TRANSACTIONS

OF THE

PERTHSHIRE SOCIETY OF NATURAL SCIENCE.

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I.—*Rocks and Minerals of the Crieff District.*

By Walter Kerr, M.A., late Mathematical Master, Morrison's Academy, Crieff.

(Read 12th November, 1903.)

INTRODUCTION.

Acquaintance with any branch of natural science, such as geology, may be made in various ways. One may read books and study pictures, maps, or diagrams on the subject; or examine and compare specimens arranged in public or private museums; or collect for oneself the objects of Nature, and observe at first hand the facts and processes connected with them.

I suppose it will be readily granted by most people that the last is the single method best calculated to arouse, and to sustain when aroused, keenness of interest in the subject, and to lay the foundations of thorough knowledge of it. On the other hand, the individual who follows this method will be glad to avail himself of the aids furnished him by text-books and museums.

It is as one of these subsidiary aids that the following pages are offered to those who may desire to gain a practical knowledge of geology from direct observation of the phenomena presented by the rocks themselves, and by the various agents which act on them.

As a convenient centre from which one may either begin, or continue to pursue, the study of geology, as exhibited in the surface of the earth, and in the composition of its rocks and minerals, Crieff possesses several marked recommendations. It stands within easy walking distance of typical rocks of the three great classes—sedimentary, metamorphic, and igneous. It admits of a considerable range of observation over many different kinds of rocks, especially divisions of the metamorphic and igneous, and of the examination of these *in situ.*

The district exhibits a variety of scenery corresponding to the distinctive characters of these rocks, and to the effects of the great processes which have operated during geologic times throughout the district. It affords interesting illustrations of the agencies which are still at work, ever destroying, transforming, and rebuilding the earth and changing its surface. It presents highly interesting examples of the great processes of upheaval, denudation, glaciation, weathering, etc. It affords opportunities of examining and collecting *in situ* and from erratics many interesting mineral forms, and of studying their occurrence, properties, association, and alteration products.

The aim of these pages is to illustrate the geological phenomena which may be observed in each of the directions mentioned above, and in the order given. It has occurred to the writer of them that some such practical help as they are intended to afford may possibly be of use to—(1) visitors to the district who have already some knowledge of the subject, and are interested in its further pursuit; (2) residents who are anxious to take up the study, and who seek some guidance in the direction of practical work in it; and (3) pupils under tuition who may desire to lay the foundation of geological knowledge by direct observation of objects and facts within reach.

As little as possible technical knowledge of the subject will be assumed on the part of those who use these pages. At the same time it will be advantageous for positive beginners to use in conjunction with them some elementary text-book giving at least the main outlines of descriptive geology.

It has long seemed to the present writer not a little surprising that individuals who may fairly claim, or have claimed for them, some considerable degree of a many-sided culture should be devoid of interest in the thousand objects of wonderful variety and beauty to be found in the earth itself. Such a condition of things is every whit as anomalous as that of people possessing a wide range of scientific knowledge, but destitute of regard for the literature and art, the history and antiquities of their own species. It should be the aim of every one of us to acquire some knowledge of the great under-world which forms the hidden foundation on which at last stand all the natural sciences, as well as to have an ear trained to distinguish the echoes which rise from its rock-built recesses, and an intelligence capable of interpreting their message.

THE CHIEF ROCK DIVISIONS OF THE DISTRICT—SEDIMENTARY, METAMORPHIC, AND IGNEOUS.

If a straight line be drawn on the map of Scotland from Stonehaven in a south-westerly direction, it will pass slightly to the north-west of Blairgowrie, Crieff, and Callander, and will divide Perthshire into halves. This line will fairly well represent the natural boundary between the Highland metamorphic rocks and the sedimentary formations of the Central Valley. To the south-east of this line lies the lower old red sandstone of Strathmore and Strathearn, while on the other side of the line appear, usually in bolder relief, the schists and grits of the metamorphic series. These two great geological divisions, as found on opposite sides of the line of reference, exhibit masses of volcanic and plutonic rocks widely differing in age, texture, and composition.

To an observer who stands on the Knock of Crieff, the dividing line referred to follows the course of the Shaggie from Monzie to Hosh, passes through Ochtertyre, and ascends Glen Artney. Typical rocks of all the three divisions mentioned are in sight. The old volcanic formations of the Ochils and Sidlaw Hills rise as barriers in the south-east and east, while the sandstones and conglomerates of the old red extend across the strath and culminate in the broken line of hills of which Glowerowre'im, the Knock of Crieff, and Torlum form the most prominent features.

Let our observer now turn round, and, looking westward, he will have once more in view volcanic rocks in the height known as Kate Maclean and in the low-lying Laggan Hills, with their continuation through Strowan. This igneous formation occupies the line of an ancient fissure eruption. It borders on the old red, and provides the harder and more durable base over which the Highland streams descend in the Falls of Keltie, Barvick, and Turret. It is a narrow series, and is immediately succeeded by the clay slate formation, which appears as the first of the altered rocks we meet with towards the west. The bolder outlines of the Blue Craigs, Charn Chois, and the Aberuchills present examples of the complicated series of foliated and contorted rocks, which will furnish the geologist of the twentieth century with a wide field for speculation and research. Among the rugged heights that border on Glen Lednock, igneous rocks once more make their appearance in the granites and diorites of a much later age, while at intervals, alike throughout the sandstones and schists, are to be found long narrow dykes of a hard and dark igneous rock, the intrusive basalt of tertiary times, preserving a remarkable uniformity in their trend from east to west.

We shall now suppose that our observer comes down from the hill-top, and, reserving for some future time the speculations in which he may be tempted to indulge, supplies himself with a hammer of the best steel, two or three pounds in weight, with a strong handle, say, 18 inches long. With this he proceeds to one of the pebble or boulder beds on the Shaggie, Turret, or Earn, with the object of obtaining freshly broken specimens of the chief rocks of the neighbourhood. The red granite he will readily recognise as a light-red stone, hard, fine-grained, and brittle under the hammer. It may be that a still finer grained stone of much the same colour, in which the different constituents cannot be distinguished by the eye, has been hit on. This is eurite or felsite, like the rocks of upper Glen Lednock and Glen Mathaig.

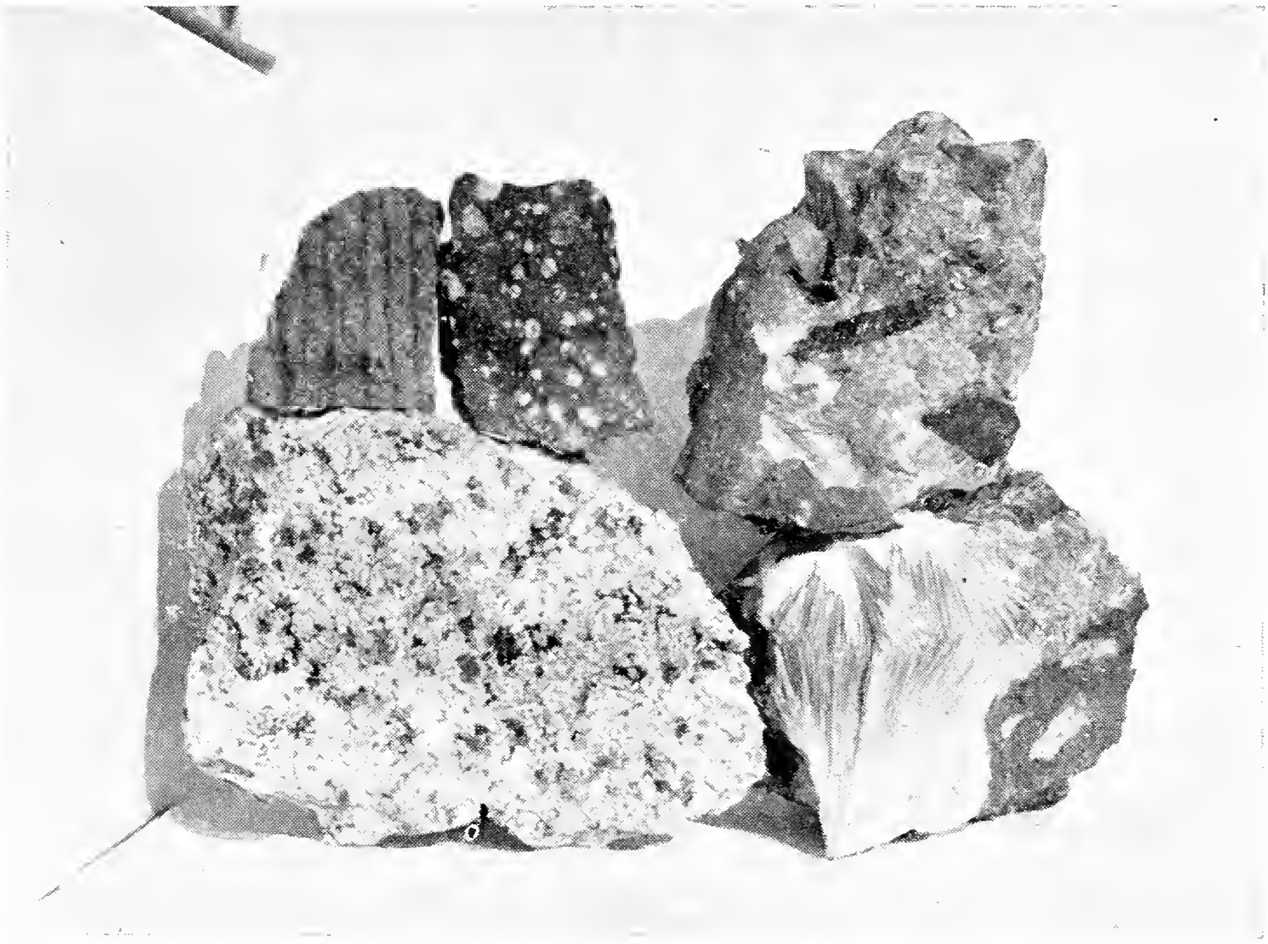
Next, perhaps, a stone somewhat similar in texture to granite is noticed, greyish in colour, coarse-grained, with its different minerals easily made out by the eye. It is tougher to break than granite, and does not afford such a clean fracture. This is diorite, and, like granite and eurite, is a plutonic rock, *i.e.*, one of deep-seated origin, thrust up in a molten state, and afterwards cooled and crystallised without being erupted at the earth's surface.

Then another dark rock will most likely be seen, rusty brown in places, with occasional white veins in it, and not unfrequently containing almond-shaped enclosures, or perhaps only the empty cavities of these enclosures. This is porphyrite, an altered kind of andesite, which gets its name from its inclusion of mineral crystals separable by the eye from the ground mass in which they are embedded. It is of volcanic origin, and much older than the plutonic rocks already mentioned.

Another hard and dark rock, the dolerite of the basalt dykes referred to above, will sometimes be met with. Specimens of this may be obtained from the heaps of road metal on any of the highways. It is granitic in texture, but in this district is too fine-grained to admit of its constituent minerals being easily distinguished.

Next may possibly be noticed a greenish stone, with dark-coloured elongated bodies included in it, and lying in all directions. It is extremely tough to break with the hammer, and never shows the clean fracture of the igneous rocks just spoken of. This is epidiorite, an altered intrusive rock found in the north-west.

Then the river beds will be found to yield abundant fragments of clay slate, a soft, greenish stone, which exhibits the well-known cleavage of roofing slate. It is another altered rock, and is believed to owe its origin to volcanic dust and mud. Flattened masses of still another altered rock will not fail to attract attention. This is full of little shining silvery plates lying between layers of quartz



[Photo by D. M. Gall, Esq., B.Sc.

Plate 1.

1. Banded Greywacke (Monzievaird). 2. Amygdaloid Porphyrite (Glenfarg). 3. Granite (Aberdeen). 4. Diorite (Crieff). 5. Natrolite (Glenfarg).

grains, and sometimes surrounding crystals of a glassy red mineral. It is the mica schist of the metamorphic area. This area will also be represented by another rock, the darkest of all in colour, indeed almost black when its surface is wet. This is known as banded greywacké, and is frequently traversed by contorted layers of white quartz. It is a somewhat scarce variety of those quartzose rocks which are abundant in the metamorphic area, and which, in their extreme variations of colour, hardness, texture, and other characteristics, present one of its most difficult problems.

Lastly, our observer will readily distinguish from the stones mentioned the moderately soft sandstone of the district, the common building material for houses and walls, reddish brown or chocolate in colour, and often breaking in a manner not unlike slate. The planes of fracture are, however, those of stratification, not of cleavage.

We shall now suppose that our future geologist brings home his collection of specimens for examination at leisure. He will find a hand lens most useful as an aid in making out the texture and composition of all, except the very fine-grained. This lens should be strongly magnifying. With it he will see some of the smaller constituents, which otherwise would have escaped notice. A little practice will enable him to recognise the different minerals which go to make up the substance of granites, diorites, epidiorites, etc., while he may break up with a hammer fragments of granitic rocks and test them with a magnet for certain oxides of iron.

Comparison of the specimens will reveal various differences of colour, structure, hardness, fracture, toughness, etc., of the rocks themselves, as well as, to some extent, of their component minerals.

Not without interest at the present stage will be some notice of the various kinds of stone used in the building of walls and houses in Crieff. Besides the lower old red sandstone of the district, which is to be seen everywhere, and is, of course, the commonest building material of the place, we find also a grey sandstone, softer and less durable than the old red. This is of carboniferous age, and has been brought from Stirling or Fife. We have also a bright red or mottled variety used for facing some buildings in Crieff. This is the new red sandstone of Dumfries, Cumberland, or Cheshire, and is of triassic or permian age. Instructive in this connection will be the observation of the special building stone used in particular places. Thus many of the Yorkshire towns are built entirely of millstone grit, Keswick and Dunkeld of slate, St. Andrews of carboniferous sandstone, Moffat and St. Fillans of greywacké, whilst in Blair Atholl the material employed is limestone.

To the beginner in geology, observation of the artificial stone dykes in and around Crieff will prove a source of unfailing interest. He will notice that they are built for the most part of well-rounded boulders of various rocks, such as are found in the streams. He will find that these boulders have been largely found on the surface of the ground adjoining or met with in ploughing. If his own thought does not supply an answer to the question, "Where did these boulders originally come from?" he had better reserve the question for later consideration. The life-history, so to speak, of these strangers in the land of the old red sandstone is intensely interesting, and forms an important chapter in the geology of the district.

THE SPECIAL ROCK AREAS OF THE DISTRICT.

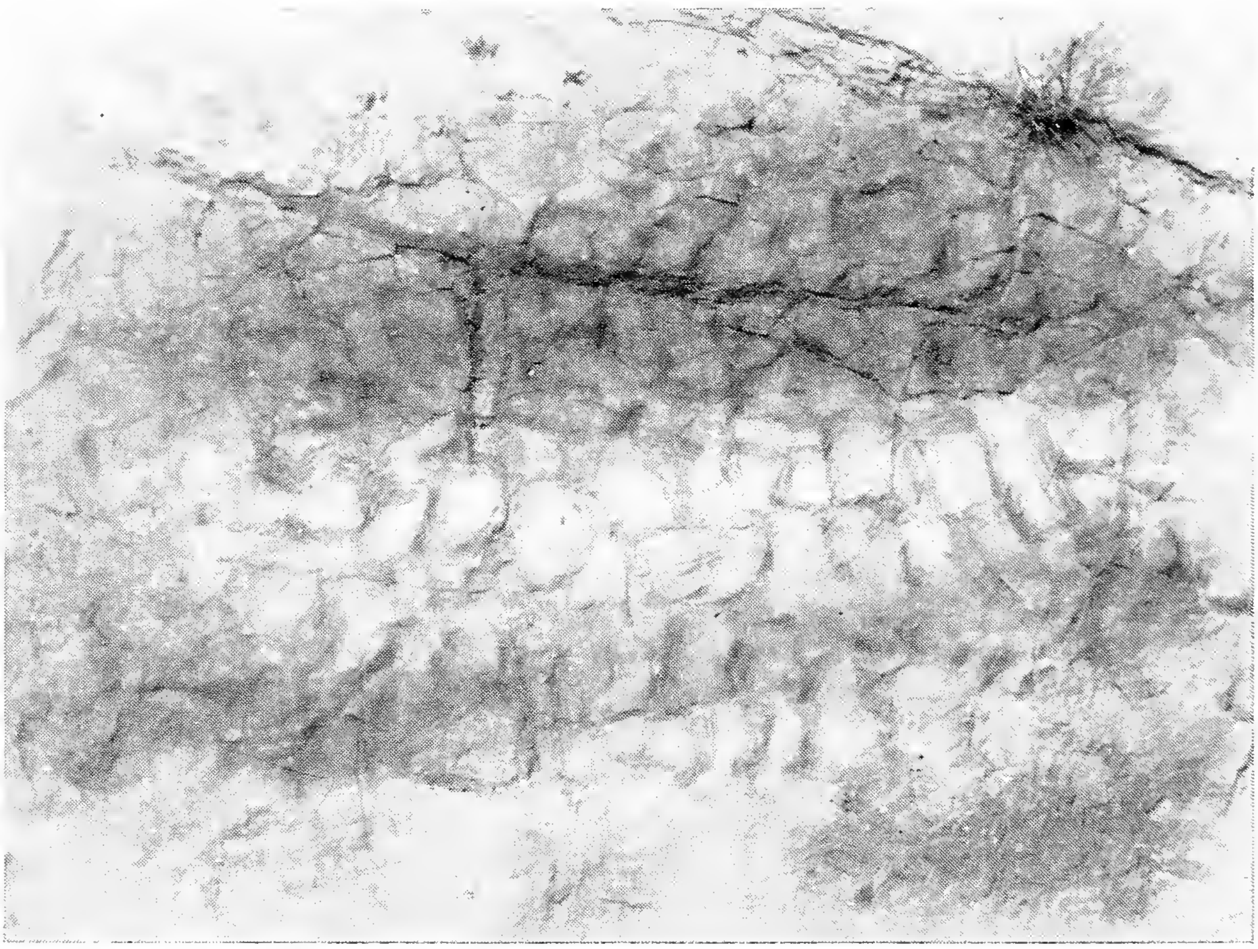
Before commencing the practical study of the local geology by examination of the rocks *in situ*, we shall suppose the student to take, so to speak, a bird's-eye view of the rock-areas by the aid of such a map as Sheet 47 of the Geological Survey, or Bartholomew's Geological Map of Scotland. By this means he will know what he may expect to find in his excursions later on, and will avoid the loss of interest which can hardly fail to follow on a mere desultory examination of rock exposures accidentally met with.

I. LOWER OLD RED SANDSTONE.

First to hand, then, is the lower old red sandstone, extending in this part of Scotland from Stonehaven to the Clyde, and from the Ochil Hills to the foot of the Grampians. This area is for the most part a synclinal trough, bordered by old red conglomerate and exhibiting highly inclined strata in its approach to the porphyrite on both sides of the trough. This inclination may be well observed on the Turret near Crieff, and in railway cuttings between Crieff and Comrie. In one old disused quarry between Baird's Monument and the next hill going east, the dip is as nearly vertical as possible. As we proceed to the south-east the dip is lessened, as seen in the old quarry on Callum's Hill, or in that on the hill beyond Gilmerton. Farther out in the strath, as exhibited in the bed of the Machany, the strata are found to be almost horizontal.

The lower old red varies much in texture, appearing as a well-bedded and fine-grained stone in places, while in others it is a conglomerate stuffed with quartz pebbles and boulders of all sizes, as at Dunnottar Castle, Stonehaven, or in the rock exposures to be seen on the south side of Torlum, Crieff. Where the old red abuts on the porphyrite, it usually contains fragments more or less rounded of the latter, a fact which throws some light on the relative ages of the two formations.

The old red, in common with other sandstones of a high colour,



[Photo by D. M. Gall, Esq., B.Sc.

Plate 2.—Sun Cracks and Ripple Marking (Laggan Sandstone Quarry, Crieff).

owes its characteristic hue to the coating of oxides of iron possessed by the constituent quartz grains. This iron occurs as its chief cementing material. Carbonate of lime not unfrequently appears in this capacity, and the homogeneous stone is often found to give effervescence with hydrochloric acid.

Veins of the mineral calcite are quite common in the old red, and it has barytes associated with it. It is the latter mineral which, though glassy and transparent when fresh, becomes opaque and pink in colour after exposure to the weather.

In some of the quarries, especially the old one near Gilmerton, nodules of a coarse chert or silicious limestone are numerous, and are said to be of aqueo-igneous origin.

In small patches the old red sandstone loses its colour and takes on a greenish appearance. The quarrymen say the green rock is much harder than the ordinary stone. In it the common oxide of iron seems to be replaced by the silicate of iron. Not unfrequently the old red degenerates into a mere shale, or even an actual clay. The latter is erroneously called till by the quarrymen. It is not of glacial origin.

In other places the flakes of mica lie in the planes of stratification, and become so numerous as sometimes to give considerable masses all the appearance of a micaceous sandstone. I have observed this in the quarry by the side of the Lover's Walk.

The beginner will notice the absence of all signs of organic life in the sandstone of the district. It is well known that abundance of iron oxide is destructive of the fossil remains of at least small forms. We thus lose all local evidence of the animal and plant life which may have existed at the time of deposition of the sandstone of this area.

Not without special interest will be found the suncracks and ripple-markings seen in some of the quarries, such as in the big quarry on Laggan Hill. These evidences of shore conditions are particularly suggestive in connection with the nearness of volcanic rock.

Signs of lenticular formation in the sandstone will be noticed in the deviation from parallelism in the bedding planes observed in some of the quarries.

We have thus in the near neighbourhood of Crieff the facts of lenticular formation, conglomerate, ripple-marking, and suncracks, suggestive of the margin of the great lake, in which, as Sir Archibald Geikie has demonstrated, the lower old red sandstone of Central Scotland was deposited.

2. PORPHYRITE.

The volcanic rocks grouped under the name of porphyrite are represented in Perthshire by the formation of the Ochil and Sidlaw

Hills, and by a discontinuous intrusion lying for the most part between the old red sandstone and the metamorphic rocks of the Highlands. The portions of the latter more easily accessible from Crieff are exposures on the Shaggie at Monzie, and on the Keltie, Barvick, and Turret in the line of the falls on these streams. Following this line onwards we find further appearance of the rock in the low hills on approaching Baird's Monument (the railway tunnel is through porphyrite), and on the opposite side of the Earn, as well as in the valley of the Ruchill above Comrie.

As we should quite expect from their volcanic origin, these rocks vary much in texture, colour, and composition. In one place we have a heterogeneous agglomerate or tuff; in another a compact and uniform lava. The latter, however, sometimes passes into a highly amygdaloidal rock, *i.e.*, one full of almond-shaped cavities, which appear to owe their origin to bubbles in the molten lava. Those vapour cavities are very generally found filled with segregated minerals, which have reached them by infiltration. Among the latter, agates, zeolites, celedonite, steatite, quartz, and calcite abound. Sometimes the cavities are large, hollow, and lined with freely crystalline minerals, among which a certain order of deposition may not unfrequently be observed.

3. CLAY SLATE.

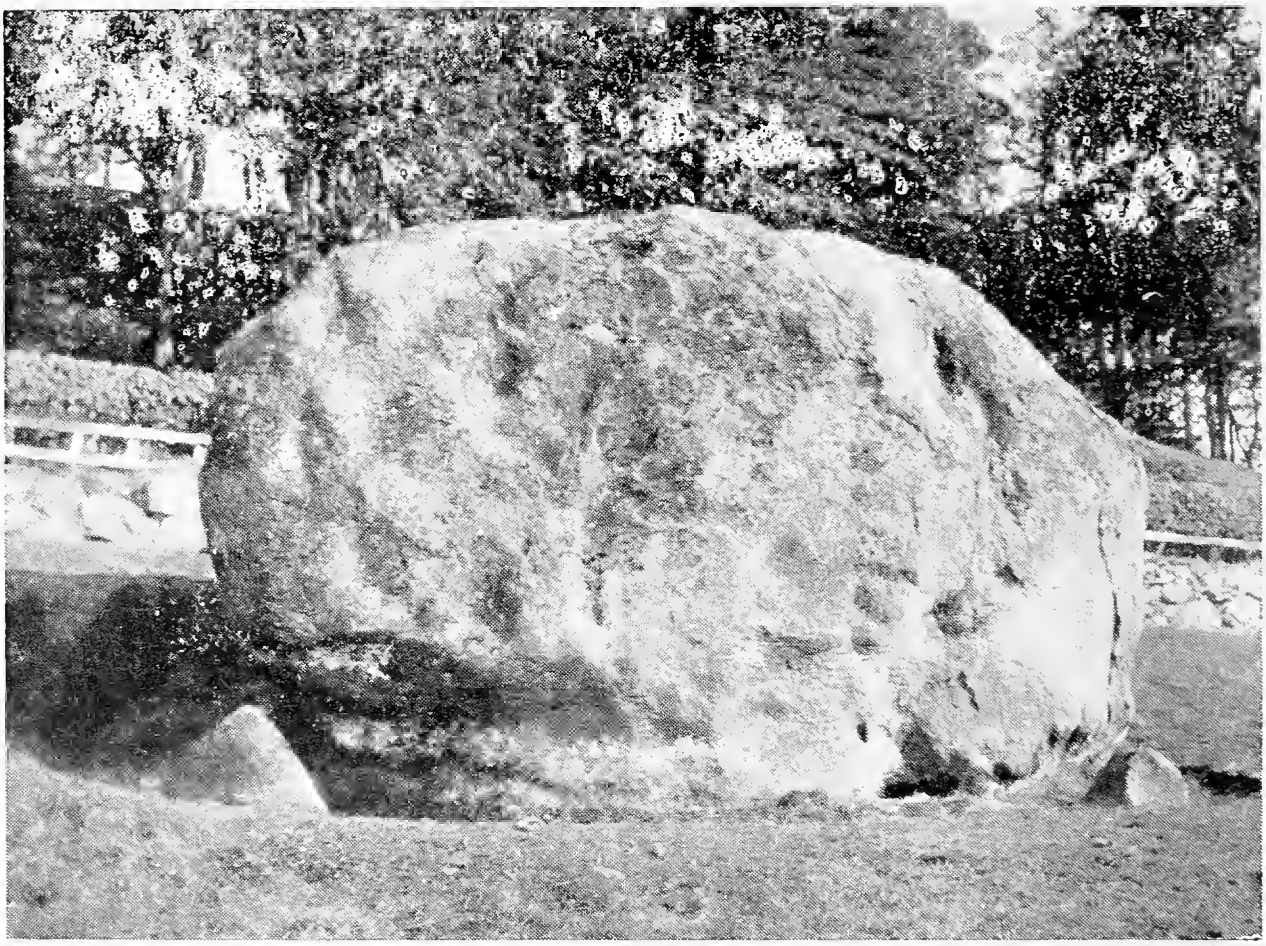
The clay slate of the district lies between the porphyrite of the line already spoken of (Stonehaven to the mouth of the Clyde), and the quartzose schists of the metamorphic area, or, where the porphyrite is wanting, between the old red sandstone and the schists. Good exposures of slate occur in the Sma' Glen, on the Turret, at Comrie, and on the Aberuchill Hills, near Comrie. The dip of the clay slate is invariably in planes towards the north-west.

4. GREYWACKE AND QUARTZOSE ROCKS OF THE NEARER HIGHLANDS.

Immediately adjoining the clay slate we have a great variety of rocks differing in colour, hardness, texture, composition, and no doubt in origin, but grouped under the general designation of quartzose. They very uniformly agree with the slate in having the slope of their schistose planes towards the north-west, and in being frequently traversed by veins of pure quartz.

It will be instructive and interesting to the student to compare carefully specimens obtained from the native rock at the following stations:—

(*a*) Railway cuttings near St. Fillans (east).
(*b*) Tunnel on railway on further side of St. Fillans (west).



[Photo by D. M. Gall, Esq., B.Sc.

Plate 3.—Erratic (Greywacke, Near Baird's Monument, Strowan).

(*c*) Glen Lednock, for specimens of contorted greywacké.

(*d*) Glen Lednock, for banded greywacké, the black bands giving a remarkably dark colour to the rock; or ridge west of the Turret, leading to Charn Chois.

(*e*) Glen Lednock (on west side of road, about 2½ miles from Comrie), for uniform compact black variety of greywacké, probably a modification of (*d*).

(*f*) The water-shed between the Shaggie, Almond, and Fendock Burn, for a fine-grained sort, which splits almost like a regularly bedded sandstone.

One of the most interesting features of certain of these quartzose rocks is the presence in them of secondary, and sometimes of tertiary, schistose planes, a fact instructive in connection with the age and alteration of these rocks.

This group is believed to represent sandstones and conglomerates, which, whilst differing in texture and to some extent in composition, have been subjected to various degrees of alteration. Thus the coarse variety (*a*), mentioned above, has undoubtedly been a conglomerate. The finer-grained (*b*), and (*f*), may have been ordinary sandstones.

The fact that the black rock (*e*) is found quite near the plutonic mass of diorite in Glen Lednock, possibly points to alteration by heat from that intrusion. Indeed this rock is almost as fine-grained and flinty in texture as the eurite of Glen Mathaig when altered by contact with intrusive basalt. The minerals contained in these quartzose rocks are, besides the regular constituents, numerous and interesting.

Specimens from (*a*) above are full of cubical pyrites, with occasional inclusion of dolomite in the massive form, while those from the cuttings immediately west of St. Fillans station exhibit well-formed cavities, with free-crystalline forms of dolomite (pearl-spar), siderite, granular mica, pyrites, and two uncommon forms of rock crystal. Specimens from (*b*) occasionally show the copper ores, chalcopyrite and malachite.

Galena has been found on the east side of the bold crags to the north-west of Melville's Monument, while the quartz veins of the Crappich ridge exhibit cavities, containing a black mineral which I take to be titaniferous iron (ilmenite), associated with free crystalline quartz of the non-symmetrical prism variety. Epidote is occasionally seen associated with quartz in the greywacké of the district, notably in erratics on the west side of Loch Turret. In addition to their employment as building material, the harder varieties of greywacké are of economic use as road metal.

5. MICA SCHIST FORMATION.

Next in order westwards we come to the mica schist formation. In Glen Lednock, the mica schist begins to appear some half mile or so above Spout Rollo, and in the Crieff and Lochearnhead Railway it crops out soon after passing the St. Fillans Tunnel, while in the direction of Loch Turret it commences a little to the east of Ben Chonzie.

The mica schist, chiefly consisting of muscovite and quartz, varies in colour, texture, and composition almost as much as the quartzose rocks already dealt with. In one place it looks like a dark glossy slate. In another it is stuffed with red garnets. In another it shows thick quartz veins sometimes containing nests of platey soft green chlorite. In another it is a mere quartz schist, light in colour, and destitute of garnets. The quartz veins of this formation sometimes carry galena associated with blende.

The mica schist of the district seems to offer as interesting a field for investigation as do the quartzose rocks. The causes of the variation mentioned, the development of secondary minerals, the former constitution of the rocks themselves, and their relation to plutonic masses either now existing or removed—these are all questions on which much light needs to be thrown.

The garnets of the mica schist are generally the rhombic dodecahedron in form. They are usually small, brittle, and difficult to extract, and when picked off the weathered surface are found to have lost their colour and transparency through exposure. On the shore of the lonely tarn where the Boltachan rises may be seen a block of mica schist with the garnets dropping off its surface to the ground.

Besides the chlorite above mentioned, we find tourmaline intimately associated with quartz in the mica schist of the district. It is fairly abundant in the pebble-beds of the Almond in the Sma' Glen. I have found it now and then on the Shaggie and Lednock, but have never met with it *in situ.*

6. LIMESTONE.

Though not covering very extensive areas, limestone is a very persistent formation among the metamorphic rocks of the Highlands. Itself an altered rock, the limestone of this district forms part of what may once have been a considerable formation, stretching through several counties, and following in the main the north-east and south-west direction so usual in the succession of this area. It now consists of disconnected portions, differing in inclination and texture, and forming a strong contrast with the fossiliferous limestones of Fife and Yorkshire, and of the more recent formations of the south-east of this island. Its bedded and crumpled character is well seen in the quarry south-west of the Garry at Blair Atholl, while great variations and inclinations are observable in the out-crops on opposite sides of Loch Tay, and west of Glen Beich on Loch Earn. The last is the most accessible from Crieff. Here the old abandoned quarries overlooking the loch are well worth careful inspection, and the distinctive black calcite which builds up the mass of the rock deserves special notice. If junction of the limestone with any of the later igneous intrusions, such as granite, eurite, or basalt, could be observed, we should no doubt find the limestone converted into a marble of well-marked features. As far as I know, no such junction has yet been discovered, but it very likely exists, as the rocks mentioned must in places be in close proximity.

7. BASALT.

The basalt of the numerous dykes throughout the district claims attention, as the most recent of its igneous rocks. As already mentioned, these dykes are remarkable for the uniformity of their general direction. They are for the most part very narrow formations, breaking through the strata of the red sandstone or the foliation planes of the metamorphic rocks. They contrast strongly, therefore, with the basaltic outflows of Ratho, Antrim, and the west of Scotland. Owing to the narrowness of the dyke the texture varies considerably within a few feet. From the coarse granitic structure observed about the middle of the intrusion it passes outwardly into a rock often as fine-grained as eurite, the coarser portions owing their distinctive features to the slower rate of cooling of the liquid lava. In only one instance that I know of is the basalt dyke a sill, *i.e.*, an intrusion between the strata of the sandstone. This is the dyke which for many years has been quarried near Monzie. I greatly regret that I did not have this quarry photographed some two years ago, when it exhibited very finely the huge prisms characteristic of basalt placed distinctly perpendicular to the dipping strata of the red sandstone. Unfortunately, further quarrying soon removed the interesting features referred to.

Here, as in other places where the junction of the lava with the old red is visible, the alteration of the latter is well shown, the colour of the rock contiguous with the basalt being changed to a dull grey.

In the Fintalich quarry, near Muthill, we have a basalt dyke some forty feet thick, which has broken through the almost horizontal strata of the sandstone. The dolerite here is particularly uniform in texture, though of course exhibiting finer grain towards the outside, and cavities in it are few and far between. Indeed, the quarrymen tell me they have come across only one during the last dozen years.

On the continuation westwards of this dyke we find the Drummond Avenue and Drummond Castle.

The fine natural wall of rock, with pine trees growing on the top, which formed the background for the old and now disused rifle range near the road between Crieff and Muthill, is part of another of the great dykes which may be traced through the country almost from coast to coast. It appears to have furnished the standing stone which is a conspicuous object in a field near the road.

The dolerite of the dykes near Crieff is lighter in colour than is usual elsewhere, and noticeably lighter than that of Ratho or Dunkeld, or that which is found near Comrie. This rock at Dunkeld appears to weather more rapidly, and contains cavities lined with crystalline quartz, goëthite, etc.

At Monzie the stone shows inclusions of calcite, quartz, and barytes, while celedonite, often in well-marked botryoidal form, appears on the joint surfaces, and occasionally small irregular cavities are found filled with a soft earthy green mineral, which I take to be chloropheite.

Basalt boulders and masses that have been long exposed to the elements may often be distinguished by crust-like scales, which are due to spherulitic weathering. It has been noticed that the decomposed rock produced one of the richest soils for agricultural purposes.

8. DIORITE.

The next igneous rock which comes under our notice is the mica diorite of Glen Lednock. It occurs on both sides of the Glen, as shown in the areas coloured green on Sheet 47 of the Geological Survey. Outcrops may be examined on the old road which, after crossing the Comrie Golf Course, follows the right bank of the Lednock, and on the new main road on the other side of the stream. Pursuing the latter as a convenient route, we first meet with diorite *in situ* on the west side of the road in a small cliff some hundred yards from the road, and about three miles from Comrie. Then the road passes over this rock near the Glen School, and the hill directly north-east of the latter is entirely made up of diorite. It is also found west of the Innergeldie Burn, south of Spout Rollo, near and immediately south of Dalginross, as well as on the Ruchill some two miles above Comrie. A rock of coarse texture and greyish in colour, it is remarkably uniform as seen in a limited area, but the texture varies considerably over greater distances, and the colour may become much darker owing to the plagioclase having assumed a dull yellowish waxy hue, as in the neighbourhood of the granite near Lurg.

Of the essential minerals in mica diorite, which are hornblende, plagioclase, and biotite, the two former as a rule distinctly preponderate,

[Photo by Wm. Reid, Esq.

Plate 4.—Basalt Dyke (Muthill).

but occasionally the last assumes considerable proportions. Magnetite and epidote are sometimes easily visible to the naked eye, as in a remarkably coarse diorite found in erratic form about Crieff. I have been unable to trace the latter to its native place. It is an excellent type of the rock for the beginner to use in the identification of particular minerals. The light-coloured plagioclase, the dark platey biotite with bronze sheen, and the green hornblende of dull appearance, are easily made out; while the coal-black magnetite, with its brilliant lustre; and the watery-green and glassy epidote, are readily distinguished from the other constituent minerals. The magnetite and epidote are accidental components of the rock, and relatively small in amount.

This plutonic rock is of great economic value. It is durable, easily worked, and accessible. The time may not be far distant when the chief buildings of the district will be at least faced with the diorite of Glen Lednock.

Another economic consideration of importance is the fact that this rock forms one of the chief original sources of the alkalies, and of the iron and lime, so essential to animal and plant life. Its conversion into soil may be well observed in favourable situations on the eastern slopes of Creag Mhor above the Lurg Burn, where large quantities of the disintegrated rock exhibit to perfection the intermediate stage between solid stone on the one hand and vegetable mould on the other, and present an interesting example of the destructive effects of atmospheric agents. Frequently the diorite boulders met with in excavating and ploughing in the immediate vicinity of Crieff, are noticed to be actually crumbling to pieces through exposure to the elements.

9. GRANITE AND EURITE.

The other plutonic rocks of the district are the red granite and eurite (otherwise called felsite or felstone) of Glen Lednock. These two rocks are of similar mineral composition—quartz, orthoclase, and mica (generally muscovite), and the eurite is merely a very fine-grained granite, exhibiting crystals of quartz in a uniform felspathic base.

The area of granite proper lies between the turn of the Lednock at Lurg and the top of Charn Chois. It is most probably a region where extensive denudation and disintegration have taken place, and though large quantities of the granite have been removed, the comparative fineness of texture in what remains points to the fact that we are nowhere very far from the surface of the plutonic intrusion. An instructive comparison may be made between the granite of this area and that of an intrusion observed on the Kincardine coast at Muchalls. The granite of the latter is fine-grained, and its junction with the metamorphic rock of the district may be observed close at hand in the adjoining cliff. I have not been able to discover a similar junction west of the Lurg Burn, but the granite and diorite may be seen not very far apart.

The granite of the area in Glen Lednock appears singularly uniform in texture wherever it can be examined in the native rock; but when erratics, found in the lower valleys and in the neighbourhood of Crieff, are compared with it, important differences are at once observed. The erratics frequently contain hornblende, which gives the stone a dark spotted appearance. Others contain epidote as an ordinary constituent. I have not been able to find *in situ* either the hornblende or the epidote variety, it being just possible that their source may be outside the district altogether; nor have I met with at all in this vicinity the garnet granite or the schorl-granite so common in Aberdeenshire.

Eurite, or fine-grained granite, is found in isolated areas, the largest outcrop being situated between the Upper Lednock and the Tarken, and bounded by greywacké on the east and mica-schist on the west. The rock assumes a foliated character sometimes, as may be observed east of the Tarken and near Loch Boltachan, while, in common with the granite of Glen Lednock, its red colour may be replaced by grey, as on a little stream which joins the Tarken on its left bank, pretty high up the latter.

Dykes of dolerite are frequently found intersecting the eurite, and the alteration of the latter shows its greater age.

10. EPIDIORITE AND HORNBLENDE SCHIST.

The epidiorite of West Perthshire occurs in dykes and outcrops of irregular form and extent over a considerable area, reaching from Loch Earn up the east side of Loch Tay; but the most extensive masses are found in the southern part of this locality, and especially about the head waters of the Mathaig and Tarken. This rock appears to bear towards the eurite of the district a relation similar to that existing between the diorite and granite already mentioned.

Epidiorite is a rock of striking appearance, and exhibits a marked range of texture, colour, and composition. A greyish-green in some specimens, with light-coloured plagioclase forming a considerable percentage of the stone, it becomes a deep blue black in others with little or no plagioclase in them. The elongated masses of hornblende, altered into uralite, lie about in the fractured face in all directions, and appear to give rise to the peculiar toughness which is observed on breaking the stone. The hornblende, completely schillerised, *i.e.*, split up into plates by a special kind of cleavage, must have formed crystals of one or two millimetres in length in some specimens, while in others the crystals would be four or five centimetres in their longer diameter. Sometimes one finds the rock almost wholly made up of green uralite.

In places epidiorite takes on a schistose character, as in the outcrop near Spout Rollo, where it may be best examined in a small cutting on the road up the Glen. It also sometimes passes into hornblende-schist.

This latter is a rock of well-marked features. In it hornblende (unaltered) and plagioclase succeed one another in fairly well-defined layers, while red garnets appear as a secondary mineral throughout the rock. Its even fracture is strongly contrasted with the irregular break of epidiorite.

Even the non-schistose epidiorite is a true metamorphic rock, and is generally regarded as an altered coarsely crystalline basalt, but whether this basalt was originally the hornblende or the augite variety is a matter of doubt.

GLACIAL ACTION AND ITS RESULTS IN THE DISTRICT.

Mention has already been made of the numerous pebbles and boulders found on the surface or buried beneath it in all the river valleys and adjoining slopes throughout the district. These, on examination, are seen to be composed of the different kinds of rocks present in the Highlands—greywacké, granite, diorite, andesite, epidiorite, etc. In any given locality the relative number of boulders of a particular rock, such as diorite, or mica schist, will obviously depend on various facts. Such are—

1. The size of the areas from which these erratics have been drawn.
2. The nearness of those areas.
3. The durability of the kind of rock of which the erratics are composed.
4. The capacity of the rock in its native place to resist disintegration by the different agents that act upon it.

Thus the most common erratic in the vicinity of Crieff is the quartzose greywacké, the source of which may be fairly presumed to be the extensive area of this rock, which lies not many miles distant. As we approach the low-lying parts of Strathearn erratics of diorite are seldom met with, since we are far from their native place; the out-crops of this rock are limited in extent, while it is a hard rock and resists disintegration. When detached, however, and carried away, it seems much more readily attacked by destructive agents than the fine-grained greywacké or granite, while natural acids more rapidly decompose its felspathic elements.

The degree of roundness of the erratics supplies us with valuable evidence as to their origin and history. Obviously the well-rounded pebbles and boulders of quartz usually occurring in conglomerates, or found loose on the sea-shore or in the beds of rivers, must, considering their hard and resisting substance, have been subjected to prolonged mechanical action since they left their native place amid the reefs of metamorphic rocks or the extrusions of granite. Their form is considered to be due chiefly to movement by water, either in the bed of a river or on a sea-shore. The vast majority of the erratics of Perthshire are, however, but imperfectly rounded. They do not need the mechanical action of shore waves to account for their present form. They suggest rather a rounding through weathering in conjunction with transit amid other loose material. Where the erratic is of volcanic origin its rounded form may be due to rotatory movement at the time of upheaval, or to subsequent action, or both; or, again, its form may be entirely due to that of the cavity in which it had origin, as in the case of agates and other nodules of igneous rocks. The rounding may be due almost entirely to a special kind of weathering, as in the spherulitic weathering of dolerite.

More or less regular grooving or striation is sometimes observed on the surface of erratics, as well as of masses *in situ*. Considerable care must be exercised in distinguishing between genuine striation through contact with harder substances, and the simulation of striation due to jointing and weathering. Instances of erratics exhibiting undoubted striation are seldom met with, but smoothed and grooved surfaces of rocks *in situ* are fairly common in the Lednock and Earn valleys.

Closely connected with the erratics, and with the smoothed and striated surfaces just referred to, are the numerous banks and mounds of gravel and sand observed in all the valleys over one hundred feet above sea-level. Of these, the area lying between the Allan, Knaik, and Machany, and the valleys of the Shaggie, Lednock, and Turret, afford the best examples. The mounds of these localities seem to be composed of materials of varying degrees of coarseness, from rough gravel, with intermixed pebbles and boulders, to fine-grained and stratified sand, with admixture of clay. Sometimes the clay appears in distinct layers, as in the railway cutting west of the Turret on the Crieff and Comrie line. Sometimes a calcareous cement has consolidated the layers of gravel and sand, and thus formed what we may call a "recent conglomerate." This latter may be well seen in a cliff on the right bank of the Shaggie, between Monzie village and falls.

In studying the causes of the various phenomena now mentioned,

[Photo by D. M. Gall, Esq., B.Sc.

Plate 5.—Striated Rock in Situ (Loch Turret).

it is instructive to compare with them the similar state of things observed in such countries as Norway, Switzerland, and Iceland, where perpetual snow clothes the higher mountains, and fills with its consolidated mass the upper parts of all the valleys leading from them. These masses, known as glaciers, are ever moving slowly downwards, melting completely at the lower end, and constantly being renewed at the upper by the fresh snows of each succeeding winter. These ice-floods are seen to be ever depositing the burden of rock *débris* they bear on their surface, carry embedded in them, or thrust forward beneath them as they move along. Should the climate of the country become warmer as the years pass, the glaciers retreat further up the valleys, and the morainic materials they once carried are left far behind. This is precisely what has happened in the valleys of France, Italy, and Norway, which radiate from the Alpine heights that are still covered with perpetual snow. In such places the glaciers, as the agents of transport, erosion, and striation, are observed actually at work, and no one who has visited these localities can doubt that it is the same cause which has carried the erratics, deposited the masses of gravel, sand, and stones, and produced the striation and rounding of surfaces that are observed in the valleys of Perthshire, although the glaciers themselves must have disappeared long ages ago. Travellers in the valleys of the Nile and the Euphrates find themselves surrounded by the remains of forty or fifty centuries. We who walk out in the smaller valleys of the Shaggie and the Earn, places unromantic indeed from the standpoint of the antiquarian, may see in the drift mounds and the erratics about us the ruins of a thousand centuries, while we may reflect that ages almost indefinitely more remote, perhaps a hundred thousand centuries, look down on us, so to speak, from the top of Ben Voirlich and the Aberuchill Hills.

Geologists are of opinion that the Grampian chain was once much more elevated than at present, and that its glaciers flowed outwards across the Ochil Hills into the valley of the Forth, while at a still more remote period the glaciers of the Pentlands, then mountains many thousand feet high, deposited their rock *débris* in lower Strathearn. Certain it is that the whole of Perthshire, except perhaps its highest peaks, has been subjected to the action of an ice-sheet that at one time spread over most of northern Europe. In this district the direction of ice movement seems to have been towards the south-east, as judged by the transport of erratics and the lines of striation.

Interesting in this connection is the distinction between valleys that have been formed or deepened by glacial action, and those which have more recently been carved out by water. Obviously enough, narrow and deep glens, such as those of the Shaggie, Barvick, Turret, and Lednock, below their respective falls, have been deepened, if not almost entirely excavated, by water, while more open valleys, such as those of the Earn and of the Lednock above Spout Rollo, owe their present form chiefly to ice-agency.

The moraines at Cultoquhey, near Crieff, are interesting as having been probably deposited by a glacier which flowed between the Knock of Crieff and Milquhanzie Hill, itself a branch of the larger glacier which in all likelihood grooved out the valley of the Shaggie, and deposited the chain of gravel mounds that lie between Hosh and Monzie. No doubt at one time, a period previous to the last incursion of the sea through the estuary of the Tay into lower Strathearn, the whole of the strath lying between Crieff and the Ochils was covered with a sheet of glacial drift, rising at numerous points into conical mounds like those of Glen Turret above the Loch. Some of these mounds have survived, as at Cultoquhey and in the neighbourhood of Blackford, and they appear to owe their survival to being situated at an elevation unreached by the marine incursion referred to. The tidal currents of this marine loch must have levelled the other mounds, while their materials contributed to the formation of the gravel banks and raised beaches found in the lower reaches of the valleys of the Tay and Earn. The mounds of Glen Turret, scattered over the space intervening between Loch Uaine and Loch Turret, offer an attractive opening for observation. These mounds are for the most part conical heaps of coarse gravel, with intermixed stones that vary in size up to blocks several feet in diameter. They are distributed quite irregularly over the bottom of the valley and throughout the rising ground on each side of it, and appear covered with coarse grass and heather, except in places where the loose gravel they contain is falling away.

The present form which the glacial mounds exhibit is due in all probability to a variety of causes. We may suppose the valley bottom, on the withdrawal of the glacier, to have been covered with a sheet of rock *débris* of considerable thickness, except where the stream, issuing from the lower end of the glacier, kept open a channel for itself. The remaining sheet of loose material would be broken up into separate areas by the tiny rivulets caused by rain and melting snow. Large quantities of the gravel and finer *débris* would in time be thus removed, and the remaining masses would assume their present form under the further action of rain, snow, frost, and wind, while the last agent would carry the seeds of plants now found growing on the surface of the mounds.

The effect of moving ice in grinding away and smoothing surfaces of rock *in situ* may be well seen at various places in the valleys of the

[Photo by S. T. Ellison, Esq.

Plate 6.—Ancient Moraines (Glen Turret).

Turret, Lednock, and Earn. Special mention may be made of the following:—

- *(a)* The small outcrop of hard compact greywacké, on the east side of Loch Turret, about a quarter of a mile from the dam, and quite close to the road. It is instructive to notice that, at this point, the valley narrows, and at it the ice-pressure must have been especially great.
- *(b)* Beds of slate rock on the Comrie Golf Course at the tee of the second hole.
- *(c)* Rock area (greywacké), on the south side of the road leading up Glen Lednock, at a point a few hundred yards short of the Glen School.
- *(d)* Large surface of epidiorite, on the east side of the Lednock, a quarter-mile above Spout Rollo.
- *(e)* Rock surfaces, close to the road on the south side of Loch Earn, about one mile from St. Fillans.

Striation on these surfaces is as a rule very imperfectly exhibited, but in the case of *(a)* and *(e)* above mentioned, probably the most sceptical will admit glaciation as the cause. In these instances we observe just such a degree of irregularity in the scratches as might fairly be expected from glacial action.

These markings, or *striæ*, seem to have been best preserved where the surface has been covered up and only recently exposed. This is the condition of things at each of the two places specially pointed out. The direction of the markings will be observed to follow the course of the valley in each case. Most of the lines of striation will have long since disappeared, for it is not to be expected that rock surfaces subjected to ice-action and afterwards exposed to weathering agents for a hundred thousand years would still show the markings chiselled by pointed fragments of rock embedded in the glacier which has flowed over them.

We may then go back in thought to a time extremely remote in a historical, but quite recent in a geological sense, when the glaciers of the Highlands, as they slowly withdrew from the lower reaches of the Forth valley and the estuary of the Tay, left behind the rounded outlines of rock and hill apparent everywhere, together with a sheet of rock *débris* covering all the lowlands and the valley bottoms. On the one hand these contours would be altered by the action of water in deepening valleys and by the gradual disintegration of rock surfaces, while on the other, morainic products would be moved by wind and water, carried away, sifted out, and accumulated afresh at lower levels. The fertile soils of carse and strath, which now support a thousand forms of organised existence, have thus been prepared for this useful office by the interplay of the ruder forces of nature operating through long ages, and what was formerly a monotonous and desolate waste—ice-bound, treeless, lifeless—now teems with variety, life and enjoyment.

Appendix I.

REFERENCE TABLE OF ROCKS OF THE DISTRICT.

Name of Rock.	Constituent or Included Minerals.
Sandstone (Lower Old Red).	Clastic materials—Quartz, mica, oxides of iron, etc.; calcite and barytes in veins.
Porphyrite (Altered Andesite).	Plagioclase, chalcedony, cacholong, carnelian, quartz, opal, calcite, barytes, turgite, hæmatite, goëthite, pyrites, magnetite, steatite, celedonite, chlorite, garnet, idocrase, prehnite, pectolite, copper, malachite, chrysacolla, chalcopyrite, zeolites (natrolite, fargite, mesolite, etc.), chalcocite.
Clay Slate (Highland Metamorphic Series).	Pyrites.
Greywacké.	Quartz, pyrites, chlorite, ilmenite, dolomite (pearl spar), chalcopyrite, malachite, siderite, epidote, galena, blende, aragonite.
Mica Schist.	Muscovite, biotite, chlorite, quartz, garnet, rutile, pyrites, chalcopyrite, tourmaline, galena, blende.
Granite.	Quartz, orthoclase, muscovite, hornblende, biotite, epidote.
Diorite.	Plagioclase, hornblende, biotite, epidote, magnetite, actinolite.
Epidiorite.	Plagioclase, uralite, calcite, augite.
Hornblende Schist.	Plagioclase, hornblende, garnet.
Dolerite.	Augite, plagioclase, calcite, celedonite, quartz, barytes, pyrites.
Limestone.	Calcite.

Appendix II.

NOTE ON ROCK-JUNCTIONS IN THE DISTRICT.

The alteration of rocks through the intrusion of molten or heated matter is a subject of special interest to the geologist, as affording, among other things, conclusive evidence as to the relative age of the rocks concerned. The following examples occurring in the district may be mentioned :—

1. Junction of basalt with sandstone, quarry near village of Monzie, Crieff. Interesting example of a sill.
2. Fintalich Quarry, avenue (east of road), Drummond Castle, Muthill. Alteration of sandstone by basaltic intrusion.
3. Junction of basalt and greywacké in whinstone quarry on hill north of Comrie.
4. Road cutting (and railway cutting near by), between Comrie and St. Fillans. Narrow basalt dyke in greywacké.
5. Alteration of eurite by heat of basalt intrusion. Top of Glen Mathaig. Eurite takes on flinty texture.

II.—*The Amœboid Agates of Monzie, near Crieff.*

By Walter Kerr, M.A.

(Read 12th November, 1903.)

For the sake of clearness we must have recourse to definition. Much confusion attaches to the use of one of the terms placed at the head of this paper. In many books on mineralogy, including even recent ones, the agate is considered as a mineral, and appears in lists of minerals. It is defined as a mineral, and treated as of definite form and constant composition. I venture to submit that some change in the use of the term is desirable, a change in the direction of greater exactness and at the same time of wider range.

For the purposes of this paper, an agate may be defined as a particular rock structure consisting of a segregated mineral or minerals arranged in layers, some form of quartz, either crystalline or colloid, being present as the main constituent. It will be fairly obvious, after study of the Monzie specimens, that the term agate needs some such revision as suggested, unless these specimens are to be excluded from the category. I feel sure, however, that few geologists will, after consideration, doubt that these nodules are true agates. If the agate is regarded as "a banded chalcedony," as it is sometimes defined, we at once see, on application of the term to many of the fine Montrose specimens, that the outer layer of celedonite, as well as the inner layers of crystalline quartz, oxide of iron, or opal, must be left out of account. The reason for retaining crystalline layers as part of the agate itself is greatly strengthened when we carefully observe the Monzie specimens, for some of these specimens contain no chalcedony at all, and yet they are composed of at least three well-defined layers of segregated minerals.

LOCALITY.

The place where these amœboid agates are found is a small area in the bed of a stream which joins the Shaggie on its left bank about a quarter-mile above the village of Monzie. The exact locality of the specimens is immediately below the point where the old road between Hosh and the Sma' Glen crosses the stream. Published geological maps place the boundary between sandstone and porphyrite some distance to the west of the locality indicated, but, as a matter of fact, a considerable area marked on the maps as lower old red sandstone is igneous rock, which, for the most part, is covered with glacial drift. The agates are found at a place where the little stream has cut through the drift and exposed the porphyrite.

ASSOCIATION.

The rock at this place is not nearly so uniform and compact as at other points of outcrop to the south-west. Some fifty yards down the stream we find a vein of barytes, about nine inches in thickness, which is cut through by the stream. Proceeding up stream, porphyrite is met with, containing small amygdules of calcite, quartz, and chalcedony, and of quite the usual egg-like form. Still higher up, we find the larger agates under consideration, characterised by the distinctive form for which I have suggested the term amœboid, on account of the remarkable resemblance of their projections to the pseudopodia of the amœba.

Further up the stream, and east of the road referred to, the mineral inclusions of the rock assume the form of jasper veins, running in various directions. Probably the reef of barytes already mentioned continues beyond this point, as I have found loose pieces of this mineral in the bed of the burn at the place.

SIZE AND FORM OF THE AGATES.

The size of the specimens met with ranges from one to six inches in longer diameter. In general shape they are oval nodules, but with a highly irregular surface, owing to the projections mentioned. When the outer layers have been weathered away, or artificially dissolved by hydrochloric acid, the remaining body presents a very striking appearance. Hollow spherical depressions lie between the projections, while the complete surface itself, including the projections, offers one of the most interesting examples of natural mould formation. The exact reverse of a crystalline surface of rhombic form is presented to view.

COMPOSITION AND ARRANGEMENT OF PARTS.

As already indicated, the nodules consist of well-defined mineral layers. These are:—Oxide of iron (probably turgite), dolomite (in the free crystalline form of pearl spar), carnelian, cacholong or other opal, and rock crystal. Some variety in arrangement of these layers is observed, but the oxide of iron (with platey structure) is always the outermost, *i.e.*, next the rock wall; and the pearl spar always forms a single layer superimposed on the turgite. In the remaining portion of the nodule, *i.e.*, that within the mould of pearl spar, we notice the following varieties:—

1. Solid unbanded carnelian, with or without a hollow centre. In the former case the free surface of the carnelian has the usual botryoidal form. Often the hollow is found filled with secondary calcite.
2. Solid crystalline quartz.
3. Solid calcite.
4. Solid finely banded carnelian, with no cavity.
5. Broad band or bands of carnelian next the dolomite, with quartz heart. This is the commonest variety.
6. Solid finely banded carnelian or chalcedony, filling the heart of the nodule, and surrounded by a layer of crystalline quartz, which again is separated from the dolomite by a layer of carnelian.
7. Within the pearl spar a layer or layers of carnelian, succeeded by a single thin band of cacholong, enclosing a quartz heart.
8. A layer of carnelian succeeded by alternating bands of cacholong and chalcedony surrounding a heart of quartz or calcite.
9. Alternate bands of carnelian and crystalline quartz (repeated up to four times), with quartz heart.
10. Like (5), but with central heart of carnelian.

In consequence of the action of weathering agents, water and air, the layer of pearl spar is sometimes dissolved away and the layer of oxide of iron reduced to a purplish-red ochre. Occasionally one is fortunate enough to find the jacket of pearl spar left *in situ*, while the body of the nodule has been removed. The well-known botryoidal or knob-like form of the pearl spar is then seen. It is this structure which gives rise to the spherical depressions observed on the surface of the inner core already mentioned.

NEGATIVE FEATURES.

Certain negative features of interest may be observed in connection with the Monzie agates :—

1. They have no celedonite or other talcose mineral associated with them.
2. No suggestion of stalactitic structure appears in them.
3. Onyx structure is entirely absent.
4. Other gravitational effects, such as unequal thickness of layers, do not seem to be exhibited.
5. No definite tube of escape has been noticed in them.
6. Disk formation, eye structure, faulting of bands are not met with.

ORIGIN.

I venture to suggest that the amœboid agates of Monzie are probably different in their origin from ordinary agates. The current conception of a simple vapour cavity will scarcely account for their highly irregular form. No doubt a vapour cavity in a viscous lava in motion, and subject to pressure, may assume an elongated or flattened form, as observed in the common agate, but some subsequent change, such as the partial bulging in of the rock walls, seems necessary to the production of the cavity in the case of the Monzie agates. It is worthy of notice that it is not only the core within the dolomite layer that exhibits the irregular form referred to, but this form characterises the whole nodule within the rock walls. Further, it seems to me probable that the substances which contributed the different layers—iron oxide, dolomite, carnelian, etc.—existed together at one and the same time in solution within the cavity, and then as changes of temperature and pressure took place, successive deposit was effected from within, instead of from without, and through the layers already formed as in ordinary agates. I would suggest that the fact of the outer layers of the nodule being crystalline, instead of colloidal, points to an origin different in essential features from that of other agates. At any rate, the unique features of highly irregular form and outer crystalline layers observed in the Monzie specimens cannot fail to afford special interest to those who have given attention to the study of mineral segregation.

III.—*Preliminary List of Minerals occurring in Perthshire.*

By WALTER KERR, M.A.

(Read 12th November, 1903.)

Name.	Locality.
Actinolite,	Glen Tilt, Crieff (rare, in diorite erratics).
Amphibole, (See Hornblende).	
Analcite,	Glen Farg.
Andalusite,	Glen Lochay.
Apatite,	Pitlochry.
Aragonite,	Glen Tilt, St. Fillans.
Asbestus,	Aberfeldy.
Augite,	Glen Tilt, Rannoch.
Azurite,	Kenmore.
Barytes,	Kinnoull Hill, Crieff, Monzie, Tyndrum.
Beryl,	Kinloch Rannoch.
Biotite,	Blair Atholl, Glen Lednock.
Blende,	Tyndrum, Glen Lednock.
Bornite,	Birnam.
Bronzite,	Glen Tilt.
Cacholong,	Kinnoull Hill.
Calcite,	Crieff, Glen Farg, Kinnoull Hill.
Celedonite,	Kinnoull Hill, Glen Farg.
Cerussite,	Tyndrum.
Chabazite,	Glen Farg.
Chalcedony, (Veins and Nodules banded as Agates).	Kinnoull Hill, Glen Farg, Ochils generally, Monzie, Strowan.
Carnelian,	Monzie.
Chalcocite,	Glen Farg.
Chalcopyrite,	Tyndrum, Tomnadashan, St. Fillans.
Chlorite,	Glen Tilt, Blairgowrie, Glen Beich.
Chromite,	Glen Lochay.
Copper,	Glen Farg.
Dolomite,	St. Fillans, Monzie.
Datholite,	Glen Farg.
Edenite,	Glen Lochay.
Epidote,	Blairgowrie; in erratics of granite, epidiorite, and greywacké (Crieff, Glen Lednock, and Loch Turret).
Erythrite,	Tyndrum (Clifton Mine).
Fablerz, (Tetrahedrite).	Tomnadashan.

Name.	Locality.
Fargite,	Glen Farg.
Fluor,	Glen Tilt.
Galena,	Tyndrum, Glen Lednock, Glen Lochay.
Garnet,	Kinnoull Hill, Glen Lednock, Loch Tay.
Glauconite,	Bridge of Cally.
Goëthite,	Kinnoull Hill.
Gold,	Lochearnhead, Tomnadashan.
Graphite,	Glen Shee.
Hæmatite,	Dunkeld and Birnam, Ben Cleuch, Kinnoull Hill, Ben More.
Heulandite,	Glen Farg.
Hornblende,	Glen Lednock.
Idocrase,	Kinnoull Hill.
Ilmenite,	Blair Atholl, Krappich (Comrie).
Kyanite,	Ben Vannoch, Glen Tilt.
Laumontite,	Glen Farg.
Limonite,	Glen Quaich, St. Fillans.
Magnetite,	Monzie, Glen Lednock.
Malachite,	Glen Farg, Grandtully, St. Fillans, Kenmore
Microcline,	Blair Atholl.
Mispickel,	Lochearnhead, Tomnadashan.
Molybdenite,	Killin, Tomnadashan.
Muscovite,	Blair Atholl, Tyndrum, Glen Lednock.
Natrolite,	Glen Farg.
Orthoclase,	Glen Lednock.
Pectolite,	Glen Farg (rare).
Penninite,	Glen Lochay.
Pentlandite,	Loch Tay.
Plagioclase,	Glen Lednock.
Prehnite,	Glen Farg, Kinnoull Hill (rare).
Prochlorite,	Glen Lyon, Crianlarich, Dunkeld.
Pyrites,	Sma' Glen, St. Fillans.
Pyrolusite,	Loch Tay, Glen Lednock (erratic), Kinnoull Hill, (rare).
Pyrrhotite,	Glen Shee, Kenmore.
Quartz,	Glen Farg, Kinnoull Hill, St. Fillans, Glen Lednock.
Amethyst,	Kinnoull Hill, Ochils.
Cairngorm,	Kinnoull Hill, Ben Lawers.
Heliotrope,	Kinnoull Hill.
Rose Quartz,	Kinnoull Hill, Monzie (erratic).
Zeolithic Quartz,	Kinnoull Hill.
Kilpatrick Quartz,	Glen Farg.

Name.	Locality.
Opal,	Glen Devon, Pairney Glen.
Ripidolite,	Blair Atholl.
Rutile,	Creag na Caillich, Tyndrum, Killin, Crianlarich.
Saponite,	Kinnoull Hill, Glen Farg.
Serpentine,	Glen Lochay.
Picrolite,	Glen Lochay.
Siderite,	Ben Ledi, St. Fillans.
Silver,	Glen Esk.
Steatite (Talc),	Bridge of Cally, Glen Farg.
Stibnite,	Ben Lawers.
Stilbite,	Glen Farg.
Tourmaline,	Ben More, Dunkeld, Sma' Glen.
Uralite,	Glen Lednock.
Zeolites, Natrolite, etc.	Glen Farg.

IV.—*Further Lights on the Roman Occupation in Caledonia.*

By Sir Alexander Muir Mackenzie, Bart.

(Read 10th December, 1903.)

The Society of Antiquaries (Scotland) have been engaged in making a systematic investigation of the different stations occupied by the Romans in Caledonia, so as to connect them with some possible "iter" northward, if not that one described by Richard of Cirencester, and adopted by Roy. This is illustrated by a map and list of stations from the Wall of Antoninus, near Falkirk, to Mons Grampius, modern Mormond in Aberdeenshire, and so on to Photoroton (Inverness).

First we start from the Fort of Camelon (or Camelot), a short distance to the north of the Wall of Antoninus. Poor Hector Boece, indeed, has committed the enormity of stating that this "citie" was "biggit" by Crutheus, King of the "Pichtes," thus connecting its existence with the Picts, and not with the Romans. Roy gives a good map of the old city (whoever were the founders), but Buchanan, Camden, and Gordon dispute Boece's authority, just as Colenso did that of the writer, or writers, of the Jewish records. The account of these explorations, and that of Castle Cary, is elaborately given in the Society's Transactions, 1900, but it may be permitted to make reference to one most interesting point in connection therewith.

PITS AT CAMELON.

On opening up the ground a number of pits were found, and the conjecture naturally arises, what was the intention of placing pits in such a position—for defence, or for social purposes? They may well have been dug so as to embarrass horsemen or footmen in the event of an assault on the fort, and it will be remembered that, not so far from Falkirk, Bruce, in after times, did protect his position at Bannockburn by such an arrangement of sunken pits, so this conjecture is quite within reason, and is strengthened by analogy.

The excavations at Cranbourne Chase (Dorset), Winklebury (Wilts), and notably at Worleberry Camp (Somerset),* all show pits, more or less irregularly placed in or around the "enceinte." Some of these pits had been evidently used as the bases of small huts, or shelters, probably of "daub and wattle" construction, some for social or domestic purposes, while some had undoubtedly been used to shelter armed men.

The similarity in these camps, so widely apart, is, I venture to think, a remarkable point.

Then to revisit Ardoch, which, it was a pleasure to note, was in such a good state of preservation. The main outlines of the camp are very distinct, and the works plainly traceable, an excellent object lesson to those who wish to read history as "she is writ" in these mounds and ditches. "'Tis pity" that a former owner has, in a most Philistine manner, destroyed the southern outlines of the camp. My main object was to make all due research into a matter to which my attention had been drawn by an able and friendly criticism on a small work † on the Roman occupation. "The writer," it is remarked, "has not paid sufficient attention to the evidences of Caledonian occupation of Ardoch, and other points," *prior* to the Roman invasion. He had humbly considered he had made a special point of this, comparing the "Roman camps" in the north with those he had visited in the south of England at places already named, and he confesses respectfully, but firmly, his belief that the native tribes did so occupy such coigns of vantage, as was Ardoch, long before the Romans were heard of. His critic certainly instanced Karnack (in Brittany) as a case in point, but it is not a parallel case. Karnack should be compared with a Stonehenge, an Avebury, or even a Stanton Drew (probably the grandmother of the above), and not with the rude fortifications, and ruder huts, of our predecessors, such as are to be found in "Caledonia, stern and wild." But my opinion on this point is strongly opposed.

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* At Worleberry there have been found, in conjunction with the pits, a number of small "platforms," presumably for the use of "slingers." (Comp. "Dymock.")

† "Delvine and the Romans," 2nd edition, by Sir A. Muir Mackenzie.

Dr. Christison, the learned and experienced secretary of the Society of Antiquaries in Scotland, lays down the law as follows:—"It is evident that any previous occupation" (to that of the Romans) "must be denied. . . . There are strong objections to a native claim to any share of it. . . . There is almost an entire absence of works of a type which can even be suspected of being native." He further considers "the small rectangular space in the centre of the camp to have been a chapel in later Christian times." Sir John Clark, of Pennycuik, conceives that the Romans may have had a temple on this site, subsequently turned into a Christian chapel.

Dr. M'Kenny Hughes, in a volume of "Archæologia," combats this view, and advances "the ingenious theory that the Romans placed their station within a native work, and preserved a part of the original lines."

I respectfully give my adhesion to the last-named authority. As already stated, there is every reason to suppose that the Caledonians would occupy such a favourable site as that at Ardoch. Indeed, the rectangular space referred to by Dr. Christison is not placed in conformity with the "four square" defences of the camp, and it may well have been a "rath,"* or small fortified dwelling, used by the chief or chiefs of the native clan, afterwards to be made use of by the dispossessing Romans as a fort, or a temple, as suggested by Dr. Hughes. That a Christian chapel was subsequently erected on this site is not only possible, but probable.

From Ardoch you can follow the Roman march to Strageath (Ierne), *via* Orchil, and so on to Dupplin and further on to Grassy Walls (Perth). For details, drawings, and tracings consult Transactions, 1900.

The plan of Agricola evidently was to connect the Wall of Antonine and his most northerly point by a "limes," such as was the work of the Romans in Germany, from the Rhine to the Danube, as his large camps and smaller outposts point out. Indeed, a comparison of the methods by which the "limes" were constructed, with the intention of restricting the wild tribes in either country, may well reward the student of history. In this connection one is tempted to envy the Germans, whose Kaiser has so well restored "Saalberg," a notable Roman camp near Homburg, and would fain sigh for some one so to restore Ardoch.

In studying the operations of Agricola in Caledonia, and the relation of Ardoch thereto, notice should be taken of the situation in which he found himself. Starting from Ardoch, his large intrenched camp, he finds himself advancing from south-west to north-east along

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* See *infra*.

a centre line, parallel, to a more or less degree, to two others, each on either flank—the sea-coast, along which his fleet was hovering, on the one side, and on the other the *horrendum jugum Grampium.* He was in constant danger of attack from the tribes assembled under shelter of the latter, but always able to communicate with, and receive supplies from, the former.

I followed the flank line of march over the hill to Comrie, near to which place a camp was formed at Dalginross.

On the northerly slope, in full view of the *horrendum jugum Grampium*, we cross Blair-in-Ron, or Blair-in-Roinn, where Gordon insists that "The Battle of the Grampius" was fought; but, apart from other reasons discussed elsewhere, evidence of a conclusive and *decisive* conflict at this point is plainly wanting. I venture to assert that the camp at Dalginross was a "temporary" camp, like to that at Inchtuthill, and that any conflict was more an affair of outposts, and undertaken to secure the real "line of communication." But it may have been that Agricola pushed on a light body through the Sma' Glen, and even on to Fortingall. Nay, it was suggested to the writer that the Romans had even got as far as the "Moor of Rannoch." "They were never so daft!" as a most highly respected resident of Strathtay immediately and indignantly rejoined.

The last exploration made by the Society has been at Meikleour, which, on the evidence of Skene and Playfair, disputes with Inchtuthill the right to claim to have been Agricola's camp previous to a great battle fought on the slopes of Gormack and Ballied. The following notes have been kindly supplied by the Hon. John Abercromby. A full account of the work will be found in the Society of Antiquaries' Transactions, 1904.

The mounds known as the "Prætorium" and the Black Hill Tumulus were thoroughly explored and the results given at length.

The different queries as to their origin and use are herewith published as a guide to further investigation, and it is hoped that the "antiquaries" will not halt here, but pursue the "iter" as far north as is possible.*

The theory that the Cleaven Dyke did at one time join both Tay and Isla, when these two streams undoubtedly washed the shores of the Meikleour promontory, was well illustrated by Mr. Coates' able diagram showing the ever-changing course of a river or rivers, through an alluvial district, and forming continual river terraces and banks.

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* I have since examined the site named by Jamieson ("Roman Army in Scotland"), near Stonehaven, as that of "The Battle of Mons Grampius," and also that of Mormond, near Fraserburgh, which Roy gave as "Mons Grampius," pure and simple; but they are only as conjectural as other sites, and cannot be accepted as final any more than either of the sites claimed in Perthshire.

PRÆTORIUM.

NOTES ON MEIKLEOUR EXCAVATIONS.

These "mounds," so to speak, are within the delta formed by Tay and Isla at their junction just below Meikleour. This delta is shut off landward north and east by the Cleaven Dyke, so well described by Mr. Ross in his paper to the Society's Transactions, 1901. The description need not be repeated here. It is considered by him that it was a Roman vallum to protect their encampment on the delta, and doubtless the "dyke" stretched from shore to shore of the two rivers, which at that period flowed close in to the banks of the high land, and not as now, about one mile further in the haugh or low land. The writer, following on his own lines, and fancying he traces a similarity to like places in Scotland and England, gives to this "vallum," and indeed to the whole locality, a native origin, and sees, or thinks he sees, evidences of a native fortified encampment, from which, as he readily concedes, the Caledonians were ousted by the Roman legions. There is a close similarity between this situation and that of Inchtuthill, and also with that of Worleberry, England. In all the three are found a fortified oppidum, or rath, ditches and rampires, and a broad vallum at some distance from camp.

Chalmers and Skene both considered this work and the Tumulus as Roman. It contained three cinerary interments.

The notes on which this lecture is based were kindly supplied by the Hon. J. Abercromby, and the accompanying maps were lent by Mr. Ross. To both of these gentlemen are my thanks due.

BLACK HILL TUMULUS.

This is a small isolated hill, with a height of from 30 to 40 feet, and a length of about 150 yards It is considered by some to have been artificial. From its size, this is improbable, and the geological theory would explain its existence as that of a simple "tor," or islet. On the top of the rounded hill stands a small earthwork. (The measurements, and conjectures thereon, are all detailed with much accuracy and at some length. The student will read them in the forthcoming Transactions of the Society of Antiquaries.) Small pieces of iron, a piece of blue glass, one or two bits of burnt bone, and charcoal were found. The iron would connect the building with the iron age, subsequent to the neolithic. There were remains of a possible "cist," or interment, which may have been anterior to the building, and destroyed by the builders. In the excavations a bronze pin, possibly part of a "fibula," was discovered and a few flattish freestones, possibly part of said cist. The date of the earthwork is therefore Roman, as similar pieces of iron and glass are found in similar camps elsewhere.

The construction of the diminutive earthwork is a matter of conjecture. Certainly an extended view could have been obtained from its summit, and signal fires may have been lit thereon. It conforms to O. Curry's definition of a "rath," or a simple circular wall or enclosure of raised earth, similar to the small forums, or "djema," seen in Algeria, in which stood the residence of the chief, and sometimes the dwellings of one or more officers or chief men of the tribe. Iron nails point to a wooden structure. There is no evidence of pottery, or marks of cooking fires. (See my remarks on Kabylie and Scarth in "Delvine and the Romans," on the subject of a water supply). Conclusion, that this was a fortified residence, and not a fort to defend a particular point, more or less temporary.

Mr. A. thinks the "tumulus" may have been the prætorium, and not the mound called by that name.

QUERIES.

With regard to the "prætorium," several questions present themselves. 1. Was it Roman or native? 2. Was it intended for a fortified post? 3. Is the sepulchral mound coeval with the ramparts?

In answer to the first question, it may be said that the work is native. The irregularity of the traces, and the complete absence of any find of Roman origin, leave no doubt on this point. (Compare A. N. on Inchtuthill).

The second question cannot be answered so positively, though the site is in some respects favourable for a fortified post. It is situate in a shallow natural basin, and with a limited view. On the other hand, it is protected on three sides by the Isla, which here forms a large loop. It does not seem to have had any relation to the Cleaven Dyke, for, if (?) this work extended from the Isla to the Tay, its front would have been to the north, and the "prætorium" lies a few yards to the south or rear. (*Note.*—It may have been a sort of *tete de pont*, like the redoubt at Inchtuthill.)

The third question cannot be answered with certainty. A sepulchral mound, surrounded by a ditch in circular form and external ramparts, is a recognised type, especially in Wiltshire and Dorset. But here the nearest ditch is outside the nearest rampart, and there are four ramparts and ditches, which do not conform to the circular shape of the enclosed mound. It is therefore probable that the mound and the interments are later than the ramparts. It may be that the prætorium was not a fortified post, but merely a fortified dwelling, afterwards turned into a burial ground. In Ireland burials have frequently been found in "raths."

(This mound seems to me to be similar to the many "tors," or islets, geological formations, of which such conspicuous examples may be seen on the Somerset plains below the Mendips.)

V.—*The Salzkammergut, Austria: its Features and its People.*

By Miss Murray MacGregor.

(Read 11th February, 1904).

