THE
QUARTERLY JOURNAL
OF
THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS
OF
THE GEOLOGICAL SOCIETY.

APRIL 22, 1857 (*continued**).

3. *On the GEOLOGY of STRATH, SKYE.* By A. GEIKIE, Esq.,
of the Geological Survey of Great Britain. *With Descriptions of
some FOSSILS from SKYE*; by T. WRIGHT, M.D., F.R.S.E.

[Communicated by Professor Ramsay, F.G.S.]

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Introduction.—The first notice of the district described in the present paper was that published in 1800 by the late Professor Jameson in his ‘Mineralogy of the Scottish Isles.’ It is exceedingly meagre, having been compiled from the notes of a brief excursion in bad weather, and contains only a list of minerals found in the ascent of Beinn na Cailleach, with the mention of numerous basalt-veins

* See vol. xiii. pp. 360 *et seq.*

† The Sections figured on this Plate have been selected from the series of sketches communicated by the author as illustrative of the Geology of Strath, and now in the Society’s Library. The unfigured Sections will be referred to in the paper.

that traverse the limestone in every direction*. Eighteen years later Dr. Macculloch published his 'Description of the Western Islands,' wherein he pointed out the existence in Skye of secondary strata—the equivalents of the lias and oolite of England, extending in broken and irregular series up to what has since been determined to be the equivalent of the Oxford Clay†. He also described with considerable minuteness some of the more remarkable features in the geology of Strath. Yet of the structure of the district he seems to have had but a vague general idea—not a few of its most important features having escaped his notice, while of some of the facts which he mentions he has failed to perceive the true bearing. I shall even have occasion to show that, notwithstanding the minuteness of his description, he can only have examined a limited portion of the district, and that too but superficially.

Several years later Sir Roderick Murchison examined the eastern coast-line of Skye, and, from a comparison of fossils, ascertained the existence and limits of strata belonging to the lias, and the lower and middle oolite‡; and I am not aware that, since the date of this paper, any further observations have been made upon the south-eastern part of the island.

That portion of Skye of which I offer a description to the Society comprises nearly the whole of the parish of Strath. It may be regarded as an irregular belt from three to six miles in breadth, extending from sea to sea where the island narrows most. Its physical features are those of a wide undulating valley between two elevated ranges—the red sandstone and gneiss hills of Sleat to the south, and the syenitic mountains of Beinn na Cailleach and Beinn Dhearg to the north. This district—embracing an area of nearly thirty square miles—includes the largest development of the lias in Scotland; and, indeed, as that formation in its lower and middle divisions reaches here a thickness of not less than 1500 feet, it may be regarded as no unfair representative of that of England. The geological structure of Strath—so intricate and confused—gives to these liassic beds an additional and peculiar interest. Along the shores the strata form low reefs and skerries, brown with algæ, and extend in regular sequence throughout their series. Yet no sooner do they strike into the interior than, in many localities, all seems to be involved in hopeless confusion; regularly stratified limestones become crystalline amorphous marbles; shales assume the appearance of metamorphic clay-slate or burnt pottery; great outbursts of syenite cut through the beds, dislocating, contorting, or overspreading them; trap-dykes in countless numbers traverse the glens and the hill-sides; while, by the agency of faults, higher members of the group are thrown down among the lower, and long tracts of red sandstone are brought into the heart of the lias. Before attempting to detail these complicated appearances, I shall describe the character and order of the beds from their base upwards.

* Jameson's 'Mineralogy of the Scottish Isles,' vol. ii. p. 91.

† Forbes, Quart. Journ. Geol. Soc. vol. vii. p. 104.

‡ Trans. Geol. Soc. 2nd series, pp. 293, 353.

I. Character and sequence of the Liassic beds of Strath.

It is a somewhat remarkable fact that in Scotland the Lias invariably rests on a palæozoic or metamorphic base—usually Old Red Sandstone. And it is equally striking that the formation is confined to the northern counties, among the hypogene and older palæozoic districts; none being found to the south of the great granitic barrier. These facts are of importance in investigating the physical history of the country. The lias of Skye rests sometimes conformably and often unconformably upon red sandstone or purplish-grey quartz-rock. These underlying beds have never yet yielded any organic remains, so that it is uncertain whether they should be regarded as Old Red, Silurian, or some of the later portions of the gneissic series of central Scotland. They graduate southwards, according to Macculloch, into a series of gneiss- and mica-schists; but considerable doubt rests upon their stratigraphical relations, and it does not seem probable that the difficulty can be cleared away without a careful and somewhat extended examination, not merely of the rocks in Skye, but of their prolongations into the mainland*.

The boundary-line of the lias and red sandstone commences on the north-eastern shore at the village of Lussay, whence it proceeds in a south-westerly direction for three miles to a point about half a mile south of the village of Sculamus, from which it runs nearly due south to the hamlets of Heast on Loch Eishort. See Map, Pl. I. fig. 1. This is a well-marked line; for the observer may not unfrequently stand at the same moment upon lias and red sandstone. The only part on which there hangs a shade of uncertainty is at the turning of the beds near Sculamus, where, owing to the thick covering of peat and the swampy nature of the ground, the two rocks cannot be approximated quite so closely as along other parts of the line. Yet this and similar obscurities could be shown only on a map of a very large scale.

I have been not a little surprised by the manner in which this line is mapped and described by Dr. Macculloch. He commences it at the head of the long narrow creek of Obe Breakish, instead of at the village of Lussay, thus colouring as red sandstone a space of fully two miles in length, which is actually lias. After quitting the shore his line is undefined, the formations being shaded into each other, indicative of a very uncertain boundary. Beyond this a large mass of syenite is introduced, breaking through the line, and for about three miles separating the two rocks. They are represented as meeting again to the south of the syenite, whence they run south-west to the shore of Loch Eishort, near the farm of Borereg—an error of considerably more than a mile. His lines are thus frequently set down at random, great tracts of red sandstone are altogether omitted both in map and memoir, the existence of faults is ignored, long tracts of syenite are inserted where none exist

* Since this paper was written, Professor Nicol's Memoir "On the Red Sandstone, Quartzite, &c. of N.W. Scotland" has appeared in the *Quart. Journ. Geol. Soc.* vol. xiii. p. 17.

in nature, and false dips are given, by which the very lowest beds are made continuous with the highest parts of the series. It pains one therefore to find such statements as the following :—“ Fortunately a rigid topographical detail is but of little moment ; ” “ and there is the less reason therefore to dwell on those minutiae, though they have been examined in the most scrupulous manner ; ” “ commencing from the lowermost beds, it must be remarked, that it is impossible to trace their common boundary with the red sandstone*.” And there are many other passages where, by a similar bold assertion or by a certain vagueness and ambiguity, the author leads his readers to take for granted what he affirms, and to give him credit for having observed a great deal which he has not thought it necessary to narrate.

These remarks are made with much diffidence and reluctance. It is a delicate task to criticise the labours of one of the earliest cultivators of geological science, especially one of his works which has ever ranked among the standard treatises on British geology. And when I reflect that his account of this limited area is one of the fullest and most elaborate parts of his “ description,” embracing about twenty-five pages of letter-press, I am sensible that my remarks tend to throw a shade of discredit over other portions of his work on the Western Islands. But it was impossible to pass over the subject in silence.

