the subject will be smooth and pleasant henceforward. Arran is an epitome of the globe, our Wayside Museum is an epitome of Arran, in so far as a collection of rocks is concerned. In two or three visits to this collection, with a book in his hand descriptive of rocks, or a friend by his side qualified to instruct him, the student will gain an acquaintance with rocks which he can never learn from hand specimens,—an acquaintance which is absolutely necessary to all true progress in the science.

The collection of which we speak is easily visited. Leaving the village of Lower Invercloy at the smithy, and passing up the hill along the old Lamash road, we are upon it at once. It is simply a stone fence, bounding the road on the east side, and reaching from the brow of the old seacliff to the top of the hill. The stones of which it consists were gathered from the adjoining fields, across whose surface they were spread out during the “diluvial era,” or the “glacial period.”

We shall merely name the principal rocks found here, without attempting any description. Granite, several varieties; primary slate, banded like gneiss; hornblende rock, mica clay and chlorite slates, and quartz; red sandstone and conglomerate, containing mica-slate and quartz pebbles; pitchstone and pitchstone porphyry, several varieties; a complete suite of the trap rocks;—from coarse crystalline greenstone through basalt to pitchstone, a regular gradation may be traced. There are two principal varieties of trap porphyry, that is, fine greenstone containing imbedded crystals—

not properly a porphyry, for the base ought to be simple. One is speckled with felspar dots, the other more homogeneous and dark-based. Concentric spheroids of greenstone occur, and several varieties of black basalt. A few blocks are met with of a very interesting rock, which we have never found *in situ* in Arran; it is intermediate between basalt and pitchstone, and links them together as products of fire generated at different stages of the cooling process. It is hard and tough, and almost homogeneous, like basalt, while it has the semivitreous aspect and colour of a dark blue pitchstone.

86. We may visit two other objects of interest by the same way-side. Descending from the top of the ridge into the Birk glen, and crossing the burn, we come upon the great pitchstone vein. It crosses the road nearly at right angles, ranging 35° N. of E., and is thirty feet broad. This is not, however, the true breadth of the vein at right angles to its upper and lower surfaces, but merely the extent of the upper surface here stript of its sandstone covering. It is green, of lamellar structure, and contains in parts felspar crystals, giving a porphyritic aspect. Thin white films form on the exposed surfaces, by disintegration; and when in contact with running water it decomposes into a tenacious clay, which forms a thin coating on the surface. The vein is seen in the bed of the burn, of about the same width. The contact with the sandstone is not very well seen; but there does not appear to be any remarkable alteration upon it. A dike or bed of trap is connected with the vein on the lower side; but the relation of the two rocks cannot be made out clearly.—The other object of interest to which we referred, is a vein or bed of claystone on the east side of the new Lamlash road, almost in the line of bearing of the pitchstone. A quarry of road metal has here been opened upon it; eastwards it can only be traced a very little way, but westwards it is seen below the road in the direction of the pitchstone vein. Its range thus seems to be 60° N. of E., or slightly transverse to the other vein, which probably cuts it off, as the claystone is not seen in the river bed on either side of the pitchstone vein. In the quarry the claystone splits below into rhombic blocks; in the upper part it is slaty. We have referred to this quarry already (Art. 57, p. 83); and also alluded to the many claystone beds on the north front of the ridge of Dun-fion.

We may return by the new Lamlash road; but there is more variety to be met with in descending the stream, and passing through the ornamental grounds connected with the hotel. The sandstone strata are well exposed, and there are some curious dikes.

EXCURSION V.

TO THE NORTH SHORE.

87. THE coast section from Corrie to Loch Ranza is full of interest. A long summer's day will be required to examine it carefully,—several days, if we stop to collect the fossils which abound in some of the beds. The scenery, too, is full of beauty, in parts bold and picturesque in the extreme: we shall be tempted to stop very often to add some new treasure to our portfolio. Leaving Invercloy by the first steamer for Glasgow, we shall be at Corrie for an early breakfast, and be ready to start fresh while the day is yet young. Corrie is, in fact, for several excursions an admirable point of departure.*

The strata at the base of the carboniferous system, and their contact with the old red sandstone, are well exposed upon the shore. We shall trace them in ascending order, beginning a quarter of a mile north of Corrie, at the march of Achab farm, where the road bends toward the N.W.† This is the base of the series; but it is not a well defined base;—there is, in fact, a gradual passage from the old red system into the carboniferous strata. The old red is here a conglomerate; and is overlaid by a limestone with imbedded pebbles, the same as those in the conglomerate, forming a calcareous conglomerate. This bed is followed by gray sandstone, and concretionary limestone, or cornstone, consisting of red nodules, imbedded in shale. A bed of gray limestone succeeds, and then various beds of sandstone and shale, till we reach an enormous vein or dike of trap, which occupies the shore for more than 300 yards. In this are found basalt, greenstone, amgydaloid, and concretionary trap, exfoliating in concentric coats; and it is traversed by numerous veins of calc spar, steatite, and quartz.‡ The next beds seen are a red and a gray limestone; there is then a whin dike; south of which, from the gate upon the road to the limestone quarry, the shore is occupied by sandstone. The strata

* A handsome and commodious hotel has very recently been erected; and under its present management is a most comfortable and pleasant residence for a few days.

† Mr. Douglas, postmaster at Corrie, and his two sons, are highly intelligent and obliging persons, well acquainted with the strata in the vicinity, and with the geology of the island generally.

‡ Ramsay's *Arran*, p. 20.

of limestone extend up the hill, rising towards the north, and dipping S.E. at 36° . The rock is of a bluish-gray colour, about twenty feet thick, and consists of twenty-two beds of limestone, interstratified with the same number of beds of red shale, the thickest stratum seldom reaching one foot. The workings are inclined adits descending in the line of dip. Over the limestone are shales with hematitic iron ore. Several dikes traverse the limestone, and alter its structure;—fossils abound, but are procured with difficulty. It has been remarked, as indicating the tranquil nature of the deposit, that the large producti uniformly rest with the convex side of the valve downwards. In the sandstone upon the shore in front of the village several common species of coal plants are found. A little south of Corrie, near the fall on Lochrim burn, another bed of limestone occurs; that under Maoldon has been noticed already (Art. 82). The many interesting trap dikes have also been noticed;—and those curious irregular ridges on the surface of the sandstone mentioned as occurring on the Corregills shore, are even more remarkable here. They sometimes stand up six or eight feet above the surface, and have very sharp jagged edges. In most cases they are independent of whin dikes, and consist of matter originally less liable to disintegrate than the sandstone, and probably introduced into fissures in this rock after it had consolidated.

88. We return now to the contact of the carboniferous rocks with the old red sandstone at the march of Achab farm, and follow the latter rock northward along the coast. Expanding inland, it rises into high cliffs. The forms into which these have been moulded by the action of the sea, the disposition of the natural wood upon them, and the huge granite blocks which stand prominent by the road-side, give a unique and most picturesque character to this part of the coast. One of the largest blocks (on the western edge of the road among trees) we estimated at above 200 tons; farther north on the eastern edge of the road is another very large block standing upright on its apex, perhaps let down so from a floating berg, or originally imbedded in sandstone, afterwards worn away as the tide ebbed and flowed around. A melancholy interest attaches to another boulder south of the march of Achab farm. A garrison of eighty men had been left in Brodick Castle by Cromwell; against these the natives became so irritated, on account of the excesses of some of the soldiers, that when they were out upon a foraging party in this direction, the Arran men rose against them, and put them all to the sword, except one poor fellow who escaped, and hid under this stone.

His place of concealment being soon discovered, he shared the fate of his companions.

We cross the Sannox burn by a rustic bridge, where it comes flashing down along its bed of granite sand, among wild copsewood, through green shadows and gleams of sunlight. Our path is now by the farm-house on the shore; but we must not pass so near the finest view of Glen Sannox without stopping for a little to look upon it. This point will be readily found upon the road towards North Sannox house. We look down upon a broken foreground, sloping on both sides towards the stream. On the right the glen is bounded by the long, steep ridge of Suithi-Fergus and the Castles; on the left by that of Cioch-na-Oigh and the prolonged ridge of Goatfell. Cior-Mhor stands proudly up, closing the long vista.—We return to the shore. The high ridge of ground dividing North and South Glen Sannox terminates on the shore, in a precipice called the Blue Rock, from a decomposition taking place upon it, due to the presence of iron and manganese, acted on by trickling streamlets. Here, and along the shore, the strata of old red still retain their southern dip, at a small angle. But when we cross the North Sannox water, we find the inclination southwards much less; and as we advance a little, the strata become horizontal. Still advancing, we find them dipping in the opposite direction, at angles gradually increasing till the original dip of 15° or 20° is reached, but now directed N.N.W., instead of S.S.E. The line *from* which these opposite dips are thus directed, and which is nearly in the direction of North Sannox Glen, is called the Anticlinal axis. The name was applied by Murchison and Sedgwick; but the relations of the strata were first pointed out by MacCulloch. It is obvious, then, that the strata are successively newer as we advance along the shore towards Loch Ranza. We shall pass over their baset edges rising southwards, the dips being northerly, and the inclinations on the shore from 10° to 15° and 20° ; while on the face of the hills above they are from 50° to 70° , but in both cases alike towards the same point of the compass.

The Old Red here is cut by several dikes, of which two are extremely interesting. One of these is about half-a-mile north of North Sannox burn; it entangles a mass of altered sandstone, wedge-shaped at either end, five yards long and seven inches thick; the range is nearly north-west. The other dike is at the angle of the shore, where the Fallen Rocks first come into view, at little more than half-a-mile distant. The dike is best seen in the sand under the grassy bank. The structure of the trap varies, much of it being

a fine blue greenstone or basalt. The change on the sandstone is remarkable. The interlacing of the two rocks, and intrusion of string-like veins of trap among the sandstone strata, as forcibly attest as any dike in Arran the irruption of a liquid stream of lava into the crevices of a fissured mass.

The Fallen Rocks are about two miles from Sannox; they are an immense debacle of masses of old red sandstone hurled from a hill above where an overhanging cliff gave way; and now strewing the beach and steep slope in magnificent confusion. They seem freshly fallen, yet Headrick described them fifty years ago as we see them now.

89. Immediately west of the Fallen Rocks, we come on the lower beds of the carboniferous series following conformably on the old red sandstone. They are very similar to the corresponding beds at the march of Achab farm, near Corrie; a calcareous conglomerate, with beds of white limestone, being the lowest. These are followed by sandstone and shale, with nodular limestone and thick bedded red and white sandstones, till we reach the limestones near the Salt Pans, which are the same as the Corrie beds. But we must not omit to notice the great trap beds of Lagantuin bay, which upturn the shales from their usual inclination of 20° to an angle of 58° . These traps are amygdaloid with zeolites, steatite, and carbonate of lime, claystone, and porphyritic greenstone or trap porphyry with crystals of diallage. The coast section near the coal pits is very interesting; it is thus given by Murchison and Sedgwick, as seen west of Millstone point:—

1. Blue shale, with limestone,	. . .	25 feet.
2. White sandstone,		2,700 „
3. Carboniferous limestone and shale, alternating,	120	„
4. White sandstone and variegated shales,	. 2,000	„

Sandstone and shale, containing seams of coal, succeed these till the beach is obscured by shingle. The principal seam is three or four feet thick; but has been worked out, as far, at least, as the level of the sea, which now invades the seam. It was used only at the adjoining salt and lime works, and never exported. There were workings on two or three seams in the direction of the dip, which is nearly at 45° north, but all were abandoned, when, from the depth of the workings, the sea gained access to the pits. The coal is of that variety called *blind coal*, containing an unusual quantity of carbon, and burning without flame or smoke. Many vegetable impressions, chiefly ferns and calamites, were found in the coal

below the shale; the stems of the latter being formed of a hard coal with a bright shining fracture. This character of the coal may be partly due to the action of several dikes which here cut the strata. An adit was opened in the hill above on the strike of the seam, but no coal was found.

A little to the west of this, beyond a shingly beach, sandstones and shales again appear. The shales contain beds of ironstone, some of which have the structure of septaria; and these, with the variegated shales, form on the shore a flat platform, with a tessellated appearance, like a mosaic pavement. "I doubt," says Mr. Headrick (p. 210), "if the most skilful mason, or even a mathematician, could produce anything more regular or more beautiful."

Farther on—about half-way between the Salt Pans and the "Cock of Arran"—several beds of red limestone, rich in fossils, and of red shale, occur. It is interesting to notice the perforations of pholades in the limestone above the level of the present tides, as being a striking collateral proof of that change of level to which we have so often alluded.

These limestones are succeeded by a series of sandstones, shales, and fine conglomerates, overlaid in their turn by variegated marls, containing nodular ironstone, and by white sandstone. Over the latter, a little way east of the Cock, lie beds of fine red sand, alternating with fine conglomerate, the dip of both being 65° W. of N., at 23° . These beds, with the white and red sandstones which succeed them westwards till the schist is reached beyond the Scriden, are the uppermost members of the whole series, which begins to overlies the old red sandstone near the Fallen Rocks. From their position and mineral character they have been classed as new red sandstone by Murchison, Sedgwick, and Ramsay. Mineralogically, they have a much greater resemblance to lower permian strata than any of the rocks in the southern district; but we refer them, notwithstanding, to the upper carboniferous series, till fossils shall be found which may decide the question.

The Cock of Arran near which this series begins, is a large isolated mass of sandstone, resting on the beach, a noted landmark among sailors. When seen in front from the sea the block had the form of a cock, with expanded wings, in the act of crowing. The resemblance is now less striking, as the head has been broken off. Beside this block there are two singular whin dikes close together, on the flat beach, about two feet wide. They terminate in the sandstone, almost opposite to one another, and are prolonged in contrary directions.

90. The following list comprises all the known fossils of the car-

boniferous series in Arran. The old red sandstone has not as yet yielded any organic remains:*

Plants.

Stigmaria ficoides: Corrie sandstone; Salt Pans.
Sphenopteris? Salt Pans.
Calamites? Corrie; Salt Pans.

Crustacea.

Phillipsia pustulata: Salt Pans, in red shale.

Brachiopoda.

Productus giganteus.	Orthis resupinata.
—— Scoticus.	Spirifer bisulcatus.
—— spinosus.	—— undulatus.
—— latissimus.	—— octoplicatus.
—— Martini.	—— lineatus.
—— punctatus.	—— papillionaceus?
—— lobatus.	Rhynchonella pleurodon.
—— costatus.	Athyris ambigua.
Chonetes variolata.	—— another?

Monomyaria—Dimyaria.

Avicula modiolaris.	Nucula attenuata.
—— pecten.	Cardium alæforme.
Venus, two species?	Cypricardia rhombea.
Nucula undulata.	

Gasteropoda.

Buccinum acutum: above Corrie, in red shale.
—— ampullaria, do.
Natica elliptica, do.
—— variata, do.
Murchisonia? do.
Bellerophon striatus, do.

Cephalopoda.

Orthoceras (undetermined): Corriegills, in sandstone.†
—— unguis: Corrie, in shale.
—— attenuatum: Salt Pans, in shale.

Radiata.

Archæocidaris Urii.

Zoophyta.

Cyathophyllum, two species?	Calamopora tumida.
Lithostrotion Martini.	Fenestella flustriformis.
Cellapora Urii.	Stems of Encrinites.

The Scriden is a headland whose base is strewn with immense

* Many of the best fossils on this list were collected by Mr. John Young, of the Hunterian Museum, Glasgow. The trilobite was found by him at the Salt Pans in September last. Nelson Mitchell, Esq., of Glasgow, who has carefully examined the limestones and shales in several localities, has supplied several good species. I owe also to his kindness many interesting observations on different parts of the island. Several species have been kindly made known to me by Thos. Chapman, Esq., of Glasgow. The species whose localities are not given are common to the Corrie beds and those of the north shore.

† The sandstone is so much altered by the dikes which here traverse it that the species cannot be exactly determined.

masses of sandstone. These fell about 100 years ago with a loud noise heard in Bute and Argyll. The debacle is more extensive than that of the Fallen Rocks, but inferior in grandeur. It was produced by a landslip of the mountain side, the traces of which yet remain in a long deep rent near the summit. Scrambling for a long way among the fallen masses, we reach an open shingly beach, along which the line of the old slate advancing from the interior, strikes the shore, and cuts off the red sandstone; but the nature of the ground does not permit the junction to be seen. The slate here dips about S.E. at 40° . The change takes place near a glen, with a burn, called Alt-Mhor (large burn.) The variety called chlorite slate occurs here, and quartz abounds in veins and beds in the slate.

91. A short distance forward, at Newton point, where the coast bends round into Loch Ranza, and a small stream, called Alt-Beith (birch burn), enters the sea, there occurs one of the most instructive sections to be seen in Arran. Strata of sandstone again occupy the shore for 300 yards, dipping into the sea, and resting along the platform in front of the cliffs upon the upturned edges of the strata of slate. These make an angle of 40° with the horizon, and dip 40° E. of S.; the strata of sandstone are inclined at 25° and dip 55° W. of N.; the dips being thus nearly in opposite directions (see Art. 45, *sub fin.*) This unconformability indicates that the slate, itself a sedimentary deposit, had not only been formed in this regular stratification, but had undergone a general disturbance, before the sandstone beds were thrown down upon it. The position of the slate-strata has no relation to the granite of the nucleus;—the dip and strike are related to the great axis of elevation traversing the country in the direction of the Grampian chain. This position had been acquired before the Arran granite was injected amid the strata of slate, and ere yet any of the sandstone beds which succeed it had been deposited. These sandstones (old red and carboniferous) are conformable to one another, and the deposits blend, at both sides of the section, Achab farm and the Fallen Rocks. But we see here, as repeatedly noticed already, that neither deposit has any relation to the stratification of the slate, which had sustained extensive dislocation before the deposit of the old red sandstone had begun. The cut annexed represents the appearances at this place.

The sandstone strata here alternate with beds of limestone and conglomerate. The lowest bed, *b*, next the slate, *a*, is a hard crystalline white limestone, about six feet thick; it contains quartz pebbles, schist, and diffused siliceous matter; and is without fossils. There are several beds higher in the series, but the thickness is less.

The total thickness of the various beds is not more than fifty feet. Whin dikes traverse both the slate and sandstone. The

(a) Slate; (b) beds of white siliceous limestone; (c) sandstone and conglomerate.

presence of this peculiar limestone fixes the age of the deposit, which resembles, in all respects, that already noticed at Achab farm, and the Fallen Rocks, as forming a gradation from the old red to the carboniferous series—there being a difficulty in determining to which it ought to be assigned. We are inclined to the view that it is the lowest member of the carboniferous system. The occurrence of the limestone here has been noticed by Jamieson (*Min. of Scot. Isl.*, vol. i., p. 78, edit. 1800), from whom our cut is taken; by Headrick (p. 206, 1807); and by MacCulloch (vol. ii., pp. 376, 356, 1819). Later writers have classed it as new red sandstone, overlooking the limestone, and have given the dips erroneously. The deposit is a mere isolated patch, and has no connection with the sandstones eastwards, which abut upon the slate, and are clearly the uppermost members of the carboniferous series in this part of the island.

Very few granite blocks occur along the north shore, and none of more than two to three tons in weight. But as we enter Loch Ranza and its glen opening directly on the granite nucleus, we meet with boulders of great magnitude. Two of this kind, with many lesser, rest on the beach at the north-east angle of the bay.

92. One generally reaches this point late in the day, when the rays of the declining sun already fall strongly on the outer part of the bay, the upper portions being in the deep shadow of the high western hills. The old castle on its raised bank of shingle, which has kept its place steadfastly against wind and tide for at least 2,000 years, is a fine object in the foreground. The middle of the picture is occupied by boats, in from the fishing, and by nets suspended between high poles, beyond which is a line of white cottages on the west side, and houses of higher pretensions on the east, from which the curling smoke rises up invitingly. The background is a dark circle of gloomy hills, now reflected in the lipping tide, which give an air of peculiar solemnity and seclusion

“To the lone hamlet, which her inland bay
And circling mountains sever from the world.”

Beyond, and over all, rises the serrated granite ridge of Castle

Abhael and the Sui, gleaming now in the golden light of sunset, and contrasting strongly with the dark slate hills of Ben-Leven and Tornidneon, thrown into deeper shade by the high hills on the west. The place altogether has a singularly picturesque and unique aspect; the stranger will say he has never seen such a hamlet and bay before. Yet will he find most comfortable quarters at the unpretending inn, and even luxuries not easily found elsewhere.

The stranger who has got but one night at his disposal to spend in Loch Ranza, should contrive to reach the place so early that he will have time for a stroll along the sea shore, to the west, in the direction of Glen Catacol. Towards sunset, on a clear and still summer evening, the scenery appears to the highest advantage. It has then a quiet but touching beauty, which steals into the very soul.