The Salzkammergut, a very beautiful part of the Austrian Empire, distinguished by some extremely interesting features, is not very well known in this country, and having spent eight happy summers there, I purpose this evening to offer you a few details regarding it, though it cannot be adequately described in the space of one evening.

Many who have not visited the district, or have hastened through it without much study, imagine that it is a part of the Tyrol; but this is an error, both as to geographical position, inhabitants and history. It is a mountain region between Styria and the Duchy of Salzburg. The name signifies "Salt-exchequer property." It is a private domain of the Emperor of Austria, who is beloved by the people as their kind and fatherly landlord as well as their sovereign. With regard to the scenery, I may quote a few lines from Murray's Handbook:—"The chief beauty of the Salzkammergut lies in its numerous lakes, forming a chain, strung together as it were by the Traun, the main artery of the district, passing through them in succession. They are commonly bordered with lofty mountains, whose precipices, rising abruptly from the very water's edge, without the smallest ledge or foreland, impart an extremely sublime character to these Alp-locked reservoirs."

One of the best lines of route by which to approach these Austrian Highlands is from Salzburg, the splendid situation of which, with its castle rock like Edinburgh, cannot here be dwelt upon. My first visit was in 1869, in the halcyon days before the construction of a railway, and thus I had more leisure for observation. On this account the first journey, with its original impressions, will best convey some idea of the country. The distance from Salzburg to Ischl in the Salzkammergut is thirty-three miles by road, passing the Wolfgang See. Ischl, famed for its baths, is little more than a village, beautifully situated, surrounded by very fine wooded hills, with the river Traun running through it on its way, eventually, to the Danube. The Kaiser and the beautiful Kaiserin Elizabeth, since cruelly murdered, annually spent several weeks at this their highland home in the summer. But as it is a very hot and very expensive place, it is best to proceed as soon as possible to our destination, the Lake of Hallstatt, distant ten miles. A landau and pair can be procured from the post, the driver wearing a grey jacket with green collar, and carrying a small posthorn suspended by a cord of black and yellow, the "Kaiserliche, Königliche" colours (Imperial and Royal). Crossing the Traun, we proceed southwards along the right bank. The near hills are not remarkably high, but wooded from the base to the summit, chiefly with spruce, the shapes are remarkably abrupt, and the colour of the limestone rock, where visible, is light grey or white, mixed farther on with what is called in German "hornstein." The angular outlines, the stiff trees, and the contrast of dark green against the white rock are hardly attractive, but afterwards the drive through deciduous woods, beside the beautiful and turbulent Traun, green as a beryl, and past picturesque villages, is fascinating. Pretty children, with little bare feet, run after the carriage, and throw in small bouquets of the wild cyclamen *(Cyclâmen europæum)*, just in flower (middle of July), and that flower for ever after has for us a charm. Almost too soon, wending between hills of fantastic shapes, we reach the Hallstätter See, or Lake of Halstatt, only a small portion visible at first, with a marshy edge, and with sluice gates across the Traun to control the amount of water required for the passage of the salt-boats to Ischl. Crossing the river by a long narrow wooden bridge, Steg is reached, an inn and group of houses at the foot of the lake, ten miles from Ischl. On the eastern side of the "See" a portion of the hill Sarstein appears. It is of immense height, and almost perpendicular, but for a short distance along its base there is sufficient space between it and the lake for a few houses, small bits of cultivated ground, and woodstacks. On the left shore the road becomes exceedingly picturesque. It is cut in the face of a steep hill, and in places overhangs the lake, till, 1½ miles from Steg, it terminates abruptly at the door of the pretty inn of Gosan Mühle, the farthest point to which a wheeled conveyance could reach on either side of the lake till about 1876. The inn and sawmill are built on a promontory jutting out into the "See," which here widens and arrives straight from the southern boundary. More than fifty upright saws are employed at the mill cutting up the magnificent trees into logs. From the balcony of the inn, or "gasthaus," the expanse of water on which we gazed was very fine, walled in by gigantic and densely wooded hills. At some distance on the opposite shore, in a diagonal direction, the little châlet for which we were bound could be descried, and a pleasant row of about fifty minutes, in one of the country boats, landed us in the ideal abode, a little white house, with brown balcony and projecting roof, called Eggel, standing on a ledge below the Sarstein, the massive hill (height 6568 feet) forming the separation between the depression of the Hallstatt See and that of another Traun lake at Aussee. Some years previously, a young artist and two reading friends from England, in their enthusiastic admiration of the scenery, bought a piece of the narrow strip of flat land on a little promontory at this spot, and built on it a little home, which, in their absence, they kindly lent, with an excellent Austrian cook, to appreciative friends.

In the early days it was impossible to reach Eggel except by water. Active pedestrians might make their way round by the south end of the lake, but as it would have been a very long rough walk, with a river to cross, very few attempted it. Water carriage was the ordinary mode of transport, and consequently, for those who were not expert climbers, opportunities of exercise on foot were rare. But the water-way has great charms; the boats are all built in the gondola style, only without the little covered seat which prevails at Venice, and they are unpainted. Being flat-bottomed, with an elevated prow, they have the advantage of being easily run to land, or into one of the numerous boat-houses along the shore, and they are also easy to enter or leave. The mode of progression is by long paddles, working in loose loops ("Rudderband,") made of twisted twigs of dog-wood *(Cornus sanguinea)* attached to the sides of the boat instead of row-locks. The rowers stand facing the prow, and bend forward to dip the paddle at every stroke. The most experienced person takes the paddle nearest the stern, which acts as a rudder, enabling the boat to be steered. Men and women alike row, and children take a paddle at the prow at an early age; a crew of four is a good number. The small boats carry two passengers on a low seat in front of the steerer, looking forwards; but the larger "schiffe" have a seat along each side facing each other, and often protected from the sun by an awning. All the population seem to be amphibious, and swim from an early age.

The Hallstätter See is 1½ miles broad, and 5 miles long from the outlet at Steg, to the southern boundary, where the mountains, mostly bare, rise quite precipitously from the water's edge. There the lake, at its fullest breadth, takes a turn eastward for a mile to Obertraun, the inlet of the Traun. On every side the hills make a wall round the "See"; on the west and east they are clothed with trees, but the actual tops recede and are invisible from the water, which appears to be of a deep green colour from the reflection of the surrounding woods. From Eggel the great hill, the Plassenstein, 6,499 feet above sea-level, is seen directly opposite, but only the wall of its first rise, about 1,100 feet, is visible, covered with trees, but seamed with seven water courses, which, after a shower of rain, come tearing down, carrying with them trees and rocks and earth. We also see to the south-west the bright village of Hallstatt at the foot of the Plassenstein. Embarking on our own schiffe, manned perhaps by the cook and her two little boys, we cross over in a slanting direction, in twenty minutes, to the little market town or village, which is most picturesque. A rounded spur of the very steep Plassenstein surmounts it, clothed to a height of 1,000 feet with deciduous trees, chestnuts, oaks, beeches, elms, wild cherries, &c. (for in Austria the limit of the zone where these trees can grow is higher than in Scotland), the shoulder cleft by a steep rocky ravine, down which a stream from the salt-mine falls in broken cascades into the "See," with scarcely twenty yards of flat ground anywhere between the lake and the rocky terraces above. The houses rise one above the other, and seem to cling to the hill-face like limpets. When climbing the narrow paths which give access to them, you may peep down the chimney of one and up the ladder stair of another. They are mostly of two storeys, built of stone washed over with lime. Along the gable, which generally faces the lake and contains the windows, run one or more galleries of wood. The upper part of the sidewalls, and an attic in the gable, are generally of larch; the action of the weather and of the sun turns the colour of the wood in about seven years to a beautiful shade of golden brown, best represented by burnt sienna. The very projecting and high pitched roofs are covered with wooden slates or shingles of ordinary deal, which simply turn grey, and a wooden gutter along the eaves is carried several feet beyond the projection of the gables, making, in the event of a shower, a convenient little waterfall several feet from the house. Outside shutters painted green add to the cheerful and bright effect of the dwellings.

At the usual landing-place for the boats, an inn, or "Gasthaus," with a terrace and balcony close over the lake, forms a pleasant resort for afternoon coffee. On one side stands the Protestant Church, and on the other, a little way back, the Roman Catholic Church, built on the hill in a commanding position. It was consecrated in 1320, and is extremely picturesque. A narrow terrace and parapet wall surround it, the view from which looking over the lake is most beautiful. A very pretty path, or bridle road, led from Gosan Mühle as far as the entrance to Hallstatt, but not beyond it; of late years, however, it has been made into a carriage road, and continued below the town for about a mile.

The important feature of Hallstatt, which must now be noticed, is the great salt-mine, which forms the industry of the place. It is in the Plassenstein, the mountain which forms the western boundary of the lake from Gosan Mühle to the Waldbachthal. A zig-zag path leads from the village up the face of the hill through a beautiful wood, and partly follows the edge of the deep ravine of the Muhlbach, already described, as falling into the "See" near the Protestant Church. Those who are unequal to a long walk uphill are carried in "Sessels" or chairs between two "Träger" or porters, in their picturesque dress, two other men keeping near to afford assistance in steadying the poles, either behind or in front when descending the hill, and also to relieve their comrades every half-hour or less. A halt is made at a tower called Rudolph's Thurm, at a height of 1,150 feet above the town; it serves as a museum, and contains some fossils and a number of ancient Celtic bronze ornaments found in six hundred graves on the hill, and believed to date from the 3rd or 4th century. After passing the tower a grassy glen between two rocky shoulders of the hill leads gently upwards to the entrance of the mine, which dips into the Plassenstein 500 feet above the tower, and about two miles back from it. In a central office suitable canvas overgarments are provided, and guides. The descent can be made either by walking down a very long flight of steps, or by sliding down a kind of bannister, holding on to the guide in front. These are brine mines worked chiefly by the action of water. "The salt" (I quote here from Murray's Handbook) "in these limestone mountains is dispersed in veins and threads, intermingled with bituminous clay, marl and gypsum, which are soft and crumbling and easily dissolved in water." A small chamber is excavated and a mountain stream led into it from above till it is entirely filled. The water washes the salt from the sides and roof, dissolving it, while the clay and earth fall to the bottom, and by this accumlation the floor is gradually raised, but as the top is proportionately heightened, by washing away the surface, the whole chamber gradually attains a higher level, whilst others are formed beneath it. In this mine it takes six weeks to convert the water into brine; it is then drawn off by a pipe below, and conveyed in wooden pipes down hill to the boiling houses or "Sudhausen" at Lahn, close to Hallstatt.

The southernmost shoulder of Plassenstein forms a very precipitous wall of rock to a deep valley, which lies between it and another hill called Hierlatz, a favourite hunting-ground for chamois. Through this valley, which affords a very charming walk, with luxuriant grassy meadows and charming woods, a glacier stream called the Waldbach comes from one of the Dachstein Eisfelds, and falls into the lake at the southern limit of Hallstatt. At the foot of the wild stream a kind of delta has been formed by the *debris*, and here the salt-works are situated near the corner where the lake trends eastward to Obertraun, so that from this village of Lahn you can see opposite the east end of the "See" at a distance of two miles. Enormous woodstacks line the shore, of splendid trees sacrificed as fuel for the salt-ovens, but as there was no outside market to which these glorious firs could be conveyed, the waste was less to be regretted. The ground is covered with buildings containing great furnaces and vast shallow pans, into which the brine is led and subjected to very great heat. These trays of iron plates stand on firebrick pillars about three feet high, between which the fuel is placed; a current of air causes the flame to spread out in all directions under the pan. The fire is kept up for three weeks continuously. The boiling brine is stirred every alternate hour, day and night. The salt first rises to the top, then falls to the bottom of the pan, from which it is eventually shovelled into moulds, in which it is formed into white cones like sugar loaves, which are next baked hard. It is calculated that 100 lbs. of saturated water produce 26 lbs. of salt. The salt loaves, at the time of which I am speaking, were packed on peculiar barges, with a dozen or more compartments, covered with low boarded roofs, and these barges were punted round the western edge of the lake and down the Traun to the markets on the Danube.

The "Saline" or salt-works give employment to all the inhabitants of Hallstatt and the neighbourhood. The people hold their houses from the Emperor, who is a just and kind landlord, free of rent, but with the obligation to work for the "Kaiser" so many days in the year. The greater number are employed in the salt-mines and the boiling-houses. In both cases they go on duty for eleven days and nights at a time. During the period of duty some are on the day shift and others on the night shift alternately. Each time a squad begins to work they repeat together a short prayer or chant, asking for protection. The men are generally tall, and very good looking, remarkably contented, but not very healthy. During the weeks that their time is their own they follow their labours as smiths, carpenters, "Trägers," &c., working for pay. Their usual food, especially when absent from their homes, consists of "Knödeln," a little dumpling of flour and water. Stores required at the mine are carried up on a wooden framework fitted to a man's back, and a guide or hunter usually carries on his back a leather bag drawn in at the top with leather strings, and attached with straps. The inhabitants are very intelligent, very gentle, and very kind to one another. They may be called by the old expression "a God-fearing people," whether Catholic or Protestant, and they now live in peace together, though there were formerly persecutions. The Protestants chiefly inhabit the Obertraun valley, from which they come over to church in their boats. At the age of eighteen the young lads go off to the army as recruits for three years' service. They return with polish of manners and intelligence. They go out to training for a few weeks for several succeeding years, gradually at longer intervals, till later the old soldiers form the corps of veterans. There is not much drunkenness. All drink light beer in covered mugs, very slowly, as they sit out in the sunshine, and it does not appear to intoxicate them. There are, however, men and women who imbibe some horrible spirit called "Schnapps," and who ruin themselves and their homes like drunkards in all countries. The native costume of the men is very pretty, and resembles the Tyrolian. Round their soft felt hats they wear a green ribbon, into which they stick wild flowers, especially "Edelweiss," beginning at the back and working forwards. The head-dress of the women is a black silk handkerchief tightly drawn over the head and tied behind with the corners hanging down. All are extremly found of music. The authorities of the salt-works have a very good band of wind instruments. The boatmen and others sing and jodel beautifully as they go about their work, and the sounds harmonise well with the surrounding scenery. A favourite instrument is the zither, on which they play the characteristic airs of the country.

From Eggel an expedition by boat can be made along the eastern expansion of the lake to the village of Obertraun, where the river Traun enters, coming from a series of lakes, whence it gathers some of the volume of water which characterises it. The Obertraun valley, and that of the Waldbach Strub, almost exactly opposite, are the only bits of meadow-land near, and the grass in both grows tall and rank. Cows are not kept at Hallstatt, but flocks of pretty goats are taken out and in to the Waldbachthal every day by a little herd-boy, and on their return, each goat clambers up to the house of its mistress. The southern margin of the lake is bounded by a very fine range of hills, mostly bare, with several separate peaks or "Kogel," each of which bears a separate name, but they are all part of the massive shoulders of the Dachstein, the great snow-capped glacier hill of the district, 9,900 feet above the sea. In winter, for two months, the sun is hid from Hallstatt by this range; for two other months he can be seen at mid-day between two of the summits. On an elevated spot at Hallstatt, near the corner of the Waldbachthal, the inhabitants congregate to a fine chesnut tree, with a seat round it, joyfully looking for the sun on the first day that he is again visible after the short winter days.

The people are fond of sport, shooting at a mark, playing at skittles, and in winter, at a game resembling curling. At an inn, some way up the Waldbachthal, a rink is prepared by letting water run over the beaten snow on a tract of grass, and the projectile is a small wooden cone, with a short upright handle at the apex. The handle is grasped, a twist given, and the cone curls along on its flat base. The rules of the game appear to be on the same lines as our curling.

On the face of the southern range of hills there are hollows and corries, invisible from below, which yet afford space for good short grass and pasturage for a few cows. These "shealings" are called alps or alms, as in Switzerland. Early in the summer the cows are driven up to these almost inaccessible places, attended by the "Sennerinn," or milk-maids in charge, who remain on the heights in wooden huts, and by jodelling can hold any needful communication with their friends below. Early in October the "Ruckkehr," or return of the cows, takes place from all the alps in the neighbourhood, and it is celebrated as a very great festival. Garlands adorn the necks of the cows, and amidst the tinkle of their different toned bells, the blowing of horns, and beating of drums, quite a noisy procession homewards is formed.

A few sheep are to be seen in the Obertraun valley, but grain and crops are not grown nearer than Aussee on the east, or the district of Gosan on the west; there is no suitable ground near Hallstatt. The trees near the lake are magnificent—pines, spruce, larch, in some place chestnuts, oaks, beech, elms, and varieties of underwoods, red-berried elder, euonymus, wild cherries, etc.; on the top of the high hills "krumholz" (*Pinus montana*), and *Pinus cembra*, the only five-spined pine in Europe.

The flora, though less rich than that of the Engadine, is very interesting. The chief beauty is the *Alpen rosen*, *Rhododendron ferrugineum*, which grows luxuriantly everywhere. One rare specimen of *Rhododendron chamæcistus* grew in a cleft of a rock overhanging the lake. The cyclamen, growing thickly in the grass under the trees at the back of Eggel, was perfectly lovely. *Anthericum ramosum*, with its white stars, was found on the alps of the Rauhe Kogel, at the southern end, just at the edge of the snow. The foxgloves are yellow; the pinguicula white; *Linaria alpina*, with its purple flowers brightened with orange, is quite different from the common yellow toadflax. The queen of the Salzkammergut flowers, and better beloved than even in Switzerland, is the Edelweiss. It is only to be found high up on the way to the Dachstein, but the "Tragers" (porters) bring it back from their expeditions and present it to those who value it. On the summit of the Krippenstein there is a very fragrant grassy blade, called by the natives "speick." It would be tedious to read the names of all the plants personally found, but I have subjoined a list that can be studied by any who care to see it.

The chamois, called in German "Gemse," is plentiful round Hallstatt, chiefly on the Hierlatz and the southern hills. The shooting is always let, and many men are employed as "Jägers," huntsmen, and "Bergknecht," acting as beaters and carriers. The sport is dangerous, from the nature of the ground, the steepness of the hills and the rocky precipices. Often in August and September the "Jägers" come through the town carrying on their backs in picturesque form the slain half-deer, half-goat. Once only I saw some living "gemse" quietly feeding on a ridge opposite to that on which we were standing, in the Gosan district.

I cannot enumerate many birds. Eagles appear to be extinct; but there is a large bird called in German "Geier," one of which frequented a rock on the Sarstein. It was probably of the vulture tribe. A pair of nuthatches amused themselves with stripping a small nut tree on a little island close to Eggel. In the end of October a pretty dark green water bird swam about the lake in flocks. It may have been a wild duck, but I never saw it rise. There were numerous gulls and waterfowl.

The fishing of the lake and district was let to a local fisherman, and it was extremely difficult for a private individual to get any fishing either for love or money. The official mode of fishing was with two of the long country boats; the net was paid out between them, after which they drew together, lifted the net, and took the fish. Almost the only kind they got was an indifferent sort called "Reinanken," translated "lamperns." Perch could be got, also chub (called "Alte") and the queer looking "burbot." At the mouth of the Traun near Ebensee excellent grayling abound, and there are a few "Lacks Vorellen" (salmon trout), also pike and crayfish. A very important feature of our lake must not be omitted, the sudden and violent storms which came down upon it and lashed its calm waters into fury. The usual lap or current of the water opposite Eggel came from the south or south-east, especially in the morning, but when it suddenly changed, the alarm was given that a storm was coming, and the north wind rushing down from the Ischl quarter broke violently with resistless force. In spite of every precaution, on several occasions our boat was overtaken by the gale, and thankful all were to reach the boathouse safe. Storm-beset neighbours from the shore north of us often put in to Eggel for shelter, for when at its worst not a boat could live on the "See." The waters dashed up to within a few feet of our front door, but never nearer. Every shutter was quickly shut. Fortunately the storms usually subsided almost as quickly as they came on, and then the ground dried very quickly, like plates set up on edge.

The elevation of the surface of the lake above the sea is 1,700 feet. It has been carefully measured and sounded by a great Viennese scientist, Professor Simoni, who has carried out for the Austrian lakes what is being so munificently done for ours in Scotland.

I hope my learned friends will excuse all shortcomings from one who has no scientific knowledge, and who claims merely to be an enthusiast as regards scenery and national characteristics.

Hallstatt.

List of a few flowers personally noted, July and August:—

Aconitum.
Anthora—on an Alm.
Adenostyles—both albifrons and leucophylla.
Anthericum ramosum—grew high up on an Alm near Snom.
Aquilegia.
Arnica.
Campanula—many species.
Chrysanthemum.
Clematis alpina.
Cyclamen europæum.
Delphinium.
Doronicum.
Draba.
Digitalis—white and yellow.
Empetrum nigrum.
Epilobium Dordonæi.
Epipactis.
Euonymus.
Gentiana—chiefly the large kinds at that season.
Geum.
Gnaphalium Leonlopodeum and others.
Helianthemum.
Helleborus.
Hepatica.
Hypericum.
Lilium Martagon.
Linaria alpina.
Lloydia.
Lychnis.
Orchis—various species.
Pedicuiaris.
Pinguicula alpina (white)—on an Alm.
Phyteuma Scheuchzeri (purple)—on an Alm.
Potentilla.
Primula spectabilis—purple, very pretty, like Chinese, on an Alm.
Ranunculis alpestris, and Anemonoides—on an Alm.
Rhododendron hirsutum and Chamæcistus.
Rosæ.
Saponaria.
Saxifraga.
Sempervivum.
Senecio.
Silene.
Statice.
Thalictrum alpinum—on an Alm.
Trientalis.
Thlaspi alpinum.
Veronica.
Viola.
Vaccinium Vitis Idæa.

VI.—*Goethe as a Scientist; and his Relation to the Present Position of Evolution and the Doctrine of the Descent of Man.*

By JOHN LYELL, M.D.

(Read 11th March, 1904.)

The enunciation and establishment of the theory of evolution are considered by many to have been among the most noteworthy events of the past century. Evolution, however, is not wholly a product of recent years, as some imagine. Its inception can be traced to a remote period of European history, the notion of the immutability of species having been seriously doubted by certain of the early Greek philosophers so long ago as 600 years B.C. But it was not till within the last fifty years that man's speculations regarding the origin of the organic world, and of his own species, have attained to anything like rational clearness. We owe our present enlightenment upon these important questions, as you are all aware, to our celebrated countryman, Charles Darwin. But, as has been well observed, all great discoveries are made, not by individual men, but by the age. The theory of evolution, in its modern form, may be said to be the joint conception of a group of remarkable men who flourished about the beginning of the 19th century, not the least of whom was the greatest poet and thinker of Germany, Johann Wolfgang Goethe. There is no doubt that we owe to him, as much as to any of the others, the development of the great ideas of the unity of nature and the common origin of all organic forms, which lie at the very foundation of modern science. To Darwin and his school was merely left the task of putting these ideas upon a firm basis of fact, and of demonstrating, by an incomparable process of inductive reasoning, the laws which bind the organic universe into a living whole.

It is unnecessary for me to refer at length to the genius of Goethe as a poet and man of letters. His most enthusiastic admirers consider him as the greatest of the moderns, and there are few who will deny him a place among the leading spirits of all time. He was first made known in this country through the translations and essays of our own countryman, Thomas Carlyle, but of late there has arisen quite a Goethe cult, and his various writings have undoubtedly exercised a widespread influence upon the character of much of our recent literature. To-night, however, we are not concerned with Goethe as a poet, but as a man of science. This aspect of his character has been a good deal overlooked by his exponents on this side of the channel, yet it may truly be said that he was one of those who helped to usher in the great era of scientific enlightenment in which we now rejoice. He was born in 1749, and died in 1832, and thus lived through that most interesting period when modern science may be said to have passed through its infancy and reached its majority. Looking back upon those early years, we are now able to trace the leading impulses which contributed to the growth of science. One of these was without doubt the genius of Goethe. Yet it is only within recent years that this truth has become apparent. Goethe's scientific writings, though indeed well known to his contemporaries, were unfortunately so advanced that they were but little understood or appreciated; and besides, the fact of his being celebrated chiefly as a poet caused his theories and discoveries to be looked at askance by the specialists. But we are now able to judge of Goethe's studies of nature from a very different point of view. While Goethe in many respects saw far deeper than the men of his own day, we have now reached a stage when science has advanced far beyond the poet's profoundest speculations. Yet so far-reaching and penetrating were these speculations that they still remain as guiding principles of perennial significance for all students of nature, and it will be part of our task to-night to glance at some of them, more especially in their relation to the great theory of evolution, which at present dominates the whole modern philosophy of science.

I.

The crude state of general scientific thought at the time when Goethe lived has been touched upon by himself in various parts of his writings. He describes the professed exponents of science as being lost in dry details, and unable to grasp general laws and principles; as given over to whimsical fancies and metaphysical abstractions. The true scientific spirit hardly existed except amongst a few elect men of genius. It was from this chaos, however, that there was shortly to arise the noble structure of modern science, and the foundations were already being laid in ways that were little suspected by the dilettantes and dabblers of that polite age.

Intellectually Goethe stands out pre-eminent amongst all his contemporaries. One of the greatest names that survive to us from the very unscientific 18th century is undoubtedly that of Linnæus, the famous Swedish botanist; but he was a firm believer in the theory of special creations, which had been accepted from time immemorial. The same may be said of Cuvier, who considered the permanency of species as a necessary condition of scientific natural history. Goethe, on the other hand, was one of the first to rise above the commonplace empiricism which characterised the science of his day. He was a leading spirit in the great speculative reaction which arose about this period, and which was represented chiefly by the names of Lamarck, St. Hilaire, and Oken, the real pioneers of the evolutionary movement. "I possess the developing, unfolding method," Goethe says, "in no wise the collecting and arranging method. With phenomena placed side by side I know not what to do. I, on the contrary, take up my attention with their filiation." He was a thinker, in short, not a mere empirical observer like Linnæus. His view of nature was remarkable for its breadth of outlook and deep discrimination. Its leading feature was the recognition of the essential unity of all organic forms, upon the basis of a primary or fundamental type. This thought permeates all his speculations in a greater or less degree, and was the means of leading him to more than one remarkable generalisation of permanent significance.

It is not my intention to deal with any of Goethe's scientific achievements in detail. During his long life he was in the habit of turning to the study of nature as a relief from the cares of official life, and when his poetical powers were in abeyance. Botany, anatomy, optics, geology alternately occupied his thoughts, and it may be said that upon every subject which he touched his penetrating genius was able to throw some new and startling light. In botany, for example, which may almost be considered Goethe's forte, he was the founder of the doctrine of the metamorphosis of plants, which remains, with some modifications, as a principle of present-day science. This doctrine implies the derivation of all the rich variety of plant life from a primitive or typical plant form, and of the different organs of the individual plant from a single primary organ, viz., the leaf. In comparative anatomy, again, Goethe made the remarkable discovery of the intermaxillary bone in man, and thus brought the human species fully in line with the rest of the animal kingdom. He also endeavoured, in his remarkable vertebral theory of the skull, to reduce the complex cranial bones to a common type, and to work out their homologies with one another. Interesting and valuable, however, as these speculations are, our concern is rather with Goethe's view of nature as a whole, and the peculiar position which he holds in relation to the great evolutionary movement. We must therefore consider for a few moments some of the more remarkable passages in his writings, in which he foreshadows the leading conceptions implied in the present-day doctrine of descent with modification.

II.

There is no doubt, in the first place, that Goethe fully grasped the fundamental truth of the perpetual mutability of the whole organic world. "When we observe all forms," he says, "especially organic forms, we nowhere find a standing-still, a resting, or completion of action, but all rather fluctuates in constant movement." In an interesting passage in his autobiography, he tells us that he had come to the conclusion "that the various plant forms which surround us are not originally determined or fixed, but that there is lent to them, in spite of a persistent generic and specific stability, a happy mobility and pliantness, in order that they may be able to adapt themselves to the various conditions which act upon them all round the circuit of the world, forming and transforming themselves accordingly." Underlying all this variability, this action and reaction, we are, however, gradually forced to the conviction that there must exist a fundamental type or idea, the plan on which nature works. There is an internal formative tendency or "centripetal" force, which determines the building up of an organism, and the final relation of its perfected parts to one another. But over and against this tendency, another, or "centrifugal" force is at work, viz., that of metamorphosis or adaptation. While the organism remains ever true to its original type, it is subject to a constant necessity of adjustment to external circumstances. "Variations in the soil," for example, as Goethe says, "may come into consideration. Richly nourished in the damp valley, stunted by the drought of the mountains, protected from frost and heat in every degree, or unavoidably exposed to both, the genus resolves itself into species, the species into variety, and this again, under other conditions, into endless changes of form."

While Goethe thus attained a clear conception of the mutability of nature, he was a strict opponent of the doctrine of geological cataclysms, which, during his day, was accepted as a dogma of natural science, and did not receive its final blow till the appearance of Sir Charles Lyell's great work in 1830.* "The violent and revolutionary character of this theory of cataclysms," Goethe says, "is offensive to me because it is contrary to nature." In fact there could be nothing more alien to the genius of Goethe than any sympathy with a doctrine which implied repeated arbitrary interruptions of the great march of natural law. To one who was so convinced of the unity and uniformity of nature, no words were strong enough to express his reprehension of all such "lumber-room" conceptions of the universe, as he calls them.

Perhaps nothing is so remarkable about the speculations of Goethe as the uncompromising honesty with which he was prepared to carry them to their logical issue. As a result of his profound and varied investigations in every branch of natural science, we cannot therefore be surprised that he was led to the following very striking

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* "Principles of Geology, being an enquiry how far the former changes of the earth's surface are referable to causes now in operation," 1830-1832.

generalisation, which may almost be considered as reaching the high-water mark of evolutionary speculation prior to the advent of Darwin. "Without hesitation," Goethe says in a memorable passage, "we are now able to declare that all highly developed organic creatures, amongst which we recognise the fishes, amphibia, birds, and mammals, *and at the summit of the last, man himself*, are all formed upon one primary type, deviating, it is true, in its stationary elements, but forming and transforming itself by endless reproduction."

III.

In short, it is impossible to read through the scientific writings of Goethe without being struck with the remarkable way in which he seems to have grasped the fundamental conceptions of the doctrine of evolution. Haeckel, the chief exponent of the doctrine in Germany, places him along with Lamarck as the most distinguished of all the precursors of Darwin. It was a misfortune that Goethe himself was not acquainted with the writings of the great French naturalist whose name has just been mentioned, for had he been so he would have found much in them that was fully in line with his own speculative tendencies. Jean Lamarck published his celebrated "Philosophie Zoologique" in 1809, but for many years no one paid any attention to it. It was not, indeed, till fifty years later, when Darwin had enunciated his great theory, that it was seen how clearly Lamarck had realised the idea of the mutability of species at a time when men's minds were still bound in the trammels of mediæval orthodoxy. His speculations showed a considerable advance in clearness and exactness on those of Goethe, and to Lamarck, therefore, will always belong the distinction of "having for the first time," as Haeckel says, "worked out the theory of descent as an independent concept of the first order, and as the philosophical basis of the whole science of biology." Lamarck reached the important conclusion that all animal and plant forms, which we distinguish as species, possess only a relative and temporary persistence, and that varieties are commencing species. The course of development of the earth and its organic inhabitants was continuous, not interrupted by violent revolutions. In the first beginnings the very simplest and lowest animals and plants came into existence; those of a more complex organisation only at a later period. The differences in the conditions of life on the one hand, and the use and disuse of organs on the other hand, have a constant transforming influence upon the organisms; these factors cause, by adaptation, a gradual change in form, the fundamental characters, however, being carried on from generation to generation by inheritance. The whole system of animals and plants is therefore to be considered as a genealogical tree, "which unveils for us the circumstances of their blood-relationship."

Present-day science stands very much in debt to these bold and far-reaching conceptions of Lamarck. They constitute the true programme of evolution, which it has been the task of modern science to carry out into its details. I do not need to tell you that the theory of evolution is now accepted all along the line. It is true that we do not now think much of the services of Goethe and Lamarck as the founders of the doctrine. Their names have been overshadowed by the transcendent achievement of Charles Darwin, which has made evolution a household word in the domain of natural science. Yet we must remember that Darwinism is only a part of evolution. It was Darwin who gave the theory a thoroughly scientific groundwork, but he was by no means its originator. Indeed, his concern was almost solely with its biological aspects, and he did not trench much upon other fields. Evolutionism must be looked upon as a complicated intellectual movement. Its obscure beginnings date back many centuries, as we have seen; but in its latest developments it is peculiarly a product of the nineteenth century, and the joint conception of a number of scientific workers and theorists of different degrees of eminence. After all has been said, however, there is no doubt that Darwin's labours, as Grant Allen puts it, form "the central keystone of the complex and many-sided evolutionary system. For what others suspected, he was the first to prove; while others speculated, he was the first to observe, to experiment, to demonstrate, and to convince."

The leading doctrines of the Darwinian theory, as you are aware, are expressed in the now familiar phrases, "struggle for existence," and "natural selection" or the "survival of the fittest." Starting from the well-known phenomenon of the variability of offspring, Darwin shows that individual differences constantly arise amongst plants and animals, both in a state of nature and under domestication. The extraordinary diversity in domesticated animals has been due to the careful selection by man of useful or pleasing varieties, and the perpetuation and accentuation of their good qualities by interbreeding. In nature, however, there is no such artificial selection; the process is purely automatic. Every organism is so constituted that it possesses the power of almost unlimited reproduction, but the restrictions of space and of food render it impossible for more than a very minute fraction of all the eggs or seeds that are produced ever coming to maturity. A fierce struggle for existence takes place, and only the most vigorous embryos, or those possessing some advantage over their fellows in function or structure, are able to survive and perpetuate the species. This is what is meant by natural, or "unconscious" selection, as it might be called.

It is to these two great factors that Darwin chiefly attributes the unfolding of the vast and varied panorama of organic nature as we see it to-day, and as we know it has existed during past geological ages. "Growth, with reproduction; inheritance, which is almost implied by reproduction; variability, from the indirect and direct action of the conditions of life, and from use and disuse; a ratio of increase so high as to lead to a struggle for life, and as a consequence to natural selection, entailing divergence of character and the extinction of the less improved forms." These, in his own words, are the causes which, "from the war of nature, from famine and death," have led to the production of the diversified organic life which peoples the globe.

IV.

I have thus, in a very imperfect and fragmentary manner, endeavoured to trace the "evolution of evolution," as one might say, from its earliest beginnings to its present-day maturity, dwelling more especially upon the part played by the great German poet and philosopher in its inception and fundamental embodiment. But our interest, as students of natural science, is rather with the immediate application of the theory to our own special department of work. I shall therefore hasten on to refer very briefly to some of the most recent developments of the doctrine of descent, and I shall, in so doing, endeavour to indicate to you the present-day trend of opinion regarding the whole subject.

The great advance which Darwin made over all previous evolutionists was, as we have seen, in the discovery of an adequate cause for the diversity of species. Lamarck's explanation was insufficient, and hence his speculations made little impression on his contemporaries. He laid too much stress upon the use and disuse of organs, and though he grasped the great fundamental principles of adaptation and inheritance, he failed to realise their true relation to each other. There was one question, however, of transcendent importance raised by Lamarck, which was not answered finally by Darwin, and which, at the present moment, is the subject of burning controversy. One of the essential conceptions of the Lamarckian doctrine was that new characters acquired by the parent, through use or disuse, or through habit or changed conditions, may be transmitted directly to the offspring. Darwin only goes the length of saying "that these factors of use and habit have, in some cases, played a considerable part in the modification of the constitution and structure; but that the effects have often been largely combined with, and sometimes overmastered by, the natural selection of innate variations."

The camp of the new evolutionists is therefore at present divided into two great factions. On the one hand we have the school of the neo-Lamarckians, chiefly represented in America and France, whose contention is that variations in an individual organism may be directly caused by the force of external circumstances, such as climate, the conditions of nutrition, or the influence of disease, and that these acquired changes can be directly inherited. On the other hand we have a powerful movement, headed by the now famous name of August Weismann, whose celebrated doctrines of heredity and the continuity of the germ-plasm, involve a direct negative to the views of the neo-Lamarckians. As these doctrines of Weismann are of great importance, and have received very considerable support in this country, even more than in Germany, it will be necessary to consider them in a little detail.

V.

Starting from the familiar yet extraordinary circumstance "that, in the higher organisms, the smallest structural details, and the most minute peculiarities of bodily and mental disposition, are transmitted from one generation to another," and from the further consideration that this transference occurs through the medium of a single cell or ovum thrown off by the parent, and capable of gradual but, strictly speaking, independent growth into the new individual, Weismann states the great problem of heredity in the following sentence: "How is it that such a single cell can reproduce the *tout ensemble* of the parent with all the faithfulness of a portrait?" Darwin had already given a provisional answer to the question by supposing that gemmules are given off from the cells of the mature organism, which become congregated in the sexual cell, and thus determine its power of heredity. After showing that such and all other suggested theories are inconceivable, and do not explain the facts, Weismann proceeds to state his belief that the essential element of the germ cells is not derived at all from the body of the individual, but proceeds directly from, and is a continuation of, the parent germ cells. The germ-plasm he illustrates by the metaphor of a long creeping root-stalk, from which plants arise at intervals, these latter representing the individuals of successive generations. This is the fundamental conception upon which Weismann builds up a system of remarkable consistency, though in some of its details of great complexity. It would be impossible to go further into these at present. You will, however, at once see the trenchant nature of these speculations, If it be true that the basis of heredity is a continuous thread of cellular material running on from generation to generation, and thus maintaining intact the ancestral peculiarities of the species, the idea puts a new aspect upon the whole question of the inheritance of acquired characters. The germ-plasm, to fulfil its purpose, must be conceived to be of such stability that the mere transitory influences which may modify the individual during life can have no action upon it, or else it would afford no guarantee of the permanency of the species. Hence the theory involves a direct denial of the transmission of so-called acquired peculiarities, and Weismann holds that this denial is borne out by the facts of the case. The whole burden of the origin of species is thus thrown back with redoubled force upon natural selection. Suppose, for instance, to use an illustration of Lamarck's, some aquatic animal by its efforts to swim began to develop webbed feet, this advantage could not be transferred directly to its offspring, because the germ-plasm of that animal is not, strictly speaking, an intrinsic part of itself, but an ancestral possession, which it must transfer unchanged to all its progeny if these are to maintain their specific characters intact. The only way therefore in which such a property as webbing of the feet could arise would be by a primary variation in the germ-plasm itself, leading to the sudden appearance of the peculiarity as a kind of sport of nature, which, being for the advantage of the possessor, would give the organism a pull in the struggle for existence, and enable it to transmit the useful mechanism to its successors. The germ-plasm, while thus the medium by which the physical nature of the parent is carried on to the offspring in its minutest details, does not necessarily lead to the perpetuation of a succession of identical individuals. Were this the case the rich development of organic life upon the earth would be inexplicable, and the theory of evolution an absurdity. The variation of offspring, however, is a matter of every-day observation, and whatever view of heredity is taken, variation remains as the foundation of the whole doctrine of descent with modification. The important question is: What are the causes of variation, and how far is variation directly or indirectly determined by external circumstances? Weismann believes that the main influence at work in the production of hereditary differences is to be found in sexual reproduction, which consists essentially in the coalescence of two distinct germ cells, derived from different individuals. This brings about the summing up of the small variations existing in two separate hereditary stems, and thus gives natural selection the material with which it has to deal in the production of new characters.

The difficulty, however, does not end here. In fact, it is only put one stage backwards, because, if the union of two hereditarily different stems produces variation, we have still to ask why these two stems came to vary from one another, and so on through an interminable series of past generations. Weismann, indeed, is forced to assume that the real origin of hereditary individual variation must be sought in the primordial unicellular organisms from which all life has sprung. This, however, as all must admit, is a vast and staggering assumption.

Be this as it may, the *fact* of variation remains, whatever its origin is assumed to be. The kernel of the doctrine of descent, however, consists in the continual selection of such variations only as are *useful*, and the perpetuation of these by heredity. But the question next arises, How is it that just these very variations which are useful for the organism happen to arise at the proper time and place for natural selection to make use of them? There is no doubt that such useful variations must always have been present, and the inference, as Weismann says, is very plain, that there must be some profound connection between the utility of a variation and its actual appearance; or, in other words, the direction of a variation must be determined by its utility. In order to explain this difficulty, Weismann has resorted to the further theory of "germinal selection," which is the last of his contributions to the elucidation of the problem of evolution. It amounts to this, that within the germ-plasm itself there is a struggle for existence amongst its determining components, in such a way that "the germ is progressively modified in a manner corresponding with the production of a definitely directed progressive variation of the part." It is questionable, after all, whether this theory gives any material help. It is of course no solution of the fundamental problem of the real origin of useful variations. It only serves to explain how the useful variations are accentuated, and how they come to acquire selective value, but the main difficulty remains untouched. In fact, as Ziegler says, Weismann leaves us in the same position as other authors have taken up of being compelled, after all, to attribute variation to some unknown laws or internal tendencies which are as yet beyond our power to estimate.

VI.

I am not, however, going to weary you with attempting a full exposition of Weismannism, one of the most elaborate products of the subtle German intellect. What I have already said will have sufficed to impress upon you the elements of Weismann's fundamental doctrines of the continuity of the germ-plasm and the non-transmission of acquired characters. The first proposition has been hailed as a most fertile principle by naturalists of all shades of opinion. Wallace and many others consider Weismann's discovery of the secret of heredity (if finally established) to be the most important contribution to the evolution theory since the appearance of the "Origin of Species." The second proposition is, as I have said, the subject of much controversy. On the side of Weismann are ranged such eminent names as Ray Lankester, Wallace, Hertwig, Butschli, and Ziegler, while the opposite school is represented by men of no less note than Spencer, Cope, Eimer, and Haeckel. Who shall decide, we may well exclaim, when specialists disagree? The most exhaustive discussion has been carried out in the pages of *Nature* and of the *Contemporary Review* during recent years, and there is not a present-day article or publication upon the subject of evolution which does not touch upon these questions. Whether the controversy is at an end it would be impossible to say. There is no doubt that much confusion has been caused by a want of agreement upon the real meaning of an acquired character, and until the term has been strictly defined and restricted little advance can be made.

At the present moment, however, there seem to be indications that a new departure is being made by the vanguard of the evolutionary movement. After all, the real crux of the controversy is the fundamental question as to the nature and origin of variation. If all variations can be shown to be innate or germinal, then acquired characters cease to have any direct significance. It is frankly admitted by all naturalists that the real causes which determine variation are still doubtful. Yet we are warranted by all precedent in believing that this primary phenomenon of all living organisms must be governed by definite laws, however obscure these laws may be. Darwin himself held that external conditions acting upon the parents might lead to variability in the offspring, but he did not conclude that bodily characters, acquired by the parents as a result of such conditions, were those which manifested themselves as variations in the offspring. On the contrary, as Ray Lankester points out, he showed that the effect of changed environment is merely a "breaking-down, as it were, of the hitherto fixed characters of the race, leading to the reappearance of long lost characters, and to the appearance of absolutely new characters, having no more (and perhaps not less) relation to the existing cause which acted through the parent than has the newly-formed pattern in a kaleidoscope to the tap on the tube, which initiated the new arrangement." * It would seem that we have hardly got much beyond this position of Darwin's, the result of his elaborate investigations on the variation of animals and plants under domestication. Hence Bateson and others have argued rightly that the task of the biologist now is to endeavour, as

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* *Nature*, Vol. XLI., p. 129.

he says, to get "beyond the present condition, and penetrate further into the mystery of specific forms" by the closest and most painstaking study of the *facts* of variation. It is by a return to Nature herself, and not by mere theorising, that we can hope to discern those deeper laws which lie at the foundation of the differentiation of all organic species.

VII.

It is impossible to leave the subject of evolution without touching very briefly upon the present position of scientific opinion regarding the descent of man. I have shown how Goethe long ago saw with his unerring glance that man himself must be included in all speculations regarding the origin of the organic world. It is to Darwin and Huxley, however, that we owe the full application of the doctrine of descent to the human species. Huxley's "Man's Place in Nature" was published in 1863, and Darwin's "Descent of Man" in 1871. Considerable advance has been made in our knowledge of primæval man since these books were written, but though much yet remains obscure, no fact has come to light which tends otherwise than to confirm the views which these writers enforce. Let me endeavour as briefly as possible to lay before you the leading arguments used by these authors, and the additional confirmatory evidence which has been gained during recent years.

In the first place, there is no doubt that man is an animal, and that he belongs to the great class of the Mammalia, amongst the various orders of which he most closely resembles the apes. This was recognised more than a century ago by Linnæus, who included man, the apes, and the lemurs in his order "Primates." The question therefore narrows itself down to whether this classification is justifiable in the light of modern science, or whether man is so "different from any of the apes that he ought to form an order by himself." The important conclusion reached by Huxley, and which was fully adopted by Darwin, was that in "every visible character man differs less from the higher apes than these do from the lower members of the same order of primates." The proof of this weighty statement, which goes by the name of Huxley's pithecometric law, is largely an anatomical one. The comparison between man and the apes is based first of all upon embryology, and it is shown that it is only in the later stages of development that the young human being presents any marked differences from the young ape, or dog, or fish; next, from the consideration of various rudimentary structures possessed by man, the most intimate connection is found to exist between his bodily frame and that of the lower animals, especially the apes. Then it is demonstrated that, bone for bone, muscle for muscle, and organ for organ, there exist the most striking resemblances between the human species and the gorilla or the chimpanzee—greater resemblances, indeed, than are to be found between those animals and their lower congeners. Even in the structure of the brain the same law holds good, "the difference between the brains of the chimpanzee and man being almost insignificant when compared with that between the chimpanzee brain and that of a lemur." The facts taken in their entirety, according to Wallace, "amount almost to a demonstration that man, in his bodily structure, has been derived from the lower animals, of which he is the culminating development."

The confirmations of this view, which are being slowly added to year by year, are many and interesting. It is impossible to refer to them in detail, as they are mostly of a highly technical nature. I must, however, mention the recent extraordinary investigations of Friedenthal, who has shown that man is apparently an actual blood-relation of the apes, that, in fact, the same blood flows in the veins of both. It has long been well known that the blood of animals of any given species is chemically a poison to those of all other species. For example, if the arteries of the cat and the rabbit are connected by a tube or cannula, so that their blood streams intermingle, these animals both die of rapid convulsions. Two cats, or two rabbits, however, can be thus connected without any serious results. By numerous similar experiments, it is found, as a general law, that "*like family has like blood.*" Thus horse and ass, hare and rabbit, dog and wolf, admit of free exchange of blood in the manner indicated. Friedenthal has tested this law in the case of man. He has been able to demonstrate that human blood serum destroys the blood corpuscles of the horse, ox, rabbit, guineapig, dog, cat, and numerous other animals, including the lemurs, the New World apes, and even certain of the Old World apes. The blood corpuscles of the chimpanzee, gibbon, and orangutang, however, form an extraordinary exception, for upon them alone human blood serum has no more effect than upon the corpuscles of another man. Professor Branco, of Berlin, in commenting on these remarkable results, adds, "There can no longer be any doubt. To one and the same family belong man and the anthropoid apes. If identical blood flows in their veins, it is clearly because that blood is an inheritance from a common ancestor."

The view that man has been derived from any of the present-day anthropoid apes is, of course, not correct, though it was the one which was originally taken up by the laity, and even yet survives to some extent in the popular mind. The true doctrine is, as you are all aware, that mankind and the apes are derived from a very ancient common progenitor, from which both types have since diverged to a very considerable extent, so that the relationship between them is now comparatively remote, but of exactly the same nature as that between "the hare and the rat, the ox and the goat, or the gorilla and the chimpanzee" (Ziegler), namely, the relationship of common descent. This conception of the evolution of man has been very much strengthened by the recent investigations of Professor Hermann Klaatsch of Heidelberg, upon the origin of the upright position in man, and of the peculiar structure of his hand and foot. Numerous marks of footsteps in Palæozoic and Mesozoic strata prove to us that long millions of years ago land vertebrates existed, whose extremities already possessed the full characteristics of the primates, as they are found at the present day, that is to say, five fingers on the hand and five toes on the foot, the first digit being in each case opposable to the others. It is to be noted, also, that we still find amongst certain of the lower mammalia, viz., the marsupials, the possession of the typical feet of the primates. This forces us to the conclusion that we must refer the origin of man to a much remoter point than has hitherto been adduced, viz., to the old primary mammalian stem, from which all the different types of that great kingdom have, at different periods, branched off. Amongst these the monkeys and anthropoid apes retained the power of opposing the toe to the foot, while man lost it owing to the development of his foot into an organ for progression in the upright position. This view is also confirmed by the comparatively primitive structure of the human teeth, which is found to have a greater similarity to that of the Eocene mammals than to that of the anthropoids. Klaatsch is therefore of opinion that we ought really to exclude the apes altogether from the direct line of human progenitors. Instead of speaking of ape-like characters in man, we ought more correctly to use the simple expression "animal-like." Man, according to this eminent authority, "is a central mammalian and primate form, primitive in his limbs and dentition, highly developed merely through the evolution of his brain."

As to the interesting question of the antiquity of man, there is now no doubt that we have to go back to Tertiary times for the momentous period when the divergence took place between primitive man and primitive ape. The evidence upon which this conclusion is based is too elaborate for consideration here. Some authorities consider that it is very probable that we may have to go back to the Eocene to find the common ancestor of man and the quadrumana, and that we must therefore assume for man's existence upon the earth a period of between one and two million years, a mere fraction, of course, of geological time. Exact figures in such a question are plainly impossible, because they pre-suppose a knowledge of what was the real length of the glacial epoch, which, as you are aware, is still a much disputed point. That man, however, existed right through Quaternary time is now no longer a matter of dispute. His remains, in the shape of celts, arrowheads, and other stone implements, have been found in numerous localities in association with the bones of the mammoth, woolly rhinoceros, cave bear, reindeer, and other characteristic fauna of glacial and pre-glacial times. The high antiquity of our race is therefore proved beyond the shadow of a doubt, and the question of the exact number of years which have elapsed since the human type first became clearly differentiated must be left for the final decision of geological and anthropological experts.

In drawing this paper to a close, let me impress upon you that the views which we have been discussing are all of a highly speculative and controversial nature, and many of them still entirely *sub judice*. From the very nature of the case, the theory of evolution can never reach absolute finality. There must, in fact, always be an evolution of evolution, and the future developments of the doctrine may involve very different conceptions from those which at present dominate the field. One thing, however, is certain: the great law of descent with modification must continue to form the keynote of all modern speculation regarding the origin of the organic world. This can never be gone back upon. But for many years to come discussion and enquiry will centre round the problem of the *factors* of evolution. I have endeavoured to indicate the trend of present opinion upon this point, and to show how a large school of modern biologists still hark back upon the position of the early evolutionists, of whom Goethe and Lamarck were amongst the most eminent representatives. With regard to the origin of man, much yet remains obscure, and here, as in all questions of organic evolution, it is to the great science of palæontology that we must look for confirmatory evidence of the theories based on comparative anatomy, embryology, and anthropology. The problems involved are vast and interminable, but they will ever furnish scope for the exercise of the best intellects of all future time.

Let me close with the memorable and beautiful words of Goethe:—"There is nothing beyond the pleasure which the study of nature produces. Her secrets are of unfathomable depth, but it is granted to us men to look into them more and more; and the very fact that she remains at last unfathomable perpetually charms us to approach her again and again, and ever to seek for new lights and new discoveries."

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VII.—*The Riverside Marshes between Errol and Invergowrie.*

By William Barclay.

(Read 8th April, 1904.)

When the river Tay, having broken through the barrier of the Sidlaw hills, turns to the north-east, the main current, inclining more to the south than to the north side, leaves a broad, nearly level stretch of mud and marsh between itself and the coast of Perthshire. Between Errol and Longforgan this wide tract attains its greatest breadth, and shows best the points to which I wish to direct attention. Its outer boundary, as I have said, is the main channel of the river. On the inner side it is bounded by the escarpment of what is marked on the geological map as the 40-feet terrace, a wide level plain formed by the river when the land surface of our island stood at a lower elevation above the sea than it now does. This escarpment forms for most of the distance a more or less steep bank planted with deciduous trees, oaks chiefly, but also comprising beeches and elms in some quantity, with a sprinkling of some few others. Its vegetation does not offer any peculiarity worthy of special remark, consisting mainly of the trees already mentioned, with an undergrowth of shade-loving plants, and a scattered fringe of rose bushes, or an occasional bramble, on the lower edge.

A first glance at the marsh from the top of this bank would lead one to think that its vegetation consisted of one huge bed of one plant only, *Phragmites communis*, Trin., the common reed. This is not really the case, but assuredly the *Phragmites* forms the most striking, if not the most important constituent of the flora of the marsh. It extends in practically an unbroken belt, 250 yards broad or more in some places, though narrowing at others, from about a mile above Errol down to the farm of Monorgan, near Longforgan. In autumn this great bed of reeds, ten to twelve feet high, crowned by the dark feathery plumes of flowers, bending, swaying, and rustling in the breeze, forms a very impressive picture, though, if you require to walk alongside for several miles, it becomes somewhat monotonous. The stems last through the winter, and well on into spring. In the beginning of April, if you look you will see myriads of sharp spear-like points protruding from the marshy ground among the reeds. These are the young shoots, whose leaf-sheaths enwrap each other closely, forming a stout pointed weapon well-fitted to pierce the somewhat tough crust which forms the upper soil of the reed bed. As the young plants grow, the old stems of the former year become broken down, and their fragments are strewn on the floor of the bed. Later these are covered with silt left behind by the river when in flood, so that if you penetrate below the surface you find that for some distance the soil is composed of fine mud filled with the *debris* of former generations of reeds, along with the still-living underground rhizomes, and the rootlets which spring from their joints, the whole forming a spongy somewhat elastic mass, resting apparently on a softer and wetter stratum below.

At certain places there are dykes which have been built, passing right through the marsh to the brink of the main channel of the river. Taking advantage of one of these, we pass through the reed bed till we reach its outer limit. Here, on softer mud, we find a parallel belt of another plant, *Scirpus maritimus*, Lin. This runs alongside the reed belt as far as the latter extends. It is not so very broad at first, but widens as it goes downwards, and at several points forms a broader band than the reed bed itself. Here and there, especially in its upper part, it is displaced by patches of *Scirpus Tabernamonti*, Gmel., the glaucous stems of which contrast strongly with the bright green of *Scirpus maritimus*; but, on the whole, the latter predominates to such an extent that this second belt may be described as consisting of *Scirpus maritimus*. Outside the second belt is a third one of naked mud, except that here and there over its inner half it is studded with outlying beds of one or other of the two sedges mentioned. Where these do not occur, the surface of the mud is ridged and roughened, sometimes cracked if it has been dry for any length of time, marked here and there by the feet of wading birds. You can see, not continously, but in rows and patches, faint tinges of green in the surface, and if you manage to obtain a bit of the mud at one of these places, and wash it well, you will find that it is permeated by the living and dead threads of a *filamentous alga*, marking the first visible effort of nature to adorn and utilise the naked mud-flat.

These three bands, the outer nearly naked mud, the middle band of sedge, and the inner reed bed, occupy the whole breadth of the marsh, except for a certain distance extending from a little above Seaside to Powgavie burn. At this part the reed bed retires from the escarpment, and between these there stretches a tract of more or less boggy land, not dry enough for cultivation, but sufficiently firm to be pastured by cattle. The pasture is certainly not of very high quality, as it consists chiefly of *Agrostis palustris*, Huds.; *Glyceria aquatica*, Sm.; *Holcus lanatus*, Lin.; *Alopecurus geniculatus*, Lin.; *Festuca elatior*, Lin.; *Deschampsia cæspitosa*, Beauv.; and *Juncus gerardi*, Lois.; diversified on its inner margin, where it has been strewed to a greater or less distance by *debris* from the bank above, by scattered clumps of *Juncus effusus*, Lin.; *Juncus glaucus*, Leers; *Carex vulpina*, Lin.; *Œnanthe crocata*, Lin.; *Carduus arvensis*, Hoffm.; *Spiræa ulmaria*, Lin.; intermixed here and there with *Lathyrus pratensis*, Lin.; *Potentilla anserina*, Lin.; *Centaurea nigra*, Lin.; *Angelica sylvestris*, Lin.; *Lychnis Flos-cuculi*, Lin.; and in wetter spots *Ranunculus sceleratus*, Lin.; or a plant or two of *Caltha palustris*, Lin. The width of this tract is increased by the fact that the cattle in spring enter the reed bed and eat down to a certain distance the young reeds, at that time juicy and tender, though they do not touch them after they have grown to a sufficient height to become drier and more woody. At a short distance below Seaside there occurs, close to the escarpment, a considerable stretch of *Glyceria aquatica*, Sm., not wide enough, however, to reach more than about half-way to the reed bed, and occupying probably a tract which is kept moist by water issuing from the bank or oozing up from below. As you come nearer to Powgavie, the abundance of *Glaux maritima*, Lin.; *Triglochin maritimum*, Lin.; *Glyceria maritima*, M. & K.; and in wet parts *Aster Tripolium*, Lin., shows that a maritime influence is now telling upon the vegetation. Below Powgavie this inmost belt of boggy ground is not found, as the reeds again approach close to the bank.

Near Monorgan farm this great tract of marsh and mud, with its parallel bands of different vegetation, practically comes to an end. A tongue of higher ground, bounded on the inner side by a much more sloping escarpment, projects for some distance. This is margined on the outer side by a narrow marshy and stony fringe, with a vegetation now distinctly maritime, consisting mainly of *Juncus gerardi*, Lois.; *Triglochin maritimum*, Lin.; *Armeria maritima*, Willd.; *Plantago maritima*, Lin.; *Glaux maritima*, Lin.; *Glyceria maritima*, M. & K.; and *Aster tripolium*, Lin.; whilst the stony margin is thickly studded with truly marine *algae*.

Below this, at the lower part of Monorgan burn, there is for a short distance a recurrence of the mud tract, with its parallel belts, but on a much smaller scale, and less distinctly marked.

It is plain, I think, from the above account, that in the great marsh and mud flat above described we have a river terrace in the making. The whole tract is only under water during high floods or tides, and on such occasions a more or less thick deposit of fine silt is left behind when the water retires. Near the main current of the river the mud deposit is soft and quite naked. Then *filamentous algae* to some extent bind the surface, and render it fit to support first detached beds of *Scirpus*, which, further in, form a continuous belt. A further stage is marked by the *Phragmites*, rendering the soil firmer and drier, though still spongy and damp. Inside this, again, a further stage occurs, where the soil has consolidated sufficiently to bear the weight of cattle, and to supply a coarse kind of pasture.

It is plain also that the flora of this marshy tract forms a distinctive association, is, in fact, an estuarine flora of a very marked character, specially fitted for its own locality, and performing there a distinctive and important work. Professor Trail informs me that a similar association exists towards the mouth of the Ythan in Aberdeenshire; and doubtless, in many other places where similar conditions prevail, the same plant association will be found to exist.

These great beds of reeds and sedges were formerly of much greater commercial value than they now are. When thatch was the common covering of ordinary dwelling-houses, a considerable revenue was obtained by cutting down the reeds and selling them for roof-coverings. To some extent they are still cut down and employed for thatching grain stacks, and small quantities are occasionally sent to the north for the purpose, according to my informant, of thatching game-keepers' cottages, or an occasional shooting lodge, where the proprietor has an eye for the picturesque and the antique. Observing that a man employed in cutting for thatch had passed through the reed beds, and was cutting down the *Scirpus maritimus*, though this entailed working on softer mud and carriage for a longer distance through the marsh, I enquired the reason, and was told that this sedge makes a better thatch than the reed, lasting longer and keeping out the rain better.

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VIII.—*The Voyage of the "Scotia."* *

By R. N. Rudmose-Brown, B.Sc.

(Read 12th January, 1905.)

Since the memorable expedition of the *Erebus* and *Terror*, under Sir James Clark Ross, in 1839-1843, the Antarctic regions received little attention from geographers—except for a flying visit of the *Challenger*—until the last decade of the nineteenth century. Probably the great distance of these regions from the exploring nations of the world had a great deal to do with this, and while Africa, America, and Asia, and even the Arctic regions, had almost yielded their secrets to explorers, our knowledge of the South Polar regions still remained fragmentary and superficial in the extreme. In the year 1893, after the visit of the Dundee whalers to the Weddell Sea and Graham's Land, there were some signs of reawakened interest in this part of the world. The *Belgica* and the *Southern Cross* expeditions added considerably to our knowledge of South Polar seas and lands, but the area to be explored was so vast that a scheme of exploration on a far larger scale was necessary. Four nations agreed to take part in this scheme—Germany, Sweden, England, and Scotland—and the year 1901 saw three Antarctic expeditions set out from Europe. The Germans in the *Gauss* were bound to the regions south of Kerguelen, the Swedish in the *Antarctic* to Graham's Land, and the English in the *Discovery* to Victoria Land. While these three expeditions were largely supported by grants from their respective governments, the fourth expedition, the Scottish one in the *Scotia*, was financed entirely by public subscription in Scotland, and foremost among those patriotic Scotsmen who sent out the *Scotia* must ever be remembered the names of Mr. James Coats, jun., and Major Andrew Coats, of Paisley. The idea of a Scottish Expedition to co-operate with those already in the field originated with Mr. W. S. Bruce, and had it not been for his untiring energy and enthusiasm in the face of many difficulties, the expedition, of which he was the leader, could never have sailed.

The *Scotia*, which was a rebuilt Norwegian whaler, was a barque-rigged auxiliary screw steamer of 360 tons, 140 feet in length, and drawing 15 feet of water. She was built of wood throughout, and sheathed in greenheart as a greater protection from wear among the ice. She was especially strengthened with huge beams 15 inches

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*I must express my indebtedness to Mr. W. S. Bruce, the leader of the expedition, for permission to publish this account of its work.—R.N.R.-B.

taken daily, and baited traps were examined in different parts of the bay every morning. Collections of birds, rocks and plants (a few mosses and lichens) were made. Meteorological observations of temperature, pressure, humidity and sunshine, etc., were continued, and tidal observations were, for six months, taken half hourly; and a detailed survey of Scotia Bay and a smaller scale one of the whole island were begun. But the work that occupied the crew, and scientists also, for the greater part of the winter was the building of a house. This house was built with a view to leaving a party of scientists in the Antarctic to continue the meteorological and biological work in the following spring, while the *Scotia* returned to civilization for a few weeks to coal and refit. We began building operations in April on a spot at one corner of a small level plain lying between Scotia Bay and a bay opening on the north of the island.* The work was very arduous, particularly as no one could lay claim to any skill in house-building, and we were unprovided with cement or even the requisite tools. The building material was quarried out of the frozen glacial moraines or dug from pits sunk in the beach. The frequent heavy blizzards and short days of winter interrupted the work to some extent, but by spring the house was complete. It was not a very pretentious building, but was substantial and very comfortable. The interior dimensions were 14 feet square and 6 to 8 feet in height. The walls, which were extremely thick, were built on the "dry-dyke" principle and lined internally with canvas. Adjoining the house was a coal and store shed, and not far off were the meteorological screens, while at the other end of the beach was the little wooden magnetical observatory.

It was during the winter that we experienced the great misfortune of losing one of our little company. After a long illness Allan George Ramsay, chief engineer, died on August 6th, 1903. It was out of devotion to the work of the expedition that he stuck to his post; had he spoken earlier of the illness he felt coming over him he would never have been allowed to go beyond the Falkland Islands. His name is perpetuated in Mount Ramsay, the highest peak in the island, at whose foot he lies buried. Several sledging journeys were undertaken in spring for sounding and surveying, and though none of them, on account of the size of the island, were very long in point of distance, they nevertheless entailed many weeks' absence from the ship. In September many Weddell Seals *(Leptonychotes Weddellii)* resorted to the islands for the birth of their young, and in October and November the penguin rookeries on all sides were reinhabited *(Pygoscelis adeliæ*

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*This bay has since been named Uruguay Cove, after the ship which the Argentine Government sent to these islands to relieve Mr. Mossman and his party.

and *P. papua* chiefly) and various Antarctic and sub-Antarctic birds came to nest. There was plenty of work for the naturalists to do, and the tameness of the birds made it easy to observe their habits and to photograph them. The eggs of the Cape Pigeon (*Daption capensis*), previously unknown to science, were secured.

The spring was well advanced when at last the floe in Scotia Bay gave way, and a few days later (November 27th), after landing a party of six men to remain at Omond House, the *Scotia* returned to the Falkland Islands. On her way a trawling was taken on the Burdwood Bank, off Cape Horn, which resulted in the richest haul of the whole voyage.

It is impossible in this article to dwell on the experiences of the *Scotia* at the Falkland Islands and during her voyage to Buenos Aires and back; this part of the cruise must be reserved for another article. At Buenos Aires the *Scotia* was dry-docked, and a few repairs effected, but the principal object in going there was to enable Mr. Bruce to try to arrange with the Argentine Government to continue the Meteorological Station at the Scotia Bay. This they readily agreed to do. On our departure for the south we took with us three Argentine scientists. Calling at Port Stanley, Falkland Islands, on our way, we made a quick run to the South Orkneys, and anchored again in Scotia Bay on February 14th, 1904. The Scottish scientists were re-embarked, and the Argentines left under the leadership of Mr. R. C. Mossman, the meteorologist of the expedition, who had consented to stay for another year. This party was relieved on January 1st, 1905, by the Argentine sloop *Uruguay*, and another party of five left in their place for the current year.

The disposition of the pack ice was very different this year. The South Orkneys and the adjoining seas were clear of ice, which enabled a south-easterly course to be set into the Weddell Sea, cutting between the two tracks of the previous year. The first ice met with was in the latitude of the Antarctic circle. In the beginning of March we had passed our previous year's record, and, where we then were stopped by inpenetrable pack, we now found nothing but loose ice or open sea. Our soundings so far had shown the same uniform depth which we found last year further to the westward, but in 72° 18′ S. 17° 59′ W. we reached bottom in 1131 fathoms. This sudden shallowing was unexpected, and almost at the same time land was reported ahead. The ice was tightly packed off this land and the ship could not get nearer than about two miles. We saw stretching before us a lofty barrier of ice running N.E. and S.W. from horizon to horizon. Inland it could be seen rising upwards, and further to the south, as we cruised along it, could be seen far in the interior a range of lofty mountains. Two miles off the ice cliff, which we estimated was some 60 to 100 feet high, the water shoaled to 150 fathoms. There was no doubt that the Scottish Expedition had here discovered a new part of the Antarctic continent, and it was named "Coats Land."

It was off this land that we attained our most southerly latitude, 74° 01′ S. 22° 0′ W. and at the same place we narrowly escaped disaster, or at least having to spend a winter under somewhat dangerous conditions. In a severe blizzard the *Scotia* was driven into the pack, and drifted helplessly before the gale. The pressure of the driving ice became very great as it piled up against the ship's sides, and she groaned ominously under the strain. This was the crucial test of the *Scotia* as an ice-boat, and she answered splendidly; as the pressure increased she was lifted bodily some four feet, and the ice met below her, and this of course relieved her of pressure and removed the source of immediate danger. However, in a day or two we found ourselves frozen firmly into the pack. As it was then the beginning of March we could not look forward very hopefully to being liberated that season. To winter thus frozen into the pack in the open sea is very dangerous. The *Belgica* did it and luckily escaped injury, but it is impossible to safeguard a ship under such circumstances; she is quite helpless, and may be carried with the driving pack and hurled on to the land or be crushed against an iceberg. We were therefore not sorry when the ice suddenly gave way, despite the zero temperatures we had been experiencing, and under the skilful guidance of Captain Robertson the *Scotia* once more reached the open sea.

After this providential escape it would have been unwise to again attempt to penetrate the pack for any great distance. We therefore turned northward, and found the water rapidly deepening again. A short easterly deviation in about the latitude 71° S. again resulted in shoaling water, which showed that we were approaching the continent, whose edge apparently ran in a north-easterly direction here. After spending a few days in trawling with great success, we steered for the so-called "Ross deep," where Ross in 1843 reported in 4000 fathoms no bottom. A sounding which we took here resulted 2660 fathoms, showing that the long supposed deep had no real existence.

The *Scotia's* course was then northward along the meridian of 10° W., with Gough Island as a prospective goal. No pack ice was met with, but icebergs were very frequent up to the latitude of 54° S. Sounding and trawling were systematically carried on, and all other observations continued. In the latitude of about 60° S. the weather began to get very bad, and we were continually battling with heavy gales from the N.W. and N.N.W., which made progress slow, while the furious seas greatly hindered the scientific work, and at times made it well nigh impossible to carry on anything but the meteorological observations and the tow-netting.

Yet one of our most important discoveries was made during this part of the voyage, namely, the extension of the mid-Atlantic ridge to the south of Gough Island, cutting off the deep water on the west from that on the east. It is this long ridge which rises above the waters in the rocks of St. Paul's, and the islands of Ascension, Tristan da Cunha, Inaccessible Nightingale, and Gough Islands. It was formerly supposed to end at Gough Island, but we proved its prolongation to 53° S., where it probably turns eastward towards Bouvet Island.

Ultimately, on April 21st, 1904, the Scottish Expedition reached Gough Island. This island lies about 200 miles from Tristan da Cunha, which is the nearest land, and about 1500 miles from Cape Town, and some 2000 miles from Cape Horn. Beyond an occasional visit from South Sea whalers and sealers, there was no record of any observations on this island, and practically no scientific collections from it were known. It covers some 20 to 25 square miles, and rises from the sea on all sides in lofty precipices several hundred feet high, leaving only a narrow strip of beach, in most places, at low water. The interior of the island is rugged and mountainous, and is apparently only accessible from the coast up a narrow glen, at whose mouth we succeeded, after some difficulty, in making a landing. To eyes long accustomed to sea and sky or ice and snow, the island was most enchanting, and probably even to more critical eyes it would appear very beautiful, with its tumbling mountain torrent and leaping cascades pouring over the cliffs into the sea, and its moss-clothed cliffs and luxuriantly growing ferns and flowers, while among the undergrowth the black and scarlet water rail *(Porphyriornis comeri)* occasionally showed himself, and on the trees or by the water's edge the green and brown finches *(Nesosriza jessiæ and N. goughensis)* flitted to and fro.

After a few hours we returned to the ship laden with collections, though, unfortunately, we had not been able to penetrate far into the inland; the weather was squally and the anchorage very bad, so that we had to remain within reach of the beach, in case a sudden recall to the ship should prove necessary.

The *Scotia* spent two other days off Gough Island, but on neither would the state of the sea permit landing. We, however, considerably enriched our large collections of birds, to which we had added a new albatross a few days previously. On leaving Gough Island we turned eastward, and, favoured by fine weather, succeeded in sounding a stretch of previously uncharted ocean, finally reaching Cape Town on the evening of May 5th, 1904. Two weeks later the *Scotia* left South Africa, after a two days' call at Saldanha Bay, and touching at St. Helena, Ascension, and Fayal (Azores), at each of which a stay of a few days was made, reached the Clyde, and on July 21st, 1904, anchored off Millport.

Such is an outline of the voyage of the *Scotia*, and the results achieved. There are few branches of science that do not benefit from such a voyage, but it takes time to put the results in order. In some three years' time the real work done by the Scottish Expedition will be available to the scientific world, and then only can an accurate estimate of its success be made; but from what is known already of the observations and collections, it is not too much to claim that the Scottish National Antarctic Expedition has fully justified the hopes of those who so patriotically sent it out on its voyage of discovery. But the Antarctic regions are vast, and much remains yet to be done. When the results of the German, Swedish, English, and Scottish expeditions are published, it will be possible to see more definitely the direction that exploration should take, and to understand more clearly the problems awaiting solution; then it will be time for another attack on these unknown regions, and it is to be hoped that Scotland will again take her share in it.

IX.—*The Carpathians.*

By Miss Murray Macgregor.

(Read 9th February, 1905.)

Entering the kingdom of Hungary from Vienna, the railway, proceeding along the left bank of the Danube, near the station of Marchegg, crosses the river March or Moravia, the boundary between Austria and Hungary, passing just before Presburg, by a tunnel 1,800 feet long, under one of the spurs of the lesser Carpathians at their south-west corner, where they sink into the plain. The range bounding Hungary on the west stretches northwards to the Polish border, where its mountains attain their greatest height, and, skirting that frontier, the chain returns southward and with a broad sweep westwards again separates Transylvania from Wallachia. Pest was reached in seven hours from Vienna. It is not our purpose to give any account of this finely situated but modern city, nor even of the more interesting Buda on the opposite side of the Danube, with its fortress placed on an elevated rock, and with the Burg or King's palace; but we had, however, the good fortune to be there on the day of the opening of the "Landstag" or Parliament, when we saw all the Magyars driving over the Suspension Bridge to the Burg to visit the

Plate 7.—Saddle Island, South Orkneys.

Plate 8.—Glacier at Head of Macdougal Bay, North Coast of Laurie Island.

Plate 9.—Cape Dundas and Ferrier Peninsula, eastern extremity of Laurie Island.

Plate 10—Glen on Gough Island.

Emperor King. All wore their national dress, magnificent furs, chains studded with hereditary jewels, "kalpags" of fur on their heads with herons' plumes and sparkling aigrettes, velvet tunics, white pantaloons and high boots. There were mostly handsome men, and the whole scene was a spectacle of old-world grandeur not to be witnessed elsewhere.

To reach our ultimate destination, the small town of Igló in the "Zipzer Comitat," near the northern Carpathians, we were recommended to go by Kaschau, to which the line of railway northward was fairly direct, but we made a longer turn to visit the interesting town of Debreczin. On leaving Pest towards the east, the traveller enters the Puszta, one of the largest plains in Europe, stretching from Pest to the borders of Transylvania, and from Belgrade to the hills of Hegyalja, and occupying a space of nearly 5,000 square miles. Dead level everywhere, not the varieties of light and shade and slight undulations of the Egyptian desert, but an unbroken flat grassy surface. To the natives of the land of the mountain and the flood it seems monotonous, yet the illimitable space, the distant horizon, the great expanse of sky have a charm, while the varieties of flocks and herds, each with its own guardian, afford delight to those who enjoy the novelties of travel. The inhabitants of these vast plains are as enthusiastic in their love for them as we Highlanders are of our hills. They keep very much to their own castes as regards occupation. Shepherds, carrying crooks with rings attached to the curve making a tinkling call; cattleherds, horseherds, careful to protect their charges from the professional horse stealer or "Czigos," a most gentlemanly man, who rides about and catches his fancy horse with a lasso; swineherds, gooseherds—all of these are to be seen dotted about on the short herbage, or walking along the white dusty roads; and great is the variety of their dress, but over it almost every Hungarian peasant wears a "Bunda," or cloak of sheepskin, the leather tanned and ornamented with coloured embroidery; he wears the woolly side out in ordinary weather, but when it is very cold, it is turned inside, and then the embroidery can be admired. Wherever there is a habitation, a row of sunflowers can be seen, looking very attractive in the absence of other plants of similar height; they are planted to supply oil for the peasants.

One of the best writers on Hungary, John Paget, in 1855 remarks on the very scanty population of the country. This did not strike us. On the contrary, at the railway stations the number of people travelling seems extraordinary, if it is not compared with the immediate neighbourhood of London or the running of excursion trains. The third-class carriages had two tiers of floors like some sheep trucks, and the peasants crowded into these. Their ordinary dress was very wide canvas or coarse linen trousers, easily mistaken for a nightgown, reaching below the knees. These were tucked into high black boots where the wearers did not prefer, as they often did, to go barefoot, whilst a short shirt or jerkin, also of linen, just met the trousers at the waist. Some had their toilettes completed by little open jackets of light blue with silver buttons. The railway trains are specially convenient for those who are in no special hurry. At the proper time for supper a halt is made that passengers and officials may enjoy that meal in peace. After crossing the river "Theiss" or "Tisza" we observed huge watch-fires lighting up the darkness, and groups of peasants and shepherds sitting or lying around. It was past 2 A.M. before we reached Debreczin. It is called the largest village in Europe, with low mostly one-storied houses, very wide streets paved down the centre, and the sides left free for dust or mud according to the weather. It is a free town, containing 30,000 inhabitants, mostly Calvinists, and it has a large Protestant Church and a College.

The next day's journey was by Tokay, where the famous wine is made from grapes grown on the Hegyallja Hills; there the Puszta ends. The train proceeds by Miskolz to Kaschau (in Hungarian Kassa), a free town of 22,000 inhabitants (in 1873), situated at an elevation of 1,064 feet above the sea, and it is a very central station. Our present route was westward by a very pretty line of railway along the valley of the river Hernad, with a remarkably steep ascent and numerous sweeping curves. Leaving Kaschau at 5.30, we reached our destination, Igló, to be welcomed by a most kind host, Major Hamilton Dundas, a Scotchman in the Austrian service, who had married a very charming Hungarian lady, and had two daughters. Visiting them twice, and spending many weeks with them on each occasion, viz., in 1872 and 1880, we had time to become acquainted with the country, especially as every one was anxious to supply all information possible and to show whatever was considered most interesting.

Igló is one of the sixteen free Zips towns founded by Saxon immigrants in the twelfth century. It is very long, but in other respects resembles a village. It has a Catholic and a Protestant Church, a town hall and a few good houses; the out-skirts have very picturesque peasants' dwellings, with dark grey wooden gables facing the immensely wide street, quite peculiar to Hungary. The view of the Tatra group of the Carpathians, at about thirty miles distance, is very fine; the range of high hills is bluish as in Scotland, with many lights and shades playing upon it, and it rises somewhat abruptly from the plains beneath. The Tatra, which is the portion of the chain visible from Igló, forms a very distinct group, bounded at each end

Plate II.—Kohlbach Valley from the Ridge.

by a valley, and has a variety of beautiful summits. It separates the north of Hungary from Poland.