The lowest bed of the lias (Pl. I. fig. 2) is a sandy conglomerate, averaging 2 or 3 feet in thickness, and traceable from near Lussay at intervals along the boundary-line to Heast. It is formed of well-rounded pebbles of red sandstone and white quartz—the waste of the surrounding knolls that formed reefs and skerries when the Scottish lias began to be thrown down. To this succeed, at Lussay, beds of white and greenish chloritic sandstone, varying from 3 or 4 to fully 15 feet in depth. Next follows a seam of dark-blue compact limestone about a foot thick, surmounted by a stratum, irregularly 2 feet deep, of massive *Isastrææ* enveloped in a dark sandy clay. This remarkable bed escaped the notice of Dr. Macculloch : it was first observed by Sir Roderick Murchison ; and afterwards examined and described† by one who has scarcely left a district of his country unvisited, or unrecorded by his classic pen—the late lamented Hugh Miller.

I have not succeeded in detecting the coral-bed in the interior of the island ; it probably thins out at no great distance from the shore.

Above the corals there are 7 or 8 feet of a calcareous grit, which shades off into a series of dark blue limestones with occasional courses of shale. The calcareous beds are not peculiarly fossiliferous, showing however on the weathered surface mouldering casts of *Ammonites* and *Gryphææ*, and on a fresh fracture the minute joints of *Penta-*

* Description &c. vol. i. pp. 316, 317.

† In a paper read before the Royal Physical Society of Edinburgh, 21st April, 1852. This coral was mentioned at the Cheltenham Meeting of the British Association by the Rev. P. B. Brodie, to whom I sent a specimen. See also Edinb. New Phil. Journ. April 1857, p. 263.

crinites. The shales too, when contrasted with those higher up in the series, are remarkably barren in fossils.

The long narrow peninsula at Obe Breakish consists, on its south-eastern side, of beds of white sandstone, and along its north-western shore of a thick deposit of dark sandy micaceous shale abounding in *Gryphææ*. Above these shales there occurs in the interior a stratum of brecciated conglomerate formed of lias-limestone and red sandstone fragments.

From Breakish to Broadford the shore is occupied by low shelving reefs of dark blue limestone with alternating courses of shale. As the rocks approach Corry, beds of calcareous grit often charged with *Gryphææ* begin to appear. The series described up to this point corresponds in position to the lower lias of England.

Beyond Corry and on the opposite island of Pabba there begins a series of dark micaceous and sandy shales abounding in fossils*, and answering to the lower horizon of the English middle lias. The syenite of Beinn Bhuidhe descends to the shore north of Corry; but the shale can still be traced along it as far as the entrance of the Sound of Scalpa, where the last beds visible are of sandstone, greatly disturbed by syenite and trap-dykes. The series is, however, prolonged on the coast of Scalpa Island near Scalpa House, where a series of calcareous shales rest unconformably on the red sandstone, which has here a south-easterly dip. The organisms of these shales are in a wretched state of keeping, but some of the better-preserved *Pectens* suggest a comparison with the marlstone of England.

The continuation of the series through the upper lias will doubtless be made out along the eastern coast-line of Skye and Raasay, but my explorations have not hitherto extended further north than Scalpa. The sequence of the beds described will be at once perceived from the subjoined Table.

Table of the Lias of Strath.

Middle Lias.	Dark calcareous shales (with <i>Pectens</i> , &c.).....	Scalpa.
	Dark-grey or brown, sandy, micaceous shales (with numerous fossils)	Pabba.
	Calcareous grits (with <i>Gryphææ</i>).....	Broadford Bay.
	Limestones and shales in alternate bands	
	Calcareous brecciated conglomerate.....	(Inland.)
Lower Lias.	Dark brownish-grey sandy shale (with <i>Gryphææ</i>).	Obe Breakish.
	White sandstone.....	
	Limestone and occasional seams } (with <i>Ammo-</i>	Lussay.
	of shale.....	
	Calcareous grit; 7 to 8 feet ...	
	Coral-bed; 2 feet (<i>Isastræa</i>)	
	Limestone; 1 foot	
	Green and yellow sandstone; 3 to 15 feet	
	Fine conglomerate; 2 to 3 feet.....	
Red sandstone and quartz-rock.		

The dip of these beds from their base at Lussay to their top at Scalpa House (fig. 2) is pretty uniformly 5°–8° to the north-west;

* For a description of the fossils collected in Strath I am indebted to the kindness of Dr. Wright. See APPENDIX.

and, as the distance is nearly four miles, their entire thickness must be at least fully 1500 feet.

II. *Geological Structure of the Strath Valley.*

Coast-sections.—The previous enumeration of the liassic strata of Strath is in reality a description of the beds seen in section along the north-eastern shore (Pl. I. fig. 2). They follow each other regularly, from the sandstones and coral-bed of Lussay up to the Scalpa shales, with no material disturbance from faults or igneous rocks. The structure of the south-western coast-line is somewhat more complex.

At the head of Loch Slapin (fig. 4), among the roots of Beinn Chro and Beinn Dhearg Mor, there occurs a set of limestones and shales occupying the same horizon as those of Breakish. In the bed of the stream that descends between these two mountains a few yards of altered limestone abut against the syenite of the hills; this is followed by a series of indurated shales with occasional fragments of *Belemnites*; and further down the water-course, a hard bluish-grey and streaked metamorphic limestone becomes the prevailing rock. The dip of these beds is S. by W. at angles of from 25° to 60°. They are capped on the shore at Torrin by a small patch of shale, seen only at low-water, which may possibly represent the under portion of the Pabba series. Following the eastern shore of Loch Slapin, we find the dip turning round to the north-west, and the same series of altered limestones again presenting itself. The bedded structure of the rock is nearly obliterated; but, where the angle of dip can be observed, it increases southwards beyond the Torrin promontory, until the shore is covered by a great protrusion of syenite, which stretches eastwards for three miles, forming the long ridge of Beinn an Dubhaich. It extends along the shore for about half a mile, and, at the promontory south of Camus Smalaig, is succeeded by the limestone as before. South of this junction the beds dip S.W. at 15°–25°, where the bedded structure begins to reappear. They gradually lose their metamorphic aspect, till at the mouth of the stream which descends from Glen Kilbride, they pass into a coarse shelly limestone abounding in *Gryphææ*. The grits and limestones, which for a short space succeed, are the equivalents of similar beds between Broadford and Corry; and, as in that locality, so also here, they are surmounted by a thick set of dark micaceous shales, identical in character and fossils with those of Pabba. They stretch into the interior for upwards of a mile, whence they deflect to the south, and reach the shore of Loch Eishort at Borereg,—thus occupying the tongue of land which separates the two lochs. At Suishnish Point they are covered by a patch of yellow calcareous sandstone, which, at one part, displays a rude grotto with pendent stalactites, like not a few other caves formed by the decomposition of trap-dykes along “Slapin’s caverned shore.” This lip of sandstone is succeeded by the same series of shales dipping N.W. at 3°–5°. Half a mile from Suishnish they are interrupted by a large mass of augitic greenstone, which has broken through and overflowed them atop. The headland of Carn Nathrach is formed by this protrusion of greenstone surmounted by another of

fine-grained syenite. At Borereg the shales strike inland, as already mentioned, and are succeeded by a set of limestones and thin shales—the representatives of the limestones of Broadford and Torrin*. The Sketch No. 1. illustrates this locality.