There are several objects of much interest about Loch Ranza. The castle is still in tolerable preservation, though now roofless. It stands on a bank of shingle, running across the mouth of the bay, and forming the harbour. We first find it mentioned as being a hunting seat of the Scottish kings, in 1380; it was then reckoned one of the royal castles. But the date at which it was erected is not known. The Montgomeries of Skelmorlie, ancestors of the Eglinton family, afterwards possessed it, with much of the north end of the parish. They, however, lost the entire property, as an unredeemed mortgage, to the Hamilton family (*New Statist. Acct.*, vol. v.) The ruins of the Convent of St. Bride, which till lately existed here, are now swept completely away. The only interest connected with it lies in association with the well known scenes in Scott's *Lord of the Isles*, in which the scenery of "fair Loch Ranza" is very prettily and graphically described. The harbour is the resort of fleets of fishing boats. It is a most picturesque and exciting scene to witness the launching of these boats on a summer evening, under a favouring wind. In rapid succession they drop down from the harbour into the outer bay, and dart away in bounding glee, some out north into Loch Fyne, and others away to the left, across the broad waters of Kilbrannan sound. Though so land-girt and safe looking, Loch Ranza is by no means a safe anchorage. The most fearful squalls, sometimes even in summer, fall upon it from the narrow opening of Glen Eis-na-vearraid, between Tornidneon and Meal-Mhor. The currents of a S.E., S., or S.W. wind traverse the whole length of this long glen, hemmed in between high hills, and issue from the narrow gorge with terrible violence. Vessels are thus often driven from their moorings, and obliged to seek safety in the open frith, or by running for Loch Fyne.

The only object of great geological interest near Loch Ranza is the granite junction at the base of Tornidneon. This bold and finely-shaped mountain, about 1,500 feet in height, rises on the east side of the gorge above referred to, through which a torrent descends into the head of the loch, having cut a deep channel in the solid rock. The place is wild and picturesque; at some points great caution must be used in selecting our footsteps. We are upon the junction in the river bed, at the upper end of the gorge, where the open glen begins. Many fine branching veins of granite run into the slate, narrowing to threads as the distance increases, the granular structure becoming at the same time more minute; some are interstratified with the slate. As already noticed at the Glen Rosa junction, the slate is banded with quartzose layers; and these, as well as the slate layers, are much contorted. In some of the larger veins the granite is coarse-grained, but usually a more compact or confusedly crystalline strip separates these from the slate. The front of Tornidneon shows several fine veins and alternations where the two rocks approach, as already noticed in Art. 52. The whole appearances are strongly confirmatory of the intrusive character of the granite; and this junction early became celebrated in the discussions between the abettors of the igneous and aqueous theories.

Some fine junctions may also be seen across the hill tops between this point and Glen Catacol. We may ascend from here and return from Catacol by the shore; or first visit Catacol from Loch Ranza, examine the terraced ridges at its mouth, and then ascend by the granite junction at the N.E. angle of the glen. The descent upon Loch Ranza from the high platform is not difficult. The walk affords many grand views.

EXCURSIONS VI., VII., VIII.

93. THREE interesting excursions may be made from Loch Ranza, from none of which, however, will it be easy to return to this place on the same day. They may, therefore, be taken at different times, after an interval. Most tourists will prefer the last—a return to Corrie by the inland route.

A walk by the shore, from Loch Ranza to Dugarry, about eleven miles, will more amply reward the lover of the lonely, the

wild, and picturesque, and the botanist, than it will the geologist. Still there is the slate to study; the whole walk is upon slate; and the many changes in its mineral character, the effects of former sea action upon it, as shown in the ancient cliff, which in some places advances boldly on the shore, and in others retires inland, and as compared with the like action on the sandstone, will form interesting subjects of inquiry. Abrupt changes in dip will be noticed in the slate, at the north side of Glen Catacol. With the exception of a few singular inversions, due, probably, to dikes, it maintains a pretty uniform dip and inclination, 40° E. of S. at about 40° , till we approach Glen Catacol, north of which an anticlinal seems to occur, owing to an advance of the granite in the direction of the bay. On one side the slate rises up towards the granite, as if thrown off from it, the dip being 65° W. of N. at 53° ; on the other it dips E. and S.E., at about 30° to 40° . But this dip is not maintained; it is sometimes directed towards the granite, in other places, "end on" to it, or southward, and in others again off the nucleus, or nearly west; but there is never exhibited that mantling stratification around the nucleus which is usually seen in granite tracts.

It is only on this extreme north-western border of the slate tract that the micaceous character which prevails in Cantire is assumed by the slate. Near the Free Church, which stands on a lovely picturesque spot in North Thundergay, a fine mica slate, banded with quartz, occurs; east of this there is much chlorite slate, and one mile west of it, near the secluded burying-ground, blue argillaceous slate, mixed with the chloritic variety. But generally there is on this side a greater tendency to the micaceous character. On the Imochair shore, and towards Dugarry, the ordinary character has become again established.—There are comparatively few dikes on this coast. A little east of the Free Church there are two, each of which appears to bifurcate. On the Penrioch shore a great bed of greenstone, 100 feet broad, occurs. We did not notice a single bed either of porphyry or claystone. Many boulders of granite occur; northwards they are of the coarse-grained variety, but of both varieties on the South Thundergay and Penrioch shores. A few were estimated at as much as twenty to thirty tons weight.

As the coast from South Thundergay southward, is somewhat monotonous, we would recommend the tourist, if the day be clear and steady, and he has had an early start, to diverge inland at South Thundergay, visit the lovely and secluded corrie and tarn, called Corrie-an-Lachan (hollow of the lake), ascend Ben-Varen from the north, pass along its eastern ridge, and descend upon Iorsa water-

foot, through Glen Scaftigall. He will be delighted with the wild scenery, and will notice many objects of geological interest.

The terraces already noticed (Art. 58) at the mouth of the Iorsa, in front of the Duke of Hamilton's shooting lodge, are very striking—by far the most remarkable in Arran.

There is no hotel in this part of the island, but very comfortable quarters can be had at a farm-house in the hamlet of Auchincarr, a short distance east of the lodge. The tourist can then easily find his way to Brodick, or he may pass along the shore by Mauchrie waterfoot to Tormore and King's Cove. Glen Iorsa opens on this part of the coast; and here the number of granite boulders greatly increases, the proportion being now in favour of the fine-grained variety, which exists throughout the whole of Glen Iorsa. From Iorsa waterfoot the coast section presents first old red sandstone and conglomerate, and then carboniferous sandstones, but no junction is visible of the slate with the Old Red. We observed scratched boulders about Auchincarr.

94. A walk across the interior of the granite nucleus, from Loch Ranza to Iorsa waterfoot, will be good work for a long summer day; or the geologist may return from Auchincarr to Loch Ranza by this route. We preferred the former, diverging westwards at the base of Ben-Varen, ascending that mountain, and descending upon Imochair, to reach Dugarry by the coast road.* In this way we can visit the Tornidneon junction, pass up Glen Eis-na-vearraid, by the burn, fully examine the two granites, visit the lakes (Art. 43, p. 62), trace the dikes in the fine-grained granite (Art. 46), inspect the great beds of china clay under Ben-Varen, to the N.W. of the head of Loch Tanna, and either mount to the summit of Ben-Varen, or pass on southwards by the base of Sal-halmidel to the mouth of the Iorsa. The botany of this part is meagre, but objects of geological interest will be met with, allusion to which now would be mere repetition of what has been already stated.

95. The inland route from Loch Ranza to Corrie presents a few objects of interest. A walk of three miles by the high road, which winds screw-like along the hill-sides, by the edges of the deep glens, brings us to the summit of Glen Chalmidel, and the watershed into north Glen Sannox. The views of the northern front of the ridge of the Castles and the Sui are very grand from this point. A few hundred yards below the summit, as we pass down into Glen Dhu, granite appears by the road-side; and in the river bed, a little farther,

* By previous concert with friends at Brodick, a vehicle may be in waiting at Dugarry.—Very welcome it will be after so long a march.

a junction of the slate and granite is very well exposed. A glance at the map will explain the occurrence of the granite here. The principal junction is at the point where the river comes close in under the bank, along which the road passes. Here there are some peculiarities well worthy of notice. The two rocks are seen to come close up against one another, 'most distinctly contrasted; but there are no veins emanating from the granite. This rock is coarse-grained, much coarser than in any other junction we have noticed, yet it is more compact than the coarse-grained granite usually is, and, though hard, brittle. About one hundred yards down the stream a vein of fine compact granite, five feet broad, traverses the slate; and thirty yards farther, another vein, one foot broad, bluish coloured, fine-grained, and very brittle. The entire mass of slate, between this lowest vein and the main junction above, is much altered; it is extremely hard and tough, contorted in the laminæ, and being much veined with quartz, is assimilated in aspect to a granitic rock. Below the lowest vein it speedily assumes its usual appearance. Mr. Ramsay was the first to notice this interesting junction; and it is well described by him. Several other junctions may be seen in the branches of the main stream.

A little farther down the glen, and less than one mile from the bridge, some well marked glacial striæ are seen on the road-side, upon a mass of slate *in situ*. They cross the laminæ, and are directed nearly due east and west. The slate also is rounded off.—On the hill to the north, some great blocks of coarse granite rest upon the slate. These travelled blocks reach a good way up the south front of the coast range; but in crossing, on one occasion, along the summit, keeping generally near the edge of the cliffs, we did not find a single block. It would seem, therefore, that the few, and comparatively small blocks, on the north shore, must have worked round, from either side, under the force of the waves. Slate was found everywhere on the summit, and far down upon the steep fronts, where the junctions take place.—Some curious varieties of slate will be observed in the river bed, on both sides of the bridge. A short distance below the bridge, we leave the slate, and, after an interval, come on coarse conglomerate, no junction being visible.

Many years ago, a large population, the largest then collected in any one spot in Arran, inhabited this glen, and gained a scanty subsistence by fishing, and by cultivating fertile plots on the sunny hill-sides. Forty or fifty years ago they were obliged to leave, and furnished with the means of reaching Canada. Garden enclosures, and ruined wallsteads, still remaining, give a melancholy interest to this secluded glen.

Near the summit level of the road between north and south Sannox, and a little to the north of Sannox house, the sandstone strata, on the east side of the road, are marked with striæ, rendered somewhat fainter than those on the slate by the effect of decomposition. Like these they are transverse to the laminæ, and are directed 5° S. of W. (70° W. of magnetic N.), that is, in the direction of the ridge of Suithi-Fergus. If we assign their origin to ice, then we must admit that the moving masses advanced in parallel courses, in both cases, from high ground on the west.

We are now within a few yards of the spot where the finest view of Glen Sannox is obtained, and to which a former excursion brought us. Taking another survey of the grand scene in its evening aspects, we press forward to Corrie, to catch the Clyde steamer on her way to Brodick.

EXCURSION IX.

TO HOLY ISLE.

96. MAKE choice of a day when it is high water about noon, and leave Invercloy for Lamlash by the mail steamer from Ardrossan. The captain, whose polite attention to all visitors is well known, will land you at the wooden pier on Holy Isle, and on reaching Lamlash, will order a boat to fetch you to the mainland at any given time. A few hours will suffice to examine the island and ascend the mountain. The basis of the isle all round is sandstone, which rises to the height of 100 to 150 feet; the rest of the mountain, to the height of 1,020 feet, is composed of claystone, so that this rock has the thickness of about 850 or 900 feet. On part of the east side, however, it is much less than this, as the sandstone rises there much above its usual height. The rock is of igneous origin, a member of the trap family, and varies in structure from a soft claystone to a compact felspar; the harder varieties are called clinkstone. As in most traps, the prevailing form is prismatic; and on the E. and S.E. sides of the island, columns of great length appear in the high precipices. But the schistose structure is also common; and, as in cases already mentioned at Corriegills, both structures occur in the same mass, the slaty fracture being at right angles to the axis of the prisms; the ends of the prisms first divide into laminæ, and the mass gradually assumes the slaty structure. The

weathering of the rock is remarkable, and extends to a considerable depth, presenting successive concentric zones of different colours, which have a very pretty appearance in many specimens. The slaty structure itself, in the case of this rock, seems to be but a step in the process of decomposition.

Various masses of greenstone occur, both as dikes and beds; one on the S.E. side presents remarkable alternations with the sandstone, and alters its structure. The felspar rock itself is seen in one place on the east side to intersect the whole body of strata, and to be connected above with the overlying mass of the same rock. Here, also, there is a very interesting vertical vein or dike, intersecting an oblique trap vein, and showing in the centre fine black basalt, containing zeolites and glassy felspar; on each side of this there is a lamina of a black substance, intermediate between basalt and pitchstone, and at the outer surfaces a coating of vitreous pitchstone one-tenth of an inch in thickness. These substances, indeed, are all of one origin, the variations found here, as well as in other places, being due merely to different rates of cooling in the once fused mass. The same oblique vein is intersected by a vertical vein of concretionary trap. Dr. MacCulloch gives a drawing representing the appearances (*West Isl.*, vol. iii., pl. xxiv., fig. 2).

The granite blocks on this island have been already noticed (Art. 59). On the west side, near the landing, there is a raised beach or shelly deposit thirty feet above the present sea level. Adders abound upon the island, but their number is said to be diminishing.

97. The tourist must visit the hermitage of St. Molios. It is situated a mile south of the landing place, and is a natural excavation in the old sea cliff. The following is the correct legend of St. Molios. The conjectural account usually given is quite inaccurate:—"The legend of St. Lasrian, or Molassus, is well known to Irish antiquaries; it was printed in the Bollandists' collection, *Acta Sanctorum*. He was born in Ireland A.D. 566, educated in Bute by his uncle, St. Blaas, returned for some years to Ireland, and afterwards, when yet only twenty years of age, retired to an island in Scotland, where for some years he led the life of a hermit—probably in the cave which is still pointed out as his in Lamlash Isle, *i. e.*, 'Isle-a-Molass,'* later named the 'Holy Isle.' About the year 614 he was elected Abbot of Leighlin, in Ireland, and was afterwards made a bishop, and Apostolic legate to the Church in Ireland. He died in the year 640.

* Lasrian and Molassus are radically the same. "Las," meaning "light," was probably the proper name; the prefix "mo," and affix "rian," mean "very" and "good," expressing approval or endearment.

The inscription on the roof, in Runic letters, has no reference to Molassus. The words, '*Nicolas hann raisti*'—‘Nicolas this engraved’—are Norse or Icelandic, and clearly refer to a Norwegian hermit who resided here at the time when the Northmen ruled the Western Isles, or about A.D. 1100. Wilson (*Arch. of Scotl.*, p. 531) identifies this hermit with a bishop of Man. He would make the inscription refer to the excavation of the rock. But this has clearly been the work of the sea; and, besides, the cave was the abode of St. Molassus at an earlier period. Mr. Wilson gives some other fragmentary Runes. A small cell or monastery was erected in connection with the hermitage, apparently by Reginald de Insulis, between 1206 and 1212, probably in connection with the monastery of Saddell, in Cantire, founded by him, and to which he granted lands in Arran. It seems to have been an abbot of this small monastery, whose tombstone, bearing his chalice and pastoral staff, but without any inscription, is still extant in the ruins of the ancient burying place and chapel at Clachan glen, and which is popularly called St. Molios' grave."* The traces of this monastery were till lately to be seen north of the cave, beside a burying-ground, which was long used as the chief place of sepulture for Arran, till the loss of life by the upsetting of a boat led to a discontinuance of the practice.—A pure spring of water close by the cave, was long famous for supposed healing qualities.

EXCURSION X.

TO WINDMILL HILL AND PLOVERFIELD.

98. THE Windmill hill is conspicuous from all parts of the Brodick coast, as the high narrow crest of a long ridge which divides Glen Shirag from Glen Cloy. It may be readily ascended from any side. If we pass along its north front from the String road, we shall see the pits from which shell limestone, like that at the Chapel of Ease, was formerly quarried; but the ascent along the south-eastern front will best expose to our view the structure of the hill. We pass up the lovely banks of the Cloy burn, fragrant all the way with blossoms of the choicest wild-flowers, till we reach the bridge leading to the old mansion of Kilmichael. This is the seat of the Fullarton family, proprietors of an estate here—the only por-

* This corrected legend has been kindly made known to me by John Mackinlay, Esq., of Bonnington.

tion of the island not possessed by the princely house of Hamilton. The *Statistical Account* informs us that the grant of the lands of Kilmichael was made by King Robert Bruce for services rendered by an ancestor of the Fullarton family, called MacLuoy or MacLewis—a name only now preserved in the designation of the glen. But this statement is not correct: Bruce had no lands in Arran to bestow, the whole island, except some church property, then belonging to the Stewart family. The grant was made by King Robert III., who belonged to this family, about the year 1391; and the charter then given is still extant. The Hamilton family acquired the greater part of the island by marriage in 1474. Arran, erected into an earldom a short time before, was given as dowry with the Lady Mary, sister of James III., on her marriage with the Lord Hamilton.

The front of Windmill hill is formed, through about half its height, of columnar felspar porphyry, similar to that of Dun-Dhu, already described (Art. 77). The columns are four, five, and six-sided, with flat jointings; the pillars lean in various directions. The junction with the sandstone below is nowhere visible. About the middle of the front of the hill, a mass of altered sandstone, 12 feet wide, is imbedded in the porphyry. Close to this is a whin dike, running 10° N. of E. Several others traverse the ridge of porphyry—another example of the posteriority of the common trap or whinstone to all the rocks of Arran. The plane of contact between the sandstone and porphyry gradually ascends westward, and, on reaching the S.W. shoulder of the hill, we find a wedge-shaped mass of sandstone connected with the body of this rock below, and apparently separating the porphyry from the granite which immediately succeeds. No true contact of these rocks is observable. Sandstone, slaty pieces of porphyry, granite sand, and bits of granite are seen lying about, mixed up confusedly, and no line of demarcation can be laid down. Presently the hill-side shows granite only. Eastwards all the high ridge of Windmill hill is porphyry; sandstone is seen at the north base, but no contact is visible. The base of the porphyry is an intimate mixture of felspar and quartz, of a gray or bluish-gray colour, with imbedded felspar crystals, bits of quartz, and occasionally well formed crystals of this substance. We have already (Art. 50) described at sufficient length the relations of the sandstone to the Ploverfield granite, to this porphyry, and the syenite of the hill-sides westwards, into which the granite seems to shade off; and need not now recapitulate. The series forms an interesting study. The granite, porphyry, and syenite,

are all posterior to the sandstone; but we have as yet no means of knowing the age of the porphyry in relation to the granite. The common greenstone of the dikes, and detached knolls upon the plateau southwards, is the newest of all these igneous products. Sir C. Lyell, following Prof. Ramsay, remarks on "the overlying trap ceasing here very abruptly on approaching the boundary of the great hypogene region, and terminating in a steep escarpment facing towards it as at 5 *f*, fig. 702, p. 591. When in its original fluid state it could not have come thus suddenly to an end, but must have filled up the hollow now separating it from the hypogene rocks, had such a hollow then existed" (*El.*, edit. 1855, p. 592). By this "overlying trap" is meant the common trap of the southern plateau, as is seen by referring to Ramsay's section, copied by Lyell; but there is no such rock here. The porphyry is the only erupted rock, and its occurrence in this sharp-crested hill must be explained as we explain the existence of granite in mountain peaks, or basaltic lavas in the mural precipices of Mull, and the Giant's Causeway. There is no igneous rock of any kind "at the points 5 *f*," overlapping the carboniferous sandstones and resting on the old red sandstone (see Art. 46, *sub. fin.*)

99. Passing round the heads of Glen Dhu and Glen Cloy (Art. 50), we come over the edge of high sandstone cliffs bounding Glen Cloy on the south. On a grassy ledge under the western part of these cliffs there occur two remarkable dikes, producing a highly interesting change upon the sandstone. A large body of this rock, between the two dikes, is altered to the state almost of quartz rock, and beautiful crystals of amethyst are developed in it; quartz crystals, both colourless and with a slight tinge of yellow, also occur. The dike on the S.E. side is a brick-red porphyry, resembling that on the Corriegills shore; it appears also in the cliffs above, where, by wearing, a fissure is formed upon it; the dike on the N.W. side is of greenstone. There is a third dike or mass of trap outside the porphyry; but neither its relation to the others, nor of these to another, can be well made out. The locality altogether is fully as interesting as any in the island. The isolated high round knolls, called the Sheeans, over the head of Glen Cloy, are trap. Passing from them to the head of Lamlash or Bein-Leister glen, we meet with a few low knolls of like composition, but no body of overlying trap. Lamlash glen affords a fine section of the carboniferous series: red limestone and red marl at the top of the glen, and lower down two other considerable beds of limestone, the last being about a mile and a-half from Lamlash. They contain the usual fossils, and occur amid

massive sandstones. A short distance below the lowest limestone, a dike of felspar rock, or quartziferous porphyry, fifteen to twenty feet wide, crosses the bed of the river, ranging nearly N. and S. The sandstone is greatly altered by it. Between this point and the alluvial plain there are several veins or beds of claystone and greenstone, breaking through the sandstone of the river bed.—In the village of Lamash we may pay a visit to John Allen, the only collector of minerals and fossils that we know of in Arran, and engage his services for an excursion to Ceim-na-Caillach.

EXCURSION XI.

TO CEIM-NA-CAILLACH AND THE CASTLES.

100. EXCURSIONS in Arran may be varied indefinitely according to the taste and objects of the tourist or student. We have indicated a few best fitted to show the geological features of the island; and as we have now described the different formations and the most remarkable appearances which they exhibit, we shall only mention shortly the chief remaining objects of interest which in other excursions might be visited.