A short digression may here be permitted in reference to what perhaps belongs properly to the ethnological department. It is very curious to observe in Hungary the great number of nationalities united under one government. Igló is in the county Zips, in Hungarian "Szepes Varmegyr," the nobles are true Magyars, the peasants chiefly Slavonians, and the middle classes in this county Germans, who emigrated from Saxony and settled in Zips under one of the Hungarian Kings in the twelfth century. The Slavonians were the occupants of the country at the time of the first invasion of the Magyars in the ninth century, and have continued to live amongst their conquerors as a perfectly distinct people. They are chiefly Roman Catholics, and are of an amiable, patient, and very domestic disposition, but are said to be greedy and deficient in intelligence. The gentry in Hungary require to know a variety of languages. The two delightful daughters of our host spoke perfect English, their father's tongue; Hungarian, their mother's; some broad Scotch picked up from the old stories of their father's aunts in Scotland; Latin, as the received medium of culture throughout the kingdom; German, as necessary in the Austrian dominions; French, as the old Court language; and Slavonian, in which to speak to the servants: and they could rapidly change from one to the other. All the family were well versed in the history, the traditions, and the peculiarities of their country, and rejoiced in them. When walking or driving, one met specimens of many different types, a Trentschiner or native of Trentschin in the Waag Valley, hung over with what looked liked mousetraps, but which were really tin wares of various kinds, which these men make and hawk about. Further on, one would meet a man hung round with coils of wire; he was a "Drahtzieher," and he was welcomed in most households, to mend kitchen utensils and to work a kind of wire protection to the stewpans, which, being of earthenware, often got cracked. Sometimes even a "Gortziva" or native of Görz, near the Adriatic, got as far north, carrying, in nets, sponges and little bottles of figs and candied fruits. Then the gypsies, the most fascinating types of individuality! This is the land of the "Czigany," where they flourish and seem most at home. Indeed, they have been settled here since early in the fifteenth century. The children run about without a stitch of clothing, looking like little brown bears, or run after the carriages, turning somersaults and begging for coppers. The men have a natural turn for music, and the favourite Hungarian bands, so popular in Great Britain, are chiefly gypsies. They play entirely by ear. The leader of the orchestra goes to Pest or wherever he can hear the newest music, and on his return instructs his comrades.

When they have saved a little money they remain idle, sitting on the tops of their houses, and fiddle away for their own amusement, till their funds are expended, when they must recommence their travels. Large sums are given to them by Hungarian nobles, who delight in their music. It is also considered lucky to meet a gypsy, whereas to meet a priest ruins the sport for the day, and Jews are equally unlucky. There are a great many of these, chiefly occupied in keeping little shops or small inns, which are usually remarkably clean, although the host himself is very much the reverse.

To visit the Ice Cave we drove westwards through Donnersmarkt, and crossing the Hernad, passed southward through a range of low hills clothed with a mixture of deciduous trees, firs, and spruces. The Slavonian charcoal burners were very characteristic, with long black hair, dark faces, and enormous hats, rattling along in light carts with four or five horses, full tilt downhill, cheerfully willing to upset themselves into a ditch, or anywhere, to make room for a gentleman's carriage. We slept at the house of the manager of the Palzman Ironworks, belonging to our host and hostess. Next morning, after visiting the works, we drove on, passing, at the village of Sztraczema, the ironworks of Prince Coburg Kohary, who married Princess Clementina, daughter of King Louis Philippe, and who was then the head of the Roman Catholic branch of the Coburg family; thence on through an exceedingly pretty country, hills and grey rocks of fantastic shapes partially wooded. The road perpetually crosses the very rapid river, so that there are no fewer than twenty-six bridges in a few miles. We drove through a natural archway of rock, the "Felsen Thor," and eventually turning away from the river towards the south, came to some conical shaped hills. Near one of these, the "Knockstein," we drove over the grass to a keeper's house, and, leaving the carriage, ascended by an easy zigzag path the wooded hill where the Ice Cave was to be explored. Visitors are enjoined to halt for an hour in a covered shed before entering the chilly atmosphere underground. After this, all superfluous garments were discarded, and we entered the cave. A few loose stones and rocky steps led to the entrance, through which we had to stoop for four or five paces, then, descending a flight of wooden steps, we reached a space like a vast hall. The guide lit up lime lights, when arches and columns of glistening ice appeared all around. The ground, being a mixture of wet earth and ice, was very slippery. We passed some springs, where the water bubbled up in a perpetual fountain round a central stem of ice. After walking along several galleries, we descended a long series of stairs; some of the steps were cut in the ice, with only a tottering handrail; others of wood sloped uncomfortably backwards, to prevent the visitor falling forwards. Below were

Plate 12.—The Polish Comb and Ice-fields.

shown various strange forms of ice, the most remarkable of which was a round veil of thin transparent ice, like a frozen shower bath, of which only the outer rim had fallen; a light held behind it had a beautiful effect. In another place we saw an actual glacier, a curved slope of thick ice, without any ridges to break its smooth surface, and at one point we were able to go below the glacier as under a bridge. The guide descended by a ladder to a lower cave to get us some stalactytes. The ascent on the slippery steps, clinging to the handrails, made knees shake and arms grow stiff. The temperature was said to be not lower than 25° Fahrenheit, but when we emerged again the change to the open air felt like a Turkish bath. This cave, the name of which is the "Dobschauer Eishole" or "Dobsinai Jegbarlang," belongs to the town of Dobschau, and was only discovered in 1869. Another Ice Cave, "Demenfalva," mentioned in Paget's Hungary, is situated farther west in the same range of limestone hills.

Returning to our headquarters, Igló, we will start fresh from there for an expedition to the Tatra range of the Carpathians. This group is about 72 miles long from east to west, and 27 broad. The mountains rise out of the plain like a wall, without what is significantly known elsewhere as "Voralpen" or lower hills. The region contains 112 lakes or tarns, called in German "Meer Augen," or eyes of the sea. There is a railway running west from Igló to Oderberg, but we preferred to drive the whole way, partly along the same road as to the Ice Cave, but it must be borne in mind that the country we then visited was a good bit southward from the Carpathians, whereas our present object was to get to them. We therefore turned north at the little town of Poprad, and just before it, at a place called Hozelecz, came to one of the European watersheds. Here a slight rise divides the valley of the Hernad, which river flows through the Theiss and the Danube into the Black Sea, from the little river Poprad, which, skirting a corner of the Tatra range, makes its way into Poland and, by the Dunayecs and Vistula, into the Baltic Sea. As regards the drive onwards, I will here quote from my own journal:—"The view of the Carpathians was magnificent, the Tatra range rising abruptly from the undulating plain, each end of the chain quite detached from other hills; the grey summits are rocky and precipitous, the shoulders covered with scanty herbage of a delicate green, bare of trees except in the deep corries which divide the peaks, or on the lower slopes. The foreground alone was deficient in feature, consisting merely of low willows; yet the picturesque carts and varied figures might have remedied this want in artistic hands. Leaving the high road at Felka, a stony track between stubble fields leads to the villages of Gross Slagendorf and Neu Waldorf, thence a broad road through a plantation leads straight uphill to Schmöcks, in Hungarian, "Tatra Fured," a watering-place, consisting of a group of châlets, very much frequented by Hungarians, and said to have a remarkably healthy climate. It is at an elevation of 3258 feet."

The following quotations from a book called "Magyarland," published in 1881 by "A Fellow of the Carpathian Society," will give some details for the benefit of our botanists:—"In consequence of the Tatra being exposed to the north wind during the greater part of the year, vegetation is much retarded, and the elevation at which the various species of coniferæ grow is considerably lower than that of Switzerland. For example, the zone at which the pine, *Pinus picea* (silver fir), is found in Switzerland is 4077 feet, whereas in the Tatra it is only 3585; whilst the difference in the altitude at which the Scotch fir, *Pinus silvestris*, grows in both regions is 900 feet. The larch, on the contrary, is met in the Tatra at almost the same elevation as in Switzerland." Again a quotation for our geologists:—"Nowhere in the region of the Tatra are there any real glaciers, but lying in some of the valleys towards the north there are vast fields of perpetual snow, together with unmistakable evidence of the existence of glaciers at some former period. The snow does not lie much on these peaks after June, the reason assigned being that their extremely sharp declivities afford no flats or ledges upon which it can rest."

"The principal constituent of these mountains is granite, though of a somewhat different kind from the ordinary crystalline rock of that name. This difference is not observable in small blocks, but is very marked in some of the rocky precipices, for example, in those of the Lomnitzer group. There, where the rock forms an upright precipice, the parallelism of the strata, which often measure four feet in thickness, is very clearly distinguished. The bed dips from east to west, slightly inclining from the ridge, which circumstance causes the small peaks or needles of this mountain to bend over and assume very singular and fantastic forms."

In the forests, besides ordinary game, there are wolves, bears, and polecats; in the higher regions, chamois and marmot; and amongst the rocks, golden eagles and vultures. The highest peak is the Gerlsdorf, 8750 feet; next, the Eisthaler Spitze, 8690 feet; the third highest is the Lomnitzer Spitze, 8648 feet.

Above the group of châlets forming Bad Schmöcks looms the great Lomnitzer Spitze. The Bad is a delightful spot for intrepid mountaineers as a starting-point for excursions. Near the baths and mineral springs, walks and convenient paths have been made to places of interest. In 1873 "The Carpathian Exploration Society" was formed for the purpose of investigating the mountains from a

Plate 13.—The Felkar Lake, Flower Garden and the Gerlsdorf Peak.

scientific point of view, making and improving paths over the various passes, erecting places of refuge for travellers, and organising the proper training of guides. A comparatively short expedition is to the waterfalls of the Kohlbachthal. This valley lies between the Lomnitzer Spitze "and the Konig's Nase, which summit is seen just north of Igló, where it is held to be a weather prophet. The upper part of the valley is divided by a hill called the Mittelgrad into two glens, in which run the streams called the Great and the Little Kohlbach." The latter is at a high elevation, and is reached by a passage over granite blocks called the "Treppen," from its resemblance to steps. This burn comes from the Funf Seen, or five lakes, which are said to be wonderfully beautiful and wild, lying immediately below the rugged peaks called the "Polnischer Kamm." The two streams unite near the lowest of three falls, to which the masses of rock give much grandeur. A few spruces follow the course of the stream, although, from the absence of trees along the greater part of its stony bed, it derives its name of "Kohlbach," or "bald brook." Mist concealed the tops of the hills (our visit was late in September), but the valley was exceedingly curious and unlike anything I have seen elsewhere. With immense fragments of grey rocks strewn wildly about, *Pinus montana* and juniper the only verdure, the whole effect was one of devastation, truly magnificent!

Not having been able to scale the higher parts of the Tatra, I beg to quote here an admirable description from a work published in 1862, called "Across the Carpathians," by the late Miss Muir Mackenzie of Delvine, our friend Sir Alexander's sister. Although the weather was uncertain, the guides undertook to show Miss Mackenzie and her travelling companion the "Felka See," the "Blumen Garten," and the "Polnischer Kamm." After a difficult ride from Schmöcks through the forest to the open side of the hill, the narrative continues, "At our feet lay the valley of the Felka, with the lake, before us a frozen waterfall flung its glittering veil over the precipice, behind us rose that garnet-studded cliff called the 'Graneten Wand.'" The horses having been left, the travellers succeeded in scaling one side of the ice-encrusted rock, thus gaining a sort of second storey, once the basin of a second lake. "In this ice-bound region our feet rested on a carpet of flowers, large white anemones intermingled with purple bells." "To the Langer See, on a still higher storey, we attained after a still harder climb. This long narrow lake is one of the highest in the Tatra and in colour like an emerald, as deep, as clear, as green. From its shores no peaks are visible, nothing but the straight-backed perpendicular ridges to which the Ziper Saxo have given the name of 'Kamme' (Combs). The back of the Polnischer Kamm commands a view on both sides of the mountains but its side seems shattered to pieces and the cracks filled up with half-melted snow." Another writer mentions that one of the attractions of the Felka See is the "Graneten Wand" a purplish rock rising from it. The shore beneath this mountain is strewn with fragments in which the crimson stones lie almost as closely as currants in a plum pudding, varying in size from a pea to half an inch in diameter. "Immediately above this lake is the Gerlsdorfer Spitze and the following are the geological facts mentioned in connection with it:—'On the western side, and 150 feet above the level of the valley, there exist evidences of glacial action in the bed of an ancient moraine, a mile in length, containing pointed and jagged blocks of granite, which could not have fallen from the precipitous heights which rise on either side (these being formed of dolomite), and must therefore have been brought hither from a considerable distance by the slow but steady course of the glacier.'"

My subject, I fear, has occupied already too much time this evening. I may, however, mention one other expedition through the Tatra range by the Magura Pass when we stayed two nights at a very old castle belonging to some Hungarian friends. Nedecz is perched on an eminence overlooking the river Dunajaz, the boundary between Hungary and Poland, where on the opposite bank a still more ruined castle, "Czorcztyn," keeps guard. In the character of the Hungarians we found a great deal to admire, and with which natives of Scotland can sympathise. They are full of spirit, of generosity, and of genial hospitality.

FLORA OF THE TATRA.

Atragene alpina, L.
Thalictrum minus, L.
Anemone pulsatilla, L.
Adonis aestivalis, L.
Myosurus minimus, L.
Ranunculus aquatilis, L.
Ranunculus aconitifolius, L.
Ranunculus montanus, Willd.
Trollius europaeus, L.
Aquilegia vulgaris, L.
Aconitum moldavicum.
Aconitum variegatum, L.
Actaea spicata, L.
Cimicifuga foetida, L.
Corydalis cava, Schwgg.
Arabis hirsuta, Scop.
Arabis arenosa, Scop.
Arabis Halleri, L.
Cardamine amara, L.
Cardamine hirsuta, L.
Dentaria glandulosa, W.K.
Dentaria bulbifera, L.
Hesperis matronilis, L.
Alyssum calycinum, L.
Lunaria rediviva, L.
Thlaspi alpestre, L.
Lepidium draba, L.
Lepidium ruderale, L.
Biscutella laevigata, L.
Viola palustris, L.
Viola mirabilis, L.
Viola tricolor, L.
Viola biflora, L.
Reseda lutea, L.

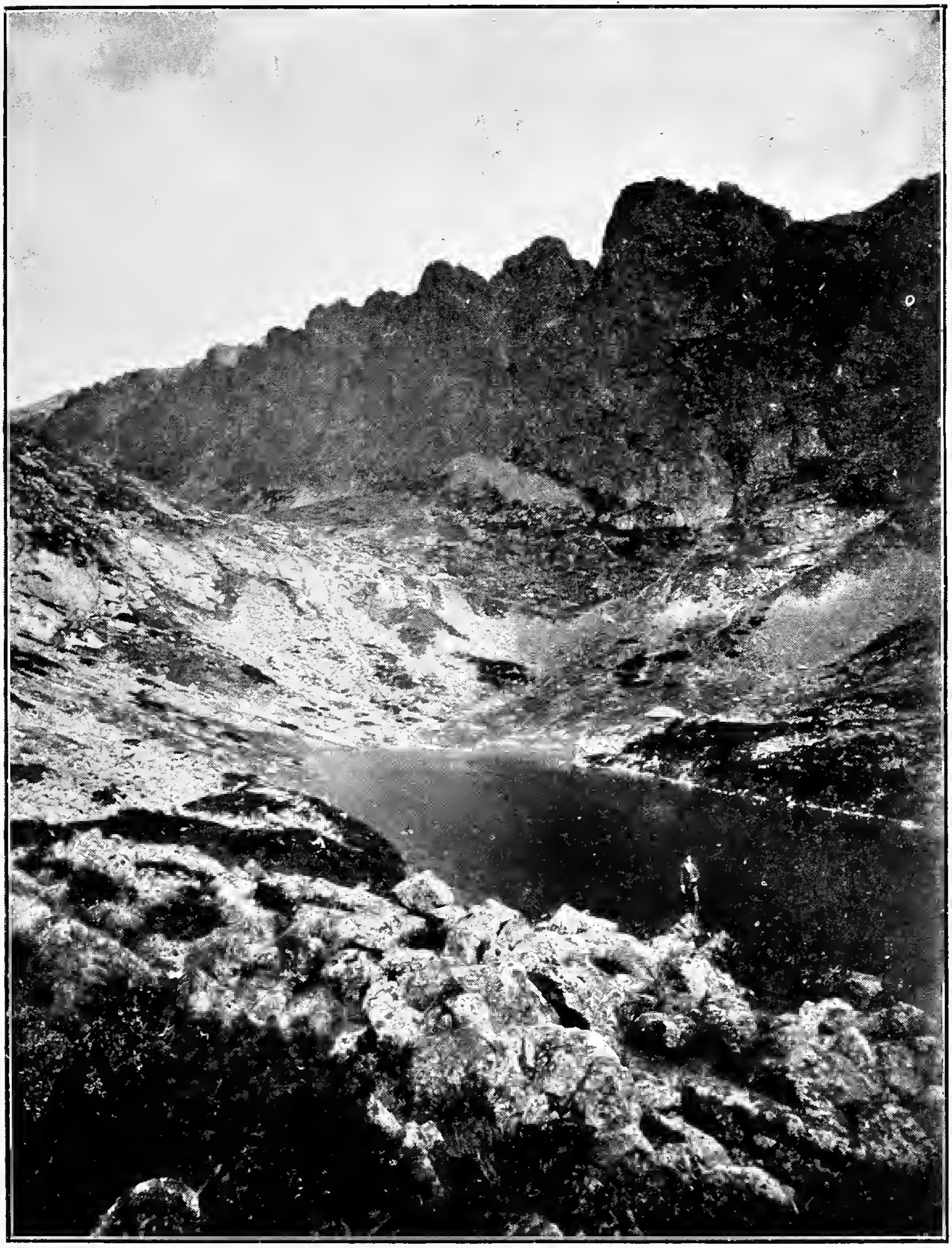


Plate 14. – Felkar Lake with the Garnet Rock.

Drosera rotundifolia, L.
Polygala major, Jacq.
Polygala amara, L.
Spergula nodosa, Fenzl.
Alsine rubra, Wahl.
Alsine verna, Bartl.
Alsine laricifolia, Whlnb.
Moehringia trinervia, Clairv.
Stellaria uliginosa, Murr.
Stellaria nemorum, L.
Malachium aquaticum, Fr.
Cerastium glomeratum, Thuill.
Cerastium longirostre, Wick.
Dianthus deltoides, L.
Dianthus plumarius, L.
Silene italica, Pers.
Silene nutans, L.
Linum flavum, L.
Lavatera thuringiaca, L.
Malva silvestris, L.
Hypericum quadrangulum, L.
Geranium silvaticum, L.
Geranium bohemicum, L.
Geranium robertianum, L.
Cytisus nigricans, L.
C. hirsutus, L.
Trifolium medium, L.
T. alpestre, L.
T. pannonicum, Jacq.
T. fragiferum, L.
T. spadiceum, L.
Astragalus hypoglottis, L.
A. glycyphyllos, L.
Hippocrepis comosa, L.
Onobrychis sativa, Lam.
Vicia pisiformis, L.
Vicia silvatica, L.
Vicia pannonica, Crntz.
Lathyrus hirsutus, L.
Orobus vernus, L.
Rubus saxatilis, L.
Comarum palustre, L.
Potentilla alba, L.
Potentilla aurea, L.
Potentilla verna, L.
Spiraea Aruncus, L.
Epilobium (Species).
Myriophyllum verticillatum, L.
Sedum fabaria, Koch.
Sedum album, L.
Sempervivum soboliferum, Sims.
Saxifraga aizoon, Jacq
Saxifraga tridactylites, L.
Saxifraga granulata, L.
Pimpinella magna, L.
Falcaria Rivini, Host.
Bupleurum falcatum, L.
Bupleurum longifolium, L.
Seseli glaucum, Jacq.
Seseli coloratum, Ehrh.
Libanotis montana, Crntz.
Selinum carvifolia, L.
Angelica silvestris, L.
Laserpitium latifolium, L.
Torilis Anthriscus, Gmel.
Anthriscus alpestris, W. & Gr.
Chaerophyllum bulbosum, L.
Pleurospermum austriacum, Hoff.
Sambucus ebulus, L.
Galium boreale, L.
Galium pusillum, Sm.
Asperula tinctoria, L.
Asperula galioides, M.B.
Centaurea montana, L.
Carduus Personata, Jacq.
Carduus defloratus, L.
Carduus collinus, W.K.
Cirsium canum, M.B.
Cirsium heterophyllum, All.
Cirsium eriophorum, Scop.
Leontodon incanus, Schrnk.
Scorzonera humilis, L.
Hypochoeris radicata, L.
Hypochoeris uniflora, Vill.
Prenanthes purpurea, L.
Mulgedium alpinum, Cass.
Crepis praemorsa, Tausch.
Crepis Jacquini, Tausch.

Crepis succisifolia, Tausch.
Hieracium pratense, Tausch.
Hieracium aurantiacum, L.
Hieracium saxatile, Vill.
Hieracium murorum, L.
Phyteuma orbiculare, L.
Phyteuma spicatum, L.
Campanula rotundifolia, L.
Campanula latifolia, L.
Campanula carpatica, Jacq.
Campanula Scheuchzeri, Vill.
Adenophora liliifolia, Le.
Pirola chlorantha, Sw.
Pirola rotundifolia, L.
Pirola secunda, L.
Pirola uniflora, L.
Monotropa hypopitys, L.
Vincetoxicum officinale, Mnch.
Gentiana asclepiadea, L.
Gentian verna, L.
Gentiana ciliata, L.
Erythraea linariifolia, Pers.
Erythraea pulchella, Fr.
Cynoglossum officinale, L.
Symphytum tuberosum, L.
Cerinthe minor, L.
Pulmonaria angustifolia, L.
Verbascum Lychnitis, L.
Scrophularia Scopolii, Hoppe.
Digitalis ambigua, Murr.
Veronica latifolia, L.
V. dentata, Schmt.
V. spicata, L.
Euphrasia salisburgensis, Funk.
Pedicularis silvatica, L.
Pedicularis Sceptrum Carolinum L.
Melampyrum pratense, L.
Melampyrum silvaticum, L.
Orobanche coerulea. Vill.
Orobanche flava, Mar.
Orobanche Galii, Duby.
Lathraea squamaria, L.
Origanum vulgare, L.
Calamintha acinos, Clairv.
Calamintha alpina, Lmk.
Melittis Melissophyllum, L.
Stachys alpina, L.
Stachys recta, L.
Primula longiflora, All.
Primula officinalis, Jacq.
Primula auricula, L.
Cortusa Matthioli, L.
Soldanella alpina, L. (major and minor).
Trientalis europaea, L.

FLORA OF THE ZIPSER TATRA.

No. 1. The Wood Region (Missing out Ferns, Grasses, &c).

Berberis vulgaris, L. (rare).
Acer Pseudoplatanus, L.
Cotoneaster vulgaris, Lindl.
Spiraea media, Schmidt.
Rosa alpina, L.
Rosa pimpinellifolia, L.
Prunus avium, L.
Sorbus aucuparia, L.
Ribes Grossularia, L.
Ribes alpinum, L.
Sambucus nigra, L.
Sambucus racemosa, L.
Lonicera nigra, L.
Lonicera Xylosteum, L.
Valeriana tripteris, L.
Scabiosa Columbaria, L.
Adenostyles alpina, Bluff et Fing.
Aster Amellus, L.
Bellidiastrum Michelii, Cass.
Solidago Virga-aurea, L.
Achillaea tanacetifolia, All.
Chrysanthemum rotundifolium, W.K

Artemisia Absinthium, L.
Gnaphalium silvaticum, L.
Doronicum austriacum, Jacq.
Cineraria crispa, Jacq.
Senecio silvaticus, L.
Carlina vulgaris, L.
Vaccinium Myrtillus, L.
Vaccinium Vitis-idaea, L.
Vaccinium uliginosum, L.
Calluna vulgaris, Salisb.
Arctostaphyllos officinalis, Wimm.
Andromeda polifolia, L.
Polygonum amphibium, L.
Daphne cneorum, L.
Fagus silvatica, L.
Quercus sessiliflora, Sm.
Betula alba, L.
Betula pubescens, Ehrh.
Salix pentandra, L.
Salix riparia, Willd.
Salix Capraea, L.
Salix silesiaca, Willd.
Salix aurita, L.
Salix nigricans, Sm.
Salix myrtilloides, L. (rare).
Corallorhiza innata, R. Br.
Orchis mascula, L.
Orchis sambucina, L.
Orchis globosa, L.
Gymnadenia odoratissima, Rich.
Ophrys myodes, L. (rare).
Epipactis latifolia, All.
Neottia Nidus-avis, Rich.
Cypripedium Calceolus, L.
Crocus vernus, L.
Galanthus nivalis, L.
Tofieldia calyculata, Whlnb.
Veratrum album, L.
Lilium Martagon, L.
Gagea arvensis, Schult.
Allium carinatum, L.
Allium acutangulum, Schrad.
Paris quadifolia, L.
Convallaria Polygonatum, L.
Convallaria verticillata, L.
Convallaria majalis, L.
Majanthemum bifolium, Schmdt.
Abies excelsa, Lk.
Abies Larix, Lmk.
Abies alba, Mill.
Pinus Cembra, L.
Juniperus communis, L.

No. 2. The "Krumholz Region."

Anemone alpina, L.
A. narcissiflora, L.
Ranunculus alpestris, L.
R. Thora, L.
Delphinium elatum, L.
Aconitum Napellus, L.
Arabis alpina, L.
Arabis ciliata, R. Br.
A. neglecta, Schult.
Cheiranthus helveticus, Whlnb.
Petrocallis pyrenaica, R. Br.
Draba aizoides, L.
D. tomentosa, Whlnb.
Kernera saxatilis, Rchb.
Cochlearia officinalis, L.
Hutchinsia alpina, R. Br.
Helianthemum oelandicum, Whlnb.
Spergula saginoides, Sw.
Arenaria ciliata, L.
Stellaria cerastoides, L.
Cerastium alpinum, L.
Cerastium latifolium, L.
Gypsophila repens, L.
Dianthus superbus, L.
Silene quadrifida, L.
Silene acaulis, L.
Empetrum nigrum, L.

Linum perenne, L.
Trifolium badium, Schreb.
Phaca alpina, Jacq.
Ph. frigida, L.
Oxytropis montana, D.C.
Astralagus australis, Lmk.
A. oroboides, Horn.
Hedysarum obscurum, L.
Potentilla verna, L.
Geum montanum, L.
Dryas octopetala, L.
Epilobium alsinaefolium, Vill.
Rhodiola rosea, L.
Sedum atratum, L.
Sedum repens, Scleich.
Sempervivum montanam, L.
Ribes petraeum, Wulf.
Saxifraga hieracifolia, W.K.
S. caesia, L.
S. muscoides, Wulf.
S. perdurans, Kit.
S. androsacea, L.
S. adscendens, L.
S. carpatica, Rchb.
Bupleurum ranunculoides, L.
Meum Mutellina, Gärt.
Gaya simplex, Gaud.
Conioselinum Fischeri, Wimm.
Archangelica officinalis, Hoffm.
Heracleum augustifolium, Jacq.
Laserpitium Archangelica, Wulf.
Myrrhis odorata, Scop.
Aster alpinus, L.
Erigeron atticum, Whlnb.
Erigeron alpinum, L.
Erigeron uniflorum, L.
Chrysanthemum alpinum, L.
Artemisia spicata, Wulf.
Gnaphalium Leontopodium, Scop.
Gnaphalium norvegicum, Gunner.
Gnaphalium carpaticum, Whlnb.
Aronicum Clusii, Koch.
Centaurea kotschyana, Heuff.
Taraxacum officinale, Web.
Hieracium villosum, L.
Hieracium humile, Host.
H. prenanthoides, Vill.
Campanula alpina, Jacq.
Gentiana punctata, L.
Gentiana acaulis, L.
Gentiana nivalis, L.
Swertia perennis, L.
Cerinthe alpina, Kit.
Myosotis silvatica, Hoffin.
Veronica aphylla, L.
Bartsia alpina, L.
Pedicularis versicolor, Whlnb.
P. Hacquetii, Graf.
P. verticillata, L.
Rhinanthus alpinus, Baumg.
Pinguicula alpina, L.
Androsace villosa, L.
A. obtusifolia, All.
Primula minima, L.
Plantago montana, Lmk.
Polygonum viviparum, L.
Salix hastata, L.
Salix Myrsinites, L.
Salix reticulata, L.
Salix retusa, L.
Gymnadenia albida, Rich.
Listera cordata, R. Br.
Lloydia serotina, Salish.
Allium Schoenoprasum, L., var. alpinum.
Streptopus amplexifolius, D.C.
Luzula spadicea, D.C.
Luzula spicata, D.C.
Juncus filiformis, L.
Juncus trifidus, L.
Juncus triglumis, L.
Carex lagopina, Wahl.
Carex caespitosa, L.
Carex atrata, L.
Carex capillaris, L.
Carex fulignosa, Schk.
Carex sempervirens.
Carex firma, Host.

Eriophorum vaginatum, L.
Eriophorum Scheuchzeri, Hoppe.
Phleum Michellii, All.
Phleum alpinum, L.
Agrostis rupestris, All.
Avena versicolor, Vill.
Avena flavescens, L. var. carpatica.
Festuca varia, Haenke.
Festuca carpatica, Dietr.
Pinus Mughus, Scop. (from 1450 to 1700 or even 1920 Austrian Metres).
Juniperus communis, L., var. nana, Willd.
Lycopodium Selago, L.
Lycopodium alpinum, L.
Selaginella spinulosa, A. Br.
Woodsia hyperboraea, R. Br.
Aspidium Lonchitis, Sw.
Cystopteris montana, Link.

No. 3. Hoch Alpen Region (High Alpine Region).

Ranunculus rutaefolius, L.
R. glacialis, L.
R. pygmaeus, Whlnb.
Papaver alpinum, L.
Cherleria sedoides, L.
Dianthus glacialis, Haenke.
Geum reptans, L.
Saxifraga retusa, Gouan.
S. oppositifolia, L.
S. bryoides, L.
Senecio abrotanifolius, L.
S. carpaticus, Herbich.
S. incanus, L.
Saussurea alpina, L.
S. pygmaea, Spr.
Leontodon Taraxaci, Loisel.
Hieracium glanduliferum, Hoppe.
Phyteuma pauciflorum, L.
Gentiana glacialis, Vill.
Oxyria digyna, Camp.
Salix herbacea, L.
Chamaeorchis alpina, Rich.
Sesleria disticha, Pers.
Poa laxa, Haenke.

IX.—*The Nesting of the Great Crested Grebe (Podiceps cristatus) in Perthshire.*

By W. Whyte.

(Read 12th January, 1905).

On the 18th of June last year the members of the Society were invited by Mr. Cox of Snaigow to make one of their summer excursions the occasion of a visit to his place. Unfortunately the leading ornithologists of the Society were unable to be present owing to other engagements. The object of the excursion was primarily to ascertain if the Spotted Craik might be found breeding in the vicinity, as Mr. Cox had shot one earlier in the season. Mr. Rodger and I arrived at Murthly Station and found that we were the only passengers for Snaigow, although we did meet a pair of cyclists on the road who meant to go there, but must have missed the way, as we saw them no more again that day. After a stiff walk of three or four miles we arrived at Snaigow House, where we were very kindly received by Mr. Cox. After showing us his gun-room, some very fine stuffed specimens of game and other birds, and a very pretty collection of eggs, a conveyance was got ready, and Mr. Cox drove us to a sheet of water on the estate, where we might expect to meet with the object of our search. Having got the boat out, we rowed along the edge of the loch, and after I had made an abortive attempt to search the shore, which was rendered almost impossible owing to the luxuriant and tangled nature of the vegetation, and the many marshy inlets which extended for a considerable distance inland, I received a signal to re-embark, for which I was not sorry, and was informed that they had found the nest of the Great Crested Grebe, and on pushing the boat through the long reeds which fringe a portion of the loch, I saw the rather bulky structure which forms the nest of this bird. It was floating in water about knee-deep, and was attached to the upstanding reeds to keep it stationary.

There were four eggs in the nest. Originally pure white, they were now stained a dirty yellow by the weeds with which the parent birds cover them when leaving the nest. But in this instance, owing no doubt to the bird having been come upon suddenly, so that she had no time to perform this operation, they were uncovered. Rowing further along the reed fringe, we came upon numerous vacated nests of Coot and Waterhen, and were fortunate in again finding the nest of the Crested Grebe. This time the bird had got notice of our approach, as the four eggs were carefully covered with green weeds, which were twisted into the consistency of a thin rope. The eggs were very deep set, and would probably have been hatched in a day or two.

Mr. Cox insisted on our taking an egg from each nest for the Museum, and promised to send on the nest as soon as the young had flown, a promise which he has since fulfilled. The Society is therefore now in possession of the nest and eggs of the Crested Grebe, not only found in the county, but in the district. We now returned to the boat-house, where we were met by a messenger from Sir Alex. Muir Mackenzie, inviting the party to walk down to Delvine to see some object of interest; but our time being limited, we were compelled to decline his kind invitation. We now drove back to Snaigow House, and, after some refreshment, were driven to Murthly Station, after a pleasant and successful day's outing.

The Crested Grebe at one time bred in fair numbers in the fen districts of England, but owing to drainage, and to the persecution it was subjected to by sportsmen, and for commercial purposes, it has become more rare, and now breeds only in some favoured localities, where it is pretty safe from molestation.

In Ireland it is also far from common, but is known to breed on some of the lakes there.

In Scotland it is met with frequently in the winter, principally on the east coast. Mr. Gray, in his "Birds of the West of Scotland," says that the Crested Grebe has come less frequently under his notice than any of the other Grebes. On the Tay, Colonel Drummond Hay considered it as only a winter visitor, although he mentions a pair that were supposed to have been shot on Loch Ordie in full breeding plumage.

Records as to the Crested Grebe having bred in Scotland are extremely meagre, and in the Society's Library I have come across only one really authentic record of the nest and eggs having been found. The record I refer to is from the Lake of Menteith in Stirlingshire, in the year 1896, and from the rarity of its occurrence, and the graphic account given by Mr. Lee of the nesting habits of the bird, I am tempted to borrow the following:—

"In the spring of 1895 I observed a pair of Crested Grebes on the Lake of Menteith, but failed to locate their nest. On the 28th April, 1896, however, I arrived at the lake, determined to find the nest if it was there, and was rewarded by seeing a fine male in full breeding plumage diving about near a large bed of reeds. He was very tame, and allowed me to row within thirty yards of him without paying the least attention to me, so that I had ample leisure to admire him through my glasses. I failed, however, to find the nest that day, so on the morning of the 29th I started early, as I was quite sure that the female was sitting on eggs not far off. I commenced operations by beating up the reeds, and as I came close to a swan's nest, I saw a tell-tale ripple and line of bubbles running out from a point among the reeds, just like some big pike making off to deep water, and to my delight the female Crested Grebe appeared about seventy yards off. In less than three minutes I had found the nest. It was rather an insignificant pile of dead reed stems, decayed weeds, and freshly plucked water-lily leaves, floating in about two feet of water among the tall reeds, and anchored to them. It contained two eggs, which were carefully covered up and felt quite warm.

"After disposing of my boat at some distance I waded in among the reeds and hid myself behind a thick clump about fifteen yards from the nest. I could see the two Grebes out in the open water, abouty eighty yards oft. They sat low in the water, and the male would now and then swim round about his mate, ducking and bobbing his head, and striking the water with a stroke of his wing. The female, however, paid little attention to his blandishments, as her eye was fixed on the vicinity of the nest. They swam about in the same spot for about half-an-hour, and, just as my patience was becoming exhausted, the female swam closer inshore, and after looking cautiously about, she dived.

"I kept my eyes glued on the nest, and suddenly she appeared about three feet from it, but must have seen me, as she dived almost immediately, and reappeared about forty yards off. I changed my position, getting further behind the reeds, and in about fifteen minutes she suddenly appeared again beside the nest, and after a hurried look round, got on to it, and carefully uncovered the eggs, arranging all the weeds on the nest before she finally turned the eggs with her bill and settled herself on them. The male appeared immediately after, about six feet from the nest, with a young water-lily leaf in his bill. This he deposited on the side of the nest, the female giving it two or three playful dabs with her bill.

"After he dived away the female composed herself to rest, and buried her head among her feathers. By this time I was getting very cold and stiff, as I had been standing in the water for about two hours without waders. Keeping my eye on the sitting bird I made a slight movement. She jumped up and hurriedly covered up the eggs, remaining bolt upright, with head erect, and listening intently as if she had not spotted me. On my next movement she dived noiselessly into the water, and appeared about sixty yards off in the open water. I was so cold and stiff that I could hardly wade ashore, but I was amply rewarded by my glimpse at the habits of these beautiful birds at their nest."

The bird here exhibited was shot by Mr. Cox on the loch where we got the two nests, and is a young male not yet in full plumage. But this other bird is an adult male, and exhibits the Crested Grebe in full feather. I am sure many of the ladies present will recognise in the beautiful satiny breast of the Grebe the material from which the muffs and collarettes were formed some years ago, but, happily for the Grebe, they are at present out of fashion, and may they continue to be so; and I am sure, that under proprietors like Mr. Cox, the Crested Grebe may be induced to extend its breeding boundaries in the county, and to become as familiar an object on our Perthshire lochs as it is now rare.

X.—*The Agates of the Sidlaws.*

By R. Dow, Schoolhouse, Longforgan.

(Read 13th April, 1905).

THE SIDLAWS.

As the student of field geology wanders in search of science and of scenery among the solitudes of the Sidlaws, the contrast between the peacefulness and the beauty of the landscape to-day and the geologic past now long gone by, when volcanic fires were in action, when streams of liquid fire deluged and desolated the landscape, is powerfully impressed on the imagination.

The great volcanic ridge across the midlands of Scotland continues almost unbroken in the Campsie Fells of Stirling and the Ochils of Perthshire. In the vicinity of Perth, this persistent ridge branches into two divergent portions, one of which runs on through the north of Fife until it sinks in the ocean at Tayport, while the other, after sinking beneath the alluvial deposits of the Earn and Tay, mounts once more into the precipitous cliffs of Kinnoull Hill, and thence stretches eastward into Forfarshire as the Sidlaw Hills.

The rocks of the Sidlaws consist of successive sheets of andesite lava, of the familiar types easily recognised in hand specimens, and varying in colour through shades of blue, purple, and red, and in texture from a dull, compact, almost felsitic, or micro-granular character, to more coarsely crystalline varieties. The sheets are often amygdaloidal, especially in the upper and lower portions of the individual flows. These lava flows are not infrequently separated from each other by courses of conglomerate, sandstone, and grit. Of these, four are of sufficient thickness and persistence to be mapped, and are shown on the Geological Survey Sheet No. 48. The pebbles of these intervening conglomerates range up to blocks 2 ft. in diameter, and consist chiefly of andesites, but include many pink felsites and pebbles of greenish sandstone. These alternating sheets of sandstone and lava clearly demonstrate that the volcanic fires, which gave rise to the Sidlaws, ranged over immense periods of time, probably throughout the entire Old Red Sandstone Age.

Another interesting proof of the volcanic origin of the Sidlaws is the neck of one of the volcanoes to be found at Over Durdie. It is 500 yds. in mean diameter, and is plugged with pinkish granular tuff full of andesite blocks. It remains still one of the unsolved local geological problems, why these volcanic necks are so sparse in the

Ochils and Sidlaws, and yet so numerous in the old volcanoes of the carboniferous system of Fifeshire.

But this volcanic neck, and a similar, though much smaller, one some distance to the south-west, remain as unimpeachable witnesses that the volcanic fires, now quenched, once were in fierce action, though now quiescent for geological æons. The lava streams that once descended from these cones have been cut into ravines, and isolated into separate hilly masses, by the streams that have deeply trenched them.

AGATES.

Ruskin, in the preface to "The Stones of Venice," makes this observation, "It is not easy to be accurate in an account of anything, however simple; zoologists disagree in the description of the curve of a shell, or the plumage of a bird, though they may lay their specimens on the table and examine them at their leisure." And I venture to think that this may be said with equal truth regarding Scotch agates. In shape, in colour, in markings, their forms are quite bewildering.

"With figured veins its various surface strewed,
Painted by Nature in a sportive mood;
Strange to relate, 'twas to no artist due,
Nature herself the wondrous picture drew."

Beautiful and precious stones have always had a strong fascination. In the dawn of history they were regarded as magical charms, protecting the wearer against all kinds of mundane evils; by a slight transition, denoting, however, considerable progress, they were regarded as possessing medicinal powers; and finally, by a further transition, leading up to our own times, they have, with the ever-widening sweep of true scientific inquiry, been the objects of much investigation.

The highly cultured Greek had full faith in their occult power, and they are frequently referred to by classical writers. Orpheus, in his ode on gems, refers to them as the highest gift of Jove to mortals, bestowed as a sure remedy against all earthly woes, and hidden by the gods underground in mystic caves, and those who find them will be rewarded by endless blessings, and to them care and sorrow will be unknown. In specifying the virtues of each individual gem, Orpheus thus writes—"If thou wearest the agate stone on thy hand, the immortal gods will be ever pleased with thee; and if the same be tied to the horns of thy oxen, when ploughing, or round the ploughman's sturdy arm, wheat crowned Ceres will descend from heaven with full lap to throw the grain upon the furrow." This belief in stones as charms, dating back to remote ages, still flickers on in this scientific age.

There is something very attractive about a good polished specimen of an agate, or, to give it its more familiar name, a Scotch pebble, as a glance at the fine collection gathered by the late Professor Heddle, now in the National Scottish Museum, Edinburgh, will show. The great majority of agates show almost endless combinations of cream colour, delicate pearl grey, slate colour and lavender tints, while the infinite variety of pattern in which these are arranged delights the eye of those who regard them simply as objects of beauty. But to the inquiring scientific mind the problem of how these patterns and tints were formed is still more interesting.

It is no simple matter to find out in what way Nature worked in elaborating these beautiful agate patterns. There have been many guesses into the secret, and much scientific thought has been expended in the endeavour to clear up the mystery. Many of the problems remain still unsolved, but by the extensive researches of Prof. Heddle considerable advance has been made. It hardly need be stated that a full account of the principles upon which Nature has fashioned them would involve extensive reference to chemistry and physics. But for the present a general idea of their nature must suffice.

The lava cools, it ceases to boil, and at last we have a solid rock, containing many cavities of various shapes and sizes, which are the casts of the steam bubbles, arrested in their ascent and imprisoned by the thickening lava. Hence the shape of an irregular ovoid, originally spherical, but drawn out as they rose in the flow of the viscous fluid. Up to this point geologists agree as to the history of the lava and the cavities in which the agates are formed. In the main, too, they agree that the agate material is deposited from an aqueous solution in layers upon the walls of the cavities by secretion, segregation, or infiltration of such solution. Beyond this point, however, there are two distinct theories. We may call them the hot and the cold water theories. Hot water containing an alkaline solution dissolves silica (the material from which agates are formed) very freely. Cold water containing alkali is a poor solvent of silica. The hot water theorists hold that the formation of agates was therefore contemporaneous with the formation of the lava. The lava contained much highly heated water, which was probably, and almost certainly, saturated with siliceous or agate material. As the lava cooled, the water collected in the vacuous cavities, depositing layer after layer of silica in the form of chalcedony.

The cold water theorists maintain that the lava was cold, and the steam cavities empty to start with. Percolating rain water slowly sank from the surface of the rock, dissolving on the way down a very small quantity of alkali; this, in its turn, dissolved the silica, and from the solution the agates were slowly layer by layer deposited. It has been calculated that it would require one and a quarter million years to deposit a pound weight of silica in this fashion. The two theories originated in Germany, and each has had its supporters in this country. The late John Ruskin clearly supports the hot water theory. He was a keen observer, but not a trained geologist, chemist, or physicist. The great exponent of the cold water theory is Professor Heddle, a keen observer, a clever reasoner, a practical mineralogist, and an expert analyst. A writer in a recent number of *Chambers' Journal* wisely holds that perhaps both theories are correct, the hot theory to begin with, and the cold to carry on and finish Nature's work.

THE SIDLAW AGATES.

Though volcanic action and lava streams are to be found in every geological formation, from the oldest to the youngest, it remains yet an unsolved problem why agates should be confined to the lavas of the Old Red Sandstone formation, and, even within that formation, to lavas only of andesite composition. Very few agates, and these imperfectly formed, have been obtained from basalt, and they seem to have been unknown from trachytes and more acid volcanic rocks, as rhyolites, obsidians, and granites. More puzzling still, agates are not well developed in the andesites of the Old Red Sandstone except in certain localities, of which the Ochils and the Sidlaws are the chief, and not in every lava flow even of them. Very beautiful agates do occur in the andesite lavas of the same formation in the Cheviots, bnt they are far from common. Agates also occur in the same rocks in the Pentland Hills, but they are rarely so fine as those from the Ochils or the Sidlaws.

While agates may be found less or more over the entire range of the Sidlaws, it is only within the following localities that they have been found of superior quality and comparative abundance:—Kinnoull Hill, Glendoick Hill, Pitroddie Den, the Pebble Knowe, and Ballindean, at Inchture. As the andesite rock from which the pebbles are procured is too soft for road-making purposes, it is seldom indeed that the geologist has the opportunity of extracting them from the living rock in the quarry, or in co-operating with the quarrymen themselves. The agates to be seen in private and museum collections have almost entirely been gathered from the debris and skrees, which accumulate at the base of the cliffs in the hills just mentioned, and which have weathered out of the precipices above. Many fine specimens may still be gathered in autumn after subsoil ploughing on the knolls above Ballindean. But these are becoming fewer, owing to the recent fashionable craze for jewelled nick-nacks mounted with local agates.

Ballindean Quarry, and the knolls above Ballindean House, seems to have been a happy ground with the late Professor Heddle, of St. Andrews. In his "Mineralogy of Scotland," published after his death, frequent reference is made to the Ballindean agates, *e.g.*, "The Ballindean agates are of the most delicate tints of lilac, flesh red, and rose, or grey blue chalcedony, often with an outer layer of milk white opal, and are the most exquisite and delicately tinted agates known." Again, "I have seen magnificent specimens from Ballindean of stalactite agates, of variegated and unusual colours, sometimes ochre yellow, diversified with pink. The milk white opals, gathered from the Pebble Knowe, Ballindean, are exquisite, with outer layers nearly one-quarter inch in thickness. The heliotropes from Ballindean are beautifully stained in various shades of green. Moss agates from Kinnoull Hill beautiful and delicate."

THE SHAPE OF AGATES.

The shape of the vapour cavity is determined by the fluidity or viscosity of the molten rock, and also by the state of flow, whether of rapid or slow motion, or even of rest. The cavity will be circular on the whole if there is little or no motion and great fluidity. It will be balloon in shape if the lava flow comes to rest. If the viscosity of the lava is great, the cavities will be almond-shaped, giving rise to what is known as amygdaloidal formation. This seems to have been the state of the lava over wide areas of the Sidlaws. But it is to be observed that the amygdaloids are seldom subsequently filled by siliceous agates, but by various chlorites, or green earths, of a dark olive green colour, and often so soft as to be powdered between the fingers. It is generally understood by most geologists that they are the result of decomposition of the hornblende of the overlying rock mass. This formation of vapour cavity may be seen at any time by a visit to Corsiehill Quarry.

But all lavas have motion more or less. If the motion is slow, with much fluidity, the cavity will be pear-shaped, with the round end in front; but if the motion is rapid, the shape tends to become pointed at both ends or lance-shaped. There can be no question that the bewildering varieties of the shapes of the cavities have arisen, not only from the state of motion and of fluidity, but also of the rate of cooling. As to size, the cavities may range in size from mere pinholes to a foot in diameter.

THE SKIN OF THE AGATE.

A well-marked feature in nearly all agates when they have been extracted from their rocky bed is the green scaly covering, forming the outermost coating of the rounded nodule. This coating has a fairly definite composition, and, being exceedingly soluble, is the first substance to be carried downwards, and deposited on every side of the cavity. It is of an ivy-green colour, forming the pigment known to artists as terra verte, and constitutes the priming, to use a painter's term, on which the subsequent coats are laid down. It forms what is popularly known as green earth, and may be seen in any basalt quarry coating the joints and faces of the rock, and may be easily scraped off with the finger nails. It is simply the result of the decomposition of the augite, the main constituent of all volcanic rocks. The little grains of augite are easily recognised on a fresh cleavage face, usually of a dark green colour, in volcanic rocks older than the Old Red Sandstone. These grains have by various metamorphic movements been drawn out into needle-like crystals of hornblende. Usually this layer is very thin, but in others the process has continued so long that the whole cavity becomes filled with green earth. Abundant specimens with vesicles, thus entirely filled with green earth, may be gathered in any of the quarries of the Sidlaws, usually small, ranging from the size of small shot to nodules as large as beans. Where these are found in abundance in the rock mass, it is almost certain that genuine agates will be rare indeed. Dr. Heddle has named this green outer-coating "celadonite." This mineral substance is extremely soft, as already stated, and is detached with ease from any surface which it has coated.

After the augite of the andesite lavas, the next chemical ingredient which is most easily dissolved is felspar, and that form of felspar known as labradorite, a lime soda felspar, the commonest of this group of minerals. Fine crystals of labradorite are found in the diabase quarries of the eastern Sidlaws. I have gathered beautiful specimens from the Knapp Quarry, which nestles at the foot of Rossie Hill on its northern slope. The constituents of this felspar, after being carried down, consolidate as a layer of zeolite. It often happens that the formation of the zeolite material is continued until the whole cavity is filled to the exclusion of further agate materials. When this is the case the zeolite, however, assumes a crystalline form. Any one who has once examined a nodule filled with zeolite will not readily forget this pretty mineral, its peculiar pearly lustre especially on certain plains of cleavage, its fine needles of silky texture and sheen, radiating in tufts from the circumference inwards. The vapour cavities of the Glenfarg district are almost entirely filled with zeolites. In the debris left after the tunnelling, and which lies so conveniently to the geological hammer, one can easily gather many of these pretty nodules without coming across a single agate. Zeolites are so called from their boiling and swelling when heated by the blow pipe, a proof that water is chemically combined with the felspar. These two layers, the outer green celadonite, and the inner red zeolite, may be regarded as but the forerunners of the deposit of silica which is destined to reach the cavity at a later period and to end in filling up the whole cavity with the materials of the agate proper.

AGATE CHALCEDONY.

The question now to be considered is of prime importance in a study of the formation of an agate. How has silica, which forms the agate proper, been dissolved out of the rock mass? Without doubt it was by water. Rain water, pure and simple, would probably accomplish very little, even in the course of prolonged periods of time; but rain water is seldom pure, and after it has passed through the soil it is still less pure. Organic agencies in the soil assist materially the solvent action of all surface water. The chief of these are compounds of carbon or carbonic acid gas. The humus acids are well known, even to the chemically uninitiated, when we talk of land being sour. These humus acids are now beginning to be recognised as agents of considerable importance in many changes that affect the earth's surface. Given suitable conditions, and long enough time to do their work, they are competent, when dissolved in rain water, to decompose all the substances to be found in an agate. The silica of an agate is one of the most indissoluble substances found in Nature; but when attacked by water charged with carbonic acid, combined at a later stage with soda and lime, and the other constituents of the rock mass, it dissolves out little by little the silica, to become in time crystalline quartz, amethyst, carnelian, jasper, and chalcedony. The action was probably always slow and feeble, and the dissolved silica was so small in proportion to the amount of water, that one can speak of it only as a weak solution of flint jelly. But here, as in other geological problems, the operations of the forces of Nature arise from feebly acting causes, working through long periods of time, and not from prodigious forces acting quickly. At this point an unsolved problem awaits solution. Why is it that in some cavities the dissolved silica has crystallised into rock crystal, and, on laying open the cavity with your geological hammer, you look with admiring gaze, to quote from Ruskin's "Ethics of the Dust," "on a thousand separate pyramids, each facet as pure as a mountain spring, and each crystal unsullied in its purity," whilst the cavities under consideration are filled with banded agates?

The solution to this problem may be that when the dissolved silica remains uniform, with little change of composition rock crystal is formed, but when disturbing factors enter into the action, as change of temperature and of pressure, changes in the composition of the solution, silica in its colloidal form is the result. These two forms of silica, the crystalline quartz and the jelly-like chalcedony, bear the same relation to each other that crystalline sugar does to the well known barley sugar.

The principle by which matter in solution is conveyed through apparently solid walls is one which operates widely in the organic and inorganic world, and is known as osmosis. It is owing to this diffusive force that the sap rises in plants in opposition to gravitation, and it is the same law that allows the gradual inflow of weak solutions of silica jelly, to whose subsequent coagulation and hardening the finished agate is due. The finished product may be clear water chalcedony, milk white chalcedony, carnelian, or jasper. These are deposited in bands of ever-increasing thickness on every portion of the wall of the cavity.

It is still a fruitful field for speculation and conjecture why the silica should in some druses assume the crystalline form of amethyst or quartz, and in the same rock and side by side harden into agate, the colloid form of quartz.

This at least is certain, that if the silica is deposited in the agate form as a pure solution of silica, and unalloyed by any foreign substance, it is deposited layer after layer over the whole inner surface, just as thickly on the roof and walls as on the floor of the druse. It is water-clear or ice-clear in colour, and therefore quite transparent. When we examine a number of specimens, or even the bands in any one specimen, it is seen that the water-clear bands form a small percentage of the agate. Commonly some foreign ingredient is present, generally a small admixture of zeolite matter, and then the chalcedony, instead of remaining clear and transparent, passes into a turbid form of the colour of milk or chalk, known as cachalong. A common form of agate to be found in many parts of the Sidlaws shows alternate bands of ice-clear and milk-white bands fading into each other, with a faint colouring of lilac. It is this common form of agate that is so extensively used for jewelled trinkets, and so often seen in jewellers' windows.

A well-marked feature in many agates, including those from the Sidlaws, is that the purely agate material has not entirely filled the cavity. When this occurs, the inner chalcedony layer becomes coated with crystals of quartz in its colourless form, forming rock crystal, or in rarer instances by quartz of a smoky colour, as cairngorm, or by quartz coloured violet, resulting in amethyst. The forms resulting from these three conditions are quite different in appearance. The amethyst core makes a beautiful agate when cut in polished sections, and is the result of manganese being carried into the cavity with the silica jelly. Manganese is used in the arts to give a violet colour to glass, and for neutralizing the green colour of inferior kinds of glass, and the crystals so coloured are usually called amethyst. The faint violet tint so often seen on ordinary banded agate is due to the same cause, of weak solutions of manganese, which, along with iron, is always to be found in lava.

ONYX.

In a normal agate the layers of chalcedony are deposited in thin bands, one upon the other right up to the centre, and are more or less conformable in pattern to the shape of the cavity; but there is one very remarkable exception to this general rule, in the bands of what is generally known as onyx or opal. In these the dissolved material subsides in horizontal bands to the lowest part of the cavity, and never rises along the walls; that is to say, the layers of an onyx are laid down solely under the law of gravitation, and are always parallel, while those of an ordinary agate may vary in thickness. Conversely, all layers that do not climb the sides are onyx or opal, and all that do so are chalcedony. As no Scottish agates show a second opal layer inclined to the first, it follows that the opals of Scottish agates were deposited before any disturbance of the rocks took place. It may be further stated that it is from these onyx agates that cameos are cut.

MOSS AGATES.

Beautiful specimens of moss agates have been found at Kinnoull Hill and Ballindean. It is still a widely popular, though foolish, belief that the moss-like material enclosed within the agate is real moss, and no argument seems convincing enough to dispel this preposterous idea. When we consider that the rock enclosing the agate was originally a molten mass at white heat, how absurd is it to believe that any vegetable organism could have come through the fiery ordeal without being annihilated. The moss-like structure is, however, so real and life-like that the popular belief still lives, and even good observers have been deceived, and regard the enclosed moss-like material as of vegetable origin, much in the same way as flies are to be found enclosed in fossil amber. It has already been observed that the lining of the cavity is first made up of the most easily dissolved constituent of the rock, to which the name celadonite has been given, but which is popularly known as one of the green earths. It is quite soft and easily detached. Torn and shredded portions hang in irregular moss-like masses from the dome of the cavity, or became detached, and, having afterwards been enveloped in the water-clear chalcedony, show all kinds of an open network of interlacing tortuous strings of celadonite. Moss agates, when cut in thin slices, show the moss-like arrangement to perfection if held up and viewed in the bright light of a gas jet.

As has already been observed, chalcedony, when pure, is water-clear like ice, and of silver grey colour, which deepens into a slate colour in thick masses; if admixed with impurities, these give rise to cream colour, pale lavender, dove and dark slate colour. If the celadonite in solution goes on concurrently with the silica, then a deep green ivy leaf colour is the result, such agates being known as heliotrope; if speckled with red, as bloodstone.

CARNELIAN AND JASPER.

When the clear chalcedony is mixed with some weak solution of iron, the agate is known as carnelian, and is translucent when held to the light. If the iron solution has developed to a greater extent than in the last, then jasper is produced, which, in cut sections, is quite opaque. If the iron solution, instead of ordinary ferric oxide, is ferric hydrate, then the jasper is yellow and opaque. Ferric hydrate gives the yellow tint to bog iron ore, and to the yellow sandstones of the younger geological formations. It is precipitated as a yellow-brown deposit in bog pools and stagnant ditches. This ferric hydrate never occurs in milk-white chalcedony layers, as these do not stain readily. It must be observed, however, that we have conclusive proof that many agates have been coloured, subsequently to their formation, by staining from without, and at a late period, from colouring material percolating from the lake bottoms of the Old Red Sandstone, the process being analagous to that employed in the preparation of biological subjects for the microscope.

XI.—*Notes on the Discovery of the Remains of an Earth-house at Barnhill, Perth.*

By Alexander Hutcheson, F.S.A. Scot., Broughty Ferry.

(Read 13th April, 1905).

In the month of April, 1904, in the course of the construction of a new road at Barnhill, near Perth, on the property of Sir Alexander Moncrieff of Culfargie, K.C.B., some lines of stonework suggestive of a structural formation were uncovered.

The discovery was communicated to Sir Alexander Moncrieff, who immediately stopped the works and made intimation of the discovery to the Society of Antiquaries of Scotland. I was honoured by the Council of the Society with a request that I should visit the site and report, which I did, and my report appears in their volume of *Proceedings* for the year. By favour of the Council, I am permitted to give an adaptation of that report for the information of the Perthshire Society of Natural Science, and in doing so I take the liberty of amplifying the introductory part, with the view of recording briefly the general features of the particular class of structures of which that recently discovered at Barnhill is an example.

These structures, so far as known, are peculiar to Scotland, but are fairly common over the whole eastern area from Berwickshire in the south to the Shetland Isles. Many examples have been explored and recorded in volumes dealing with Scottish antiquities, but mainly in the Proceedings of the Society of Antiquaries of Scotland, to which latter volumes I beg to refer those who may desire to investigate the subject more closely. It may suffice to state here a few of the special features of these structures. As the name earth-house usually given to them implies, they are found wholly below the surface, concealment having been apparently one of the purposes they subserved. The usual type presents a long narrow curving gallery, entering by a low and confined aperture nearly on a level with the surface, thence widening and deepening from the entrance inwards, turning usually first to the left in a curving direction until about half the length has been traversed, and then to the right for about an equal distance, it terminates abruptly in a closed end. The letter S-like form is not, however, invariably followed. Some few curve to the left without any turn to the right, others curve at once to the right, while still fewer although curving, deviate very little from a straight line.

The typical mode of construction is side walls built of rough boulders or slabs without any dressing or mortar in the joints, gradually converging somewhat towards the roof, which at a height of 5 or 6 feet from the floor is formed with large and weighty slabs of stone overlapping on the rude walls. In some cases it would seem as if timber must have been used as a roof covering. This may have been the case in the Barnhill example.

Some of the earth-houses possess an inner doorway, probably as an additional protection, while one or two have two external entrances.

It is probable that the earth-houses were always associated with overground habitations, whence in the case of danger from an approaching foe, or in winter for greater warmth the people could descend by what was doubtless the well-concealed and narrow entrance into the laboriously constructed secret chamber. As these chambers have not been found elsewhere than in Scotland, underground structures which have been found associated with fortified places in Ireland and elsewhere not being of the Scottish type, it is possible they would be unsuspected by a foreign foe, but against marauding neighbours retreat into these dark labyrinthine recesses would only be at best a mode of passive resistance to foes who probably would grudge the time and labour, not to speak of the personal danger which breaking in would involve, especially when it is considered that all the plunder they were likely to get was probably already above ground and in their hands.

Dr. Joseph Anderson (*Scotland in Pagan Times; The Iron Age*) has summed up the evidences and the argument as to the age of these structures. He assigns them to the comparatively narrow period that "will lie between the time of the general establishment of Christianity and the departure of the Romans from Scotland," with much propriety judging that the relics found in the earth-houses and our knowledge concerning them are as yet all too scanty to warrant wider conclusions.

To come now to the Barnhill earth-house, despite of certain peculiarities of construction, which, however, are I think susceptible of explanation, I had no difficulty in recognising the remains as those of one of the underground structures referred to.

I prepared the annexed plan showing the form and dimensions of the remains. The structure has now unfortunately been removed, the completion of the new roadway not having permitted of its retention.

The entrance to the earth-house, which was 2 feet 3 inches in width, faced towards the south-west. The wall forming the left-hand side of the entrance was continued inward to form the western wall of the earth-house, but the right-hand side of the entrance was prolonged inwards only 6 feet 4 inches, and then formed a projection, behind which was a recess 3 feet in depth and about 4 feet in width. The entrance passage, this recess, and a portion of the structure extending backward 8 feet from the inner end of the passage were rudely paved with cobble stones laid on the rock. From this point the earth-house exemplified the usual characteristics of its class by sloping downwards and curving rapidly to the left with an average width of about 8 feet, for a distance in all of about 45 feet from the entrance, measured along the medial line, to where the two side walls abruptly terminate, having doubtless been cut off when the public road between Perth and Dundee was diverted and cut through it, presumably in the early years of last century.

As to the features of the situation, it is known that these structures have been commonly found occupying level or at least arable ground, in other words, sites suitable for, and in modern times given over to, agriculture; hence they have been generally discovered by the plough coming into contact with the roofing slabs, and so leading to an examination of the obstruction. But the Barnhill earth-house has differed from the usual type in occupying the summit of a rocky knoll, where presumably, if covered or roofed over in the usual way with large slabs of stone, it must have been partially formed above ground, and afterwards covered from sight by earth being heaped above it to such depth as afforded that concealment which seems to have been the invariable rule, if not indeed the originating cause, of the typical form of these structures. No covering slabs now exist, nor has any evidence of them here been discovered. The walls were dry-built, and formed of superincumbent lines of stones. The stones of the first or lowermost line averaged 2 feet 6 inches long, 2 feet high, and 1 foot 6 inches thick. They were water-rolled and ice-scratched boulders of whin, diorite, granite, etc., nowhere exhibiting toolmarks or any evidences of artificial shaping. The stones had, however, been placed with some recognition of a principle of construction. They were set with their longer axes in the line of the wall, and had their smoothest and flattest surfaces facing inward to the earth-house. At the date of my visit practically only one tier of stones remained, with here and there portions of a second tier; but I learned from the workmen that before the artificial character of the remains was recognised, one and in some places two tiers of stones had been removed from the walls. The result of this removal has been to deprive us of the possibility of now deciding whether the walls in their complete state were erected with that inward convergence of the upper part which characterises these structures.

It was a singular place to select for an earth-house. The rock, which protruded through the surface at the apex of the knoll, must have shown the prospective builders what they had to expect in forming there an underground structure. Are we therefore to assume that they contemplated a certain amount of scarping of the rock to attain their ends? I was at first inclined to think they had done so, from certain appearances of the rock, which forms everywhere the floor, shelving downwards at the entrance, and also on the left side about half way towards the end; but on reflection I gave this up, since, even if necessary to scarp the rock at the entrance and further in, it was not necessary to make this supposed scarping extend underneath the stones forming the side walls, which, on examination, it was found to do. I therefore concluded that the supposed scarping was only the natural slope of the rock; and in this opinion I was glad to have the concurrence of Mr. Alex. M. Rodger, Curator of the Museum of Natural History, Perth, who is well acquainted with the geology of the district. It seems, therefore, that this structure, which conforms to so many of the features of an earth-house that it seems impossible to assign it to any other known class of early structure, yet differed from the type in having been only partially excavated, and consequently formed partly above ground, being afterwards covered over with soil so as to be hidden from view, as all others wholly excavated were.

From the entrance the floor sloped pretty equally downwards until it attained a depth of 4 feet 6 inches at a point opposite to the end of the west wall. Here the rocky floor began to slope upward again, and had risen about a foot when the end of the eastern wall was reached. Beyond this point, as already explained, a portion of the knoll together with the earth-house had been cut away in the alteration of the public road between Dundee and Perth, so that, unless some record has been elsewhere preserved of the discoveries of that period, it may be impossible now to determine how much further or in what direction the structure may have extended.

Before my visit the interior had been cleared out down to the rock, and the material spread out on the surface of the new road. I was informed that the men were careful to keep a good lookout for relics, and some bones and a broken nodule of black flint were picked up and preserved, but a practised eye might have detected other articles. I cleaned out carefully the joints and cavities of the rocky floor and between the paving stones, but beyond a thin skelb of black flint, about an inch square and dressed on one edge, and a few pieces of charred wood, nothing of interest was detected. The flint may have travelled from the surface, but was found between two of the cobblestones in the recess at the entrance.

Sir Alexander Moncrieff obligingly supplied workmen to clear the floor and make other excavations in aid of these investigations, and I was also indebted to Mr. James T. Sellar, of the firm of Messrs. R. H. Moncrieff & Co., W.S., Perth, Sir Alexander Moncrieff's agents, for affording me much valuable assistance at my first visit, and subsequently, when the secondary excavations were being made.

XII.—*On the Phenomenon of Sinistrorsity in the Mollusca.*

By Rev. G. A. Frank Knight, M.A., F.R.S.E.

(Read 13th April, 1905).

Monstrosities in organisms have always been regarded by the vulgar with curiosity and wonder, as being extraordinary departures from what is customary, but latterly monstrosities have been looked on by the eye of science with a kindlier and more intelligent glance, as being very interesting problems for careful investigation. If a so-called "monstrosity" can legitimately be reckoned a "variety," then, for all we know, it may be on the high road to become a fully-

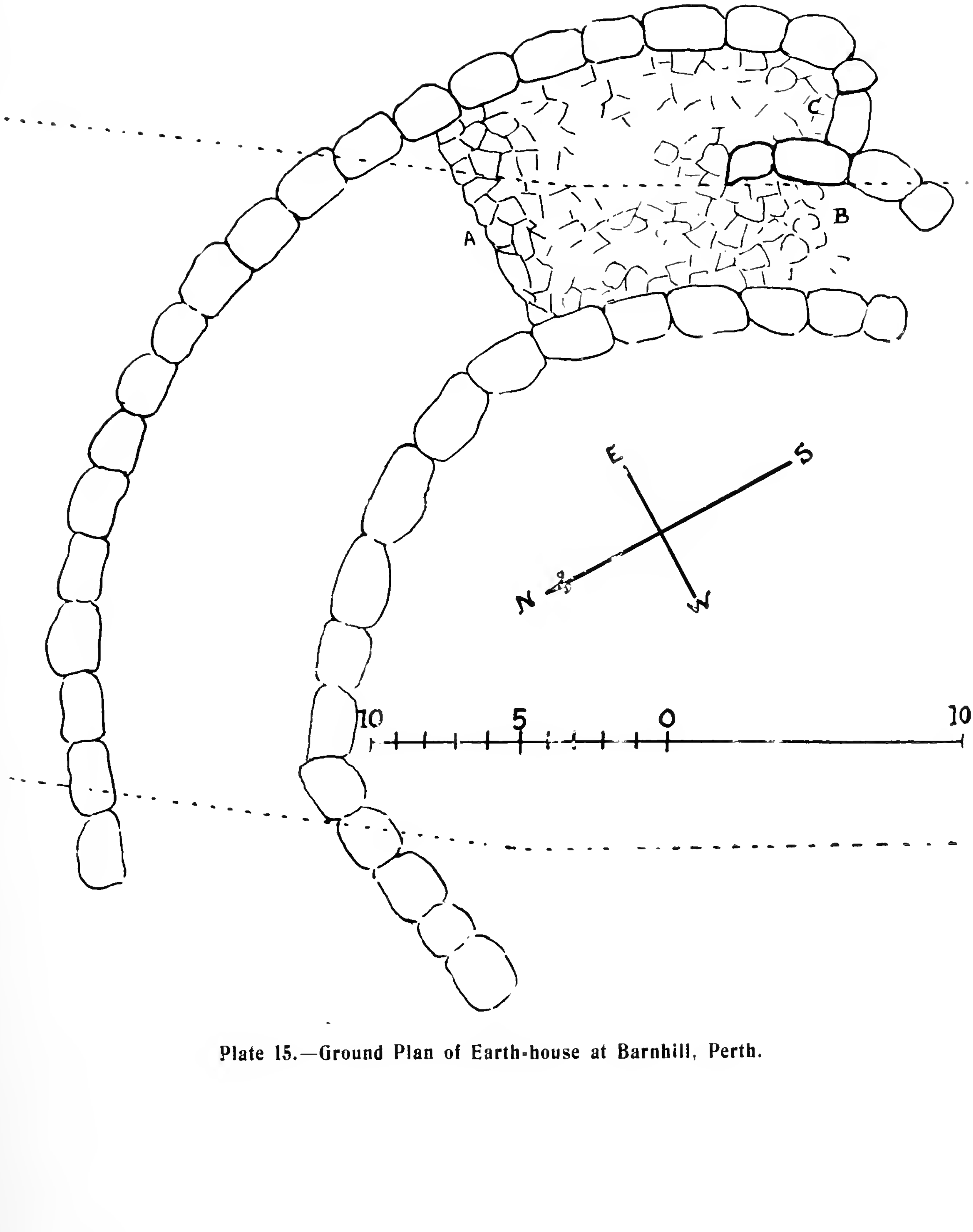
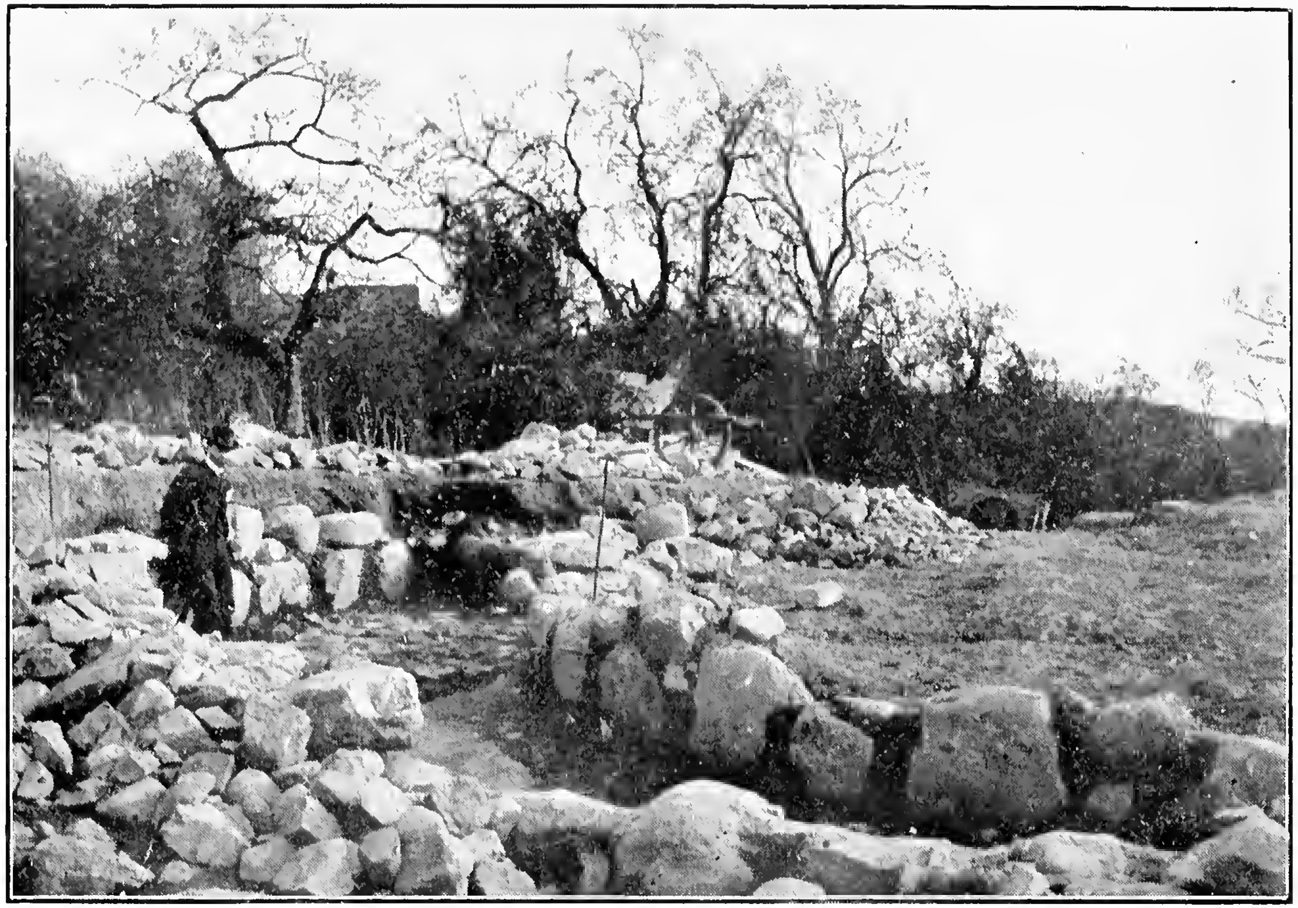


Plate 15.—Ground Plan of Earth-house at Barnhill, Perth.



[Photo by A. M. Rodger.

Plate 16.—View from the Lower End.

developed "species." Darwin has taught us to consider very closely every apparently aberrant form, for nearer investigation may lead to discoveries of singular interest. But it is not my intention to discuss the abstract question whether sinistrorsity among molluscs, speaking generally, is to be classed as the impulse of the animal towards the creation of a new species. There is no doubt a very great deal of truth in the dictum, "Varieties are incipient species," for every slight divergence from the normal type may be regarded as the initial effort on the part of an individual to break away from a hard and fast rule into the liberty of a "variety," a liberty which may ultimately lead to the establishment of a full-fledged "species." But I am afraid that in the vast majority of cases, if not in all, sinistrorsity in shells must be looked on as a mere malformation, congenital, hereditary, or acquired, as the case may be. I propose, therefore, to give in this paper a summary and outline of what has been discovered in regard to this widespread and interesting phenomenon.

A univalve spiral shell is said to be "dextral" when the mouth opens to the *right* hand of the observer, as he holds it with the spire pointing upwards. A univalve spiral shell is said to be "sinistral' when the aperture is to the *left* hand of the observer, as he holds the shell with its apex upwards. If we imagine the interior of the shell to be a spiral staircase, then, as we ascend a *dextral* mollusc, the "axis" or "columella" of the stair would always be at our left hand, and similarly, if the mollusc be *sinistral*, the stair up into its interior would always curve round the axis on the right hand.

The whole subject of convolution in the mollusca is one of extreme interest, and has excited the enquiries of eminent scientists. As far back as 1838, we find the Rev. Canon Moseley contributing an elaborate essay "On the Geometrical Form of Turbinated and Discoid Shells," which was published in the *Philosophical Transactions* for that year. In this paper he proves that the laws which determine even such an apparently insignificant matter as the mode in which the shells of univalves are spirally twisted, are as mathematically true as the conic sections which regulate the orbits of the planets and comets! He shows that the size of the whorls, and the distance between contiguous whorls, in such shells as the common *Turritella* of our shores, or *Planorbis* of our ponds, follow a geometrical progression. The spiral formed is the "logarithmic," of which it is a property that it is everywhere the same geometrical curvature, and is the only curve, except the circle, which possesses this property. Obeying this law, the mollusc winds its dwelling in a uniform direction through the space around its axis.

Now it will be readily understood that, as the mantle of the mollusc secretes the shelly integument, there is before the animal an almost infinite choice as to the way in which it will build up its home. So long as the form of the shell is regular, following out the principle of a cone curved into a spiral, and descending in a screw-like manner from the apex (or initial whorl) to the aperture, the animal may select almost any variety of convolution. If uninterfered with by any foreign obstruction, the animal, with unerring certainty, will mould for itself a habitation, which, as I said, will be finished with an absolutely perfect devotion to geometrical curves, proportion, and principles. It is therefore a fascinating study to observe how infinitely varied the series of curves may be, and how wide is the scope granted to every mollusc in the erection of its home, the only condition being that, in the case of the "regularly spiral" shells, the law of "the spire of the logarithmic" must be strictly adhered to.