The occurrence of quartz-beds in the limestones at this locality is interesting, inasmuch as it proves that pure white crystalline quartzite is not necessarily a product of igneous influence. The syenite of Beinn na Charn, it is true, is only a short way distant; that it could not, however, have had any material effect upon the quartzite is abundantly evident from the unaltered character of the interstratified limestones; and if further proof were needed, it would be found in the occurrence of a precisely similar quartzite among the limestones of the interior, on the ridge to the south of Glen Kilbride. There it rests on an elevated belt of red sandstone, and is overlaid by a limestone-breccia, and a series of unaltered limestones. The nearest syenite is that of Beinn an Dubhaich on the other side of the Glen, but a large fault intervenes between them. There is, indeed, a small basalt-dyke traversing the lias-beds at this point, but it is of much too trifling extent to have produced the supposed metamorphism; while I shall take occasion to show that the trap-dykes of the district generally have not exercised any marked influence upon the texture of its rocks. Of the quartz-beds on Loch Eishort, the upper, as exposed on the beach, is much jointed and fractured; and, as far as I could penetrate into its substance, it seemed to be a nearly transparent crystalline quartzite, with an occasional tendency to be dull and subgranular. The under bed is also a good deal fractured, owing, perhaps, at least in part, to the proximity of a fault. It forms a tall cliff, remarkable for its brilliant whiteness, and for the large snowy blocks that cumber the beach around its base. A fresh fracture shows that this peculiar brilliancy is chiefly owing to a thin crust, from $\frac{1}{8}$ th to $\frac{1}{12}$ th of an inch in thickness, consisting of minute aggregated granules or crystals of quartz. Further from the surface the rock assumes the character of a very fine quartzose grit.

The shore of Loch Eishort is now occupied by a great tract of red sandstone, extending inland as far as the north-eastern corner of Beinn na Charn. Its western boundary is formed by a fault, which throws out fully 400 feet of the lower lias, and brings down the Sculamus and Broadford limestones against the palæozoic beds. The dip of the sandstone is generally westerly, at angles varying from 20° to 50° . Its eastern edge has likewise been produced by a fault that extends from near the north-east corner of Beinn na Charn to the village of Heast. This latter dislocation has thrown out a still larger portion of the lower lias; and the effect of the two movements together has been to cut a rude scalene triangle out of the lias limestones and shales, inserting in their stead a corresponding area of red sandstone. The Heast fault can be well observed in the channel of the stream, where the fractured ends of the limestones, shales, and breccia distinctly abut against those of the older strata. Beyond

* With the above description of this coast-section, for the accuracy of which I can vouch, compare that by Macculloch; Description, vol. i. p. 328.

the cultivated patches of Heast the coast-line is fringed with sombre, lichen-clothed crags of red sandstone and quartz-rock, stretching away to north-east over a bleak moorland region, and swelling southwards into the grey wrinkled mountains that form the long peninsula of Sleat.

Interior.—I have now gone over the coast-sections of the district, whence a good idea may be gained of the general arrangement of the rocks in the interior. To describe that arrangement regularly in detail would be not a little tedious, and, from the want of local references, would be attended with inconvenience and difficulty. I have accordingly drawn several sections through the more remarkable parts of Strath, whereby much is shown at a glance that could not be so well understood even from the clearest description. These sections, with the accompanying map, will, I trust, convey a fair idea of the structure of the district. They show the Liassic region of Strath to be a great synclinal trough bounded on the north-west by syenite, and on the south-east and east by red sandstone, and ridged up along its centre by an anticlinal axis.

Notwithstanding this seemingly simple structure, there is not a little complexity when we descend to details. Thus, we should expect that along the outer edges of the synclinal hollow, the lowest beds would be always those visible, but this is not strictly true. The most northerly of the sections, Pl. I. fig. 2, exhibits no sign of any bending of the beds: these follow each other in regular sequence from the lower conglomerate and coral-bed up to what is probably the marlstone. Section III., MS., and fig. 5 display the full swell of the anticlinal axis, and likewise the effects of denudation in partly baring the sandstone-ridge of its mantle of limestone. The lower beds seen at the eastern end of the line do not rise against the syenite at the western; those visible along the flanks of Beinn na Cailleaich belong to a higher part of the series. The shales and limestones at the foot of Ben Chro are not the bottom beds, nor do these occur at the other edge of the trough on the shore of Loch Eishort, for there, as shown above, the fault cuts off all the strata below the white quartzite. And thus, though the general structure of the district is that of a synclinal hollow, its regularity has been assailed by syenite and faults.

Nor is there greater regularity in the occurrence of the central anticlinal ridge. Eastwards it is produced by a broad undulation of the red sandstone and superincumbent lias without visible igneous rock; westwards it is caused by a long protrusion of syenite, while midway there is a confused coalescing of the two axes. Moreover, throughout nearly the whole extent of this central area, the limestones have been so altered that it is no easy task to ascertain their true dip. They are ploughed up on all sides by trap-dykes; faults have dislocated their connexion; great protrusions of syenite have ridged them up, and long tracts of red sandstone are found running through their centre.

Instead, therefore, of attempting to describe this confused district, I must refer to the map and sections alluded to for the general disposition and relations of the rock-masses, and content myself with

describing under three or four subdivisions those appearances that seem most worthy of consideration in the geology of Strath. The first subject to which I shall advert is the long sandstone-ridge and its accompanying breccia.

Limestone-breccia.—In detailing the sequence of beds along the north-eastern shore, reference has been made to a bed of limestone-breccia which, though not visible on the coast, can be seen at many places in the interior. This rock and its attendant circumstances appear to have escaped the notice of Macculloch *; yet it is a point of not a little interest, and throws some important light upon the physical history of the district. Its horizon lies a short way above the thick shale that occurs in the lower portion of the series at Breakish; and this position it probably always retains. It varies in thickness from 3 or 4 feet to 10 or 12, and is made up of rounded and subangular fragments of quartz-rock, red sandstone, and lias-limestone.

Its line is accurately defined by the eastern edge of a long belt of red sandstone (similar to that whereon the lowest lias-beds repose), around which it seems moulded. This narrow strip of sandstone is bounded on the west by a fault that runs through the valleys of Glen Kilbride, Loch Lonachan, and Glen Shuardail, and is well exposed in the channel of the Shuardail Water, where it gradually dies out before reaching Sculamus. The other edge of the sandstone-belt is fringed by the breccia. Except at one spot on the southern ridge of Glen Kilbride, where, for a short way, there intervenes the lenticular mass of white quartz-rock already noticed, and also on the western slope of Beinn Shuardail, where the breccia is overlapped by limestone, the sandstone is always found to have a capping of breccia; and, I make no doubt, were the anticlinal ridge of Beinn Shuardail stripped of the limestone by which it is enveloped, the sandstone below would be found girdled by a zone of breccia. The only locality where I have detected the latter rock away from the sandstone is in the bed of the stream that descends from the Black Lochs to Heast. The following sections will explain the structure of that part of Strath.

The Section through the northern end of Beinn Shuardail (fig. 5) crosses the anticlinal of red sandstone with the flanking breccia and limestones. The breccia probably thins out over the older limestone and shales as here delineated. Had it been continuous, we should have found it at *b'* above the Breakish-shales. These lower beds must abut against the bottom of the breccia in the manner shown in the section; for that they cannot pass above the breccia, is proved by the position which it occupies at Heast, and by the limestone-fragments with which it abounds. Assuredly it cannot be on the same horizon with the lower conglomerate found resting on the red sandstone from Lussay to Heast (fig. 4).