The principal object in our present excursion will be to look for “the black crystals,” as the smoke-quartz crystals are called. Their chief repository is the north side of the Suithi-Fergus ridge, and that of the Castles. They are found in the coarse-grained and rapidly disintegrating granite of the great northern ridge. Allen knows their localities, and is often successful in collecting them. We pass up by the N.E. angle of Glen Sannox, and then diagonally along the back of the ridge.

Ceim-na-Caillach, or the Carlins’ Step, is an immense chasm or gash in the ridge, overlooked by granite walls several hundred feet in height. The interior of the fissure can be easily reached by entering laterally at a pretty low level on the north side. We find it to be merely a whin dike worn down to this great depth below the containing granite. The rock is a dark coloured fine-grained greenstone of loose texture; it exhibits the concentric spheroidal structure so often alluded to as characteristic of common whinstone. There is no trace of any other rock; and we cannot understand how it has come to be so often said that this dike is pitchstone. The

dike and chasm pass down into Glen Sannox, but it is impossible to descend by this way. The view is very wild and grand. When the morning mists are hovering around Goatfell, and rolling into the depths of Glen Sannox, now hiding and now revealing the mountain with the ridges and peaks adjoining, the scene from the summit of Castle Abhael is extremely grand.—Various ways are open for us by which to return. We were once surprised here by a thick fog with heavy rain, and guided partly by a compass, and partly by keeping as close as possible to the junction of the coarse and fine granite, we found our way safely along the edge of the great circular ridge which runs from the N.W. base of Castle Abhael, in the direction of Glen Dhu, at the upper part of North Sannox. But the convenience of our companion, with his load of “black crystals,” must now be consulted in regard to our homeward route.

EXCURSION XII.

GLEN SANNOX AND GLEN ROSA.

101. This is a favourite excursion with visitors to Arran; many will devote a day to it in preference to others which are less easily taken from Brodick as a centre. But there are comparatively few objects of geological interest, and we shall not therefore enter into any detailed description.

There is an interesting old burying-ground at the entrance of Glen Sannox. It is all that remains of a church or monastery dedicated to St. Michael. A rude image of the saint is to be seen upon a stone built into the wall. The house was probably connected with the Abbey of Kilwinning, to which Sir John Monteith, Lord of Arran, granted, in 1397, the lands of Sannox and patronage of the churches. The barytes mill sadly mars the solitary grandeur of the scene which opens as we reach the plateau at the mouth of the glen. It was erected here some years ago to work veins of the sulphate of barytes, or heavy spar, which traverse the old red sandstone. These are seen in the bed of the stream, running in a direction nearly N.E. and S.W., and dipping nearly N.W.; they appear also on the hill-side southward. The junction in this burn has been noted already. By the bank of this fine stream of crystal water, rushing over its bed of granite sheets and granite sand, amid

huge rolled masses of the rock, is a delightful walk. Near the head of the glen we may diverge a little to the right, and examine, at this lower level, the dike and great chasm descending from Ceimna-Cailliach. Following it southward on its line of bearing we trace it entering the granite precipices in front of the base of Cior-Mhor, and passing on over the col, in the direction of the axis of Glen Rosa. The safest pass into this glen is at the western side of the col, or ridge joining Cior-Mhor to the base of Goatfell. In the hollow up which we pass we have a whin dike beneath our feet, and granite walls on either hand—the pathway, in fact, has been formed by the disintegration of this dike. On reaching the summit we observe a great dike, most probably a continuation of this one, ranging right up the front of Cior-Mhor. When one reflects upon the mode of origin of these two rocks, granite and greenstone, it strikes one with wonder to perceive the curious relations which they maintain, and the important part in the physical condition of the region which the dikes play. M. Necker goes so far as to suppose it quite possible that the excavation of Glen Rosa may have been determined by the great dike above noticed. In the lower part of the glen the river runs upon it, between high granite walls, for a long distance (Arts. 64, 65). It is thus by far the most continuous dike yet traced in Arran.

M. Necker describes a very curious dike as existing on the ridge between the two glens, which we were not so fortunate as to notice in any of our walks this way. "It passes along the ridge between the glens, on the S.E. side of Cior-Mhor, ranging nearly east and west. It consists of five bands; in the middle, there is green pitchstone, on each side of this a band of claystone porphyry, two feet broad, beyond which are two bands of common trap seven and a-half feet broad each. The dike forms a deep ravine, which reaches to the summit of the mountain. The claystone disappears aloft, and the pitchstone is then five feet broad, and each band of trap four feet; the band on the north side shows the spheroidal decomposition."—(p. 693 of *Mem.*, quoted p. 83.) We noticed no dike on the summit, nor upon the S.W. and western sides; but it is quite possible it may exist there.

There is little else of much interest in Glen Rosa; the granite junction has been described already in our first Excursion (Art. 64), and the singular chasm just noticed will be seen as we pass along. The adder (*Pelias berus*) is often met with in the glen, in places where there is a dry bottom under the heather; and the tourist in crossing these will do well to use caution. Again

and again we have narrowly escaped treading upon them in such situations, here, in N. Sannox, in Lamlash Glen, and other places. We have never seen them higher, however, than about 1,000 feet; nor are they as abundant on the west as on the east side of the island. They occur also in Holy Isle. A long and interesting account of the creature, with figures, will be found in Bell's *British Reptiles* (p. 61-75). It is the only British representative of the poisonous group of serpents; but there is no authenticated case of fatal effects resulting from its bite in Arran or elsewhere in Britain. We have heard of more than one case of severe symptoms; but these were removed in a few days by an application of herbs boiled in butter.

The burns of Arran are all beautiful and picturesque, but in different styles, according to the nature of the rocks across which their courses lie. Those of the granite and slate tract are the most beautiful; and this Rosa burn, especially in its lower course, and after it enters Glenshant, far surpasses in romantic beauty all the bright streams of this lovely island.

102. Over the wood which covers the eastern end of the ridge on the south side of Glen Rosa a curious meteorological phenomenon is often witnessed. When the wind is at S.W. or W. with a damp and warm atmosphere, a column of vapour is seen ascending from near the centre of the wood, remaining in a nearly steadfast position for some time, and then suddenly vanishing; to be again formed, and again as suddenly disappear; and this is repeated through a period sometimes of several hours. The explanation, no doubt, is that currents of wind descending Glen Shirag on one side, and Glen Rosa on the other, produce, by the rapid out-draught into Glenshant, a partial vacuum and vortex of light ascending air over the middle of the wood, which is completely sheltered; and by this relief of pressure a condensation of vapour takes place, just as a cloud is formed in the exhausted receiver of an air-pump.

We may mention now, when on the subject of meteorology, an interesting case illustrating the relations in which the different kinds of clouds stand to one another:—On a bright hot day, after rain on the day previous, a pretty rapid current of wind from W.S.W., with scattered masses of white fleecy clouds, prevailed aloft from early morning as a land wind; while a light east wind blew below as a sea breeze. The currents met, a little way out in the channel, off the Corriegills shore; and along a strip of sky, stretching from north to south, the fleecy cumuli of the S.W. current were arrested by the current from the east, and resolved into a

broad band of cirri. By four o'clock in the afternoon the upper current had descended to the surface; and a strong breeze from the west, preceded by a whirlwind, immediately sprang up. Towards evening this gradually subsided into a gentle air.—The day was one of those delightful Sabbaths to be enjoyed only in the rural districts of Scotland, or the North of Ireland. The Free Church congregation of Brodick was observing the communion services; and a vast concourse of pious and most attentive worshippers was assembled from all parts of the island; one minister officiated in English in the church, while another conducted the service in Gaelic from a tent in the open field. Apart altogether from the solemn feelings awakened by the simple and touching service, the mere picturesque adjuncts of these scenes at Brodick will never fade from the memory of any one who has witnessed them.

MEMORANDA OF OTHER EXCURSIONS.

103. To King's Cove is a favourite excursion, and deservedly so, for the scenery there and about Drumadoon is extremely beautiful. With this may be combined a visit to the Craig-Dhu granite and the Tormore pitchstone dikes. The druidical circles at Tormore should also be visited. But all this is too much work for one day. In returning to Invereloy on foot from King's Cove or Tormore, the walk will be varied by striking off the main road at Shiskin, and crossing right over the island in the line of Clachan Glen, and descending from the high plateau above Ploverfield, either by the Windmill hill or the Sheeans. To walk from Invereloy by Mauchrie waterfoot and Tormore, and return by this route, is no mean performance for one day. But the platform ought to be gained before sunset, as twilight falls rapidly in Glen Cloy, and the ground between the Sheeans and Invereloy is broken and difficult.

THE STRING ROAD.—After the watershed is passed granite appears on our left hand, and runs a long way down the glen of the Mauchrie; then bands of the syenites from the plateau region strike in upon the road, intermingled with the sandstone. The Glen Luigh limestone will be found farther on, high on the southern hill-side, by following a bridle road leading to the old quarry. It is a crystalline lime without fossils, much altered by the trap veins which traverse it. It is in the same position as the lime at Achab farm (Art. 87), and the Fallen Rocks.

CRAIG-DHU.—The Craig-Dhu granite has been fully described already (Art. 51). Craig-Dhu is a high steep cliff fronting that part of the Shiskin road where the road to Dugarry parts off from it. A talus of blocks strewn its base. We noticed, from a distance, in driving along the road with a party of friends in July, 1855, how unlike these were to sandstone blocks, and were thus led to the discovery of the granite tract. It struck us as remarkable, that on a route so frequented, the occurrence of the granite here had so long remained unnoticed.

CLACHAN GLEN.—The upper beds of the Old Red rise into the lower part of this glen; the middle and higher parts show the lower and middle beds of the carboniferous system, which pass over the watershed towards Lamlash. High on the south side of the glen, apparently by an upthrow of the strata, beds of white limestone with quartz pebbles, like that of Achab farm and the Fallen Rocks, are brought to the surface. The metamorphic action towards the head of the glen is the most extensive and remarkable which we have seen in Arran. All the ordinary characters of the sedimentary strata are obliterated.

TRAVELLED BLOCKS.—Leaving the Shiskin road and taking that to Dugarry in order to reach Mauchrie waterfoot, we are crossing in front of the fine-grained granite tract of Glen Iorsa; and accordingly we find that here the great proportion of the boulders are of this variety of granite; while those on the eastern side and along the south plateau, are of the coarse variety. This points to a cause locally acting in the direction of the glens;—we never find Iorsa granite on the east side of the island; both kinds are mingled on the west side (see Art. 60).

THE TORMORE PITCHSTONES.—We cross from the Dugarry road by the mouth of the Mauchrie to reach Tormore. Less than a mile to the south, in front of the sandstone cliffs of King's Hill, there occurs the finest set of dikes to be seen in Arran, exhibiting, in a small space, all the members of the igneous series, greenstone and basalt, porphyry and trap porphyry, pitchstone, claystone, and hornstone. To understand the relations of the various dikes, the shore should first be traversed several times, the whole extent being only a few hundred yards. The sandstone platform is bounded southward by the sea, and by a mural precipice sixty feet high, along the base of which there is no passage southwards, except at low water. This precipice is the western front of an immense dike of felspar porphyry, eighty to ninety feet wide, ranging a few degrees N. of E., and here taking the place of the sandstone in the cliff for a con-

siderable distance. Placed longitudinally *in this dike*, westward of its middle part, there is a greenstone dike about four feet wide, running out with it seaward to the low point where the porphyry dips into the water; it is also crossed *diagonally* by a greenstone dike, which bifurcates upon it, and is seen far up on the hill-side above. Alongside the dike there is a pretty large cave. The pitchstone and other dikes traverse the sandstone platform to the north of this. The principal dike, traceable continuously for a long distance, is formed of green pitchstone; it rises from the sea southward with a range 40° E. of N., a width of ten or twelve feet, and a S.E. inclination of nearly 30° ; but the course undulates 35° or 45° , bending towards the west, or into parallelism with the shore, towards its northern termination. There are veins of slaty hornstone on both sides, next the sandstone, and on one side a thin layer of basalt. On the side of the great vein next the sea, numerous veins enter it nearly at right angles. First, a vein of hornstone six to eight inches wide; next, one of basalt five feet wide. Another vein running a little N. of W. has on its north side three feet of pitchstone, passing into hornstone, then four to six inches of claystone, and on the south side fifteen feet of basalt or fine greenstone. Next is one thirty feet wide running 35° W. of N., consisting of basalt four feet; claystone fifteen feet; basalt again six feet, containing a pitchstone vein along its middle part; lastly, a vein of greenstone five feet wide. There is here also a vein of trap porphyry four feet wide: this and the others intersect the pitchstone vein, but the intersection is obscured by debris. The last vein northwards, is one of pitchstone with hornstone and jaspery quartzite, running oblique to the shore, and varying from eleven or twelve to thirty feet. Just outside the tideway it meets and enters the great pitchstone vein, which, in its sweep north, has reached this point, ranging now 10° E. of N., and at the junction there is nothing visible but claystone, which forms the flooring at the common point of union. The great vein stops here; but that we are now noticing continues its course under masses of sandstone, but is not seen in the cliff aloft, nor can it exist there. Still farther north we noticed a pitchstone vein running E.N.E., seven to ten feet wide, and visible in the cliff above; but apparently in no way connected with the other veins. The close association of so many igneous rocks is extremely curious; we can hardly suppose the various products to be other than cotemporaneous; so that different rates of cooling and varying chemical composition must have produced the differences now

observable. Professor Jameson was the first to describe this interesting locality, which he does with great fullness and accuracy. He gives also a figure illustrating the position of the secondary or cross veins (*Min. of Scot. Isl.*, vol. i., pp. 17 and 102).

KING'S COVE—is named from King Robert Bruce having landed here from Rathlin in 1307, and remained a short time, according to a tradition which there is no reason to doubt. The caves are in soft yellow sandstone, and are the most capacious in the island. Certain characters upon the roof seem mere unmeaning scratches,—no one at least has yet deciphered them. In the bay south of the caves, veins of pitchstone are seen in the cliffs, altering the structure of the sandstone. On the summit of King's Hill, over the great porphyry dike, noticed in the last Art., we observed many granite boulders, chiefly of the fine variety. Among these one block was most distinctly marked with glacial striæ.

DRUMADOON.—Approaching this grand façade of columns we find on the shore a great dike of pitchstone porphyry tilting up the sandstone at a high angle; but its extension is not traceable. The columnar range of Drumadoon, eighty feet in height, is composed of a similar porphyry, almost exactly the same in structure as that already described on the east coast (Art. 77). The pillars rest on a laminar stratum, consisting of the base of the porphyry without the crystals, and resembling a claystone or metamorphic sandstone. South of this there are some fine dikes. The coast scenery here is most beautiful, and will bear comparison with any other in the island. The botany of the sands is rich. On the summit of the cliffs there are remains of extensive fortifications and rude dwellings, the history of which is unknown. It has been conjectured that these works, and those of a similar kind at Torcastle, near Slaodridh, which are the only remains of the kind on the west coast, were erected as a defence against an Irish invasion from Cantire about the beginning of the sixth century; and that those of the east coast, to the most remarkable of which, Dun-fion, we have already alluded, probably existed before the Roman invasion, when the Damnii, tribes of the mainland of Ayrshire, were at hostile feud with the Epidii of the island and the opposite coast of Argyll. See a paper by Mr. M'Arthur, of Partick, in *Ed. New Phil. Jour.*, vol. ix., Jan., 1859.

BLACK-WATER-FOOT.—There are here numerous dikes of greenstone, and a great bed of hard claystone, which upturns the ends of the sandstone strata where they abut against it. In some places the sandstone is greatly altered. The curved bands of claystone at

this place are illustrated by a drawing in Dr. MacCulloch's work (pl. xxiv., fig. 3).

THE TORMORE CIRCLES.—The stone circles at Tormore, N.E. of King's Hill, are the most complete in Arran; eight circles can be traced, each consisting of from four to fourteen stones, which measure from three to eight feet, and are six to eleven in circumference; the circles have diameters varying from fifteen to thirty feet. One of the stones has a perforation evidently artificial. The stones are of the same kind of rock as the Brodick pillar. (See the remarks in Art. 62). Various conjectures have been framed regarding the origin and use of these circles; some consider them as places of druidical worship; others as sepulchral monuments. The question is fully discussed in Wilson's *Archæology*, as also the probable origin of the single upright stones. Mr. M'Arthur, who has recently examined these remains in Arran, with great care adopts the latter view, which he supports by the following considerations:—First, their occasionally enclosing a cromlech, undoubtedly sepulchral; second, the discovery of urns, with bones and ashes near them; and third, their cairn-like construction. He contends that their resemblance to the enclosed British barrow is complete (paper quoted above). Stone coffins with bones, and hollowed stones, are also found; of the purpose of these there can be no doubt. Sepulchral tumuli exist in many places, as at Black-Waterfoot and in Glen Cloy.

LEAC-A-BREAC.—A walk in the late afternoon from Black-Waterfoot across Leac-a-breac to Lag, a secluded delightful spot, forms a pleasant close to the excursion to King's Cove. Leac-a-breac is a high hill with steep seaward front and long inland extension. It is composed of felspar porphyry—the largest mass in the island. The rock is well adapted for ornamental purposes. Sandstones and shales emerge from under Leac-a-breac eastwards, and occupy the shore to Benan-head, traversed by vast numbers of dikes, a group of which is noted along the coast as forming the small safe port of South-end.

SLAODREIDH WATER—shows in its lower part, at and north of the road, a great outburst of felspar porphyry in the bed and banks. It is similar to the porphyry of Leac-a-breac, but apparently unconnected with it. This rock, with syenite, greenstone, and claystone, forms much of the hill-sides on the east of the river. The bed and banks are occupied by shales and sandstones, among which a careful search would, no doubt, be rewarded with the discovery of many fossils. A walk from Lag, along this hill-side to Lamlash, forms a pleasant and instructive excursion.

LAG AND BENAN-HEAD.—We refer in another place to the inducements which Lag offers as a centre for several excursions. Many interesting appearances may be noticed in the vicinity, and in the river banks near, some remarkable dikes. Benan-head is a mass of igneous products, irregularly intermingled, so that the relations of the rocks cannot be well determined. Dark-based felspar porphyry seems disposed in alternate bands with greenstone and basalt, the porphyry prevailing upwards, and the two other rocks in the lower parts. Dikes of newer age intersect the whole series. The entire mass of the headland is wedge-shaped, narrowing downwards, the upper edge being on the same level with the strata of sandstone on either side. The ends of these strata abut against the trap throughout. On the beach westwards there is a dike of red quartziferous porphyry.

These trap rocks range over the high grounds northwards; the coast section, as far as Dippen, presenting generally sandstones and marls. The glens inland show similar sections, there being much marl like that in Bein-Leister glen at Lamash; but we did not notice any limestone.

DIPPEN.—On the road towards Dippen, east of Auchinhew farm, a stream descends over a pretty fall, seventy feet high, called Eisa-Mhor, into a large open basin, the perpendicular sides of which present a façade of pillars resting on sandstone; over this is another bed of sandstone, supporting beds of amorphous trap. Dikes traverse the whole series. The map will show the relations of the rocks here—which, all the way round to Whiting Bay, strikingly illustrate the intrusive character of trap, and in some places the connection of dikes and overlying masses. There are fine columnar trap ranges about Dippen, and a causeway on the platform of the beach. Kildonan old castle stands on a great bed or dike of trap, continued a little below the level of the water, as far as Pladda island, which is thus attached to the mainland. The island consists of a peculiar greenstone, resting on sandstone. The Duke of Hamilton has lately erected a handsome shooting lodge on a commanding site above the Dippen cliffs. Kildonan castle is an old ruinous square keep, “one of a line of watch-towers, reaching from the mouth of the Clyde to Dumbarton rock. It was originally the residence of a family called Macdonald, who owned lands adjoining. It next passed with the property, by purchase, into the hands of the Stewarts of Kilquheelly, in Bute; by them it was sold with the rest of their property to the Marquis of Bute,

from whom it was lately purchased by the Duke of Hamilton.”
—(*New Stat. Acct.*, “Bute,” p. 55, 1840).

WHITING BAY.—The sandstone of the shore is traversed here by numerous dikes, and strewn with granite boulders of the coarse variety, of which one is larger than any south of Brodie, with the exception of the great Corriegills boulder. The relation of the trap and sandstone are finely exhibited in Glen Eisdale. At the head of this glen is the finest waterfall in the island; on the brow of the hill west of the fall, and near the side of the cart-road, we noticed, upon slabs of greenstone, some well marked glacial striæ, directed nearly east and west. At King’s Cross point there is a broad bed of columnar basalt in the sandstone, the heads of the columns forming a pavement upon the shore. Between Lamdash and Clachland point there are numerous dikes, some of which stand out more boldly from the terraced surface of the old sea-beach than any dikes in Arran.

MONEADH-MHOR GLEN.—At the opening of this glen, in the bed and banks of the stream, and of the lead of water connected with the large mill adjoining, there are two great beds of pitchstone. They are finely exposed, and exhibit very strikingly those transitional phenomena already alluded to as marking the relations of this rock to hornstone and claystone.