We observe then that, as the result of the unequalness of growth in the mantle and shell there arise spiral twistings, and these eventually produce an almost infinite diversity of curve. A series of torsional convolutions may be traced, for example, from the long, many-whorled *Terebra*, to the broad, flat, depressed *Haliotis*, and from that again right on to *Patella*. Or again the regularly built-up *Turritella* may be pulled out into the fantastic contortions of *Vermetus*, and the unrolling may be carried so far that the whorls are all straightened out into a single tube like *Dentalium*. Once more, when a shell such as *Cypraea* or *Conus* is examined, it is seen that the body of it is made up simply of the last whorl, with the ghosts, so to speak, of its predecessors visible in small detail on what was once an elongated spire. But whether the spiral convolutions are visible in the adult stage, or only in the embryonic condition of the shell, the fact remains that the twist has exercised an important function in the life history of the mollusca. Prof. Sydney J. Hickson* cites with approval Lang's generalization on this subject (*Text-book of Comparative Anatomy*, Vol. II., p. 150). "The formation of a spire-like shell, which has been recognised as the starting point in the development of the asymmetry of reptant Gastropods, was the only method by which complete protection of the whole body could be attained, and must therefore be considered to have been advantageous under the circumstances."

Now all molluscs with spiral shells must, naturally, twist either to the right or to the left. And as a matter of fact, the vast majority of gastropods have dextral shells, it being the exception to find shells built up with a left-handed twist. Even amongst bivalves, again, there may be a kind of sinistrorsity when the right or left valves, as the case may be, assume the character normally peculiar to the other.

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* Torsion in Mollusca, *Journal of Conchology*, Vol. ix. (1898), pp. 9-15.

Normally the "umbo" or "beak" of a Pelecypod is turned towards the anterior side of the shell, which is generally the shorter half of the shell; but in some bivalves the beaks are reversed, and are turned towards the posterior side of the shell. But, as a rule, sinistrorsity amongst bivalves is not very marked, except in some of the inequivalve species. In the case of the naked molluscs or slugs, the phenomenon of sinistrorsity is associated with the transference of the respiratory, and other orifices, to the side opposite to that on which they are normally situated. It has been suggested by Pelseneer that the well-known *Isocardia* affords evidence of a primitive reversed embryonic twist.

But there is a subject to be investigated in connection with sinistral molluscs more intricate than that which merely concerns the reversed whorl of the external shell. The further question arises, Is the internal animal, with its various organs, also reversed? Is there a strict correspondence between the shelly integument and the mollusc, so that, if the outside spiral is sinistral, the soft inside parts are also sinistrally placed? Now the answer here is very varied.

First, in all cases where sinistrorsity occurs as an abnormal feature (*i.e.*, where the type is usually dextral, and a left-handed individual is simply "a freak"), this correspondence is maintained. The internal organs in these instances are all "reversed" too, the viscera being transposed in their relative positions. Second, in all examined cases when the shell is as often dextral as sinistral, *i.e.*, where it does not seem that we can decide which is the really typical form as to the direction of the whorl, the same rule obtains—the position of the internal organs agrees with the shell. If the shell is sinistral, the organs are sinistral; if dextral, the soft parts are dextrally arranged too. But in the case of genera which are normally sinistral, the same law does not hold. Among molluscs also, whose genus is normally dextral, but certain species of which are normally sinistral, the strangest variations occur. A shell twisted to the left may have the body of the animal twisted to the right, and *vice versâ*. In *Limacina*, *Meladomus*, and *Lanistes*, for example, the calcareous integument is sinistral, while the animal is dextral.* What are we to make of this? How comes it that the internal animal, dwelling in a house built on a left-handed spiral, has all its visceral organs arranged as if they were designed to fit into a domicile reared on the principle of a right-handed spiral? The problem, which long seemed insoluble, has recently been carefully investigated, and most ingeniously explained, through the researches of Simroth, of von Ihering, and especially of Pelseneer.

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* Rev. A. H. Cooke, *Molluscs and Brachiopods* (Cambridge Nat. Hist. Series), p. 249.

Briefly, the theory which these scientists have advanced is that of "hyperstrophy" or "over-turning," and it amounts to this, that these abnormalities and discordances between shell and animal are the result, not of sinistrorsity, but of ultra-dextrality. Let us imagine a *Physa*-shaped shell, with a spire normally sinistral, and an internal animal also sinistral. Its spire is elongated, and it presents a comparatively tapering appearance. Let us now suppose that this elongated spire is so depressed and pushed into the body of the shell that it projects very little above the level of the series of whorls. That would be a second stage towards complete inversion of the visceral organs. Depress the remainder of the spire still more, and now the apex is flush with the rest of the whorls, and lies flat like the spring of a watch. The *Physa*-like shell has become a *Planorbis*-shaped shell! But now continue the depression of the apex, push it right through to the other side, and the discoid or planorboid shape gives place to an intermediate sub-discoidal form. Continue the process still further, and you have your *Physa*-like shell back again, but now with the whorls completely reversed! The sinistral shell, with its sinistrally placed viscera, first of all passed into what might be called a neutral stage, wherein it was hard to say whether its planorboid shape meant that it was sinistral or that it was dextral; and from that it emerged into a pseudo-dextral, yet really ultra-sinistral shell, but with its viscera still sinistral! Thus it would appear that the planorboid shape is really a kind of intermediate, half-way house between, on the one hand, sinistrorsity of both shell and animal, and, on the other hand, sinistrorsity of animal, but pseudo-dextrality of shell. Naturalists of an earlier day, such as Lamarck and Deshayes, puzzled with the apparent anomalousness of these phenomena, named the genus *Planorbis* "amphidromic," or "turning in both directions," as certain species seemed to choose one course and certain others a reverse direction. But this ingenious theory of "hyperstrophy," or the turning of a mollusc inside out like the finger of a glove, entirely explains what before was so obscure.*

This process of turning inside out may take place in either direction; in other words, there may be ultra-sinistrorsity or ultra-dextrality. The former may be illustrated in the case of two fresh-water genera, *Pompholyx* from North America, and *Choanomphalus* from Lake Baikal; and the latter by the genera already cited—*Limacina*, *Melodomus*, and *Lanistes*. I have recently received a number of specimens of this last-named mollusc, *Lanistes bolteniana*, from my sister, Mrs. Dr. Boxer, who picked them up on the shores of

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* Admirably illustrated by diagrams in J. W. Taylor's *Monog. of the Brit. L. and F.-W. Moll.*, Vol. I., pp. 111, 112.

Lake Nyasa, Livingstonia, where the species occurs in tolerable frequency.

It is interesting to note that there are several collateral proofs of the truth of this "hyperstrophic" theory. One is in the position of the heart, which, in the case of a normally sinistral shell that has become pseudo-dextral, retains its relative position amongst the viscera of the newly-shaped mollusc, similar to that which it occupied while its original external form was sinistral. Similarly with the genital and anal apertures and other internal organs, while the arrangement of the nervous system affords contributory evidence. But another striking corroboration is furnished by the operculum. "It is well known," says Mr. Cooke, "that the twist of the operculum varies with that of the shell: when the shell is dextral, the operculum is sinistral, with its nucleus near the columella, and *vice versâ*. In these ultra-dextral shells, however, where it is simply the method of the enrolment of the spire that comes in question, and not the formation of the whorls themselves, the operculum remains sinistral on the apparently sinistral shell." *

Occasionally there have been discovered specimens of reversed shells which display an inclination to return to their primitive dextral condition, a process the exact opposite to that which has been described above, illustrating the instability of varieties and even of species in their typical features.

But it is open to the animal to go in for still another striking variation. This is known as "Heterostrophy," or the coiling of the shell in a different direction in the adult, from what has been the habit in the embryonic, stage. The embryonic form of *Planorbis corneus*, for example, has a spirally sinistral shell, but in the adult stage the shell becomes discoidal and practically dextral, and shows a heterostrophic change. At a certain period in life it is within the power of certain molluscs to change the direction of their whorls, and the change may be effected even almost at right angles to the original plane of the whorls, lying thus across the nucleus of the spire. This phenomenon is observable in *Odostomia*, *Eulimella*, *Turbonilla*, and *Mathilda*, all belonging to the Prosobranchiata, with *Actæon*, *Tornatina*, and *Actæonina* (Carboniferous) among the Opisthobranchs, and *Melampus* alone among Pulmonates.† *Ancylus fluviatilis*, also, which in its early stages is sinistrally coiled, only later tends to become a dextral shell.‡

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* Rev. A. H. Cooke, *Op. cit.* p. 250.

† Cooke, *Ibid.* p. 250: see Fisher and Bouvier, *The Asymmetry of Univalve Mollusca* (*Journ. de Conchyl.*, 1892, pp. 117-208).

‡ Taylor, *Op. cit.* p. 116: quoting Bourguignat *De la Sinistrorsité des Espèces*: in Moitessier's *Hist. Malacol. du départ. de l' Hérault*, 1868.

The next point which must occupy our attention is whether there is any reason which may be suggested as adequate to explain this strange phenomenon of sinistrorsity in the mollusca. Here we must frankly confess that we can only hazard conjectures, and have no certain ground to go on. Taylor states * that M. Bourguignat broached the idea "that it might be caused by *electrical conditions*, the electric current flowing in the opposite direction to the embryonal rotation, the essential conditions being a metalliferous soil, moist weather to influence the latent electricity of the metallic substances, and the conjunction of the atmospheric and terrestrial electricity, as by thunder at the period of the first manifestation of vitality by the embryo. Prof. Carus also considers that the direction of the coiling of the shell and animal may possibly be determined by *the direction of the embryonal rotation*."

An American naturalist, Mr. R. Ellsworth Call, writing on "Reversed Melanthones," believes that he has discovered the cause of sinistrorsity, at least in the genus *Melantho*, to reside in *the crowding of the embryos in the oviduct* in the early stages of their existence. He was brought to this conclusion from the statistics of mortality amongst members of the genus that were sinistral, as contrasted with those that were dextral. His researches revealed the fact that sinistrorsity was no help to the animal in the struggle for life, but decidedly the reverse. The mortality amongst sinistral specimens was markedly greater than amongst those dextrally coiled: leading to the belief that sinistrally convoluted molluscs are much more delicate in structure and liable to destructive influences than those normally whorled. "Sinistral examples constituted 1½ per cent. of the total number of the embryos in the oviduct of *Melantho integra*: and 2½ per cent. in *Melantho decisa*, while judging from the numbers gathered in the adult stage, he found that only one-tenth per cent. survived." † Emphatically, then, sinistrorsity is not a condition of life conducive to survival. This fact even is seen in the tendency of sinistral shells to revert to dextrality, when an opportunity occurs, as if through an instinct of self-preservation. A French observer, M. Sanier, who attempted to perpetuate the reversed form of *Helix aspersa* by breeding from them solely, had the mortification to find that the few resultant offspring were all dextral.

While the explanations offered above may be considered as partly contributing to the elucidation of the problem, there is this also to be rememberd that *locality* seems to have at least some influence on the

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* *Ibid.* p. 109.

† Quoted by Taylor, *Ibid.* p. 109; from Call, *Amer. Nat.*, Vol. XIX., p. 207, March, 1880.

relative frequency of sinistral shells. There are some districts much more favoured in this respect than others. Cailliaud* gives La Rochelle as a locality where *Helix aspersa* monst. *sinistrorsum* may be frequently met with: and Jeffreys† says, "The late M. d'Orbigny showed me a colony of the reversed monstrosity in his garden at Rochelle."

But there is cumulative evidence to show that *change in the healthiness and purity of the environment* has also a very distinct influence upon the question of the frequency of sinistrorsity in mollusca. It is a well-proved fact that abnormalities in most instances are the result of unnatural and abnormal external conditions. Mr. Taylor‡ remarks that "a stream of water pumped from a colliery at Leventhorpe Pastures, near Leeds, yielded a very large number of curiously twisted shells of *Planorbis carinatus*, of which a large proportion were sinistrally coiled, and all of which were thickly encrusted with a dense black carbonaceous deposit. So universally prevalent were these remarkable shells in this stream, that at one time it was a rarity to obtain a normally coiled specimen." There have now been collected from all quarters of the world so many interesting facts relative to this question of the influence of the environment upon the forms of mollusca, that it is needless that I should enter at any length upon the subject. The evidence has been marshalled in detail in the Rev. A. H. Cooke's splendid monograph.§ Impurity in the water at once affects the inhabitants of a lake, or pond, or river. Increase or decrease of salinity: the introduction of foreign matter such as chemical refuse: pollution through proximity to coal pits, iron pits, or other mineral deposits: the presence of peat in the water: the appearance of excessive vegetable, or even desmid growth in the habitat,—all these immediately have the effect of causing a tendency towards abnormalities, such as dwarfing, corrosion, twisting, inflation, and also sinistrorsity, In the Miocene Tertiaries of Asia Minor, Prof. Forbes discovered whole races of *Neritina*, *Paludina*, and *Melanopsis*, with whorls ribbed or keeled, as if through the unhealthy influence of brackish water. The fossil periwinkles of the Norwich Crag are similarly distorted, probably by the access of fresh water: parallel cases occur at the present day in the Baltic.|| The extraordinary series of variations in the shape and size of the genus *Planorbis* have been beautifully brought out in the investigations of

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* *Catalogue des Radiaires, des Annélides, des Cirrhipèdes et des Mollusques de la Loire Inférieure;* Nantes, 1865, quoted by Taylor, *Ibid.* p. 108.

† *Brit. Conchology*, Vol. I., p. 182.

‡ *Ibid.* p. 104.

§ *Molluscs and Brachiopods*, pp. 82-95.

|| Woodward, *Manual of the Mollusca*, 4th Edit., p. 37.

the strata of sand and lime near the village of Steinheim in Würtemberg, first by Hilgendorf,* in 1866, and later, by Professor Hyatt,† in 1880. Indeed, the consequences of any disturbance of the normal conditions of existence in which mollusca live are so appreciable that I think I am safe in saying that there is no class of animals more subject to variation from this cause.

Such being the case, we naturally ask, was it owing to some change in the density of the water, or to the introduction of some impurity, or to the presence in the sea of some peculiarly unhealthy constituent, that in the Tertiary deposit known as the Red Crag *Neptunea (Fusus) antiqua*, one of our largest British marine molluscs was almost invariably sinistral? While to-day to find a reversed specimen of this mollusc is a great rarity, in the Red Crag seas it was the dextral form that was the exception. Jeffreys ‡ remarks, "*Fusus antiquus* still exists and is common in our seas: but the proportion of dextral to sinistral specimens is at present exactly the contrary to what it was in the Crag epoch—the former being now the rule, and the latter the exception. A reversed specimen in a recent or fresh state is worth half-a-sovereign; while dextral specimens may be had at any street stall (with the fish) at the rate of four for a penny."

At the outset of this enquiry we ask, under what conditions were the Red Crag formations laid down? I turn to Sir Andrew C. Ramsay's *Physical Geology and Geography of Great Britain* (6th Edit., 1894, p. 210), and there I find it stated, "The Red Crag is a ferruginous sand, often crowded with shells entire and broken, and irregularly bedded, in a manner which shows that it was deposited in shallow seas, with strong tidal currents near shore, and, indeed, partly between high and low water-lines. It attains a thickness of from 40 to 150 feet,§ and when obtained at a depth below the surface, as in well-borings, it is often greenish-grey or bluish-grey in colour. At Walton-on-the-Naze in Essex, and at Felixstow in Suffolk, the Red Crag is well seen in the sea-cliffs, lying directly on the London Clay." Now, there are several phrases in this sentence which seem to give us a clue. The words "often crowded with shells entire and broken, and irregularly bedded," seem to me to suggest rather a hecatomb and a wholesale slaughter from some cause or other, than a regular and systematic deposition of strata containing mollusca which have died in a normal manner. In ordinary circumstances molluscan

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* *Monatsbericht d. k. Preuss. Akademie d. Wissenschaft zu Berlin*, July 1866.

† Genesis of Tertiary Species of *Planorbis* at Steinheim. *Anniversary Memoir of the Boston Soc. of Nat. Hist.*, 1880.

‡ *Brit. Conch.*, I., p. xxi.

§ Sir Arch. Geikie says 25 feet, *Text-book of Geology*, p. 873.

deposits are not so "crowded"; the customary mortality is so comparatively slow that we do not find dead shells piled promiscuously one on the top of another; and the question arises, what was the cause of this excessive mortality during the Red Crag Period?

I find the cause in another word in the same sentence, "the Red Crag is a *ferruginous sand.*" Now, red sandstone is an infallible mark of rapid deposition, and therefore of active physical change. The red is the result of the superabundance of oxide of iron: and as we glance over the red rocks or red deposits of all time, we discover how uniformly destructive this mineral has been in relation to organic remains. "The Lower Devonian beds in England," says Sir Arch. Geikie, "are singularly barren, having as yet yielded no gastropod nor cephalopod, and only 21 species of brachiopods."* The Middle Devonian rocks have pelacypods poorly represented, 13 genera only occurring, many of them represented by only one species; while the gastropods are represented in but small numbers and variety.† In Scotland, as soon as the Old Red Sandstone begins, the fossils rapidly die out.‡ "The physical conditions under which the precipitation of iron oxide took place were evidently unfavourable for the development of animal life in the same waters. Where the strata of the Old Red Sandstone, losing their red colour and ferruginous character, assume grey or yellow tints, and pass into a calcareous or argillaceous condition, they not infrequently become fossiliferous. At the same time, it is not unworthy of remark that some of the red conglomerates, which might be supposed little likely to contain organic remains, are occasionally found to be full of detached scales, plates, and bones of fishes."§ It is also the same with the Permian rocks, also red in colour; they are almost barren of organic remains.

Now it seems to me that the same law which obtained in the infinitely remote Palæozoic Age, represented by the Devonian and Old Red Sandstone strata, held good also in the Kainozoic or Tertiary Age, while the Red Crag formations were being laid down in Pliocene times. The so-called Crag formations begin with the White or Coralline Crag, with an abundant molluscan fauna, the species of which indicate a somewhat warmer climate than that of the British Isles at the present time, and a moderately shallow sea. But when we reach the next formation, the Red Crag, we see a falling off. The shells in this bed have a worn and almost rotten appearance, as if some disease had prevented them from attaining to their normal dimensions and normal solidity. They are thin and friable, and their aspect gives one the impression that some epidemic overtook them, and reduced them in shoals to a dying condition. All are

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* Sir Arch. Geikie, *Text-book of Geology*, p. 700.

† *Ibid.* p. 700. ‡ *Ibid.* p. 708. § *Ibid.* p. 711

deeply tinged with red oxide, to such an extent that I believe that it was this same ferruginous deposit which was the occasion of the excessive mortality. The infiltration of this iron matter was apparently accompanied with colder climatic conditions, and the result was the killing off of the more peculiarly southern fauna, and the destruction of those organisms which were unable to adapt themselves to the new environment. Hence we have in this formation the masses of heaped-up dead shells, which testify to abnormal mortality.

In the case of *Neptunea antiqua*, however, the hypothesis which I advance is this, that through the subtle operation of this pollution in the sea-water, the animal, though strong enough to resist absolute extermination, was nevertheless so influenced, that the embryo adopted a sinistral twist, and hence we have the phenomena of the mons. *sinistrorsum* being the typical form of the mollusc during this epoch. Just as to-day in Yorkshire, as we have seen, the introduction of foreign substances into a pond has a well-proved tendency to induce the creation of malformed and sinistral molluscan species: so, I believe, in the Pliocene seas, the prevalence of this oxide of iron exerted on this particular shell a strange influence, and the effect ultimately was the establishment of a sinistral form of the mollusc as the normal type during the Red Crag Period. But the sinistral coil in this particular mollusc is seemingly not natural. And no sooner were the deleterious influences removed than the shell reverted to its former dextral shape. The Norwich Crag and Chillesford Clay, which superimpose on the Red Crag, testify to the arrival of purer waters, and to the absence of that ferruginous deposit which played havoc with the shells of the Red Crag. And consequently the molluscs of these and subsequent formations in the Pliocene and Pleistocene Ages, though northern, and even in some cases Arctic, in character, show almost no tendency to congenital malformation, and sinistral shells become as rare as formerly they had been common. I am not aware that this theory to account for the sinistrorsity of *Neptunea antiqua* has been previously advocated, and I advance it now, with all diffidence, as a possible explanation of the phenomenon.

It would be hopeless to attempt to give an adequate enumeration of even the genera of mollusca throughout the world, amongst which certain species have revealed tendencies towards sinistrorsity. The phenomenon is much more conspicuous amongst land and fresh-water mollusca than amongst marine. Moquin-Tandon enumerated 38 species of French land and fresh-water shells, usually dextral, amongst which sinistral monstrosities appeared, and 5 normally sinistral shells, associated with which had been discovered dextral monstrosities.* It would be an exceedingly interesting list, if we

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* Jeffreys, *Brit. Conch.*, Vol. IV., p. 327.

possessed one, of all the reversed shells of the world, but I fear such a catalogue has never been compiled. From my reading on the subject, however, I would be inclined to prophesy that the number would be somewhat larger than is commonly supposed.

Shunning this very ample and exhaustive task, I will, in conclusion, attempt a humbler and less comprehensive effort, viz., to give a list of all the reversed shells in the molluscan fauna of Great Britain and Ireland, with their localities and the names of their finders. I am not aware that such a list has ever before been drawn up, at least I have never come across one.

I. British Marine Mollusca Showing Sinistral Tendencies.

Littorina littorea, var. *sinistrorsa* (Jeff.)—Spire of shell sinistrally coiled, that of operculum dextrorsal. "I procured two specimens at Billingsgate, and Mr. Rich obtained a third, which is now in Mr. Leckenby's collection. It is rather surprising that, considering the enormous number of periwinkles brought every year to this market, the reversed kind should be so excessively rare. I was assured by all the dealers in shell-fish that only these three specimens had ever been heard of." (Jeffreys *Brit. Conch.*, Vol. III., p. 370). See *J. of C.*, IX., 1898, p. 123.

Lamellaria.—A peculiarity of the genus is that the spire has the first or top whorl apparently semi-detached from the next, and twisted. It is an example of heterostrophic sinistrorsity.

Triforis perversa (L.) [= *Cerithium perversum*, L.]—The shell is sinistral. James Smith recorded it from Cumbrae: Norman and Landsborough states it is frequently found dead in Lamlash shell sand: the late Alfred Brown's verdict is "not uncommon dead in Clyde": Dr. Thos. Scott records it from Tarbert Bank, Loch Fyne, dead: Chaster and Heathcote mention that one living specimen was obtained off Oban: A. Somerville reports it from off Iona in 20 and 35 fathoms, and from Barra in 14 fathoms, and the present writer has dredged it inside Sanda Island in 25 fathoms, and nine miles off the Mull of Cantire in 55 fathoms. Apparently, like other sinistral shells, it shares in their racial disabilities in the struggle for life, and is slowly dying out.

The genera belonging to the family Pyramidellidæ, viz.:—*Odostomia*, *Jordanula. Liostomia*, *Brachystomia*, *Ondina*, *Oda*, *Pyrgulina*, *Spiralinella*, *Miralda*, *Pyrgostelis*, *Turbonilla*, and *Eulimella*, all more or less have the peculiarity that the embryonic nucleus, the first or top whorl, is sinistral, or reversed, and they are thus examples of "Heterostrophy."

Eulima polita (L.) seems to have an inverted embryonic nucleus, but the same feature is not observable in the other Eulimidæ.

Buccinum undatum m. *sinistrorsum* (Jeff.)—Jeffreys (*Brit. Conch.*, Vol. IV., p. 287) records it from "coasts of Kent, Sussex, Lincolnshire, and Yorkshire: it is the *B. Bornianum*, etc., of Chemnitz. I have both solid and thin specimens of this monstrosity": see also Partridge (*J. of Malac.*, VII., 1898, p. 40): Manchester mussel stall (W. Wright) *J. of C.*, VIII., 1895, p. 53: Margate (T. Edwards) *J. of C.*, VIII., 1896, p. 267: IX., 1898, p. 20: Thanet (Thos. Edwards) *J. of C.*, IX., 1899, p. 146: X., 1900, p. 34.

Neptunea antiqua m. *contrarium* [= *Fusus antiquus* m. *contrarium* Jeff. = *Fusus contrarius* L. = *Fusus sinistrorsus* Desh.]—Jeffreys gives the following as authorities:—Wexford (Sir H. James): Kelsey Hill (Prestwich): Aberdeenshire Crag-beds (Jamieson): see also Margate (T. Edwards), *J. of C.*, VIII., 1896, p. 267: IX., 1899, p. 146. I have already remarked on this characteristic sinistral shell in the Red Crag formation. It has been recorded living by Michaud at Barcelona, at Vigo by M'Andrew (see *J. of C.*, IX., 1897, p. 19), and by Jeffreys at Sicily. The *Fusus deformis*, a similar species, found off Spitzbergen, is always reversed.

Purpura lapillus m. *sinistrorsum* (Jeff.)—Jeffreys (*Brit. Conch.*, Vol. IV., p. 278) states that "a specimen of the reversed monstrosity is in the collection of the late Mr. Bean at Scarborough."

Actæon has its first whorl tumid and obliquely intorted.

The genus *Tornatina* is said also to be Heterostrophic in its embryonal whorl.

The genus *Limacina* [= *Spirialis*] has a heliciform, sinistral shell. *Limacina retroversa* (Flem.) is obtained periodically in shoals on the West Coast of Scotland.

Alexia denticulata Mont. and *Leuconia bidentata* (Mont.) [= *Melampus*] have sinistral or rather heterostrophic embryonal nuclei.

When we count the species included under these above-named genera, we find that sinistrorsity forms a very distinct feature in various degrees of markedness amongst our British Marine Mollusca. The table is as follows:—

	SPECIES.
Littorina littorea var. *sinistrorsa* (Jeff.), ...	1
Lamellaria perspicua (L.), ...	1
Triforis perversa (L.), ...	1
Odostomia, containing species to the number of	8
Jordanula, ,, ,, ,,	2
Liostomia, ,, ,, ,,	1
Brachystomia, ,, ,, ,,	7
Ondina, ,, ,, ,,	4
Oda, ,, ,, ,,	1
Pyrgulina, ,, ,, ,,	6
Spiralinella, ,, ,, ,,	1
Miralda, ,, ,, ,,	1
Pyrgostelis, ,, ,, ,,	2
Turbonilla, ,, ,, ,,	4
Eulimella, ,, ,, ,,	5
Eulima polita (L.), ...	1
Buccinum undatum mons. *sinistrorsum* (Jeff.), ...	1
Neptunea antiqua mons. *contrarium* (Jeff.), ...	1
Purpura lapillus mons. *sinistrorsum* (Jeff.), ...	1
Actæon, containing species to the number of ...	2
Tornatina, ,, ,, ,, ...	6
Limacina, ,, ,, ,, ...	3
Leuconia, ,, ,, ,, ...	1
Alexia, ,, ,, ,, ...	1
	62
Total number of genera with sinistral tendencies,	24
,, species ,, ,,	62

II. British Land and Fresh-Water Mollusca Showing Sinistral Tendencies.

[*Hyalinia cellaria* m. *sinistrorsum.*—The reversed form has never, I believe, been discovered in this country; but Mr. C. W. Johnson records (in the *Nautilus*, Dec., 1893) its discovery at West Conshohocken, in Pennsylvania, U.S.A., by the late Mr. R. Walton. (*Journ. of Conch.*, Vol. VII., 1894, p. 388.)]

Helix rotundata m. *sinistrorsum*, Taylor, very rare: one collected by Canon C. H. T. Lett, in Aug., 1888, at Aghadery Glebe, Loughbricklands, Co. Down (*J. of Conch.*, Vol. VI., 1889, p. 39): another found by Mr. Alfred Sich in his garden at Chiswick (*J. of C.*, VIII., 1896, p. 175): a fossil specimen found by Dr. Loretz in tufaceous limestone in Coburg: and one at Castleton, Derbyshire, found by Mr. J. W. Jackson (*J. of C.*, Vol. X., 1902, p. 284).

Helix obvoluta (Fér.) m. *sinistrorsum* (W. H. Heathcote), supposed to be from Ditcham, Surrey (*J. of C.*, VIII., p. 428).

Helix lapicida m. *sinistrorsum*; very rare: one by C. A. Westerlund in 1871 (*Journ. of Malac.*, Vol. VIII., 1901, p. 21): also by F. J. Partridge at Lynton, North Devon (*Journ. of Malac.*, Vol. VII., 1900, p. 180).

Helix pomatia L. var. *sinistrorsa*, in "Hunter Barron Collection of Mollusca" in Natural History Museum, Mason College, Birmingham, occurs a typically sinistral specimen. "Locality: Kent (?)" (*The Conchologist*, Vol. II., 1893, p. 96): at Box Hill, Surrey, May, 1904, found by F. B. Jennings (*J. of Conch.*, Vol. XI., 1904, p. 96): Kent, (A. Leicester) (*J. of C.*, X., 1902, p. 274): from Thanet (Thos. Edwards) (*J. of C.*, X., 1900, p. 34): (Darbishire) (*J. of C.*, IX., 1897, p. 19).

Helix aspersa m. *sinistrorsum*, Taylor: one on Redcar Sandhills, Yorkshire (Rev. W. C. Hey) (*J. of C.*, III., 1879, p. 74): Goole, Yorkshire (G. H. Parke): one at Christchurch, Hants. (C. Ashford): Garden at Notting Hill, London (H. Adams): three specimens near Epsom; one at Little Brookham: one at Uppingham, Rutland (Daniel): Dartford (Dr. Latham): near Bristol: Bath: Westbury (Miss Hele) (*J. of C.*, IV., 1883, p. 100): Whalley, Lancashire (Standen) (*J. of C.*, VI., 1890, p. 176): Mr. Standen also contributed an interesting paper following up his discovery, entitled "Observations on the Reproduction of the Dart, during an attempt to breed from a sinistral *Helix aspersa*, Müll." (*J. of C.*, VII., 1892, p. 33); Peel, Isle of Man (Cairns) (*J. of C.*, VII., 1892, p. 24; VIII., 1895, p. 52): Paddy's Lane, near Bristol (Hele) (*J. of C.*, VII., 1892, p. 41): Morecambe, Lancashire, 1841, exhibited by J. Ray Hardy (*J. of C.*, VIII., 1895, pp. 23, 52): Clevedon, Somersetshire (Norman) (*J. of C.*, IX., 1899, p. 193): Lewes (C. H. Morris) (*J. of C.*, VIII., 1897, p. 428; IX., p. 4): Raghly, Sligo, 1904 (Welch & Stelfox) (*Irish Nat.*, XIII., p. 189): Little Layton, near Blackpool, Lancashire, dead: Churchtown, Southport, living (R. Drummond) (*J. of C.*, X., 1901, p. 91): West Dulwich (C. H. Deadman) (*J. of C.*, X., 1902, p. 171): Mr. Lionel E. Adams states that the sinistral monstrosity is said to be worth a guinea (*The Collector's Manual of British Land and Fresh-Water Shells*, 1st Edit., p. 62).

H. nemoralis m. *sinistrorsum*, Taylor: West Drayton, Middlesex (Fenn.) (*J. of C.*, V., 1888, p. 357): Burnley, an immature var. *libellula* 12345, dead (F. C. Long) (*J. of C.*, VI., 1890, p. 175): near Gleninagh Castle, Cregg, about three miles from Ballyvaughan, Ireland (Collier), a mature *libellula* (*J. of C.*, VIII., 1895, p. 44): Clitheroe, Lancashire, a living *libellula* (Wigglesworth) (*J. of C.*, IX., 1898, p. 58): Bundoran (R. Welch) (*J. of C.*, IX., 1900, p. 265): Taylor remarks that "a sinistral race of *H. nemoralis*, almost analogous to that formerly existent of *Neptunea antiqua*, would appear to have at one time lived in Co. Donegal, as the very numerous sub-fossil shells, picked out of the immense sandhills about Bundoran, abundantly testify" (*Monog. of Land and Fresh-Water Mollusca of British Isles*, Vol. I., p. 108): between Blackpool and Fleetwood, one dead and two living: three dead and one living between Southport and Hightown (R. Drummond) (*J. of C.*, X., 1901, p. 91): Ballycastle, Co. Antrim (J. Wilfrid Jackson), dead (*J. of C.*, XI., p. 124).

Helix hortensis m. *sinistrorsum*, Taylor: near Bristol (Miss F. M. Hele): Keynsham, N. Somerset (Miss J. Hele) (*J. of C.*, IV., 1883, p. 35): Tenby (C. Jeffreys), of var. *lutea* (*J. of C.*, V.. 1887, p. 166): Topsham, S. Devon (Collier), of var. *lutea* (*J. of C.*, VI., 1891, p. 344): Kettering, Northants, of var. *arenicola* 123(45) (C. E. Wright) (*J. of C.*, VIII., 1896, p. 151): Links, near Aberdeen, very faded in colour, though animal apparently healthy (Prof. Traill) (*Scott. Nat.*, Vol. I., 1871, p. 155): Topsham, S. Devon, 12(345) (in Manchester Museum Collection).

Helix arbustorum m. *sinistrorsum*, Taylor: near Buxton, of the var. *flavescens* (C. Oldham) (*J. of C.*, V., 1887, p. 225).

Helix cantiana m. *sinistrorsum*: Wiltshire (Rippon) (*J. of C.*, VI., 1889, p. 33), the only British record.

As this passes through the press, a new record appears in the *J. of C.*, XI., 1905, October, p. 236, viz.:—

Helix rufescens m. *sinistrorsum*: Northants (Rev. W. A. Shaw).

Helix hispida m. *sinistrorsum*, Carphin: Eyemouth, Berwickshire (Mrs. Carphin) (*Ann. Scott. Nat. Hist.*, 1895, p. 254), the only record.

Helix pisana m. *sinistrorsum*: (Darbishire) (*J. of C.*, IX., 1897, p. 19).

Helix itala m. *sinistrorsum*, Jeff. [=*ericetorum*, Müll.)]: Bridlington (Strickland) (Jeffreys *Brit. Conch.*, I., p. 217): Bundoran (R. Welch) (*J. of C.*, IX., 1900, p. 265) (J. R. B. Tomlin) (*J. of C.*, X., 1902, p. 275).

Helix caperata m. *sinistrorsum*: Stanwich Quarry, Northants, of var. *lutescens* (Rev. W. A. Shaw) (*J. of C.*, XI., 1905, p. 170): Woolacombe, S. Devon (Collier) (*J. of C.*, XI., p. 124).

Helix virgata m. *sinistrorsum*: Afton, Isle of Wight (Ashford): Balne Moor, Yorkshire (Peace): Clevedon (Norman) (*J. of C.*, IV., 1883, p. 36; IX., 1899, p. 199): near St. Sampsons, Guernsey (Sykes) (*J. of C.*, VII., 1892, p. 44): Barnstaple (Partridge) (*J. of Malac.*, VII., 1898, p. 19): Colwyn Bay, 1894 (J. Ray Hardy): Porthleven, Cornwall (J. W. Horsley) (*J. of C.*, IX., 1900, p. 376).

Helix acuta m. *sinistrorsum*: Tenby, living (F. Taylor) (*J. of C.*, IX., 1899, p. 211), the only British record.

Pupa muscorum m. *sinistrorsum*: Abersoch, N. Wales (J. W. Baldwin) (*J. of C.*, XI., 1904, p. 11), the only British record.

Vertigo substriata (Jeff.), m. *sinistrorsum*: Shipley Glen, Yorkshire, 1898 (Fred. Booth) (*J. of C.*, XI., 1905, p. 200).

Vertigo pusilla, Müll., has the shell sinistrally coiled.

Vertigo angustior, Jeff., has a sinistrally whorled spire.

Balea perversa (L.) is sinistrally coiled.

Clausilia perversa (Pult.) is normally sinistral. There is recorded a monst. *dextrorsum* from Slamannan, Stirlingshire, by Mrs. Skilton, Brentford, Middlesex (*J. of C.*, IV., 1885, p. 265): and also from Sevenoaks, Kent (Smith) (Jeff. *Brit. Conch.*, I., p. 280).

Clausilia rolphii Gray, }
,, *biplicata* (Mont.), } all sinistral.
,, *laminata* (Mont.), }

Azeca tridens m. *sinistrorsum*: Boston Spa (J. Emmet) (*J. of C.*, II., 1879. p. 221).

Succinea elegans m. *sinistrorsum*, Baud. (*J. of C.*, VII., 1892, p, 55).

Succinea oblonga m. *sinistrorsum:* South Perthshire roadside quarry (M'Lellan) (*J. of C.*, VII., 1894, p. 367) (*Ann. Scott. Nat. Hist.*, 1894, p. 155).

Planorbis, as a genus, is hyperstrophic, the viscera being placed in an abnormal position relative to the shell. Planorboid shells are found simply dextral, and simply sinistral, and also sinistral by atavism.

Planorbis spirorbis, Müll., may be sinistrally coiled, as Stubbs shows by a series from Tenby (*J. of C.*, IX., 1898, p. 107), and Taylor (*Land and Fresh-Water Mollusca of British Isles*, p. 113), from Gorton, Manchester: Sutton Coldfield (Wood) (*J. of C.*, VIII., 1897, pp. 377, 384).

Planorbis carinatus m. *sinistrorsum*, Taylor: Leventhorpe Pastures, Leeds: Taylor (*Land and Fresh-Water Mollusca of British Isles*, p. 114).

Planorbis umbilicatus m. *sinistrorsum*, Taylor: Wye, Kent (Miss F. M. Hele) (*J. of C.*, IV., 1883, p. 37).

Planorbis corneus (L.) has a spirally sinistral embryonic shell, with the heart on the right side of the body: later the heart moves to the right, and the shell, by heterostrophy, becomes practically dextral.

Bullinus hypnorum (L.) has a sinistrally coiled shell.

Physa fontinalis (L.) is normally sinistral: but Dr. J. W. Williams found a dextral monstrosity at Barnes Common, Hammer smith (*J. of C.*, V., 1887, p. 220).

Limnæa peregra m. *sinistrorsum*: Scarborough (Bean) Jeffreys (*Brit. Conch.*, I., p. 106): Tooting (Cockerell) (*J. of C.*, VI., 1891, p. 304): near Dalmarnock Bridge on Clyde (Dr. F. B. White) (*Scott. Nat.*, Vol. II., 1873, pp. 163, 205).

Limnæa stagnalis m. *sinistrorsum*, Jeff.: Kenn Moor, Somerset (Norman) (Jeffreys *Brit. Conch.*, I., p. 112): near Doncaster, 1860 (J. R. Hardy) (*J. of C.*, VII., 1892, p. 41).

Ancylus fluviatilis, Müll, has a dextral shell, with a sinistral body.

Velletia lacustris (L.) has a sinistral shell, and a dextral body.

Acicula lineata m. *sinistrorsum* (Jeff.): rejectamenta of river Avon at Bristol (Jeffreys).

Vivipara contecta (Millet) m. *sinistrorsum:* Southport, 1864 (Dr. Alcock), a young specimen: (in Manchester Museum Collection) (*J. of C.*, XI., 1905, p. 224).

Vivipara vivipara m. *sinistrorsum;* Bardsley Canal, Lancashire (F. Taylor) (*J. of C.*, X., p. 148).

Valvata piscinalis m. *sinistrorsum*, Jeff.: Sunbury (Grove): Cresswell Crags: Derbyshire (Pickard) (*J. of C.*, IV., 1884. p. 145): Hunstanton, West Norfolk (J. E. Cooper) (*J. of C.*, Vol. VII., 1893, p. 174).

It may be convenient to sum up these results, and thus to see what has been discovered. The following table reveals the extent of the phenomenon of sinistrorsity among the Land and Fresh-Water Mollusca of Great Britain :—

The genus	*Helix*	contains species	with sinistral	tendencies to the number of	15
,,	*Pupa*	,,	,,	,,	1
,,	*Vertigo*	,,	,,	,,	3
,,	*Balea*	,,	,,	,,	1
,,	*Clausilia*	,,	,,	,,	4
,,	*Azeca*	,,	,,	,,	1
,,	*Succinea*	,,	,,	,,	2
,,	*Planorbis*	,,	,,	,,	11
,,	*Bullinus*	,,	,,	,,	1
,,	*Physa*	,,	,,	,,	1
,,	*Limnæa*	,,	,,	,,	2
,,	*Ancylus*	,,	,,	,,	1
,,	*Velletia*	,,	,,	,,	1
,,	*Acicula*	,,	,,	,,	1
,,	*Vivipara*	,,	,,	,,	2
,,	*Valvata*	,,	,,	,,	1

The total number of species showing sinistral tendencies is 48

I feel that I must not close this paper without an acknowledgment of my very grateful thanks to my friends, Dr. W. E. Hoyle and Mr. R. Standen, of the Manchester Museum, for their great kindness in allowing me to exhibit a number of lantern slides illustrative of the different shapes which the mollusca adopt in the convolutions of the whorls, and particularly for preparing specially a fine series of slides of British and foreign shells which exhibit the phenomenon of sinistrorsity.

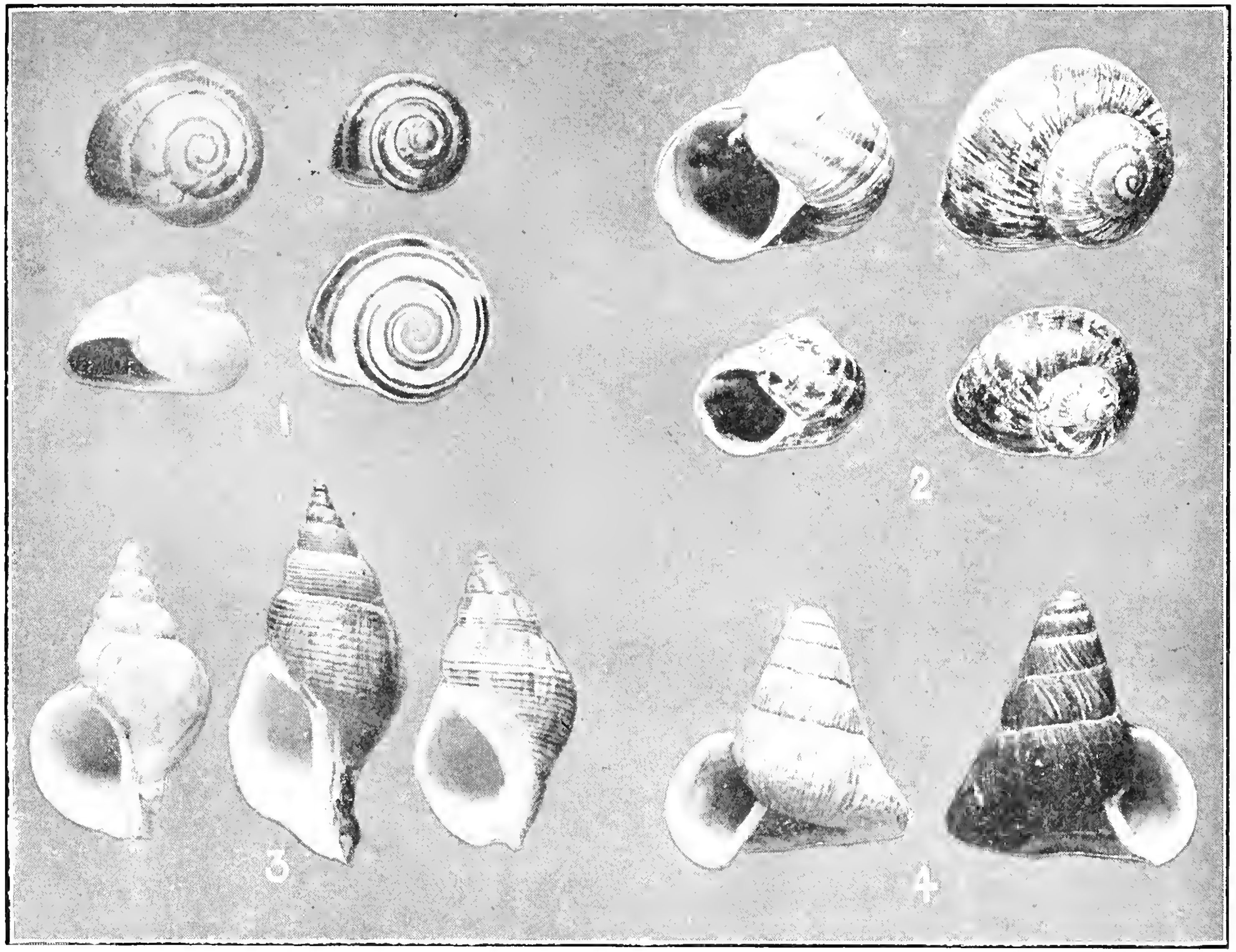
ADDITIONAL NOTE.—"Mr. Atholl Macgregor, of Ardchoile, has kindly furnished me with some facts relative to the sacred reversed conch of Travancore, which he obtained from Mr. Christopher Maltby. He states 'In the Temples the normal shells are used for blowing a call to prayer, while the sacred conch is used as a ladle for anointing the idols with oil. The monetary value of a reversed specimen is very considerable, the price of a small one about 3 inches long, ornamented with a few jewels and gold, being not less than Rs. 150."

I have also been favoured with the following interesting details given me by Mr. Robert Standen, of the Manchester Museum. He says:—"*Turbinella pyrum*, *L.* (Hindu name, "Shankh" or "Chank") is the sacred shell of the Hindus, and the national emblem of the Kingdom of Travancore. It figures on the coins of Travancore—of which there is a good series in the Manchester Museum. The god Vishnu is represented as carrying a chank shell in one hand and a chakru in the other. The Hindus believe that unless they worshipped this shell at the commencement of every religious service or prayer, their offerings would not be accepted. The first incarnation of Vishnu, called Machhávatar—which literally means transformation into a fish—was undertaken for destroying Shankhásura, the giant chank shell, in order to regain the Vedas, he having stolen them and taken refuge under the ocean.

"The fishing for these shells is principally in the Gulf of Manaar, in the vicinity of Ceylon, the coast of Coromandel, at Travancore, Tuticorin, and other places, the shells being brought up by divers from a depth of two or three fathoms. Frequently four or five millions are shipped in a year from Manaar, and the value of the rough shells, as imported into Madras and Calcutta, reaches ten to fifteen thousand pounds sterling. The shells are often used as oil vessels or lamps in Indian temples, for which purpose they are carved and sculptured. The shell, from its weight and smoothness, is used in Dacca for calendering or glazing cotton, and in Nepal for giving a polished surface to paper. The principal demand, however, is for making *bangles* or armlets and anklets, and the manufacture is still almost confined to Dacca. Some of these bangles, worn by the Hindu women, are beautifully painted, gilded and ornamented with gems, and coated inside with plaster to smooth the roughness. These bangles are not removed at death, and hence there is a continual demand for them.

"The chank shell is highly prized, not only in India, but also in China and Siam, especially a sinistral variety found on the coasts of Tranquebar and Ceylon, and made use of by the Cingalese in some of their most sacred rites. A reversed chank is so highly prized for its rarity as sometimes to sell in Calcutta for its weight in gold, or at £40 to £50 sterling. In Ceylon, also, the reversed variety is held sacred by the priests, who administer medicine by it. Such reversed shells are held in special veneration in China, where great prices are given for them. They are kept in the pagodas by the priests, and are not only employed by them on certain special occasions as the sacred vessels from which they administer medicine to the sick, but it is always in one of these sinistral turbinellas that the sacred oil is kept with which the Emperor is anointed at his coronation. The shells are often curiously ornamented with elaborate carvings."

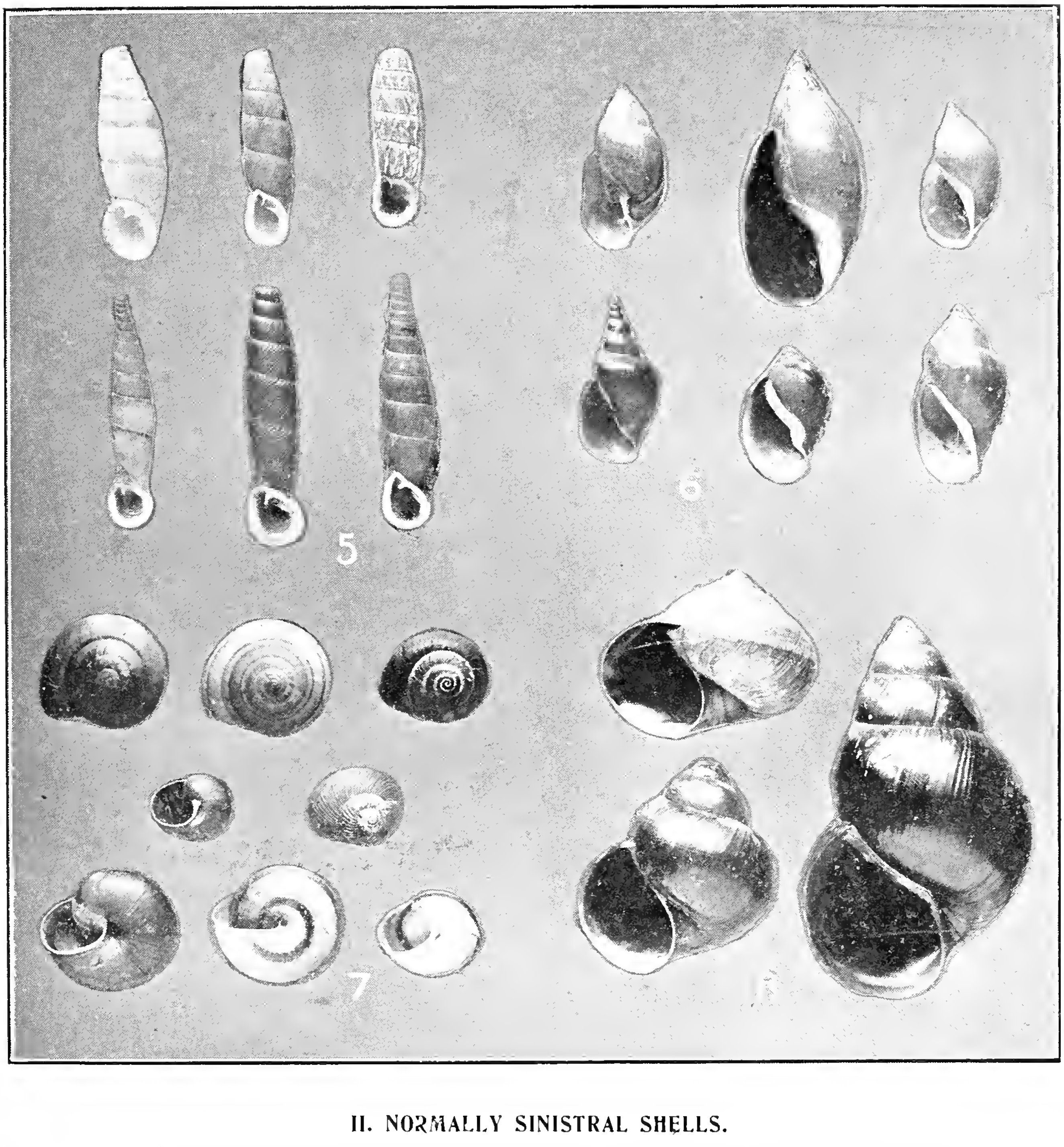
[This Part, pp. 63-119, published 17th November, 1905.]



I. ABNORMALLY SINISTRAL SHELLS.

1. Helix arbustorum, hortensis, and memoralis.
2. Helix pomatia, and aspersa.
3. Neptunea antiqua m. contrarium, and Buccinum undatum.
4. Gibbus lyonetianus.

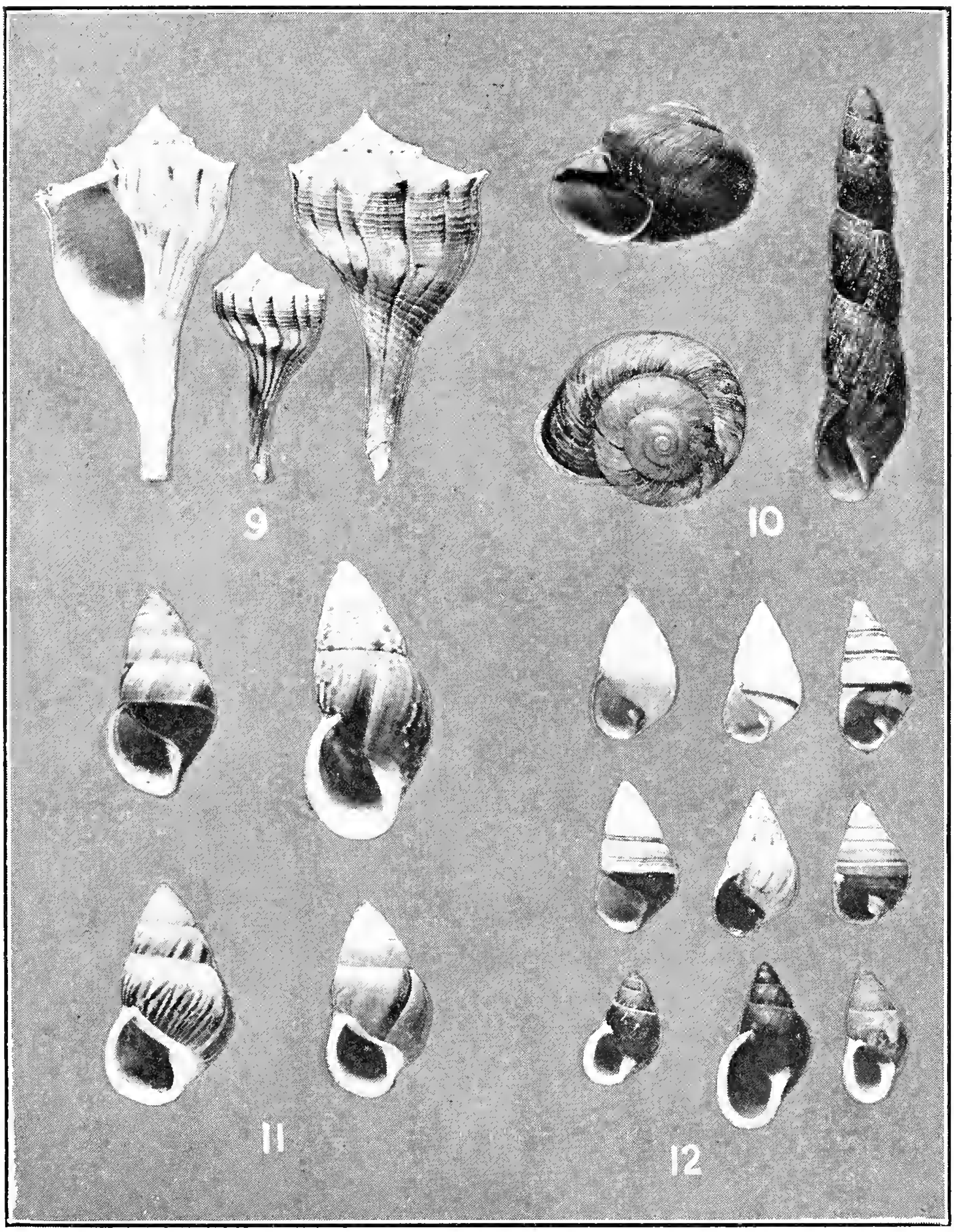
Plate 18.



II. NORMALLY SINISTRAL SHELLS.

5. Clausilia fargesiana, valida, taczonowski, messageri, majistera, artifina.
6. Physa castanea, maugeria, novæhollandiæ, tongana, perlucida, lessoni.
7. Ariophanta thyreus, regalis, lævipes, bajadera.
8. Lanistes bolteniana, ovum, olivacea.

Plate 19.



II. (Continued) NORMALLY SINISTRAL SHELLS.

9. Pyrula perversa

10. Helix quaesita and Columna flammea.

III. SHELLS SINISTRAL OR DEXTRAL IN ABOUT EQUAL PROPORTIONS.

11. Amphidromus jayanus, maculiferus, interruptus, citrinus.

12. Achatinella candicans, ampulla, fasciata, diversa, proxima, multilineata; Partula amabilis, canalis, otaheitana. (These three Partula are always reversed).

Plate 20.

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1906.

Some Aspects of the New Craniology.

BY JOHN LYELL, M.D.

(Read 14th December, 1905).

(Abstract).

Though it now seems a self-evident truth that the brain is the instrument or seat of the mind, the most divergent opinions have at different times been held as to the true function of that important organ. The ancients, for example, thought that it was of no use except to cool the circulation, while the philosophers of the Middle Ages believed it to be the source of the hypothetical "animal spirits." The phrenological school, on the other hand, conceived that the various faculties of the mind could be mapped out on its surface. Phrenology is now defunct, and has given place to the sound, but limited, knowledge of brain function which characterises present-day physiology. It is, however, chiefly certain sensory and motor functions, such as sight, hearing, speech, and muscular action, which have been definitely localised in the grey or surface matter of the brain. With regard to the higher intellectual powers it is still a question whether they have any special localisation at all, unless they reside, as some authorities believe, in what are now known as the "association areas" of the cortex. Nor have we any certain knowledge of the exact relation of the exterior of the skull to all of the convolutions lying beneath, the shape of the bones being due to other factors besides brain development.

The doctrine of evolution and the study of the origin of man throw an interesting light upon the development of the brain and skull, showing us how there is a gradation of types from the earliest fossil skulls of ape-like character to the fully evolved modern examples, such as that of the European. The characters of a low receding forehead, huge superciliary arches, deep temporal fossae, expansive orbits, and a small capacity, together with large prognathous jaws, are the stigmata of low development, and are present in greater or less degree in *Pithecanthropus erectus* * of the Tertiary period, and in the *Neanderthal* and *Spy* skulls of later date. It is remarkable

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* In reference to this perhaps most profoundly interesting fossil remnant ever discovered, Duckworth remarks that "in *Pithecanthropus erectus* we possess the nearest likeness yet found of the human ancestor at a stage immediately antecedent to the definitely human phase, and yet at the same time in advance of the simian stage." *Morphology* and *Anthropology*, 1904, p. 520. Haeckel also, as is well known, considers the *P.e.* as the "missing link."

that the lowest races of present-day man, such as the Veddah of Ceylon and the aborigines of Australia, present similar ape-like features. On the other hand, a broad and lofty frontal region, large capacity and straight or orthognathous jaws, point to advancement of type, being distinctive of the higher civilised races of modern times. The use of the terms "high-grade" and "low-grade" skull is therefore quite legitimate, according as any given example approximates in size and shape to the higher or lower types in the scale. The distinction between high and low, advanced and degraded, is no arbitrary or sentimental one, based upon mere aesthetic principles, but depends upon strictly scientific data, and is referable to the action of evolutionary laws.

THE "NEW PHRENOLOGY."

The skulls of present-day civilised men, while conforming to a definite advanced type, yet present many minor variations in shape and size, hardly two heads in a crowd being exactly the same. Though we no longer attempt to read mental qualities in the different bumps and dimples of the skull, anthropologists now look upon these variations as of great significance from a racial point of view, and an important school has arisen holding that there are also various peculiarities in the general shape of the head and face, which have a definite relation to certain mental and moral characteristics. This school is chiefly associated with the name of Cesare Lombroso of Turin, and as the doctrines of this famous anthropologist have attained great notoriety, and have an important sociological bearing, it may be of interest to examine them in some detail.

THE CRANIOLOGY OF THE CRIMINAL.

To arrive at a proper conception of the significance of morphological variations, it is always of importance to carry investigation into the sphere of the abnormal. The school of Lombroso took its origin in the study of the skulls and brains of the inmates of prisons and asylums, and it was found that amongst criminals there exists a class of individuals who differ from ordinary men and women in the possession of certain peculiarities of bodily structure, more especially to be seen in the shape of the head and face, these abnormalities being associated with an exceptional degree of that perversity and viciousness of character which are common amongst prison inmates. Such specially depraved individuals Lombroso terms "instinctive or born criminals," and the greater part of his famous book* is devoted

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* "L'Uomo Delinquente." No English translation, but well known in the French Edition, "L'Homme Criminel" (2 vols, 1895), to which the references in this paper apply.

to the proof that they constitute a well marked type of humanity, and that this conclusion is justified both upon physical and psychical grounds, which have a definite biological value.

On the physical side, the most important peculiarity is the unusual number of anatomical abnormalities which such criminals present—abnormalities, for example, in the hands and feet, in the heart and other internal organs, in the vertebrae, but more especially in the skull and face. The average size of the head is said to be smaller than that of Europeans, though the bodily height is greater. In long-headed nations the criminals have often very long heads, and in broad-headed nations they have very broad heads. The various bones of the skull present many deviations from the normal, and owing to their irregular union the head is often pointed or sugar-loaf in appearance. The most characteristic deformity, however, is a general lack of symmetry, the whole head being twisted or awry. A mis-shapen head, in short, is one of the most distinctive characters of the born criminal.*

The brain, again, is as a rule of inferior volume, and often shows evidences of disease in the convolutions, membranes or blood-vessels.§

The face is wrinkled and ugly, the forehead retreating, the profile prognathous or "snouty," the features unsymmetrical. "The majority of (born) criminals," says Lombroso, "have projecting ears, abundant hair, scanty beard, the frontal eminences and the jaws of enormous size, the chin square and salient, and the cheek bones large—the whole presenting a type resembling that of the Mongol races, and sometimes of the negro." †

Turning now to the mental and moral characters, we find that the instinctive criminal is distinguished first of all by a remarkable insensibility to pain, upon which is based that moral insensibility which is his most prominent quality. Savage and brutal, he looks upon homicide, robbery, and other aggravated forms of crime merely in a professional light, as means by which he may gratify his selfish ends, irrespective of injury and loss to his fellows. He is little influenced by punishment, lazy and idle in prison as he is outside its walls. He is vain, and boasts of his crimes, without remorse, though often sentimental and even religious. He delights to tatoo his body, is an artist in his own way, and sometimes writes poetry. He is cunning, revengeful and cruel. He is a lover of wine and of play, sensual in his tastes, addicted to the most degrading orgies, and as a result of his vices often becomes irritable and neurotic. The picture is a lurid one, elaborated by Lombroso with innumerable graphic

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* Lombroso, *loc. cit.* Vol. I., p. 171.

§ *Ibid.* p. 187.

† *Ibid.* p. 222, 263, &c.

details.* That there do exist such human monsters of iniquity and vice, corresponding in greater or less degree to this description, has of course never been doubted, but Lombroso's point is that these individuals owe their depravity to innate and congenital physical defects, which are clearly marked and referable to well-known laws.

A considerable amount of misunderstanding has arisen owing to the fact that Lombroso, in the earlier stages of his work, considered all criminals in a single class. As he proceeded in his studies, however, it became plain that different groups had to be distinguished, and amongst these the conception of the born or instinctive criminal gradually assumed shape. There are, of course, a vast number of individuals in our prisons who are simply ordinary men and women, led astray by their follies and passions, and these have, strictly speaking, nothing to do with criminal anthropology. But in the proportion of about forty per cent. of all criminals, Lombroso believes that he can find sufficient abnormality of mind and body to constitute a type distinct from the rest of humanity. There is no doubt that outside Italy the proportion is much less—certainly very much less in our own country, where serious crime does not abound. It is sufficient, however, for our present purpose to consider the type which Lombroso has set up, more especially in relation to its origin and affinities, and to enquire how far the doctrines of the criminal anthropologist have withstood the ordeal of criticism.

ORIGIN AND BIOLOGY OF THE CRIMINAL TYPE.

In the first place we must remember that too much must not be made of Lombroso's conclusions. The criminal stigmata, for example, must not be considered as absolutely diagnostic signs, from the presence of which, singly or in combination, in any individual, the criminal propensity is to be at once inferred. "It is but a clumsy way of propounding the question," as Ferri, another eminent criminologist, says, "to ask what connection can there be between the cephalic index or the transverse measurement of a murderer's jaw, and his responsibility for the crime which he has committed. The only legitimate question which can be put to anthropology," he continues, is this,—"Is the criminal, and in what respects is he, a normal, or an abnormal man? And if he is, or when he is, abnormal, whence is the abnormality derived? Is it congenital or contracted, capable or incapable of rectification?"† Lombroso's answer to the first part of the question is that many criminals undoubtedly show the presence of both physical and mental abnormalities in their organisation, and that he has not made this deduction *a priori*, but after having found

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* *Loc. cit.* Vol. I. Troisième partie.

† "Criminal Sociology," Eng. trans., 1895, p. 7,

such abnormalities in a greater proportion in criminals than in the honest. "I will say," he adds, "that for me individual anomalies are only an index, a musical note, from which I do not pretend to draw an inference, except when they are joined to other notes, either physical or moral." *

To the second part of the above enquiry, Lombroso has also a clear answer to give. For him, in the first place, the criminal is a product of the great biological process of Atavism,—a reversion, not only to savagery, but to primitive man, and the animal progenitors of the human race. In the second place, the criminal is a pathological phenomenon, and has a close relation to the lunatic, or rather to the moral imbecile. In support of these two conclusions, Lombroso adduces much important evidence, to which it is necessary to refer briefly.

With regard to the doctrine of Atavism, the evidence is largely of a psychological character. Lombroso endeavours to connect the propensities of the criminal with the crude instincts of savagery and infancy, and to show that the criminal belongs, as it were, to a lower and more primitive social state than that in which he is actually living. But Lombroso was not slow to recognise that in physical characteristics also the instinctive criminal approximates to the lower races of mankind, and to the still more degraded animal type, as represented in man's nearest biological relations, the Anthropoids. In the reduced cranial capacity, the receding forehead with prominent superciliary arches, the large orbits, massive and projecting jaws, and other characters, which, as we have seen, are common in different degrees to the criminal, the savage, primitive man, and the Anthropoids, Lombroso "finds an anatomical proof of the stratification of criminality, that is to say, of the tendency of the criminal to inherit the forms not only of the savage, but of ancient and prehistoric man," ‡ and even of the remote animal progenitors of the human race.

With regard to the resemblances between criminals and the insane, Lombroso at once recognises the difficulty that the majority of the latter are not born insane, but become so as the result of disease. The data derived from cranial measurements do not therefore afford a satisfactory basis of comparison between these two categories. On the other hand, the frequency of pathological anomalies met with in the brains of criminals brings the two classes into closer resemblance. But here again the chief evidence is psychological. There is undoubtedly a close relation between

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* Lombroso, *Loc. cit.* Préface, p. ix.

† *Ibid.* Vol. I. Chaps. I., II. and III.

‡ *Ibid.* Vol. I., p. 168.

instinctive criminality and what is known as "moral imbecility," and Lombroso indeed frankly contends for the practical identity of the two conditions.* This view has met with much hostile criticism, but it may be said that the close similarity between the criminal and the "moral imbecile" has always been recognised, the only difficulty in many cases being to determine where mere badness ends and madness begins. The great frequency of active insanity amongst criminals must also be kept in mind as another proof of the close relation of crime to insanity. But these are points which come within the purview of the alienist and jurist rather than of the anthropologist.

CRITICISM OF THE CRIMINAL TYPE.

The conclusions of Lombroso have, as I have said, been the subject of the most searching criticism,† and his conception of the "instinctive criminal" has been looked upon by many of his opponents as a mere figment of the imagination. It must be admitted that much of Lombroso's work is vague and disconnected, and in many instances he shows a fatal tendency to form hasty conclusions from large masses of indiscriminate statistics; but, on the other hand, his elaborate studies in the psychology of crime are a store of most interesting and suggestive material, from which all future investigators must draw. Discussion has centred chiefly on the biological questions which he has raised, and there is still much diversity of opinion upon the recognition of the "instinctive criminal" as a true anthropological type. A number of the best authorities do not now accept the extreme ideas held by Lombroso, but rather take up a middle point of view, which is perhaps best expressed by M. de Fleury,‡ when he says, that, though "malefactors do show vices of conformation in the skull and face which may be recognised on careful examination, these mean no more than the ordinary physical marks of the degeneration, which may, or as we all know very well, may not, accompany mental stigmata, perverse tendencies, monstrosity of mind. They are common," he adds, "not in the least specific lesions."

The criminal, therefore, in some of his aspects, may be looked upon as a product of degeneration§ and disease rather than of atavism. It is undoubtedly the case that many of the so-called anatomical stigmata of the instinctive criminal belong to the domain

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* Lombroso, *Loc. cit.* Vol. II., p. 3.

† *cf.* Francotte, "L'Anthropologie criminelle," 1891, p. 209, etc.; Havelock Ellis, "The Criminal"; Tarde, "La Criminalité comparée," 1902; Morrison, "Crime and its Causes," 1891; and many other works.

‡ "The Criminal Mind," 1901, p. 122.

§ Féré, "Dégénérescence et Criminalité," 1900.

of pathology, and fall into line with a large class of deformities of common occurrence in idiots, imbeciles, and such like, thus pointing ultimately to abnormal brain function, but not necessarily to criminality, Their presence in criminals would therefore be due to the fact that amongst these are to be found so many insane, weak-minded, and physically inferior individuals. But there are other anomalies of structure which cannot be thus explained. Many of the peculiarities of head conformation, for example, are the result, not of disease, but of arrest or variation of development, and may therefore in one sense be quite legitimately attributed to reversion to a more primitive type or stage of evolution. It is true, on the other hand, as Féré* shows, that as a whole the stigmata of the born criminal cannot be said to conform to an organisation distinctive of any special race, either prehistoric or savage, since they are quite incompatible with natural reproduction of the species. There must therefore remain a doubt as to the share which actual disease or mere disturbances in development have in the production of the anomalies in question. Much depends, it may be said, upon the point of view taken up by different observers.

CONCLUSION.

In conclusion, therefore, it must be admitted, that while it is quite out of the question to seek for indications of intellectual or moral qualities in the normal bumps and depressions of the skull, in the sense of the old-fashioned phrenology, there is a profound biological significance in the different shapes and sizes of the head. The innumerable normal variations with which we are so familiar must, however, be explained as the result of racial and family intermixture, and other obscure hereditary influences, rather than as primarily indicative of the psychical properties of the individual. A strictly scientific phrenology or physiognomy is, in fact, impossible in the light of present-day knowledge. But when we turn to the consideration of various abnormalities in the face and skull, we find that many of these can be shown to have an undoubted relation to mental and moral deficiencies of different degrees of gravity, and in certain cases to the criminal propensity. The practical aspects of the "New Craniology" do not specially concern us here. Suffice it to say that the elaborate investigations of Lombroso have helped in some measure to bring about the very general recognition which now prevails of the physical and mental abnormality—and hence diminished responsibility—of many of our worst criminals, and of the necessity for dealing with them upon more scientific and humane principles than was customary in the past.

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* *Loc. cit.* p. 67.

XIV.—*On the Microscopic Structure of some Perthshire Igneous Rocks.*

By George F. Bates, B.A., B.Sc.

(Read 8th February, 1906.)

Part I. Introductory.

Few counties in Scotland, or indeed in Britain, offer to the student of igneous rocks a finer field for investigation than Perthshire. In that part of the county lying to the north of the great fault which divides the Highlands from the Lowlands, we have the igneous rocks associated with the schists, etc., of the southern portions of the Highland Complex. These consist largely of masses of granite and diorite, as met with in the Moor of Rannoch, Glen Tilt, and to the north-west of Comrie; or of dykes of felstone or other rocks, which are met with almost everywhere in this Highland region. In the southern portion of the county we have the "porphryrites" of Old Red Sandstone Age, with their associated tuffs, building up the volcanic masses of the Sidlaws and Ochils. Along with these, but enormously younger, we find numerous dykes of a compact dark-coloured rock, termed "basalt" on the maps of the Geological Survey.

To deal fully with these igneous rocks, in all their varied aspects, would be almost the work of a life-time, and would tax severely the skill and intelligence of the most highly trained geologist. But the general facts are easy of comprehension, and it is with the hope of making them interesting that I have undertaken to write this paper.

The scientific investigation of the components of igneous rocks had its origin in France towards the close of the eighteenth century. The method employed was tedious in the extreme. A sample of the rock to be investigated was carefully crushed, and the component minerals separated from one another by the use of fluids of various densities, in which some minerals would float and others sink, or by the action of chemical reagents, or, in the case of magnetic minerals, by means of electromagnets. Much knowledge was gained in this way, but it could obviously supply little information as to the relations of the minerals to one another within the rock mass, and though the method is still in use, it is not now of so much importance as formerly, having been largely superseded by optical methods of examination. Some advance was made when a polished surface of the rock was studied by means of the microscope; but by far the most important step was made by William Nicol, of Edinburgh, who, in 1827, devised a method of making transparent slices of rocks, so that a detailed study under high powers of the microscope became possible. From that date to this much progress has been made, and now-a-days it is not considered that a rock has been fully studied until a thorough microscopic examination has been made.

Mechanical and optical skill have combined to make a modern petrological microscope an instrument of the utmost precision. Equipped with such an instrument, the angles between adjacent faces of crystals can be readily determined; also the direction and number of the cleavage cracks, and last, but by no means least, the optical properties of the minerals present in a rock section. To one who looks at a rock section under the microscope for the first time, the general idea is one of chaos; but in time the student comes to recognise the commoner minerals at a glance, and the less common ones by a few simple tests. Further reference will be made to this subject subsequently.

Care must be taken, however, not to exaggerate the importance of the microscopic examination of rocks. It is true that the microscope will tell us much about the rock—its mineral composition, relation of minerals to one another, etc.,—but this is not all. Attention must be given to the rocks as they occur in nature, otherwise the information given by the microscope may be misleading. It is possible, for example, for different portions of the same rock mass to present appearances so different that, if studied apart, it might be judged that they came from totally different sources.

We proceed, then, to discuss briefly the modes of occurrence of igneous rocks. If an active volcano and its surroundings be examined, three types of material can be recognised:—(1) The lava, or molten rock, poured out from the crater during eruption; (2) the fragmentary materials, varying from the finest dust to huge blocks, also ejected from the crater; (3) material forced into cracks and fissures, and solidifying before it reaches the surface. The last of these can, of course, only be seen when exposed by denudation. In addition, there is the subterranean reservoir of molten rock, from which the foregoing materials have come.

All of these have their counterpart in the igneous rocks which can be studied in regions where volcanic activity has long ceased. In Perthshire we have igneous rocks spread out in huge sheets, and presenting all the characteristics of solidified lavas, and associated with them beds of material which have been originally in a fragmentary condition. In nearly every part of the county we meet with wall-like masses of rock, standing up conspicuously, in many cases owing to the removal of surrounding rocks by denudation, and which have obviously been formed by the consolidation of molten rock injected into cracks or fissures. We also meet with masses of igneous rock, which, by certain well-marked characters, can be recognised as having been originally deep-seated, though it is not necessary to suppose that each of these marks the site of a volcano, for it is quite conceivable that an underground molten mass may exist without ever manifesting itself by volcanic activity on the earth's surface.

It is convenient to have names for these various types of rock, and the following are in common use:—

1. Volcanic Rocks—those formed by the solidification of material ejected at the surface.
2. Plutonic Rocks—those which have had a deep-seated origin.
3. Sub-plutonic Rocks—those which have solidified in cracks in the earth's crust.

Most igneous rocks are crystalline, and the coarseness or fineness of the crystals bears an intimate relation to the mode of occurrence. In preparing crystals artificially, it is found that the slower the process of crystallisation the larger and more perfect are the crystals formed, and there is no reason to doubt that the same principle holds good in nature. Hence if we find a rock composed of very fine crystals, we may conclude that it solidified rapidly; and conversely, a coarsely-crystalline rock may be assumed to have crystallised slowly, while one of moderately fine grain must have heen formed during a period of intermediate length. Applying this to the above-named types, it will be seen that if a rock is finely crystalline it must be a volcanic rock, for these would solidify most rapidly; if coarsely-crystalline, the rock must be plutonic; if of medium grain, sub-plutonic.

There are, however, in nature few hard and fast lines; the more superficial sub-plutonic rocks approximate to the volcanic, and the deeper ones to the plutonic.

Good local examples are:—

1. Volcanic rock—the "porphyrite" of Kinnoull Hill or Craigie Knowes.
2. Plutonic rock—the granite of Glen Tilt.
3. Sub-plutonic rock—the "basalt" dyke of Corsiehill or Pitroddie.

The crystalline components of igneous rocks are known as "minerals," and as these will be referred to later, a few words on the subject may not be out of place here. The minerals met with in igneous rocks are very numerous, and a detailed account would be quite impossible in a paper like this. They differ in colour, crystalline shape, and in optical properties, and by differences in these respects the commoner minerals can be readily recognised, as will be indicated in the study of actual rock sections. Minerals also differ widely in chemical composition; and naturally the composition of the whole rock will depend upon the composition and relative abundance of the component materials. From this point of view we may classify igneous rocks as acidic, intermediate, basic, and ultrabasic. Acidic rocks contain 65 to 80 per cent. of silica, free (as quartz), or combined with basic substances like alumina, soda, potash, magnesia, and lime; intermediate rocks, 55 to 65 per cent. of silica, usually in the combined state; basic rocks, 45 to 55 per cent. of combined silica; and ultrabasic, less than 45 per cent.

The appended table of igneous rocks summarises the modes of occurrence, structure, and mineralogical composition of the various groups, and gives examples from the better known types.

It will be convenient to begin the study of our local igneous rocks with the youngest. If we examine a geological map of Perth district we shall see numerous red lines on it, running in a general east and west direction, and a visit to Corsiehill, Pitroddie, or Campsie Linn will show that these represent wall-like masses of rock, usually termed "dykes," standing up vertically in the surrounding rocks, and even projecting in places above the general surface. These are masses of rock which have solidified after intrusion into fissures in the earth's crust, and are clearly younger than the rocks into which they have been intruded; the latter, indeed, often show alterations due to the effect of the former being forced through them in a molten and therefore highly heated condition.