The Section between Beinn na Charn and Hill of Harripool (fig. 6) passes south of the gap in the syenite-range of Beinn na Charn and

* He does, indeed, mention a calcareous conglomerate next the syenite, but adds that "its connexions cannot be traced."—Description, vol. i. p. 325.

Hill of Harripool. It differs from the preceding in so far as it shows the effect of the fault along the eastern side of Beinn Shuardail, and the reappearance of the breccia in the Heast stream at *b'*. In Section IV. M^S. a small knob of red sandstone is seen projecting through the limestone on the west side of Beinn Shuardail. I think it highly probable that this and another similar patch half a mile north are prominences of the underlying rock from which the overlying limestone has been torn away, so that the breccia, though invisible, may flank their base, as shown in the section. As corroborative of this conjecture, I may remark that at Sithean, where the sandstone, divested of its calcareous covering, descends almost to the level of the road, the breccia is found resting above it; but where the limestones begin to creep up the hill-side to the south, the breccia gets covered over, together with the sandstone below.

I am thus particular in the details of this sandstone-ridge and its casing of breccia, because the appearances described appear to me indisputably to prove that the period of the Lower Lias of Skye was marked by movements of upheaval and depression. Whilst limestones and shales were alternately accumulating at the bottom of the old liassic sea, a long low reef was thrown up, raising with it the calcareous and muddy deposits that had formed the ocean-bed. Exposed to the beating of the surf, these strata were broken up, their fragments dispersed along the slopes of the reef, and the red sandstone once more laid bare. At length the ridge began to suffer a downward movement, and, as it slowly sank, fresh accumulations of limestone gathered around and over it, in a sea swarming with *Ammonites*, *Pinnæ*, and *Pectines*.

There is another point of interest in this sandstone-ridge which I am unwilling to omit. The remarkable parallelism of the mountain-ranges and glens of Scotland long ago drew the attention of geologists, and the progress of investigation has shown that what is so marked in the north can be no less distinctly traced in the general structure of the British Islands. The great faults traced on the maps of the Geological Survey have generally a parallel strike from south-west to north-east, corresponding with the direction of the Highland glens and straths. With regard to the relative ages of these upheavals and depressions mere parallelism can prove nothing, for there is strong reason to believe that at least most of the great disturbing movements which have taken place within the area of the British Islands, from the earliest eras whereof we have any cognizance, have been along a north-east strike. Now, the sandstone-ridge of Strath preserves the same direction, and, though invaded by the syenite of Beinn an Dubhaich and shattered by the fault of Glen Kilchrist and Glen Shuardail, it is still tolerably perfect for nearly five miles. Of its age there can be no doubt; it was formed towards the close of the lower horizon of the Lower Lias, and had begun to sink when the limestones of the upper horizon of that division were deposited. Many a long year had rolled away, and its site was well nigh effaced, when the Pabba-shales, belonging to the lower and middle horizons

of the Middle series, were thrown down, enveloping the remains of *Ammonites Jamesoni*, *A. brevispina*, and *A. Davœi*. The circumstance is interesting, therefore, in a twofold point of view: 1st, because it proves that the disturbing agencies which afterwards played such an important part in Hebridean geology had already begun to show themselves as early as the time of the Lower Lias; and, 2ndly, because it clearly indicates that in the same ancient period the forces which produced the parallelism of the Scottish glens and mountain-chains acted in the prevailing north-easterly direction.

Igneous Rocks.—The igneous rocks of Strath belong to two great classes, and assume three distinct modes of occurrence. There are, first, the various hills and mountain-chains of syenite—huge amorphous masses breaking through and overlying the liassic beds; and, secondly, the innumerable dykes of augitic trap that cut the strata at every angle, and not unfrequently spread out between them in a bedded form.

The northern limit of the liassic region was described as formed by a bold eruption of syenite rising into an elevated chain of mountains (see Map, Pl. I. fig. 1). The summits of these hills, bleak and bare, rise out of a thick mantle of shattered blocks and broken debris, which, together with the scantiness of the vegetation, give them an air of ruin and desolation. Beinn na Cailleach, the highest of the range, attains an elevation of over 2000 feet. In addition to this great syenitic tract, there are numerous minor isolated portions scattered throughout the district. Of these the largest is Beinn an Dubhaich, which stretches eastward from the shore of Loch Slapin for about three miles, with an average breadth of about a quarter of a mile. Another syenitic hill of considerable size is Beinn na Charn, rising abruptly above the hamlets and cultivated patches of Borereg. It is of an irregular form, thickest towards the west, and tapering to a point in the opposite direction. The Hill of Harripool may be regarded as a continuation of Beinn na Charn. It runs as a long sloping ridge in the direction of the village from which it derives its name. The rocky headland named Carn Nathrach, that forms the point of Suishnish, is likewise a syenitic protrusion, having an irregularly oval form, and bulging out a little towards the west, like the other detached eminences. There is but one other portion of considerable size in the district,—the rounded hill, called Ben Bhuidhe, that rises over the western arm of Broadford Bay.

In addition to these, however, there occur numerous smaller eruptive masses in various parts of Strath. One juts over the rugged path along the cliffs of Loch Slapin, between Glen Kilbride and Glen Suishnish; another projects into the breccia between Loch Lonachan and Beinn na Charn. I have observed several more, and it is probable that others may have escaped my notice. Indeed, after a somewhat lengthened examination of the district, the conviction forced itself upon me that there might be large masses of syenite hidden at no great depth beneath the surface, especially in the more

highly metamorphic regions, where the syenite at present exposed would seem inadequate to explain the amount of alteration which the lias-limestones have undergone.

The syenite of Strath assumes two distinct and easily recognizable forms;—one overlying the liassic strata without markedly disrupting them; the other violently disrupting, but not overlying them. In the former case the junction of the two rocks is horizontal, or rather parallel with the plane of stratification, and the igneous rock consequently conforms to the dip and strike of the limestones and shales on which it rests. In the latter case the junction is vertical or nearly so, and the igneous rock breaks through the beds without reference either to their inclination or direction. The one class of phenomena recalls the circumstances attendant on the eruptions of the trap-family, the other reminds one of the appearances that characterize the protrusions of the granites.

To the latter class belongs that great expanse of syenite of which Beinn na Cailleaich, Beinn Dhearg, and Beinn na' a Cro are the terminal heights on the south, and which, stretching north for eight or ten miles, occupies a large area in the centre of Skye. The only part of this extended district that I have examined is the southern edge abutting against the lias from the head of Loch Slapin to the Sound of Scalpa; hence among the glens and hill-sides there may be isolated patches of the liassic limestones and shales, although the whole area is coloured and described by Macculloch as syenite.

The rock of which Beinn na Cailleaich and Beinn Dhearg are composed is a granular admixture of brownish felspar and grey quartz with a little hornblende. Occasionally a few scales of mica are observable, so that the rock is fully entitled to rank among the granites. The felspar readily crumbles away, giving rise to long tracks of debris—whence the brownish tint and rounded outline of the hills.