Associated with the pitchstones there are claystones, hornstones, quartz rock, and porcellanite. Hornstone, that is, chalcedonic or jaspery chert, seems to be the link between pitchstone and claystone. Hornstone and pitchstone are both almost entirely siliceous; the difference consisting in the colour and degree of toughness arising from a slight change in composition, or variation in the rate at which they cooled, or from both. By this change pitchstone passes into hornstone. In this hornstone a great many light-coloured spots with dark centres are gradually developed; and bands of this variety succeed the common hornstone. Next to this there follows a hard quartzose claystone, and the series terminates in the common claystone of open texture, like that of the Corriegills shore already described. The spots or specks are minute spheres, most probably of felspar or quartz, or of both, and have probably originated in the manner suggested at the end of Art. 75. They present a close analogy with the spherulitic claystone of Corriegills; but the radiated structure of the latter does not exist here. Even the larger spherules of the pisolitic hornstones do not exhibit this structure. The quartz rock at the upper end of the higher pitch-

stone vein is probably only an altered sandstone. The porcellanite alluded to above is a white substance, varying from a dull earthy aspect to that of a white enamel. It occurs of considerable thickness along the outer surface of the pitchstone, and is clearly due to a decomposition of this rock. The incipient stages of this decomposition show a structure in the rock which otherwise we should not have suspected.—The surface is traversed by a series of wavy lines, conforming to one another throughout. This indicates a laminar arrangement within; and it is along these lines that the rock splits completely up in the advanced stages of the decomposition.

The relations of these various igneous products is further illustrated by another dike which occurs a little way up this river. A great vein of claystone crossing the bed of the stream shows a distinct passage into jaspery hornstone. The jasper and chert veins in the Tormore pitchstone, with the associated claystones and basalts, place these same relations in a very clear light; and when we view the appearances which they exhibit in connection with those now described, we cannot hesitate to admit that all these products of fire blend into one another; the varying aspects which they assume being due to a slight change in chemical composition, in molecular arrangement of parts, or in the rate at which they were consolidated from a state of igneous fusion.

THE FLORA OF ARRAN.

104. IN the preceding pages it has been shown how fine a field Arran offers to the geologist, as exhibiting many diversified phenomena in a limited area. To the botanist it is scarcely less interesting—such is the luxuriance and variety of its vegetation—such the rarity of some of the plants contained in its flora. It is, indeed, true that scarcely any of these are botanical treasures of the first order; still there are several of unfrequent occurrence in the west of Scotland, and many quite new and highly interesting to the naturalist accustomed to the flora of England or the east coast.

This richness of Arran as a botanical field is owing to two causes—its geographical position and the variety it affords of situation and soil. Lying near the shores of the Scottish Lowlands, and at the same time forming one of the Hebridean chain of islands, it partakes of the flora of each region,—the common plants of its fields, woods, marshes, and road-sides belonging chiefly to the former—the maritime species to the latter. These advantages of position it no doubt does in some measure share with the coasts of the Clyde estuary generally, and especially with Bute; in Arran, however, they meet most completely; and accordingly we find that no district of equal extent in the west of Scotland can rival it in the number of species. It is to this circumstance—its situation at the junction of two dissimilar botanical provinces—that the peculiar richness and variety of the flora of the island are mainly to be ascribed.

Secondly, The geological structure of Arran impresses a marked character on its physical geography, and gives rise to the greatest possible variety of station and soil. We have lofty and precipitous mountains, wide-spread moors, small alluvial plains, hot and sheltered glens, damp woods, and sandy sea-shores. We have every kind and degree of exposure, from the bare and wind-swept top of Goatfell to the warm hollows of Glen Cloy, and this within the compass of a few miles. We have modern fir plantations and natural birch woods; cultivated fields and hedge-rows; wide stretches of peat-bog; rocky promontories and caves; open strands and sand

hills. Of soils, too, in the stricter sense of the word, there is a notable variety. The general division of earths into sandy, loamy, clayey, and so forth, is loose, and for scientific purposes inaccurate; distinctions far more natural, as well as valuable, are furnished by the nature of the rocks, whose decomposed materials form the soil. In Arran the variety of the geological formations produces a corresponding diversity in the composition of the earths; and though we are no doubt still greatly in the dark as to the influence of soil on the habitat of plants, there can yet be little doubt that the diversity of soils furnished by the granites, traps, porphyries, slates, sandstones, shales, and limestones, must exercise a powerful influence on the flora. Whatever may be the importance of these conditions generally, they certainly exist here in a remarkable degree.

To these advantages of geographical position and physical character is to be added the scarcely less important one of climate. Lying off the west coast of Scotland, and thus almost in the Atlantic, Arran enjoys a copious rain-fall, while its insular position preserves it from those extremes of heat and cold which are so injurious to vegetation. Hence it is that the climate, while in many parts quite cold enough for the ordinary plants of Britain, and while the mountains rise high enough to be a fit habitation for several alpine species, is yet sufficiently mild and equable for the growth of some usually found in more southerly regions. These conditions exist also in the extreme point of Cantyre; and accordingly we find Campbelton enjoying the mildest winter in Scotland, and many tender species flourishing there in the open air.

The effect of climate on the flora of Arran is twofold,—it increases the number of species, and it imparts a general vigour and luxuriance to the vegetation, which makes it interesting to the lover of the landscape picturesque, no less than to the botanist. Every one must have observed how much of the peculiar charm of Arran scenery is owing to this circumstance. The bright green of the fields and pastures, the woods that fringe the shore and cling to the slopes of the lower hills, add grace and soft beauty to landscapes that would otherwise be severe and gloomy in their grandeur; and while they pleasingly relieve the monotonous gray of the granite mountains, serve to heighten by contrast the effect of the bare crags and jagged peaks that rise behind them. In spring or early summer, when the grass sprouts fresh on the hill-sides, and the varied foliage of the trees still preserves the delicate green of youth, or in July, when the lower ridges are purple with the rich heather-bloom, this variety of colour is finest,—and this is the best time to see Arran scenery in

its perfection. In September, the grass is parched, the heather begins to wither, and a brown or gray tint prevails over the whole landscape, little relieved even by the red and yellow hues of the autumnal trees. While, again, if we turn our attention from the general outlines of the scene, and look more closely at its details, we shall find no less cause to admire the effects of an atmosphere moist and warm. To it we owe not only the abundant growth of natural wood which clothes the glens and sea-cliffs, but also the size and splendour of many of our finest shrubs and wild flowers, such as the laburnum, the hawthorn, the foxglove, the honeysuckle, and perhaps most strikingly of all, the luxuriant profusion of the whole fern tribe, from the stately *Osmunda* to the lowly *Hymenophyllum*.

105. On proceeding to analyze the flora of a given district, that is, to examine the internal relations of its constituent parts, noting what species, or genera, or families, are abundant, what rare, and what character is thus imparted to the vegetation, we may regard it under two aspects, as illustrating the peculiar features of the tract itself, or as indicating the relations of that tract to the surrounding regions,—what may be called its general botanico-geographical position. Glancing at the flora of Arran from this latter point of view, we shall observe some interesting facts. Writers on the botanical geography of Britain class the plants of our country according to several “types of distribution,” to denote their geographical range and affinities. Thus many species, occurring chiefly in the east and south of England, are assigned to the Germanic type; others, most of them denizens of the Scottish Highlands, are referred to the Scandinavian; while others again, characterizing Ireland and the westerly coasts of Britain, are grouped under the Atlantic type. Some few there are, found only in Cornwall and the west of Ireland, whose affinities are with the Spanish Peninsula, and especially with the mountains of the Asturias, and for these there is proposed a Lusitanian type. Somewhat similar to the position of Britain, if we may be allowed to compare great things with small, is the position of Arran. Most of its common species—the plants of the field, the road-side, the marsh—it has in common with the western Lowlands of Scotland, which stand to it in the same relation that the continent does to England. These Lowland plants form the bulk of its flora. They include almost all those of common occurrence, as well as several of the rarer sort—such as *Ranunculus Lingua*, *Helianthemum vulgare*, *Epipactis ensifolia*, *Samolus Valerandi*, the *Botrychium* and *Ophioglossum*, *Asplenium ruta-muraria*,

&c. Under this class are embraced nearly all the species that frequent the cultivated land, the marshes and streams, the woods and pastures; together with several maritime ones—as *Silene maritima*, *Oenanthe Lachenalii*, *Calystegia Soldanella*.

A second “type” discernible in Arran is that which we might call the Highland. To this group belong the alpine plants of the highest granite mountains—*Salix herbacea*, *Thalictrum alpinum*, *Alchemilla alpina*, *Cryptogramma crispa*, and others; several also occurring in elevated situations in various parts of the island—as *Rhodiola rosea*, *Oxyria reniformis*, *Hymenophyllum Wilsoni*; besides a few found in mountainous regions, though at no great altitude—such as *Corydalis claviculata* and *Polypodium Dryopteris*.

Thirdly, We have a considerable class occupying, as it were, in Arran, the place which the Atlantic type holds in Britain, including the plants peculiar to the west coast, and especially frequent in the Hebridean chain of islands. Such are many of the maritime species—*Mertensia maritima*, *Brassica Monensis*, *Sedum anglicum*, *Raphanus maritimus*, as well as *Pinguicula lusitanica*, *Gymnadenia conopsea*, *Drosera anglica*, and *Listera cordata*—plants found in various localities through the interior. This class includes many of the most interesting and characteristic plants of the island—not a few of them such as will be entirely new to the English botanist.

But the most curious feature in the botanical geography of Arran is the occurrence in its southern extremity of several species scarcely elsewhere to be found in Scotland; belonging, in fact, to the flora of central England, and here apparently quite projected, so to speak, from their ordinary range. Of these the most remarkable are the *Lathyrus sylvestris*, *Verbascum thapsus*, *Inula helenium*, *Althæa officinalis*, *Carlina vulgaris*. They all occur within the circuit of a mile, on the warm southern face of the cliffs and steep alluvial banks that front the sea at the extreme south of the island, near Benan-head. No one who examines the locality can think it possible that they should have escaped from cultivation; and it is scarcely less improbable that they should have been planted there by the hand of man. The *Lathyrus*, *Verbascum*, and *Carlina* are still abundant; the *Inula*, however, seems to have been extirpated, if indeed the report of its existence was correct. It is certainly not to be found now, yet it is difficult to see how the mistake could have arisen, as there is no plant in the neighbourhood which would be readily mistaken for it. The *Althæa* has been found within the last few years, but is now either extinct or very scarce. It is to be hoped that botanical collectors who may visit the spot

will spare the beautiful *Lathyrus*, and refrain from extirpating it in what is probably its only Scotch locality.

106. Having remarked thus on the external relations of Arran to the botanical geography of the surrounding lands, we might pass on to speak of its internal aspects, and notice the several floras of the mountain, the glen, and the shore, the moor, the wood, and the marsh; in other words, to distribute the plants according to their respective botanical *stations*. By such an examination, however, no new facts or principles of peculiar interest would be elicited. A little experience will enable the student to frame such a classification for himself.

Most of the rare plants of Arran are to be obtained on or near to the coast, some decking the bright sands, as the *Brassica Monensis*, the purple *Mertensia*, or oyster plant, as it is called from the flavour of its leaves, and the lovely *Calystegia Soldanella*, with its creeping stems and flowers of delicate pink; some dwelling in the salt marsh and wet grounds that lie between the old sea cliff and the present tide-mark, such as the *Oenanthe Lachenalii*, *Triglochin maritimum*, and *palustre*, the pretty little *Glaux*, the blue *Aster*, and several others. Here, too, though not properly maritime plants, we often find the handsome *Parnassia*, and delicate *Anagallis tenella*, *Samolus Valerandi*, *Orchis latifolia*, and in the drier spots, *Geranium pratense* and *Erythræa linearifolia*. The bare rocky crags and promontories, which here and there diversify the generally accessible coast of the island, are gay with the brilliant white, yellow, and pink flowers of *Sedum Anglicum* and *acre*, *Silene maritima* and *Spergularia marina*; the succulent *Cotyledon* fixing its roots in the rock clefts, and the glossy green of the sea spleenwort, *Asplenium marinum*. The curious sea cliff which lines the coast of the island in almost every part, marking the level at which the sea stood in some former age, is in most places thickly covered with a natural growth of oak, ash, birch, hazel, and other trees, and is kept moist by the numerous streams that trickle down its face, or precipitate themselves in cascades from its edge. The shade and humidity thus produced render its vegetation luxuriant and varied; and we find many interesting species growing on or near this line of irregular cliff, some hanging from its wooded sides, some springing rank in the wet caves that pierce it, and some inhabiting the stony and marshy ground at its base.

Here, among others, occur *Veronica montana*, *Hypericum Androsaemum*, *Geranium sanguineum*, *Sanicula europaea*, *Eupatorium cannabinum*, *Lycopus europæus*, *Listera ovata*, *Habenaria chlor-*

antha. Here too most of the Arran ferns may be found;—*Polypodium Dryopteris* and *Phegopteris*, *Cystopteris fragilis*, *Aspidium* or *Lastrea recurva* (*foenisecii*), *Aspidium lobatum* and *aculeatum*, *Asplenium marinum*, *Hymenophyllum Tunbridgensense* and *Wilsoni*, and the magnificent *Osmunda regalis*. In enumerating these plants, we do not mean that they are all to be met with in any one spot, but that they all occur in some part or other of the sea cliff, while many abound through the whole of its long extent. Those species which we have just mentioned, with the addition of one or two rarities, such as *Epipactis ensifolia* and *Thalictrum flavum*, form in the main the sylvestral flora of the island, which it is therefore needless to speak of more particularly. Similarly, there is little to distinguish the vegetation of the lower glens from that we have described as characteristic of the sea cliff and the woods, not, at least, till the point is reached where the larger trees grow scarce, finally giving place to thickets of birch or hazel, or to the open expanse of pasture and moor. Here the aspect of the scene is changed, and plants quite different attract the attention of the botanist. The greensward is gay with the purple *Gymnadenia conopsea*, as beautiful as it is fragrant, the blue *Jasione montana*, *Pimpinella saxifraga*, *Gentiana campestris*, *Erythraea centaurium*, *Habenaria viridis* and *albida*, *Orchis maculata*, and many other handsome plants. Nestling among the heather we may find *Circaea alpina*, *Listera cordata*, with its slender stem and minute yellowish flowers, the taller *Galium boreale*, and the tender green of the oak fern, *Polypodium Dryopteris*. *Rubus saxatilis* here and there trails its long stems over the stony ground, while the viscid leaves of the sundew, *Drosera rotundifolia* and *anglica*, the tiny cream-coloured flowers of *Pinguicula Lusitanica*, and straggling yellowish-green stems of the little *Lycopodium selaginoides*, mix with the moss that grows thick round the margin of the springs and rivulets. Supposing the glen, whose botany we have been describing, to be in the southern division of the island, we shall, on ascending still higher, find ourselves, after a stiff climb, on a wide expanse of undulating moorland, covered by a thick deposit of peat bog, interrupted here and there by a rocky hilltop, or the deep cut channel of some mountain burn. These moors, varying in height from 900 to 1,400 feet, have little to interest the botanist. He may travel over them for a whole day without meeting more than two or three species among the coarse grass and heather, mixed with rushes and cotton grass, which clothe the surface of the peat moss. Generally it may be said, that the flora of the higher grounds in Arran is inferior to that

of the low country. The granite mountains in the northern part of the island rise quite into the alpine region, and are covered with snow for seven or eight months in the year. Yet, when compared with the mountain tracts of the central Highlands, they will be found to possess few alpine plants. This fact seems to be mainly owing to that predominance of bare rock over grass and heather, which gives them, at some distance, the appearance of an unbroken mass of gray granite. Besides the stony character of the mountain slopes, the thinness and ungeniality of the soil furnished by the decomposed granite, the absence in the higher regions of springs and streamlets, and perhaps the very steepness of the loftier summits, may all contribute to render the alpine flora of Arran comparatively scanty and uninteresting. The commonest plants on the high mountains are *Saxifraga stellaris* and *Alchemilla alpina*; the former is scarce on Goatfell, occurring more abundantly on the heights round the head of Glen Sannox; the latter is very frequent on all the higher peaks, and covers, with the graceful drapery of its silky leaves, the ledges of many a granite precipice. *Salix herbacea*—the dwarf willow, whose woody stem scarcely rises from the ground—is found on most of the principal summits; *Oxyria reniformis* and *Rhodiola rosea* grow abundantly in the rock clefts; *Circaea alpina* and *Saxifraga hypnoides* occur occasionally near the summits of the southern hills; the pretty little *Thalictrum alpinum* may be found in many places, as on Ben-Varen, on Goatfell, at the head of Glen Cloy, and on the summit of the pass leading from Glen Rosa into Glen Sannox; *Cryptogramma crista*, the parsley fern, has been noticed in several spots, rooting deep among the loose blocks of stone that strew the mountain-side, while among the other cryptogamous plants, *Polypodium Dryopteris* and *Phegopteris*, *Cystopteris fragilis*, *Hymenophyllum Wilsoni*, and several of the alpine *Lycopodia*, may be enumerated as denizens of the glens and mountains.

Regarding the water plants of the island, those which we find in its marshes and streams, there is but little to be said. They are few in number, and not in any way remarkable. The list is nearly exhausted by the names of *Hypericum elodes*, *Ranunculus lingua*, *Drosera Anglica*, *Littorella lacustris*, *Alisma plantago* and *ranunculoides*, and several species of *Potamogeton* and *Carex*. Of true lake plants there are very few; and this fact leads us to observe how deficient Arran is in this element of the picturesque. Lakes there are several, but, with scarcely an exception, they are placed in the high bleak moors, far above the limit to which trees ascend, and generally away from the higher mountains, so that they add little either of

beauty or of sublimity to the scenery of the island. Loch Tanna, by far the largest, lies in a high and gloomy plateau strewed with blocks of decomposing granite, among which the stunted heather barely supports its existence—itself as black and uninteresting a sheet of water as any pool in the fens of Lincolnshire; the aspect of the whole scene is one of utter wildness and desolation, without grandeur. The absence, however, of this element of the beautiful in Arran scenery is scarcely remarked, being more than compensated by the character which the sea imparts to every landscape.

107. Having thus briefly indicated the plants which the botanist will meet with in each region of the island, it is scarcely necessary to prescribe for him any special excursion or walks. These are best left to his own taste and convenience. It may, however, be not amiss, in a few concluding words, to direct him to the districts where his rambles will be attended with most pleasure and success. Probably no part of the island will offer to him so many interesting species as the vicinity of Brodick, especially if he direct his walks to the Corriegills shore, proceed northwards to Corrie, or explore the tangled thickets and dripping rocks at the head of Glen Cloy. Around Loch Ranza, too, several excellent plants may be obtained; while, even if the tourist be not botanically inclined, he will find in the exceeding beauty of the coast an ample reward for his walk along the lovely shore between Glen Sannox and Newton Point. The western coast offers many striking scenes, and everywhere commands noble views of the broad sound of Kibrannan, with the hills and glens of Cantire beyond; but its botany presents little that is new to one who has already examined the eastern part of the island; while the interior of the country is occupied by undulating granite mountains, seldom, except at Glen Catacol, assuming forms of sublimity or beauty, and clothed with no vegetation beyond the grass and heather that grow among the slowly-decomposing blocks of gray granite with which the ground is strewed for miles. Such is the aspect of the country—bleak, wild, unvaried—from Loch Ranza to Loch Iorsa and Dugarry, where the slate and old red sandstone formations succeed the harsher granite, and subside with gentle declivities into the alluvial plain through which the Mauchrie water finds its way to the sea. Despite what we have said of the botanical attractions of Brodick, there is no district in Arran that will better repay the trouble of a visit than the south coast, from Slaodridh to Whiting Bay. Without any of the alpine grandeur of the north, it has many striking beauties of its own; smiling little bays, steep green banks, and bold cliffs of

basaltic rock, trap, porphyry, or claystone, jutting far out among the waves, or running in tall colonnades along the shore; seaward there is the wide expanse of glorious blue, with the magnificent pinnacle of Ailsa full in front; beyond all, closing the distant horizon, the gleaming cliffs of Ayrshire, and the far-off coast of Ireland. It is a delightful shore to wander along slowly, searching and prying for rarities in the salt-marsh by the water's brink, or up some leafy gorge through which the streamlet from the hills forces its seaward way, forgetting the world without and all its cares, delivered from the dominion of dusty roads, and the necessity of getting home in time for dinner. Let the naturalist take up his quarters in the neat little inn that lies nestling in its snug little hollow at Lag; there he may pass happy days in exploring that solitary shore, and at night pull out into the deep, and taste the unwonted pleasures of sea-fishing. From this point also the agriculturist may visit some of the fine farms along the south coast, where the best methods of cultivation are practised.

The mountains at the head of Glen Sannox will be found richer in alpine plants than Goatfell, though scarcely equalling it in height. Yet even their flora must appear scant and uninteresting to one who has botanized over the ranges of the central and eastern Highlands, Ben-Lawers, Braemar, or Clova. But at this he will have no cause to repine when he finds himself led into some of the most magnificent mountain scenery in Britain. It has been said that no scenery in Scotland but that of Coruisk in Skye, and that of Glencoe, can rival the grandeur of Glen Sannox; certainly neither the famed Perthshire Highlands, nor the English lakes, can show anything as wildly sublime as the precipices and aiguilles of rifted granite which tower around the heads of these Arran glens.

LIST OF PLANTS.