The age of these dykes has been worked out by Sir A. Geikie, who has shown that they are of Tertiary Age, and connected with the outburst of volcanic activity in Tertiary times, when the basaltic rocks of the Inner Hebrides and north-east Ireland were formed. A good example of this connection is seen in the southernmost of the two dykes which lie along the southern face of Callerfountain Hill. This dyke can be traced, with few interruptions, from its eastern extremity in Moncreiffe Hill to its western one within a few miles of Loch Fyne.

It may also be noted that some of these dykes cross rivers, as at Thistlebridge, and are then clearly seen to be older than the river valley.

Fig. 21 is from a photograph of a section of the dyke rock at Pitroddie. It shows *(a)* the felspars—lath-shaped crystals, clear and colourless; *(b)* augite—shaded portions filling up the interspaces between the felspar crystals; *(c)* iron ores, magnetite, and possibly ilmenite—more or less angular black specks. Under polarised light this section presents a gorgeous appearance (see coloured figure). The felspar crystals are seen to be composed of numerous layers, giving different colours. This is due to what is called "twinning" of the crystals, and this multiple twinning is highly characteristic of plagioclase felspars. The augite in ordinary light is seen to be of a

CLASSIFICATION OF IGNEOUS ROCKS.

Mineral Composition, ☞ Occurrence and Structure, ☟	*Acid.*—Free quartz present: orthoclase commoner than plagioclase: muscovite common: biotite more common than hornblende, and hornblende than augite. Olivine and magnetite absent.	*Intermediate.*—Free quartz rare: muscovite absent: hornblende commoner than biotite, and biotite than augite. Olivine and magnetite rare.		*Basic*—Quartz, orthoclase, muscovite absent. Plagioclase the dominant felspar. Olivine and magnetite common. Augite commoner than hornblende, and hornblende than biotite.	*Ultra-basic.*—Little or no felspar. Augite dominant. Olivine and magnetite characteristic
		Sub-acid.—Orthoclase the dominant felspar.	*Sub-basic.*—Plagioclase the dominant felspar.		
Plutonic. Coarsely holo-crystalline.	Granite.	Syenite.	Diorite.	Gabbro. Dolerite.	Picrite. Peridotite.
Sub-plutonic. Finely holo-crystalline to cryptocrystalline. Often porphyritic.	Quartz-porphyry. (Quartz-felsite).	Syenitic Mica-trap.	Dioritic Mica-trap.	Some dolerites. (Diabase).	No common examples
Volcanic. Cryptocrystalline to glassy. Often porphyritic.	Rhyolite— Stony, often with flow-structure. Obsidian— Glassy.	Phonolite. Some obsidians.	Andesites.	Basalt.	Limburgite.

pale violet-brown colour, and is recognised by this and by the cleavage-cracks, which in favourably cut crystals are seen to be nearly at right angles to one another. Under polarised light this mineral gives magnificent reds and greens.

There are two minerals in the section which do not appear plainly in the photograph. One of these is *apatite*, which, under a higher magnification, is seen as needle-shaped crystals penetrating the other minerals; and the other is *chlorite*, which appears as green fibrous and scaly aggregates, intimately associated with the augite, of which it is a decomposition product.

The relations of the felspars and augite to one another are interesting. The comparative perfection of the felspar crystals shows that they were formed first, and that the interspaces were afterwards filled up by augite, so that in section we appear to have a kind of ground mass of augite, with felspar crystals embedded in it. An arrangement of this kind, commonly, but not always, of felspar and augite, is termed *ophitic* structure.

We are now in a position to name the rock. From its mode of occurrence we see it is one of the sub-plutonic rocks, and the plagioclase felspars and augite, as well as the abundance of iron-ores, show that it belongs to the basic group. The rock is therefore a dolerite. (See classification.) And here we are met by one of the difficulties attending rock classification. Naturally, where dividing lines are vague, different authorities will differ in their classifications. On the Geological Survey Map this rock is termed a "basalt"; other authorities term it a "diabase"; while still others term it a "dolerite." The term basalt is now limited to volcanic rocks of a composition similar to this dolerite, but much finer in grain. A good example is that of the Giant's Causeway. (See Fig. 22.) It will be noticed that although the photograph of basalt is taken with a magnification of 82 diameters and that of the dolerite with 12, the component crystals appear much smaller in the basalt, and the ophitic structure is also less clearly shown. The diabase of the Geological Survey means a rock also similar to our dolerite, but of pre-Tertiary Age; it has, however, been shown that there is no essential difference between the rocks, hence a distinctive name becomes unnecessary. Other authorities apply the term diabase to the larger intrusive masses of the same nature as the Pitroddie rock, and apply the term dolerite to the smaller intrusions which approximate to the volcanic rocks in texture.

Coming now a little nearer home, Fig. 23 and corresponding coloured figure show a section of the rock quarried at Corsiehill, under ordinary and polarised light respectively. The minerals and their arrangement are the same as in the Pitroddie rock, but the grain is a good deal finer, indicating a more rapid cooling, which is due to the smaller thickness of the Corsiehill dyke. We meet here, also, a phenomenon very frequent in dykes. If we conceive a molten rock forced up from below into a fissure in the earth's crust, it will be seen that the outer parts will cool more rapidly than the centre, and hence should be finer in grain. At Corsiehill and elsewhere this is perfectly visible to the naked eye, but the photograph (Fig. 24) brings out the fact very clearly. Note that the structure approaches very closely that of a true basalt, although the section is from the same rock mass as a dolerite.

The last rock which I shall consider in this part of my paper is from the well-known dyke which crosses the Tay at Campsie Linn, a general view of which is shown in Fig 25. The rock is very similar to the two preceding ones; the felspars are, however, spotted with decomposition products, and the green chloritic material is likewise more abundant. (Fig. 26.) Some of the iron-ores in this rock are seen to be associated with whitish, semi-opaque decomposition products, and are thus recognised as ilmenite, or titaniferous iron ore. The whitish material is leucoxene, and almost invariably accompanies ilmenite. Iron pyrites is also sparingly present, and is recognised by its brassy lustre when the section is viewed by reflected light.

Fig. 27 shows a section of the rock from the marginal portion of the dyke. It illustrates the same points as the corresponding slide from Corsiehill, but is taken with a higher magnification, so as to bring out the general resemblance to the coarser grained rock in the centre of the dyke.

The internal structure of this dyke is shown very well in a quarry close to the seventh milestone on the Old Scone Road, near Stobhall, and about a quarter of a mile from the Tay. (Fig. 27.) A very common character of the finer grained igneous rocks, when seen in mass, is the jointing, often very regular, at right angles to the greater surfaces. In a vertical dyke the joints will necessarily be horizontal, and they are well shown in the photograph. This jointing may be also seen at Corsiehill (see Fig. 28) and at Pitroddie.

In concluding this portion of my paper, I have to express my indebtedness to Mr. D. S. Murray for the extreme care and skill with which he coloured the photographs used in the preparation of the coloured plates, and to Mr. H. Coates for the loan of blocks for Figs. 25 and 29.

Plate 21. — Dolerite, Pitroddie.

Plate 23.—Dolerite from centre of Dyke, Corsiehill.

Plate 24.—Dolerite from margin of Dyke. Corsiehill.

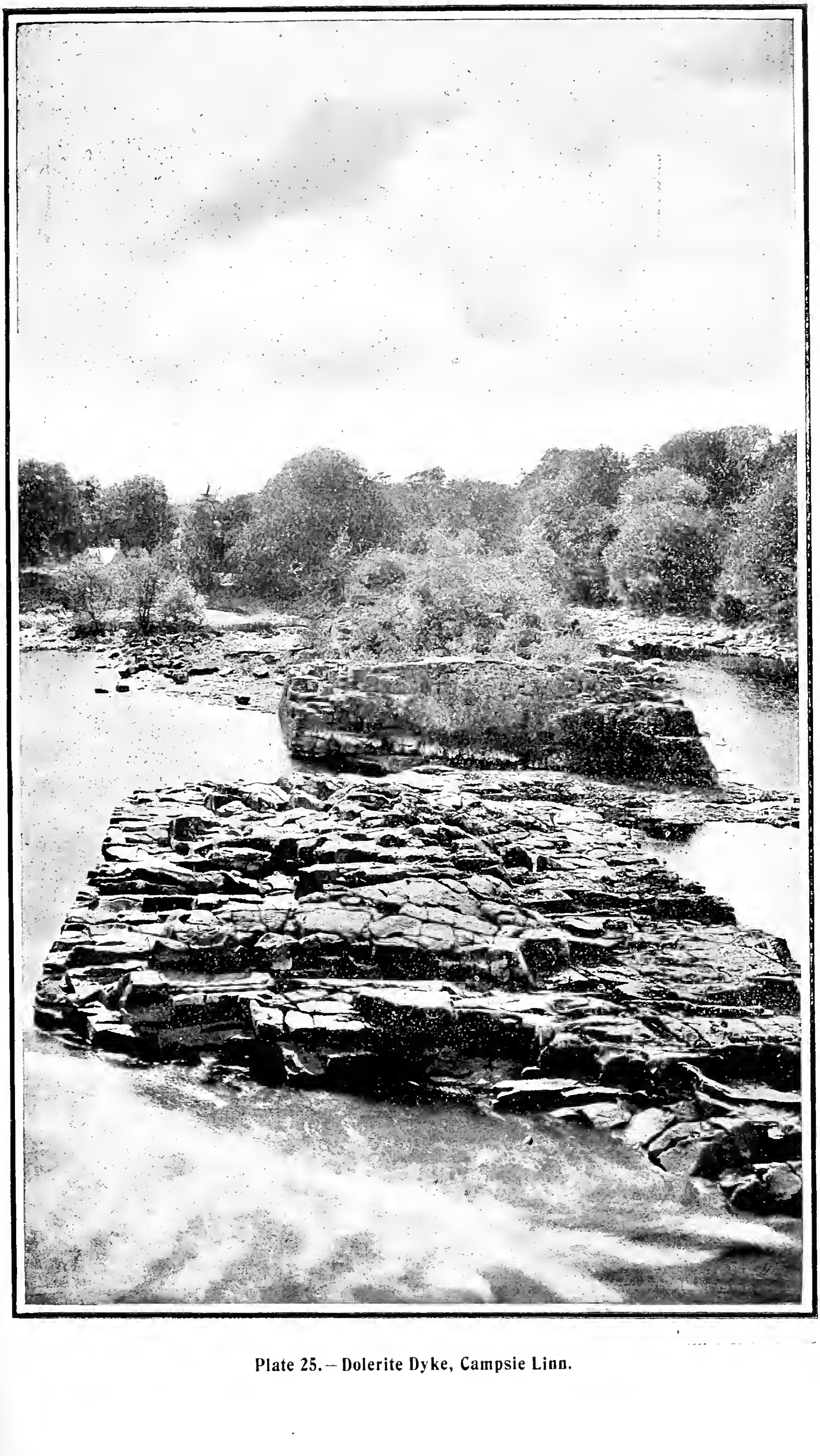


Plate 25.—Dolerite Dyke, Campsie Linn.

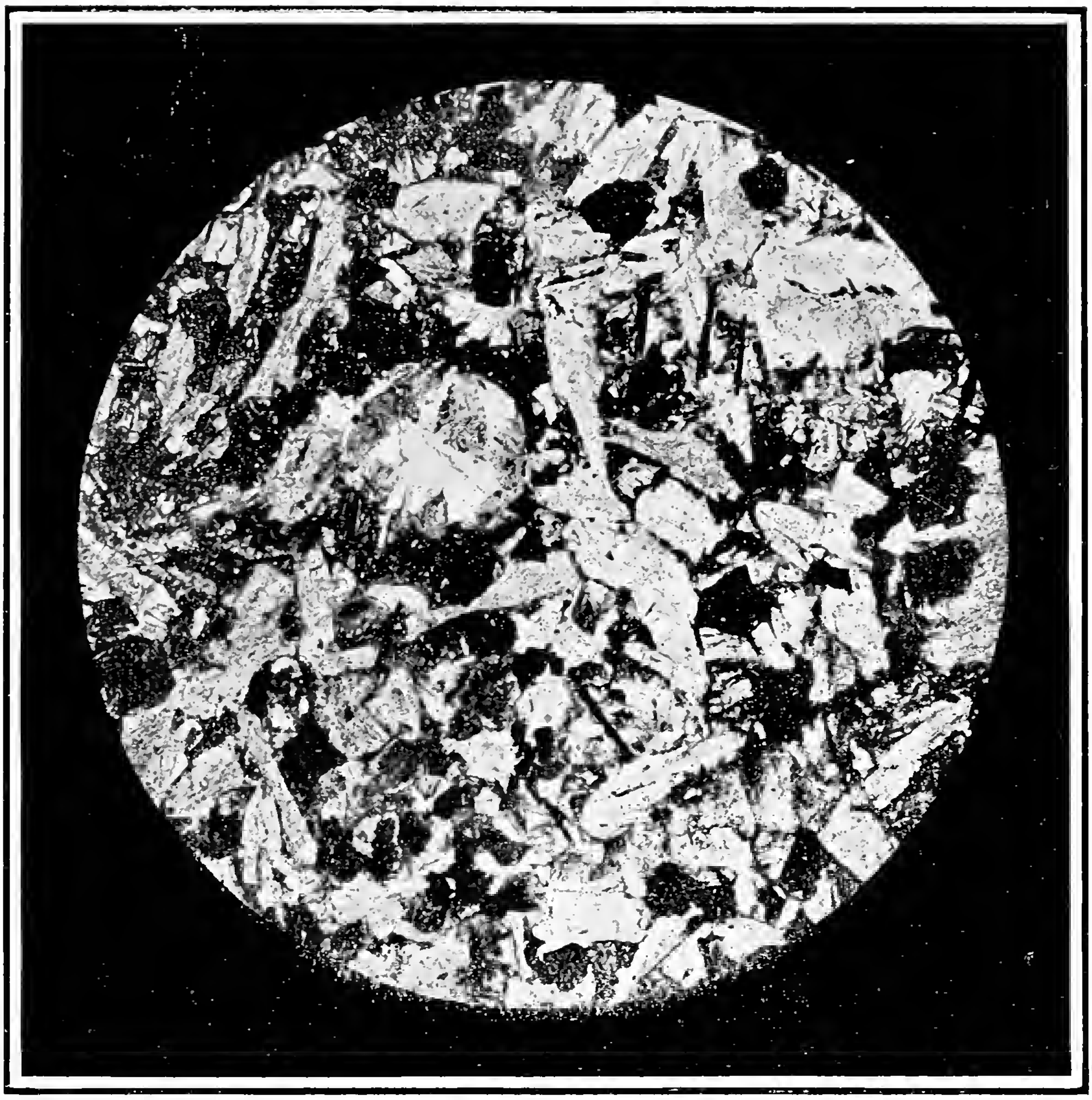


Plate 26.—Dolerite from centre of Campsie Linn Dyke.

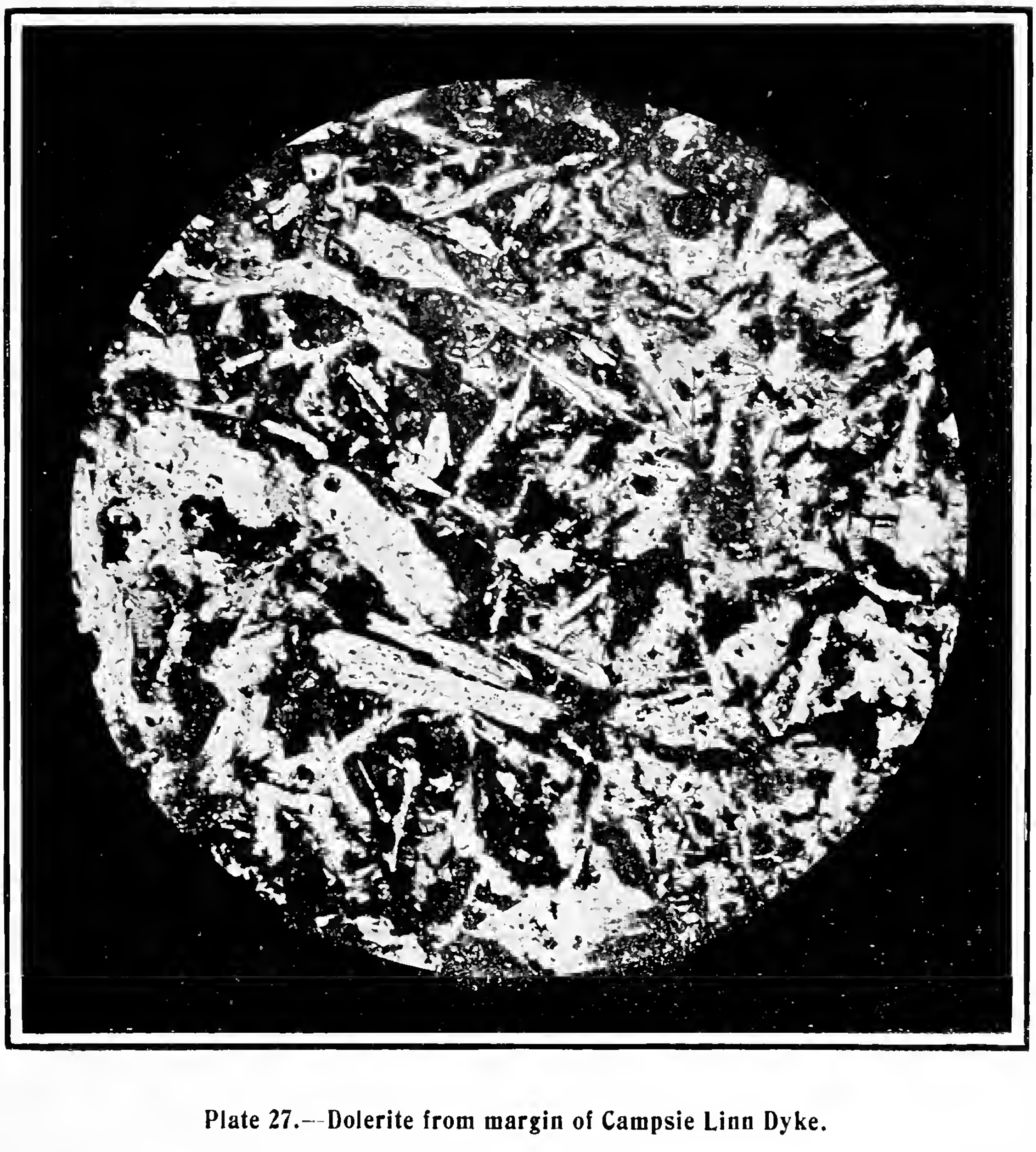
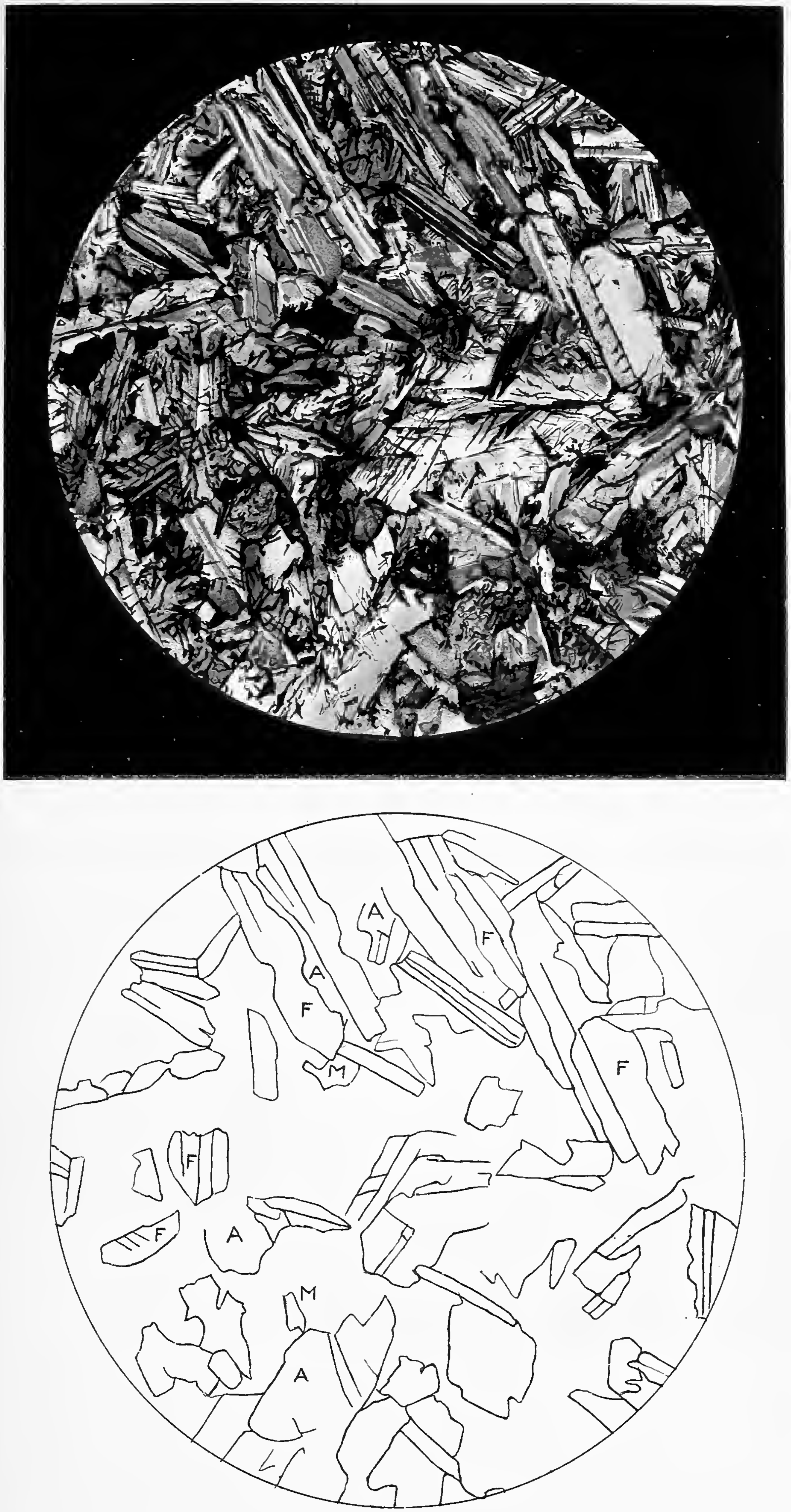


Plate 27.—Dolerite from margin of Campsie Linn Dyke.

PLATE 31



DOLERITE, PITRODDIE × 12

(Viewed by Polarised Light).

A=AUGITE. F=FELSPAR. M=IRON ORES.

PLATE 32.

DOLERITE, CORSIEHILL × 12

(Viewed by Polarised Light).

A=AUGITE. F=FELSPAR. M=IRON ORES.

XV.—*A Molluscan Visit to some of the Inner Hebrides (Islay, Coll, Tiree, and Iona).*

By Rev. G. A. Frank Knight, M.A., F.R.S.E.

(Read 12th April, 1906).

1. *Islay and Jura.*

It may be within the recollection of some members of this Society that I had the privilege, a few years ago, of reading a paper here on "A Visit to the Outer Hebrides in search of Mollusca."* The enjoyment derived from that tour through these far western isles lingered so fondly in my memory that I felt urged to take the earliest opportunity of setting foot on others of these lovely Atlantic-washed shores. The following narrative, therefore, is a report of two journeys undertaken by my wife and myself to a few of the Inner Hebrides; for such is the fascination of these romantic islands, that once one has explored a few of them, the mind refuses to be satisfied until gradually every one of these beautiful spots lying far out in the blue expanse of ocean has been visited, and its treasures enjoyed. In August, 1904, we visited Islay; and in the corresponding month of 1905 we set foot on Coll, Tiree and Iona. And as in my former paper, I followed the plan of describing the scenery *en route*, it may not be considered inexpedient if I adopt the same method on this occasion, and ask you to accompany me from Rothesay, where we started for Islay on a bright and sunny morning on board the "Columba."

The route to Tarbet and the west, as everyone knows, lies through the Kyles of Bute. One who is interested in the relation between geological changes and consequent alteration in local fauna can never sail up this quiet and sheltered waterway without recalling the fact that it was here that the late Mr. James Smith of Jordanhill pursued his researches with an ardour which has made his name to be revered as a true pioneer in this department of science. Cruising hither and thither in Clyde waters in his yacht, with the view of ascertaining, by personal inspection, reliable data as to recent elevation of sea margins, he was walking one day along the shore of the Kyles, when at a spot opposite Colintraive his eye caught sight of a number of shells lying in the shingle, which were different from those presently existing in British seas. He was soon able to make out a satisfactory list of these shells, and as a result of further

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* *P.S.N.S. Trans.*, Vol. III., 193.

dredging in the Clyde area, he established by irrefragable proof the fact that the climate of Scotland has undergone a radical change since the days when these Arctic molluscs lived and died on these shores.* What Smith discovered is now of course a matter of common knowledge to every conchologist, but he nevertheless deserves the credit of being the first to point out the connection between these shells and geological climate. The deeper waters of the Clyde are to-day, in many places, thickly heaped up with deposits of what were Arctic shells—relics of that vigorous Ice Age which once sealed up Scotland in one vast pall of ice and snow. A few of these northern forms, *e.g.*, *Arctica islandica*, *Mya truncata*, etc., still survive in our seas and lochs, having been able to adapt themselves to the changed temperature, but the vast majority, *e.g.*, *Nuculana pernula*, *Pecten islandicus*, *Macoma calcarea*, etc., have succumbed, and living representatives of these Glacial shells are no longer to be found in British waters.

Proceeding along the narrow fjord, it is interesting to observe the well-marked raised beaches on both sides. At Colintraive this feature is very prominent. It is the well-known 25-feet terrace which is so conspicuous in almost all the bays and sea lochs of the coast of Scotland. It was the elevation of this shelf which was virtually the finishing touch given to Scotland to render it a country capable of being fully utilised by man. Not that man had not already appeared during the epoch while the sea rolled 25 feet higher than it does now (for the evidences are now indisputable that man was already on the scene), but the economic value of this raised marginal terrace running round our native island cannot be over-estimated. Without this elevated beach, the coastline of Scotland would have presented an almost unbroken wall of precipitous rock, quite unsuited to the commercial requirements of an active and progressive people.†

Another feature of the scenery of the Kyles apparent to everyone is the sudden change in the character of the landscape as one proceeds from the mouth to the bend at Loch Riddon. From Loch Lomond a band of clay-slate strikes in a south-west direction across country, passes over the middle of the Gareloch, skirts the firth through Dunoon and Innellan, and is continued into Bute across the entrance to the Kyles. Everywhere along this line are observable these gentle and undulating outlines, which remind one more of the

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* The list and the account of the discovery are given in his *Researches in Newer Pliocene and Post-Tertiary Geology*, Glasgow, 1862, pp. 29-31. See also *Proc. Geol. Soc.*, 1839; Jeffreys' *Brit. Conch.*, ii., p. 390, who acknowledges the debt of conchology to James Smith; and Ramsay, *Phys. Geol. and Geog. of Gt. Britain*, 6th Edit., pp. 249-251.

† See Sir Arch. Geikie's vivid picture in his *Scenery of Scotland*, pp. 379-395.

flowing contours of the southern uplands of Scotland than the stern and rugged abruptness which we associate with Highland scenery. The clay-slate readily weathers, and its tame features are the result of the absence of hard resisting bosses. But immediately behind this belt of slate lies a district made up of hard schistose grits and fine conglomerates, so characteristic of the Ben Ledi group, and the superior resisting power of these metamorphosed sedimentary rocks produces the grand and striking features which render the middle portion of the Kyles so beautiful. This craggy, notched, and splintered formation continues over a wide stretch of country, till at Ardrishaig and Lochgilphead, and again at Easdale, one comes once more on slate bands which weather into tame and uninteresting outlines.

At the narrows in the Kyles is the little group of the Burnt Islands. Often in former years have I landed here, and observed the glacial striæ. As these rocks lie at the mouth of Loch Riddon, the great glacier, which once descended Glendaruel, must have forced its way over them with irresistible might, and the marks of the grinding ice are still clearly visible. The sides of the Glen have been planed down by the mass of ice in its passage seaward, leaving long parallel lines of striæ on either flank, and the glacier, after deeply scoring the rocks at the mouth, must have mounted the opposite hills on Bute, and pushed its way right across the island at a height of more than 500 feet, until it again reached the sea. The *roches moutonnées* at this northern extremity of Bute are remarkably well exposed, and afford an excellent study of the tremendous ice pressure to which they were subjected in the Great Ice Age.

Rounding Ardlamont Point, with its tertiary dykes striking through the schists, Loch Fyne is entered, while away to the south are seen the granite peaks of Arran. The stretch of water between the southern extremity of Cowal and the Kintyre peninsula is the deepest in the whole Clyde area.* At one point the depth is 104 fathoms, the bottom, as investigation by means of the dredge proves, being the finest and most impalpable mud. It would seem that this gigantic depression has been created by the enormous excavating power of the vast volumn of ice which once filled the basin of Loch Fyne from end to end, and overflowed the highest eminences on either side. The summits of the hills above Loch Fyne rise to the height of 1800 feet, and they are striated to the very top; and as the Loch near Tarbert is 624 feet deep, it follows that the thickness of the ice at this spot must have been more than 2500

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* See especially Dr. H. R. Mill, "Phys. Exploration of the Firth of Clyde," *Scott. Geog. Mag.*, 1886, vol. ii. pp. 347-354; and "Configuration of the Clyde Sea Area," *Ibid.*, 1887, vol. iii. pp. 15-21.

feet. Apart from the erosive agency of ice, there is no other cause adequate to explain the scooping out of this enormous hole so far beneath the surface of the waves.

Landing at Tarbert, one can obtain many an additional proof of this tremendous force which formerly planed down the rugged surface of the land. The islands which stud the entrance to the harbour, though beautifully wooded and gloriously purple with heather, every here and there reveal bare surfaces, ice-worn, and striated in the line of the ancient glacier's advance. For it is now clear that the ice which streamed from Cowal across Loch Fyne continued its course right across the Kintyre peninsula, smoothing all the rocks over which it forced its way, until it lumbered on into the Atlantic ocean.

East Loch Tarbert is a fine land-locked harbour, which has long been noted as one of the chief centres for the Loch Fyne herring fishing. Overlooking the little town is a picturesque old castle, accredited by tradition to King Robert the Bruce as its builder in A.D. 1326. The word "Tarbert" sufficiently expresses (in Gaelic) the geographical lie of the land. It means a narrow neck of land across which boats may be dragged from one sea to another. As a matter of fact, the distance from the head of East Loch Tarbert to that of West Loch Tarbert is about a mile, and history records several occasions on which vessels were successfully drawn across. Of these the exploits of the Norwegian King Magnus, and later of King Robert the Bruce, are the most famous, when :—

> "Up Tarbert's western lake they bore,
> Then dragged their bark the isthmus o'er
> As far as Kilmaconnel's shore
> Upon the eastern bay."
>
> (Scott, *Lord of the Isles*, Cant. iv. 12.)

The sail down West Loch Tarbert was one of singular beauty. The sun shone gloriously on the richly wooded shores, and such was the stillness of the loch that the little islets were perfectly mirrored in the waters as the s.s. "Glencoe" plodded her way onward. West Loch Tarbert is one of the best examples of the influence of geological structure in determining the shape of valleys. On these Knapdale shores there is quite a series of parallel valleys, each now filled with an arm of the sea—Loch Tarbert, Loch Killisport, Loch Sween, Loch Craignish—all of which have been eroded along bands of schist and slate having a south-west and north-east trend. Even the creeks, the little islands, and the headlands all run in the same direction, and the effect on the general scenery is curious, when every part of the coast—bay, sea-loch, inland loch, promontory, or island—for mile upon mile, is set out in strictly parallel lines.

Emerging from the loch, which is about nine miles in length, we passed Clachan on the left, with a conspicuous hill named Dunskeig towering above it, remarkable for its ancient vitrified fort, said to have been used by the Norwegians as a watch tower and fortress. Our little steamer began now to rise and fall on the Atlantic swell, and the air was delightful in its sweetness and freshness. Across the wide stretch of sea the splendid Paps of Jura dominated the whole outlook, while far up the Sound of Jura a glimpse was got of rocky Scarba towering up 1470 feet sheer from the sea level. In a little over an hour's time from leaving Loch Tarbert Head, we reached the island of Gigha. There are really three main islands in the group—Gigha, Cara, and Gigalum—but a host of smaller islets and skerries renders navigation in the vicinity somewhat dangerous. The largest of the three is Gigha, a long low-lying island about 7 miles in length, and from half-a-mile to two and a half miles in breadth, whose highest elevation is only 260 feet. On the east side it is mostly under cultivation, but the western seaboard is wilder, grass and heather reaching to the edge of the precipitous sea cliffs. The group of islands looked so tempting in their quiet beauty—Cara towering up into a grand precipice facing the south, and revealing on its flanks raised beaches and heather-covered rocks, and Gigha smiling in its fertility and peacefulness—that we would fain have landed and spent a day or two on the spot, but we were speedily rounding its southern promontory, and making a straight course for Port-Ellen in Islay.

From Gigha to Port-Ellen is a distance of 18 miles, and as the passage is entirely in the open sea, the little "Glencoe" has often a bad time of it.* But the sail across, as we experienced it, could not have been more delightful. The sea was exquisitely blue, the sun took all the cold out of the wind, and the Atlantic's heavings were just sufficient to give a pleasant motion to the old steamer. We could trace the long peninsula of Kintyre stretching far to the south till, beyond the gleaming sands of Machrihanish, the bold promontory ended in the Mull of Kintyre. Farther to the west lay Rathlin Island, whence King Robert the Bruce set sail on that adventurous expedition, which was to terminate so gloriously at Bannockburn, and in the dim and misty distance, we caught sight of Fair Head and the hills about Ballycastle in Ireland. Gradually we neared "green Ilay's fertile shore," sailed past Lagavoulin and the ancient castle of Dunyvig standing out on a high peninsular rock, skirted close behind the island of Texa, once inhabited by monks,

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* So bad indeed, that as a result of numerous complaints, Messrs. MacBrayne have recently placed on this route a fine, new, and much swifter steamer, the "Pioneer."

and after a wide circular sweep round the bay, reached the quay of Port-Ellen.

Port-Ellen, named after Lady Eleanor Campbell of Islay, is situated on a bay facing the south, but is well protected from all westerly gales by the massive promontory of the Mull of Oa. The little town is bright and clean, and its row of white houses encircling the inner bay is pleasing. It is to be regretted that the staple industry is the manufacture of whisky. We observed that, practically without exception, every shop-keeper claimed on his sign board to be a "general merchant," and we proved the truth of the statement, for truly cosmopolitan and universal in its range of commodities did every emporium on inspection turn out to be!

The town is fortunate in possessing in the person of its medical officer, Dr. T. F. Gilmour, an enthusiastic naturalist. It was my privilege to call on him, and to go over his collection of marine mollusca. As he is perhaps the pioneer in this field as regards Islay, I feel it is but fair that I should distinguish with an asterisk any shells of which he has been the discoverer prior to my visit.

Islay is the largest of the Southern Hebrides, measuring about 25 miles by 20 miles. It is, however, much indented by Loch Indaal on the one side and Loch Gruinart on the other, insomuch that the island is almost bisected into two unequal portions. The great headland of the Mull of Oa which juts out to the south-west is joined to the body of the island by an isthmus not more than 2½ miles across. On the second day of our stay, we drove across this neck, and found ourselves on the famed Big Strand of Laggan Bay. This noble bay stretches in a gentle curve northwards for five miles. The shore is of the finest sand, backed by sand dunes and rolling links, which under the name of the Machry course have been appropriated towards the southern extremity for the ubiquitous golf. The wind, however, blowing the sand along the shore and covering everything up, somewhat baffled our attempts to compile a satisfactory list of molluscs, and yet what we did find presented one or two features of interest. I was glad to discover *Mactra stultorum*. In my paper on the Outer Hebrides* I referred to the curious fact that a shell so abundant on the east coast of Scotland should be most scantily reported from the west coast. I stated that I had discovered it in Benbecula and Vatersay, and gave references to all the other spots where it had been observed. But now on these wide sands of Laggan Bay, it was pleasant to come across a few additional examples of this handsome shell; and as will be mentioned later on, I was

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* *Supra cit.* p. 15.

equally fortunate in Tiree. The following is a list of the molluscs picked up on this strand :—

Anomia ephippium, L.
Glycymeris glycymeris (L.)
Mytilus edulis, L.
*_Pecten maximus_ (L.)
Lucina borealis (L.)
Tellina crassa (Gmel.)
,, _tenuis_, da Costa.
* ,, _fabula_, Gronov.
*_Macoma balthica_ (L.)
Mactra stultorum L.
Spisula subtruncata, da Costa.
Dosinia exoleta (L.)
Venus gallina, L.
Tapes pullastra, Mont.
*_Cardium echinatum_, L.
,, _edule_, L.
,, _norvegicum_, (Speng).
Mya truncata, L.
Ensis siliqua var. _arcuata_ (Jeff.
Patella vulgata, L.
,, ,, var. _depressa_, Penn.
Patina pellucida, var. _lævis_, Penn.
Acmæa virginea (Müll.)
*_Gibbula magus_ (L.)
,, _cineraria_ (L.)
Calliostoma zizyphinus (L.)
Littorina obtusata (L.)
,, _rudis_ (Maton.)
,, _littorea_ (L.)
Capulus hungaricus (L.)
Trivia europea (Mont,)
Turritella communis, Lam.
*_Tritonofusus gracilis_, da Costa.
Purpura lapillus (L.)
,, var. _major_, Jeff.
*_Scaphander lignarius_ (L)

* Denotes those already found in Islay by Dr. Gilmour.

The geology of Islay has been investigated by the late James Thomson, F.G.S.,* and his researches have been revised by the officers of the Geological Survey. From these studies it would seem that the island is made up of three well-marked divisions. The central, and by far the largest portion, is composed of Silurian quartzites interspersed with thin beds of limestone. But on the north-west shore, in the great promontory known as "The Rhinns," there is a strip of clay slate along with younger schists and bands of hard greywacke: while again, to the south-east of the island, the coastline from beyond Kildalton to the Mull of Oa is made up of schists with interbanded intrusive diorites. The Mull of Oa is a most distinctive feature of the south-west of the island: it is very hilly and rocky, and its extremity ends in a succession of bold cliffs from 500 to 600 feet in height, on one of which stands the remarkable ruined fortress Dun Aidh. In the nook of the Bay of Laggan, known as Port Alsaig, the coastline is extensively broken up by marine denudation, which has been followed by land elevation. I show two slides illustrative of the fantastic shapes into which the rocks here

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* On the Geology of the Island of Islay (_Trans. Geol. Soc., Glas._, Vol. V. pp. 200-222.

have been carved, first by marine action, and subsequently by subaërial weathering. The sandstone here is of a brownish or coffee colour, in which there are patches of green carburet of copper, terminating on the shore in a coarse breccia or conglomerate. A little further down the coast is the famous *Slochd-mhaol-doraidh*, a cavernous funnel opening into a vast and spacious cave, with a roof resembling the dome of a cathedral, and with an entrance towards the sea into which the Atlantic bursts its way with overwhelming force, and sends up a hurricane of spray. It was delightful to lie here on the summit of the great storm-beaten crags, and to listen to the ocean thundering into these caves which it has succeeded in hollowing out.

Returning to Port-Ellen, we spent the following Sunday in quietness in that little town, attending the Gaelic service in the morning, and the English in the evening. On the Monday, being desirous of seeing more of the island, we secured seats on the post waggon for Bowmore. It was a conveyance which in no way reflected credit on the Government! An ancient lorry without springs, with a high rough seat in front capable of holding three passengers and the driver; and back to back with that another seat of broken thin planks; a pair of raw-boned horses in harness fortified by ropes; another horse trotting behind with a halter round its neck—such was the Islay representative of the greatest Mail Service in the world! To travel on such a ramshackle vehicle was simple torture, and the jolts and bumps on the uneven road were enough to render one black and blue. A mile out of Port-Ellen the road turns north, and for the next eight miles till Bridge House is reached, the track runs in an absolutely straight and most monotonous bee-line across the moor. Far on the left was the distant sweep of Laggan Bay, and across it the promontory of The Rhinns; on the right the somewhat featureless hills of the central portion of the island sloped up to the height of 1609 feet at their highest crest. As a north wind blew in our faces with almost Arctic severity, we were not sorry when we reached Bowmore, and had a couple of hours in which to thaw ourselves and restore animation to our benumbed limbs.

Bowmore presents an active and thriving appearance. It lies towards the head of the great bay called Loch Indaal, which almost cuts Islay in two; and through the shallowness of the adjacent waters its pier is useless except for comparatively small vessels. The old church stands at the head of the main street, a curious circular structure, with a quaint belfry which looks very imposing from certain quarters. We employed our time of waiting in exploring the shore towards the head of the bay. It was with much interest, that, on a very wet patch of by no means sweet smelling mud, I came across a few specimens of *Tapes aureus* (Gmel.) associated with *T. decussatus* (L.) Hitherto the west of Scotland distribution of *T. aureus* has been confined mainly to one quarter—Loch Ryan. Dr. Grieve* and Canon Norman† found it there in great abundance: and at Stranraer many years ago I picked up a large number of specimens in company with *Pholas candida*. The other records for its occurrence are Ayr (Smith‡ and others), Irvine (John Smith,§) Arran (Landsborough,||) Luce Bay (Robertson¶) and Jeffreys mentions Jura on the faith of Captain Bedford.° It was interesting, therefore, to come across this small colony in Islay, on a wet and slimy bottom, very similar to the shore on which it is so abundant at Stranraer. In addition to these two molluscs, the limited time at our disposal enabled us to collect only a few representatives of *Anomia ephippium*, L., *Ostrea edulis*, L., and *Macoma balthica* (L.), from the wide stretch of wet sand which fringes the head of Loch Indaal.

When we resumed our seats in the mail car, we found it encumbered with numerous trusses of hay, piles of boxes, coils of wire, hen coops, bread baskets, besides the mail bags, on which a few children squatted! The road from Bowmore to Bridgend skirts Loch Indaal, and the view was very beautiful. This part of the island is much more wooded than the eastern portion, and the river Sorn flows through extensive plantations. Before the last great land elevation, this valley must have been entirely under water, indeed "the grounds of Islay House lie wholly on a plateau of stones, gravel, and shells left by the retreat of the sea. Formerly, Islay must have been merely an archipelago of small islands. In many parts where digging is undertaken, sea sand is found mixed with shells of species still abundant in the various inlets. In some parts converted into morasses, large oaks are to be found, which appear to have been growing on a bed of clay and sand, incumbent on a bed of sea sand and sea shells."** After passing Islay House, the road crosses the island, the way being at first through well-cultivated land, till at

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* "On the Marine Zoology and Botany of Loch Ryan, Bay of Luce, and Portpatrick," by Dr. John Grieve and Mr. David Robertson. *Proc. Nat. Hist. Soc., Glasg.*, Vol. I., p. 24, 1868.

† "The Mollusca of the Firth of Clyde," *Zoologist*, 1857-60.

‡ "Catalogue of Recent Shells in the Basin of the Clyde," *Mem. Werner. Soc.* VIII., 1838; and *Newer Pliocene Geology*, p. 63.

§ *Nat. Hist. Soc. Glasg. Trans.* III. (N. S.), p. 246.

|| *Excursions to Arran*, 1847, 1851, 1852.

¶ "Recent Marine Mollusca of the West of Scotland" in *Brit. Assoc. Fauna and Flora Hand Book*, 1876, p. 46a.

° Brit. Conch, Vol. II. p. 350.

** Smith, *Newer Pliocene Geology*, p. 68.

the little village of Ballygrant, the high moor is again reached. At every turn of the route the massive peaks of Jura dominate the landscape, and their association with pine wood, or heather slope, or rushing stream, or cottage in the foreground, makes a perfect picture of Highland scenery. A mile to the west of Ballygrant lies Loch Finlaggan, with an islet on which are the ruins of the principal castle of the Macdonalds of Islay. The water in this loch is said to be of such extreme purity that trout suffer from a disease like rickets, and thus they approach the distinction which appertains to the trout found in Loch-na-Maorachan, another moorland tarn in Islay, which have no tails at all! The fins and tails of these fish are either diseased or entirely wanting; and while the anomaly has been traced to the deficiency of lime in the water,* the real cause is still a matter of dispute. Near the watershed on the hill to the left, there are discernible the remains of a disused lead mine; and then commences the abrupt descent to Port-Askaig, the road suddenly dipping down, and seeming to lead the traveller over the edge of a gulf into the Sound of Islay. The view from this point was splendid. Far to the north beyond Rhuval Lighthouse lay Colonsay, to right and left stretched the purple heather-clad hills of Islay, sweeping in flowing outline away to the south, and across the deep chasm of blue water, which was hemmed in on the south-east by M'Arthur's Head, there soared into the heavens the majestic twin Paps of Jura.

Reaching Port-Askaig Hotel, we could see across the Sound a long gleaming line of what looked like sand, stretching for some miles along the beach at the foot of the cliffs and hill slopes of Jura. But the landlord assured me that the sandy shore was in reality composed of large white stones and the coarsest gravel. My ardour to cross the Sound was therefore cooled, and as the sea was very rough, and crossing in a small boat would have been a work of some difficulty, we decided to relinquish the attempt. Since then I notice that Harvie-Brown† speaks of the shore as "a great raised beach of wave-disposed, semi-circular ridges of rounded stones"—the kind of shore, in fact, the very worst for molluscan research. The beach

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* The cause of this phenomenon has been discussed by Peach, *Brit. Assoc. Rep.*, 1871, p. 133; James Thomson, *Science Gossip*, April, 1872; and especially by Dr. Traquair, *Ann. Scot. Nat. Hist.*, 1892, Vol. I., pp. 92-103,; and Harvie-Brown & Buckley, *Vertebrate Fauna of the Inner Hebrides*, pp. 225-227, with plates of the diseased organs. See also Traquair in *Proc. Roy. Phys. Soc. Edinb.*, VII., p. 221, on tail-less trout from Loch Enoch; and Day, *Fishes of Great Britain and Ireland*, II., p. 102.

† *Op. cit.* p. lxxxii.; see also Captain Vetch "Geological Transactions" (*Edinb. New Phil. Journ.*, 2nd Ser. Vol. I.); and Captain Bedford, *Journ. Geol. Soc.* Vol. II., p. 549.

may be descried from far out at sea—a long white rampart running for miles along the western side of the island.

Giving up the idea of crossing to Jura, we contented ourselves with exploring the neighbourhood of Port-Askaig. Beautiful though the spot is, the scenery has an air of loneliness about it. One could never get away from the ceaseless roar of the tide pouring down the Sound like a river, and the high hills behind the quay cast a shadow over the village at an early hour in the afternoon. For several miles to the north of Port-Askaig the shore is a precipitous wall of rock, having a rough path at the base over the piles of fallen *débris*. Every here and there the crags open up to enclose a tiny bay in which may stand a solitary fisherman's hut, but every successive promontory was enveloped in the spray from the great waves which raced through the Sound. The view from the top of these cliffs was very majestic. "Nowhere in the Highlands," says Sir Arch. Geikie,* "can the whole of the distinctive features of quartzite scenery be seen on so grand a scale as among the mountains of Islay and Jura. In the latter island, the quartz-rock rises into the group of lofty cones known as the Paps of Jura, 2571 feet above the sea, which almost washes their base. The prevailing colour is grey, save here and there where a mass glistens white, as if it were snow; and as the vegetation is exceedingly scanty, the character of the rock and its influence in the landscape can be seen to every advantage." We were never done admiring those splendid peaks, which seemed almost to be volcanoes, as the light clouds of mist streamed away from their lofty summits, like smoke from a burning mountain.

The following morning we retraced our steps in the mailcar, which took us swiftly to Bridgend and Bowmore. The day was ideal in its beauty and freshness, and the drive down the valley through birch glade and plantation was delightful in the extreme. Arriving at Bowmore, we espied a steamer lying at anchor in the offing, and ascertaining that she was about to sail round the island to Port-Ellen, we decided to go on board her, rather than repeat the toilsome and monotonous drive of the previous day. Hiring a boat, we found that the vessel was the "Lovedale," which was taking in cargo from lighters about three quarters of a mile from the shore, owing to the extreme shallowness of Loch Indaal. After an hour we weighed anchor and crossed to Bruichladdich Pier, where we were detained for other two hours taking on board 1000 sheep and a great number of cattle, horses, and pigs—a feat accomplished through an infinite expenditure of Gaelic interjections, along with much vigorous application of sticks, whips, and shovels! When at last we got away

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* *The Scenery of Scotland*, p. 207.

from Bruichladdich, we skirted for a time close in to the promontory of Rhinns, passing Port-Charlotte, a hamlet of white-washed houses, and then struck across the loch to the great headland of the Mull of Oa. The precipices here were very grand, the high cliffs being deeply splintered by the incessant battering of the Atlantic surges, which hurl themselves with overwhelming fury on this bold headland.

On landing at Port-Ellen, two courses of action were open to us. Either we might go to Kildalton, and inspect the famous carved cross in the old churchyard there, or visit the shore of Port-Ellen Bay. We decided to do the latter. About a mile and a half from the town, there is a little creek called Kilnaughton Bay, below the churchyard of the same name, and here we hit upon the richest spot for mollusca yet encountered. A little stream flowed in at the head of the bay, and here, in a space of not more than ten yards, we found the sand absolutely swarming with the minuter forms of shells.* Boxes and bags having failed, I packed every pocket I possessed full of the precious sand, and my bulky appearance on returning to the hotel was sufficiently awe-inspiring ! When it was too late to see any more, we continued our stroll to the southern extremity of the bay. It was a night of exquisite beauty. Far out across the quiet waters of the bay, the moonbeams made a pathway of silver sheen, until they lighted up the white houses of Port-Ellen on the opposite shore, and revealed the solemn line of dark hills to the rear. The air was delightfully soft and balmy, the wind had sunk to rest, and the stillness was profound. Round inlet after inlet the path wound, until at last we reached the stately light-house, which guards the bay, and realized that we must reluctantly retrace our steps. But the marvellous and entrancing beauty of that last evening in Islay will linger in our memory.

The sand on inspection yielded a fairly long list of species, which is herewith appended :—

Anomia ephippium, L.
,, *patelliformis*, L.
Glycymeris glycymeris, da Costa.
Mytilus edulis, L.
Modiolus modiolus, L.
Modiolaria discors (L.)
Crenella decussata (Mont.)
Ostrea edulis, L.
Pecten pusio (L.)
* ,, *varius* (L.)
., *opercularis* (L.)
Turtonia minuta (Fabr.)
Arctica islandica (L.)
Lucina borealis, (L.)
Cryptodon flexuosus (Mont.)
Tellimya ferruginosa (Mont.)
Syndosmya prismatica (Mont.)

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* I am greatly indebted to Dr. Frew, of Glasgow, for his kindness in sorting out the material obtained from this bay, and for determining the minuter species.

Tellina pusilla, Phil.
,, _tenuis_, da Costa.
* ,, _fabula_, Gron.
*_Macoma balthica_ (L.)
Donax vittatus (da Costa.)
Mactra stultorum, L.
Spisula solida (L.)
,, _elliptica_ (Brown.)
,, _subtruncata_ (da Costa.)
Dosinia exoleta (L.)
* ,, _lupina_ (L.)
Venus fasciata, da Costa.
,, _gallina_, L.
*_Tapes virgineus_ (L.)
,, _pullastra_ (Mont.)
,, ,, var. _perforans_ (Mont.)
Cardium fasciatum, Mont.
,, _edule_, L.
* ,, _norvegicum_, Speng.
Mya truncata, L.
Ensis siliqua (L.)
Saxicava rugosa (L.)
Cochlodesma praetenue (Pult.)
Thracia fragilis, Penn.
Patella vulgata, L.
,, ,, var. _depressa_, Penn.
Patella vulgata, var. _cærulea_, L.
Patina pellucida (L.)
,, ,, var. _laevis_, Penn.
Acmæa testudinalis, Müll.
,, _virginea_ (Müll.)
Lepta fulva (Müll.)
Emarginula fissura (L.)
*_Fissurella græca_ (L.)
Eumargarita helicina (Fabr.)
*_Gibbula magus_ (L.)
,, _tumida_ (Mont.)
,, _cineraria_ (L.)
,, _umbilicata_ (Mont.)
Calliostoma montagui, W. Wood.
,, _zizyphinus_ (L.)
Phasianella pullus (L.)
Lacuna crassior (Mont.)
,, _divaricata_ (Fabr.)
,, _pallidula_, da Costa.
Littorina obtusata (L.)
,, _rudis_ (Maton.)
,, _littorea_ (L.)
*_Rissoa parva_ (da Costa.)
,, _inconspicua_, Alder.
,, _violacea_, Desm.
Alvania reticulata (J. Adams)
Manzonia costata (J. Adams)
Zippora membranacea (J. Adams.)
Onoba striata (J. Adams.)
Skenea planorbis (Fabr.)
Capulus hungaricus (L.)
Trivia europæa (Mont.)
*_Natica alderi_ (Forb.)
Bittium reticulatum (da Costa)
Caecum glabrum (Mont.)
Turritella communis, Lam.
Buccinum undatum, L.
Neptunea antiqua (L.)
*_Ocinebra erinacea_ (L.)
Purpura lapillus (L.)
Nassa reticulata (L.)
,, _incrassata_ (Ström.)
Bela rufa (Mont.)
Mangilia costata (Don.)
Clathurella linearis (Mont.)
Tornatina obtusa (Mont.)

Of these the most interesting finds are _Tellina pusilla_ and _Lacuna crassior_, the latter of which has been recorded only from Oban (Darbishire, and Chaster and Heathcote), and Loch Spelve (Coulson).

In addition to those shells which I obtained during this brief visit to Islay, Dr. Gilmour had specimens in his cabinet of the following, which I append for the sake of fulness, that a complete list of the molluscan fauna of the island may be given so far as it has been ascertained :—

Nucula nucleus (L.)
Astarte sulcata (da Costa.)
,, *elliptica* (Brown.)
Tellina squalida, Pult.
Venus casina, L.
Psammobia ferröensis (Chemn.)
Solecurtus antiquatus (Pult.)
Puncturella noachina (L.)
Monodonta crassa (Montf.)
Rissoa parva, var. *interrupta*, Adams.
Natica catena (da Costa.)
,, *montagui*, Forb.
Aporrhais pes-pelicani (L.)

The discovery of *Monodonta crassa* (= *Trochus lineatus*) is very interesting.

The total number of species and varieties discovered by us on this tour in Islay was	100
The number of extra species and varieties found by Dr. Gilmour was	13
Total, ...	113

In addition to these marine shells, we came across specimens of the following land and freshwater molluscs, though we did not concern ourselves specially with the non-marine species :—

Helix rotundata. Müll.
,, *pulchella*, Müll.
,, *itala*, L. (= *ericetorum*, Müll.)
,, *acuta*, Müll.
Cochlicopa lubrica (Müll.)
Limnæa peregra (Müll.)

2. *Coll, Tiree, and Iona.*

It will now be my privilege to take you to some other of the Inner Hebrides considerably further to the north. So charmed had we been with our visit to the most southerly of these islands, that last August (1905) we resolved to explore Coll and Tiree. On a lovely summer morning we found ourselves on board the s.s. "Fingal," sailing out of Oban. The route lay first of all down the Sound of Kerrera. Looking at the crags of (supposed) Old Red conglomerate and volcanic rock, one was reminded of how puzzling the geology of Kerrera has proved to be, and how great is the need of caution and of more thorough investigation before the problem of the real age of these deposits can be entirely settled.*

Rounding the southern end of the island, and sailing past the fine old ruin of Gylen Castle, we crossed the Firth of Lorne to Loch Spelve in Mull, and called at Croggan pier about a mile or more up the loch. The entrance to the loch is very narrow, but, inside, the loch opens up to right and left into a very considerable expanse of water. The scenery was charming, though a heat haze somewhat prevented us from seeing the mountains as clearly as we would have desired. Our course next lay northward, past the mouth of the shallow Loch Don, and round Duart Point, with its grand old castle, into the Sound of Mull. On the Lady Rock to our right we descried one of MacBrayne's steamers, which had been wrecked there a few months before, her bow far in the air, and her stern under water.

It is needless to speak of the beauty of the Sound of Mull,

> "Where thwarting tides, with mingled roar,
> Part Mull's swart hills from Morven's shore."

But sitting on the bridge of the "Fingal," by the kind permission of the captain, caressed by the soft wind which cooled the sun's fierce heat, it was easy to fall into a reverie, and dream of the far back history of this lovely waterway. These vast basaltic terraces on Mull towering up on the left were clearly once joined to their counterpart in Morven on the right, and were even continued beyond Loch Sunart. If, then, this basaltic plateau formerly extended over a wide area of Argyllshire, how stupendous must have been the denudation since early Tertiary times when these volcanic deposits were spread out! For the Sound of Mull—a strait twenty miles long and a mile and a half to three miles wide, and from crest to crest of the opposite hills upwards of 2000 feet deep—must have been excavated since the deposition of these terraces! Loch Sunart and Loch Aline must also have been cut out of the vast level basaltic plain since that time by sub-aërial denudation.† The surface capping of basalt has in some places been entirely removed, and far more ancient strata are now again exposed to view. Thus, on "green Loch

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* See Dugald Bell, "Notes on the Geology of Oban," *Trans. Geol. Soc., Glas.*, 1886, p. 116; and Prof. Judd, *Quart. Jour. Geol. Soc.*, Vol. XXX. (1874), p. 287 ff.

†See Sir Arch. Geikie, "Hist. of Volcanic Action during the Tertiary Period in the British Isles," *Trans. Roy. Soc. Edin.*, Vol. XXXV. (1888), pp. 90-91; also *Scenery of Scotland*, pp. 148, 216-220.

Alline's woodland shore" there may be seen a curious little deposit, a few miles long, of Cretaceous chalk and sandstone, which has now emerged once more from the cover of basalt-sheets that protected it for untold centuries from being destroyed by denudation. Another fragment of this same once widespread deposit is found on the west coast of Mull facing the island of Staffa.

At Tobermory a small regatta was in progress, but what interested us more was the eager activity with which the work of searching for the lost treasure of the sunken "Florida" of the Spanish Armada was being carried on from the deck of a salvage vessel. After rounding Rhu-na-gael Lighthouse, and skirting Bloody Bay, the scene of a great naval engagement (about 1480) for the possession of the Hebrides, we called in at Kilchoan, nestling under the shadow of Ardnamurchan Point. Now at last we were out on the open sea. The heat haze had thickened, so that the coast of Mull on the left was well nigh obscured, but we could dimly make out Glengorm Castle towering high on its rocky promontory. For a while we seemed out of sight of land, but at length we drew near to a long, low island, whose coast-line appeared the barrenest imaginable—a continuous low serrated rampart of grey, featureless crags. We sailed into the mouth of Loch Eatharna, and made our first acquaintance with Coll by landing in a small boat at Arinagour. To our dismay we discovered that the only hotel was already fully occupied, but after a little search we were accommodated in a room in one of the little cottages which flank the bay.

Coll is about 14 miles long by 3 miles broad at its widest stretch. It lies far out in the Atlantic in a line S.W. and N.E., and is thus exposed to the full fury of the ocean. Few trees therefore have been able to obtain a foothold on its surface, and these, poor and scraggy at the best, owe their existence to the protection of walls and other artificial erections.* The island struck us as being exceedingly melancholy; the shores desolate and storm-riven; the hills of no elevation, and as a rule very monotonous in outline; the soil for the most part peaty and the bogs extensive. The land is almost entirely composed of Cambrian gneiss, with bands here and there of serpentine, felspar, hornblende, and quartz, the latter breaking out at Acha towards the south of the island in an extensive ridge of almost pure quality. The northern part of the island is a waste of rounded hummocks of gneiss in interminable confusion, rising out of dark peat bogs, and there are traces that here, as elsewhere, ice has been at work in planing down the protuberances of the soil. The highest eminence on Coll is Ben Hoch, whose height reaches only 339 feet, situated

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* See "Notes, chiefly Botanical, of a visit to the Island of Coll," by Thos. Scott, LL.D., F.L.S. (*Nat. Hist. Soc., Glas., Trans.* 1st Ser., Vol. IV., p. 226.)

about the middle of the island on the western shore. There are about 18 small and large lochs in Coll, the largest being about a mile in length, and some of them are well stocked with trout. The interior of Coll has several patches of land under cultivation, but the inhabitants seem as a rule to be very poor. They are mostly to be found on the eastern shore, Arinagour being their chief port, and the entire population of the island numbers only 432. In 1755 the population was 1193; in 1831 it was 1316; in 1841 it was 1409. Since that date changed social conditions, cruelty and folly of landlords, and wholesale emigration have brought down the number to 432.

Perhaps it was owing to the gloom of the evening of the day on which we landed on Coll that we were disposed to entertain rather depressing views of the island. The magnificent weather with which we had been favoured hitherto showed signs of breaking down. We strolled along the only road to the south, then struck across the moor to a lonely tarn, and reached the sea again at a little bay opposite Eilean Ornsay. Far across the now angry sea we could discern the sombre outline of the Treshnish Islands, with the Dutchman's Cap towards the south. The waves broke with profound melancholy on the rocky shore, where a ruined cottage added to the desolateness of the scene. Sea birds screamed around us, enraged with our intrusion into their haunts, and rabbits darted into their burrows as they caught sight of us. It was in keeping with the gloom of the place that even the rabbits were, every one of them, black! *

The following morning we found that the storm warnings of the previous evening had not been false. Torrents of lashing rain, a furious wind, and a raging white sea were what greeted us. Nevertheless, as our stay on the island was to be brief, we desired to see what its western shore was like. Across the dreary road from Arinagour to Arinabost we trudged, and found that at Gallanach the road practically ceased. The western side of Coll we found to be largely composed of sand dunes, built up in rolling mounds by the Atlantic winds.† Cliad Bay, which we visited, is flanked by rocky reefs, and the coast for miles is a succession of sand links covered with coarse bent, on which were myriads of *Helix ericetorum*. The breakers were thundering over several islets in the bay, the sea birds screamed as they swooped down the gale, and the scene was weird in its desolateness. The strong wind had driven the sand over all the shells on the shore, and

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* See Harvie-Brown and Buckley, *A Vertebrate Fauna of the Inner Hebrides*, p. 45.

† Scott's epithet, "They wakened the men of the wild Tiree, and the Chief of the *sandy* Coll," is surely applicable only to this western strip and to the extreme south of this otherwise rocky island. (*Lord of the Isles*, Canto IV., 10.)

I soon saw it was impossible to do any practical work. The following meagre list of mollusca gives the scanty records of that afternoon's search :—

Mytilus edulis, L.
Pecten maximus (L.)
,, *pusio* (L.)
Donax vittatus (da Costa).
Cardium edule, L.
Patella vulgata, L.
Littorina obtusata (L.)

The following day promised better. There were blinks of sunshine between the showers, but the day at last proved as wet as its predecessor. We turned our steps towards Acha, in the hope of reaching Breachacha Castle, the old ruined fortress of the Lord of the Isles, and perhaps of visiting some of the numerous spots so famed in legend as the scenes of sanguinary encounters between the Macleans of Coll and the M'Neills of Barra. But the rain proved too much for us, and we were forced to return to the shelter of our cottage, and to the hospitable fireside of the United Free Church minister, the Rev. Roderick Ross, who kindly gave us much information regarding the island and its past history.

The "Fingal" was due to call that afternoon, weather permitting, and we anxiously awaited her arrival. It was very doubtful if she would venture to embark passengers in such a sea. While waiting at the little pier at Arinagour, I had an opportunity of conversing with the ferryman, Charles Macfadyean, on the occurrence in the neighbourhood of the largest British shell—the *Pinna fragilis*, Penn. The distribution of this mollusc is particularly interesting. Jeffrey states* "that it is sparingly and locally distributed on all the British coasts, but gregarious from low water-mark to 80 fathoms in muddy or sandy gravel." But the records of its captures in Scottish waters are exceedingly few. Landsborough says,† "*Pinna* has only once that I know of been got at Arran." The only other specimen, I believe, ever obtained in the Clyde estuary, is now in my own cabinet, having been dredged by Major Martin off Largs, given by him to Dr. C. P. Miles, F.L.S., by the latter to my uncle, Rev. J. E. Somerville, B.D., Mentone, and by him to myself. Dr. Walker is reported to have found it off Barra : a small specimen was discovered by Laskey at Scalasdale in the Sound of Mull : ‡ Montagu reported it from "the Hebrides :" Forbes § from the "Shetlands in deep water :" W.

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* *Brit. Conch.*, II., p. 100.

† *Excursion to Arran*, p. 60.

‡ "Elucidation respecting the *Pinna ingens* of Pennant's 'British Zoology,'" *Wernerian Soc. Mem.*, 1808, Vol. I., p. 102.

§ Forbes and Hanley, *Brit. Mollusca*, II., 258.

Anderson Smith * from off Canna in 136 fathoms: and Pearcey from the Minch by trawl in 80 fathoms. But what put me on the scent for the shell at Coll was Landsborough's statement, "It has more than once come to me from a friend in the island of Coll; I prized it for the rare zoophytes with which it was richly encrusted;" and a specimen had also been seen by a friend of mine in a shop window at Tobermory, with a label that it had been taken between the Sound of Mull and Coll. The ferryman at once recognised the shell of which I spoke, and said he had frequently seen them brought up in the trawl, and though they were now rarer than they used to be, he would try and procure me a specimen. This, however, he has not as yet been able to do.

At last the "Fingal" rounded the point, and after a stiff pull through the breakers we found ourselves on board the little steamer. The voyage to Tiree was carried out with the most disagreeable accompaniments—a wild gale, a bitter wind, and torrents of rain at intervals. As there was no shelter on the deck over which the seas repeatedly broke, the captain kindly allowed us to sit on the bridge and to crouch behind the protecting canvas sheeting. The small steamer no doubt behaved as well as could be expected in such a storm, but the passage will long be remembered by us for its severity and its trials. Slowly we fought our way in the teeth of the gale past Crossapol Bay, the largest indentation at the south end of Coll; got a glimpse through the flying spindrift of Gunna, the small island which lies between Coll and Tiree, and, while the darkness closed in, at last neared Scarinish. Tiree is so flat that the houses on shore loomed high, and it seemed from the deck of the steamer as if we could almost have seen across the island to the other side. On landing in the small boat—a risky undertaking in such a sea—we found again, to our dismay, that the only hotel was filled to overflowing. We were, however, very kindly accommodated overnight in the hospitable manse of the Rev. D. T. Mackay, the United Free Church minister.

The next morning everything was marvellously changed. The sun shone from a cloudless sky, the sea was blue as the Mediterranean, the island beamed in its harmonious colouring of soft green turf, snug little sandy bays, and rocky headlands. If Coll had borne an aspect of dreariness, Tiree on the contrary was eminently cheerful. Scarinish has a tiny harbour suited only for small craft in fine weather, a picturesque lighthouse overlooks the landing-place, and the hotel is immediately behind. The cottages have an air of comfort and neatness, which those in Coll hardly possessed. As a rule

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* "The West Coast Expedition of the 'Garland' during July and August, 1892, *Scott. Fish. Bd. Rep.*, 1882, Part III., p. 167.

they have walls of rounded stones cemented together from three to five feet thick (at least at the doors); the roof is of tarpaulin neatly fixed down, and weighted with stones to prevent destruction by the furious Atlantic hurricanes which sweep over the island. The people seem most contented and prosperous, and we were impressed with the joyousness and the freeness of the life lived in this far western isle.*

Geologically, Tiree is of the same age and formation as Coll, but the differences between the two islands are very striking. On Tiree there is no heather, while Coll is covered with it. Everywhere on Coll grim bosses of gnarled gneiss appear above the bogs, cold, naked, and inhospitable: on Tiree are acres and acres of rich pasturelands, while the air is laden with the sweet scent of clover fields, golden with broom and buttercups. To the north there are wide and noble shallow bays, fringed with the finest and hardest white sand, and broken up here and there by vast promontories of intrusive dykes. The surface of Tiree being as a rule so flat, any

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* On the other hand, the *New Statistical Account* (1840-43) remarks (Argyllshire, p. 211): "In Coll, notwithstanding the general rockiness of the ground, the crops are much more productive," and again (p. 218), "the absence of peat from Tiree is a serious drawback to the natives of that island, as the annual expense of importing fuel from Mull and Coll amounts to £2000." In connection with the general prosperity of the island at the present day, the following statement from the *Scotsman*, October, 1905, may be of interest:—

"REVIVAL OF A HEBRIDEAN INDUSTRY.—During the whole of the nineteenth century kelp-making constituted an important industry in several of the Western Isles, and afforded employment to all the available workpeople in the districts where it was carried on. For a number of years back it has been greatly on the decline, and its total abandonment—which ultimately took place—was regarded by cottars and the poorer class of crofters as nothing short of a disaster. Three years ago the British Chemical Company, Limited, deemed it expedient to wind-up their business in Tiree, and their horses and other effects were sold. Under peculiarly favourable conditions, the occupation has now been revived in Tiree and the Long Island, at the instance of the old company. There are now dispatched from Tiree alone every fortnight cargoes of tangle ash and kelp amounting to 120 tons in weight, and equalling in value £600. It is stated that of the cargo shipped during the first week of July 80 tons were collected in the west end of the island, one man contributing 14 tons, roughly estimated, valued at £70. Many crofters last season paid their rents and had besides £30 or £40 to draw on account of what was only a few weeks' labour. Workers now receive payment in cash—not in meal, groceries, and other commodities, as was formerly the rule. Four and a half tons of air-dried tangle, which still retains nearly 40 per cent. of moisture, usually yields about a ton of ash, for which the crofter receives £5. The amount of exertion involved in tangle-gathering and burning operations is very small, and is, for the most part, so simple and light as not to be beyond the strength of women and children. An average family, it is stated, may often earn £1 a day. At Ross of Mull and other centres, where drift-weed is frequently cast ashore in enormous quantities, the company intend to appoint agents, who will receive tangle ash from all who care to engage in its preparation."

slight elevation stands out as large as a mountain. In the S.W. of the island rises Ben Hynish, seen from far, though its height is only 460 feet. Beyond this hill is Kennivara (Ceann-a-Bharra), of which the *New Statistical Account* (1840-43) quaintly remarks:—"It forms the western headland of the island, as its name imports, and is chiefly remarkable for a number of hideous clefts and chasms facing the sea, inhabited by myriads of wildfowl, chiefly of the aquatic kind, whose screams and discordant notes, when they are disturbed in their residence, form a most Babylonish compound, not at all grateful to the organs of those who like the 'concord of sweet sounds.'" Evidently the worthy man was no lover of ornithology! Both Coll and Tiree are extraordinarily rich in archæological remains—prehistoric, Norwegian, Danish, and Christian. These have recently been thoroughly explored and described in a magnificent monograph by Dr. Erskine Beveridge.*

In Gott Bay, and in a number of smaller creeks, we found a considerable variety of mollusca, and the list appended reveals a fairly large number of species and varieties (85 in all), most of which are entirely new records for this island:—

Anomia ephippium, L.
Glycymeris glycymeris (L).
Mytilus edulis, L.
Modiolus modiolus, L.
Modiolaria discors (L.) (?)
Crenella decussata (Mont.)
Ostrea edulis, L.
Pecten maximus (L)
,, *pusio* (L.)
Turtonia minuta (Fabr.)
Arctica islandica (L.)
Lucina borealis (L.)
Kellia suborbicularis (Mont.)
Lasæa rubra (Mont.)
Scrobicularia plana (da Costa.)
Tellina crassa, Gmelin.
,, *tenuis*, da Costa.
Macoma balthica (L.)
Donax vittatus (da Costa.)
Mactra stultorum, L.
,, ,, var. *cinerea*, Mont.
Spisula solida (L.)
,, ,, var. *truncata*, Mont.
,, *elliptica* (Brown.)

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* "*Coll and Tiree, their Prehistoric Forts, and Ecclesiastical Antiquities, with notices of ancient remains on the Treshnish Islands*," Edin., 1903. As regards the name "Tiree," the latest writer (Dr. Gillies, *Gaelic Place Names*, 1906), remarks:—"Though Tiree is Gaelic, signifying 'the land of corn,' the localities on the island have mostly Norse names. The explanation is that while in other parts we find Norse names upon sheltered bays and running from the sea into the green fruitful valleys, in Tiree the Norseman was 'thorough.' He held it all, and named it all. It is distinctly remarkable that the modern Gaelic names are found filtering inwards from the sea-border, and not outwards from the interior as is usually the case. The meaning of this is evident. The Norseman kept to the sea, or within reach of it always, so that inland names and places escaped him; but in Tiree the old Gaelic names were blotted out, not only on the coast, but over the whole island, and Norse names took their place. The restoration of Gaelic has been from without, so that the inland names remain Norse."

Spisula subtruncata (da Costa).
Lutraria elliptica, Lam.
Dosinia exoleta (L.)
,, *lupina* (L.)
Venus casina, L.
,, *gallina*, L.
Tapes virgineus (L.)
,, *pullastra* (Mont.)
,, ,, var. *perforans*, Mont.
Gouldia minima, Mont.
Cardium echinatum, L.
,, *edule*, L.
Mya truncata, L.
Ensis siliqua (L.)
,, ,, var. *arcuata*, Jeff.
Saxicava rugosa (L.)
Cochlodesma praetenue (Pult.)
Thracia fragilis, Penn.
Patella vulgata, L.
,, ,, var. *elevata*, Jeff.
,, ,, var. *picta*, Jeff.
,, ,, var. *depressa*, Penn.
Patina pellucida (L.)
,, ,, var. *lævis*, Penn.
Acmæa virginea, Müll.
Lepeta fulva, Müll.
Fissurella græca (L.)
Eumargarita helicina (Fabr.
Gibbula magus (L.)
,, *cineraria* (L.)
,, *umbilicata* (Mont.)
Calliostoma zizyphinus (L.)
Phasianella pullus (L.)
Lacuna divaricata (Fabr.)
,, *pallidula* (da Costa.)
Littorina obtusata (L.)
,, *rudis* (Maton.)
,, *littorea* (L.)
Rissoa parva, da Costa.
,, ,, var. *interrupta*, Adams.
Alvania cancellata (da Costa.)
Manzonia costata (J. Adams).
Onoba striata (J. Adams.)
Jeffreysia globularis, Jeff.
Skenea planorbis (Fabr.)
Trivia europæa (Mont.)
Natica catena (da Costa.)
Bittium reticulatum (da Costa)
Caecum glabrum, Mont.
Turritella communis, Lam.
Aporrhais pes-pelicani (L.)
Buccinum undatum, L.
Tritonofusus gracilis (da Costa.)
Ocinebra erinacea (L.)
Purpura lapillus (L.)
Nassa reticulata, L.
,, *incrassata* (Ström.)
Bela rufa (Mont.)
Tornatina mammillata (Phil.)
,, *obtusa* (Mont.)
Scaphander lignarius (L.)

Of these, perhaps the most interesting are (1) *Scrobicularia plana*, whose West Coast distribution has hitherto been somewhat scanty. Outside the Clyde, where it is very sparingly found, it has been recorded by Forbes from Skye; by A. Somerville from Ganavan Bay, Loch Creran, and Rum; and by Norman, Darbishire, and Coulson from Oban; (2) *Tellina crassa*, which has been singularly seldom reported from the West Coast; (3) a few valves of *Mactra stultorum*, and of its variety *cinerea*; (4) *Alvania cancellata*, recorded only by Barlee and Jeffrey, from the "Hebrides;" off Iona, and in the Minch off Barra by A. Somerville; and one dead in Kerrera Sound by Chaster and Heathcote;* (5) *Jeffreysia globularis*, whose only previous West

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* "Mollusca of Oban." *J. of Conch.*, VII. (1894), p. 297.

of Scotland record had been on *Laminaria* at the Croulin Islands by Barlee and Jeffreys. For the identification of many of the smaller species I am again indebted to Dr. Frew, Glasgow, who kindly went through the bag of sand I brought home.

The sand dunes at the head of Scarinish harbour bore evidence of having been recently raised above sea-level In places where a roadway had been cut through them, large numbers of *Purpura lapillus*, *Littorina littorea and Patella vulgata* were embedded in the sand, while here and there fragments of rusty iron protruded from the steep bank. The sand dunes seemed to a certain extent stratified, gravel and sand being arranged in consecutive layers, the shells being found in principally one of the strata; the elevation, however, above sea-level was probably not more than 12 to 20 feet. On these dunes and on the shore the following land molluscs were picked up:—*Helix pulchella*, Müll.; *H. aspersa*, Müll.; *H. nemoralis*, L.; *H. itala*, L.; *H. caperata*, Mont.; *H. acuta*, Müll; *Cochlicopa lubrica*, Müll.; but no special search was made for other non-marine shells.