The line of junction of the lias-beds and syenite can be accurately traced for some distance along the western flanks of Beinn Dhearg. In the bed of the stream which flows down the glen between that hill and Beinn na' a Cro, there occur the limestones and shales already described, dipping away from the hills at angles (decreasing as they retire) of from 50° and 60° to 20° . They cannot be seen in contact with the syenite, but that rock can be traced down to a few yards from them, well displayed in the channel of the stream. From this spot the line of demarcation strikes up the slope of Beinn Dhearg, and, though the exact point of junction always eluded me, the two rocks, judging from the contour of the ground and from the section cut by a stream between Beinn Dhearg Mor and Beinn Dhearg Beag, must have a very nearly vertical line of separation. If there be any inclination, it is probably that of the lias-beds dipping away from and resting against the syenite, which along some parts of the line courses the hill-sides like a ruined wall, its base thickly strewn with prostrate blocks that obscure the line of contact. Occasionally, as on the flanks of Beinn na Cailleaich above the milestone on the Sligachan Road, there are large masses of limestone caught up by and resting on the syenite. They do not usually appear im-

bedded in the igneous rock, but rather look as if lying upon it or sunk into it. The syenite can be seen at different points protruding among these detached masses of limestone, but in no instance did I observe it enveloping and overlying them. It is, moreover, equally void of all fragments of altered limestone or shale, such as one sees caught up in many greenstones, especially along the sides of dykes; nor, save in one or two doubtful instances, did I detect it sending out veins into the adjacent rock. I may remark, in passing, that these isolated masses of limestone, as well as the great body of that rock for some distance from the syenite, are highly altered, assuming, in fact, the aspect of a crystalline marble. To this remarkable metamorphism I shall refer more at large after the igneous rocks have been described.

The class of disrupting syenites includes, in addition to the hills above described, the long irregular ridge of Beinn an Dubhaich. This eminence exhibits along its northern boundary the same abrupt vertical junction with the limestone that is shown on the sides of the opposite hills. Its southern edge is more irregular, containing many isolated masses of limestone, like those referred to on Beinn na Cailleach, while the contiguous limestone in turn contains not a few protruding knobs of syenite. In short, it is a repetition on a smaller scale of the great syenitic zone that girdles in the Strath Valley to the north. But as its western extremity has been much wasted by the waves of Loch Slapin that come surging in from the Atlantic, a section has been cut across its breadth, and its contact with the limestone is accordingly well displayed on both sides. The following cliff-sections convey an idea of the appearances here presented.

The South junction of Syenite and Marble on Loch Slapin (Sketch No. 4, MS.).—Here the marble has a vertical dip, and a few yards southwards it inclines to the south-west. The syenite is a coarse granular rock, meeting the marble vertically below and bending a little over above. A syenite-vein is seen extending into the marble horizontally for 2 or 3 feet from the main mass of syenite. It looks as if it had been squeezed into an open fissure.

The North junction of Syenite and Marble on Loch Slapin (Pl. I. fig. 7) represents the junction at Camus Smalaig. The marble here is a pure white, almost saccharoid rock. It seems to have a rude dip to the north-west, but this may be deceptive. The syenite assumes a somewhat finer texture along the line of contact, and at the lower part of the visible junction is charged with green serpentine, which likewise discolours the contiguous marble. Neither in this junction, nor in the corresponding one, half a mile south, does the syenite overlie the limestone. At the southern locality it falls over atop, as above stated, but the appearance is probably caused by a sudden change in the strike of the line of demarcation, whereby, in place of its edge, its plane is presented to view.

The remaining masses of syenite belong, for the most part, to the second or overlying class, of which Beinn Bhuidhe may be taken as

an illustrative example. This hill forms the elevated promontory between Broadford Bay and the Sound of Scalpa, and occupies an area of not much less than a square mile. The coast-line is fringed with low flat reefs of black shale, identical with that of Pabba; and as the waves have in many places cut a steep cliff that topples over the beach, the connexion of the igneous rock with the lias-beds can be accurately studied. Nothing could present a greater contrast to the junction of the syenite and marble along the flanks of Beinn Dhearg or Beinn an Dubhaich, than the junction of syenite and shale along this sea-margin of Beinn Bhuidhe. Here we see no great tilting of the beds, no wide-spread metamorphism, no wall-like contact of the two rocks. On the contrary, the shales dip gently under the sea, showing in many places no evidence of their proximity to a large mass of igneous rock. They are unaltered except within a foot or thereabouts from the syenite, and at the contact show a flinty porcelain-like texture. The syenite has manifestly rolled over them, catching up fragments in its progress, insinuating itself, after the manner of the traps, into cracks and fissures, and conforming exactly to all the inequalities of the stratification. Fig. 8 shows the manner in which this junction is displayed along the cliff-section.

The Junction of Syenite and Shale at Beinn Bhuidhe (fig. 8).—Here the syenite is a lighter-coloured, more felspathic, and finer-grained rock than that already described. At the point of contact it is very homogeneous and compact, and hand-specimens may easily be obtained showing the two rocks fused together—an appearance nowhere observable among the disruptive syenites.

The headland of Carn Nathrach must be referred to the same overlying class with Beinn Bhuidhe. Its structure is represented in fig. 4.

The overlying nature of Beinn na Charn is well displayed along its eastern boundary, where the limestones and shales dip under it, unaltered save near the point of contact; and there, it may be remarked, they are not by any means so much changed as near the disruptive masses; nor is the limestone in any instance altered into a white crystalline marble, as it is along the northern hills.

The Hill of Harripool is more complex in its structure, and not less manifestly a superjacent, intrusive mass (see fig. 3). At its northern extremity it subdivides, shales and limestones being found between the separated portions. In truth, it is identical in its mode of occurrence with an ordinary greenstone, which it further resembles in the limited amount of its attendant metamorphism.

Such, then, being the marked differences between these two forms of syenite, I think the inference may be legitimately drawn, even were there no other evidence, that they are not probably the products of contemporaneous eruptions. At Beinn Bhuidhe they approach within a few hundred yards of each other, and it is inconceivable how at the one spot the rock should have tilted up, pierced, and greatly metamorphosed the strata, after the manner of the granite

of Arran; while at the other it in no way disturbed either their dip or their texture, save along the immediate line of contact, but insinuated itself between their planes, and conformed to every inequality of the floor over which it rolled. There is usually, moreover, a marked difference between the mineralogical texture and even the composition of the two rocks. The disrupting class are coarse-grained, and of a brownish-yellow tint; the overlying and intrusive are of a finer texture and lighter shade, and generally considerably more felspathic. There are indeed exceptions to this rule, as in Beinn na Charn, where the rock approaches more closely to the texture of the northern hills; but the distinction is in most cases sufficiently obvious. It seems impossible, therefore, to avoid the conclusion that the one series of outbursts must be older than the other.

But there is another source of evidence, of a somewhat negative kind, which not only corroborates this inference, but indicates, as far as merely negative evidence can do, to which of the two classes the higher antiquity should be assigned. For, as in no observed instance do they intersect each other, it is obvious that they do not of themselves furnish material for a determination of their relative ages. Yet I believe an answer to the question may be gathered from a survey of the other igneous rocks of the district; and to these I shall now refer.