108. The following list comprises only the rarer plants of Arran, including under this title both those which, though frequent in the west of Scotland, are seldom found in other parts of the country, and those which, while abundant in Britain, may appear rarities to one who knows only the botany of the west coast. It often becomes very difficult to draw the line, and to say what plants should be omitted and what inserted. We cannot hope to have decided always judiciously; when we have erred it has probably been in admitting plants which may appear common to the practised botanist.

All the species of the fern tribe known to exist in the island have been inserted, and their localities given in full detail; partly because they bear a larger proportion than usual to the flora of Arran, and partly for the sake of those who may take a special interest in them, or wish to procure specimens for cultivation.

The genera are arranged according to the natural orders, and the names those which appear in Hooker and Arnott's *British Flora*.

Our best thanks are due to Professor J. Hutton Balfour of Edinburgh, for his kindness in placing his lists at our disposal. On the authority of these many species have been inserted. A few not observed either by Dr. Balfour or ourselves are inserted on the authority of the late Dr. Landsborough. To these the letter L is affixed. Plants which we suspect to be not truly wild are indicated by an asterisk. We may add, that as such a catalogue can have no claims to perfection, any hints for its correction or extension will be gratefully received.

Thalictrum alpinum, . . .	{ Goatfell, head of Glen Sannox, Ben-
----- flavum, . . .	{ Varen, head of Glen Cloy.
----- minus, . . .	Whiting Bay (L).
Ranunculus hederaceus, . . .	Whiting Bay.
----- Lingua, . . .	In many places.
----- acris (var. pumilus), . . .	Lamlash.
----- scleratus, . . .	Near Lamlash.
Trollius Europæus, . . .	.
Corydalis claviculata, . . .	House roofs and woody places.
Cardamine pratensis, . . .	Abundant.
----- hirsuta, . . .	Near Lamlash.
Cochlearia officinalis (several vars.)	On the shores.
Cakile maritima, . . .	Frequent on sandy shores.
Lepidium Smithii, . . .	Brodict.
----- campestre, . . .	Loch Ranza (?)
Sisymbrium Sophia, . . .	Sandy sea shores.
Brassica Monensis, . . .	{ Sands at Brodict, Sannox, Black-
----- oleracea, . . .	{ Water-foot, &c.
----- campestris, . . .	Lag.
Crambe maritima, . . .	Mauchrie.
Raphanus maritimus, . . .	Imochair.
Helianthemum vulgare, . . .	Southend.
Viola tricolor (var. arvensis) . . .	Kildonan.
----- palustris, . . .	.
Drosera Anglica, . . .	Marshy places.
----- rotundifolia, . . .	Frequent.
Parnassia palustris, . . .	Do.
Silene maritima, . . .	Do.
Lychnis diurna, . . .	Shores—frequent.
----- vespertina, . . .	Common.
Agrostemma Githago, . . .	Do.
Sagina maritima, . . .	Cornfields—common.
----- nodosa, . . .	On the shores.
	Lamlash.

<i>Honckenya peploides</i> , . . .	Sandy shores.
<i>Stellaria media</i> , . . .	Frequent.
——— <i>holostea</i> , . . .	Do.
<i>Spergularia marina</i> , . . .	On the coast.
<i>Radiola millegrana</i> , . . .	Goatfell, Loch Ranza, Springbank.
<i>Althæa officinalis</i> , . . .	Struey Rocks (?)
<i>Malva sylvestris</i> , . . .	
<i>Hypericum perforatum</i> , . . .	In several places.
——— <i>dubium</i> , . . .	{ Invercloy, Whiting Bay, &c., abun-
——— <i>Androsæmum</i> , . . .	dant.
——— <i>quadrangulum</i> , . . .	Frequent.
——— <i>humifusum</i> , . . .	Wet places.
——— <i>pulchrum</i> , . . .	Frequent.
——— <i>hirsutum</i> , . . .	Do.
——— <i>elodes</i> , . . .	Lamlash.
<i>Geranium pratense</i> , . . .	King's Cove and Loch Ranza.
——— <i>sanguineum</i> , . . .	Brodick, Benan-head, Holy Isle, &c.
——— <i>dissectum</i> , . . .	Struey, Thundergay, Dippen.
——— <i>pusillum</i> , . . .	Frequent.
<i>Oxalis acetosella</i> , . . .	Do.
<i>Trifolium filiforme</i> , . . .	Do.
——— <i>medium</i> , . . .	
——— <i>procumbens</i> , . . .	
<i>Anthyllis vulneraria</i> , . . .	Frequent.
<i>Lotus major</i> , . . .	Common.
<i>Orobis tuberosus</i> , . . .	In the woods.
<i>Vicia sylvatica</i> , . . .	King's Cove, Kildonan, &c.
——— <i>hirsuta</i> , . . .	
——— <i>Cracca</i> , . . .	Frequent.
——— <i>sepium</i> , . . .	Do.
<i>Lathyrus sylvestris</i> , . . .	Struey Rocks.
<i>Geum intermedium</i> , . . .	Frequent.
——— <i>urbanum</i> , . . .	Common.
——— <i>rivale</i> , . . .	Frequent.
<i>Comarum palustre</i> , . . .	Frequent.
<i>Alchemilla vulgaris</i> , . . .	Common.
——— <i>alpina</i> , . . .	On the mountains.
——— <i>do.</i> (var. <i>conjuncta</i>), . . .	Glen Sannox.
——— <i>arvensis</i> , . . .	Frequent.
<i>Agrimonia Eupatoria</i> , . . .	On the south coast.
<i>Prunus communis</i> , . . .	
<i>Rosa spinosissima</i> , . . .	Frequent.
——— <i>canina</i> , . . .	Common.
——— <i>involuta</i> , . . .	Lamlash.
——— <i>tomentosa</i> , . . .	Dippen.
——— <i>villosa</i> , . . .	
<i>Pyrus aucuparia</i> , . . .	Frequent.
——— <i>pinnatifida</i> , . . .	Glen Eis-na-vearraid, Caistael Abhael.
<i>Rubus carpinifolius</i> , . . .	Lamlash.
——— <i>corylifolius</i> , . . .	Do.
——— <i>Idæus</i> , . . .	Woods and mountains—frequent.
——— <i>saxatilis</i> , . . .	Head of Glen Cloy.
——— <i>suberectus</i> , . . .	Holy Island and Lamlash.
——— <i>glandulosus</i> , . . .	
——— <i>rhamnifolius</i> , . . .	
<i>Circea Lutetiana</i> , . . .	Frequent.

<i>Circæa alpina</i> , . . .	Glen Cloy, Bein Leister Glen.
<i>Peplis Portula</i> , . . .	.
<i>Lythrum salicaria</i> , . . .	Frequent.
<i>Montia fontana</i> , . . .	.
<i>Scleranthus annuus</i> , . . .	In many places.
<i>Cotyledon umbilicus</i> , . . .	Frequent.
<i>Sedum Rhodiola</i> , . . .	Mountains—frequent.
———* <i>Telephium</i> , . . .	.
——— <i>acre</i> , . . .	Frequent on the shores.
——— <i>Anglicum</i> , . . .	Common.
<i>Saxifraga stellaris</i> , . . .	Mountains—frequent.
——— <i>hypnoides</i> , . . .	Glen Cloy, &c.
<i>Hydrocotyle vulgaris</i> , . . .	Common.
<i>Æthusa Cynapium</i> , . . .	Waste ground.
<i>Sanicula Europæa</i> , . . .	Thickets.
<i>Eryngium maritimum</i> , . . .	Sandy shores.
<i>Bunium flexuosum</i> , . . .	Frequent.
<i>Helosciadium nodiflorum</i> , . . .	Shore at Leac-a-Breac.
——— <i>do.</i> (<i>var. repens</i>), . . .	Lamlash.
<i>Carum</i> * <i>Carui</i> , . . .	.
<i>Pimpinella Saxifraga</i> , . . .	Frequent.
<i>Oenanthe Lachenalii</i> , . . .	Corriegills, &c.
<i>Conium maculatum</i> , . . .	Dippen, Lag.
<i>Smymnium olusatrum</i> , . . .	Dippen (L).
<i>Scandix Pecten</i> , . . .	Frequent.
<i>Myrrhis odorata</i> , . . .	Dippen.
<i>Ligusticum Scoticum</i> , . . .	Southend, Kildonan, &c.
<i>Apium graveolens</i> , . . .	Shore at Lag, and Loch Ranza.
<i>Galium boreale</i> , . . .	{ Glen Laodh, North Sannox, and other places.
<i>Asperula odorata</i> , . . .	Woods.
<i>Valeriana officinalis</i> , . . .	Frequent.
<i>Fedia dentata</i> , . . .	Loch Ranza.
<i>Cnicus pratensis</i> , . . .	.
<i>Carlina vulgaris</i> , . . .	Struey Rocks.
<i>Carduus palustris</i> , . . .	.
<i>Bidens cernua</i> , . . .	Brodick.
——— <i>tripartita</i> , . . .	Lamlash.
<i>Inula Helenium</i> , . . .	Struey Rocks (?)
<i>Eupatorium cannabinum</i> , . . .	In many places.
<i>Antennaria dioica</i> , . . .	Pastures and moors.
<i>Cichorium Intybus</i> , . . .	Whiting Bay.
<i>Gnaphalium uliginosum</i> , . . .	Loch Ranza.
——— <i>sylvaticum</i> , . . .	Loch Ranza.
<i>Aster Tripolium</i> , . . .	Salt marshes.
<i>Hieracium murorum</i> , . . .	Near Lamlash.
——— <i>sylvaticum</i> (<i>var. vulgatum</i>)	Glen Eis-na-vearraid.
<i>Filago Germanica</i> , . . .	Brodick, Glen Eisdale.
——— <i>minima</i> , . . .	Glen Eisdale.
<i>Solidago virgaurea</i> , . . .	Glens—frequent.
<i>Senecio sylvaticus</i> , . . .	Lamlash.
<i>Pulicaria dysenterica</i> , . . .	Struey Rocks.
<i>Matricaria maritima</i> , . . .	Sea coast.
<i>Jasione montana</i> , . . .	Common.
<i>Lobelia Dortmanna</i> , . . .	Small loch at Loch Ranza; Loch Iorsa.
<i>Vaccinium Myrtillus</i> , . . .	Frequent.
——— <i>Vitis-Idæa</i> , . . .	On the higher mountains.

<i>Arctostaphylos Uva-ursi</i> , . . .	Holy Isle, Glen Eis-na-vearraid.
<i>Pyrola minor</i> , . . .	Holy Island (L).
<i>Ilex Aquifolium</i> , . . .	On the cliffs.
<i>Fraxinus excelsior</i> , . . .	Rocks at Glen Catacol.
<i>Erythræa Centaurium</i> , . . .	Frequent.
——— <i>linearifolia</i> , . . .	Shore at Corriegills, &c.
<i>Gentiana campestris</i> , . . .	Moors and pastures.
<i>Menyanthes trifoliata</i> , . . .	Springbank, &c.
<i>Convolvulus arvensis</i> , . . .	Corrie.
<i>Calystegia sepium</i> , . . .	Hedges—frequent.
——— <i>Soldanella</i> , . . .	Black-Water-foot.
<i>Cuscuta *epilinum</i> , . . .	Lamlash.
<i>Lithospermum officinale</i> , . . .	Loch Ranza.
——— <i>arvense</i> , . . .	.
<i>Mertensia maritima</i> , . . .	On the sands, Brodick, Sannox, &c.
<i>Solanum Dulcamara</i> , . . .	Brodick, Holy Island, &c.
<i>Veronica montana</i> , . . .	Blue Rock, &c.
<i>Melampyrum pratense</i> , . . .	Abundant.
<i>Scrophularia aquatica</i> , . . .	Near Sannox.
<i>Digitalis purpurea</i> , . . .	Frequent.
<i>Linaria vulgaris</i> , . . .	.
<i>Verbascum Thapsus</i> , . . .	Cliffs at Struey and Dippen.
<i>Lycopus Europæus</i> , . . .	Sannox.
<i>Mentha sylvestris</i> (var. <i>velutina</i>),	.
——— <i>sativa</i> (var. <i>rubra</i>), . . .	Lamlash and Whiting Bay.
——— <i>viridis</i> , . . .	Near Corrie.
——— <i>rotundifolia</i> , . . .	Brodick.
<i>Galeopsis versicolor</i> , . . .	Frequent.
<i>Calamintha Clinopodium</i> (?)	.
<i>Lamium amplexicaule</i> , . . .	Loch Ranza.
——— <i>incisum</i> (?) . . .	Do.
——— <i>intermedium</i> , . . .	Lamlash, Kildonan, Mauchrie, &c.
<i>Stachys ambigua</i> , . . .	Slaodridh.
<i>Scutellaria galericulata</i> , . . .	Brodick, Struey, &c.
<i>Origanum vulgare</i> (?) . . .	.
<i>Pinguicula vulgaris</i> , . . .	Abundant.
——— <i>Lusitanica</i> , . . .	In the bogs.—now less frequent.
<i>Utricularia vulgaris</i> , . . .	Loch-in-Davie, Loch Iorsa.
——— <i>minor</i> , . . .	Loch on the shore, near Mauchrie.
<i>Glaux maritima</i> , . . .	Salt marshes.
<i>Anagallis arvensis</i> , . . .	In cultivated ground.
——— <i>tenella</i> , . . .	Abundant in the bogs.
<i>Samolus Valerandi</i> , . . .	Marshes—frequent.
<i>Armeria maritima</i> , . . .	Sea shore—abundant.
<i>Littorella lacustris</i> , . . .	Loch Ranza.
<i>Plantago maritima</i> , . . .	On the shores.
——— <i>coronopus</i> , . . .	Dry places.
<i>Atriplex laciniata</i> , . . .	Sea shores.
——— <i>angustifolia</i> , . . .	Shore at Struey.
——— <i>do.</i> (var. <i>erecta</i>),	Slaodridh.
<i>Salicornia herbacea</i> , . . .	Loch Ranza.
<i>Suaeda maritima</i> , . . .	On the shores—Loch Ranza, &c.
<i>Salsola Kali</i> , . . .	Sandy shores—frequent.
<i>Rumex conglomeratus</i> , . . .	.
——— <i>pratensis</i> , . . .	Lamlash.
<i>Polygonum Raii</i> , . . .	Shore at Lamlash, Lag, &c.
——— <i>Convolvulus</i> , . . .	On the shores.

<i>Oxyria reniformis</i> , . . .	Mountains.
<i>Empetrum nigrum</i> , . . .	Lag.
<i>Parietaria officinalis</i> , . . .	Brodict Castle.
<i>Ulmus montana</i> , . . .	.
<i>Callitriche pedunculata</i> , . . .	.
<i>Myrica Gale</i> , . . .	Abundant.
<i>Betula alba</i> , . . .	Frequent.
<i>Salix herbacea</i> , . . .	Mountain tops.
<i>Corylus Avellana</i> , . . .	Abundant.
<i>Populus tremula</i> , . . .	Torlin.
<i>Juniperus communis</i> , . . .	Mountains.
———— <i>nana</i> , . . .	Goatfell (?)
<i>Epipactis ensifolia</i> , . . .	Slaodridh, Invercloy, Whiting Bay.
<i>Listera ovata</i> , . . .	Lamlash.
———— <i>cordata</i> , . . .	Cior-Vor, Suithi-Feargus, Glen Cloy.
<i>Orchis mascula</i> , . . .	Abundant.
———— <i>maculata</i> , . . .	Do.
———— <i>latifolia</i> , . . .	Do.
<i>Habenaria bifolia</i> , . . .	Do.
———— <i>Chlorantha</i> , . . .	Do.
———— <i>viridis</i> , . . .	{ Whitefarland, Eiss-a-mhor, Loch
	{ Ranza.
———— <i>albida</i> , . . .	{ Loch Ranza; and dry heaths, in
	{ many places.
<i>Liparis Loeseli</i> (?) . . .	.
<i>Gymnadenia conopsea</i> , . . .	Abundant in fields and heaths.
<i>Malaxis paludosa</i> , . . .	Kildonan.
<i>Allium ursinum</i> , . . .	Abundant.
———— * <i>Schoenoprasum</i> , . . .	Glen Shirag.
<i>Agrophis nutans</i> , . . .	Abundant.
<i>Juncus triglumis</i> , . . .	Goatfell.
———— <i>trifidus</i> , . . .	Do.
———— <i>compressus</i> (var. <i>Gerardi</i>), . . .	Salt marshes.
<i>Juncus glaucus</i> , . . .	Torlin.
———— <i>maritimus</i> , . . .	Sea shores.
<i>Narthecium ossifragum</i> , . . .	Abundant.
<i>Alisma Plantago</i> , . . .	Brodict, &c.
———— <i>ranunculoides</i> , . . .	In several places.
<i>Triglochin palustre</i> , . . .	Frequent.
———— <i>maritimum</i> , . . .	Salt marshes.
<i>Typha latifolia</i> , . . .	Mill-dam, Whiting Bay, &c.
<i>Sparganium ramosum</i> , . . .	Lamlash.
———— <i>simplex</i> , . . .	.
<i>Potamogeton plantagineus</i> , . . .	Brodict.
———— <i>oblongus</i> , . . .	Loch-in-Davie.
<i>Zostera marina</i> , . . .	Abundant.
<i>Eriophorum vaginatum</i> , . . .	Goatfell.
———— <i>polystachion</i> , . . .	.
———— <i>angustifolium</i> , . . .	Abundant.
<i>Schoenus nigricans</i> , . . .	Sea shores.
<i>Eleocharis palustris</i> , . . .	Do.
———— <i>do.</i> (var. <i>uniglumis</i>), . . .	Sands near Kildonan, and at Lag.
———— <i>multicaulis</i> , . . .	On the coast.
<i>Blymus rufus</i> , . . .	On the sea shore.
———— <i>compressus</i> , . . .	Do.
<i>Scirpus maritimus</i> , . . .	Do.
———— <i>pauciflorus</i> , . . .	Corriegills, and Corrie shore.
<i>Carex ampullacea</i> , . . .	Near Mauchrie.

<i>Carex lævigata</i> , . . .	{ Road-side, between Brodick and Lamlash; Loch Ranza, Corriegills.
—— <i>vulpina</i> , . . .	Shores.
—— <i>pauciflora</i> , . . .	Ascent of Goatfell, and in Glen Rosa.
—— <i>arenaria</i> , . . .	Sandy shores.
—— <i>remota</i> , . . .	.
—— <i>curta</i> , . . .	On the moors.
—— <i>divisa</i> , . . .	Frequent.
—— <i>distans</i> , . . .	Imochair.
—— <i>extensa</i> , . . .	.
—— <i>fulva</i> , . . .	.
—— <i>glauca</i> , . . .	.
—— <i>muricata</i> , . . .	Dippen.
—— <i>ovalis</i> , . . .	.
—— <i>Oederi</i> , . . .	Near Dugarry.
—— <i>paniculata</i> , . . .	.
—— <i>rigida</i> , . . .	Goatfell.
<i>Rhynchospora alba</i> , . . .	North Glen Sannox, &c.
<i>Isolepis Savii</i> , . . .	Corrie.
—— <i>setacea</i> , . . .	Frequent.
<i>Avena paniculmis</i> , . . .	{ Said to have been found in Glen Sannox.
<i>Ammophila arundinacea</i> , . . .	On the shores.
<i>Elymus arenarius</i> , . . .	Sandy shores.
<i>Briza media</i> (?) . . .	.
<i>Aira alpina</i> , . . .	Goatfell (?)
<i>Brachypodium sylvaticum</i> , . . .	Woods.
<i>Catabrosa aquatica</i> , . . .	Shore at Kildonan and Lag.
<i>Festuca bromoides</i> , . . .	Lamlash.
—— <i>gigantea</i> , . . .	Corriegills.
—— <i>vivipara</i> , . . .	Goatfell.
<i>Molinia coerulea</i> (var. <i>alpina</i>), . . .	Mountains.
<i>Poa maritima</i> , . . .	On the shores.
<i>Triticum junceum</i> , . . .	Shore at Slaodridh.
—— <i>laxum</i> , . . .	Sands at Struey.
<i>Polypodium vulgare</i> , . . .	Very common.
—— Phegopteris, . . .	{ Abundant in the woods, and along the sea cliff; frequent also in sheltered spots in the glens; and sometimes found in rock crevices at the tops of the highest mountains.
—— Dryopteris, . . .	{ In the woods, and very abundant in damp sheltered spots in the glens and among the heather; often ascending the highest mountains along with the last species.
<i>Aspidium lobatum</i> , . . .	{ Frequent on cliffs and banks near the sea; sometimes in exposed situations, passing into a form resembling <i>Aspidium lonchitis</i> .
—— <i>aculeatum</i> , . . .	Frequent in hedges and woods.
—— <i>Oreopteris</i> , . . .	{ Very abundant in the glens and on the moors, often, as in the lower part of Glen Rosa, covering the whole hill-side with the delicate yellowish-green of its young fronds.