When Sunday came round, Rev. Mr. Mackay prevailed on me to preach for him at a remote spot named Cornaig on the N.W. of the island. On an exquisite summer evening he drove us in his trap to the other side of Tiree. Proceeding north by the shores of Gott Bay, we could see the grand old ruined chapels at Kirkapol—ancient —perhaps pre-Reformation-Churches—now given over to solitude and decay. At Ballyphetrish Hill we stopped to admire the wonderful and far-stretching view. Away to the north, beyond Coll, lay Rum and Canna, and still further in the misty distance the dim outline of the Coolins in Skye. To the west, where the sun was sinking into the ocean in richest splendour, though with an ominousness in its glow which bespoke a change of weather, we could see Hecla, the grandest of South Uist's peaks, Heaval in Barra, and the crags of Mingulay and Bernera. To the south lay Colonsay, Jura, and distant Islay, while the east commanded the long range of summits from Ardnamurchan through Sunart and Appin to where Mull's basaltic terraces towered over the Treshnish Islands. At Ballyphetrish are the well-known white and rose-coloured marble strata, with other formation of limestone and intrusive felspar. The bay of the same name we found to be a noble beach a mile long, composed of the coarsest gravel and stones, pounded continually by the unrestrained fury of the Atlantic.

The service being over, we returned to Scarinish by another route known as "The Reef." This is a plain which crosses Tiree from north to south, so little raised above the level of the sea, that in the winter gales it is said to be sometimes possible, while standing on one shore, to see the waves breaking on the other strand.* It has undoubtedly been elevated at no very remote epoch, and its name still suggests the time when the sea swept across the 2½ miles of what is now splendid pasture land. On this "Reef" thousands of cattle find the richest grazing, and it was rather a weird experience to drive across the veldt in the gathering gloom, and to steer our way, drawn by a horse aged 29 years and of uncertain docility, through these vast herds of oxen, which are not always noted for quietness of disposition! As the wind sweeps over this level sward, with nothing to interrupt its hurricane blast, the Messrs. Barr, who own the farm, have erected high and broad walls, which run for more than a mile across the island, and afford protection to their cattle, etc.

The following day we recognized that the weather signs of the Sunday night were abundantly proved true. The dash of rain on the window, the shriek of the blast from the Atlantic, and the roaring of the sea proclaimed that we were storm-stayed on Tiree. No steamer could call to take us off. Passing the day in further exploration of the shores, though getting sadly drenched for our pains, we waited for the promise of another morning. By Tuesday the wind had moderated somewhat, and we resolved to cross to Iona in the "Dunara Castle," which lay rolling in the offing. There had been a horse fair at Scarinish, and now horses by the score were being embarked for transport to Mull. It was a most arduous task to ship those frightened animals in that sea, and many hours passed before the cargo of horses, cows, and sheep, to the number of upwards of a thousand, had been conveyed on board.

The sail from Tiree to Mull was enjoyable in the extreme. The sun shone on a sea of deepest blue, and we drank in the ozone of the Atlantic with the keenest delight. The swell still ran high, and the steamer nearly rolled her scuppers under water, but the voyage was in every way delightful. Gradually Tiree faded out of sight, and we were skirting the most southerly of the Treshnish Islands. The three main islands of this group—Fladda, Lunga, and Bac Mor or the Dutchman's Cap (so called from its close resemblance to that article of apparel)—are imposing remains of that once widely extended basalt plateau which embraced Mull and Ardnamurchan and Sunart. These lonely stacks, entirely uninhabited except by herds of cattle which feed upon their rich sweet grasses, are built up of horizontal basaltic strata, and their desolate grandeur, standing far

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*A submarine forest has been described as existing near this "Reef": Smith, *Newer Pliocene Geology*, p. 69; see also *New Statist. Account*, Vol. VII. p. 202 (1840), where it is said that "in the mossy ground the remains of decayed trunks and roots of trees, and nutshells in a pretty entire state, have been frequently discovered," where trees will not now thrive.

out in the ocean, makes one realize the stupendous denudation which must have taken place since they were united with the distant coast of Mull. They lie in a long line, about five miles from north to south, the highest being Lunga, whose summit is 337 feet, while the Dutchman's Cap reaches 284 feet. Their precipitous sides render landing a matter of extreme difficulty. Yet there are ruins on these islands of ancient churches and other ecclesiastical remains, showing how indefatigable were the former Hebridean residents in maintaining places of worship. It was a matter of much regret that circumstances prevented us from landing on Staffa, but as we sailed to the south of it, we were able through the glass to make out clearly the celebrated basaltic columns, which have rendered Fingal's Cave a household word for what is marvellous.

We now came under the shelter of Mull, and in a short time we were at anchor in the beautiful Loch na Lathaich, and facing Bunessan. Here we had to land our cargo of horses, and it was interesting to observe how the feat was accomplished. Each horse was pushed overboard with a halter round its neck, held by a man in a small boat alongside. Sinking out of sight with an immense plunge, it reappeared and was directed in its swim ashore by the man in the boat who held the cord. But once or twice it happened that the animal attempted to swim out to sea, rather than follow the boat; in that case a dog in the boat, evidently trained for the work, sprang into the water, leaped on the horse's haunch, barking furiously, and turned its head in the right direction! This long swim the dog repeated time after time.

Most striking was the view of the vast basaltic masses piled tier above tier on the other side of Loch Scridain, and reaching their summit in Ben More. Probably there is no locality in Britain where basaltic structure can be better studied than in Mull. Sir Arch. Geikie, who has done so much to elucidate the history of these gigantic formations, estimates their total thickness, as they rise in horizontal beds up one vast sweep of precipice and terraced slope, to be about 3500 feet!* Prof. Judd has stated that they must have grown by accretion of volcanic matter till they rivalled Etna in height, and seemed as if they might last for ever.† But in the immediate neighbourhood of Bunessan, stretching along the north-east shore of the loch, there are other geological phenomena of the greatest interest. I refer to the famed Ardtun "leaf-beds." In 1851 the late

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*"History of Volcanic Action during the Tertiary Period in the Brit. Isles." *Trans. Roy. Soc., Edin.*, 1888, Vol. XXXV., Part 2, p. 92; also *Scenery of Scotland*, p. 146.

†"On the Ancient Volcanoes of the Highlands," *Quart. Jour. Geol. Soc.*, Vol. XXX.

Duke of Argyll discovered here thin leaf-bearing beds of shale, intercalated among beds of basaltic lava, tuffs, or volcanic ashes, and these plant remains being the first ever described from volcanic strata, excited much interest. Mr. Starkie Gardiner has since then worked over the ground, and his researches have shown how these vegetable remains have a unique importance in determining the age of the basaltic outflow which extended from Greenland to Antrim. He remarks on "the extraordinary fresh condition of the vegetation, stating that one of the leaf-beds he found to be made up for an inch or two of a pressed mass of leaves, lying layer upon layer, and retaining almost the colour of dead vegetation."* MacCulloch, earlier in the century, had discovered and described a large coniferous tree trunk (a Sequoia) five feet in diameter, still to be seen under the basalt precipices of Gribon, that had been enveloped, as it stood to the height of 40 feet in one of the flows of trap.† These organic remains prove the existence of long quiet intervals between the successive outbursts of volcanic energy, and seasons during which fresh-water lakes were formed, and forests sprang up, on the margin of inland waters.

Reluctantly quitting these most interesting spots, we resumed our voyage round the Ross of Mull, proceeded down the Sound of Iona, and in due course landed on the sacred isle. It is unnecessary that I should even attempt to describe the ecclesiastical and antiquarian riches of this Isle of Saints; that task has been accomplished in many a volume. We visited and photographed the Nunnery, the three celebrated carved crosses—all that are left of the 360 that were thrown into the sea by ruthless iconoclasts at the time of the Reformation—St. Oran's Chapel, the tombs of the Scottish, Norwegian, and Irish Kings, and last the Cathedral. Of these I will say nothing, ‡ but of the beauty of the island I must speak. It may have been the exquisite freshness of the morning, or the balminess of the air, or the absolute peacefulness resting on sea and land, but whatever the cause might be, we agreed that no island we had visited could compare for beauty with Iona. We walked to the headland at the north end of the island, and feasted our eyes on the glorious panorama of blue ocean, rocky cape, giant mountain, green isle, and

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***Quart. Jour. Geol. Soc.*, xliii. (1887), p. 283; and Duke of Argyll, *Ibid.* vii., p. 89.

†*Western Islands*, i., p. 568, and Plate xxi. Fig. 1.

‡We felt, however, we could fully endorse the famous sentence of Dr. Johnson, "That man is little to be envied whose patriotism would not gain force upon the plains of Marathon, or whose piety would not grow warmer among the ruins of Iona." Perhaps the late Duke of Argyll caught the spirit of the Isle, and most felicitously reproduced it in his work *Iona*, Lond., 1871.

golden strand. The Treshnish Islands, Gometra, Ulva, and "all the group of islets gay that guard famed Staffa round," gleamed in the sunlight, and the glory of the scene was superb. The northern shore has a curious long narrow passage about five feet across, which winds in and out of the rocks that tower on either hand and is dry at low-water—evidently the decayed track of an ancient volcanic dyke. The numerous little sandy bays and creeks yielded the following mollusca, none of them, however, of any rarity :—

Anomia ephippium, L.
Glycymeris glycymeris (L.)
Mytilus edulis, L.
Pecten pusio (L.)
Lucina borealis (L.)
Spisula subtruncata (da Costa.)
Dosinia exoleta (L.)
Venus casina, L.
Tapes virgineus (L.)
Mya truncata, L.
Ensis siliqua (L.)
Patella vulgata, L.
Patella vulgata var. *depressa*, Penn
Patina pellucida, var. *lævis*, Penn.
Gibbula cineraria (L.)
,, *umbilicata* (Mont.)
Littorina obtusata (L.)
,, *rudis* (Maton.)
,, *littorea* (L.)
Trivia europea (Mont.)
Velutina laevigata (Penn.)
Buccinum undatum L.
Purpura lapillus (L.)
Helix aspersa, Müll.

The "Grenadier," on which we returned to Oban, took the southern route round Mull. Quickly we rounded the island of Erraid, and steering our way through a labyrinth of skerries between the Torran Rocks and the Ross of Mull, with its famous red granite quarries, we made a straight course for the celebrated Carsaig Arches. All the way the coast of Mull is a vast wall of rock, broken here and there by a sectional gorge. The cliff reaches its highest elevation at the Carsaig Arches, where it is 1082 feet high. These arches are hollowed out of limestone into quite a variety of fantastic shapes, and numerous fossils have been discovered at the spot. Skirting the mouth of Loch Buy, and crossing the Firth of Lorne, we found ourselves sailing up the quiet waters of the Sound of Kerrera, and in the purple gloaming reached again the old pier at Oban.

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XVI.—*Prehistoric Burials.*

By Sir ALEXANDER MUIR MACKENZIE, Bart.

(Read 8th November, 1906.)

I may have presumptuously thought bed rock was touched in surveying the mighty ruins of Stonehenge, Avebury, and their reputed grandmother, Stanton Drew, but old as these are, and marking as they doubtless do, with their attendant "barrows," the burial places of ancient heroes, they are almost modern when compared with the burial land further south. The sea itself is the graveyard of half of Cornwall, and "Lost Lyonnesse" is as much a romantic as a geological problem. On the lonely Dartmoor, in the wind-blown waste of "Cornubia," and in many a cave and creek (Cornish "gweek"), there are evidences of prehistoric animals, and of human remains which are of an age impossible to dogmatise upon. The bone caves of Kent's Cavern and Brixham yield masses of "stalagmite" encrusting bones of man, probably contemporary with the mammoth or cave bear. In the recent discoveries at Mentone similar remains, accompanied by flint chips and other signs of a bygone age, confirm these conclusions. A skeleton was found in Gough's Cave at Cheddar, Somerset, enshrined in two beds of stalagmite* differing in thickness,† and it is computed that the skeleton must be 10,000 years old at least—enough to demonstrate the tremendous age of this "lukewarm bullet" speeding through space, and of the length of time when man began to walk on the earth. But this is not a geological essay, but rather a study of the remains and burials we find in these lonely corners and on barren moors.

Among the monuments left us we notice the *barrows*, in shape long, bowl, round, or convex, denoting difference in tribal attributes or the mode of the time and circumstances. Those of Stonehenge and Avebury are the most remarkable, but a long line of these burial mounds is to be seen and explored on the melancholy Goonhilly downs near the Lizard.

The mighty Cromlechs,‡ or Dolmens, the Menantols,‖ and the numerous circles, all point to ancient, if not prehistoric, burials. Space will not allow of more than a few of the most noticeable.

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* I need not remind the student that *stalactite* is the dripping column, on to *stalagmite*, the base, both formed by the dissolution of lime by carbonic acid.

† The growth of stalactite depends on the ease with which the deposit passes through the strata, and cannot dogmatically be defined. Given at one-fifth inch in a hundred years. During 67 years Mr. Gough saw no increase in one pendant.

‡ Cromlechs are defined thus:—(1) Somewhere called dolmen, a "trilithon," 3 stones; (2) closed in, called "kistivaën"; (3) covered in by earth, "barrows."

‖ Men-an-tol—*Lit.* "Great stone with hole in it"

The circle of the "Hurlers," Liskeard, Cornwall, and that of Boskednan, are undoubted burial-places. Beautiful crosses, those of St. Columb, mark others. The Lanyon Cromlech, that at Chagford, and that yclept the Devil's Dyke, at Marlborough, are fine examples, while the great hut circles at "Grimspound" on Dartmoor, or "Chrysoster," near Penzance, show where men were born, had lived, died, and were buried.

Inscribed Stones.—Several of these monoliths are found, some with the Ogham lettering, and others of later and Christian times. They cannot be called "prehistoric burials." Notable are the "men crwfa" at Lanyon, and those of a British king about 400 A.D. at Liskeard.

Cists found at Harlyn Bay, Cornwall, and at Bamburgh, reveal skeletons similar to the one referred to above of Gough's Cave, and were reported upon in print by the present writer as follows:—*

"The recent discovery of a second skeleton in one of the cists at the Harlyn Bay burial-ground, and the finding of several more slate implements, has again awakened interest in the prehistoric wonders that have been unearthed at this little Cornish watering-place during the last two years. Indeed, there would seem to be no end to the treasures hidden away at this particular spot, and every now and again a new 'find' is being reported.

"Before describing the treasures, a brief reference as to how they were found will not be inappropriate. Harlyn Bay is a pretty little spot some two and a half miles from Padstow. Here, overlooking a pleasant bay, with its white shell-sand, is one of the quaintest museums in this country, while attached to it is a burial-ground where the tourist may inspect graves that were dug and used long before the ancient Britons were conquered by Cæsar's legions.

"Like many other famous discoveries, the remains were unearthed by accident. It appears that in August, 1900, a private gentleman, Mr. Reddie Mallett, attracted by the quiet beauty of the spot—for at that time Harlyn Bay was almost unknown except to those who love the wild rock scenery of the beautiful North Cornish coast—purchased some three acres of land here for the erection of a private dwelling-house. He little knew what prehistoric treasures kind Dame Nature had hidden beneath her soil. During the work of digging for foundations and prospecting for water, a slate cist, or tomb, was unearthed at a depth of about fifteen feet, and therein was found an interment with characteristic ornaments and implements of a very early stage of civilisation. Mr. Mallett at once communicated with various antiquarian bodies, and within a short time an influential

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* Published with illustrations in "County Gentleman," London.

committee was formed. They examined the ground, and were not long in discovering that the site was nothing less than a very ancient burial-ground of the neolithic or bronze age, going back 2,500 years or more.

"Funds were raised for carrying out systematic excavations, which were conducted under the direction of the Royal Institution of Cornwall. In all the excavators opened no fewer than one hundred graves, going down to a depth of fifteen feet, and removing no fewer than 2,000 tons of blown sand which had accumulated on the spot. The find was the richest in the number of stone cists, skeletons, and their accompaniments that has ever been discovered in any one spot in the British Isles, and the burial-ground naturally attracted wide attention, not only in anthropological circles, but among the general public. Nearly all the skeletons and the objects found in or near the graves by the excavators of the Royal Institution of Cornwall were removed to the Truro Museum, but quite a large number have since been found, and are now to be seen in the specially-equipped museum on the spot, while some six cists in the burial-ground have been roofed over with glass to enable the general public as well as anthropologists to view them. Hence, the Harlyn Bay Prehistoric Museum is one of the quaintest in the United Kingdom, and thousands of people from all parts of the country travel to Harlyn Bay to see it. In fact, it is a case of skeletons founding a seaside resort, for Harlyn Bay is not only known to antiquarians, geologists, and everybody in Cornwall and Devon to-day, but to the general public at large. Yet a few years ago the spot, delightful though it is, was almost unheard of.

"As soon as the excavators of the Royal Institution of Cornwall had finished their work, Mr. Mallett proceeded with the erection of his house, and it was not long before he made other "finds." Being much interested in anthropology and prehistoric relics, he decided to found a museum, and for the next two years privately carried out more or less extensive excavations. That his labours were well rewarded is shown by a visit to the museum and an inspection of the burial-ground. Unfortunately, he was forced to give up his beloved work and the treasures he had accumulated, owing to the death of his wife, and his museum and other buildings which he had erected were sold, and are now in the possession of Colonel Bellers, who kindly took the writer over the spot and showed him the numerous relics.

"The museum consists of one large room, measuring about twenty-four feet by eighteen feet, and is really the lower half of a private dwelling-house. There are some twenty cases in the museum, as well as a complete cist with a skeleton in it, taken, of course, from the burial-ground near by. To describe in detail the various relics in the cases would occupy too much space. They include spindles, whorls, rings, bracelets, beads, and brooches, found with the skeletons.

In addition to the above there are numerous slate, shell, and flint implements. It was thought by many that the slate implements were really pieces of sea-washed rubble. But their well-developed edges, and also the fact that some of them show decided attempts at rude ornamentation, such as the scratching of lines and even crude designs, at once disposes of this theory. There are no fewer than two hundred of these implements in the museum—spear-heads, scrapers, hammers, keen-edged knife blades, well-made awls, and tapering bodkins.

"More interesting than the museum is the burial-ground, entered through a wooden gate close to the dwelling-house. In appearance it is as much unlike a cemetery as one can imagine. It looks like an untidy garden, with here and there a number of glass-covered cases like so many cucumber frames. But these are the graves, and it is through the glass-covered roofs that one peers into the curious tombs and detects the skeletons lying in them.

"As to the age of these prehistoric remains, there would seem to be no doubt that they belonged to the neolithic period, and anthropologists are virtually agreed that the skeletons recently found must have been buried here 2,500 years ago. Objects found with the skeletons, such as spindles, rings, bracelets, beads, brooches, etc., were submitted to Sir John Evans and Mr. Read, of the British Museum, for their opinion as to their age, and several of the skulls were sent to the eminent craniologist and anthropologist, Dr. John Beddoe, for a like purpose. All these authorities are agreed that the cemetery was no doubt a burial-place of the neolithic age, or bronze age period. Dr. Beddoe has pointed out that the skulls represented people of a very old race, and were of a kind which existed before the rounded head of the bronze people. 'As for the date of these deposits,' he declared in his report, 'we may conjecture with some confidence that it was after the Gallo-Belgic and before the Roman Conquest' about 500 B.C. Dr. Beddoe also examined the teeth. He found the surfaces, particularly in the adults, excessively worn, which shows, he declares, that 'these ancient people fed largely on grain or other coarse food. This would accord with the conclusion to be drawn from the absence of weapons and of notable wounds that this was a peaceable and sedentary community, not a nomadic or predatory one.' It is interesting here to note that not a single coin has been unearthed, which, as Sir John Evans, who made an exhaustive examination of the implements, said, 'virtually confirms the very ancient age of the cemetery. The discovery of a single coin might have put a different aspect on the matter.'"

It may be interesting to compare with that of Harlyn another ancient burial-place situated about three miles south of Bamburgh Castle, and opposite the Farne Islands, on a hill about 75 feet high, and about 400 yards north-west of Seahouses Railway Station. This was disclosed when making excavations for a reservoir for a water supply to the district in May and October, 1905. The cists were constructed during the bronze age, *i.e.*, about 3,000 years ago, when Israel was in Egypt.

The contents of the cists were as follows:—

No. 1 contained a skeleton in good preservation and an urn, or food vessel.

No. 2 a skeleton and urn, both damaged by workmen in removal.

No. 3 a skeleton and an urn.

Nos. 4 and 5 were smaller than the other cists, *i.e.*, about 18 inches square, and nothing but earth was found in them. It has been suggested that they had contained the bodies of children, the bones of which had entirely mouldered away.

No. 6 held a skeleton in very good preservation and an urn, which had been placed in the right hand of the body. The bottom of this cist was covered with water-worn peebles carefully laid and arranged.

No. 7 was a large stone slab, under which was found a complete skeleton which had evidently been exhumed and reinterred. There was no cist. It was close to the adjoining cist No. 6.

The cists Nos. 1 to 6 were all filled up with fine earth, which had evidently been washed in by rain, or carried in by earth-worms, snails, rats, and mice, etc. A great number of snail shells and the bones of rats and mice were found in this earth. The snails no doubt went in to hibernate, and the rats and mice found them convenient nesting places.

The cists were excavated in the soft sandstone forming the subsoil. It is curious that they had not been noticed before, as coal had been worked quite near, and an old coal-shaft, which had been filled up, was within a few feet of the tombs. The stone slabs forming the sides and covers of the cists had been used just as they were found on the foreshore, then more than three miles away, no tool marks of any kind being visible on them. Exactly similar slabs may be seen on the foreshore at the present time, the sea having encroached in the interim on the land to the extent of nearly two miles. The corners and the joints of the stones were luted with clay, which was still in position when the cists were opened.

No tools, implements, or ornaments of any kind were found in the cists, though a careful search was made, the urns or food vessels being the only articles of manufacture of which any traces remained. The skeletons were of medium size ; in two cases they would appear to have been females, and the skulls were those of intellectual persons, and by no means low-type savages. Nearly every hill and elevated spot in the district, locally known as Bamburghshire, has been an ancient Celtic burying place, indicating that this county from 500 to 1000 B.C. had a considerable population.

In our own country there are fine examples. The circles, as yet in fair preservation, of Airlich, Strathbraan ; Croft Moraig, Aberfeldy ; burial cists found on North Esk, Penicuik,* and the gigantic Cromlech, or Menantol, on Craigmady, Strathblane, called the "auld wives' lifts," 3 great megaliths, the top stone being yclept the "Quoit"—all testify to the burial monuments of the dead, and the respect shown in those barbarous times to their departed heroes. A mound called the Women's Knowe, near the reputed Celtic "town" of Inchtuthill, was the burial-place of a Caledonian princess.

A note on the curious custom of preserving human heads in Ecuador follows :—

NOTE BY M. EMHAULT ON SHRUNKEN HUMAN HEADS.

"War trophies of Livarros Indians, Ecuador. These heads are prepared by removing the skull, leaving only the flesh of the head. Hot stones are then put in the head, and are kept moving by shaking and turning, so as to bring them (the stones) into contact with all parts. The process of shrinking is contiuued for two weeks."

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* See Vol. XL. (Fourth Series, Vol. IV.), 1905-6, of the *Proceedings* of the Society of Antiquaries of Scotland.

The accompanying Plates, Nos. 38-39, were kindly lent by the Society for publication in this journal.

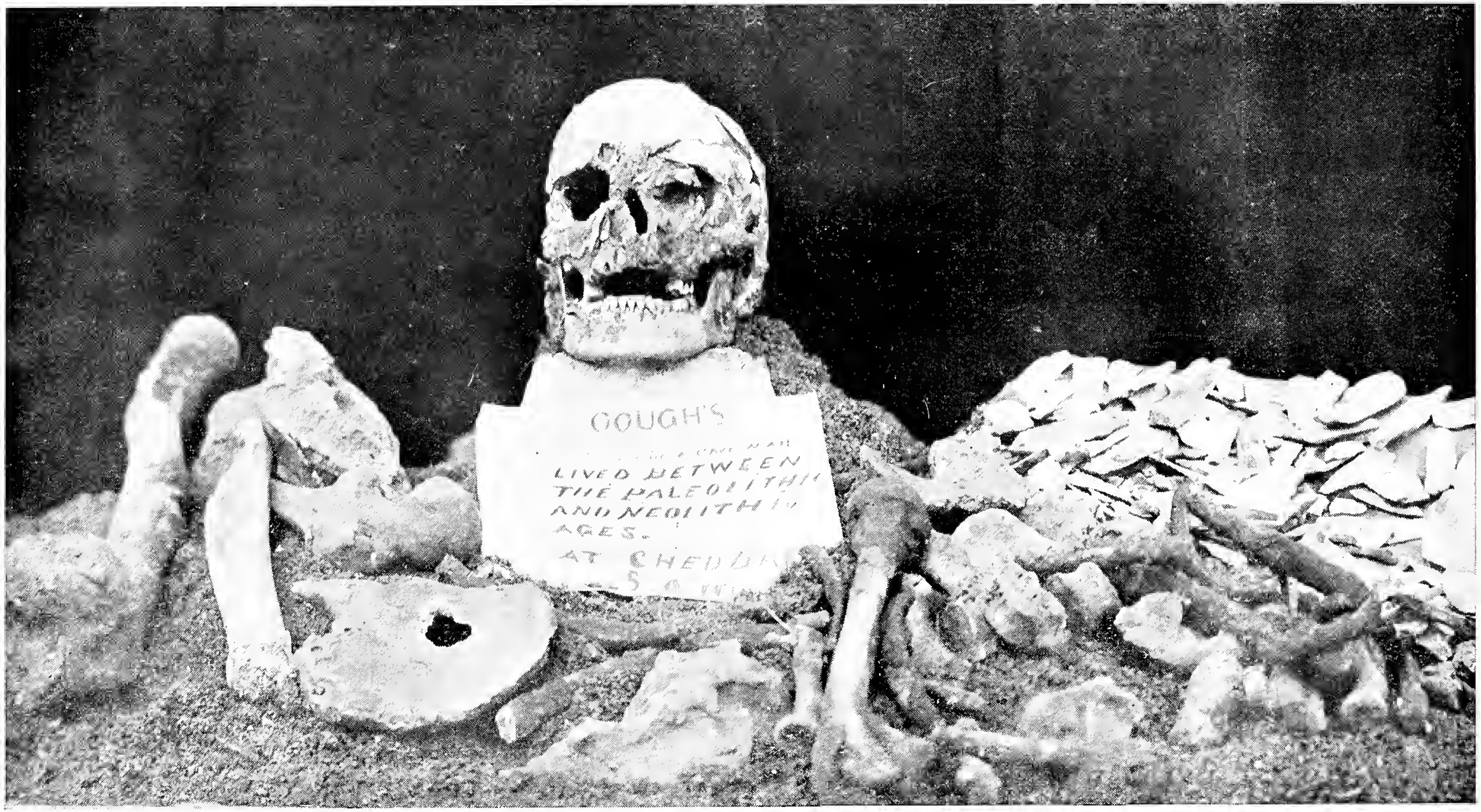

Plate 33 -- Skeleton found in Cheddar Caves.

Plate 34.—Skeleton found in Harlyn Bay, Cornwall.

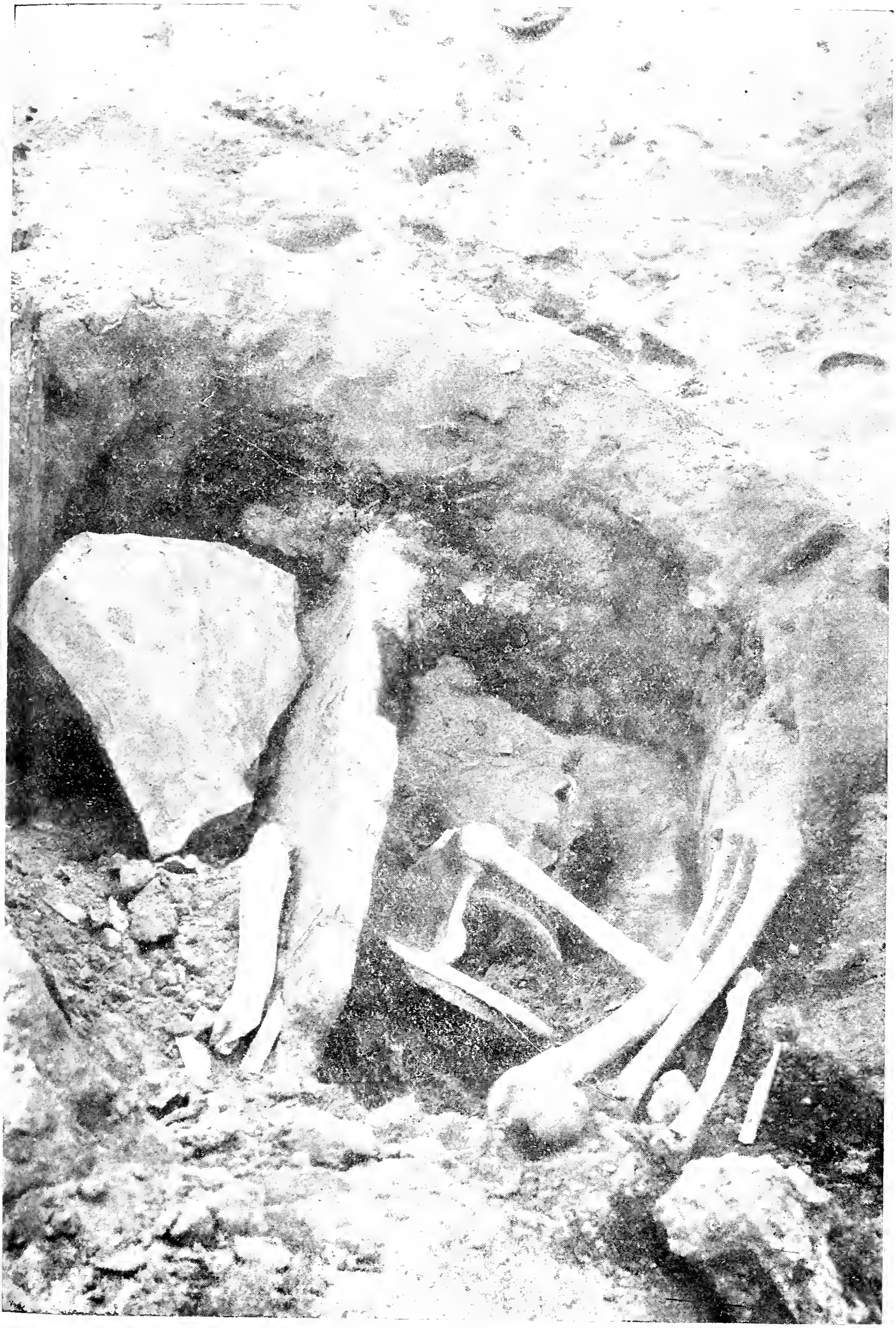

Plate 35.—Grave found at Bamborough.

Plate 36.—Skeleton found in Harlyn Bay, Cornwall.

Plate 37.—Stone-lined Long Graves on the Island in the North Esk Reservoir.

XVII.—*A New View of Human Descent.*

By JOHN H. LYELL, M.D.

(Read 13th December, 1906).

(Abstract).

The question of human descent is one which has a perennial fascination for all who are interested in the deeper and more speculative problems of Biology. The advent of the theory of evolution has entirely altered our point of view towards such subjects of enquiry. Indeed it is only since the time of Darwin and Huxley that the origin of man has come to be seriously looked upon as a problem of Biology at all. When Darwin published his epoch-making "Origin of Species" he hardly dared to include mankind in his speculations. But not many years elapsed before it was seen that there was no other way for it, and we have now reached the stage when it is no longer a matter of controversy that man is an integral part of the animal kingdom, and like every other living creature has been slowly evolved from more primitive ancestors which peopled the globe in remote geological eras.

It must be admitted, however, that while we are compelled to accept the general truth of man's evolution from the lower animals, much obscurity still rests upon the various stages passed through in the process, and more especially upon what were the immediate progenitors of man in the evolutionary series. The popular mind has for long associated what is known as Darwinism or the Darwinian Theory with the very unflattering notion that our race is descended from those gorillas, chimpanzees, and other larger apes, with whose uncouth forms we are made acquainted in museums and zoological gardens. It cannot, however, be too often pointed out that Darwin never said any such thing. In no case does he go further than to state his conviction that "man is an offshoot of the Old World simian stem," that he is a descendant of "some tailed quadruped, probably arboreal in its habits, which, if its whole structure had been examined by a naturalist, would have been classed amongst the quadrumana (or anthropoid apes), as surely as the still more ancient progenitor of the Old and New World monkeys." The derivation of man from some primitive, but now extinct, member of the ape family is therefore the true Darwinian doctrine. Present-day ape and man are divergent branches from a common ancestral form, which already possessed the distinctive simian characters clearly differentiated.

The great majority of naturalists have for many years accepted this theory as the only explanation of the extraordinary anatomical and physiological resemblances between man and the anthropoid apes. It is an interesting fact, however, that of late various considerations have been brought forward, chiefly by American and German investigators, which would lead us to believe that this doctrine is subject to several very important modifications. A more profound study of various peculiarities in human anatomy seems, in short, to point to a much more remote origin for our race than directly from the simian or ape stem. There would now appear to be good ground for the opinion that man is after all one of the great primary branches of the fundamental mammalian stock, the apes being merely a parallel race, whose only affinity with man is in virtue of the close origin of both types from the primary root out of which all the different branches of the great class of the Mammalia have sprung. The most recent conception of the descent of man is thus that he forms a root-branch of the great mammalian tree, growing up for a time very close to the ape stem, but afterwards diverging from it on totally independent lines, and finally overtopping the whole growth.

The chief argument advanced in favour of the new view is that although man has far outstripped all other animals in the development of his brain, he still retains in various parts of his bodily structure the undoubted evidences of an extremely primitive origin. One of man's most distinctive characters, for example, is the formation of his hands, in respect of which he really stands quite unique in the animal kingdom. The human hand is undoubtedly the most perfect mechanical device in nature. Its varied uses have helped to raise man above every other living creature, and hence there is no part of the body which strikes us more forcibly as being one of the highest triumphs of evolution. We are thus very naturally led to the supposition that it must be one of the last acquirements of the race, or at least of our more immediate progenitors. This, however, is quite a false conclusion. The hand is really one of the most primitive structures in the whole class of the Mammalia, and to find its earliest prototype we must retrace our steps to the very lowest representatives of that great group, and to their remote ancestors in far-distant geological time. Away back, towards the end of the Primary, or commencement of the Secondary Period, there existed certain large forms of land vertebrates with grasping extremities, which must have closely resembled those of present-day men or apes. The well-known Chirotherium footprints of Permian or Trias age might almost have been made by the large muscular hands of a modern working navvy. The thick cushion of the ball of the thumb, and even the very creases between the joints of the fingers, are faithfully preserved for us upon the hardened surface of the primeval sand. These footprints show us, more especially, the vast antiquity of the pentadactyle extremity, which is one of the fundamental characters of the structure of the Mammalia. It must have been inherited by them from their predecessors in the evolutionary series, —the Amphibia and Reptilia, which are older types than the Mammalia, still retaining the same peculiarity, as may be well seen in the foot of the tortoise or salamander.

We are all familiar with the extraordinary process of modification which has taken place in the extremities of present-day mammals. A law of simplification, indeed, can be traced through the whole class, consisting first of all in a diminution, or removal of the innermost digit, giving us a foot such as that of the hippopotamus with four toes; next of the outermost digit, giving us the foot of the rhinoceros with three toes; then of the second digit, giving us the foot of the ox or the deer with two toes; and finally of the fourth digit, leaving us the one-toed foot of the horse. It will thus be seen that in the mammalian series the middle digit remains the most constant and important, the innermost digit, corresponding to the thumb or great toe, being the first to disappear. The full complement of digits has been retained by certain carnivora, apes, lemurs, and marsupials, besides man himself; but in man alone has the primitive pentadactyle character been preserved in its full perfection. Now it is a most significant fact that in the anthropoid apes, whose hands most resemble those of man, this reduction of the innermost digit is well-marked. It is most conspicuous in the gibbon, but is to be clearly seen in the hands of the gorilla and chimpanzee. The same peculiarity is found even to a greater extent in the lower apes, some of the monkeys indeed having lost their thumbs altogether. In man, however, all the five fingers are complete and functionally active, the thumbs especially, by their strength and mobility, giving the hands their peculiar usefulness as organs of skilled movement. With regard also to the foot, the hallux or great toe is larger and longer in man than in any other mammal, and serves as the chief support of the weight of the body in walking. Man, therefore, in the structure of his extremities, retains the fundamental mammalian characters more completely than the other members of the class, in which those organs have undergone modification. This shows, according to the new school, that his line of descent is to be traced to the primitive mammalian root, rather than to any independent branch such as that of the apes, because if man were decended from the latter he would have inherited from them the tendency to a reduction in the first digits of hand and foot. In this respect, however, it would appear that the two lines of descent must have diverged from the very outset.

Turning now to the dentition, which is one of the most important guides to the history and affinities of different animal types, we find again that man has more primitive associations than other mammals, not even excepting the anthropoid apes, whose teeth resemble our own in so many respects. Amongst the Mammalia we have the most extraordinary differences in shape and size and number of the teeth. There are the rodents, for example, with their highly developed incisors; the herbivora with their broad, many-ridged grinders; the carnivora with their huge canines; the whale and the ant-eater with no teeth at all, and so on. These variations naturally demand a common ground type, and this must be supposed to be one in which no special group of teeth is more developed than the others. Here again we gain assistance from Palæontology. The remains of the earliest mammals show that their dentition was comparatively undifferentiated. But amongst living forms the dentition of the primates is really nearest to the ground type from which all others can be derived. Man himself, in fact, possesses the most primitive set of teeth, neither incisors, nor canines, nor molars being unduly developed at the expense of the others. It is important to note that in this respect he is even more elementary in structure than the apes, in all of which the canines are enlarged to a greater or less extent for grasping and tearing purposes. But not only is this the case in regard to the absence of marked differentiation of the various groups of teeth, it is also so in the actual formation of the individual teeth themselves. "The four-cusped molar tooth of man," for example, says Klaatsch, "is one of the weightiest documents of our position in the animal series. It represents a possession which at one time pertained to the ancestors of all now existing land mammals." Going back to Eocene times, we find forms which stood very near to the common root of the Mammalia, uniting in themselves the characters of what are now very sharply defined groups. Amongst these primitive forms were the ancestors of present-day carnivora, ungulates, and so on, which showed a remarkable approximation to the lemurs and other lower primate types. Now it has been found that the molar teeth of the Eocene mammals differ no more from those of man than the latter do from the molars of the anthropoids. "Man has thus," continues Klaatsch, "retained the form of dentition which was general in Eocene times, and therefore remains, so to speak, in this respect at the early Tertiary stage of the evolution of the Mammalia." These considerations, in short, show that in his teeth man is less highly evolved than the apes, and indeed than most of the other groups of existing mammals, and hence that his derivation is more primitive and remote.

Such then, in the briefest possible words, are a few of the arguments adduced in favour of the new view of human descent. From the fact that man presents none of those extreme modifications of the instruments of locomotion and mastication which give their peculiar character to other mammals, we are led to the conclusion that his origin is to be traced direct to the primitive mammalian root, rather than to any collateral branch, such as that of the apes. "Man is a central primate and mammalian form," says Klaatsch, "primitive in his extremities and dentition, highly developed merely through the unfolding of his brain." In the great struggle for existence the remote ancestors of our race must therefore have owed their survival to their relatively superior cerebral endowments, having had their high destiny stamped upon them from the very outset. This new theory is an attractive one, conferring upon our species a certain dignity of descent which does not pertain to the older Darwinian view; but whether the arguments with which it is supported will stand the future criticism of experts remains to be seen. They have been urged by some of the most distinguished American and Continental authorities in anthropology, and have recently been popularised in Germany by the attractive pen of Professor Klaatsch of Heidelberg. It has been my endeavour to give a brief exposition of the new theory in the hope that it may stimulate the interest of the Society in one of the most fascinating of all modern problems—the origin and evolution of man.

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XVIII.—*The Archæology of Tentsmuir.*

By Alexander Hutcheson, F.S.A. (Scot.), Broughty Ferry.

(Read 14th March, 1907).

The district of Tentsmuir lies in the extreme north-east of the county of Fife, and may be roughly described as that approximately level sandy tract, mostly muirland, which lies to the eastward of the N.B. Railway line between Tayport and Leuchars, and is bounded on the east by the German Ocean, on the south by the estuary of the River Eden, and on the north by the estuary of the Tay. This district extends about 5 miles in length from north to south, and is about 2½ miles in width from east to west. Originally it was all included in the parish of Leuchars, but in 1606, when the village of East or South Ferry, later called Ferry-port-on-Craig, now Tayport, (for by all these designations has it been successively known), was disjoined from Leuchars and erected into a parish known as Ferry-port-on-craig, a small portion of the Muir along the north was included in the latter. But while for convenience of description I have assumed the line of railway as the western boundary, it is proper to state that at the northern end a portion of the Muir lies to the west of the railway; and to the south, the village of Leuchars, together with a considerable extent of agricultural land, interposes between the Muir proper and the railway line. In olden times, however, the Muir was of much greater extent, and included all the low-lying and flat grounds adjoining, to the west of the rallway, which are now under cultivation. This seems to have been the case down to the beginning of the nineteenth century.

Previous to 1780 the Muir was the site of extensive lochs, or rather shallow pools of water, but about that time the proprietor of Leuchars, Sir David Carnegie, caused a large drain or ditch to be cut to carry off the water. This ditch was 20 feet wide and 14 feet deep, for a considerable distance above the outlet, and 3 miles long, but it proved insufficient for its purpose, and had to be enlarged by his successor, the Hon. Robert Lindsay, to whom he had sold the property, before the western part of the Muir could be cleared of its waters. Bleau's Map of the County, published 1654, shows the extent of some of the larger lochs, but while these were drained by the operations referred to, many smaller pools, which attained to considerable dimensions in the winter, remained undrained down to recent times. I can remember an old man of the name of Terras who, when a boy, used to accompany his father duck-shooting, in a flat-bottomed boat on a "loch," as he called it, which then covered what for many years since have been cultivated fields, but which, strange to say, have within a year or two past been again converted into a loch by the proprietor, and stocked, it is said, with Loch Leven trout. So does history repeat itself.

Tentsmuir, I venture to think, is a part of Fifeshire which is very little known, although replete with interest to the archæologist, the botanist, and zoologist. Many a day have I spent on it without meeting a single human being. But it is not in a day, nor in many days, that the visitor can hope to unravel its secrets. This may help to account for its not being more popular as a resort. One hears of the strange finds occasionally made there, and resolves to spend a day in making a search, but from not knowing where to look, nor anything of the conditions under which the relics were to be looked for, is disappointed in meeting with no reward for his toil and never goes back. To supply in some measure information as to the relics which are to be found on the Muir, and the conditions under which they are to be looked for, is the object of this paper.

But first I must refer to earlier notices of the Muir. The earliest reference I have found to Tentsmuir is a brief notice in Sir Robert Sibbald's History of Fife and Kinross. I quote from the edition published in Cupar, Fife, 1803, which is said to be taken from the edition of 1710. Dealing with Leuchars, Sibbald says, "Two miles eastward unto the ocean, is a plain heath and full of marishes, with a few cottages scattered over them called Tentsmuir, and inhabited by a very rustick sort of people," to which a footnote is appended as follows:—"It has been supposed that these people are the progeny of some ship-wrecked Danes or of the remnant of a defeated army; but it is probable that the rusticity of their manners arose merely from their residence in a desolate wild, secluded from the intercourse and comforts of society." p. 418.

The tradition here mentioned by Sir Robert Sibbald as to the foreign origin of the inhabitants of Tentsmuir had evidently a strong hold on local imagination, for it is met with again and again in literature, and prevails to the present day in the district.

The next reference to Tentsmuir and its antiquities is contained in a letter communicated to the Society of Antiquaries of Scotland on 14th December, 1784, by Dr. William Brown, Professor of Church History in the University of St. Andrews, and published in the Archaeologia Scotica, Vol. II., p. 192, in which he describes a visit he made to the district (in the year 1778 as it would appear) mainly, as he tells, for the purpose of ascertaining whether he could procure any confirmation of a tradition that the Danes, after their defeat at the legendary battle of Luncarty, retreated thither, and made a stand along these muirs against their pursuers, where the trenches and embankments said to have been thrown up by the fugitives were still pointed out by the country people. The Professor's description of the part of the muir visited by him is so interesting that I make no apology for quoting a few sentences from his letter:—

"About a mile beyond the village of Leuchars, and to the eastward of a ditch that runs southward by the back of the house of Earlshall, there is a large tract of level, swampy, sandy ground, lying between the rivers Eden and Tay, which bears the name of Sheuchy Dyke, so called, as I suppose, from its being intersected with ditches called sheuchs, and dykes, or walls, built of earthen sods or turf; of which material all the houses are built, no stone or materials for brick being to be found throughout the whole tract. Within the limits of Sheuchy Dyke, and about a mile to the eastward of the ditch above mentioned, one enters upon the Tents Moors, comprehending a large tract of ground, where the Danes are said to have encamped, and afterwards settled. To the north-west of the Tents Moors, there are six lochs or lakes, very long and very narrow, running parallel to each other, and between these moors and the adjacent country.

"One of these lakes is called the Canal Loch, and seems to have been the longest and deepest of the whole. To the southward of this, and next to the moors, there is another, called the Foremunt Loch; and, pretty near the middle of the line formed by it, a farmstead, built on the south side of it, called the Foremunt also. At the west end of the lochs, but more towards the south than Foremunt, there is another farmstead called Big-end; and more southerly still, and nearly in the centre of Tents Moors, there is a farm-stead called Kingshaldrie, where it is said the tent of the King of the Danes was pitched."

The Professor then tells of interviews he had with old inhabitants of the muirs, whose forefathers and they had lived there during six of seven generations, but he was not successful in eliciting evidence, either from existing surnames or the survival of Danish words, of the truth of the tradition referred to. All, however, were conversant with the tradition, which the Doctor summarizes as follows:—"That the Danes, after their defeat at Luncarty, fled from the field of battle by that range of hills which runs along the southern banks of the Tay; but being hotly pursued and overtaken, many of them were killed near to Naughton, where several tumuli are still to be seen. That after this they took possession of a rising ground to the southward of Sandford (now St. Fort), whence they had a prospect of the mouth of the Tay; and as, upon examination, it has been observed that some stones, raised upon the top of this eminence into a tumulus, have been scorched with fires, it is conjectured that there they lighted fires, as a signal for their shipping. But these not appearing, and they being again attacked by their pursuers, and several of them killed, as indicated by a number of tumuli observable there also, they fled at last to the Tents Moors, and there entrenched themselves, waiting an opportunity to escape out of the country by sea; but no such opportunity offering, upon their submission, they were allowed to remain and settle there."

So far the tradition; the Doctor wisely concludes "that it does not appear probable that all these circumstances, if there had been any foundation for them, could have escaped the notice of all our historians; neither that any enemy, so hotly pursued, and so frequently routed, could have had numbers, utensils or leisure sufficient for throwing up such extensive works as these entrenchments must have been, provided the lochs upon Tents Moors really be entrenchments; or admitting that in all respects they were equal to such an undertaking, I do not see how they could have subsisted on this barren inhospitable spot, during the execution of it, . . . and that if the Danes, who encamped and settled in these Moors, were any part of the remains of Luncarty, they must have been so few in numbers as to have been beneath the public notice or resentment."

In the latter sentence the Professor virtually abandons the theory that the Danes had anything to do with the supposed entrenchments. He makes no mention of any other antiquities. He tells of a belief in fairies among the people on the Muir, and relates his meeting with an old man, an elder of the Kirk, who had never seen a fairy himself, but was well acquainted with a man whose child was carried away by them, and a fairy infant left in its place; that the goodman never recovered his own, but got rid of the fairy child by burning its toes in the fire. And that he was likewise well acquainted with another man whose wife was carried off by the fairies; that frequently she appeared to her husband afterwards, and urged him to win her back from them; but being married to another, he refused. "I had great curiosity," says the Professor, "to know by what means the honest woman was to be won." But the old elder, perhaps out of fear of the minister who was present, did not choose to inform him.

A year or two before the Professor's visit, Dr. Johnson visited Leuchars, and was told by the minister about the supposed colony of Danes in the parish, which the Doctor rather discredited, but it does not appear that anything was done in the way of investigation.

In the account of the parish of Leuchars, written about 1795, by the Rev. Robert Kettle, minister of the parish, and published in the Old Statistical Account of Scotland, we learn more about the Muir; and particularly as to diggings made in it, and as the writer gives his theory of the origin of the Muirs, and attempts to account for the name Tentsmuir, I shall extract this part of the account. It will be observed that he makes no reference to the fugitives from Luncarty, but accounts for the presence of Danish inhabitants in another way. "Sheuchy-dyke, or Tentsmuirs, is a very large flat part of the district on the east, about which many wonderful stories have been told concerning the original inhabitants, and the peculiarity of their manners. After the most laborious enquiry, I find no reason to conclude, according to general report, that this part of the parish was peopled by the crews of a Danish fleet wrecked on the coast. I presume that the greatest part of this flat, moory, benty, sandy ground has been left by the gradual retiring of the sea. The sea has been making a gradual retreat from that part of the parish for many years past, and has left what seem to me strong proofs of having once flowed and ebbed on those grounds. The name seems to me to have been founded in that caution and economy with which men take possession of property they are not sure of holding, for when the people took their station where the sea formerly made her furrowed bed, they must have entertained a fear that she would in some future storm return and occupy those parts she had been accustomed to travel over. They did not at first, therefore, build houses, but erected tents on those parts that swelled a little above the surrounding flats; and to make the situation of their tents more comfortable and dry, they dug a sheugh or ditch, laying the sod, and casting the earth inwards; hence seems to be derived the name Sheughy-dyke. The tent erected in the middle gave rise to the other name Tents Moors. When these moors have been opened by digging, there has been found in several places a greater variety of shells and fish-bones than could be reasonably supposed to fall from the tables of these tent-dwelling inhabitants; and seem to lead the mind to conclude that the aged and storm-struck inhabitants of the ocean being washed to the shore, obtained a grave by the next tide covering them with sand." This may have been the original derivation of the Muir, but certainly not so recently as Mr. Kettle has supposed. This I shall hope to show later on. Mr. Kettle is more practical when he deals with what he calls the "canals." He says "there are four long, broad, beautiful, and almost parallel canals,"—the longest not two miles long. He refers to the tradition that they were formed by the shipwrecked Danes to defend them from the inhabitants of the surrounding country, to which story he gives no credence, since, as he points out, the canals possess no depth of water to render them a defence, and moreover an enemy could have attacked by flank movements, since the canals do not extend to the sea; and on the whole he concludes the canals have been formed by the retiring ocean.

It will be observed that Professor Brown, who visited the ground in 1778, mentions "six lochs or lakes, very long, very narrow, and running parallel to each other," while Rev. Mr. Kettle, in 1795, gives the number as "four"; possibly by his time some of them had been drained, just as since his day all of them have been denuded of their waters.

Standing at the southern end of these alternating ridges and hollows, and casting the eye along their straight outline until they are lost in the distance, it is not wonderful that they were regarded as military works of defence, and it is difficult to look upon them as anything else than a work of art. Rev. Mr. Kettle's theory that they are the product of the retiring ocean at first looks feasible, but has any one anywhere seen parallel and straight ridges of sand of such a breadth as these, and miles in length, thrown up by tidal action? I have seen on the site of the Culbin sands in Morayshire successive parallel ridges of gravel running for long distances among the sand-hills, when the wind has cleared away the sand, such ridges having undoubtedly resulted from tidal action at a period when the waters of the Moray Firth surged and flowed miles inland from its present boundary, but those ridges of gravel differed from the ridges of Tentsmuir in being less regular in height and width than these; but I have never seen such ridges of sand. Perhaps excavation in the embankments of Tentsmuir would set at rest the question of their origin.

I have said Mr. Kettle's theory of their recent origin cannot be entertained. The discovery of implements of flint and bronze, scattered more or less all over the Muir, must be taken to indicate human occupation for a period long before written history.

A word is necessary as to Mr. Kettle's theory that the name Tentsmuir was derived from the earliest occupants, uncertain of possession, and in dread of the return of the sea to submerge the muirs, erecting tents, and to make them more dry and comfortable they dug a sheugh or ditch, laying the sod and casting the earth inwards. Hence he says seems to be derived the name Sheuchy-dyke, while the tents erected in the middle gave rise to the name Tentsmuir. All this is very ingenious, and doubtless the reverend gentleman was thoroughly satisfied that his argument met all the difficulties. But how would it be possible in a climate like ours for people to live in tents, especially on such a bare and exposed place, open to all the winds? That an armed host may at one time have temporarily occupied the Muir is possible, but such occupancy would have been very different from that supposed by Mr. Kettle. At the same time I am inclined to think the name was derived in some other way; perhaps from a Gaelic root, like so many of the place-names on the Muir.

The name Tentsmuir is at least as old as the beginning of the seventeenth century, when it appears in Bleau's maps. But the name Sheughy-dyke does not appear in any map so far as I have seen. It was probably local to the neighbourhood of Leuchars, and derived from the wet ditches or shallow "canals" as Mr. Kettle calls them, which characterised that part of the Muir. We are, however, indebted to Mr. Kettle's argument for a very useful piece of information, namely, that he had observed the circular hollows, running from ten to fifteen feet in diameter, and surrounded by an earthen mound, which are undoubtedly the remains of early dwellings. Probably the presently low earthen mound was originally five or more feet in height, and roofed over by branches of trees, and covered with sods or heather on the plan of the bee-hive huts of the western isles.

This form was probably common in Scotland at one time. These huts may be traced in the like ruinous condition on many of the Highland muirs. The sunken floor was an invariable feature of the huts of the peasantry of Scotland, a feature that may yet be seen in the more primitive dwellings in the Highlands. It added to the warmth of the interior. It reduced the amount of surface exposed to wind pressure, and gave the houses "a guid grip o' the ground." Then the circular house was at once the simplest and strongest form of construction. Doubtless also it was the earliest form, so that in the circular hollows with enclosing mound on Tentsmuir, we are brought, so to speak, face to face with the relics of a very early form of artificial, overground human habitation, and this further disposes of Mr. Kettle's theory of a recent submergence of Tentsmuir by the ocean.

The turf formation of the walls of dwelling-houses prevailed in Scotland until the middle of last century, and while no longer erected of turf, specimens yet remain in out-of-the-way places. A very few years ago quite a number of these turf-built houses could have been seen on the sandy flats at Barry a few miles east from Dundee.

A native of Tentsmuir, who would be born about 1820, told me that in her youth there were many small dwellings on the muirs, and in particular that there were more than forty houses on the ground to the east of Earlshall, where now there is only one house. When asked how she would account for their total disappearance, she replied that the houses were all built of feal or sods and thatched, and when once abandoned, and the doors, windows, and timbers of the roof removed, the materials of the walls were speedily carried away by the strong gales, which, for want of anything to afford shelter, blow with terrific force on the Muir. "In my father's house," she said, "there was not a stone but the hearth-stone, and very few of the houses had even that, for the hearths were just laid with chuckie-stones brought from the beach."

There is a tradition that a church stood at one time on the Muir, at a place known at the present day as Kirkhill, and that this church, like the houses, was built of feals and thatched; but I have not been able to find any record of a church there. There may, however, have been in pre-Reformation times more than one church on the muirs, for a knoll to the north-east of Earlshall bears a name which is distinctly gaelic, that of "Tammie Knowe." This is evidently Tom-a-naomh (pronounced Tom-a-nuv), the holy or consecrated hillock. Many of the place-names on the Muir, as I have already remarked, are of Gaelic origin, such as Kinshaldy, Fetters, Shanwell, Reres, Garpit, Culbaikie, etc.

I forbear to follow up this line of investigation, tempting as it is; Gaelic phraseology is plastic enough to yield any desired result to ingenuity of suggestion, and only those who are Gaelic scholars can deal with such questions.

The sandy surface of Tentsmuir, where not under cultivation, is covered by a vegetable coating of heath and bent grass, broken in some parts into hollows, where the sand is blown out in stormy weather. In these hollows, and chiefly after a gale of wind, small articles of antiquarian interest are occasionally to be found; although they may also be picked up in certain of the cultivated fields in dry weather, and after a gale has blown away the sand and left the heavier particles, such as stones, cinders from the manure, etc., and sometimes amongst these a specimen of the handiwork of a long-past age.

The articles of antiquarian interest here alluded to are fragments of pottery of the Bronze Age, and of much more recent date; implements of flint, and other relics of the Bronze Age, such as whetstones, beads, bronze buckles, and needles made hollow by rolling up a thin sheet of bronze to the required form; hammer-stones with abraded ends of a uniform type, showing that they have been used in some special art that required repeated strokes with the stone delivered in the same direction and at a uniform angle; brass pins, having heads of twisted wire; spinning whorls or charm stones, iron fish-hooks found at about a mile from the coast; the small pipe-heads of the class known as "Picts' Pipes," but known to be much more recent than the Picts; silver and copper coins, mostly Scottish, from Robert Bruce downwards to Charles II.; with many articles of more modern origin, such as buttons, etc.

When the drains or ditches were being dug to carry off the water from the then numerous pools as formerly mentioned, there were found many fragments of the horns of the extinct red deer of Scotland *(Cervus elephas)*, and in one instance the skeleton of a boar, having long curving tusks like the wild boar of India.

Numerous collections of shells have also been cut through, as mentioned by Rev. Mr. Kettle. They are, however, close to the surface, and not, as he seems to say, at a depth below it. There are also to be seen on the Muir many shell-mounds, varying in height from a few inches to eight or nine feet. These demand more than a passing notice.

I shall deal with these first, and then pass on to describe briefly one or two of the antique articles mentioned above which seem to require more than a passing reference.

In regard, then, to the shell-mounds, it is necessary to mention that no part of the muirs rises to more than 25 feet above high water of ordinary spring tides, and even that height is only reached in the case of some of the sand-hills, and in the highest of the shell-mounds. I have used the term shell-mounds, although they are commonly spoken of as kitchen middens, and they are so named on the maps of the Ordnance Survey. They are not, however, characterised by the usual contents of the kitchen middens of Denmark, which contain, along with shells, many implements of stone and bone, together with the bones of animals, birds and fishes, fragments of deer horn, and pieces of burnt wood and charcoal giving evidences of fire, whereas in the shell-mounds of Tentsmuir there is nothing but shells mixed with sand. Even of the later pottery, which is so common on the muirs, there is not a scrap. Pottery, however, is not a usual relic in the true kitchen midden. What, then, has been the origin of the shell-mounds of Tentsmuir? Some of them are at a great distance from the shore. The shells are of edible kinds, the cockle, mussel and whelk. A remarkable feature is that the shells are all of comparatively small dimensions; whereas one would have expected that the largest specimens would have been collected, as has been found to be the case in the Danish kitchen middens. Another equally noticeable difference is that the shells seem all to be on the top of the mound. On digging downwards, one gets beyond the shells into pure sand. It is the same in the smaller shell-mounds away in the heart of the muirs. These, however, are rather shell patches than mounds.

One sees a whitish patch among the heather. On going up to examine it, it is found to be a thin layer of shells, mussel and whelk mostly. And here also, in digging downwards, the pure sand is found, where there are no shells. It would seem as if all these collections of shells had once lain at a considerably greater elevation than at present,—that as in the course of years the sand was blown away, the shells being heavier would drop downwards, but in the process the shells would offer an obstacle to the denuding power of the wind, and so the mounds of sand would come to be formed, for the so-called shell-mounds are really sand-mounds with a collection of shells on the top. This, however, leaves us still in the dark as to why these shells are in groups, and if to be regarded as of human origin, why there are no relics of man among them, no flints, no bones, no pottery.

It has been suggested that they may be the work of sea-birds, or perhaps of crows or ravens, which, in bearing the shells inland to break them up if that were possible, and alighting many times on the same spot, came in the course of time, it might be of centuries, to form these accumulations of shells. Much might be said both for and against this theory, but this would take up too much time on the present occasion, and I have not been able to arrive at any satisfactory solution of the problem. It ought to be mentioned that the largest and most important group of these mounds, some ten or eleven in number, are situated not far from the mouth of the Eden.

I now proceed to notice the pottery. It is of two kinds, first, the prehistoric or urn type; and second, what for want of a better name I shall call the late medieval or jug type. Of the first very few fragments are to be found. It is usually in very small pieces, and is about half an inch in thickness. It is coarse in grain, and bears on the outer surface the "herring-bone" and "twisted-cord" impressions characteristic of this type. I have found fragments of this pottery in patches of dark earth that suggested an ancient burial-place and a cremated burial. Doubtless the absence of stones with which a cist might be formed had induced urn-burial in the sand, and doubtless also in the course of ages the urn, soaked with water in wet weather, and parched and cracked in dry weather, at last collapsed, leavlng only a few fragments of the harder-baked parts of the urn, and the dark stratum of sandy earth mixed with minute particles of charcoal to show that a burial by cremation had there been consummated untold ages ago. Dr. Blair, Tayport, was fortunate on one occasion in recovering all the parts of an urn of the "drinking-cup" form, a thinner and more artistic variety, which he reconstructed. It was exhibited to the Society of Antiquaries of Scotland in 1883, and the urn is now in the Dundee Museum. The urn is five inches in height, of Bronze Age type, and of special interest, inasmuch as it exhibits a peculiarity which renders it unique. This is the appearance of having been impressed externally in the soft clay with a twisted cord wound spirally around the urn from the lip to the foot. This has been demonstrated by winding a fine cord around the vessel following the markings. No other instance of a spirally ornamented urn has been recorded.

The other class of pottery found on the muirs is of a very different type and widely different period. It possesses, however, well marked features, which serve to distinguish it, even to the smallest fragment. It is to be found all over the Muir, lying on the surface or in blown out hollows, or in rabbit-holes; everywhere that the surface is broken it is visible, but always in fragments an inch or two across. It has been turned on the wheel, but bears the marks of the hands of the potter. Especially is this latter peculiarity visible around the lip, which is frequently ornamented wlth a sort of "frilling" produced by the thumb and finger working in concert in something like the same way as bakers used to fashion the edges of their cakes of shortbread before the introduction of moulds, and as is yet more roughly exhibited round the edges of oaten cakes in those households where this almost forgotten art is still practised by the careful housewife. Some of these jars or jugs had been furnished with handles like the ordinary water-jug; and the handles also show at the ends the impress of the potter's finger and thumb.

Some of the jugs have been glazed on the outside with a greenish yellow glaze, very thin and imperfectly put on. The pottery itself, which averages one quarter of an inch in thickness, is of a light creamy colour, with dark grey granulations. Some of the vessels had been of considerable size, pieces of the lips having been found indicating a diameter of 9 inches, but I have as yet found no means of determining their height. It is very strange, when one thinks of the multitude of fragments, that no completely entire specimen, so far as I have been able to discover, has yet been found, or even such a fragment as would determine depth. Dr. Blair was just as anxious as I was to secure if possible a whole jar, and enlisted in the search all those dwellers on the Muir whose occupation led them to be much abroad among the sand hills, so that a watch might be kept for any appearance of a whole specimen or even of a larger fragment than usual. The Doctor's experience with one of these individuals may here be related, as it may help to enliven a dry subject, and, moreover, it illustrates the too common characteristics of his class, who when they find any valuable curiosity usually break it to find out of what it is made. Dr. Blair, interviewing this individual, asked, "Did you ever see a whole jar anywhere on the links?" and received the following reply, "Weel, Doctor, I canna' say I ever saw a hale ane. I've whiles seen, whan gaun through amo' th' bunkers efter a gel o' wind, I 've seen me noticin' ane o' thae jougs stickin' oot o' th' sand, an' I've taen'd a bit bash wi' my spade as I gaed by, but I cudna say 'at I ever saw a hale ane. No, I never saw a hale ane, Doctor!" It is almost needless to say that this reply carried with it conviction.

The Doctor could only inwardly groan, and outwardly implore this worthy if in future he should adventure upon any other such specimen, to refrain if possible from "bashing" it with his spade, at the same time promising as an encouragement a substantial reward for his forbearance, but sad to say without any satisfactory result. Perhaps our friend found his predilection for testing the strength of an earthenware jar with his spade too strong for him to resist. When such a spirit is abroad among the "rustick" inhabitants on the Muir, it is no wonder that the pottery has come down to us in fragments.

It is difficult to assign a period for this class of pottery, as it displays no distinctive features. I have called it late medieval, and probably we should not be far from the date if we attribute it to the sixteenth century, some of it earlier and some later. It probably was made in Holland; there was much intercourse between Scotland and the Low Countries during the period named, and many vessels crossed the North Sea, only to be cast away on reaching the rocky and shoal-encircled coast of Scotland. Not a few of them would come to grief on the sandy shallows which fence Tentsmuir from the ocean; and doubtless many a valuable cargo intended for other hands would be gathered in and stored in all the nooks and hiding-places in and about the clay biggins on the Muir, the more by token that the Muir-dwellers were evil spoken of as wreckers, luring the storm-tost and belated mariner to his doom. In this way, we cannot doubt, the presence of much of this pottery from the Low Countries may be accounted for.

The flint implements are found all over the Muir. They are of usual type, arrow-heads, scrapers, saws and flakes, worked and unworked. They are finely polished by the sand blowing over them for centuries.

It is different with the bronzes, which are only to be found in the sand hollows. They are all excessively fragile, and will scarcely bear handling. The searcher had therefore better provide himself with a few small boxes of stout make to resist the effect of pressure in the pocket, tin match-boxes or a nest of the ordinary wood boxes in use by druggists are suitable, and with some cotton wadding, for the safe conveyance of articles of bronze, coins, pins, or other fragile objects which may be met with, otherwise if such are instead placed in vest pocket or purse, all that will be found on reaching home will probably be a little greenish dust, to represent what may have been a relic of extreme rarity. Allied to the bronzes, as being also of the Bronze Age, are those exceedingly rare small whetstones of which several have been found on the Muir. (See *Proc. Soc. of Antiq.*, Vol. XXIV., p. 382).

I have already referred to the smooth rounded pebbles with abraded ends, which I have termed hammer-stones, to distinguish them from stone-hammers, a stone implement shaped like a hammer, and with a hole through it for a handle. No example of the latter, so far as I am aware, has ever been found here, whereas hammer-stones are numerous. The stone implement known as a celt is also almost unknown on the Muir, only one, so far as I know, having been discovered, and as it was found in a field, it may have been imported.

Much more might have been said about these and other "finds" to be made on the muirs. I have only hinted at the coins, the brass pins, the pipe-heads, etc. From a consideration of these many interesting particulars might be gleaned, but I feel I have said enough to give an idea of what may be looked for, and to interest those who may meditate a visit to the district of Tentsmuir. For it must not be forgotten that it is a district of considerable extent, It cannot be adequately inspected in a day. I have known some men who with much show of enthusiasm rushed off after breakfast to "do" Tentsmuir, and were home to a mid-day dinner. That is not the way to do justice to it. Make an early start; take a good lunch in your pocket to which you can return again and again; it is a hungry place, and there are no restaurants. Choose a good day if you can, for it is not a nice place to be caught on in a thunder storm, or in an easterly haar, when you do not possess the ghost of an idea as to the way home. A waterproof coat or an umbrella is essential, better if you take both.

Then too much must not be expected from one visit. I have spent many a day in traversing the Muir, and met with no reward in the shape of relics save a pocketful of the ever prevalent pottery which I picked up more from custom than from any new features it presented. I can, however, promise those, who may visit the Muir, that should they fail to enrich their collections by specimens of its antique treasures, they at least may see its shell-mounds, peradventure they may stumble, metaphorically I hope, upon some remains of the circular houses Mr. Kettle describes. They may perambulate the long embankments once divided by canals, and meditate upon the possibility of these being really the remains of Danish or other military entrenchments; they may walk over variegated hillocks of sweet-scented thyme, whence they may see, if not also hear, the foam-crested billows as they break along the shore, and listen to the cry of the sea-birds as they flash seaward in the sunlight. All this they may accomplish, and return refreshed and rejuvenated in spirit by communion with nature in one of her most secluded haunts.

NOTE UPON THE GROUP OF KITCHEN-MIDDENS ON TENTS MUIR, NEAR GUARDBRIDGE.

The following notes, kindly communicated by Mr. S. J. Shand, will be read with interest as a supplement to the foregoing paper:—

These shell-mounds lie about 2 miles E.N.E. from the Guardbridge Paper Works, upon the open moor some 500 yards above high-water mark. They are eleven in number, arranged along two parallel lines which run roughly N.E. and S.W.; the distance between the first and last mounds is about 200 yards. Several of the mounds appear to have been largely levelled down by weather, by burrowing rabbits, or by previous excavators. One of them, No. 5 on the plan, has been so completely removed that it is impossible to say with certainty that a mound was ever there. The best preserved mounds (Nos. 2, 6, and 7 on plan) are 5 to 6 feet in height, and cover areas of about 20 by 25 yards; they are roughly circular in section, or elongated from E. to W. All are sparingly covered with a thin layer of turf, the heather which covers the moor stopping short at the foot of the mounds. Remarkable is the appearance on some of the mounds of a quantity of nettles, which are not noticed elsewhere. This perhaps points to recent turning of the soil on the mounds in question.

The mounds consist essentially of shells and sand: but in only three of them (Nos. 2, 7, 8) is any regular arrangement of these materials observable. Upon all the others the shells constitute an irregular top-dressing of a foot or less in thickness, the base of the mound, down to the level of the moor, being simply sand. In No. 2, however, which appears to have been little disturbed by burrows or excavations, a good stratification was recognisable, the order of succession of the layers being as follows:—

(1) Top-dressing of turf and shelly sand.
(2) Thick bed of cockles.
(3) Thin bed of mussels.
(4) Second bed of cockles.
(5) Second mussel bed.

Total thickness of these beds, 2 to 3 feet, the rest of the mound down to the level of the moor being sand. In the upper layers we found a fair quantity of bones and fragments of pottery, with a very little burnt wood. Mound No. 7 showed a similar succession of cockles and mussels, but only one bed of each, the total thickness being 1 to 2 feet, and resting as before upon pure sand. In both these cases the east side or end of the mound contains few shells, and may represent a later deposit of sand in the lee of the shell mound.

Fragments of rough pottery occur in almost all the mounds. Bones were found by us only in No. 2. No axe-heads or implements of any kind other than the above were discovered.

The shells are similar in all the mounds, *Cardium edule* and *Mytilus edulis* predominating over *Buccinum undatum*. *Solen siliqua*, *Purpura lapillus*, and *Lutraria elliptica* are of the utmost rarity, and appear to complete the list.

Among the bones were portions of the jaw and rib of an ox, the forefoot of a horse, the radius of a sheep or pig, and various fragments from smaller animals.

The pottery is only fragmental. It is very coarse, and devoid of ornamentation; some pieces are glazed interiorly.

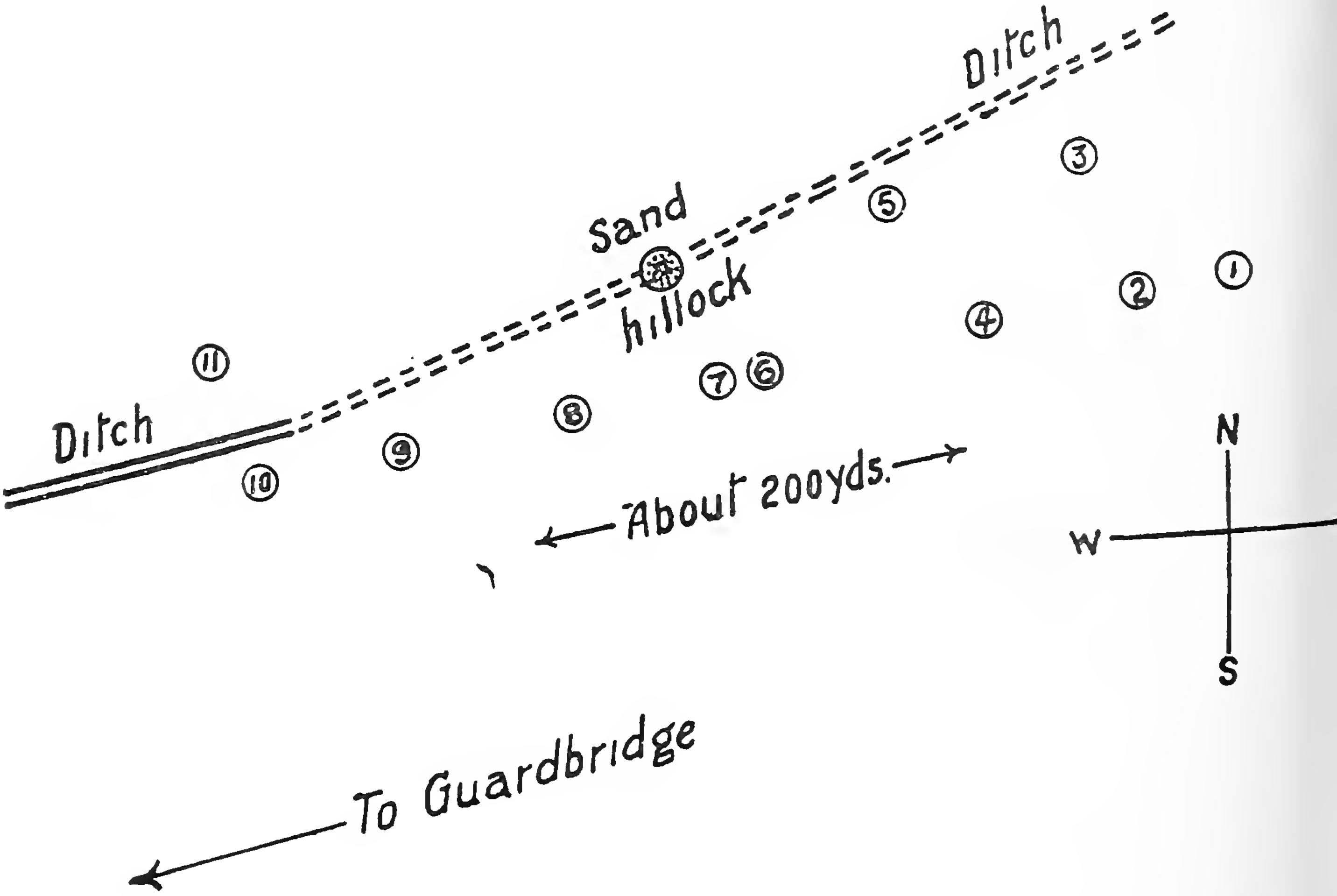
Small pieces of burnt wood or bone have been found.

DESCRIPTION OF THE INDIVIDUAL MOUNDS.

1. Low and small, with only thin top-dressing of shells.
2. Has already been described. Bones and pottery found here. Height, 5 feet.
3. As No. 1.
4. Sand in middle; thin coating of shells at either end. Pottery found here.
5. As No. 1. Almost entirely removed.
6. Shell layer, 1 foot thick. Pottery found here. Height, 6 feet.
7. Mussels below cockles. Total thickness, 1 to 2 feet, upon sand. Pottery. Height, 6 feet.
8. Interstratified shells and sand.
9. As No. 1. Height, 5 feet.
10. As No. 1. Height, 4 feet.
11. As No. 1.

The above is the result of one day's digging by the present writer and Mr. David Rollo of Newport, in the autumn of 1906. The articles found, together with specimens of the shells, have been handed over to the Museum.

S. J. Shand.



XIX.—*The Microscopic Structure of some Perthshire Igneous Rocks.*

By GEORGE F. BATES, B.A., B.Sc.

(Read 11th April, 1907.)

PART II.

In the first (introductory) part of this paper the rocks dealt with were the youngest of the igneous rocks which occur in Perthshire. Their mode of occurrence, as dykes cutting through all other rocks, and often standing up in vertical wall-like masses, clearly distinguish them as something different from the general mass of the rocks of the district. As already mentioned in Part I., it has been shown that these dykes are of Tertiary Age, and connected with the outbursts of volcanic activity which produced the lava plateaux of the Western Islands and of North-East Ireland.

The rocks to be considered in this part of the paper are almost inconceivably older than the rocks constituting the dykes. Perhaps the best way of realising the vast interval is to try to bear in mind that by far the greater part of the rocks out of which England is built—from the white cliffs of Dover to the Carboniferous limestone of the north—are of ages intermediate between our dykes and the rocks which they traverse.

All the rocks in the immediate neighbourhood of Perth are of Old Red Sandstone Age. Even to that much talked-of individual, "the man in the street," the name "Old Red Sandstone" conjures up memories of Hugh Miller and of uncouth forms of armoured fishes, but it is not with sandstone of any kind that we are concerned just now. For, during this same geological period, what is now Central Scotland, or at all events Southern Perthshire and its neighbourhood, was the scene of such volcanic activity as has perhaps not very often been paralleled. The area was then occupied by a sea, nowhere probably of very great depth, and cut off more or less completely from the main body of the ocean as it then existed. This inland sea, extending in a N.E. and S.W. direction from the East of Scotland into North-Eastern Ireland, has been named by Geikie, Lake Caledonia. Similar inland seas occupied what is now North-Eastern Scotland, Orkney, etc., the Lorne district, and the region of the Eastern Cheviots. To these seas the names Lake Orcadie, Lake Lorne, and Lake Cheviot respectively are given, the latter being possibly connected with Lake Caledonia by a northerly extension. Far beyond the limits of Scotland, Lake Munster occupied what is now South-Western Ireland, and the Welsh lake South-Eastern Wales and the neighbouring parts of England. I mention these particulars to show that the conditions which prevailed in our immediate neighbourhood were by no means exceptional, but occurred elsewhere during the same geological epoch. In the waters of Lake Caledonia were deposited the materials which now form the sandstone and conglomerates which cover so large an area in Perthshire and elsewhere.