Trap-dykes.—Certainly one of the most remarkable features in the geology of Strath is the almost incredible number and variety of its trap-dykes. From their greater permanence they are visible at a considerable distance, now coursing up the hill-sides like ruined walls, now plunging deep amid the heather of the glens, now damming up the channel of some mountain-torrent that pours over them its white cascades. They preserve a general north-westerly strike, but frequently intersect each other or unite, being seldom continuous for long distances. These features are well displayed along the eastern shore of Loch Slapin, where for upwards of two miles the waves have cut a vertical line of cliff. Along this cliff, and on the beach below, the dykes may be seen running parallel, uniting, again bifurcating, interlacing in labyrinthine confusion, now thickening, now thinning, terminating abruptly and commencing again, entangling masses of limestone, and sending out minor veins; at one time rolling in an undulating course, wholly irrespective of the dip or strike of the beds, at another running along the line of the natural joints; now seeming to conform to the planes of bedding, now cutting through them like walls of masonry, and at length ending off in a point sometimes well nigh as fine as that of a pen. In truth there are few localities where the nature of trap-dykes could be better studied than along this coast-line, for there is both an admirable ground-plan of them along the beach, and, for a considerable part of the shore, they are exposed in section along the cliffs. (Pl. I. fig. 9, and MS. Sketches Nos. 8 and 9, illustrate the trap-dykes on the shore of Loch Slapin.)

The eastern margin of the island also exhibits the trap-dykes in

abundance; but they are there more regular, and generally keep parallel to each other in a north-west direction.

On Pabba Island they are also numerous, running along the line of the natural joints, with the usual north-westerly strike. Here they show very unequal degrees of permanence, in some cases crumbling away as rapidly, or even more so, than the surrounding shale; in others jutting up like walls. Of the latter kind one very noticeable example occurs on the northern shore of the island. A dyke, from 3 to 4 feet thick, and, next the cliff-line, about 30 feet high, crosses the beach and runs out to sea (MS. Sketch No. 11). The shale has been washed away on all sides of it, and it blocks up the walk along the beach like a wall of smoothly built masonry. These Pabba dykes are of interest in so far as they enable us to estimate the extent to which trap-rocks have altered the strata of the district; for in Strath there is so much metamorphism and so many protrusions of syenite, that one is apt to miscalculate the amount of influence of the different igneous eruptions. Pabba, however, is nearly two miles distant from the nearest point of syenite, so that this rock could not have had any effect upon the shales of the island. There is thus no conflicting agency to mar or heighten that of the trap-dykes; and, as in Pabba they fully equal in number those in the most metamorphic regions of Strath, it follows that, if, either wholly or in part, they have produced the metamorphism of Strath, they must have caused a corresponding amount of alteration in Pabba; but in that island there is no metamorphism beyond the mere hardening of the shales in immediate contact with the trap. At the distance of 2 feet they are generally as soft and fissile as when furthest removed from dykes. It is evident therefore that the remarkable metamorphism I have yet to describe cannot have been produced by the trap-dykes, startling as their number may seem. Their effect is limited to a few inches from their edges, and even this slight alteration becomes undiscernible in the interior, where it is lost in a far more extended and complete metamorphism.

The trap-dykes, like the syenites, are divisible into two well-marked classes, differing from each other in mineralogical texture and in age. The one group comprises nearly all the dykes of the district, and is formed of a dark-grey or bluish-black basalt*, not columnar, but much jointed. The rock is exceedingly hard, and weathers with a greenish-brown crust. The dykes of the other class are not numerous, and consist of a dark crystalline augitic greenstone*, which sometimes approaches the basalt in texture.

The annexed ground-plan (fig. 10) of the neighbourhood of the old Manse at Kilchrist shows the relation of these two classes to

* These terms are here used, as they have, I think, always been in Scottish mineralogy, to signify two rocks differing from each other, not in composition, but in texture; *basalt* being a compact black mixture of augite and felspar without visible crystals, *greenstone* a lighter-coloured mixture of the same minerals, the crystals being easily recognizable. When hornblende replaces the augite, it is called a hornblendic greenstone. In Scotland, where so large a proportion of the traps are augitic, this distinction is a very useful one.

each other. The greenstone-dyke extends from the road at Loch Kilchrist in a south-easterly direction for fully half-a-mile, cutting through marble and syenite. Along both edges of the syenite-belt there are numerous smaller basalt-veins cut off abruptly, together with the marble which they intersect. Similar appearances are visible on the south front of Beinn na Cailleach, where all the basalt-dykes of the Sithean valley are truncated by the syenite, while a large one of greenstone, traversing perpendicularly the bare slope of the mountain, forms a prominent dark scar. These facts seem to me to show that the trap-dykes are of two ages; those of basalt being older than the disruptive syenites, those of greenstone later. The intrusive syenites are not traversed by basalt-veins, but they are intimately connected with the greenstones; and this relation, when examined, throws important light upon the respective ages of the different igneous rocks of the district.

Reference has been already made to the headland of Carn Nath-rach, that divides Lochs Slapin and Eishort (fig. 4). It is formed by a great sheet of augitic greenstone, surmounted by an irregular bed of fine-grained felspathic syenite. The greenstone, which resembles in texture and mode of occurrence the other rocks of the same kind in the district, forms a bed of considerable regularity, and is connected at its southern edge with a thick dyke that cuts vertically the nearly horizontal shales of Suishnish. The syenite, owing to its liability to decay, has a somewhat irregular surface; but it undoubtedly forms a bed, and is everywhere found resting on the greenstone. At the large loch on the top of the headland it has carried up a considerable fragment of the calcareous sandstone of Suishnish Point, and there can be no question that both greenstone and syenite are alike intrusive.

Along the eastern base of Beinn na Charn there are also at several points indications of a substratum of greenstone. The same fact is observable in the Hill of Harripool: that eminence forms a long ridge extending southwards from the village of Harripool and merging into the northern projection of Beinn na Charn. At its seaward end it consists of limestones and shales belonging to the Breakish-series; and, about two miles south from the sea, beds of syenite, probably ramifications of the main mass east of the Black Lochs, are found intercalated with the liassic strata: at several points the syenite has a distinct capping of greenstone, perhaps the result of a difference in cooling, but more probably the product of a different eruption.

The connexion of these intrusive syenites with the greenstones is such as to leave no doubt that they are both later than the disruptive masses; that in truth they must be regarded as the latest of the igneous products of Strath. Thus the greenstones, whether regarded as merely the result of a difference in cooling, or as the products of distinct eruptions, confirm the conclusion that the syenites are of two ages, and indicate with tolerable distinctness to which class the higher antiquity should be assigned.

It may be well, ere passing on, briefly to sum up the evidence here
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collected as to the dates of the igneous eruptions of Strath. 1st, they are all posterior to the Middle Lias, being intrusive and not contemporaneous; 2ndly, the first period of igneous action gave rise to a great profusion of trap-dykes, which intersected every part of the district; they did not, however, produce any marked alteration of the general stratification and texture of the rocks, but rather conformed themselves to the natural joints of the beds, and hence acquired a prevailing strike to north-west; 3rdly, subsequently vast tracts of syenite tilted up the liassic strata, in a manner analogous to that of the Arran granites, and produced in them an extensive and complete metamorphism; 4thly, the last period of igneous action was characterized by the outburst of great hills of fine-grained syenite, that intruded itself among the beds without either tilting them or producing any considerable amount of alteration upon them; at the same period sheets of greenstone were occasionally thrust among the syenites and limestones, or broke through them as massive dykes*.