Aspidium Filix mas, . . .	Abundant everywhere.
———— spinulosum, . . .	<p>This variable and perplexing species is very abundant in several varieties, one of which, with an ovate or ovate-lanceolate frond, is frequent on the highest mountains.</p> <p>Frequent on the sea cliff—as at Corrie, North Sannox, Salt Pans, and Whiting Bay; in rocky and wooded ground at the head of Glen Cloy, under the Sheeans.</p> <p>Rocks at the head of Glen Cloy; cave in the old sea cliff at Blue Rock; near Glen Sannox; and in several other spots among the mountains, as, near the top of Ben-Ghnuis, on the Ceims, &c. It generally, if not always, occurs in the form <i>dentata</i>.</p>
———— recurvum (Foeniseeii), . . .	
Cystopteris fragilis, . . .	
Asplenium Ruta-muraria, . . .	<p>Old walls at Brodick Castle, and probably in other places.</p> <p>Common on rocks and walls.</p> <p>Abundant on limestone cliffs at the head of Bein-Leister Glen, above Lamlash; on rocks near the head of Glen Cloy, sparingly.</p> <p>Occurring here and there in caves along the old sea cliff. It is now scarcely to be found on the east and north coasts of the island, but may be obtained in many places on the south and west, as at Benan-head, King's Cove, and Imochair. At Leac-a-Breac, near Black-Water-foot, we have gathered fronds eighteen inches long.</p>
———— Trichomanes, . . .	
———— viride, . . .	
———— marinum, . . .	Abundant on banks and rocks.
———— Adiantum nigrum, . . .	<p>Very abundant and beautiful, and presenting an infinite variety of forms.</p> <p>Hedges, banks, and rocks; often very luxuriant.</p> <p>Very common.</p>
———— Filix-fœmina (Athyrium Filix-fœmina), . . .	
Scolopendrium vulgare, . . .	<p>Among granite blocks at the head of Glen Sannox, under the crags of Cior-Mhor, abundant; also on the pass leading from Glen Rosa into Iorsa, in small quantity, and probably in several other places. One very small plant we found, on one occasion, at the summit of Ben-Ghnuis.</p>
Pteris aquilina, . . .	
Cryptogramma crispa, . . .	Common.
Blechnum boreale, . . .	<p>Fields near the String Road in Glen Shirag; also on the shore at Invercloy and Corriegills, and in dry pastures in several other places.</p>
Botrychium Lunaria, . . .	

Hymenophyllum Tunbridgense,

On sheltered rocks in several places, as in a plantation near Invercloy, in the wood at Brodick Castle; near Corrie; at Fallen Rocks; and at the entrance of Glen Eisdale, Whiting Bay. It is remarkable that, in all these localities, it is found growing upon the old sea cliff; as is also the case where it occurs at Dunoon, Holy Loch, the Kyles of Bute, and the shores of Lochlomond, at Tarbet.

————— *Wilsoni*, . . .

Abundant in many spots, as near Corrie; sea coast at Sannox; Glen Cloy; Bein-Leister Glen; Birk Glen, above Invercloy, often growing along with the last-mentioned species, but also ascending to the tops of the highest mountains, where, as on Ben-Ghnuis, it covers the most exposed rocks at a height of 2,500 feet, and is with difficulty distinguished from a moss. In general, it prefers damper spots than *H. Tunbridgense*, and can stand exposure much better.

Osmunda regalis, . . .

Frequent, on the sea cliff, all round the island, often very luxuriant, attaining the height of 10 or even 12 feet. Now less abundant on the coast, but may be found in profusion near Loch Ranza, and at King's Cove.

Ophioglossum vulgatum, . . .

In a meadow between Benan-head and Torlin, and probably in other places.

Lycopodium clavatum, . . .

Abundant on the hills.

————— *Selago*, . . .

Moors and mountains—frequent.

————— *annotinum*, . . .

Said to have been found on Goat-fell, but in all probability erroneously.

————— *selaginoides*, . . .

Boggy and springy places on the hills and glens—frequent.

————— *alpinum*, . . .

On the mountains.

Equisetum fluviatile (*Telmateia*),

Frequent in damp ground.

————— *arvense*, . . .

Common.

————— *sylvaticum*, . . .

In the woods and glens, not unfrequent.

————— *limosum*, . . .

Ditches and ponds.

————— *palustre*, . . .

Boggy places—frequent.

MARINE ZOOLOGY OF ARRAN.

109. THE *coast-line* of Arran abounds with objects of interest. Nor is this interest confined to geological science. The naturalist—and especially the student of marine zoology—will find here a field for investigation; and even the casual visitor, if endowed with the faculty of inquisitiveness, may obtain instructive and amusing occupation.

Let it be understood that the waters of the sea, generally, teem with animated beings of an endless variety in form, size, and structure, and that myriads of these creatures are the inhabitants of rock-pools, where they share the vicissitudes common to mortality—sporting, at one moment, in the full enjoyment of the pleasures of life, and at another instant either wrangling or wrestling with an antagonist—perhaps for a mouthful of food—or “scudding” with all their might from the open jaws of an approaching and ravenous enemy.

We will suppose that we are now standing at Corriegills, on the sea shore in Brodick bay, about one mile from Invercloy. The rocks are of the red sandstone formation; and the soft material, yielding to the action of ceaseless tides, and to the lashing waves of the winter storm, has been hewn in all directions into fissures and small basins, which, renewed with fresh supplies of water by each returning flood, are the “habitats” of plants and animals. Look into these adjacent pools. They appear to be almost covered with tiny sea-weeds. Yet the jungles of India are not more fully occupied with their appropriate denizens than are these patches of the sea. They abound with microscopic life, generated under the warmth of the sun; and, by stooping down and watching for an instant, you will observe as much bustle, enterprise, and activity, with the usual accompaniments of success and misfortune, as are characteristic of an opulent city. The water at this moment is perfectly still. There is not a breath of air to disturb its surface. But do you notice that ripple? Depend upon it there is some mischief not far off. See! there is a prawn, or something like a prawn, swimming with the

greatest eagerness towards a piece of rock almost concealed by marine vegetation. Nay, there is a whole fleet of these creatures, trying to outvie each other in speed, and all shaping their course in the same direction. With the help of our gauze or muslin landing-net we will endeavour to catch a specimen. Skill and patience are required, for they are uncommonly agile—they *leap* with the suddenness and rapidity of a grasshopper, and they are too “knowing” to enter a *bag*, however fine may be its fabric, unless they are enticed or surprised by stratagem. Look how carefully that individual is keeping his *face* towards your net—see how deliberately he “backs astern,” with an occasional jump, when you think that he cannot possibly escape:—but now, keep your hand steady; he will approach; he will inspect your net with all imaginable curiosity. Observe how skilfully he uses his “horns,” or antennæ—exquisitely formed instruments, half as long again as his entire body, and which, as with the insect tribes, are delicate organs of inquiry. He will creep round the net and touch every part within his reach. But stop—here is a chance of catching him—run him gently back into that nook in his immediate rear, dip your net under him, and then, if you are smart in raising your hand, he will be your prisoner. Bring him on shore, and, inverting the net into a glass vessel of sea water, we will be able to examine him at leisure. But what has become of his companions? Whither were they bound? And on what errand were they so swift? It is a case of piracy. These crustaceans, which we saw swimming in such haste, are a fleet of sea-robbers; they are at this moment plundering a colony of helpless zoophytes, and, as often happens under analogous circumstances, they are quarrelling among themselves. Look, first, at these two warlike specimens of their race engaged in combat—each endeavouring to get at the prey. They do not appear to use their eyes, although these organs are well developed; but, feeling about on all sides with their antennæ, they no sooner *touch* each other than the strongest of the two rushes forward, assaults, and beats back the weaker, which, after being foiled in repeated attempts to hold his position and obtain a share of the spoil, retires to another portion of the invaded colony. Now observe their thieving propensities. Here is a group of sea anemones, just below the surface of the pool, curiously fixed with their base in a chink of the sandstone rock, whilst their upper or anterior parts, fringed with tentacula, are exposed, like the sunflower when its petals are expanded, to the cheering rays of light. These are at present undisturbed. Here is another group; and of these several have made prize of some food,

brought within their reach by the graceful vibrations of their tentacula. The crustaceans—whether they *scented* the dainty morsels or not we cannot determine—have hurried to the spot in order to appropriate as plunder what has been legitimately obtained by others. Each prawn is helping himself, drawing the coveted bits from the grasp of the helpless and disappointed zoophytes: and see how he scampers off with both hands full to a place of retreat. But look once more. You observe an anemone in the act of swallowing a piece of decayed shell-fish—his mouth opens wider and wider—and now the morsel has disappeared. Here is a prawn just arrived—almost too late—he feels with his finger and thumb about the lips of the closed mouth—there is apparently nothing for him; yet he seems to know what he is about;—and true enough; for see how artistically, how professionally he introduces his hand into the mouth of the anemone! He will not be defeated. Nor has he any compunction. He thrusts his hand down, and down, and yet deeper still, into the very *stomach* of the animal. He has actually got possession of every particle that had been swallowed; and now he is off with all possible speed lest his ill-gotten booty should be snatched from him by a prawn more valiant than himself.

This colony of plundered zoophytes is formed by a species of anemone common only on certain parts of the coast—it is the *Actinia bellis*, described by naturalists. It sometimes escapes detection from the fact, that almost the whole body is often concealed within the chink of a rock, whilst the expanded disc and the surrounding tentacula are partially obscured by the shade of adjacent sea weeds. It assumes a variety of shapes; it can change its locality at pleasure; and, having apparently an aversion to the solitary life, it is usually found in clusters of perhaps a dozen or more individuals huddled together in close compact. The species can scarcely be mistaken. In the same pool are other species of the same genus. The most abundant of all the anemones, *Actinia mesembryanthemum*, is seen on all sides. It inhabits nearly every place at the sea side—adhering to stones or to the sides of piers, and is easily recognized, either as a gelatinous rounded body, not unlike a ripe cherry, when closed during the recess of the tide, or, when in the full enjoyment of the returning waters, it exhibits the form of the flower from which its name has been derived. A careful examination of some of the deeper pools in this neighbourhood will probably expose to view very fine specimens of the larger species—*Actinia coriacea*, and *Actinia crassicornis*. The former of these is abundant on many parts of the shore, sometimes buried in the sand, and gregarious, or

hidden under fragments of rock between the tide marks, or in the possession of a luxuriant pool. It may be known by the following characters:—body conoid, or wider at the base than above; skin opaque, coriaceous, or leathery, covered with warts, variously coloured, but usually dull red; tentacula numerous, in three or four series, and, when expanded, marked with rings. The other species, *A. crassicornis*, although commonly found attached to shells or stones in deep water, may often be obtained in rock crevices, at low water during the spring tides, or even in the large pools. It may be procured at Corriegills, or among the rocks at the south-east side of Holy Island. It resembles *A. coriacea* in shape; but it is a finer species; it grows to a larger size, it is less coriaceous, and more vivid in its colours. It is a handsome object for the aqua-vivarium, where, after a short period, it will be observed that the body becomes filled with water, so as to be greatly enlarged and diaphanous, or almost transparent; the tentacula, at the same time, are elongated, increase their diameter, and exhibit their tubular form. This diaphanous appearance is perhaps the most striking character by which it is distinguished from *A. coriacea*. It will add considerably to the interest of the vivarium—provided the tank can afford accommodation—if three or four individuals of this fine species are placed artistically among the rock-work; for, by a careful selection, specimens may be introduced of variegated hues, some of cream colour, some of scarlet, some of saffron, with orange stripes, or marbled with red and white. There are, indeed, certain people who entertain *other ideas* as to the proper destination of *Actinia crassicornis*. “For, of all kinds of sea anemones,” says Dicquemare,* “I would prefer this for the *table*;—being boiled some time in sea water, they acquire a firm and palatable consistence, and may then be eaten with any kind of sauce. They are of an inviting appearance, of a light shivering texture, and of a soft white and reddish hue. Their smell is not unlike that of a warm crab or lobster.” But whatever importance the *epicure* may attach to the above information, the sea-side visitor will do well to watch the manœuvres by which the anemones are themselves enabled to gratify their tastes by a variety of dishes. It is most amusing to observe the apparent cleverness—the agility and artifice exercised by these curious creatures for the capture of their food. “On one occasion,” says Mr. Couch, “while watching a specimen (*A. coriacea*) that was covered merely by a rim of water, a bee, wandering near, darted through the water to the mouth of the animal, evidently mistaking the creature for a flower, and, though it struggled a great

* Johnston's *British Zoophytes*, vol. i., p. 227.

deal to get free, was retained, until it was drowned, and was then swallowed." * They are at once the most abstemious and the most gormandizing of animated beings. They will live without food for upwards of a year, and yet they may be seen at all hours, and every day, angling, as it were, with their tentacula, and catching crabs, prawns, limpets, periwinkles, dog-whelks, small fish, and, in short, whatever, in the shape of fish, flesh, or fowl is brought within their reach. They retain their food for ten or twelve hours, and then eject from the stomach the well picked bones—the emptied shells of the crustaceans and mollusca. Occasionally a bone will stick in the throat. "I had once brought me a specimen of *A. crassicornis* that might have been originally two inches in diameter, and that had somehow contrived to swallow a valve of *Pecten maximus* of the size of an ordinary saucer. The shell, fixed within the stomach, was so placed as to divide it completely into two halves, so that the body, stretched tensely over, had become thin and flattened like a pancake. All communication between the inferior portion of the stomach and the mouth was of course prevented, yet instead of emaciating and dying of an atrophy, the animal had availed itself of what undoubtedly had been a very untoward accident, to increase its enjoyments and its chances of double fare. A new mouth, furnished with two rows of numerous tentacula, was opened up on what had been the base, and led to the under stomach:—the individual had indeed become a sort of Siamese twin, but with greater intimacy and extent in its unions." † Another remarkable character in the natural history of the Actiniæ is, that, though impatient of ill-treatment under certain conditions, as when torn abruptly from their attachment to the rock, or when confined in water not sufficiently pure, they are almost indestructible by the usual methods of destruction. "They may be immersed in water, hot enough" says Dr. Johnston, "to blister their skin, or frozen in a mass of ice and again thawed; and they may be placed within the exhausted receiver of the air-pump, without being deprived of life, or disabled from resuming their usual functions when placed in a favourable situation. If the tentacula are clipped off they soon begin to bud anew, and if again cut away they grow again." ‡ The finer specimens of these two species, as found in this locality, will occasionally measure from four to six inches across.

110. With the exception of the above examples, the coast line of Arran is not prolific in a variety of zoophytes. A few other forms

* Johnston's *British Zoophytes*, vol. i., p. 225.

† *Ibid*, p. 235.

‡ *Ibid*, p. 239.

may be procured in deep water by means of the naturalist's dredge. There are, however, two more species that will possibly attract the attention of the inquisitive Rambler along the shore: they belong to genera closely allied to *Actinia*, viz., *Anthea cereus*, and *Adamsia palliata*. The former frequently chooses for its position the leaves of the grass wrack, or sea grass (*Zostera marina*), extensive beds of which constitute submarine meadows in sandy districts. This wrack (including the other species, *Z. nana*,) is the only instance of a British flowering plant that lives in the sea. Now, wherever there is a bed of this plant, the student of marine zoology (and also the algologist, or marine botanist,) may pause and examine; and, if he does not object to wade knee deep, at ebb-tide, he will almost to a certainty be repaid for his trouble. Large numbers of creatures revel and thrive in this forest—fish, crabs, shell-fish, annelids or sea worms, and zoophytes; and here, dependent from the long riband-like leaves of the *zostera*, you may often discover *Anthea cereus* with his lengthened tentacula, on the look-out for his prey. The following characters will be sufficient for identification:—body cylindrical, smooth, adhering by a broad base; tentacles numerous, longer than the body, and, unlike those of the *Actiniæ*, these arms cannot be retracted, or are scarcely retractible, into the body of the animal. It attains in this neighbourhood the size of about three inches, measured from the base to the oral disc, or mouth;—and it is of a light brown, or dull ash colour. Beds of the *Zostera marina* occur at Lamlash, on the sandy shore opposite the village; also, on Holy Island, not far from St. Molios's cave; but, even where the sea wrack does not grow, *Anthea cereus* may be found attached to one of the commonest of our sea-weeds—*Fucus serratus*. The other species—*Adamsia palliata*—will not so readily be discovered by the casual visitor, for it prefers the deep water. The dredge, when let down to ten or twenty fathoms, will often bring up a dozen specimens at a time. This zoophyte may be grouped among the most curious of creatures. It will be sure, when once seen, to arrest attention. Its *habitat*, or dwelling-place, is the exterior wall of a deserted shell, as, for example, the dead shell of a buccinum, or whelk, or of a trochus, or fusus, over the greater part of which the animal is extended as a flattened mass about three-tenths of an inch in thickness, varying from a light brown to cream colour, and having the whole surface of its body streaked and spotted. The situation of the oral disc is distinguished by three or four rows of tentacula, short and white, forming an oval margin round the mouth. A thin substance, like horn, will be observed covering part of the empty

shell, to which horny material the body of the *Adamsia* is attached; and, when excited, apparently by pleasure, as with feeding, it emits long filaments, like white threads or delicate silken cords. But a singular circumstance has yet to be mentioned:—The dead shell, over which this zoophyte is spread, is generally inhabited by a hermit crab, and always, as is supposed, by the same species, viz., *Pagurus Prideauxii*. It is exceedingly curious to watch how advantageously to both parties the arrangement works. Of course the *Adamsia*, without any fatigue or effort, is carried by the roaming propensities of the crab over a large district; and, in this way, he commands an extensive market for the acquisition of food; whereas the *Actiniæ*, being fixed to rocks or half buried in the sands, must either undertake a slow and wearisome journey, by their own unassisted labour, or be satisfied with the supplies brought by the wind or tide within reach of their feelers. The hermit, on the other hand, is also recompensed; for, as the writer of these notices has frequently observed, the palatable morsels secured by the tentacles of the zoophyte are instantly seized by the claws of his crustacean companion, and without any apparent apology or subsequent remorse, are partly appropriated to his own immediate use. "In all likelihood," says the late Rev. Dr. Landsborough, "they in various ways aid each other. The hermit has strong claws, and while he is feasting on the prey he has caught, many spare crumbs may fall to the share of his gentle-looking companion. But soft and gentle-looking though the *Actinia* be, she has a hundred hands, and woe to the wandering wight who comes within the reach of one of them; for all the others are instantly brought to its aid, and the hermit may soon find that he is more than compensated for the crumbs that fell from his own booty."* Specimens of this curious and beautiful zoophyte may occasionally be procured by a search in the *zostera* beds at Lamlash, or in other places at low water. Dr. Landsborough first saw it at the mouth of the Glen Rosa burn, in Brodick bay.

