
Chapter 17 Post-igneous, glacial, and post-glacial geology of Arran

Post-igneous and pre-glacial geology

So far as is known there are no deposits in Arran belonging to the period intervening between the close of the Cainozoic igneous episode and the beginning of the glacial epoch of the Pleistocene. The only guides to the geological history of this time are the major topographical features which were initiated during this interval. That the origin of the present topographical features of Arran long post-dated the end of the igneous episode is shown by the way the valleys cut the later dykes. If the valleys had been in existence towards the end of the igneous period lava would have been poured out into them. Similarly the major topographical features predated the Pleistocene glaciation, as can be shown by the distribution of the glacial deposits and strip.

There can be no doubt but that at the close of the igneous period Arran formed part of an elevated plateau which included most of Scotland. This plateau extended far to the north-west, and had a gentle inclination to the south-east. From it the existing Highland topography has been developed mainly by river erosion. According to Prof. J. W. Gregory, North Arran probably presented the appearance of a gently-undulating tableland 2000 feet or more above sea-level, and at this stage some consequent valleys, such as the Glen Chalmadale–North Sannox 'through' valley, may have been incised on its surface.

The Thousand-foot Platform — From many viewpoints the northern granite mountains are seen to be surrounded by a well-marked rock platform, at heights of from 800 to 1200 feet. The well-known view of Goatfell from Brodick Bay ((Plate 1), *Frontispiece*) shows a remarkable development of this feature on both sides of Glen Rosa. Another viewpoint from which the platform can be well seen is Windmill Hill, near the summit of the String Road. Other fine developments of the platform are to be seen on the west side of the mountains south of Pirnmill, and between Glen Catacol and Glen Easan Biorach. This feature has been closely studied by Dr. F. Mort<ref>The Sculpture of the Goatfell Mountains, *Scottish Geogr. Mag.*, vol.xxvii., 1911, pp. 632–643; The Sculpture of North Arran, *ibid.*, vol.xxx., 1914, pp. 393–404; North Arran: A Physiographic Study, Thesis for D.Sc., University of Glasgow, 72 pp., 1914.</ref> and by Prof. J. W. Gregory.<ref>The Pre-Glacial Valleys of Arran and Snowdon, *Geol. Mag.*, vol. *Ivii.*, 1920, pp. 148–164.</ref> According to the latter author the platform varies in height from 800 to 1200 feet around Goatfell and north-west of Brodick, 700 to 1000 feet

The platform can be recognized at a lower altitude in the southern part of the island, although it is not so conspicuous as in the region adjacent to the mountains. Prof. Gregory states that its height varies from 500 to 750 feet in the south-western part between Blackwaterfoot and Glenscorrodale, and from 500 or 600 to 900 feet in the south-eastern part of the island. The uplift that produced the platform must, therefore, have been differential, with the greatest amount of uplift north of Brodick.

Around the granite mountains the platform is everywhere quite independent of the nature of the underlying rock formation. It is eroded on schist and granite indifferently. Its drainage is remarkably immature, and the surface is practically untrenched by stream erosion.

The age of this feature is certainly pre-Glacial, for its surface is plastered with drift, and deep valleys with glaciated floors on which are well-preserved moraines, have been cut through it. The 'thousand-foot platform' of Arran is correlated both by Dr. F. Mort and Prof. J. W. Gregory with the Pliocene plateau, of which remnants are widespread throughout Great Britain, and which is especially clear in North Wales and Cornwall.

Dr. F. Mort advances good reasons for regarding the 'thousand-foot platform' as due to marine erosion, in which opinion Prof. Gregory concurs. If this is so, it is evidence of an uplift of at least 1000 feet, probably much more if the buried valleys of southwestern Scotland are taken into account.

Fragments of a lower platform at 400 to 500 feet above sea-level can occasionally be detected, as Dr. Mort points out. One of the best examples of this erosion plane is the platform which rises immediately west of Corrie. Inland from Lamlash and Whiting Bay there are also traces of a platform at about this level.

The Valley System of Arran — A radial system of valleys, diverging approximately from the centre of the granite mass, is discernible in North Arran (p. 3), but as Prof. Gregory has shown^{<ref>Op. cit., p. 150.</ref>}, this system is subordinate to a major system of three 'through' valleys which run roughly north and south. It may, however, be pointed out that the main direction of the Catacol-Scaftigill, and the Easan Biorach-lorsa valleys is N.N.E. to S.S.W., whilst that of the upper part of Glen Rosa runs approximately N.N.W. to S.S.E. The Catacol-Scaftigill depression has been guided by a shatter-belt or zone of crushed granite which was first pointed out by Mr. John Smith^{<ref>Trans. Geol. Soc. Glasgow, vol. x., part ii., 1896, pp. 228, 254, and Plate V. 17</ref>} (Plate 3), while the Glen Rosa valley coincides with the direction and outcrop of one of the longest basalt dykes intersecting the granite. The line of the Glen Rosa valley is continued southeastward over the col through which the Brodick-Lamlash road passes, and by the channel between Holy Island and Kingscross, as is well shown by the view up Glen Rosa the traveller gets when sailing from Whiting Bay to Lamlash on a clear day (cf. (Plate 6)). The Chalmadale-North Sannox valley to the north-east, which, as Dr. Mort suggests, was probably cut by a consequent river at an early stage in the physiographic history of the island, seems to have been guided to some extent by the important zone of fracture which bounds the granite on its north-eastern side, and which is continued to the north-west by the fiord inlet of Loch Ranza. As Dr. A. Scott mentions,^{<ref>Notes on the Physiography of Arran, Scottish Geogr. Mag., vol. xxxiv., 1918, pp. 90-99.</ref>} the only large valleys in the northern part of the island which do not conform to the approximate north to south trend are Glen Sannox, and the White Water south of Corrie, which, apart from the middle course of the Sannox (south-west to north-east), run roughly west to east. It may be pointed out that the lower part of Glen Catacol runs south-east to north-west. Hence valleys in the northern half of Arran tend to run parallel to the major tectonic directions which have been impressed upon the granite and its surrounding rocks, and to be guided by the zones of weakness which have been produced by the tectonic conditions.