Metamorphism.—The general arrangement and effects of the igneous rocks having been pointed out, I shall proceed to describe the metamorphism so often alluded to. The metamorphic district, as may be conjectured, lies among the disruptive syenites. Its north-western limit is formed by the great syenitic chain of Beinn Dhearg and Beinn na Cailleaich; the hillward slope of Beinn Shuardail and the hollow of Glen Kilbride bound it on the south-east; the shore of Loch Slapin, from Beinn na'a Cro to the mouth of Glen Kilbride, forms its south-western termination; while to the north-east it approaches Beinn Bhuidhe and Broadford. Within this area the bedded limestones of Broadford Bay are altered into a crystalline mass; stratification is usually obliterated, along with all trace of fossils, and what was before a dull blue limestone assumes all the sparkle and varied tints of a primary marble, mottled sometimes like that of Balahulish, or pure like that of Carrara.

The action of atmospheric agents upon this rock has caused it to weather in a very singular manner. The eminences which it forms, in not a few instances, look as if a shower of oblong grey blocks had been shot into their soft peaty surfaces. In some places the marble assumes a finely cavernous exterior, pitted all over, like a sandy beach after rain. At other times the blocks are smooth as tombstones, and stand out in bold relief from the heath and furze that surround their base. No moss or lichen can cling to them, nor does the vegetation of the soil cluster up their sides, as it never fails to do round the mouldering dykes, so that the marble-hillocks arrest the eye at once, and can be distinguished at a considerable distance. This manner of weathering is not, however, peculiar to the marble. It may be seen, though in a much less marked manner, along the outcrop of unaltered limestone south of Sculamus. But the most

* The geological era of these events has still to be fixed. Professor Edward Forbes was of opinion that the trap-hills of the north-east of the island were of Middle Oolite age, but admitted that the district would require a more extended investigation before the point could be made out with certainty. See Quart. Journ. Geol. Soc. vol. vii. p. 109.

remarkable example of weathering is probably that on the beach south of Camus Smalaig, where, to the action of the atmosphere, there has been added that of the waves. The rock is there of a leaden-blue colour, and its surface bristles thickly with sharp rough irregular fragments, having a greenish hue and adhering to the marble often by the merest point. These small roughnesses are so angular as to wound the hand when it is passed even gently across them, and they render walking dangerous alike to boots and skin. I can compare them to nothing but what we might conceive would be the appearance presented by a shower of moist tea-leaves that had been thrown athwart a freezing pond and become hard and fixed in the ice.

The texture and colour of the marble vary in different parts of the district. The whitest varieties are to be seen at the Kilchrist quarries, and in the vicinity of Kilbride. In each of these localities there is a large mass of syenite close at hand. Various shades of grey occur, in some instances (as on the shore south of Camus Smalaig), in contact with the syenite,—the marble assuming a crystalline or saccharoid texture. Green streaks of serpentine mottle the rock where it is intersected by trap-dykes, and also, at Camus Smalaig, where it is cut through by syenite. Specimens may also be obtained prettily veined with blue and purple (rarely with red) even in the immediate vicinity of the purest crystalline varieties, as at the Kilchrist quarries. As the marble recedes from the syenite it darkens in colour, loses its metamorphic aspect, and gradually passes into an ordinary limestone.

On the exposed marble-cliffs that fringe Loch Slapin, a little way north of Glen Kilbride, I have found what appears to be the fragment of a Pentacrinite. With this exception I have not succeeded in detecting in the altered limestone any trace of organic remains. There are, however, a number of rough nodular accretions of cherty carbonate of lime, of great hardness, that protrude, sometimes in considerable numbers, from the smooth surface of the marble. These may represent some of the organisms seen along the eastern shores, and I have sometimes fancied that my eye could detect what bore a remote resemblance to a Gryphite. If such irregular nodules do actually represent *Ammonites*, *Gryphææ*, &c., these organisms must have undergone no little distortion and obliteration—Pentacrinite, Ammonite, and Pecten being jumbled together into rugged lumps of cherty limestone.

The passage of the metamorphic into the unaltered limestone is a point of considerable interest, and may be studied to advantage on the shore of Loch Slapin at the mouth of Glen Kilbride (MS. Sketch No. 13). There the altered limestone is seen abutting against the syenite of Beinn an Dubhaich. As it approaches the sea it becomes dark, compact, and dull in grain, with streaks of white, but devoid of fossils. Then occur seams of lighter-coloured limestone and hard shale with *Gryphææ*, succeeded by a dark blue close-grained limestone with *Ammonites*, &c. These beds are followed southwards by calcareous grits, sandstones, and limestones similar to those above

the Broadford-limestone; while, as the strata pass towards Suishnish, the Pabba-shales supervene. I know of no other locality where a similar section can be seen. Macculloch indeed describes one on the shores of Loch Eishort near Borereg*. But he has mistaken the quartz-beds there for altered sandstones, and consequently has been deceived as to the true character of the interstratified limestones. They are assuredly not metamorphic, for they contain *Ammonites*, *Gryphææ*, and comminuted fragments of shells, and are identical in position and texture with the beds along the Broadford shore†.

The amount of alteration is not uniform throughout the metamorphic area. It is greatest in the immediate vicinity of syenite, and slightest where that rock is at a distance. Perhaps the most thorough degree of alteration has taken place in that limestone-patch enclosed in the syenite of Beinn an Dubhaich, whence Lord Macdonald has quarried some large blocks of snowy whiteness. It is exceedingly hard, and probably could not be worked without considerable labour and cost. It has moreover the defect of losing its brilliant purity on exposure: a fragment that was polished about twenty years ago has a dirty yellow surface, while a piece of Carrara marble that was prepared at the same time is still as bright as at first.

A less amount of metamorphism is discernible among the knolls round Torrin, where the marble possesses in some places an easily discernible stratification, and dips north-west at from 20° to 37°. The texture of the rock at these points is usually crystalline, sometimes dull and compact, having a bluish-grey shade that merges on the one hand into white, and on the other into a dark leaden-blue. The faintest trace of alteration can be observed at the spot on Loch Slapin, where the metamorphic shades off into the unaltered rock. In these instances, as in the district generally, the amount of metamorphism is regulated, on the whole, according to the proximity of the igneous rock. But, as stated above, the alteration in parts of the district removed some way from any syenite is still so great as to suggest that it may have been produced by igneous masses which,

* Description, vol. 1. p. 327.

† The section given by Macculloch (Description, pl. xiv. fig. 2) of the northern coast-line of Loch Eishort bears at best but a remote resemblance to nature. The long ridges of marble, which he there inserts, have no existence; and the vast tract of syenite, represented as stretching away eastward across the red sandstone, is equally imaginary.

Another section (*ibid.* pl. xviii. fig. 3), explanatory of the occurrence of the marble, cannot be passed over without comment. It is entitled a "Sketch of the relative position of the marble and shelly limestone at Kilbride." Now it so happens that at Kilbride there is no shelly limestone. The whole district is one of crystalline marble, except at the roots of Beinn Dhearg, where the shales already described occur. Nor is there, that I am aware, either at Kilbride or anywhere else in Strath, such a thing as a mass of marble intercalated with shelly limestone in the way shown in this section. He observes that "these circumstances are all much more obvious in nature than in the sketch." Yet I have very carefully gone over the whole of that locality without discovering where the sketch was taken, or what appearances it was intended to represent. The only passage of marble into shelly limestone is that noticed above; but the repeated intercalation of the one rock with the other, so very obvious in the sketch, is not observable in nature.

having never reached the surface, may be the underground prolongations of the hills now visible. The minor protrusions of syenite seen in various parts of the metamorphic region seem to favour this supposition*.