But the quiet deposition of sedimentary material was much interrupted by the volcanic activity already referred to, more particularly in the region now occupied by the Ochils and Sidlaws. From the submarine volcanoes were poured out, in successive eruptions, vast sheets of lavas and accompanying tuffs, until volcanic rocks had accumulated to a depth of not less than 6,500 feet in the Western Ochils. There is plenty of evidence to show that the volcanic action really was submarine. Beds of lava are found intermingled with sandstone and conglomerate, and pebbles of the former are found in the latter rocks, often constituting a considerable proportion of them, in a way that can be explained only by supposing the eruption of the lava to have taken place under the sea, and to have been exposed after solidification to the action of comparatively shallow water, for conglomerates and sandstones are not formed as a rule in deep water.

The lava, volcanic dust, etc., as erupted, would spread out in beds along the floor of the sea in an approximately horizontal direction. It is possible that they were buried, at all events in part, by deposits of a later geological age, for we have near Dron a small area occupied by Carboniferous strata, and this may be a remnant of a much larger deposit, covering perhaps the whole of the Old Red Sandstone area. Anyhow, if such a covering of later rocks did exist, it has long since been denuded away, with the exception of the small portion referred to, and along with the covering an enormous amount of the Old Red strata themselves. But not only has there been excessive denudations, which could of course only take place after elevation into a land surface, but the rocks have been folded into a huge arch, of which the crest runs in a general N.E. and S.W. direction, and after all their vicissitudes now form the hills with which we are familiar as the Ochils and Sidlaws. In this connection, the view from the top of Moncreiffe Hill offers one or two points of interest. Looking down the estuary of the Tay, it is seen that the hills on both sides present steep slopes towards, and gentler slopes away from, the river. The gentler slopes coincide generally with the dip of the rocks away from the crest of the arch; the steep slopes, or escarpments, are the results of denudation which has taken place along the crest. It is interesting to note that the valley now occupies what was the highest ground. This phenomenon is by no means unique, but it would be out of place here to discuss the origin of it.*

The volcanic rocks formed by the consolidation of the lavas, etc., referred to above, are almost everywhere in evidence in the south of Perthshire. They are exposed by denudation in scores of glens and valleys, and they have been, and are still, extensively quarried for road metal. The weathered surfaces are, for the most part, singularly unpromising and unattractive, and as the changes due to weathering penetrate to considerable depths, it is only in quarries that satisfactory specimens can be obtained. Reference to a geological map will show that the name "porphyrite" is applied to all those rocks which are regarded as solidified lavas. This might seem to imply a uniformity which does not exist in actual fact, for the rocks vary enormously in both colour and texture; in colour they are usually black, purple, or chocolate-brown; in texture they range from close-grained varieties, in which no crystalline forms can be seen without magnification, to those which exhibit quite large and conspicuous crystals set in a more compact base, while not unfrequently the rock is amygdaloidal, that is, contains numerous rounded or almond-shaped cavities, filled more or less completely with minerals, often of a very different type from those occurring in the mass of the rock. These cavities were formed during or before consolidation of the rock by the expansion, as pressure was relieved on eruption, of steam or gas bubbles imprisoned in the lava, and later the cavity was filled with mineral matter by the infiltration of water. Where the amygdaloidal rock has been exposed to weathering agencies, the amydules are dissolved out, and the rock assumes a vesicular or spongy texture.

The rocks are usually traversed by numerous joints, often extremly irregular, but in a general way at right angles to the greater surface of the bed. Frequently the surfaces of the rock adjacent to the joints are covered with dark green material of a chloritic nature, derived from the more highly ferruginous minerals in the mass of the rock. The joints presenting this appearance are often said to be "slickensided," but in my opinion this is a somewhat unwarranted extension of the real meaning of that term. The regular columnar jointing of dolerite and basalt is usually conspicuous by its absence. It is interesting on this point to compare the internal structure of the dolerite dyke with that of the "porphyrite" in Corsiehill Quarry, where both are well exposed side by side. The fracture of porphyrite is irregular and splintery, with a slight tendency towards conchoidal in the finer-grained varieties.

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* A full and most interesting account of the volcanic activity of the Old Red Sandstone period may be found in Geikie's "Ancient Volcanoes of Great Britain." It is written with the lucidity and "readableness" which characterise the whole of Geikie's writings.

From these preliminary remarks we may now pass to the special subject in hand, the microscopic structure of the rocks. We shall begin close to home, and study first a section of the Corsiehill rock, not, of course, the dolerite of the dyke which was considered in Part I. of my paper, but the rock through which the dyke was intruded, and which is now being worked to the right of the dyke. (Plates 40 and 41.)

We observe most conspicuously abundant large crystals with long narrow outlines. From the facts given in Part I. these will be recognised as porphyritic crystals or phenocrysts—crystals, that is, formed at an early stage in the consolidation of the rock, perhaps even before eruption. They are not quite clear, but contain strings and patches of darker material, some of which may be due to alteration after consolidation, others to portions of the magma being included during formation. This point will be referred to again, where it can be demonstrated more clearly in another rock. The shapes, and more especially the optical properties of these crystals, show them to be plagioclase felspars, probably labradorite or andesine, and further reference will be made to them later.

Then we have a number of fairly large patches, some with more or less definite crystallographic outlines, which come out almost black in the photograph. These are really green to brown, or greenish brown in the actual section; they are pyroxene crystals, and, like the felspars, will be considered in further detail presently. Lastly, we note the ground mass in which these larger crystals are embedded, and which consists of much smaller materials than those already noticed, but of the same general type. This is seen more clearly when the ground mass is viewed with a higher magnification, when we recognise not only the felspars and pyroxenes, but iron ores (chiefly magnetite) and irregular green chloritic masses, which are alteration products derived from pyroxene. It may be of interest at this point to consider the mode of formation of such a rock. It is a well-known fact that large crystals require both time and space for their formation, so it would appear that the large crystals observed in this rock must have been formed at an early stage in its history, probably while the general mass of the rock was still fluid. We can imagine a mass of lava existing in a subterranean reservoir before eruption, cooling to such an extent that crystallisation of certain minerals might begin. The cooling and consequent crystallisation would take place with extreme slowness, and the latter process would commence at points comparatively far apart, so that the resulting crystals would tend to be large and perfect. But let us suppose that, before crystallisation has proceeded very far, eruption takes place. The crystals already formed would be carried out by the still fluid portions of the lava, and as cooling would now be comparatively rapid, the latter would solidify between and around the already formed crystals as a finely crystalline or even glassy ground mass, because if a lava solidifies quickly enough a glass is often formed through lack of time to form crystals. The resulting rock would then be like our type; it would consist of comparatively larger crystals embedded in a finer grained ground mass. Such rocks are said to have a "porphyritic" structure, and the larger crystals are termed the porphyritic constituents or phenocrysts.

We may now proceed to discuss the constituents of the rock in greater detail. We select a well-developed felspar crystal and examine it with a higher magnification than before, and are at once struck by the fact that it is not a section of a perfectly clean and transparent mineral that we are looking at. We see numerous specks and granules, usually of a greenish or brownish colour, some rounded, and some angular in outline. Some of these show a tendency to lie along the cleavage planes of the crystal, and are probably products of the alteration of the felspar, while others lie in the body of the crystal, and represent portions of the original magma taken up by and enclosed in the crystal at the time of formation. With a sufficiently high power these latter can be seen to be composed of excessively small rudimentary crystals; they solidified in all probability in the first instance as glass, which gradually became devitrified, *i.e.*, lost its glassy character and became imperfectly crystalline.

We next insert the polarising apparatus in its place, and immediately our crystal shines out with new beauties, for it is now seen to be composed of fine layers, which are coloured alternately with complementary tints. No photograph can do justice to this object, but an attempt has been made in the case of a similar crystal from another rock. (Plate 42.) This appearance is due to what is called twinning; the crystal is really compound, being built up of layers, each of which is in a position reversed as regards those on either side of it. These alternating layers behave in different manners towards the polarised light: hence the alternating colours. When twinning is repeated over and over again, as here, it is known as multiple twinning, and is very characteristic of plagioclase felspar.

We now bring one edge or cleavage line of our crystal parallel to one of the cross wires in the eyepiece of the microscope, which wires are parallel to the axes of the two prisms composing the polarising apparatus, and rotate the stage till our crystal appears at its darkest. It is then said to be in the position of extinction, and the angle through which the stage is rotated is the angle of extinction. The angle of extinction, measured with all due precautions, is characteristic for any given mineral, and when once known can be used to identify the minerals seen in any rock section, or for confirming the identification made in other ways. The extinction angle of our present felspar shows it to be one of the plagioclase felspars, probably andesine or labradorite.

We may now turn our attention to the second of the porphyritic crystals referred to above. One of my sections shows exceptionally good examples of these, which have apparently undergone, for some reason or other, less alteration than most of the crystals of this kind, and are also larger. (Plate 43.) In the actual section the crystals are of a greenish brown colour. From the shape of the crystals, the direction of the cleavage cracks, and the optical properties, they may be safely put down as rhombic pyroxenes. The pyroxenes are a group of silicates of iron and magnesia, and are of two kinds, according to the system in which they crystallise—monoclinic and rhombic. Of the rhombic pyroxenes the best known are enstatite, bronzite, and hypersthene, and the crystals in question are probably hypersthene. Other crystals of this mineral show alteration into a fibrous material known as bastite. Of the monoclinic pyroxenes the commonest is augite, which will be remembered as an abundant constituent of the dolerites treated in Part I. of this paper. Now, in rocks of the class we are considering, a monoclinic pyroxene nearly always accompanies the rhombic, and so although there is apparently no recognisable augite in our section, the abundant chloritic material present in the rock has been probably formed by the alteration of the original augite.

It will be observed that near one end of the largest pyroxene crystal shown in Plate 43, what looks like corrosion of the crystal has occurred, part of it being as it were eaten away, and the cavity filled up with new material. This corrosion of phenocrysts, especially of ferro-magnesian minerals, is very common, and is due to partial re-dissolving of the crystal on eruption of the lava, relief of pressure having the same effect as rise of temperature.

We may now examine the smaller opaque masses in our section. These, when viewed by reflected light, are seen to be both black and brown, the former being magnetite and the latter haematite. Some of the magnetite shows more or less distinct crystallographic outlines, and is to all appearance an original constituent of the rock; while in other cases its intimate association with the remains of other minerals shows that it has been derived from them by alteration. The haematite has been derived from the magnetite and other minerals rich in iron by oxidation, and is not likely to have been an original constituent of the rock.

Before attempting to name the rock, I should like to refer to another constituent which is by no means abundant. This constituent is altered olivine, and, as far as my sections show, it is better developed in a neighbouring rock, and will be referred to more fully later. The crystals are of a rich reddish brown colour, with greenish lines strung across them.

Now, having got the "thing," let us try to work out its name. Reference should here be made to the Table of Igneous Rocks given in Part I., and it will be seen that we are dealing with a volcanic rock of intermediate type, and as plagioclase is the dominant felspar, it must be an andesite. But the term andesite is hardly precise enough of itself; the ferro-magnesian constituent may be utilised to give more precision. We have seen that the rock contains a rhombic pyroxene and probably the alteration product of a monoclinic pyroxene, both of these being ferro-magnesian silicates, *i.e.*, silicates of iron and magnesia. We may therefore define our rock as a pyroxene andesite, and thus distinguish it from andesites in which the ferro-magnesian constituent is hornblende or biotite.

The presence of olivine is so noteworthy that we might also term the rock an olivine andesite; and taking into account the alteration of the olivine into iddingsite (see below), we may give to the rock the name "iddingsitic olivine andesite."

The relative abundance of magnetite, and the presence of altered olivine, show that our rock approaches the basic type very closely, and is indeed not very far removed from basalt. If we look at the maps of the Geological Survey we shall find it named a porphyrite. This term, however, is vaguely used, for rocks of diversified types are covered by it, and if it has any precise signification at all it means an altered andesite—one, that is, in which the constituent minerals have been altered by various agencies from their original form. As this is the case usually with rocks of more than Tertiary age, porphyrite has come to mean pre-Tertiary andesite. There is, however, no real necessity for the term, and as necessary terms are already sufficiently numerous, the term porphyrite may be conveniently dropped or merely used as a general field term.

Before we leave Corsiehill there are one or two other items that should be referred to.

It was mentioned above that andesite is frequently amygdaloidal. A section through an amygdule, magnified ten diameters, is shown in the accompanying photograph. (Plate 44). The rounded form is well seen; the contained mineral appears to be mainly steatite, but a greenish yellow material, probably of a chloritic nature, together with a few granules of magnetite, appear near the centre. A detailed study of the minerals found in amygdules would require a paper to itself, but agates, quartz, calcite, and various forms of zeolites may be mentioned as of common occurrence.

An examination of the rock exposed in Corsiehill Quarry will show a comparatively soft grey rock, in intimate association with the andesite, especially with its amygdaloidal portions. Microscopic examination shows it to be composed almost entirely of very fine irregular particles, some of which can be recognised as fragments of minerals similar to those found in the andesite. There can be little doubt that we have here a consolidated volcanic dust. Extremely fine dust, or ash, as it is frequently termed, is commonly erupted from volcanoes, especially in the earlier phases of activity, and is usually regarded as having been formed by violent subterranean explosions—explosions sufficiently powerful to blow into fragments any material lying between the actual seat of the explosion and the outlet above it. Two notable instances of recent date may be mentioned in which inconceivable quantities of dust were erupted—the eruption of La Soufrière, St. Vincent, in May, 1902, and that of Vesuvius in April, 1906; but perhaps the most remarkable case is the eruption of Krakatoa, which occurred in 1883. In this case an island, roughly four miles long and two miles broad, and including a mountain over 2,500 feet high, was blown practically to pieces, and some of the dust produced fell over 300 miles away, while the finer particles remained suspended in the upper regions of the atmosphere for months afterwards, giving rise to those gorgeous sunsets which many of us can remember so well.

Now if such a dust eruption took place under water, the material would be spread out by the action of the sea, and tend to fill up inequalities of the surface at the bottom in a somewhat stratified form, and it is thus that we find it now at Corsiehill, intermingled with the andesites. The rock is known as "aqueo-igneous tuff," a term which implies that, although of igneous origin, the materials have been arranged by the action of water. The occurrence in connection with the more amygdaloidal portions of the andesite is readily explained. The surface portions of a lava flow would have a greater tendency to become vesicular, and subsequently amygdaloidal, than the inner portions, and the irregularities of the surface would then be filled up by the dust erupted on a renewal of activity, and then the whole would be buried by later lava flows. (Plate 45.)

It may be of interest to pause at this point and try to realise some of the changes which have occurred in our neighbourhood. As far back as we can go in the depths of time we find the waters of an inland sea, not only covering the site ot the Fair City, but extending for many a mile in every direction. Like modern seas, it acts as a denuding agent on its shores, and is a receptacle for materials brought down by rivers. All these materials are distributed by the waves so as to form vast beds of sand and gravel, which are now sandstone and conglomerate. But over and over again the bottom of the sea is shaken by the forces imprisoned below; volcanic eruptions take place, sheet after sheet of lava is spread out, intermingled with fragmentary materials and fine dust. But as time passes the volcanic activity exhausts itself; sediments, lavas, and tuffs are buried under, it may be, hundreds of feet of other rocks. Eventually elevation takes the place of depression; slowly the solid earth appears above the waves; atmospheric agencies come into play; vast masses of rock are removed; and the igneous beds finally stand out as hills overlooking the plains, which are underlain by the softer sandstones and conglomerates; river valleys are carved out, and the landscape slowly and imperceptibly acquires the features with which we are so familiar to-day.

The next rock which I have examined for the purpose of this paper is that exposed in Muirhall Quarry, which is situated some two miles north-east from Corsiehill, not far from Muirhall Farm. This rock is of the same general type as that at Corsiehill, but is on the whole fresher, and offers several points of interest. We may note first two items already referred to in dealing with the Corsiehill rock. One of these is the nature of the large felspar phenocrysts (Plate 42). As this has been fully discussed above, it need not be more than just mentioned here. The second is the presence of olivine. One of my sections of Muirhall rock shows an exceptionally good crystal of this mineral, a photograph of which is shown in Plate 46. This photograph gives a very poor idea of the original, owing to its non-actinic colours. Its interest, however, is considerable. Olivine is a mineral which is rarely found fresh, as it is so liable to alteration, and this is particularly the case in ancient rocks, such as we are discussing. Alteration usually proceeds along the cleavage cracks, which are somewhat irregularly developed, and results in the formation of strings of serpentine, which enclose kernels of unaltered olivine, and may extend until the whole mineral is altered. In some cases, however, where the olivine is rich in iron, alteration produces a large amount of iron oxides, and of a rich brown secondary mineral to which the name iddingsite has been applied. This is what has taken place in our crystal. The dark lines and masses of the photograph are in the original of a rich brown colour, frosted with gleaming specks of silvery black magnetite. The clearer portions are less altered and of a greenish colour, and retain some of the characters of the original olivine, most conspicuous being the roughened appearance of the surface, almost like fine ground glass, which is due to the high refractive index of the mineral. The reason for the name "iddingsitic olivine andesite" applied to the Corsiehill rock, and of course equally to the Muirhall rock, will now be apparent.

In addition to the foregoing, the ground-mass of the Muirhall andesite shows a point of considerable interest, as it shows exceedingly well in parts what is called hyalopilitic structure. In a typical unaltered andesite some of the magma generally remains non-crystalline or glassy, owing to its having solidified too rapidly for crystallisation to take place. In the altered andesites the glassy base, as it is termed, has, as already noticed, become devitrified. But associated with the glass we have a kind of felt formed of minute rod or lath-shaped crystals. It is this ground-mass of glass and felted crystals to which the term "hyalopilitic" is applied, and the term is still retained when the glass is devitrified. In places the small crystals of the ground mass appear to lie with their longer axes in the same general direction, or to form eddies round the larger phenocrysts, as if movement had taken place while the lava was still semi-fluid. This arrangement is known as flow-structure, and it is frequently much more evident than in our andesites.

I have dealt at some length with the rocks from Corsiehill and Muirhall, as they are on the whole the freshest which I have been able to find in the district. Sections of rocks from a quarry on the shoulder of Dunsinane, near Collace, from Glenfarg, and from Friarton Hill, have been examined, and, though they show the same general characters, none of them are so fresh as those we have been considering. Altered olivine is present in the rocks from Dunsinane and Glenfarg, but alteration has proceeded so far that nothing is left but aggregates of brown material. It appears to be absent from the Friarton Hill rock; at all events none is recognisable in any of my sections.

Our next type of rock is from a more distant locality, Craig Rossie, near Auchterarder. The Ochils in this neighbourhood are built of a succession of agglomerates—rocks, that is, built up of coarser fragmentary materials ejected during volcanic eruptions—and lavas. Some of these latter are quite like the corresponding rocks in the immediate neighbourhood of Perth, but others are very different. Still, according to the nomenclature of the Geological Survey, they are still "porphyrites"—a good example of the vagueness of that term. The rock to which I wish to call your attention is of a bright pinkish colour, and in places shows very obvious flow structure. It is well exposed on the left bank of a little gorge through which the Pairney Burn flows, and again near the summit of the hill. There is a quarry at the foot of the hill, but it has apparently not been worked for a considerable time, so that some difficulty is experienced in hammering out fresh specimens. When examined microscopically, porphyritic felspars, much altered, are at once recognised. The characters of these show that they are of a more acid nature than those in the andesites already examined. The iron ores are also very conspicuous.

Plate 40.—Andesite, Corsiehill, x 10.

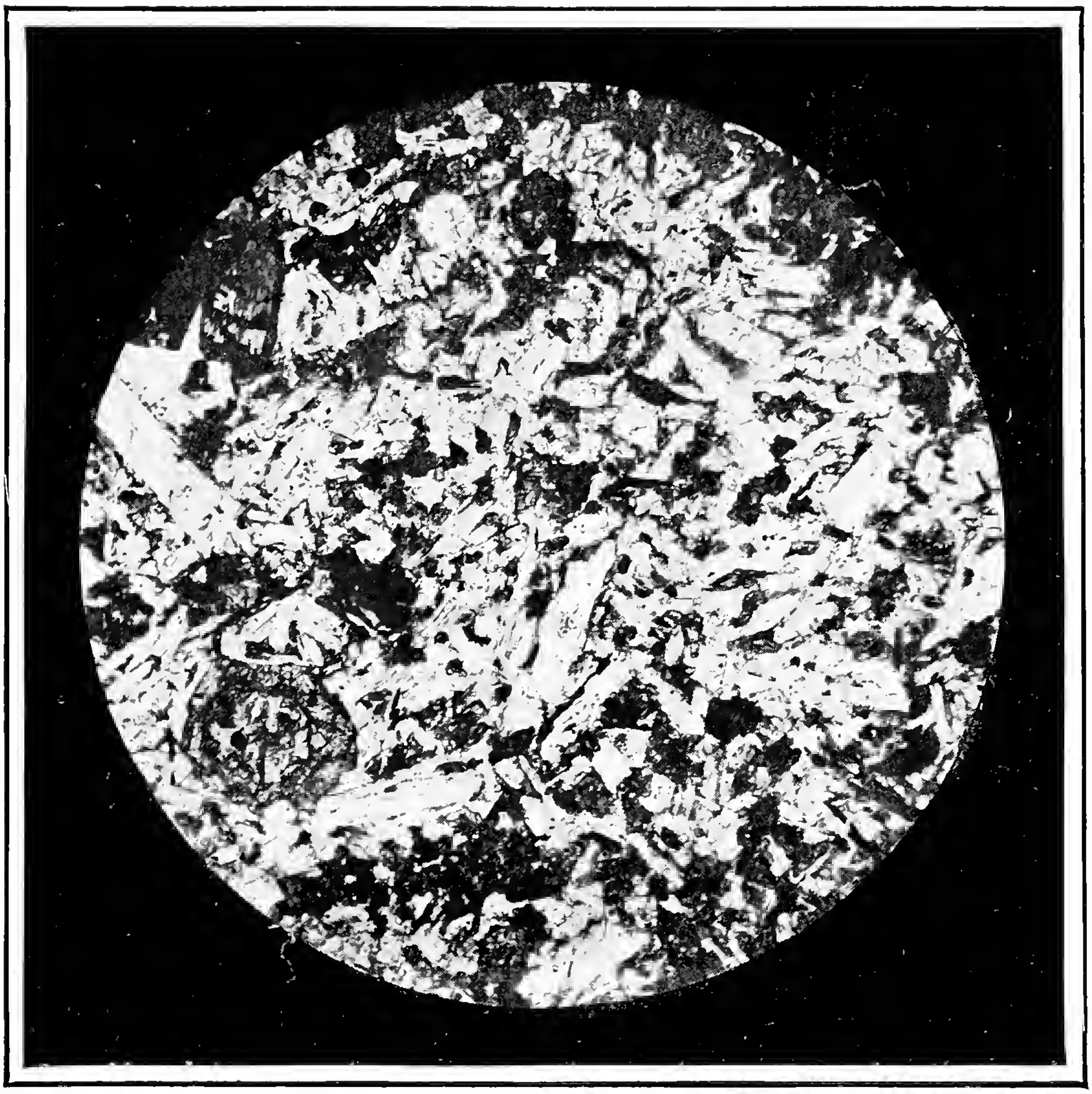

Plate 41.—Corsiehill Andesite, Ground Mass, x 50.

Plate 42.—Felspar Phenocryst viewed by Polarised Light, Andesite, Muirhall, x 36.

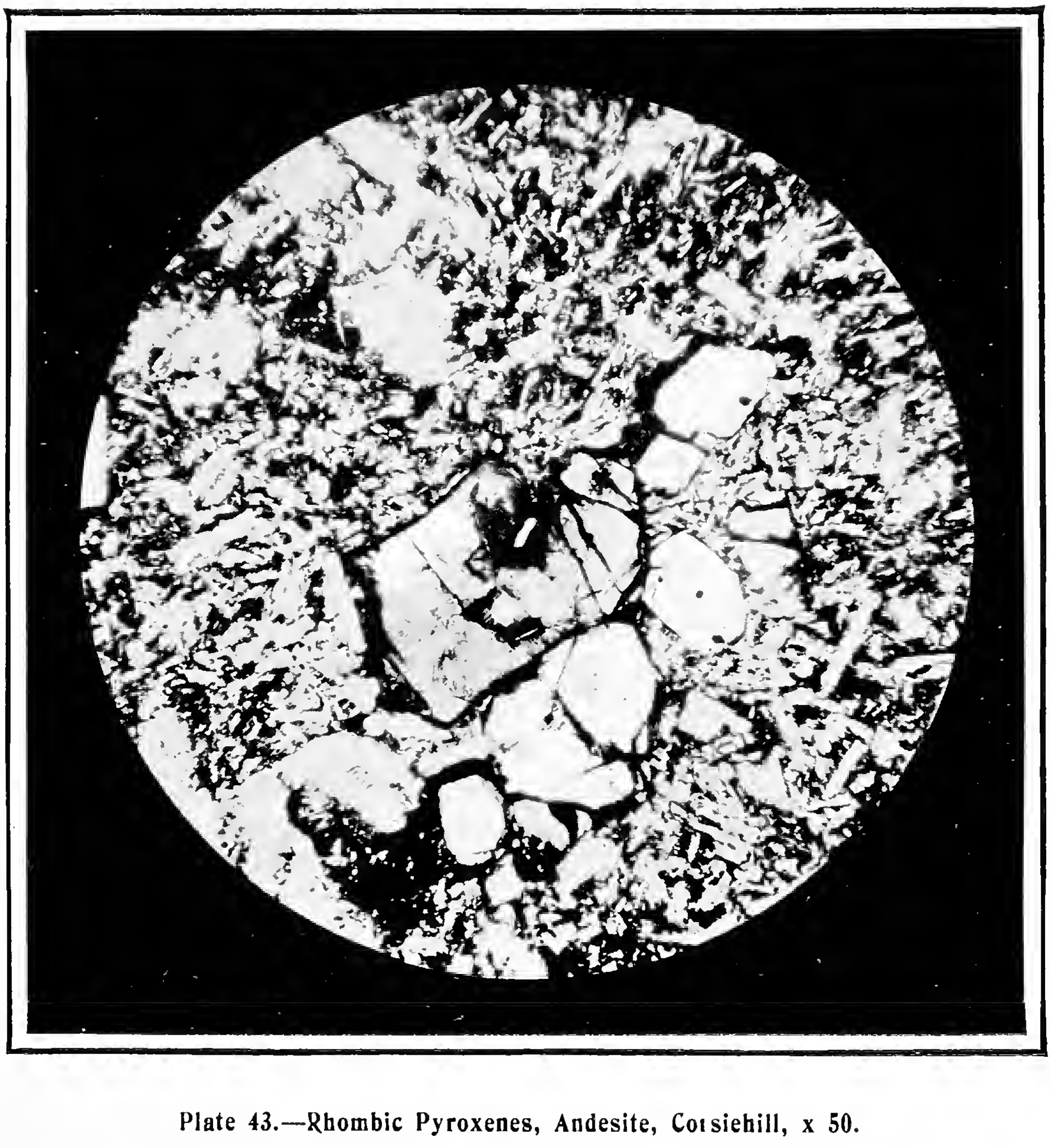

Plate 43.—Rhombic Pyroxenes, Andesite, Corsiehill, x 50.

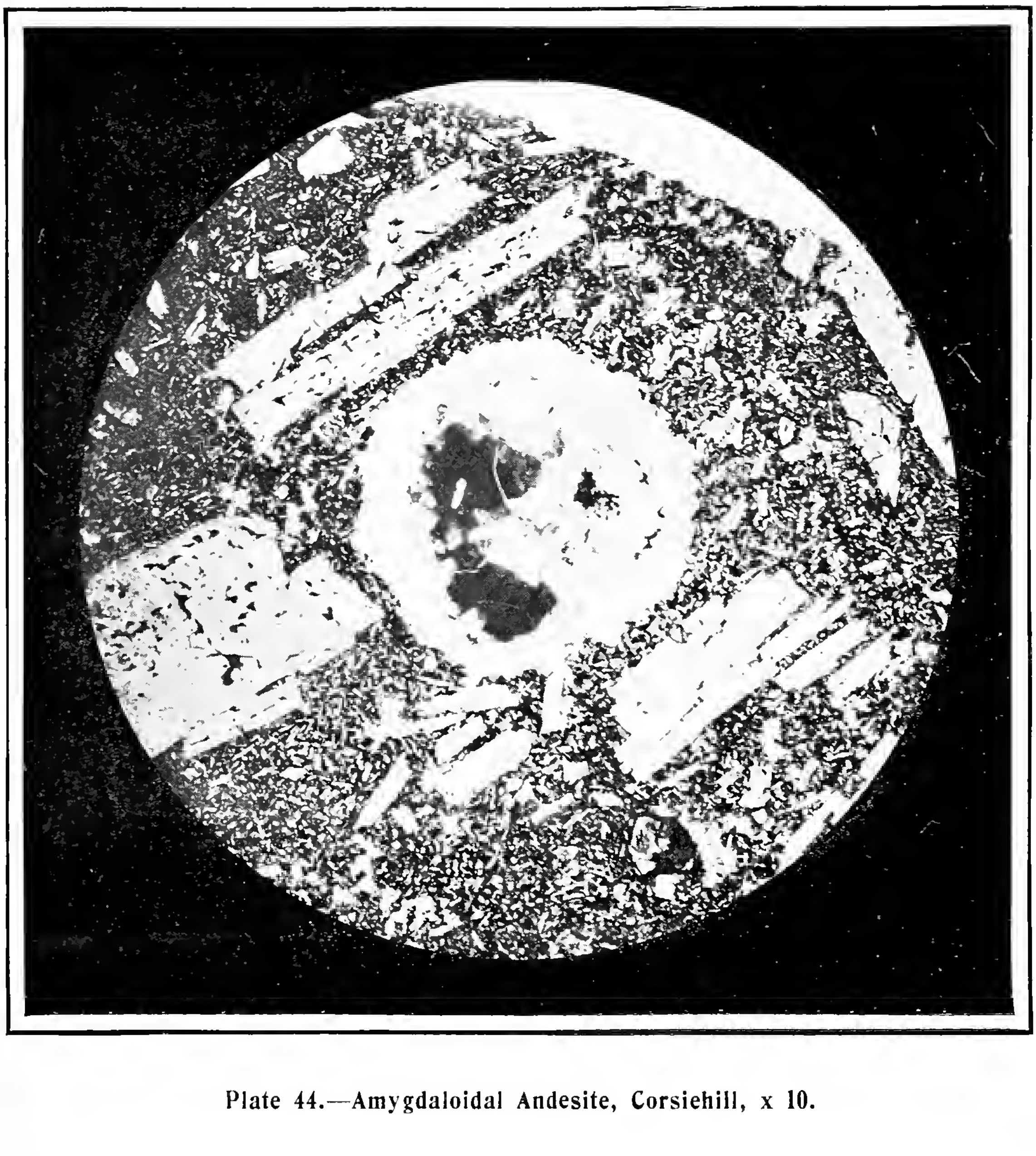

Plate 44.—Amygdaloidal Andesite, Corsiehill, x 10.

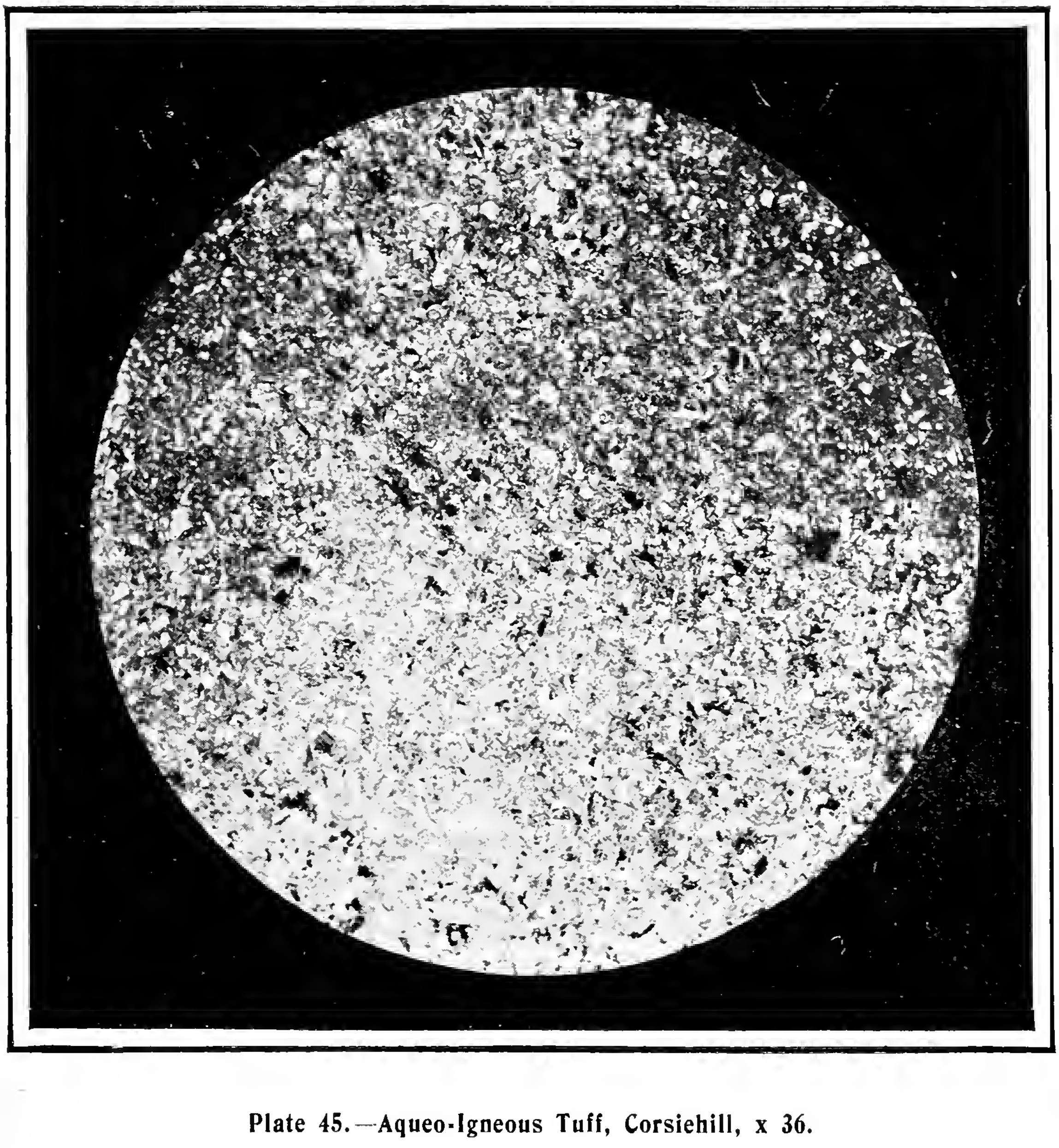

Plate 45.—Aqueo-Igneous Tuff, Corsiehill, x 36.

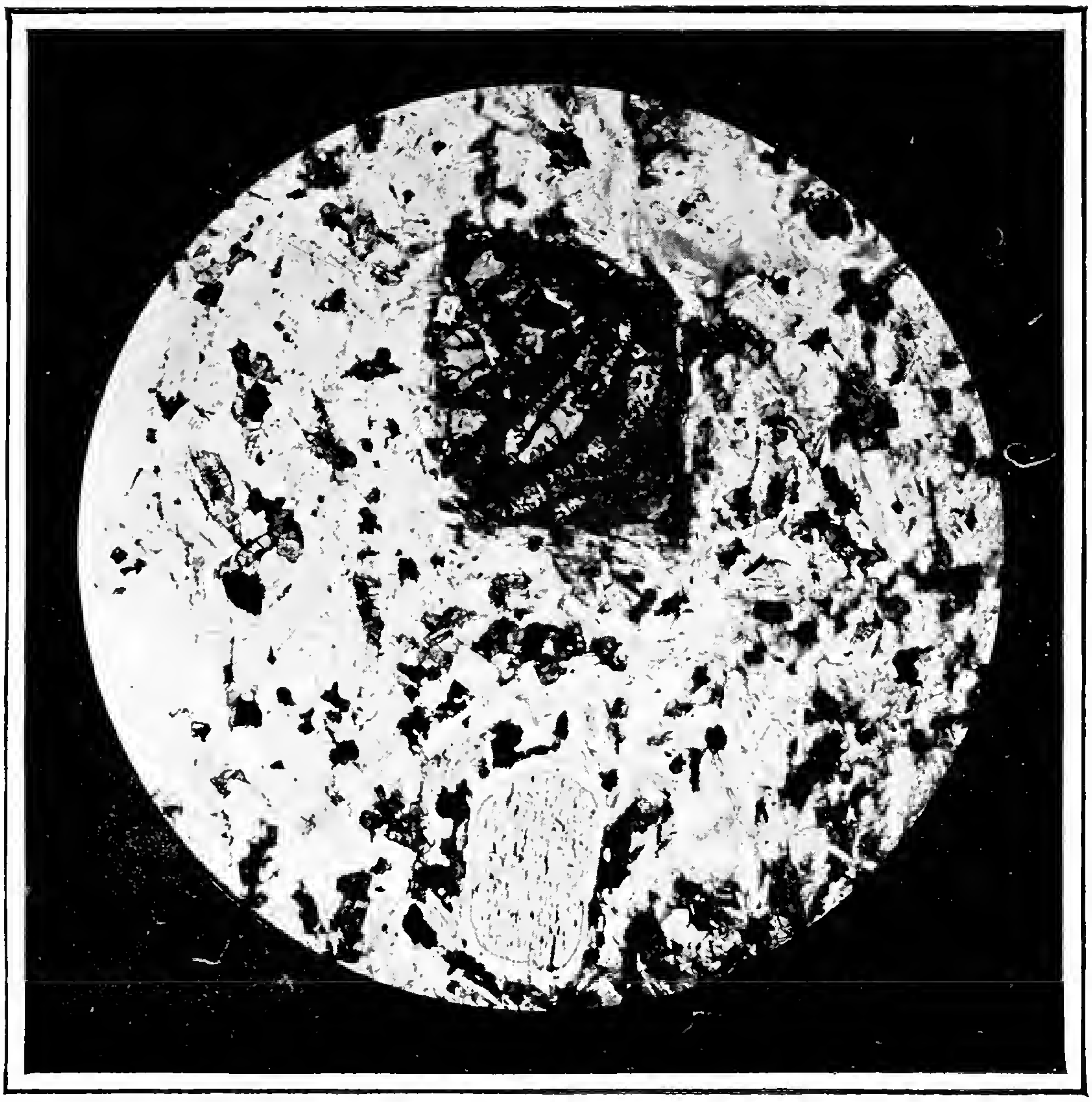

Plate 46—Altered Olivine Crystal, Andesite, Muirhall, x 36.

Some of them are of the ordinary type; others, however, have not the crystalline form that we associate with magnetite, but rather that of biotite or brown mica. Some of the masses show sufficient unaltered material to make it pretty plain that the original mineral was biotite. When one mineral replaces another in this way the new mineral is said to be a pseudomorph of the old one. We have here, then, pseudomorphs of magnetite after biotite.

Then we have a few fragments of a clear glassy mineral, readily recognised as quartz. Some of these fragments show irregular cracks, and one at least, in my sections, has an irregularly oval cavity containing a round enclosure, in a manner very typical of quartz. It will be noted that quartz is quite a new mineral in the rocks we have been discussing.

Finally, the ground mass is of a new type. With low powers of the microscope it appears to be of a finely granular nature, but as it depolarises light when examined between crossed nicols, it must be of a finely crystalline nature; and there is good reason to believe that it consists of an intimate mixture of quartz and felspar. Such a ground-mass is termed felsitic, or when excessively fine, as here, micro-felsitic. (Plate 47.)

In this rock from Craig Rossie, then, we have (1) felspars of an acid type, (2) pseudomorphs of magnetite after biotite, (3) quartz; the whole set in a microfelsitic ground-mass. The presence of quartz and of felspars of acid type shows that this rock is of a much more acid nature than the typical andesites, so much so that it can hardly be called an andesite at all. It is rather difficult to give a precise name, unless we adopt that of quartz-andesite or dacite. Another name which might be applied is micro-granite. Granite, as reference to the table will show, is a typical acid rock, composed essentially of quartz, felspar, and mica. All these are present, or have been present originally, in the Craig Rossie rock; it is, however, different in appearance and mode of occurrence from a typical granite, being fine grained and volcanic, hence we can only apply to it the qualified term micro-granite.

In conclusion, the Craig Rossie lavas illustrate a well-established principle in the theory of volcanic action. It has been recognised in many areas that the lavas erupted during the later phases of volcanic activity are more acid in their composition than the earlier ones. Investigation of various exposures of the Craig Rossie lavas shows that they are the latest erupted of all which occur in that neighbourbood.

NOTE.—It is interesting to observe that the Iddingsitic change in olivine has apparently not been previously observed in any British rocks. The paper containing the original notice of it is in the Bulletin of the Geological Department of the University of California for 1893.

XX.—*Half-a-Day on Tentsmuir.*

By Wm. Whyte.

(Read 11th April, 1907.)

On June the 6th of last year the members of the P.S.N.S. who are interested in ornithology paid a visit to Tentsmuir, famous as the breeding-place of the Terns. The day being fine, the party, to the number of 17, entrained at Perth General Station at 9.30, and after the usual wait at Ladybank, arrived at the quaint old-world village of Leuchars about mid-day.

Proceeding through the village, we reached the Church, which presented features of architectural interest to some of the party, and were duly photographed. After about a mile's further walk we reached Earlshall, where we found Mr. Young, the gardener, waiting for us. Accepting Mr. Young's invitation, we proceeded to inspect the house and grounds. The building itself is a most interesting structure, and the present proprietor, Mr. Mackenzie, has restored it to what one might call its pristine glory, as everything about it is suggestive of a bygone age, when knights were bold and barons held their sway. It is beautifully situated, with a spacious park in front and lovely terraced lawns at the back, bordered by finely arranged flower-beds, the whole forming, as the property advertisements say, a most desirable residence and within easy distance of the sea. More photographing ensued, after which, accompanied by Mr. Young, we made tracks for the moor, and the real business of the day began. The moor itself is flat, and rather uninteresting from a scenic point of view, covered with short scrubby heather and greyish moss in some parts, and in others with coarse grass and heather of a more luxuriant growth; while along the beach runs a double row of sandhills, and beyond that stretches the broad blue waters of the Firth of Tay, shimmering and glinting in the brilliant sunshine, and the waves lap in lazy indolence on the golden sands. It is among the short coarse moss and among the sand dunes that the Terns breed, and to see them in the full flush of nesting-time formed the principal object of this excursion.

The Terns rise from their nests whenever they see an intruder near their ground, as they know that their white plumage would, if they remained sitting, prove a sure guide to their nests. They therefore depend on the protective colouring of their eggs, and the almost entire absence of nest formation, to enable them to escape detection. We were unfortunately a week too early on this occasion, and did not find the colony full. In the previous year I spent two days on the moor, and found every nest full, but this year it was a week later. On that occasion there was a perfect cloud of birds wheeling and circling on graceful pinions high in the air, and emitting angry cries at this intrusion on their sacred domain. I am sorry to say that there seems but little protection afforded to the Terns on the moor, as, on walking over the same ground on the following day, I found nearly every nest empty, and the footmarks of three individuals in the sand plainly indicated the cause.

We, however, found some typical nests, and had an opportunity of seeing the great variety of colouring which exists among the eggs of this species, and, in fact, among those of all birds that breed in colonies. There are, however, other inhabitants of the moor who deserve more than a passing notice. Chief among these are the Shell Duck and Eider Duck. The Shell Duck is one of the most beautifully marked species of the duck family, and is quite a feature of the moor in the nesting season. They always fly in pairs from the sea to their nest, and on approaching the rabbit's burrow, where the nest is always placed, the female drops suddenly to the ground and disappears in the burrow. Her mate meanwhile continues his flight and circles rapidly back to the beach. While watching a pair of these birds flying over the moor, I saw both of them drop to the ground, and after waiting some time, I took advantage of any shelter that the ground afforded to enable me to get as near as possible. Suddenly the ducks rose, and walking rapidly to the spot, I found a family of seven young Shell Ducks marching along the bottom of a deep dry ditch which runs right down to the beach. Pretty little creatures they were, with lovely marbled plumage, staring in wide-eyed wonder at the first human being they had ever seen.

The Eider Duck is fairly common on this part of the moor, and we saw about six nests, with some of the young fully downed with that soft grey down which is such a valuable commercial asset. They nest, as a rule, among the long heather, and it takes a keen eye to discover the sitting bird, so closely does her plumage correspond with her surroundings. But there is generally a tell-tale tuft of down dangling from a spray of heather, which induces the searcher to make a close scrutiny of the surrounding ground, and he is rewarded by seeing the bird sitting watching his every movement. On one occasion she allowed me to stand over her before she rose, and then my olfactory organ was assailed by one of the most virulent smells it has ever been my lot to sample. It was simply overpowering, and I had to retire to a distance and allow the fresh breeze to clarify the nest before I could again approach it. The nest, like that of all the ducks, is downed as incubation proceeds, the mother plucking it from her breast.

The rest of the bird tenants of the moor had by this time completed the hatching of their respective broods, and were anxiously watching lest we should come across some of their hidden treasures, which were lying low among the heather. That wary bird, the Golden Plover, was ever in evidence. Sitting on the top of a little hillock, he would give his plaintive whistling cry, and then as we approached would shift a little further on. The Dunlin, of which there were three or four pairs, pursued the same tactics, and, in fact, in a frontal view their plumage exactly resembles that of the Plover, although the bird is much smaller.

Grouse do not appear to be at all plentiful on this part of the moor, as we only flushed one pair. The Wheatear is abundant among the rabbit holes, where they nest. The Ring Plovers are also numerous, and we saw a very pretty clutch of these eggs. I think that about sums up the birds that came under our notice, except the Gulls, which at low water may be seen in a long string along the water edge, with their shoulders humped up, as if they were working off a severe attack of indigestion. They do look most dejected specimens of the Avifauna.

We have now covered the ground mapped out for the day, and reaching the shepherd's house, we find an excellent sunk well, and there, like a party of wandering Bedouins, at this little oasis in the desert we quench our thirst, which is great, and are again photographed. We now made tracks for the road, and after parting with Mr. Young, and thanking him warmly for his valuable assistance and for the kindly interest he had taken in the day's work, the party made for Leuchars and Perth, after a pleasant and successful day's outing.

XXI.—*Birds observed during Winter of 1906-7.*

Carrion Crow,	4	Muir of Ward. 11th November.
Jay,	2	Glensaugh, Bankfoot. 17th September.
,,	1	Muir of Ward. 11th November.
Fieldfare,	flock,	Corsiehill. 17th November.
Redwing,	1	Muirhall. 17th February.
,,	flock,	Newburgh. 9th March.
Brambling,	flock,	Craigend, Edinburgh Road. 9th March.
Goldfinch,	7	Mouth of Earn. 3rd November.
Geese,	—	Lower Tay. From 3rd November till 9th March. On January 12th Messrs. M‘Nicol and Robb killed 24, comprising 4 species—Grey, Pink-footed, White-fronted (1), and Bean (1).

Mallard,	—	Lower Tay. Less numerous than last year.
,,	15	Perth Bridge. 11th February.
Teal,	—	Lower Tay. Numerous.
Wigeon,	—	Lower Tay. Large flocks from the middle of September till middle of January.
Goldeneye,	1	Mouth of Earn. 1st December.
,,	—	Newburgh. Large numbers during January.
Goosander,	5	Perth Bridge. 11th December. Various numbers till 1st March. Nine on 1st February.
Tufted Duck,	—	Lower Tay. Large flocks 1st January.
Cormorant,	2	Mouth of Earn. 8th December.
,,	1	Perth Bridge. 18th January till 1st February.
Common Gull,	—	Perth Bridge. More numerous than other species on 1st February.
Snipe,	—	Lower Tay. Numerous all season.
Jack Snipe,	1	Lower Tay. Found dead, September.
,,	1	Lower Tay. 1st December.
Water Rail,	—	Mouth of Earn. Heard 3rd November and several times after.
Little Grebe,	1	Perth Bridge. 12th December and 14th January.
Brambling,	flock,	Deuchney Woods. 30th December. About 2000 birds.

[This Part, pp. 163-203, published 9th November, 1907].

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1908.

XXII.—*British Monuments.*

By Sir ALEXANDER MUIR MACKENZIE, Bart.

(Read 14th November, 1907.)

The South of England, as Sir Richard Hoare tells us in his "Antiquities of Wiltshire," is very rich in all kinds of monuments, and although Wiltshire may possess such grand temples as Avebury and Stonehenge, it is to Cornwall one must go to find at every turn "stones" as evidence of the "ceremonies" of the people of those bygone ages, contemporary monuments being found "manywhere," and thereby inviting comparison or affording proof. The "many-headed" generally are content with the historical adjective "Druidical," but those who have "ta'en to the antiquarian trade" are not always satisfied with such generalities, and search for types of older forms of monuments erected by older races. Mrs. Wade was the prophet of the former, and Baring Gould the sweeping critic of the later school. But the fact remains that there is plenty of room for both, and the boundary line is very faint and dim. Alliteration certainly lends its artful aid in Cornubia, there being "cromlechs," "circles," "crosses," "Chrysoster" (the name of British village, and hut circles), to which may be added, as things of Cornwall, crabs and clotted cream,* as also the expressive word "clitters," heaps of loose granite.

Taking these in order, and distinctly avoiding any pretence of dogmatising, we will notice a few of the most prominent of these monuments of a bygone age and peoples. Byron, on visiting the ruins of Rome, exclaims, "Temples, baths, or halls?" so we, in finding a "monolith"—a menhir—standing singly as would an obelisk, or grouped as "trilithons," may ask reverently, "Temple or tomb?" Even the experts have to translate and define. "Cromlech—(1) a dolmen with three stones, (2) closed in a kistvaen, (3) covered with earth, a barrow."† Fine instances of these are the Zennor, the Trewithy, the Lanyon (restored) in Cornwall, which may be compared with "the Table" at Carnac, Brittany, the Dolmen at Chagford, Devon, the Devil's Dyke at Marlborough, and, by no means least, Craigmaddy in Lanark, this latter well described in *Scottish Antiquarian Transactions*, Vol. XL.

The ordinary form is that of two uprights (menhirs) and a capstone, usually called a "quoit" from its resemblance to a disc,‡ while

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* The so-called Devonshire Cream is but a base imitation.

† Borlase on Cornwall.

‡ The "coit" is found often among these "old stones," and signifies as often a single stone as an impost.

"cromlech" means the leaning stone. How these capstones were raised and placed has puzzled the antiquarian as well as the engineer. Some suppose that the "tomb" was excavated, and the capstone thus could be hauled or rolled on the level; but in the large temples—such as Stonehenge—this is inadmissible, and there it is surmised that the pillars were erected, and the capstone dragged up an inclined plane, there to be fixed by "mortice and tenon" in grooves.* In the case of the Cromlechs above mentioned there is no means of fixing the stone by "tenon," implying an earlier age and ruder style of architecture, probably belonging to the earlier neolithic age. Earlier still probably is the single menhir, the "*men-an-tol*" ("big stone with a hole in it"), or forming a natural arch, when its cognomen would be that of a dolmen. The "Pipers," near Penzance, are grand examples of the monolith, and Lanyon a fine specimen of the men-an-tol.

There is a most curious stone called the Maen-roch, a huge round ball of a stone, its base squared out so that it looks like a great Greek omega.

Many menhirs, having served the old generations, are now used by the Philistines as boundary or milestones, some as gate posts, some built into pigsties, some acting as posts for shoeing oxen, and some as scratching-posts, so that a man might say, "Gott pless the Duke o' Argyle!" *Sic transit.*

CIRCLES.

These circles or temples, so far as the larger ones are concerned, are so well known and so oft described that any notice of Stonehenge, Avebury, and Stanton Drew, the grandmother of both, must simply refer the student to the many splendid works thereon, from John Rastell's quaint account to Stukeley's, "*cum multis aliis*," not forgetting the important work in later days of Professor Gowland, at the instance of Sir Edmund Antrobus, the owner of Stonehenge,† and to whom its preservation, if not restoration, must be attributed. The smaller class are found in the Nine Maidens, the Bolleit Circle, the Bookedna Circle, and that of the Hurlers at Liskeard, each and all evidently placed for some religious, judicial, or ceremonial purpose. These may be compared with the circles in Scotland, notably those of Croft Maraig and Airlich, in Strathbraan, the geese on "Mucklestane Muir" (Black Dwarf), with others in Banff and Aberdeen.‡

The astronomical position of these circles and monuments as to their orientation is at present a debatable matter. There can be no

---

* Professor Judd.

† See Lady Antrobus' book on Stonehenge.

‡ *Scot. Antiq.*, Vol. XL.

possible doubt whatever that there are examples, which none can mistake, where the astronomical theory is bound to be accepted. Stonehenge is without doubt placed so that the summer solstice, as well as the winter solstice, can be accurately marked. The circles at Stanton Drew are held to be those of the sun, the moon, and the planets (otherwise "The Weddings"). The two stones guarding the men-an-tol at Lanyon are placed north and south of the circular centre-stone, and in the great "parallelolithic" or double avenue at Merivale, Dartmoor, the orientation from west to east is clearly marked. The "Nine Maidens," like the "Weddings" at Stanton Drew, the "Cones" at Hamman Meskoutin, Algeria, and others more or less known, share the old legend that they were mortals turned to stone for offences against the Deity. Lot's wife comes naturally into this category. But at a reunion of antiquarians and astronomers at Torquay, lately held, some plain speaking took place, and any hard and fast rule of astronomical lines denied, so with all deference the matter can be left there, as some of the theories are so clearly out of the running.

The curious circles called the Hurlers, near Liskeard, resemble the plan of the huge circles at Avebury, for which the serpentine or dracontian form is claimed by Stukeley, and referred to by Aubrey. The Hurlers were thought to mark the tombs of ancient British heroes, but it is surmised that they were invested with this story to prevent any desecration of the old stones, whatever be their origin. "Hurling" the disc was an ancient sport, and a game with a silver ball is peculiar to St. Colomb in Cornwall, and survives to this day. Hard by are two very ancient monuments, one fashioned by Dame Nature in her most extravagant mood. The gigantic "cheesewring"—a collection of disc-shaped stones, like so many "Kilmarnock bonnets"—although but of one rock, have been so weathered that they lie piled one on another to the height of about 25 feet, a truly enormous idol at which the "devils" might well tremble if believing. Another is a finely inscribed stone to the memory of one of the earliest British kings, "Dungurth, King of Wales."

There is another remarkable inscribed stone near Lanyon, of which the lettering resembles that of "Ogham," about the earliest of all written languages.

CROSSES.

Crosses are very plentiful in South Britain. Leland, the best authority, says they are of three forms—Greek, Latin, and transition.

The Greek cross is not necessarily a Christian cross, and in its shape, generally incised within a wheel, is more of an ornamental than of a religious character. We see the cross tatooed on the faces of the Kabyles of Algeria, and the Touaregs, the wildest of desert tribes, have their saddlebows in form of a cross, and a cross formed on their "boucliers"* (shields or bucklers).

The beautiful carved crosses at St. Colomb and St. Buryan are fine examples; and a notable cross, with the five bosses representing the five wounds of our Saviour, is at Saint Merthyr Uny. Then the "transition" period came on, and the crucifix appeared on a lengthened design. Then came the more graceful Latin pattern, from which comes the sculptured Gothic, or marked with the "triquetra" knot denoting the Trinity.

Many of the crosses were used as boundary stones, and so came into use as milestones. The figure, more or less distinct, of the Saviour on the Cross is often found, some with the "seamless robe," arms outstretched, and the head lowered and inclined to the right hand. St. Buryan Cross is a very fine example of the short broad cross, and the curious attenuated-long slender column surmounted by a crucifix is an antithesis. On St. Michael's Mount, that curious cone-like island, there stands a long cross, as it were the guardian angel of the splendidly isolated islet. "Dunno anything about a stone cross hereabouts, but there is a nice iron cross down along, put up by the road people," was one answer out of many I received.

HUT-DWELLERS.

Among the ancient monuments must be classed the homes of the hut-dwellers. Excellent remains of the beehive huts arranged in circles occur at "Chrysoster," near Penzance, and at "Barsthenes," called by Blight "Dwellings in the South" (*Archæological Journal*, Vol. XVIII.). On this hill are ruins of seven or eight of these huts, ancient British residences, consisting of rude walls put together without cement, and covered with poles and reeds or brushwood. The inner cells are constructed with stone roofs, beehive shape. First, there is an elliptical wall about three feet thick, faced externally and internally with stones; within its breadth are four compartments. In these the stones overlap each other as they approach the top, so that a beehive appearance is secured. The centre of the hut is occupied by a large open space, from which are entrances into the smaller divisions. This area probably served to secure cattle at night from marauders.†
In the centre of one of the cells is a small bowl-like depression,

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* M. Duveyrier claims the association of this wild desert tribe with early Christianity, and in any case the Touareg declines to be Islamised, and is "Makesh Arab." (Not at all Arab).

† This is more or less the "kraal" system which was adopted by the Britons in the South, notably at Worleberry, in Somersetshire, and which is responsible for so many "Roman Camps" of the amateur antiquarian.

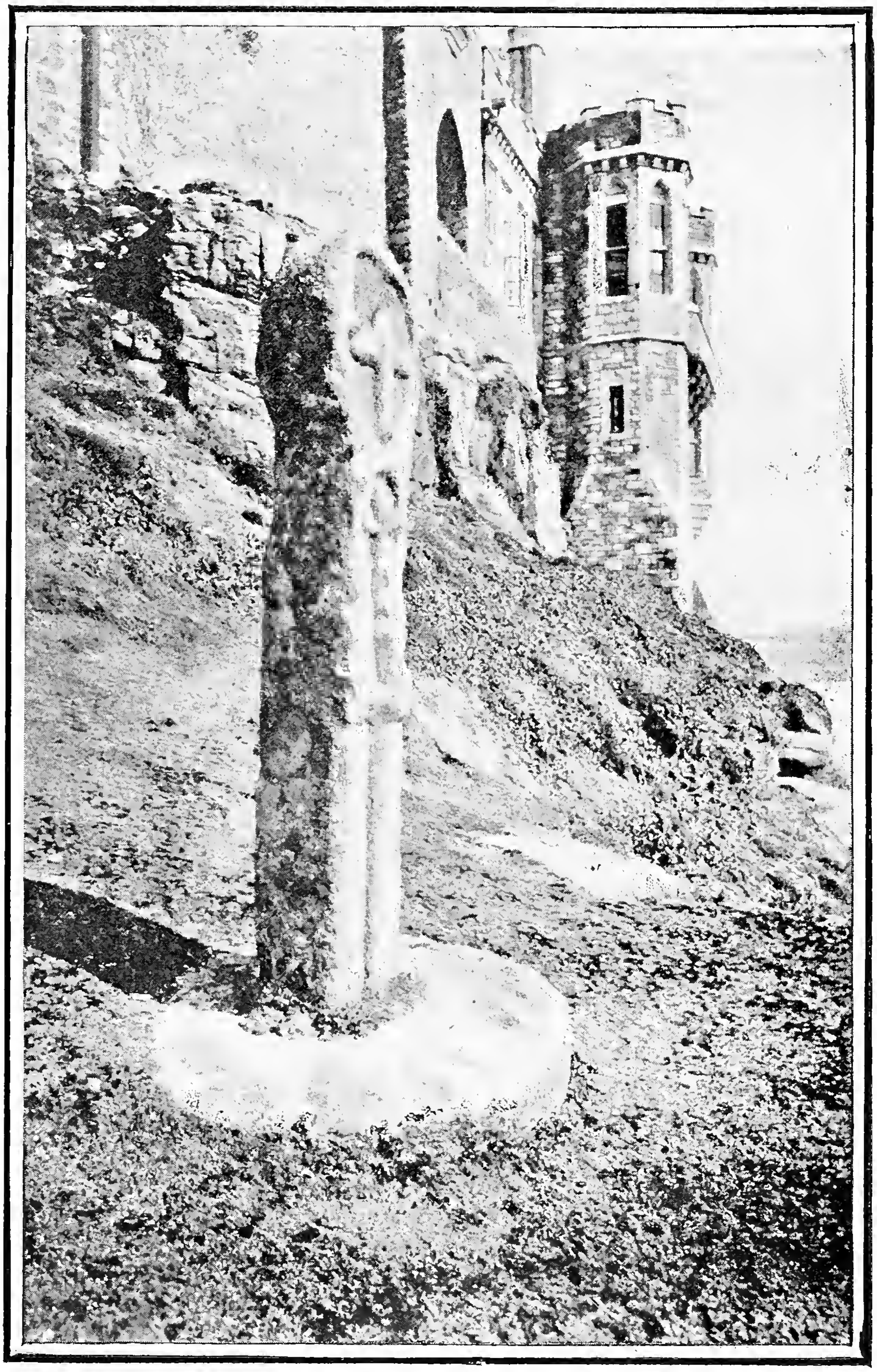

Plate 48.—Old Cross, St. Michael's Mount.

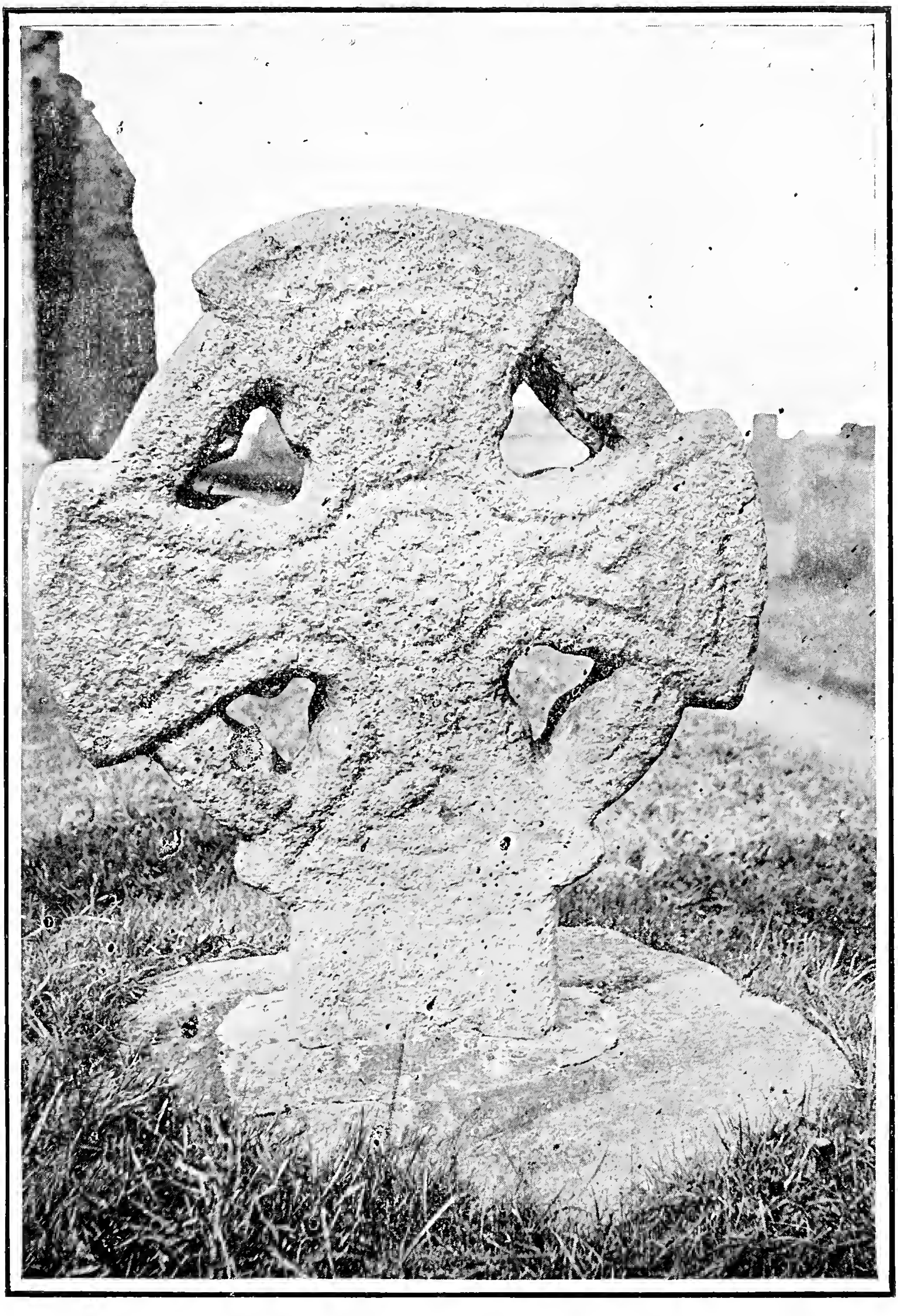

Plate 49.—Cross at St. Columb.

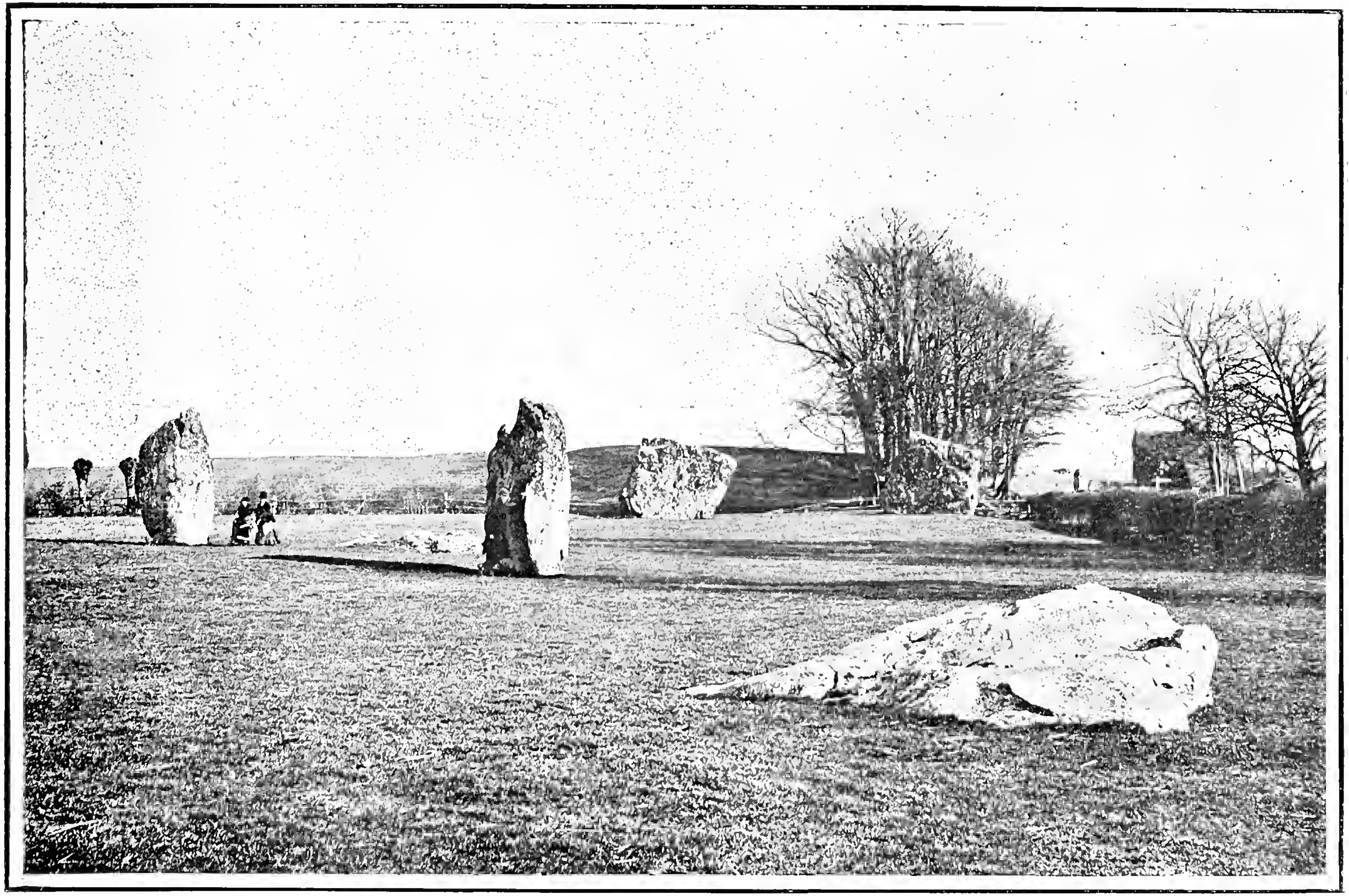

Plate 50.– The Great Stones at Avebury.

noticeable as a possible Druidical rock basin, or as a socket for a central pole from which would radiate the roof-structure. On the ledge of wall near the entrance was another bowl resembling a "holy water font." (On Goonhilly Down, near the Lizard, found in a hedge hard by a rude cromlech (3 stones) were two basins, called by the folk the "bowl and ladle," the why and the wherefore profoundly hidden from the enquirer). These structures are surrounded by numerous "gurgos," broken-down fences or dykes, forming enclosures of fantastic shapes. The hut-dwellers baked their bread on "gradles"—our girdles—and venison roasted on flaming fern must have been "gey guid."*

WHITE HORSES.

These monuments of British history, or rather Saxon history, are found all along the line of the chalk downs. They are held to have been cut in commemoration of the exploits of Alfred, *circa* 879, near Ashdown, and one was known to be existing in 1100. Similar figures were cut at Cherhill, Alton, and Bratton, the latter probably in commemoration of Alfred's victory at Clayhill (A'glea). The "Scouring of the Horse" is well told by Hughes, and at various times the other white horses have been cut or rejuvenated, giving the critic the chance to sneer at those modernities. But as Mr. Wise remarks, "It is worthy of remark whether their authors had not preserved the tradition of some older monuments now obliterated, or of some older festival now forgot."

The myth of the "White Horse" is of great antiquity, and Mr. Thoms considers that memorials of the conversion of the Saxons to Christianity were preserved in form of white horses in ash groves. (Plenderleath, *Wilts. Arch. Mag.*, Vol. XIV.).

Long may the "white horses" race along our shores, and, as British monuments, guard and defend our native land.

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*See description of feast by Arnold in "Iyvinda."

NOTE.—Most of these historical notes were published by the present writer in "Historic Wilts."

XXIII.—*Note upon Crystals of Grossularite from Corsiehill Quarry.*

By S. J. SHAND, B.Sc., Ph.D., the Royal Scottish Museum, Edinburgh.

(Read 9th January, 1908.)

Two small specimens of garnet-bearing rock from Corsiehill Quarry were sent to the Royal Scottish Museum by Mr. Rodger in 1906. In examining these I noticed some interesting points connected with their genesis and crystalline form, and on my mentioning this to Mr. Rodger, he was kind enough to place at my disposal for investigation all the remaining material from this locality. I also made two visits to the quarry in his company, but failed to find any more of the material, which appears to have been exhausted.

The specimens were found by Mr. A. Grant Ogilvie and Mr. A. Gray, at the junction between the andesite and the large Tertiary basalt dyke which cuts the latter; they appear to have lain on the andesite (South) side of the junction, and to have been broken away during the quarrying of the basalt. I have had microscopical sections made of both the andesite and the basalt from various points in the quarry, but in no case is garnet present as a constituent of either rock. Even a specimen with visible garnets on the surface contained none internally.

The garnets are associated with incrustations of saponite, quartz, and calcite. In a few cases the garnets are seen to lie directly upon the andesite, but in general the following order of succession obtains among these four minerals, from within outwards:—

(1). Layer of dark green saponite.
(2). Layer of prismatic quartz.
(3) and (4). { Scattered crystals and grains of calcite, and
Scattered crystals of garnet.

The *saponite* forms a dark green to almost black layer on the surface of the decomposed andesite. The name saponite is used here in generic rather than specific significance, as the material is too earthy and impure to admit of exact determination; it is probable that it contains more than one member of the saponite family.

Upon the saponite there is in most cases a layer of compact crystalline *quartz* consisting of prisms standing perpendicular to the surface of the saponite, and terminated above by the usual hexagonal pyramids. The surface of this quartz layer is stained brown, and it shows here and there traces of a second deposition of saponite.

The *calcite* is in roughly-shaped scalenohedral crystals and rounded grains. These are sprinkled liberally over the quartz, and among and upon them lie the garnets. The calcite and the garnets appear to have been deposited almost simultaneously, as each species may be observed to cap crystals of the other.

The *garnets* belong to the species grossularite or calcium-aluminium garnet, and to the variety known as cinnamon-stone. They vary in colour from nearly white to pale yellow and rich cinnamon-brown. In size they are minute, few exceeding 1 millimetre in diameter and none rising to 2 millimetres. The best individuals are beautifully transparent, and possess a high lustre, thanks to which their minute facets readily catch the eye. Faces belonging to at least five forms are recognisable; they are thus by far the most richly facetted garnets yet found in Scotland. (See Fig. 1).

The predominant form is the icositetrahedron $n = (211)$. The faces of this form are large and bright. They show numerous fine striations parallel to the edge *dn* (Fig. 2), which are caused by the presence upon *n* of a vicinal hexakisoctahedron. The faces of the latter are sometimes developed as indicated in the lower half of Fig. 2, each face of *n* being replaced by two faces which lie almost, but not quite, in the same plane. The above type of striation is quite unusual in garnet.

The rhombic dodecahedron $d = (101)$ is represented by very small facets, of which the full complement is seldom present. They show no peculiarity.

A second icositetrahedron is represented by four minute and strongly curved faces (*m*) at the octahedral corners. The curvature of these faces is so pronounced that the angle *nm* varies from a minimum of about 10° to a maximum of nearly 20°. The former value agrees with that required by the form $m = (311)$, to which these faces are here referred. This form has not previously been recognised in Scotland.

Truncating the edges *nn* are the narrow facets $r = (332)$ of a triakisoctahedron. These are always rounded and not adapted to measurement, but the formula is given by their position. This form is also new to Scotland.

The remaining form is a hexakis-octahedron indicated in Fig. 1 by the letter *t*. This replaces each octahedral edge by two facets, and lies therefore in the zone *nn*, and not in *dn* as is usually the case. Its faces are sharp and brilliant, but so narrow that the strong diffraction caused by them in reflected light prevented the formation of an image suitable for accurate measurement. From their zone-relations it is deducible that the formula is of the type (2 h. h. l). By approximate adjustment of each face to its position of brightest reflection, I obtained the following rough values for the angles :—

$$n \wedge t,\ 9\tfrac{1}{2}^\circ;\quad t \wedge t,\ 28^\circ;\quad t \wedge n,\ 9\tfrac{1}{2}^\circ.$$

Since the above was written I have been enabled, by the kindness of

Professor Lewis and Dr. Hutchinson, to repeat these measurements with a small Fuess goniometer in the Mineralogical Laboratory at Cambridge. For the crystal registered in this Museum under the number [370-179a] I obtain the following values, measuring from *n* to *n* across an octahedral edge :—

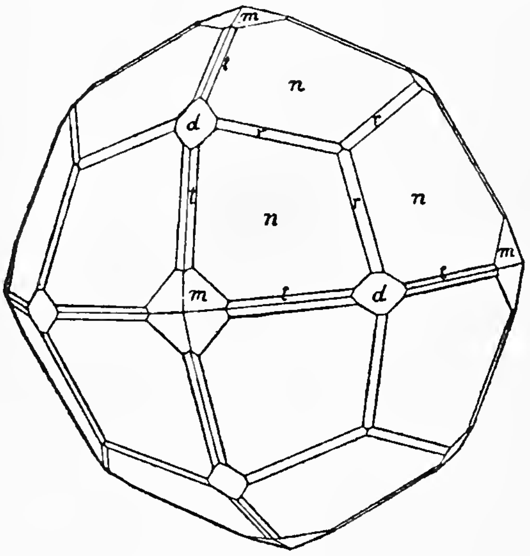
$n_1 \wedge t_1$;	*max.*, 10° 17′ ;	*min.*, 8° 48′
$t_1 \wedge t_2$;	29° 22′ ;	28° 46′
$t_2 \wedge n_2$;	10° 5′	8° 50′

If t = (14 7 4), the theoretical values of these angles are $n \wedge t = 9° 46'$; $t \wedge t = 28° 39'$

The agreement with this form is therefore fairly good. The form (14.7.4) is entirely new for garnet, the usual hexakisoctahedra lying in the zone *dn*.

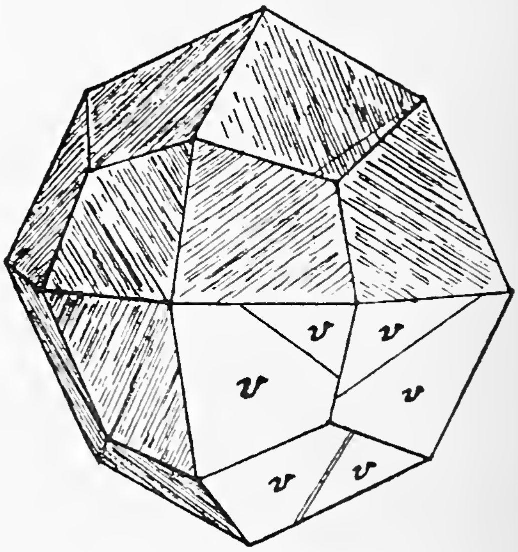
From the nature of the occurrence and of the associated minerals, there can be no doubt whatever that these garnets are of aqueous origin. As they are found only along the line of junction of the andesite with the intruded basalt, it is reasonable to conclude that they date from the time of irruption of the latter, and that they owe their formation to the action of the heated waters which accompany every demonstration of igneous activity. The curvature of the faces appears to be an original phenomenon, as it is in many diamond crystals, and not a result of secondary re-solution.