111. We must now inquire about the *prawn* captured at Corriegills. Look at it through the sides of the glass vessel. The creature is almost transparent. This is *Palæmon Squilla*; it is smaller than the common prawn, *Palæmon serratus*, and differs in a few other points from that species. It is readily found in the rock pools on Holy Island, on both sides of Brodick bay, and indeed almost everywhere on the Arran shore and on the Ayrshire coast. It is an interesting object for the vivarium, both on account of its general appearance,

* Landsborough's *Popular History of British Zoophytes*, p. 230.

and from its activity in plundering the sea anemones. Other crustaceans abound in this district. The numerous rocks are places of retreat and shelter for the common edible crab, *Cancer Pagurus*, which, in moderate size, is caught in the creels by local fishermen, whilst the younger individuals of this species may be recognized scampering about the shore in search of food, or hiding themselves under stones, in the enjoyment of a siesta. The common shore or harbour crab, *Carcinus Mænas*, inhabits the same localities, and may be seen anywhere, or everywhere, in pools, under sea-weeds, beneath rocks, or in the sands. Turn over the stones, and another species will invite inspection—*Porcellana platycheles*—distinguished at once from every other crab by the breadth of its hands. But, of all the crustaceans, the hermit crab, already mentioned in connection with an associated zoophyte, seems to afford the most amusement to the sea-side rambler. There are several species of this singular crab inhabiting deep water; but the most common kind, *Pagurus Bernhardus*, may be procured in any quantity by strolling along the shore. The peculiarities of these hermits are of no mean order. Each individual resides, hermit-like, solitary, in a shell, which, either by fair or foul means, is obtained and appropriated for self-protection. Nature has been considerate in supplying a shield (the carapace) that entirely defends every species of crab, except the genus now under our notice, viz., *Pagurus*, which, whilst tolerably safe as to the head and thorax, is in constant danger from the utterly unprotected state of the posterior portions. The abdomen and tail are without the usual covering of a coat of lime;—they have no *shell* in these parts, and, consequently, at any moment they might be at the mercy of a hungry neighbour or spiteful antagonist. But here, as elsewhere in the wonderful economy of Nature, the animal finds *compensation* for the deficiency, either in the use of its instinct, or rather, perhaps, in the exercise of *good sense*, by which a remedy is provided equal to its necessities. Its usual habit is to take possession of the empty shell of a dead shell-fish—one of the univalves, such as the common whelk—and, introducing the whole of its soft parts into this cherished prize, it hooks its tail round the innermost whorl of the shell, and, keeping both eyes and claws ready for action, it bids a hearty defiance to every opponent. You may seize the exposed claws and tear the hermits into pieces; but, so apprehensive are they of danger, and so tenaciously do they cling to their support, you will seldom either persuade or force the creatures to come out of their abodes. It is equally curious to observe

the cleverness shown when required to meet another difficulty. A *young* hermit occupies a *small* house. This is a necessary conclusion, inasmuch as the shell has to be dragged about by its occupant. But juvenile hermit crabs, like other young creatures, increase in size, and, as they grow, they find that the abodes selected in their youth have become inconveniently small; for, of course, the dead shells cannot be enlarged for their accommodation. This embarrassment is easily obviated. It is merely a matter of change of residence. You will see the hermit—if you watch on the sea shore, and happen to be in the right place, at the right time—bring himself into close proximity to a shell, empty, and larger than the one then in his possession. His next step is to take an accurate survey on all sides, to see that the coast is clear, and to make sure that he can move from one house to the other without the risk of a *disadvantageous* encounter with an enemy. It is the work of a moment, provided that the new house proves to be more commodious than the old one; but it sometimes happens that the crab is mistaken in his calculation, and, in this case, it is most amusing to watch our friend running about, half naked, and half frightened, among a group of deserted shells, poking its tail first into one and then into another, twisting itself in various directions, and assuming different attitudes, in order to test the suitability of the proposed arrangement; and, finally, when fitted to its entire satisfaction, it walks off, evidently pleased with its success, and generously leaves the old shell for the accommodation of any future house hunter less corpulent than itself. Not unfrequently two hermits will meet and dispute the possession of a vacant shell. Arbitration is never sought in these cases. It is simply a contest between the two for mastery—a trial of physical power—and, where the combatants are well matched, the conflict is generally of a fatal character; for the possession of a convenient house is considered of such vital importance that the one or the other is determined to obtain the coveted shell, and, at all times pugnacious, each is resolved to die rather than yield ingloriously to its opponent. This sea-fight often occurs. The slain are not a few. Sometimes a less serious encounter may be witnessed, as when *might* exercises its too frequent tyranny over *right*. The following incident affords a good illustration:—Two hermits met, accidentally, it may be supposed, within the vivarium on Holy Island. The one was somewhat stouter than the other; and the weaker brother, appearing at first sight to possess the larger house, received an immediate summons to turn out and vacate his premises. The summons was disputed, a furious

combat commenced, and, after a variety of manœuvres, with thrusts and counter thrusts, the stronger, with a dexterous use of the hands, seized the little fellow by both his wrists, and endeavoured to *shake* him out, despite the opposition that was offered. The shells rattled against the glass wall. It was a fierce engagement. At last the older hermit, coming partly out of his shell, seemingly for the purpose of obtaining a better purchase and a greater command of his strength, pulled, and pulled, and pulled again—still drawing himself farther out of his shell, as if he felt that the work was desperately tough—until the youngster, giving way, stood, unhoused, discomfited, and embarrassed, to abide the good pleasure of his master. The next scene was amusing enough. The conqueror came entirely out of his house, and—retaining a firm grasp of his victim to prevent him from bolting off with either of the two shells now empty—backed himself into the new abode, just to inquire if it would really prove a more convenient residence than his own, but, disappointed in his anticipations, he returned to his former shell, released his young friend without further detention or injury, and apparently, with a polite “good morning,” they separated, as if nothing discourteous, or, at least, unusual had occurred.

112. The star-fishes will also afford interest during a ramble along the shore. The most common species, *Uraster rubens*, is really too common to be further noticed. Some kinds, as *Palmipes membranaceus*, *Cribella rosea*, *Asterias aurantiaca*, and others, can be procured only by the dredge; but several of the deep water species may occasionally be found by wading through the *zostera* beds at Lamash, or by examining the pools and rock crevices, especially after a storm, on Holy Island. In this way, *Luidia fragillissima*, *Uraster glacialis*, *Cribella oculata*, *Goniaster Templetoni*, *Solaster papposa*, with some of the species of *Ophiocoma* and *Ophiura*, may be picked up without much trouble. In a few places, the smallest of British star-fishes, *Asterina gibbosa*, may be obtained; but good eyes and some patience are required. Try the pools at the north end of Holy Island; also Clachland point, in Arran. Turn aside the sea-weed; and it may be, after considerable search and disappointment—for this species is by no means abundant—you will see the little creature, grayish in colour, and gibbose and angulated in form, adhering to the side of the rock. In Lamash bay, *Uraster glacialis* is plentiful. It may often be observed, on a calm day, when the water is as clear as crystal, directing its course among the algæ at the depth of 10 or 15 feet—the creature itself, perhaps, two feet in length—and, on nearer inspection, you will distinguish

it at once from *Uraster rubens* by the spines situated on the back of each ray. Care is needed in the preservation of this species, for it has the knack of dislocating its arms under your most cautious treatment. But the star-fish that has gained most notoriety from the facility with which it can, apparently at pleasure, dismember itself—nay, break itself into any number of fragments—and, vexatiously enough, at the very moment when you think the animal is deceased, and preserved uninjured, is *Luidia fragillissima*. The subjoined description is from the pen of the late Professor Edward Forbes:—"The first time I ever took one of these creatures I succeeded in getting it into the boat entire. Never having seen one before, and quite unconscious of its suicidal powers, I spread it out on a rowing bench, the better to admire its form and colours. On attempting to remove it for preservation, to my horror and disappointment I found only an assemblage of rejected members. My conservative endeavours were all neutralized by its destructive exertions; and it is now badly represented in my cabinet by an armless disk and a diskless arm. Next time I went to dredge on the same spot, determined not to be cheated out of a specimen in such a way a second time, I brought with me a bucket of cold fresh water, to which article star-fishes have a great antipathy. As I expected, a *Luidia* came up in the dredge—a most gorgeous specimen. As it does not generally break up before it is raised above the surface of the sea, cautiously and anxiously I sunk my bucket to a level with the dredge's mouth, and proceeded in the most gentle manner to introduce *Luidia* to the purer element. Whether the cold air was too much for him, or the sight of the bucket too terrific, I know not, but in a moment he proceeded to dissolve his corporation, and at every mesh of the dredge his fragments were seen escaping. In despair I grasped at the largest, and brought up the extremity of an arm with its terminating eye, the spinous eyelid of which opened and closed with something exceedingly like a wink of derision."*

Experience has since shown that the means by which either *Luidia* or *Uraster glacialis* can be secured for cabinet specimens is, not to destroy them violently by plunging them into fresh water, but to let them die by a more quiet process, viz., by leaving them in a vessel of sea water until life is exhausted. Under these circumstances they are not prone to break, and thereby disappoint their captors.† *Luidia* will be recognized by its light orange or buff colour; its rays

* *British Star-fishes*, page 138.

† Dr. Carpenter has found that, by placing *Luidia* in a pan of *Glycerine*, the creature dies at once, and without disfiguring itself.

are smooth on the back, and provided with spines on their margins ; specimens measuring a foot may be picked up on the shore in Lam-lash bay, and individuals of twice that size are procurable by the dredge, or may sometimes be hooked up in shallower water with a common rake. There is another singular creature of great interest to the naturalist—it is *Comatula rosacea*, or the rosy-feathered star-fish—a beautiful and elegant example of the radiated form of animated beings. It is found abundantly in Lam-lash bay, near the pier on Holy Island, and in other parts of the locality ; but the dredge is required, as this species inhabits deep water—that is, depths of about ten fathoms. At some seasons almost any number may be obtained. They are brought up attached to the large seaweed, *Laminaria saccharina*, from which they must be removed with care, as they are exceedingly brittle, and, like the *Luidiæ*, can break themselves into fragments with astonishing and unpleasant speed. The best way, perhaps, to prepare dry specimens for the cabinet is to treat them as the marine botanist treats the more delicate algæ—spread them on drawing paper, place over them a piece of smooth linen, and let them dry between folds of blotting paper, under slight pressure ; but, in the first instance, they must be allowed quietly to die in sea water, or more rapidly in a solution of alum—for, if immersed in *pure fresh* water, they will lose their beauty, by the removal of their colouring matter. In order to appreciate the exquisite form and elegant movements of this star-fish, the creature must be seen and watched in a vivarium, where it will voluntarily fix itself to the sea-weed or to a piece of rock, and, by graceful undulations of its arms, will be certain to command admiration. The picture will be greatly enhanced if several individuals of various colours—orange, purple, crimson—are introduced, and judiciously dispersed.

113. Before we leave this division of the subject, it will suffice to make brief mention of the well known sea hedgehog, *Echinus sphæra*, common in most parts of the Clyde, and of which fine specimens are found clinging to the rocks on Holy Island, and at Clachland Point. This curious creature should be carefully examined by the young student of marine zoology. It is allied to the star-fishes ; for although spherical in form, the radiated structure is readily perceived. In short, it is a star-fish, with the spaces between its rays filled up by plates of carbonate of lime—the rays themselves consisting of the same material—the whole exterior being bent over into a hollow ball, and armed, hedgehog like, or like the star-fish *Uraster glacialis*, with numerous sharp spines. The viscera, or digestive organs, of

the echinus are contained within the ball; and its mouth is provided with a beautiful piece of mechanism, worthy of examination, and designed for crushing the shells of molluscous and crustaceous animals on which it feeds. Its mode of progression, by means of its spines and suckers, is both interesting and wonderful. Specimens are frequently found of the richest crimson or purple. Another species of this genus, *Echinus miliaris*, is also common in the pools. It is more diminutive than the former. The dredge will generally be needed to obtain living specimens of the other forms of these echinodermatous or radiated creatures—such as *Spatangus purpureus*, *Echinocyamus pusillus*, and *Amphidotus cordatus*, or the common *Heart Urchin*, of which the dead and empty shells, with their spines rubbed off, may frequently be noticed washed up and left upon the sands.

114. The study of another important division of animated nature—the mollusca—has been a favourite pursuit of scientific men and of amateur observers. To this division the marine shells belong. Here the conchologist finds his delight in the examination and arrangement of the materials of his department—admiring the endless variety of form, and colour, and sculpture; whilst the zoologist is laboriously occupied in determining the anatomical structure of the *inhabitants* of the shells—tracing the peculiarities of the different genera and species.

The waters around Arran produce a considerable number of shells; but, with few exceptions, the species are common to all parts of the Clyde. The *dredge* is required to procure specimens of interest; and for the information of naturalists unacquainted with the district, it may be stated, that the most profitable dredging ground, in Lamash bay, lies between Hamilton Rock, near Clachland Point on the Arran shore, and the north and north-east sides of Holy Island, extending the whole way across, and in depths from fifteen to forty fathoms. A full list of the species will be given at the end of these notices; but the following genera, as being found in this particular locality, may be here mentioned:—*Aporrhais*, *Artemis*, *Astarte*, *Cardium*, *Cerithium*, *Ghemnitzia*, *Circe*, *Corbula*, *Crania*, *Cylichna*, *Cypræa*, *Cyprina*, *Dentalium*, *Emarginula*, *Eulima*, *Fissurella*, *Fusus*, *Kellia*, *Leda*, *Lima*, *Lyonsia*, *Mangelia*, *Modiola*, *Montacuta*, *Nassa*, *Natica*, *Nucula*, *Odostomia*, *Pecten* (including *P. striatus* and *P. tigrinus*), *Pectunculus*, *Philina*, *Pileopsis*, *Pilidium*, *Psammodia*, *Puncturella*, *Rissoa*, *Scalaria*, *Scaphander*, *Tellina*, *Terebratula*, *Thracia*, *Trichotropis*, *Trochus*, *Turritella*, and *Venus*. Several of these genera occur also in other places in Lamash bay,

and round the coast. On the other hand, Brodick bay, Whiting bay, and the vicinity of Pladda, have hitherto proved to be exceedingly unprofitable. Loch Ranza, notwithstanding the apparent advantage of its position, did not yield anything, after several hours of active dredging in all parts of the bay, except the commonest of the scallops, *Pecten opercularis*—an excellent bait for fishermen, and which may be procured here in any quantity. The strait which separates Arran from Argyllshire, known as Kilbrannan Sound, will probably yield richer results than other parts of the Clyde; but these waters have not yet been sufficiently examined to warrant more than a conjectural opinion. The south end, and the south-east side, of Holy Island are also unprofitable.

It must not be expected that the rarer molluscous animals or shells may be obtained from the pools, or from the sands, or rocks, forming the coast-line. Yet an attentive investigation will not be without its reward. In the vicinity of Clachland Point, where the excavated sandstone affords numerous places of retreat, and where each returning tide supplies the wants of the tenants, a variety of creatures may be seen grouped together in quest of the enjoyments of life. Let the crevices be carefully searched—turn over the fronds of the seaweeds—capsize the loose stones—look under the ledges of the rocks—select a calm day, during the spring tide, when the water has ebbed to the lowest—and there will not be any need, at least for the young student, to complain of the result. A curious mollusc inhabits this station—*Aplysia hybrida*, or the sea hare, which will be recognized, whilst in a state of activity, by the peculiar shape of its antennæ; for these, when expanded, are something like the erect ears of the common hare. Another mollusc, found upon the shore, and not without pretensions to respect, as well from its lovely orange colour, as from the gracefulness with which it moves, is the *Pleurobranchus*, which, being nocturnal in its habits, may be caught napping at the period most convenient to its captor. It is a good object for the vivarium, where, lying concealed during the day, it will be observed, at midnight, traversing the tank, like a solitary watchman on his rounds; but, unlike the guardian of our streets, its purpose is—not to defend property, but to appropriate to its own use without fear of detection, whatever it may regard as palatable to its taste, or requisite for its necessities. Both the *Pleurobranchus* and the *Aplysia* may be procured from pools at the north end of Holy Island. At Lamlash, in the neighbourhood of the old quay, the blocks of sandstone, which lie scattered in all directions, contain, here and there, good specimens of one of the *borers*—a

division of the mollusca, whose habit is to penetrate either sand, as the common cockle, *Cardium edule*—or wood, as the different species of *Teredo*—or stone, as the genus *Pholas*, a bivalve, of which the shell in some species is extremely fragile, and although wonderfully well adapted to its work as an excavator of solid rocks, requires the utmost caution when being handled in our collections. The species that bores through the sandstones at Lamlash is *Pholas crispata*. The wood-borer, *Teredo navalis*, is common in many parts of the Clyde, as may be proved by witnessing its destructive operations at Ardrossan and Fairlie on the Ayrshire side, where also its ally, *Xylophaga dorsalis*, has done its full share of mischief. Another species, less common, and of larger growth—formerly unknown, as is supposed, higher up the Clyde than Port Patrick, viz., *Teredo Norvegica*, introduced itself into Lamlash bay, and, during the short period of about seven years, it had almost demolished the massive supports of the pier—a commodious and substantial landing place, erected, as the owner undoubtedly thought, for the convenience of himself and friends. The *Teredo*, however, commenced and continued its operations unnoticed—not one pile of the water-covered timber escaped—the whole was pierced in lengths varying from a few inches to about two feet, when, in the hurricane of February, 1856, a vessel was driven upon the spot, and almost the entire structure was swept away.* On an examination of the fragments thrown upon the island, several specimens of the calcareous tube, formed by the animal in the course of its progress, and a few of the valves, were secured for private cabinets; and pieces of the bored timber were given to the museums of Glasgow College and of the Andersonian University.

The most abundant species of *Trochus* on these western shores is *T. umbilicatus*, which, with *T. cinerarius* and *T. tumidus*, may be procured in any quantity on Holy Island. Here also the following shells are not uncommon:—*Acmaea testudinalis*, *Kellia rubra*—a minute bivalve attached to the dark low growing plant, *Lichina pygmaea*, which overspreads the rocks near the sea;—*Patella athletica*, *P. pellucida*, *Tapes decussata*, with different species of *Littorina*, and other equally common and widely diffused forms. In the sands, at Lamlash, at low water, *Macra solida*, and *M. subtruncata*, are plentiful. But, leaving the coast line, and letting the dredge drop in about ten fathoms, at the north end of Holy Island, or between the north point of the island and the pier, a peculiarly interesting shell may be collected in large quantities—*Lima hians*,

* This pier was built by the late Mr. Oswald, member for the city of Glasgow.

the inhabitant of which constructs and occupies a *nest*. The shell is of delicate texture, and, when deprived of extraneous matter by careful washing, is entirely white, and, being graceful in form, is an acquisition to an ornamental cabinet. It is desirable, however, to preserve specimens of the nest as well as of the shell, and to allow both to remain, as far as possible, in their natural position. The nest is formed of materials collected at the bottom of the sea—either pebbles, or broken shells, or both shells and pebbles—and these are brought into a mass and bound together by a glutinous thread secreted by the animal. Sometimes the *Lima* is solitary—having built a house simply for itself; but, generally in Lamlash bay, the dredge brings up large patches of this compacted debris, in which will be found a colony living in apparent comfort, security, and friendship—each individual, however, having a separate and snug berth. A supply of specimens may be secured in a few moments. The *animal* is also a beautiful object in the water—its numerous tentacula, which extend beyond the limits of its shell, are of a fine orange colour, and, being a bivalve, it moves from place to place with ease and agility, by the rapid opening and closing of its valves. Although rare in many localities, *Lima hians* has an extensive range in the Clyde—the nests being found off the coast of Islay, between Largs and the Cumbraes, and on the Argyllshire side, as high up as Hunter's Quay, Dunoon. But the station where it is really abundant is Lamlash bay, where also the other species, *L. loscombii*, and *L. subauriculata*, may be procured.

115. Although many objects of interest have now been mentioned, there remain a considerable number of living creatures, more or less wonderful both in structure and in habit, which, from various causes, have not yet been sufficiently examined on this coast; and, consequently, any information respecting them must necessarily be meagre. Among the *Annelids*, or sea-worms, the following genera are known to belong to Lamlash bay:—*Aphrodita*, *Arenicola*, *Eunice*, *Nereis*, *Pectinaria*, *Serpula*, *Spirorbis*, *Terebella*. The young student will be usefully employed in the search and study of these curious forms of life, for, notwithstanding that they take no higher rank than worms, they exhibit, in some species, characteristics so peculiar, and colours so gorgeous, as to attract even the popular eye and to excite unsparing admiration. Who is not familiar with the *Serpulæ*, whose heads are crowned with radiating threads of varied hue? These singular tufts, which the animal protrudes for health and pleasure, and which, with the rapidity of thought, are withdrawn into its calcareous tube on the first symptom of alarm, are its gills,

or organs of respiration. Let the shadow of your hand pass near the side of a glass vessel, in which a living specimen is contained, and instantly the head starts back into concealment; but watch, and in a few moments its brilliant coronet will reappear. The *Pectinaria* resides in a house made of the finest sand cemented in the form of a tapering tube; and its gills, in shape like a minute comb, are as bright as burnished gold. In the *Terebellæ*, inhabitants of mud, the numerous and long worm-like tentacles present the appearance of so many separate *Annelids* entwined around their common prey. The genus *Eunice* occupies a tube composed of a substance not unlike thin horn or the slender quill of a bird. The spiral white spots frequently spread over tangle or other large sea-weeds are examples of *Spirorbis*. The sea-mouse, *Aphrodita aculeata*, obtained with the dredge, will easily be recognized by the metallic lustre of its long bristles, which, partially covering the animal, give out the colours of the rainbow. Some of the marine worms are remarkable from the enormous length to which their thread-like bodies are extended. Another class of widely diffused beings, not yet sufficiently investigated on the Arran shores, and which, like the *Annelids*, are worthy of a more honourable name than is assigned to them in popular language, are—the *Sea slugs*, known in scientific phraseology, as the *Nudibranchiate mollusca*. These are within the reach of every observer—for, at low water, they may be seen reposing under loose stones or adhering to *Algeæ*. Some of the species, especially of the genus *Eolis*, are really charming objects—elegant in form, and beauteous in colour. They cannot be mistaken. Place a specimen in a tumbler of sea water, it will unfold itself, and its gills, differently situated in different species, will be seen expanding into full operation as the little creature pursues its journey round the sides of the vessel. It enjoys the learned appellation of *Nudibranch*, because its *branchiæ*, or breathing organs, are *naked*, or exterior to the body of the animal. The genera *Doris*, *Eolis*, *Goniodoris*, *Lomanotus*, *Polycera*, and *Triopa*, have been found in the bays of Brodick and Lamlash; but, if an active search be made, the number of ascertained species will doubtless be greatly augmented, and the labourers in this department will be amply rewarded. Nor must we altogether overlook, as among the more remarkable forms, the *Acalepha*, to which the *Medusæ* and other *Jelly-fish* or *Sea-nettles* belong. Some of the larger and coarser species are familiar to sea-bathers by the stinging qualities of their tentacula. But there are other species as harmless as they are lovely. On a calm summer day,

when there is not a ripple to disturb the sea, these exquisitely formed creatures may be witnessed in hundreds, like a vast fleet of fairy ships, lying upon the surface. Such are the *Beroe* and the *Cydippe*. Let specimens, captured carefully in a gauze net, be transferred to a vessel of water, and, low as they are in organization, they will not be dismissed without commanding surprise at the delicacy of their structure and at the facility with which they traverse their allotted space.