I should leave my notice of the metamorphism of Strath incomplete were I to omit mention of the fact that, as the basalt-dykes were erupted previous to the syenite, they must have suffered from the general baking of the rocks. The dykes of the altered area are perhaps harder and closer-grained than those among the unaltered strata. But I confess that the great variety in the texture of the basalt-dykes, as a whole, renders it difficult, if not impossible, to establish any distinction among them.

Faults.—The faults of the district are not very numerous, nor do they merit special remark. Their general strike is northerly, varying a few degrees east or west; the details of several have been given above, and for the others I must be permitted to refer to the accompanying map and sections (Pl. I.).

Conclusion.—I have thus gone over what seemed most worthy of notice in the geology of Strath, and, in conclusion, will now briefly sum up these scattered facts, that the general bearings of this paper upon Hebridean geology may be distinctly seen.

The old basement-rock upon which the various changes described took place, is the Red Sandstone of Sleat. As it has never yielded any fossils, its age is still matter of doubt. It can scarcely be Old Red Sandstone; possibly it is Silurian, or one of the later deposits of the gneissic series, for it graduates southwards into the schists of the Sleat hills. The geological history of Strath accordingly opens among the records of a venerable antiquity. But here a great gap occurs in its chronology. The district contains no memorials of palæozoic life; and thus, while other parts of Scotland had successively their land and sea of the Old Red Sandstone, Carboniferous, and Permian periods, the old grey hills of Skye seem to have remained unchanged.

After the lapse of long centuries, the Red Sandstone, shattered and broken, slowly sank beneath an ocean in which *Ammonites*, *Belemnites*, and *Gryphææ* began to appear. The margin of the foundering land was first fringed with a band of conglomerate as the waves broke against the cliffs, while greenish sand accumulated farther from the shore. In deeper and stiller water the peculiar organisms of the Lias began to abound; seams of limestone were slowly aggregated, and, at least at one spot, a reef of massive *Isastrææ* gleamed white beneath the waves. The growth of these corals was suddenly arrested by the inroad of a large amount of muddy sediment, which silted up around them, and insinuated itself into their minutest crevice. By degrees the waters became clear, organisms began once more to swarm, but the *Isastrææ* had perished for ever. Beds of limestone, occasionally checked by irruptions of argillaceous matter brought by the shifting currents, were gradually elaborated; and when they had attained a

* I find that Macculloch throws out a similar conjecture (Description, vol. i. p. 333).

thickness of fully 150 feet, the series was suddenly brought to a close by a protracted accumulation of sandy mud, abounding in *Gryphææ*, which now forms the shale-reefs of Obe Breakish. This muddy sediment had ceased to darken the water, and the abundance of animal life had spread a limy floor below the sea, when, like a premonitory symptom of the changes of after-times, the long ridge of Beinn Shuardail was upheaved. Its summit, exposed to the dash of the waves, was ere long bared of the capping of lias-beds under which it rose, and fragments of limestone, red sandstone, and quartz-rock, some well-rounded, others sharp and angular, rolled down the sides to form the limestone-breccia already described. The reef, wasted by the surf, began at length to sink together with the surrounding ocean-bottom. Limestones formed over its site, many of them richly charged with the characteristic organisms of the Lias, and often seamed with thin courses of shale. And when they had attained a depth of not less than 200 feet, a change in the direction of the currents, or some other modifying cause, brought the calcareous series to an end. Dark sandy mud settled down on the floor of the sea, entombing in rich profusion the remains of *Ammonites*, *Belemnites*, *Pectines*, *Gryphææ*, *Pinnae*, *Pentacrinites*, and many others. The thickness attained by these argillaceous deposits fully doubled that of all the preceding beds, and my excursions have not yet carried me further than the shales of Scalpa, which are not probably the close of the series. These latter strata seem to be the equivalents of the Marlstone of England. It remains as the labour of future years to carry on this history through the Upper Lias and Lower and Middle Oolites that fringe the eastern shores of Skye, as far as its most northern promontory—the pillared cliffs of Duntulm.

The next point in the geology of Strath to which the evidence conducts us, is the eruption of the igneous rocks. I have said that there is nothing in the district itself to indicate how long after the deposition of the Scalpa-shales the first of these eruptions took place. That is a question which a careful examination of the northern part of the island may do much to solve. Meanwhile we are in possession of some important facts in the history of the igneous eruptions of the Hebrides. The district of Strath affords convincing evidence that at a period posterior to the Middle Lias, there was an extensive outburst of basalt, which, in the form of dykes, penetrated the liassic strata throughout their entire area, without, however, effecting any marked alteration of them; that at a subsequent time a tract of syenite fully forty square miles in extent, along with several minor masses, broke through the beds, tilting them on end, and producing in them a widely diffused and complete metamorphism; and that at a still later period a series of syenitic and greenstone eruptions forced their way among the limestones and shales, not, however, tilting them, nor giving rise to any extraordinary amount of alteration.

Future labours in other parts of Skye, and among other islands of the Hebrides, will probably throw much light on the history and age of these volcanic rocks. The Western Islands, unquestionably, must have been the seat of powerful igneous action during the

later secondary or earlier tertiary epochs ; and I am much inclined to think that some of the later felspathic ashes and basalts which dot the mainland, together perhaps with not a few of the great parallel faults and dykes, may belong to this volcanic era. A thorough examination of these islands cannot fail, therefore, to elicit much truth as to some obscure points in the physical history of Scotland.

Of the geology of Strath, however, there is one branch that seems to be complete in itself, whereon we can expect little light to be thrown from other districts. I allude to what is certainly its most characteristic feature—the metamorphism of the lias-limestone. Strath may be surpassed by other localities among the Western Islands in the preservation and number of its organic remains ; but I despair of meeting with a more striking example of metamorphism. The igneous rocks of this parish, with their varieties of kind and form, and their effects on the surrounding strata, impart to it an interest all its own.

Notes to the Map and Sections : Plate I.

The accompanying Map has been taken partly from that of Dr. Macculloch, partly from the Charts of the Admiralty Survey, of which a tracing was kindly sent me by Captain Wood, R.N., Kyle, and partly from bearings with the azimuth-compass. It is far from being accurate ; yet the errors are not probably so material as to affect to any considerable extent the general bearings of the geological lines.

With regard to the geological part of the Map, there is but one remark needed here. The irregular bulging hill of Creag an fithick, south of Beinn Dhearg, is coloured (in the original) like the syenite, but of a fainter tint. The rock has puzzled me not a little. Sometimes it seemed like an earthy greenstone, sometimes like a felspathic porphyry ; at some points it assumed many of the characteristics of an ash or tufa, with fragments of altered shale ; at others it approached in texture and general appearance the syenite of the contiguous hills. It is likely that there may be several kinds of igneous rock in the series of lumpy knolls from Kilbride north-eastward, but I was unable to separate them out, and I have coloured the whole as one mass. It is by no means easy to ascertain to what age these rocks belong ; they seem to have come up in the rent formed by the disruptive syenite of Beinn Dhearg, and to have flowed over atop. But it would be rash at present to hazard any conjecture regarding them.

[The lines of sections, with roman numerals, on the Map, fig. 1, refer to the MS. Sections.]

The Sections are drawn on the scale of 1 inch to the mile, except with regard to the height above the sea-level, which in most cases has had to be exaggerated. [In fig. 8 the syenite has been lessened in height.] The upper horizontal line in each of the Sections marks the sea-level, and the space between that line and the lower one represents a thousand feet of vertical depth.