Fig. 1.



n=(211).
m=(311).
d=(101).
r=(332).
t=(14.7.4).

Fig. 2.



Showing striations upon the *n* faces due to oscillatory combination of the vicinal faces *v* which are shown in normal development in the lower right-hand octant.

XXIV.—*Notes on the Natural History, Geology, and Antiquities of Duror, Argyllshire.*

By Rev. G. A. Frank Knight, M.A., F.R.S.E.

(Read 13th February, 1908.)

It is often a question by no means easy to solve where one's holidays should be spent. There are some places so crowded with visitors, so given over to noise and bustle, that even although the air may be bracing, and the scenery and surroundings may be pleasing, the tired city dweller returns to his work at the close of his holiday with the sense that he has never been away from the roar of the world's din. To a lover of quiet glens, of lonely shores, of wide silent moors, of sweet rustic life, such fashionable centres offer no charms. But if anyone desires a locality with beauty in whatsoever direction one looks, with delightful seclusion from "the madding crowd," with ample scope for scientific and archæological study, with the purest air and the grandest mountain and loch scenery, I can heartily commend Duror in Argyllshire.

Anyone who remembers the character of the weather last August will be ready to confess that a wetter holiday month could hardly be imagined. As a matter of fact, it was our privilege to enjoy only two days during which it did not rain. The incessant torrents to a large extent prevented my studying the district as I would have liked, and I must make the wretched weather my apology for the meagreness of the following notes on the locality, and for the unsatisfactory character of the slides which I show on the screen. In such sunless and dripping weather it was almost impossible to obtain good negatives. I propose to take up (1) The Marine Conchology, (2) The Geology, and (3) The Antiquities of Duror.

I. THE MARINE CONCHOLOGY.

Not having my dredge with me (fortunately—for the weather all the month would have been too stormy to use it), I had to be content with shore collecting. The mollusca of the district, however, are not numerous. The shore is as a rule rocky, and even where bays do occur, the beach is shingle of various degrees of roughness, and the patches of sand are few and far between. Loch Linnhe, moreover, penetrates so far into the heart of the country that it is not in close touch with the main ocean, and its waters therefore are not so prolific in mollusca as those swept daily by the full strength of the salt Atlantic tides. The list I submit is, accordingly, of a very meagre character, only 51 species being the number I was able to procure. The following constitutes the total:—

Nucula nucleus (L).
Glycymeris glycymeris (L).
Mytilus edulis (L).
Volsella modiolus (L).
Ostrea edulis (L).
Pecten maximus (L).
,, *pusio* (L).
,, *varius*, var. *nivea* Macgill.
,, *opercularis* (L).
Cyprina islandica (L).
Lucina borealis (L).
Tellimya ferruginosa (Mont.)
Tellina tenuis da Costa.
Macoma balthica (L).
Spisula solida (L).
,, *subtruncata* (da Costa).
Lutraria elliptica Lam.
Dosinia exoleta (L).
,, *lupina* (L).
Venus fasciata (da Costa).
,, *gallina* (L).
Tapes virgineus (L).
,, *pullastra* (Mont.)
Cardium edule (L).
,, *norvegicum* (Speng.).
Gari ferröensis (Chem.).
Mya arenaria L.
Mya truncata L.
Ensis siliqua (L).
,, ,, var. *arcuata* Jeff.
Saxicava rugosa (L).
Thracia fragilis (Penn).
Patella vulgata (L).
,, *depressa* (Penn).
Acmæa testudinalis (Müll).
,, *virginea* (Müll).
Gibbula magus (L).
,, *cineraria* (L).
,, *umbilicata* (Mont.)
Littorina obtusata (L).
,, *rudis* (Maton).
,, *littorea* (L).
Paludestrina stagnalis (Bast.),
[= *Hydrobia ulvae*].
Bittium reticulatum (da Costa).
Turritella communis (Lam).
Aporrhais pes-pelecani (L).
Buccinum undatum (L).
Neptunea antiqua (L).
Tritonofusus gracilis (da Costa).
Purpura lapillus (L).
Bela turricula (Mont.)
Clathurella purpurea (Mont.)

None of these can be said to be of any rarity, and in this respect the shore was disappointing. It was curious, however, that *Gibbula magus* was very frequent, more so than I remember in similar localities. But perhaps the most striking molluscan feature of the shore was the complete absence of *Pecten varius*, and on the other hand the comparative frequency of its white variety *nivea*. Never do I recollect meeting with so many representatives of this variety, though none were full grown, and most were only valves. This is quite in keeping with what Jeffreys (*Brit. Conch.* ii. 57) says, "I have never seen a single specimen of *P. varius* from the Hebrides." The type is certainly rare, but not so unknown as Jeffreys would make out. North of the Clyde waters, where it is comparatively abundant, I have obtained it at Port-Ellen, Islay;[*] at Onich,[†] in 14 f., about 5½ miles from Duror; and in South Uist;[‡] while it has been taken at Oban by Dr. Robertson[¶] and Rev. James E. Somerville; S.E. of Lismore by Brook;[||] in Loch Nevis by Alfred Brown;[§] and at Gairloch, Ross-shire, in 12 f., and in Loch Broom, in 20 f., by Mr. Alex. Somerville. The variety *nivea*, however, is widely dispersed throughout the Hebrides. From Oban it is recorded in 15 f. by M'Andrew,[**] Canon Norman,[††] and Darbishire;[‡‡] in 25 f. by Rev. Jas. E. Somerville and Mr. Alex. Somerville; while Messrs. Chaster and Heathcote state that it is fairly common in the Strait between Fraoch Island and Kerrera, attached by byssus to *Laminaria*.[¶¶] Mr. Frank Coulson has taken it at Dunolly in 6-15 f., in Loch Creran in 7-26 f.; and at the head of Loch Spelve, Mull. Alfred Brown obtained it also in Loch Creran; Jeffreys gives "Loch Carron," and adds he has found it "in every part of the Hebrides." (Would that he had recorded the localities!). Macgillivray mentions the Outer Hebrides; M'Intosh[||||] names North Uist; while I have found it at spots as far distant as Ganavan Bay, near Oban, and Borve Bay, on the Atlantic side of Barra. Jeffreys gives the interesting piece of information that a quarter of a century before the date (1863) of his book on British Conchology, when this pretty variety was not easily procurable, and therefore exceedingly rare, a specimen fetched £2, but he adds "fifty or more may now be had for the same price."

2. GEOLOGY.

The search after mollusca proving so unproductive, I next turned my attention to the geology of the district. Soon, however, the extraordinary intricacy of the subject became evident. The strata are so intermixed, contorted, and involved, that it was extremely difficult to read a satisfactory story out of the rocks of the locality. I therefore secured numerous petrological specimens, and sent them to the Geological Survey with a request for further help. With their wonted courtesy, Mr. Macconochie and Mr. Clough kindly identified my specimens to the best of their ability, though they confessed that some of them were quite unfamiliar, so strange was the aspect of the felsitic rocks of the neighbourhood. The district has recently been

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[*] *Perth. Soc. Nat. Sci. Trans.*, iv. (1906), p. 146.

[†] *J. of Conchol.*, vii. (1893), p. 233.

[‡] *Perth. Soc. Nat. Sci. Trans.*, iii. (1903), p. 211.

[¶] *Fauna and Flora of the West of Scotland* (Brit. Assoc. Meeting, 1876).

[||] *Royal Soc. Edinb. Proc.*, xiii. (1896), p. 166.

[§] *Scott. Fishery Board Report*, 1892, Pt. iii., p. 173.

[**] Forbes & Hanley *Brit. Moll.* ii. 277.

[††] *Quart. Journ. of Conch.*, i. 275. [‡‡] *J. of Conch.*, vii. (1894), p. 305.

[¶¶] *Ibid.* [||||] *Roy. Soc. Edin. Proc.*, v. (1866), p. 600.

geologically surveyed, but neither the map nor the letterpress are yet ready for publication.

Let me first of all briefly describe the broad geological features of the district. Duror is contained within the vast area of the Highland crystalline schists, which go to make up such a large part of our characteristic Highland scenery. But to the N.E. there towers Ben Vare, with its twin peaks, a gigantic mountain of granite, whose summits, Scuir Donill, 3284 ft., and Scuir Dearg, 3362 ft., are scarred and weather-worn to no ordinary degree. The quartz-felsite near the summit of Scuir Donill is red in colour, and in the setting sun glows with a fiery brilliance which is most remarkable. The actual summit, however, is composed of a truly cyclopean pyramid of darker granitic rocks piled, or rather weathered, on the top of each other in the most bewildering confusion, reminding one strongly of the summit of Goatfell in Arran. From the cairn a most extensive view is to be obtained, from the Paps of Jura in the South to Loch Oich in the North, and from the mountains of Rum in the West to lofty Schiehallion and Ben More in the East. While I was resting at the cairn, a splendid eagle sailed across the vast gulf between Ben Vare and Aonach Eagach, inspected me at close quarters with wondering ken, perhaps imagining I was a tempting carcase for its talons to peck at; but discovering by my raising my stick that I was still alive, it soared aloft till it must have been fully 4,000 feet above the bottom of the valley, and then wheeling round, it made a straight course for the dark crags of Bidean-nam-Bian and disappeared from view.

Lying against the granite of Ben Vare to the S.W. is the promontory of Ardsheal, composed mostly of schist, but with two intrusions of augite-diorite, one on the shoulder of Ardsheal Hill (863 feet), and one at Rudha Mor, the extreme S.W. point of the Ardsheal promontory. A little over a mile south of Rudha Mor lies Eilean Balnagowan, an island uninhabited except by cattle and sheep, where a third intrusion is found of the same augite-diorite formation.

But in between the granite mass of Ben Vare and the elevation of schist at Ardsheal Hill, there lies the snug little bay of Kentallen. A little nearer Ballachulish are the famous grey granite quarries, but between these quarries and Duror there occurs a patch of stone which has given a name to a new species of rock—Kentallenite. Its properties have been investigated, and its distribution noted in an exhaustive paper contributed to the Geological Society in 1900, by Messrs. J. B. Hill and H. Kynaston.* The authors prefer the name "Kentallenite" to that of "olivine-monzonite," which was applied to it

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* "On Kentallenite and its Relations to other Igneous Rocks in Argyllshlre," by J. B. Hill, R.N., and H. Kynaston, B.A., F.G.S. (*Quart. Journ. Geol. Soc.*, Vol. 56, 1900, pp. 531-558).

by Mr. J. J. H. Teall.* They state "At Kentallen the rock has been quarried for many years, and is locally known as 'black granite.' A hand-specimen is frequently coarse in texture, and biotite, augite, and olivine can be easily recognised with the naked eye. Brown mica occurs in large plates in the coarser varities, and shows a characteristic lustre-mottling." The authors, in differentiating "Kentallenite" from "Shonkinite" of the Yogo Peak, Montana, and from the "olivine-monzonite" from Smälingen, Sweden, investigated by Prof. Brögger, give a succinct definition of what Kentallenite is. Kentallenite, they say, "belongs to a peculiar class of basic rocks, of extremely local occurrences, but now becoming more generally recognised, in which orthoclase and an intermediate or acid plagioclase are associated with such basic minerals as olivine, augite, and sometimes also hypersthene, biotite being also generally present; and these rocks include such types as the shonkinite of Montana, and the olivine-monzonite of Scandinavia."

A section of the Ardsheal Peninsula then from Ben Vare to Rudha Mor would reveal the following particulars :—After the Ballachulish Quarry of grey granite, there comes this patch of black Kentallenite, fragmentary outliers of which are to be found in a much decomposed boss-like mass in Glen Duror, about 1½ miles S. of Kentallen, and also at a spot 1½ miles S.W. of Dalnatrat, at the mouth of Glen Salachan, where a dyke of it makes its appearance. After the Kentallenite, there comes near Lagnaha Farm a mass of quartz rock, which, when in proximity to the granite, contains crystals of felspar, and becomes almost a porphyry.† This quartz-rock is remarkable in its configuration. In some places it is planed as smooth as a slab of marble, and its dip is very much inclined. I climbed up the side of Ben Vare to where it makes its appearance. There was here a large quarry, in which a number of men were at work. The rock is hewn out in great blocks, and lowered down the mountain side to where it can be carted to the railway line. It is then conveyed either by rail or steamer to Glasgow, where it is employed for ceramic purposes. It is locally known under the name of "China-rock." As will be seen further on, this curious slab-shaped quartz formation makes its appearance at several points along the shore of Cuil Bay, dipping under the schistose rocks of Ardsheal Hill.

Then follows a stratum of grey limestone, about 12 feet in thickness, and above this limestone a section of dark grey slates, the slates dipping in the same direction. But now cross the shoulder of the

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* Ann. Rep. Geol. Survey, 1896 [1897], pp. 23, etc.

† "On the Rocks of Portions of the Highlands of Scotland, South of the Caledonian Canal; and on their equivalents in the North of Ireland," by Prof. R. Harkness, F.R.S., F.G.S. (*Quart. Journ. Geol. Soc.* Vol. xvii., 1861, p. 266).

hill and descend on Cuil Bay; here you recover the slates, but the inclination of their strike is reversed. Once again you meet, as I said, with the slab-like quartz formation; and then finally the quartzites repose against a mass of granite, which forms the extreme S.W. shore of the Ardsheal peninsula.

After this general survey of the district, I should like to take you in a geological excursion along the shores of Cuil Bay, starting from the Railway Station, and proceeding to Rudha Mor. Only in this way will the exceeding perplexity, and also the great interest of the coastline and its geological structure be shown. I will enumerate the changes of rock formation as we go along, and show slides illustrative of the strata, etc.

1. At the Railway Station there are a number of gigantic masses of quartz. On some of them seeds have found lodgment, and have sprung up as trees. Their great white masses stand out most conspicuously above the grass.

2. Below them and the grassy meadows lies the bed of the River Duror, in which, in addition to fragments of schist, granite, and other rocks, I found a small stratum of marble. It occurred in the face of a steep portion of the right bank of the stream.

3. From the river to the first of the three large rocky promontories there stretches the Bay of Cuil, made up of shingle of varying degrees of coarseness, and terminating in sand at the low water mark. The land behind is used for grazing and arable purposes. It is manifestly a raised beach, and the waves must formerly have washed the base of the half-circle of slopes which rise up into Ardsheal Hill.

4. Cuil Bay terminates in a promontory, formed of a dyke of felsitic igneous rock, varying in width from 6 to 20 feet, which Mr. Maconnochie describes as "very puzzling."

5. Veins of siliceous rock with iron pyrites.

6. Stratum of mica schist, 2½ feet wide, on edge, and very rotten, probably from the dark slate series of the Ballachulish area.

7. Felsitic igneous dyke, 2½ feet wide.

8. Stratum of mica schist, varying from 20 to 30 feet in width.

9. Felsitic igneous dyke, 1 foot broad.

10. Mica schist lying unconformably.

11. Veins of pure white quartz; some one inch broad, some at right angles to main line of bedding, forming square pockets enclosing schist.

12. On the top of the promontory a boulder of granite.

13. Mica schist in a different strike from 10, lying E. and W., and facing N.

14. A small bay of rough big stones and gravel, 32 paces across.

15. Second promontory of schistose rocks.

16. Veins of quartz 1 to 8 inches broad, faulted thus 

17. The wedge-shaped promontory of contorted schists has been planed down by ice quite smooth. Beautiful striae running S.E. and N.W., are visible at right angles to the strike of the rock.

18. On the western side of this promontory, the schist is dark and silvery.

19. The promontory is bounded on its west side by a vein of brown intrusive felsitic igneous rock, intensely hard, which splits into two or three smaller veins, ranging from 1 inch to 2½ and 4 inches.

20. Next this is a thin strip of rock mostly vein quartz, but dark in hue.

21. Another curving beach of stones, below the salmon fishers' hut.

22. In this bay is a small promontory, which is an island at high tide. The schists here have been planed down most beautifully by ice, and the striae, running E. and W., offer a splendid example of *roches moutonnées*.

23. The low promontory has a depression on its W. side, and in the middle between two spurs of rock lies a loose big boulder. It is an ultra-basic igneous rock of hornblende and biotite.

24. A small bay only a few paces across, lined with stones.

25. Another promontory of mica schist, with same strike as main body elsewhere.

26. Mass of intrusive felsitic igneous rock, cutting across the schists in a big boss.

27. Mica schist, very rotten and friable, probably from the black schists of the Ballachulish district.

28. Beach of stones, varying from 10 to 30 feet across.

29. Dyke, varying from 3 ft. 9 in. to 4 ft. 4 in. wide, of black felsitic rock, faulted in places, and lying in the same tilt of angle as the inverted schists.

30. Mica schist.

31. Small boulder of white vein quartz, lying on surface.

32. Mica schist.

33. Dyke of intrusive felsitic igneous rock, ranging from 5½ to 7 feet in width, and tapering to a narrow point.

34. Mica schist.

35. Dyke of felsitic igneous rock, bright red on surface varied with black, through weathering.

36. Mica schist.

37. Dyke of intrusive igneous rock 1½ feet wide.

38. Mica schist.

39. Dyke of black intrusive igneous rock 1 ft. wide.

40. A beautiful sandy bay.

41. Halfway along this bay, above the highest tide marks, lies a remarkable heap of stones, a distinct evidence that the soil between the shore and the hills is merely a raised beach. The stones are scattered over a wide area very thickly and deeply, and the land behind is seen to be a continuation of the same stony tract, the heather merely covering what was once a shore littered with loose stones.

42. This sandy bay is bounded on the west by another great promontory of inverted schist, whose margin I shall ask you to proceed along till the point is reached, and then double back to the mainland by the other side.

43. For a long stretch along the eastern shore the sides of the promontory are at a steep angle, planed smooth across the upturned edges of the strata, which run from N. to S. These smooth sides are furrowed at right angles to their lie by rills of water, which have attacked weak spots in the joints. But half-way to the point, the strata are thrown into the utmost confusion, by a mass of intrusive volcanic matter, which has tossed the schists into every conceivable position, and a picture is presented of the havoc wrought by the upwelling of an eruptive dyke through superincumbent layers of rock.

44. This obstruction past, the strata resume their former regular tilted lie, but now the schists are intercalated by thin bands of calcite-silicate, which, however, do not extend to any great distance.

45. Further on, we come upon a dyke, which has been eroded, and has left a chasm about 4 ft. deep; a smaller companion dyke, 6 ft. away, presents a similar phenomenon.

46. The point itself affords a very odd appearance, the strata being almost on edge, and the upturned truncated surface being much eaten away by sub-aërial denudation, and more or less covered with sea-pinks.

47. Doubling back to the last bay, and pursuing our course along the opposite side of the promontory, the shore line, owing to the lie of the strata, is seen to be much more rugged and broken up and precipitous than the corresponding side that we have already traced. Near the beach there lies a large mass of vein quartz, whose dazzling whiteness make it a very conspicuous object against the background of dark contorted schist.

48. A curving beach of stones and gravel, for about ⅛ of a mile.

49. The last promontory of all—Rudha Mor—is full of interest.

At the spot where it juts out from the beach, there is a succession of massive fine-grained quartzite dykes, faulted every here and there, and lying inclined at a gentle angle of about 10°. Their surface is perfectly smooth, and their appearance at first suggests vast slabs of marble. In reality these slabs are the continuation of the so-called "China-rock" which we saw in the hill quarry behind Lagnaha Farm.

50. Proceeding along the promontory seawards, the strata are greatly broken up. The fine-grained quartzite appears in thin bands which have weathered into extremely rugged bosses, which render walking difficult.

51. Some thin strata of schist.

52. The fine-grained "China-stone" quartzite now appears in the form of a regular gradation of steps and stairs, forming a remarkable structure.

53. Embedded at right angles to these quartzites are numerous very thin veins of pure quartz, as a rule ½ inch in breadth.

54. A tiny little bay of gravel.

55. Continuation of the promontory, the "China-rock" steps and stairs formation very massive.

56. The "China-rock" slabs have weathered blue-grey in some places, alongside of other portions yellow and white, exhibiting a remarkable appearance.

57. The extreme tip of Rudha Mor is a surface of flat rock still of the same formation, and littered thickly with the broken shells of *Mytilus edulis*, *Buccinum undatum*, *and Purpura lapillus*, along with those of several species of *Echinus*. These form the remains of the dinners of innumerable gulls, who for ages have used these broad slabs of rock in this solitary spot as a suitable table on which to smash their victims' dwelling places! The slabs taper off under water, and in clear weather can be seen projecting southwards for some distance beneath the surface.

58. Returning along the western shore, the first feature of interest is what looks like a "shute." It is a smooth slab of quartzite rock with high sides, for all the world like those tilted wooden gangways down which passengers' luggage is shot from the quay into the holds of steamers. It presents an extraordinary appearance.

59. All the way back on the west shore the coast is much indented, and every here and there gigantic masses of granite emerge. Some of these have been moulded and striated to a very remarkable degree by the glacier ice which must have passed down Loch Linnhe in a broad compact mass.

60. The confusion of granite and quartzite at this part of the Ardsheal peninsula is perfectly bewildering, and it will be interesting,

when their Memoir appears, to see what success the officers of the Geological Survey have had in unravelling geological problems so intricate.

Such in briefest outline is the series of geological phenomena to be witnessed in the course of a stroll from the Railway Station at Duror along the Bay of Cuil, following the indentations and curvings of the shore as far as Rudha Mor and the western side of the Ardsheal Peninsula. All the way the scenery is most beautiful, and the loneliness of the coast (for, apart from cattle and sheep, you never meet a living creature) adds greatly to its charm.

But now, before I pass to the antiquities of Duror, let me, in a word or two, refer to one of the excursions which can so easily be made from this spot. The savage Glencoe is within easy reach, whether by train or by cycle. The road from Duror by Kentallen to Ballachulish undulates along the shore, and at every turn new visions of beauty arrest the eye. After passing the narrow entrance to Loch Leven at Ballachulish Hotel, the route curves round the southern shore to where the river Laroch rushes down from the back of Ben Vare. The once flourishing and famous slate quarries were silent, owing to industrial disputes, and hundreds of the workmen had found employment in building the new town, which is being erected at the head of Loch Leven for the Loch Leven Water Power and Electric Company. Leaving the half-deserted village, the road passes under a lofty archway of slates, and curves round the bay to the Bridge of Coe. On the opposite side of the bay, Invercoe House, the residence of Lord Strathcona, occupies a most prominent position, its red roofs contrasting with the green woods that stretch up the lower slopes of Sgor-na-Ciche, the Pap of Glencoe.

Just beyond the Bridge of Coe, on a knoll stands the Monument commemorating the atrocious Massacre of Glencoe in 1692, a deed of darkness that will be remembered as long as Glencoe itself. Hitherto the rocks have been schistose in character, but as one proceeds up the Glen there is an emphatic change. At Clachaig Inn to right and left vast granite peaks emerge. Those on the right comprise the An t Sron granite and granitoid porphyritic masses, while to the left there tower overhead the crags of Aonach Eagach, of the same geological formation. Half a mile further up the glen, Loch Triochatan comes in view, with tremendous frowning crags overhead, and here there are evidences at its western margin of a powerful fault, which throws the lavas of the upper portion of the glen in truncated masses against the schists and granite. For several miles after this the glen is flanked by terrific black precipices of volcanic rocks of the Lower Old Red Sandstone age, regarding which Dr. Peach and Mr. Muff have reported as follows :—“On the N. side of Glencoe the volcanic rocks are separated from the underlying schists by greenish grey conglomerate, sandstone, and shale. In places, the conglomerate is like a *remanie* breccia of quartzite and vein quartz, but for the most part the boulders are large and well rounded, being set in a sandy matrix. Some consist of andesite like the overlying lavas, showing that the volcanic condition had already existed for some time in the region, and that the lavas had been exposed to subaërial denudation near at hand. The most striking boulders, however, are of granite, diorite, and other granitoid rocks, many of which are so large as to suggest that they are not far from their parent source. As most of them are isolated in sandstone it is not improbable that they may have been floated into their present bed. These sediments are succeeded by a pile of basic andesitic lavas and agglomerates with a few thin intercalations of reddish shale between some of the flows. The basic andesites are succeeded by a thin zone of rhyolitic lavas and agglomerate, which have a much greater development on the south side of the glen, and these are in turn overlaid by andesitic lavas and agglomerates. On the south side of the glen, the basic andesites of the lower zone rest unconformably on the denuded edges of the schists, and comprise many lava flows, between which thin beds of agglomerate or red shales are occasionally found." *

3. ANTIQUITIES.

The name *Duror* is of somewhat doubtful etymology, but it is not improbable that it may be derived from *dyr* + *â-r*, *dyr* being the Norse for a deer, or wild animal.† *Ardsheil* is said to be from *Seile*, *a'ghlas sheile*, the water-brash ; for "although there is no river named Seile near this spot now, it may almost be taken for certain that the stream falling into Kentallen Bay *(= Cinn an t'-sailean)* was so named in the past."‡

There are not many features of antiquarian interest in the neighbourhood, but such as there were, I did my best to visit. The oldest of all is the solitary monolith, 13 feet high, which stands by itself in a field of rank grass. I tried to discover any local traditions regarding it, but my investigations were in vain. Its erection must date back far into an age before written records. It is therefore strange to observe a Caledonian train running at the rear of this standing stone, thus linking the 20th century with prehistoric times! The stone, however, has given a name to the farm and estate on

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* *Summary of Progress of the Geological Survey* for 1903, pp. 69-70. See also further Report by Mr. Muff, in the *Summary of Progress* for 1905, pages 95-97, where a geological sketch map of the Glencoe region is given.

† H. Cameron Gillies, M.D., "The Place-Names of Argyll," 1906.

‡ *Ibid.*

which it stands—Acharra (*achadh à charraigh* = the field of the standing stone or pillar).*

From the age in which this menhir was erected to the building of Castle Stalker may represent, for all we know, an entire millennium. The castle, which lies on an islet, just off Portnacroish in Appin, was founded by Duncan Stewart of Appin, as a hunting seat for his monarch, James IV. Its name, *Eilean an Stalcaire*, "the island of the falconer" has been corrupted into Castle Stalker. The keep was of the usual structure of those days: three storeys in height, with the indispensable prison vault dug in the rock underneath. James IV. seems to have had a strong liking for this neighbourhood, game of various kinds probably being plentiful—deer in the glens and corries, salmon and trout in the river, grouse on the moors, seals in the quiet sheltered bays, of which there are so many in the vicinity. He must also have been an energetic hill climber, if it be the case that he left a memorial of his presence on the rugged summit of Ben Vare.

In 1892, the late Dr. Stewart of Onich, the well-known "Nether Lochaber," graphically described to me how one day a stalwart shepherd appeared at his door with a tale on his lips and the proof of the story in his hand. He had, he stated, been looking after his sheep on the broad flanks of that mighty Ben, and as the sun was westering he reached the cairn, and sat down for a few moments to admire the magnificent view. Idly he was striking the loose mountain moss with his crook, when lo! as he raised it to strike once more, he found dangling from the end of it no less than a massive brooch! He placed the relic in his pocket, and came straight across the ferry at Ballachulish to the doctor, who was the recognised authority, and the man to be consulted, on everything in the parish. "Nether Lochaber" took him into the kitchen; weighed out to him on the kitchen scales as many shillings as the brooch was heavy, and the shepherd departed in high good humour. On being cleaned, the brooch was discovered to be the veritable brooch of King James IV., who must have lost it while hunting on the top of Ben Vare, sometime about 1490-1510, A.D. It is now in the Museum of the Society of Antiquaries of Scotland in Edinburgh.†

It is, again, a long interval from James IV. to the rebellion under Prince Charlie in 1745; but the next subjects of antiquarian interest are concerned intimately with that rising. The Stewarts of Ardsheal,

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* *Ibid.*

† In a letter received subsequent to the delivery of this lecture, Dr. Joseph Anderson, of the Museum of Antiquaries in Edinburgh, informs me that he is afraid that Dr. Stewart's zeal has outrun his facts in this matter. He states that though the brooch is ancient, and a handsome specimen, there is no mark on it to identify it with James IV.

like their relatives the Stewarts of Appin, threw in their lot with the head of their clan, Prince Charles Stewart. After the defeat of Culloden, the Ardsheal estates were confiscated, but were restored about 1770. Colonel Charles Stewart, however, had to remain in hiding for a considerable period after the battle, ere he could make his escape to France. I was curious to see for myself his place of retreat. It is a cavern in the side of a deep ravine which flanks the quarry where the quartz "China-stone" is excavated. One of the quarrymen kindly guided me to the spot, and indeed, without his help, I question if I could have found the road to the cave. The way was up the face of the precipice formed by the excavation of the quarry till the shoulder of the hill was turned, then by the margin of the ravine, through which thunders a noisy stream 100 feet below, to a spot where, at the foot of one waterfall and at the head of another the cave is seen. I had to pass behind the waterfall, and reached the interior in safety. A secure enough retreat, I daresay, but wretchedly damp, always moistened by the spray of the cataract which pours over the front of the cave. The cavern might hold from 20 to 30 men, but I do not envy the refugee who was forced to spend weary months in this lonely solitude, with the never-ending roar of the waterfall almost drowning all speech.

But Duror has become immortalised in literature through being the scene of the celebrated Appin Murder case of 1752, and the story of that event has been told with scrupulous exactness and marvellous vividness in Robert Louis Stevenson's "Kidnapped" and "Catriona." The incidents connected with that *cause célèbre* are as fresh in the minds of the natives of the district as if they had occurred last month, and every one speaks of James Stewart and Alan Breck with an intimacy that betrays how deeply the story of the tragedy has sunk into the minds of those resident in the neighbourhood. The series of slides I show will bring out some of the main incidents of the story.

James Stewart of the Glen, as he was called, was concerned in the rising of 1745, and possibly was at Culloden. He was pardoned, however, and returning to the West, became farmer of Glenduror, where he remained till 1751. He then moved across the river Duror to the farm of Acharn. The old house is still standing, with walls three feet thick, at the back of the more modern steading. The barn is a little further up the hill to the rear. The approach to the house is most beautiful, the stately avenue of trees skirting a pleasant grass park, while overhead towers rugged Ben Vare. A sweeter spot could not be found in all the Highlands. Here James brought up his family, Allan, Charles, and Elizabeth, and also an orphan boy of a neighbouring farmer, Alan Breck Stewart. The latter became a soldier of fortune, a spendthrift, and a prodigal.

The Ardsheal tenants not only paid taxes to King George, but also sent extra rents to their exiled chief. Just at this time there was appointed factor of the forfeited estates of Ardsheal, Callart, and Mamore, a neighbouring proprietor, Colin Campbell of Glenure, locally known as the "Red Fox," the eldest son of Patrick Campbell of Barcaldine and Glenure, and married to a niece of Lord Reay. Affairs became more and more complicated. Glenure was a Campbell, James a Stewart. They were opposed in everything—in clan attachments, in politics, in the sides they had chosen in the late rebellion. Misunderstandings, suspicions, and embitterments grew more and more keen. Then at Whitsunday, 1752, it was proclaimed that a number of Jacobite tenants on the Ardsheal estates would be evicted. Great was the wrath of the countryside.

On Thursday, 14th May, Glenure, who had been at Fort William, came through Onich to Ballachulish ferry. He travelled with a party of three, and intended to pass the night at Kentallen Inn. As they rode through the wood of Lettermore, a shot rang out, and Mungo Campbell, the Edinburgh lawyer, who was one of the Red Fox's companions, heard Glenure exclaim, "O, I am dead!" He turned and saw at some distance a man with a short dark-coloured coat and a gun in his hand climbing the hill and disappearing from view. Glenure soon afterwards expired. His cairn stands to this day. Who had shot him? Not James of the Glen, for the terrified servant found him at his own farm of Acharn a little later, quietly engaged in his accustomed duties; and his distress on learning of the murder was evident. Alan Breck with good cause was suspected, but he could not be found. His adventures to avoid arrest form the exciting incidents in "Kidnapped." But the Government of the day conceived it necessary to strike terror into the Highlands, and by making an example of one man, to pacify the whole Gaelic speaking population. James was arrested and illegally imprisoned in Fort William; counsel denied him for a long time; then with every semblance of justice, but before a packed court of Campbells, Stewart was tried for his life at Inveraray. It was the greatest judicial trial of the 18th century, but it says little for the cause of justice. With a Campbell on the bench in the Duke of Argyll, and eleven other Campbells among the jury, the hereditary foes of his clan, what chance of an acquittal had a poor Stewart? Andrew Lang has said, "James Stewart was, to speak plain words, judically murdered," and Mr. Omand, in his "Lord Advocates of Scotland," boldly asserts that "there can be little doubt that Stewart was sacrificed to political considerations."* James was sentenced to be hanged for the crime of murdering

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* *Trial of James Stewart (The Appin Murder)*, "Notable Scottish Trials," p. 28, edited by David N. Mackay, 1907.

Glenure, though every man in broad Scotland knew he was innocent. He maintained his innocence to the very end, and his speech at the foot of the gallows tree is a very remarkable one indeed. The last evening of my stay in Duror, I went to the spot of his execution. It is the top of a knoll, at that time bare, but now thickly covered with trees, that stands immediately behind the Ballachulish Hotel. The holes dug for the gallows are still visible, and as I stood in the light of the setting sun the full pathos of the scene came back upon me with great force. The 35th Psalm, which James recited before his execution, is still known all over the Western Highlands as "Salm Sheumais a' Ghlinne"—"James of the Glen's Psalm."

For months the body hung in chains, conspicious north, south, east, and west, on that lofty exposed knoll. Then a "daft" lad "overthrew the gallows, and cast it into Loch Leven. It floated down Loch Linnhe and up Loch Etive, landing finally, a strange piece of flotsam, near Bonawe. Here it found a humaner use, and was incorporated in the structure of a wooden bridge."* James' bones were secretly collected, and buried by night, it is said, with the kindred dust of some of the Ardsheal Stewarts in Keil Churchyard in Duror of Appin. The graveyard lies close to the sea, and forms a quiet old-world resting place for the body of one who was so cruelly and unjustly dealt with.

The last matter of antiquarian interest with which the district is associated is the alleged site of the original of Tullyveolan of Sir Walter Scott's "Waverley." An elderly farmer in Duror, who had been the cicerone of R. L. Stevenson in regard to the details of the Appin murder when that author was residing in the neighbourhood for the purpose of collecting "local colour," informed me that his father had been gardener on the estate of Ballyveolan at the head of Loch Creran. Sir Walter often visited that mansion house, and wrote some of his novels in an arbour in the garden. Readers of "Waverley" will remember that the Baron of Bradwardine had for his ancient family motto "Bewar the Bar," and that "bears" were to be seen in many carvings in all parts of the house and garden. My friend informed me that the "bears" are still to be seen. Some of them form a row of stone pillars from which are suspended gratings to keep back seaweed from being carried into the garden by excessively high spring tides. Sir Walter used frequently to converse with the old gardener, and my friend stoutly maintained that whether or not the present Bally-veolan is the actual original of the Tully-veolan of "Waverley," there is evidence to show that the idea of the "bears," and possibly the very name too, were derived from this beautiful Highland residence on the shore of Loch Creran. Certain it is that the estate

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* *Ibid*, p. 368.

Invernahyle, mentioned so interestingly in the Preface to "Waverley," is only about three miles away on the opposite side of the loch, so that Sir Walter betrays his intimate acquaintance with the legends of the locality. The laird of Invernahyle is now the owner of the house of the judicially murdered "James of the Glen" in Duror, and thus an interesting link between the two stories has been established.

XXV.—*The Microscopic Structure of some Local Igneous Rocks.*

By Geo. F. Bates, B.A., B.Sc.

(Read 9th April, 1908.)

Part III.

It is with some diffidence that I venture to put before you to-night a third portion of a paper on the microscopic structure of igneous rocks. It is not to be expected that those who profess in many cases only a general interest in Natural Science can follow with attention a succession of papers on the same subject, however engrossing it may be to one who has a special interest in it. There must necessarily be a certain sameness throughout, and bearing this in mind, I proposed that Part III. should be taken as read, so that an opening would be left for some other contributor, and it is only in deference to the wishes of the President and Secretary that I appear before you now. I take this opportunity to rectify an unfortunate oversight in Part II. of my paper. The quarry referred to on page 197 is that known as Two-Mile House Quarry, near Murrayshall, *not* Muirhall.

Before going on to the rocks which I have selected for study this evening, *i.e.*, some of the rocks of the igneous complex lying between Loch Tay and Comrie, there is one other rock which I should like to refer to in some detail. This rock would have been treated more appropriately in the preceding part, but at the time that was read I had had no opportunity of securing specimens. It is the rock known as diabase, and it occurs in various areas among the Sidlaws to the East and North-East of Perth. There is a small exposure to the north of Kinfauns Castle, crossed by the road to Balthayock; and another immediately to the west of the village of Longforgan. The largest area, however, in this neighbourhood, is to the north of the second of those just mentioned. It is well exposed in the Knapp Quarry near Rossie Priory, and it is there that my specimens were taken. To the naked eye it is a dark grey, almost black rock; compact, and obviously crystalline, but without the large porphyritic constituents so abundant in the andesites which lie to the west and north of it.

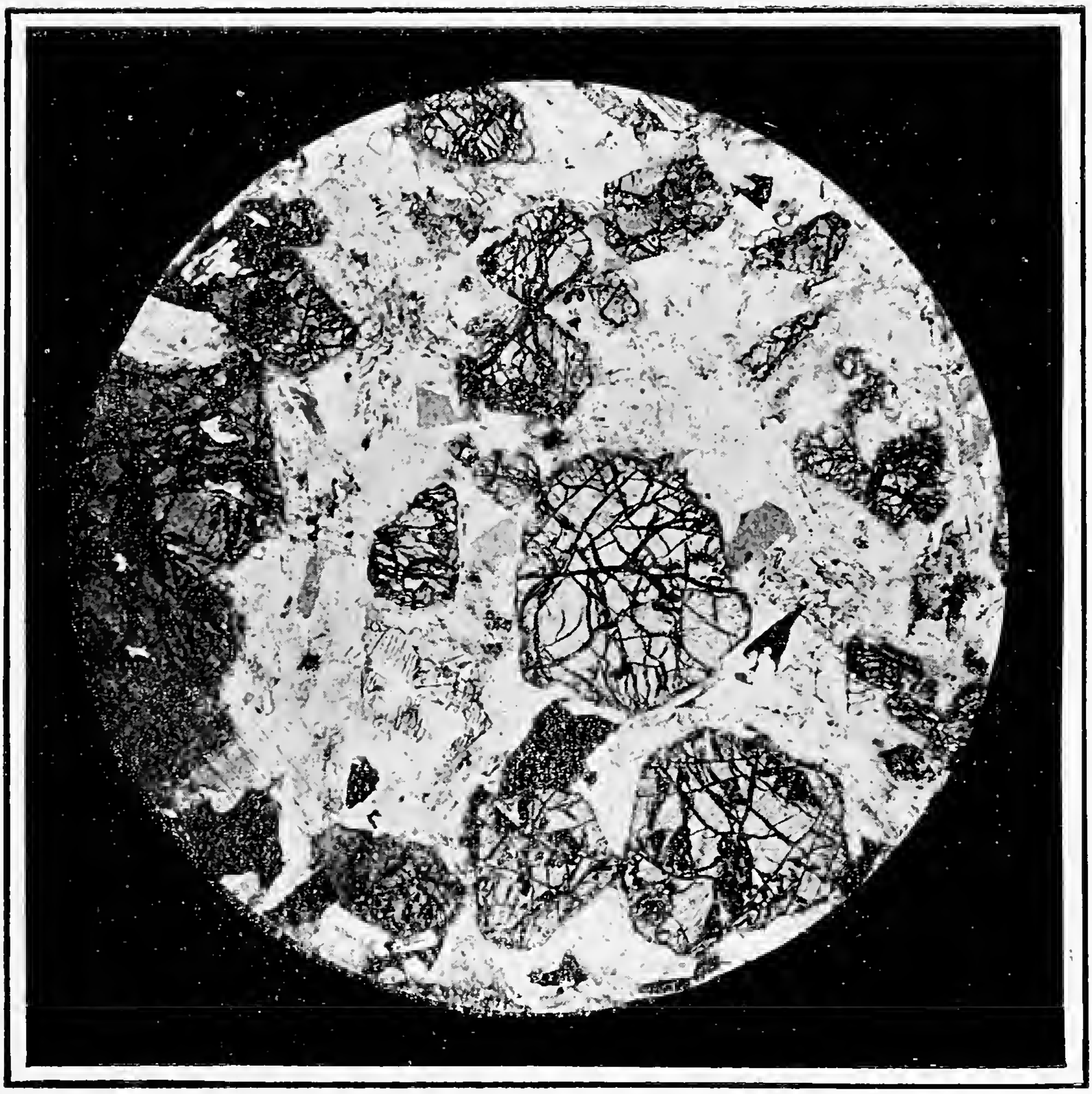

Plate 51.—Kentallenite, Duror, magnified 10 diameters.

SKETCH PLAN OF DUROR DISTRICT

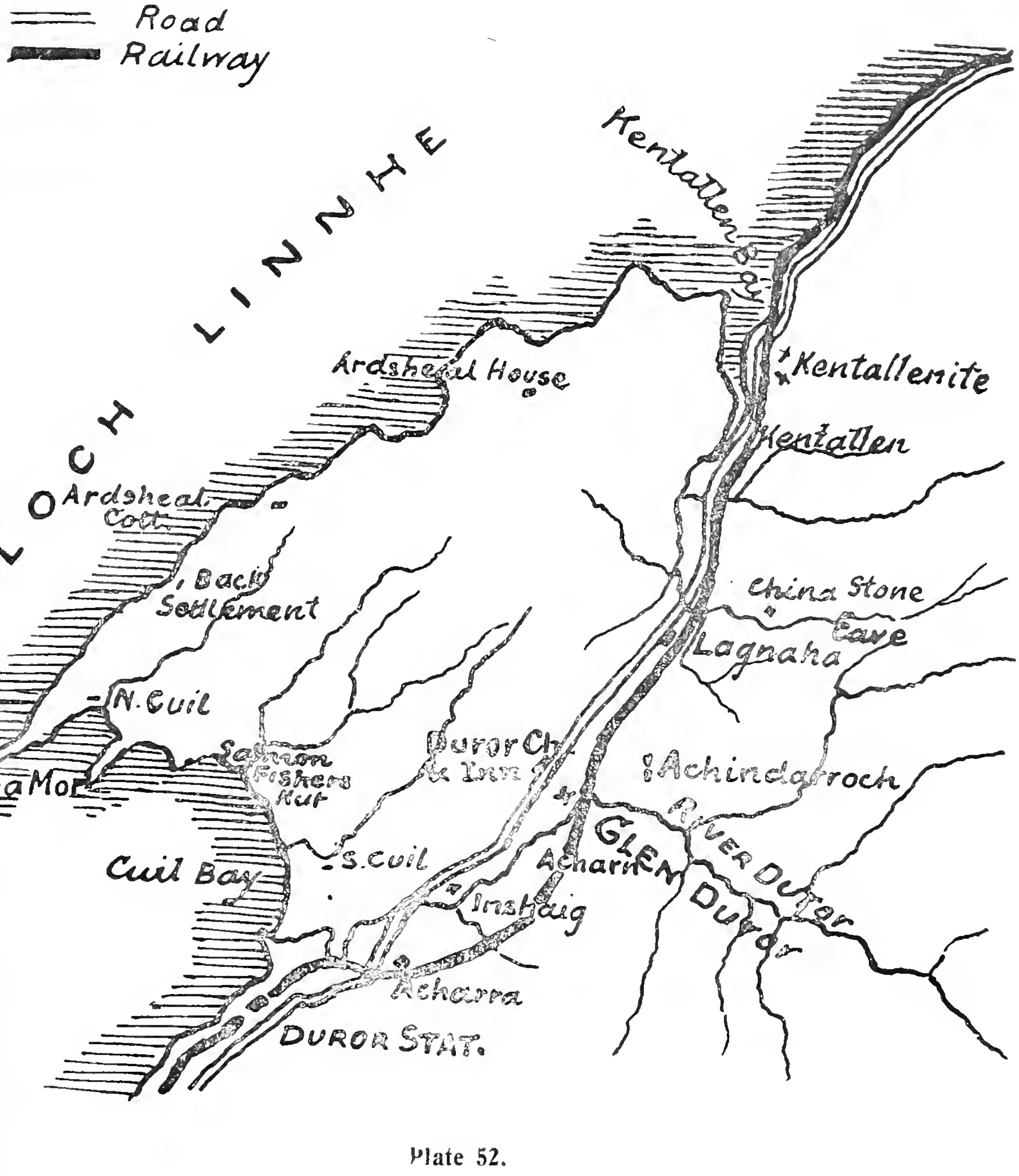

Plate 52.

When a section of this rock is made and examined with the microscope, the most abundant mineral is seen to be a plagioclase felspar, occurring in lath-shaped crystals, with the characteristic multiple twinning. The low extinction angles show that this felspar is andesine, or some closely related variety. As a result of alteration processes, most of the crystals are stained with brownish or colourless granular material.

Filling up the spaces between the felspar crystals, we find in many places a green or greenish-brown material, which under favourable conditions of illumination and magnification can be seen to have a somewhat fibrous structure; and this is doubtless a mineral of chloritic nature, developed by alteration from some original ferro-magnesian constituent, probably augite.

Less abundant than the altered augite, there are crystals—usually more or less imperfect—of a mineral which we have no difficulty in recognising as olivine. Its crystallographic contours (where present), its shagreened surface, and its irregular cleavage cracks, filled with decomposition products, all enable us to identify this mineral with ease and certainty.

There are two or three other constituents to which I shall refer presently: but we have gone far enough now to identify the rock. Reference to the table given in Part I. will show that the rock belongs to the basic division, and from its mode of occurrence and holocrystalline structure, it might be classed as a dolerite. The term dolerite is, however, usually limited to those rocks which occur in comparatively small intrusive masses as dykes and sills, while for the larger masses, such as we are dealing with, the term diabase is usually employed. Owing to the presence of olivine, the rock may be more precisely termed an olivine-diabase. Of the accessory minerals present in the rock, the ubiquitous magnetite and apatite deserve scarcely more than a passing mention. The former is fairly abundant, and in some cases presents distinct crystallographic outlines; the latter is also abundant in both transverse and longitudinal sections.

Much more interesting are quartz and hornblende, both of which are sparingly present. The former is most probably a secondary product, as original quartz is not likely to occur in a rock of so basic a type as this: the hornblende is possibly original, being of the brown variety, with characteristic prismatic cleavage.

It will be observed that this diabase has some points in common with the dolerites considered in Part I. of my paper, and others with the andesites in Part II. It differs from the latter in the direction of greater basicity, as shown by the abundance of olivine. It has been shown that of all the igneous rocks (belonging to the same period of volcanic activity) in a given locality, those erupted in the earlier stages of the outburst tend to be more basic than those erupted earlier. It is possible then that in the diabases of the Sidlaws, we have the consolidated lavas of the earlier stages in the volcanic activity of Old Red Sandstone times, and in the andesites the lavas of a later stage, and consequently a somewhat less basic type. (See Plate 53.)

Coming now to the rocks which are more particularly the subject of this paper, I will ask you to take with me, in imagination, a trip up Glen Lednock.

Starting from Comrie, we pass in the first instance through a narrow wooded gorge, with steep, and in many spots, almost perpendicular sides. This gorge has been eroded by the stream: the lower part out of the clay slate, and the upper out of a schistose grit, two of the rocks of the Highland Metamorphic Series. The burn is crossed by three dykes; these are composed of dolerite, similar, in hand specimens at any rate, to those considered in Part I. of this paper. The lowest one is well seen in a quarry to the left of the carriage road up the glen, while the highest is at the picturesque cascade known as the "Deil's Caldron." A splendid bird's eye view of this part of the glen may be had from the Melville Monument, from which point the trench-like character of the gorge is very obvious.

A short distance above the Deil's Caldron the glen widens out, becomes almost treeless, and much tamer in its aspect; but in places fine views of the enclosing hills are obtained. Our first serious stop is at a foot-bridge crossing the Lednock about a mile above the Deil's Caldron. Here we have a good exposure of the first of the rocks forming the "igneous complex" of Glen Lednock. It is named diorite on the Geological Map; but this is at least 20 years old, and its names are splendid examples of "terminological inexactitude."

Let us see what a diorite really is. Reference to our table will show that it is a rock of intermediate composition consisting of felspar—plagioclase dominant, and a number of ferro-magnesian minerals, of which hornblende is the commonest, and augite the rarest. It is also plutonic, *i.e.*, of deep-seated origin, and consequently coarsely holo-crystalline. Closely allied to it is syenite, which differs only in having orthoclase dominant instead of plagioclase. Now for our rock: a section of it is here shown (Plate 54), photographed with a magnification of 10 diameters. The large slightly clouded areas are felspars, crowded with grains of decomposition products. Examination with polarised light shows both orthoclase and plagioclase, the latter being more abundant. The irregular dark patches are biotite: in the original section it presents a bladed appearance, colours brown and green. The brown is unaltered biotite, and the green is chloritic material derived from it by alteration. Then we have augite, green in colour owing to alteration, but still showing in longitudinal sections at all events the characteristic cleavage lines.

Hornblende is also present in the rock, and is readily recognised by its prismatic cleavage and pleochroism. It varies in colour from brown to brownish-green, though much of it presents a bleached appearance, due doubtless to alteration.

A typical diorite consists essentially of a plagioclase felspar and hornblende, but it will be seen that the rock in question contains biotite and augite as additional ferro-magnesian constituents, and as it is usual to name the varieties of a rock from these additional minerals, we may name this one a mica-augite diorite.

It has already been mentioned that orthoclase is present, and we have now further to note that quartz also occurs in small quantity, playing quite a subordinate part; but the presence of these two minerals shows that our rock is of a distinctly acid type, and this is only to be expected, seeing that granite is closely associated with the diorite in the Glen Lednock area, and indeed occurs in abundance at no great distance from the point at which the diorite specimens were taken.

Two other minerals deserve mention before we pass on to consider another rock. First, magnetite is abundant, but as this mineral appears so often as a decomposition product, it is probably such here to some extent, especially as it nearly always occurs in close connection with minerals prone to yield it; some of it, however, appears to be original.

Then the almost universal apatite is well developed, forming what we might almost call "nests" of the mineral. As it penetrates, and is enclosed by other minerals, it must necessarily have been amongst the first constituents of the rock to crystallise, as usual. The slide shows several cross sections of apatite in the form of more or less perfect hexagons, and numerous longitudinal sections of approximately rectangular form. Combining in imagination these two sections of the mineral, we see that its real form must be a hexagonal prism.

For our next rock we need to go for about two miles in a northerly direction; we therefore cross the Lednock by the foot-bridge already mentioned, and follow the road parallel to the river for some distance. Every now and again we come across an outcrop of the diorite; but, by and by, as we deviate from the stream, we cross an alluvial tract, and finally come across exposures of reddish, rather fine-grained rock in the beds of the smaller burns. Numerous boulders of the same lie about, or are built into the walls, and ultimately a good exposure of the rock is found, with some difficulty, in the bed of the burn, which flows down from the lower slopes of Carn Chois past the farm of Carroglen. The exposure being a natural one, there is the usual trouble in securing fresh specimens: the outer portion of the rock is splintered by the atmospheric agencies into angular fragments, and even freshly-broken surfaces show, under the lens, considerable traces of decay. At last tolerably good specimens are hammered out of the centre of a few of the larger fragments, and from two or three of these sections have been prepared. When examined with the microscope the constituent minerals are seen to be:—

(a). Quartz: highly transparent, with abundant strings and patches of inclusions, mostly in the form of minute granules, but here and there with crystalline outlines.

(b). Orthoclase felspar, much altered and obscured by decomposition products.

(c). Biotite or black mica, in characteristic ragged looking flakes, altered here and there into green chloritic material.

There is a remarkable scarcity of accessory minerals; apatite needles occur here and there; and a small amount of magnetite appears to be derived from the biotite, as it generally occurs in intimate association with that mineral. (Plate 55.) From the above it will be seen that the rock is of acidic type, and will be readily recognised as a fine-grained granite, or, owing to the presence of biotite and absence of muscovite (white mica), we may use the term biotite-granite, or, following Rosenbusch, granitite.

The relations of the granite to the diorite in the Glen Lednock area have formed the subject of much discussion. It was formerly considered that the two rocks represented two different intrusions of igneous material, but it is now generally believed that they represent one intrusion merely, the earlier phase represented by the diorite, and the later by the granite, thus affording another example of the principle already referred to regarding the succession of the materials erupted or intruded during a period of volcanic activity. It must be noted, however, that we are here dealing with rocks of a plutonic type, which consolidated under the pressure of perhaps thousands of feet of overlying strata, and have only been exposed by subsequent denudation.

We are entirely in the dark as to the age of the diorite and granite: we can only infer that their intrusion occurred subsequent to the development of the schistose structure of the surrounding rocks; but as we know neither the age when the schists were laid down, nor the period at which the schistosity was developed, this fixes the age of the igneous rocks only in an extremely vague way.

We now make our way back to the main valley, and plod steadily ahead for several miles. There is little of interest to be seen; the rocks are covered by alluvial deposits. Everywhere, however, there are signs of intense glaciation. Past the tiny school of Glen Lednock—conspicuously perched on ice-worn rocks—the valley begins to get narrower, and in a mile or two, after crossing the Innergeldie Burn, the ascent becomes more toilsome, and we soon reach the picturesque cascade of Spout Rollo, caused apparently by the outcrop of one of the most intensely hard and tough rocks which it has ever been my lot to meet.

Quite a considerable time may be spent in hammering off a few chips, much to the detriment of hammers and chisels; in fact, the rock reminds one of nothing so much as those wonderful logs of the "Settler's ellum" used in the construction of the celebrated "one-hoss shay":—

> "Never an axe had seen their chips,
> And the wedges flew from between their lips,
> Their blunt ends frizzled like celery-tips."

This rock is described on the Geological Map as "Gabbro passing into gabbro-shist and hornblende-schist"; thus, being a metamorphic rock, and not a truly igneous one, it is out of our latitude for the present.

We therefore take the road once more, and soon find ourselves in a region where the valley widens out again, though at a considerably higher level than before. The road becomes more and more a rough track, until, after passing the lonely house of Bovaine it becomes entirely grassed over, and is distinguished from its surroundings by a few ancient cart ruts, and numerous small trenches cut across it for drainage purposes. High up on our right there soon appears a huge dyke of black rock, and scrambling up to it where it is conveniently trenched by a descending stream, we find it to be composed of the familiar dolerite, exhibiting every stage of weathering from the first rounding of the exposed edges of the rock, through spheroids of all sizes, some still massed together, others detached, to the rich brown sandy material which is so different from the original rock that one could hardly suppose them to be connected, if every intermediate stage could not be seen.

But this is not what we are in search of, so on we go again. Soon the last house on this side of the watershed comes into view, a lonely farm with a few small cultivated patches around it, serving merely to emphasise the desolate loneliness of the spot. But at the same time we see high up on the right some craggy rocks of a red colour, with a talus slope of broken fragments, half buried in heather and bracken, and extending almost to the very track on which we stand.

After much hammering away of weathered outer surface, and breaking of too highly tempered chisels, we succeed in getting fairly fresh specimens, and find it to be a compact rock, with a few medium sized porphyritic crystals scattered through it here and there.

When examined microscopically the rock proves to be a micro-granite: the ground mass is an extremely fine-grained mixture of quartz and felspar, enclosing porphyritic crystals (very sparingly distributed) of orthoclase and biotite, both much altered.

The remarks made as to the age of the diorite and granite, previously described, apply equally well here; but the fineness of the grain of the micro-granite indicate that it must have consolidated under comparatively low pressure.

We now bid farewell to Glen Lednock, and for our next specimen go to Tomnadashan, on the shore of Loch Tay, which is most conveniently approached from Killin or Kenmore. This spot is some six miles north of the point at which our last specimen was taken.

Tomnadashan is a most interesting place; though now abandoned, half a century ago it was a little hive of industry, for a number of mineral veins which occur here were then being worked for iron pyrites, which was used in the manufacture of sulphuric acid. Several interesting minerals were found, but most attention was given to the rock in which the veins occur. This is dark-grey, compact, and moderately fine-grained.

Microscopic examination shows it to consist essentially of plagioclase felspar, which shows both multiple twinning and zoning, together with several ferro-magnesian minerals, notably biotite, somewhat altered, and hornblende. These two latter minerals are intergrown with one another in a curious and interesting manner. Augite is also possibly present, but very much altered. (Plate 56.)

It will be seen that this rock presents many points of resemblance to the diorite on the other side of the watershed. It differs from it, however, in the much greater fineness of grain, so much so, in fact, that we cannot regard it as a plutonic rock at all. Taking into account the comparative abundance of mica, we might call it a dioritic mica-trap, or lamprophyre. Owing to the presence of a small amount of quartz, the rock has been described as kersantite, *i.e.*, quartz-mica diorite, the name being derived from Kersanton in Brittany, where such rocks are typically developed; and this is on the whole perhaps the best name for it.

In addition to the quartz already alluded to, we note the presence of iron-pyrites and magnetite, both fairly abundant, together with apatite, of which the section shows numerous crystals, cut both longitudinally and transversely.

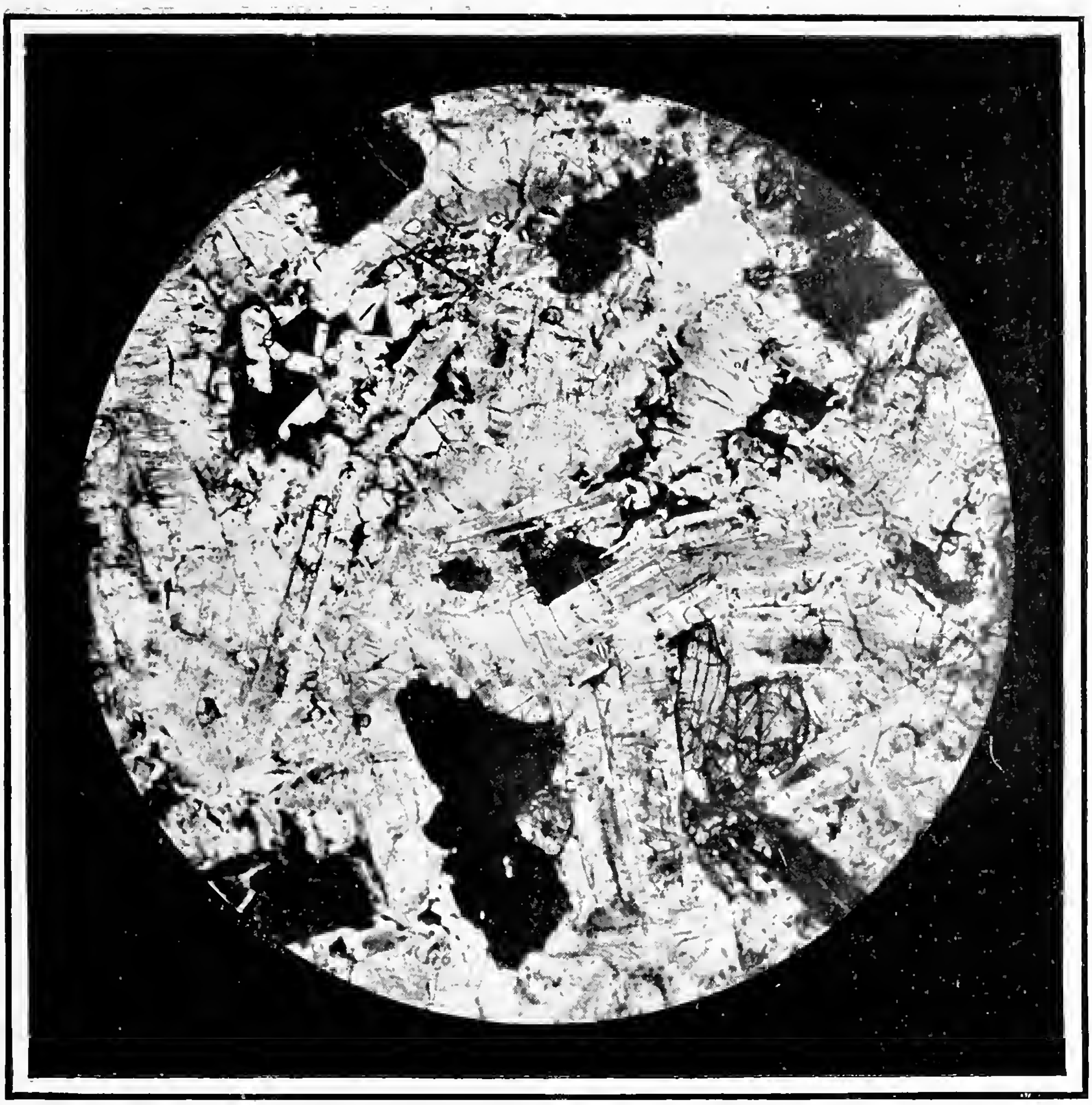

Plate 53.—Diabase, Knapp Quarry, magnified 12 diameters.

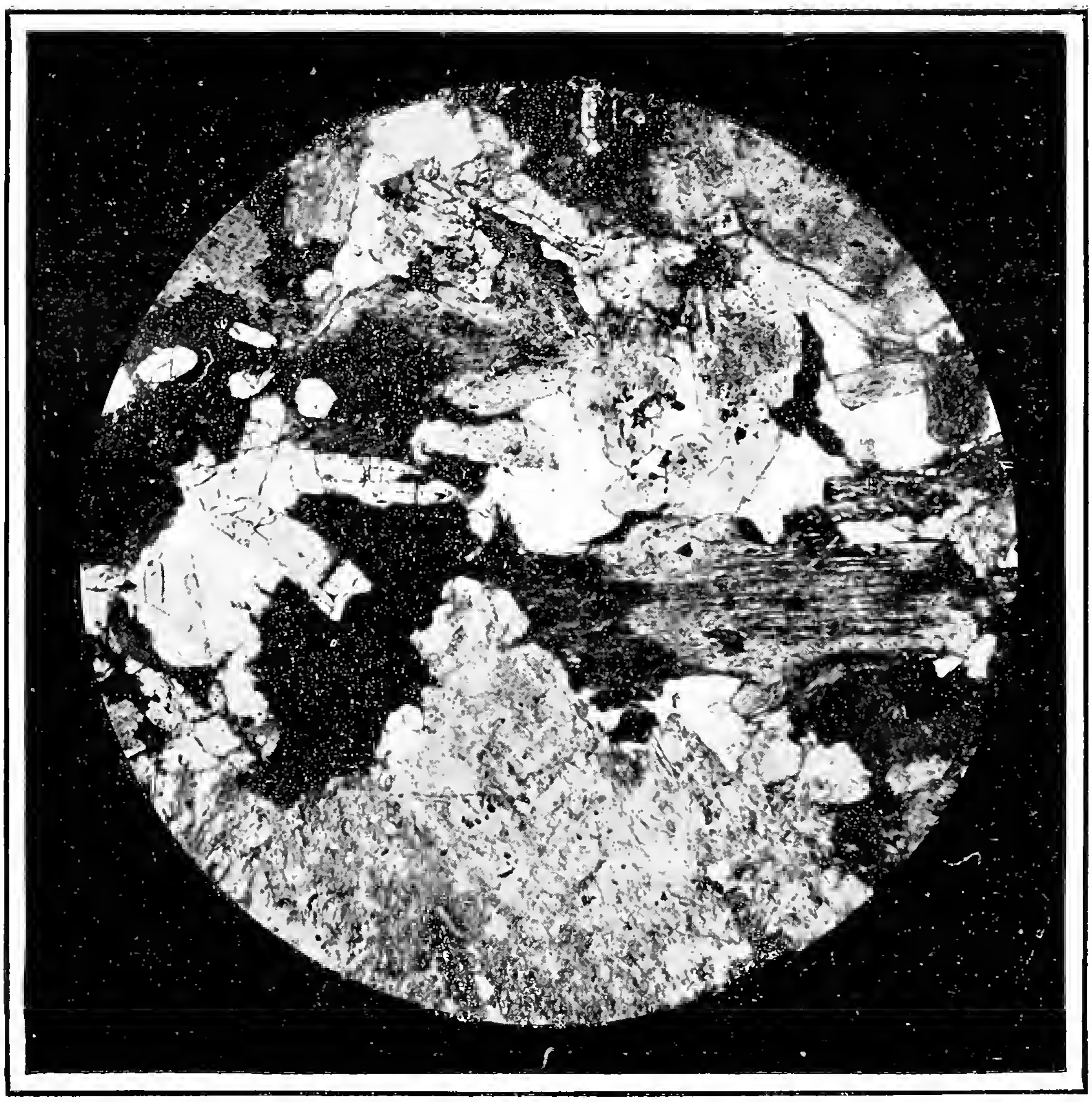

Plate 54.—Diorite, Glen Lednock, magnified 10 diameters.

Plate 55.—Biotite-Granite, Glen Lednock, magnified 10 diameters.

Plate 56.—Kersantite, Tomnadashan, magnified 36 diameters

XXV.—*The Natural History of the Mycetozoa, with Notes on some Local Species.*

By Dr. Lyell.

(Read 9th April, 1908.)

The Mycetozoa are a curious little group of organisms—seldom taken notice of, it is true, except by the naturalist—but well deserving of study, on account of the simplicity and beauty of their structure, the curious habits which they exhibit, and the strange vicissitudes of their life-story. They have a growing fascination for us—those "unassuming commonplaces of nature"—when we have learned to penetrate the humble and somewhat unprepossessing disguise under which they first attract our attention, for they have no bright colours and flaunting shapes to catch the eye, but lie hidden amongst the rubbish heaps of the autumn woods, or pass a great part of their degraded existence in the rotten stumps of trees, where even a powerful microscope might fail to detect their presence. Yet to the all-embracing glance of modern science they reveal a whole world of loveliness and interest, shedding new light more especially upon those elementary phenomena of living matter which at the present day have become an absorbing subject of investigation. In this paper it will be impossible to do more than touch upon their wider significance for the student of biology—all that can be attempted is to sketch very briefly their life-story, mode of occurrence, and local distribution, in the hope that our little friends may not be altogether passed by in our rambles in search of nature's elusive treasures.

Perhaps the most conspicuous form in which the Mycetozoa occur consists in the creeping, slimy masses of dull white or yellow tint which are often to be found in damp autumn days, growing upon decaying leaves or moss in the more secluded parts of dense old woods. On attempting to remove the organism it breaks up into a watery-looking stuff, and seems to dissolve away in the fingers. At this stage of its existence, in fact, it consists practically of naked protoplasm, and exhibits all the characteristic properties of that substance, such as free movement, the powers of assimilation and excretion, irritability, reaction to light and moisture, and so on. At a further stage, the Mycetozoa appear as minute objects of the size of rape or mustard seeds, growing in clumps on rotten branches or withered leaves, and exhibiting, under the microscope, a variety of very beautiful shapes. Sometimes they resemble tiny nails with globular heads, or little egg-cups, or miniature poplar trees, or they may be basket-shaped, or hang together like a bunch of grapes. These are the spore-cases, which when ripe, burst and allow the spores to be scattered by the wind or carried off by the rain. The germination of the spores can be watched under the microscope. In a few hours the spore opens, and a minute living organism escapes, which swims briskly about, and gradually gathering others around it, there is at length produced the creeping, slimy mass with which we started.

Such is a *resumé* of the life-history of the Mycetozoa, differing in detail according to the species, but consisting essentially of the three distinct phases which have been described, known in scientific language as the plasmodium, the sporangium, and the swarm-spore. The great interest which these organisms possess for the naturalist consists in the fact that they lie within that mysterious borderland between the animal and vegetable kingdoms, where all the well-known characters of animal and plant are lost. The Mycetozoa, however, have the peculiar distinction of being like an animal at one stage, and like a plant at another. The tiny swarm-spore has unmistakable resemblances to many of the minute protozoa which swim about by means of cilia or flagella in every drop of stagnant water, or to the amœbae which creep on the mud at the bottom of still pools in summer. On the other hand, the mature sporangium, with its stalk and capsule, and its network of threads, which expand and disperse the spores, is in every respect a plant-like structure. Hence it is that the Mycetozoa are claimed by both botanists and zoologists, according to the phase which is looked upon as the most characteristic part of their existence, and very varied are the opinions which have been expressed as to their place in the natural system. It is interesting to note that the late Dr. Buchanan White considered "that they have really as much (or more) affinity with the animal as with the vegetable kingdom."* Massee, again, comes to the conclusion that their tendencies are rather towards the plant world, and more especially in the direction of the fungi; while Lister favours the view of their animal nature. It must be said that it is difficult to decide between such important authorities, and the temptation is strong to leave the question open as to their animal or vegetable affinities, and simply classify them with Haeckel in his special group called the "Protista," or "very first forms of life," that is to say, those which have not yet attained to the distinctive structure of the higher plants and animals. Ray Lankester's view, however, that they represent more closely than any other living forms the original ancestors of all plants and animals, is negatived by the fact that the protoplasm of the Mycetozoa has been found to contain nuclei, indicating that they have travelled a long way on the path of organic

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* "The Scottish Naturalist," Vol. vi. 1881-2.

evolution. The true primordial living matter we must conceive to have been destitute of nuclei, and in this respect therefore the unnucleated blue-green Algae (to which the bacteria are closely allied) are probably nearest to the original inhabitants of the earth.

Owing to the closely wooded character of the vicinity of Perth, the Mycetozoa, in some of their most beautiful and interesting forms, are not far to seek. The creeping white or yellow plasmodium of *Fuligo septica*, for example, is very common in the Scone Woods, growing amongst the moss which covers the ground so thickly. There also may be found the clumps of dark brown sporangia of *Stemonitis fusca*, but they require careful looking for, owing to their inconspicuous colour, and their habit of attaching themselves to dead leaves left rotting on the ground. On Kinnoull Hill have been found different species of *Arcyria*, with their cup-shaped sporangia, surmounted by a network of threads; *Didymium*, notable for its beautiful lime crystals; *Tubulina*, forming an æthalium like a diminutive honeycomb; the beautiful basket-shaped *Cribraria*; and so on. In Battleby Woods have been picked up specimens of the goblet-shaped *Craterium*, and the rounded cushions of *Lycogala miniatum*. And in all these localities, and indeed in any dark, damp wood, the common *Physarum* may be readily found in clusters of minute stalked sporangia growing on rotten tree-stumps or fir branches. These names by no means exhaust the list of local genera and species, and every autumn, as the search is again taken up, some new specimen is discovered, it may be upon old familiar ground, or in some region explored for the first time.

A few words may be said in conclusion as to the mode of examining and observing these organisms. A pocket lens is sufficient to show the main features of the external structure of the sporangia, but for more details the low power of the compound microscope should be used, the sporangia being mounted on a slide, or simply illuminated by the condenser. In order to see the finer markings on the capillitium threads, the sculpturing of the spores, the movements and flagella of the swarm-cells, and the lime crystals, much higher powers are necessary, indeed the oil-immersion lens of one-twelfth inch focus, may with advantage be employed. The germination of the spores may be seen by dusting a few of them upon a cover-glass along with a drop of water, and sealing the edges to the slide with a little vaseline. This retains the water, and in the course of 8 to 12 hours, or less, according to the ripeness of the spores, the swarm-cells begin to emerge and dance about with their characteristic movements. If we wish to follow the formation of the sporangia, this can readily be done by cultivating the organisms at home. A few bits of rotten bark or chips of dead branches, picked up in a likely locality, may be kept with their ends in water in an old pickle bottle, and in a few weeks the plasmodia appear like little cushions of soft white material, and gradually develop into the sporangia characteristic of the species which happens to be present.

A list of the more important works on the subject of the Mycetozoa is appended, the books all being in the Library of the Museum.

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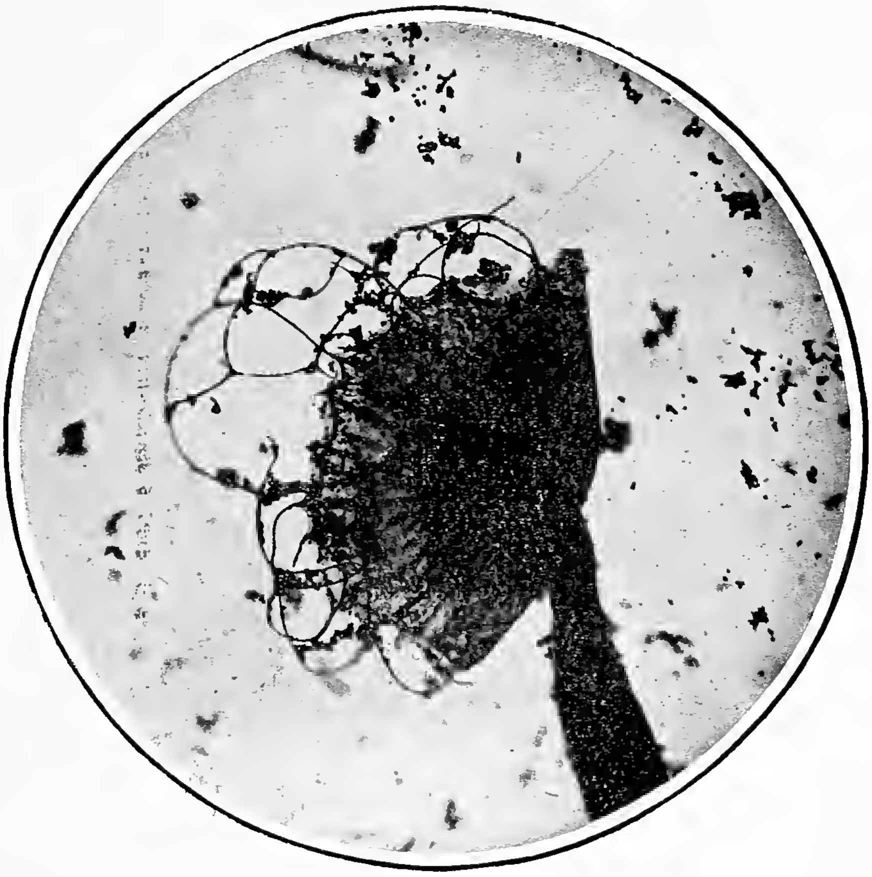

Plate 57. — Cribraria aurantiaca.

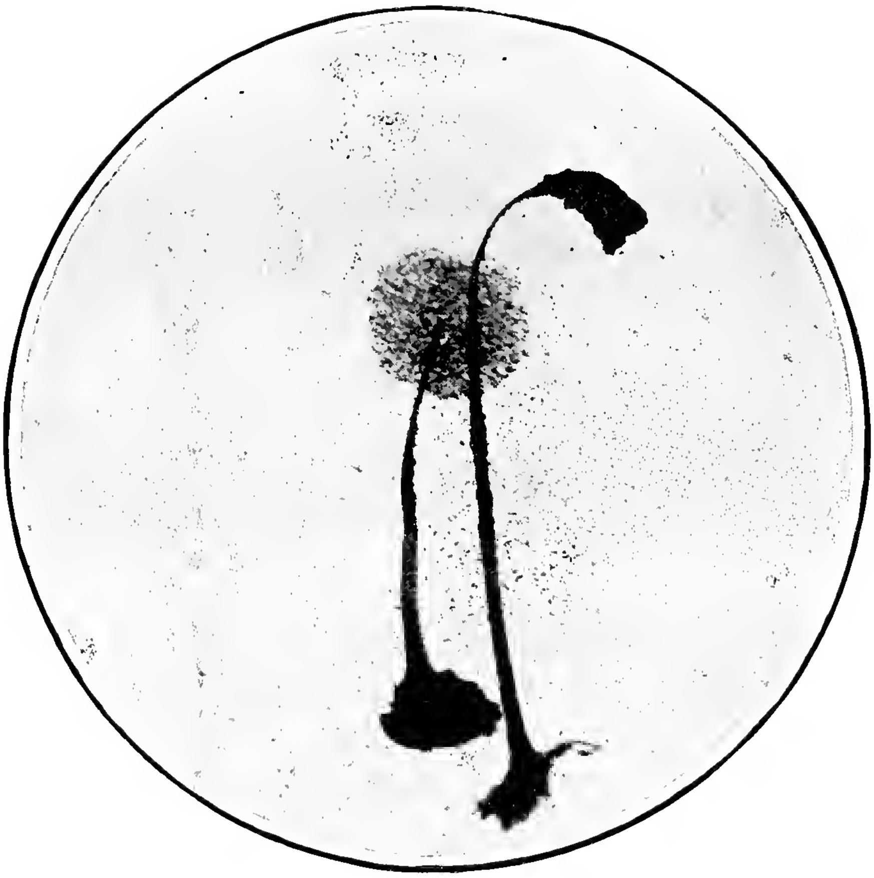

Plate 58.—Comatricha obtusata.