116. It remains only to add, after the above general view of invertebrate life, that in the various bays and inlets around Arran, almost every kind of *fish* common to our northern seas may be procured. It would be superfluous to name the species familiar to every person. But we must not omit to mention that the Lancelet—*Amphioxus lanceolatus*—has been dredged at the north end of Holy Island, where it seems to be restricted to a gravel bottom in depths of about ten or fifteen fathoms. Until recently this fish was regarded as extremely rare. It is now, however, known to be more common. Several specimens have been captured near Millport, in the island of Cumbrae, as well as in Lamash bay; and, probably, it will be discovered to have a wider range than at one time was expected. The interest attached to it arises from its anatomical and physiological peculiarities. Its spine is a cartilaginous thread-like column, without joints; it has no ribs, no pectoral or ventral fins; and, in short, although claiming rank with vertebrate animals, the skeleton is rudimentary and the brain absent. The *Amphioxus* is an excellent illustration of the law that, even where there is the greatest departure from uniformity, the *typical characters* are rigidly preserved in the development of creation.

117. In concluding our notices of the marine zoology of Arran, the subjoined tables may advantageously be added for the information of naturalists not practically acquainted with the Fauna of the Clyde. The species marked with an *asterisk* were dredged by the late Rev. Dr. Landsborough and Major Martin; and the other species were obtained by Dr. Greville and myself in our examination of this part of the coast. The list, so far as completed without the assistance of the former gentlemen, appears in the Annual Report of the British Association for the Advancement of Science for the year 1856. Dr. Landsborough and Major Martin were indefatigable in their investigation of these localities. There yet remains, however, much work to be accomplished by future inquirers—especially among some of the remarkable groups, as the Cirripeda, Annelida, Acalepha, Zoophyta, and Poriphora—as also

among the Polyzoa and microscopic forms included in the Infusoria and Rhizopoda.

TABLE I.—MOLLUSCA.

* <i>Aclis nitidissima</i> ,	The whole of the shells named in this
*——— <i>unica</i> ,	table were dredged in Lamlash
<i>Acmæa testudinalis</i> ,	Bay,—the best ground being the
——— <i>virginea</i> ,	area that extends from Clachland
* <i>Adeorbis sub-carinata</i> ,	Point and Hamilton Rock to the
* <i>Amphysphyræ hyalina</i> ,	north end of Holy Island, in from
<i>Anomia ephippium</i> ,	15 to 40 fathoms.
——— <i>aculeata</i> ,	
<i>Aplysia hybrida</i> ,	In the pools, Clachland Point.
<i>Aporrhais pes-pellicani</i> ,	
* <i>Arca lactea</i> ,	
<i>Artemis exoleta</i> ,	
——— <i>lincta</i> ,	
<i>Astarte compressa</i> ,	
*——— <i>elliptica</i> ,	
*——— <i>Scotica</i> ,	
——— <i>sulcata</i> ,	
<i>Buccinum undatum</i> ,	
* <i>Cœcum glabrum</i> ,	
*——— <i>trachea</i> ,	
<i>Cardium echinatum</i> ,	
——— <i>edule</i> ,	
*——— <i>fasciatum</i> ,	
*——— <i>nodosum</i> ,	
——— <i>Norvegicum</i> ,	
*——— <i>Suecicum</i> ,	
* <i>Cerithiopsis tubercularis</i> ,	
* <i>Cerithium adversum</i> ,	
——— <i>reticulatum</i> ,	
<i>Chiton asellus</i> ,	
——— <i>marmoreus</i> ,	
——— <i>ruber</i> ,	
* <i>Chemnitzia indistincta</i> ,	} Scarce in Lamlash Bay.
*——— <i>rufescens</i> ,	
<i>Circe minima</i> ,	
<i>Corbula nucleus</i> ,	
<i>Crania anomala</i> ,	{ Attached to stones and shells in deep water,—not scarce in Lamlash Bay.
* <i>Crenella decussata</i> ,	
*——— <i>discors</i> ,	
*——— <i>marmorata</i> ,	
<i>Cylichna cylindracea</i> ,	
*——— <i>mammillata</i> ,	
*——— <i>obtusa</i> ,	
*——— <i>truncata</i> ,	
*——— <i>umbilicata</i> ,	
<i>Cypræa Europæa</i> ,	
<i>Cyprina islandica</i> ,	Dead shells not uncommon.
<i>Dentalium entalis</i> ,	
* <i>Donax anatinus</i> ,	
<i>Emarginula reticulata</i> ,	

Eulima bilineata,	} Good specimens from gravel bottom, at about 15 fathoms, north end of Holy Island.
——— distorta,	
*——— polita,	
Fissurella reticulata,	
Fusus antiquus,	
——— islandicus,	
Kellia rubra,	} Concealed in the plant <i>Lichina</i> <i>pigmæa</i> , near the shore, Holy Island.
——— suborbicularis,	
*Lacuna pallidula,	} In different parts of Lamash Bay.
*——— vineta,	
Lamellaria perspicua,	
*Leda caudata,	
*Lepton convexum,	
Lima hians,	} At the north end of Holy Island, in about 10 or 15 fathoms. The nests of <i>Lima hians</i> , with the live shells, are very abundant in this locality; and they are worth examining for <i>Diatomaceæ</i> .
——— loscombii,	
——— subauriculata,	
Littorina littoralis,	
——— littorea,	
——— neritoides,	
——— rudis,	
*Lucina flexuosa,	
*——— spinifera,	
*Lucinopsis undata,	
*Lutraria elliptica,	
Lyonsia Norvegica,	
Macra elliptica,	} In the sands, low water, Lamash.
——— solida,	
——— stultorum,	
——— subtruncata,	
Mangelia costata,	
——— Leufroyi,	} In deep water between Clachland Point and Holy Island.
*——— linearis,	
*——— nebula,	} <i>M. Rufa</i> was dredged between Fullarton's Rock and King's Cross Point.
——— rufa, var. <i>Uhideana</i> ,	
*——— septangularis,	
——— teres,	
*——— turricula,	
Modiola modiolus,	
*——— phaseolina,	
*Montacuta bidentata,	} Attached to the spines of <i>Spatangus</i> <i>purpureus</i> .
——— substriata,	
*Mya arenaria,	
*——— truncata,	
Mytilus edulis,	} Immature specimens everywhere.
Nassa incrassata,	
——— reticulata,	
*Natica alderi,	
——— monilifera,	
——— Montagui,	
*Nucula nitida,	
*——— nucleus,	

* <i>Nucula radiata</i> ,	
* <i>Odostomia conoidea</i> ,	
* ————— <i>cylindrica</i> ,	
* ————— <i>decussata</i> ,	
* ————— <i>excavata</i> ,	
* ————— <i>interstincta</i> ,	
* ————— <i>plicata</i> ,	
* ————— <i>rissoides</i> ,	
* ————— <i>spiralis</i> ,	
* ————— <i>unidentata</i> ,	
<i>Ostrea edulis</i> ,	{ An oyster-bed, Lamlash Bay, Holy Island.
* <i>Ovulum acuminatum</i> ,	
<i>Patella athletica</i> ,	Holy Island.
———— <i>pellucida</i> ,	
———— <i>vulgata</i> ,	
<i>Pecten maximus</i> ,	{ Lamlash Bay.
———— <i>opercularis</i> ,	
* ————— <i>pusio</i> ,	
———— <i>similis</i> ,	
———— <i>striatus</i> ,	
———— <i>tigrinus</i> ,	
* ————— <i>varius</i> ,	
<i>Pectunculus glycymeris</i> ,	
<i>Philine aperta</i> ,	
* ————— <i>catena</i> ,	
* ————— <i>scabra</i> ,	
<i>Pholas crispata</i> ,	{ In the sandstones, low water, Lam-
	lash.
<i>Pileopsis Hungaricus</i> ,	
<i>Pilidium fulvum</i> ,	
* <i>Pinna pectinata</i> ,*	
<i>Pleurobranchus membranaceus</i> (?)	Under stones, low water, Holy Island.
* <i>Pleurotoma gracilis</i> ,	
* ————— <i>septangularis</i> ,	
<i>Psammobia Ferroensis</i> ,	
<i>Puncturella Noachina</i> ,	
<i>Purpura lapillus</i> ,	
* <i>Rissoa Beanii</i> ,	
* ————— <i>calathus</i> ,	
* ————— <i>cingillus</i> ,	
* ————— <i>costata</i> ,	
* ————— <i>costulata</i> ,	
* ————— <i>crenulata</i> ,	
* ————— <i>fulgida</i> ,	
* ————— <i>inconspicua</i> ,	
* ————— <i>interrupta</i> ,	
* ————— <i>labiosa</i> ,	
* ————— <i>parva</i> ,	
* ————— <i>punctura</i> ,	
* ————— <i>rubra</i> ,	
* ————— <i>rufilabris</i> ,	
* ————— <i>semistriata</i> ,	

* *Pinna pectinata* was also dredged by the late Major Martin on Skelmorlie Bank, near Wemyss Bay, Ayrshire coast.

Rissoa striata,	
—— striatula,	
*—— ulvæ,	
*—— vitrea,	
*—— Zetlandica,	
*Saxicava arctica,	
*—— rugosa,	
*Scalaria communis,	
Scaphander lignarius,	
*Skenea divisa,	
*—— nitidissima,	
*—— planorbis,	
*—— rota,	
*Sphœnia Binghami,	
*Syndosmya prismatica,	
Tapes aurea,	
—— decussata,	
—— virginea,	
*Tellina crassa,	
—— donacina,	
*—— fabula,	
*—— incarnata,	
*—— solidula,	
*—— tenuis,	
Terebratula caput-serpentis,	{ Deep water, between Hamilton Rock and Holy Island.
*Teredo megotara,	
—— Norvegica,	{ In the wreck of the pier, Holy Island.
Thracia phaseolina,	
*—— pubescens,	
Trichotropis borealis,	
Trochus cinerarius,	
—— magus,	
—— millegranus,	
—— Montaguï,	
—— pusillus,	
—— tumidus,	
—— umbilicatus,	
—— undulatus,	
—— ziziphinus,	
*Trophon Barvicensis,	
*—— clathratus,	
Turritella communis,	
*Turtonia minuta,	
Venus casina,	
—— fasciata,	
—— gallina,	
—— ovata,	
—— striatula,	
	{ Lamlash Bay. <i>T. umbilicatus</i> is common along the shore of Holy Island, also <i>T. cinerarius</i> .
	{ North end of Holy Island, in from 10 to 20 fathoms.

TABLE II.—NUDIBRANCHIATE MOLLUSCA.

Doris bilamellata,	
—— planata,	
—— tuberculata,	
	{ Under stones at low water, in many places, and not uncommon. <i>D.</i> <i>planata</i> was found in Lamlash Bay by Mr. Alder.

* <i>Eolis alba</i> ,	
*—— <i>coronata</i> ,	
—— <i>Drummondi</i> ,	{ Under stones at low water, in many places, and not uncommon.
*—— <i>Landsburgii</i> ,	
<i>Goniodoris nodosa</i> ,	
<i>Lomanotus</i> —— (?)	{ Probably a new species, dredged in Brodick Bay by Dr. Greville and Dr. Miles, in about 15 fathoms, between Invercloy and Corriegills, but the specimen was unfortunately lost before it could be sent to Mr. Alder for examination. It was two inches in length, white, with orange processes, and of rare beauty. A sketch taken by Dr. Greville was forwarded to Mr. Alder. <i>L. flavidus</i> was dredged in 1846 by Mr. Alder in Lamlash Bay.
—— <i>flavidus</i> ,	
<i>Polycera quadrilineata</i> ,	
<i>Triopa claviger</i> ,	

TABLE III.—CRUSTACEA.

<i>Balanus balanoides</i> ,	{ The <i>Cirripedia</i> have scarcely been examined.
<i>Cancer Pagurus</i> ,	
<i>Carcinus Mœnas</i> ,	{ The edible crab is common around Arran.
* <i>Ebalia Bryerii</i> ,	
*—— <i>Cranchii</i> ,	{ Dredged by Dr. Greville in Lamlash Bay.
—— <i>Pennantii</i> ,	
<i>Eurynome aspera</i> ,	{ Not uncommon in deep water. Several specimens obtained from deep water, Lamlash Bay.
<i>Galathea squamifera</i> (?)	
<i>Gonoplax angulata</i> ,	{ On the Ayrshire coast, abreast of Arran.
<i>Hippolyte varians</i> ,	
<i>Homarus vulgaris</i> ,	{ The common lobster is found among the rocks on different parts of the Arran coast and at Holy Island.
<i>Hyas araneus</i> ,	
*—— <i>coarctatus</i> ,	
<i>Inachus Dorsettensis</i> ,	
* <i>Lepas anatifera</i> ,	{ Found in Lamlash Bay on floating wreck.
<i>Lithodes Maia</i> ,	
<i>Pagurus Bernhardus</i> ,	{ In deep water, mid-channel, off Arran.
—— <i>Prideauxii</i> ,	
<i>Palæmon squilla</i> ,	{ Abundant everywhere. Abundant in Lamlash Bay, with <i>Adamsia palliata</i> .
<i>Palinurus vulgaris</i> ,	
<i>Pandalus annulicornis</i> ,	{ Common in all the rock-pools. Obtained by the late Major Martin from off Campbelton.

* <i>Pinnotheres pisum</i> ,	.	.	.	
<i>Porcellana longicornis</i> ,	.	.	.	Among the roots of <i>Laminaria</i> .
———— <i>platycheles</i> ,	.	.	.	{ Abundant under stones at low water, Holy Island and Lamlash.
<i>Stenorhynchus phalangium</i> ,	.	.	.	
				Dredged in deep water.

TABLE IV.—ECHINODERMATA.

<i>Amphidotus cordatus</i> ,	.	.	.	The following species were all ob-
* ————— <i>roseus</i> ,	.	.	.	tained in Lamlash Bay.
<i>Asterias aurantiaca</i> ,	.	.	.	Near Fullarton's Rock.
<i>Asterina gibbosa</i> ,	.	.	.	In pools, north end of Holy Island, &c.
<i>Chirodota digitata</i> ,	.	.	.	Dredged near the pier, Holy Island.
				{ Abundant in Lamlash Bay, near Holy Island, in from 8 to 15 fathoms. Solitary individuals have been traced up the Clyde as high as Hunter's Quay, Dunoon.
<i>Comatula rosacea</i> ,	.	.	.	
<i>Cribella oculata</i> ,	.	.	.	
———— <i>rosea</i> ,	.	.	.	{ This beautiful star-fish (two speci- mens) was dredged in deep water, north end of Holy Island.
<i>Echynocyamus pusillus</i> ,	.	.	.	
<i>Echinus miliaris</i> ,	.	.	.	
———— <i>sphæra</i> ,	.	.	.	
<i>Goniaster Templetoni</i> ,	.	.	.	Not uncommon in the Bay.
<i>Luidia fragilissima</i> ,	.	.	.	Not uncommon in the Bay.
<i>Ophiocoma bellis</i> ,	.	.	.	
———— <i>granulata</i> ,	.	.	.	
———— <i>rosula</i> ,	.	.	.	
<i>Ophiura texturata</i> ,	.	.	.	
<i>Palmipes membranaceus</i> ,	.	.	.	{ Good specimens, deep water, near Hamilton Rock.
<i>Sipunculus</i> ————— (?)	.	.	.	
<i>Spatangus purpureus</i> ,	.	.	.	
<i>Solaster papposa</i> ,	.	.	.	
<i>Uraster glacialis</i> ,	.	.	.	
———— <i>rubens</i> ,	.	.	.	

TABLE V.—ZOOPHYTA.

<i>Actinia bellis</i> ,	.	.	.	In the rock-pools, not uncommon.
———— <i>coriacea</i> ,	.	.	.	{ Under ledges of rocks, in pools, &c.
———— <i>crassicornis</i> ,	.	.	.	
———— <i>mesembryanthemum</i> ,	.	.	.	
<i>Adamsia palliata</i> ,	.	.	.	{ Abundant in Lamlash Bay, attached to shells occupied by <i>Pagurus</i> <i>Prideauxii</i> .
<i>Anthea cereus</i> ,	.	.	.	
<i>Antennularia antennina</i> ,	.	.	.	
* ————— <i>ramosa</i> ,	.	.	.	
<i>Cellepora pumicosa</i> ,	.	.	.	
———— <i>ramulosa</i> ,	.	.	.	
———— <i>Skenei</i> ,	.	.	.	
<i>Campanularia dumosa</i> ,	.	.	.	
<i>Flustra foliacea</i> ,	.	.	.	
<i>Halecium halecinum</i> ,	.	.	.	

* <i>Halichondria panicea</i> , . . .	
* ————— <i>suberea</i> , . . .	
<i>Laomedea geniculata</i> , . . .	
<i>Lepralia annulata</i> , . . .	} On stones and dead shells, in deep water, Lamlash Bay.
————— <i>hyalina</i> , . . .	
————— <i>Malusii</i> , . . .	
————— <i>Peachii</i> , . . .	
————— <i>trispinosa</i> , . . .	
————— <i>violacea</i> , <i>var. cruenta</i> , . . .	)
<i>Plumularia pinnata</i> , . . .	
<i>Salicornaria farciminoides</i> , . . .	
<i>Sertularia tamarisca</i> , . . .	

ENTOMOLOGY OF ARRAN

LEPIDOPTERA.

118. AMONG the Lepidoptera, or tribe of butterflies and moths, occurring in the Isle of Arran, are several of rather peculiar interest; and a work treating of the Fauna of Arran would be incomplete without some notice of them.

COLIAS EDUSA (the clouded yellow butterfly) is a species which is very seldom seen so far north; but its occurrence near Lamlash was chronicled in the *Zoologist* for 1848, p. 1985.

EREBIA BLANDINA (the Scotch Argus) is a mountain species of butterfly, which, though common in many northern localities, is esteemed a prize by all collectors of the plains, when first they meet with it. It is common on many of the hill-sides in Arran.

EREBIA LIGEA is a species closely allied to *BLANDINA*, which has been reported to occur in the Isle of Arran; and Mr. Curtis, the distinguished author of *British Entomology*, assured me that the late Sir Patrick Walker told him he had himself taken it in the island, in the second half of August. No recent captures of this insect in Britain are known; and the fact of its having ever been caught here being much doubted, the species has ceased to figure in our lists of indigenous species.

CÆNONYMPHA DAVIES is common on boggy places at some altitude above the sea.

Of the handsome genus of *FRITILLARIES* three species—*ARGYNNIS AGLAIA*, *ADIPPE*, and *SELENE*—are by no means uncommon in the little glens, up the hill-sides, and in early spring *THECLA RUBI* (the green hair streak) is frequent amongst bramble bushes.

POLYOMMATUS ARTAXERXES is a species very likely to occur in Arran, though I am not aware that it ever has been found there.

ANTHROCERA MINOS.—The recent capture near Oban of this species of *Sphinx*, found three years ago in Ireland, renders it certainly not improbable that it may occur in Arran. Like many of its congeners, it is excessively local, and may occur in some limited spot, only on one hill-side, yet there be in profusion.

Among the family of the day-flying moths, the *BOMBYCINA*, none of those which have been observed in the island are of sufficient importance to deserve special notice.

Amongst the NOCTUINA, the pretty THYATIRA BATES (peach-blossom) is common; CELÆNA HAWORTHII is tolerably plentiful; HADENA ASSIMILIS has once or twice been taken on the face of stone rocks; and PLUSIA INTERROGATIONIS is rather common than otherwise.

Amongst the GEOMETRINA which have been noticed here, may be mentioned MÆSIA BELGIARIA, which flies in heathy places; OPORABIA FILIGRAMENARIA, LARENTIA CÆSIATA, SALICARIA, and the mountain species of the pretty little genus EMMELESIA, viz.: TÆNIATA, ERICETATA, and BLANDIATA, and the pretty insect CARSIA IMBUTATA, of which the Scotch specimens are so much more delicately marked than those from the neighbourhood of Manchester.

Of the smaller species of Lepidoptera none of peculiar interest have yet been noticed in Arran; but it must be borne in mind that this portion of its natural treasures has never been thoroughly explored.

LIST OF LEPIDOPTERA COLLECTED IN 1836 BY DR. CONNELL:*

Cynthia cardui.	Hepialus velleda.
Hipparchia blandina.	———— humuli.
———— polydama.	Rumia crotsegata.
———— pamphilus.	Ophiusa lusoria.
———— hyperanthus.	Leucania pallens.
———— janira.	Plusia chrysitis.
———— semele.	Episema cœruleocephala.
Polyommatus alsus.	Leucania impura.
———— Alexis.	Larentia chenopodiata.
Vanessa urticæ.	Fidonia atomaria.
Pontia brassicæ.	Cabera exanthemata.
———— rapæ.	———— pusaria.
———— napi.	Actebia porphyrea.
Melitæa Euphrosyne.	Xylina putris.
Argynnis Aglaia.	Harpalyce fulvata.
Lycæna phlœas.	———— sylvatica.
Arctia caja.	———— ocellata.
Cerura vinula.	Margaritia verticalis.
Macroglossa stellatarum.	Botys forficalis.
Minoa chærophyllata.	Anarta myrtilli.
Anthrocrea filependulæ.	Pterophorus punctidactylus.
Spilosoma menthastri.	Nemeophila plantaginis.
Hypena proboscidalis.	Plusia gamma.
Mamestra brassicæ.	

* This list contains all that has been published up till this time, regarding the Entomology of Arran. It was furnished to Dr. Landsborough by the late Dr. Connell of the High School of Glasgow; and was published first in the *New Statistical Account of Scotland*, vol. v., and afterwards in Dr. Landsborough's *Excursions to Arran*.