A survey of the chief valleys of the southern half of Arran yields the following facts as to their average directions. The only valley that runs approximately E.N.E. to W.S.W. is the 'through' valley of Glen Shurig-Gleann an t-Suidhe. Valleys running north-east to south-west include the Machrie Burn, the middle course of the Machrie Water and its tributary the western Garbh Allt, the Black Water, the Slidery Water, the Kilmory Water, and the Glen Cloy-Glen Dubh valley. From east to west run the valleys of the lower part of Glen lorsa, Auchencar Burn, the lower part of the Machrie Water, Ballymichael Glen, Clauchan Glen, Glen Ashdale, Kingscross Burn, Monamore Glen, Benlister Burn, and Glen Ormidale. The north-west to south-east valleys are Glen Craigag, Allt Dhepin, Sguiler Burn, and Blairmore Glen north of Lamlash. The north to south valleys are comparatively insignificant, and include only the Levencorroch Burn, the Allt Mòr and other streams near Kildonan, and the Strathwhillan Burn south of Brodick.

From this it appears that the pattern of the southern valleys, with the exception of the E.N.E. to W.S.W. 'through' valley of Glen Shurig-Gleann an t-Suidhe, conforms roughly to the main structural and tectonic directions of the island, although the north to south element so prominent in the north is reduced to insignificance in the south. Dr. A. Scott regards the south-westerly valleys, such as those of the Slidery and Kilmory waters, as normal consequent streams flowing down the dip slope of the New Red Sandstone sediments.^{<ref>op. cit., p. 97.</ref>} The Benlister Burn (west to east) is regarded by him as an obsequent stream which has cut through the original watershed, and has diverted part of the headwaters of the Clauchan Burn.^{<ref>op. cit., p. 98.</ref>}

The north-west to south-east element in the pattern is due to the prevalence of dykes in that direction. Glen Craigag, the chief headwater of Benlister Burn, the Sguiler Burn, the upper part of the Allt Dhepin, and the scarp feature of Cnoc na Garbad (p. 132), are all practically on a straight north-west to south-east line nearly 10 miles in length, and over the greater part of that distance the north-west to south-east dykes can be shown to determine the directions of the valleys.

Sequence of events in Post-Igneous and Pre-Glacial Times — The system of tectonic fractures which traverses the northern half of Arran was certainly initiated before the close of the Cainozoic igneous period, for the later dykes were injected into many of the planes of weakness then produced. We may assume that at the end of the igneous episode, before the northern granite had been uncovered, Arran was joined to the mainland, and formed part of the Cainozoic plateau of Scotland from which the present topographical features of the country have been developed. Following

Professor Gregory, we believe that Arran was first planed down to a gently-undulating plateau which stood 2000 to 3000 feet above sea-level, and was trenched by one, or perhaps two, of the early consequent northwest to south-east rivers. The relics of these valleys are the Chalmadale–North Sannox 'through' valley, which may have been influenced by the system of fractures on the north-eastern margin of the granite; and the Glen Rosa–Blairmore Burn–Lamlash Bay depression, which may have been continued north-eastward along the line of Glen Catacol. This valley coincides in part with a long basalt dyke.

After the establishment of this system the country was again elevated, with the reopening of the north to south clefts across the granite, and the production of great tectonic valleys to east and west, isolating Arran from the mainland. The land must then have remained stationary for a period long enough for the formation of a low plain of marine erosion, which was raised by a third movement into the 'thousand-foot platform.' The tectonic clefts were again caused to gape, and were enlarged by denudation until their floors were but little above sea-level. Thus were produced the main north to south valleys across North Arran, although the writer believes that the Glen Rosa–Lamlash Bay depression was initiated at an earlier date than the other two, and was originally a part of the consequent drainage. During these movements the climate had gradually become colder, leading up to the Glacial Period which now supervened. G.W.T.

Glacial geology

Glaciation — At the climax of the Pleistocene Glacial Period the Clyde region was covered by an ice-sheet which moved generally from north to south. This is evident not only from the distribution of erratic boulders in various parts of the district, but more particularly from a study of the glacial stria on the solid rocks. The direction of these is almost due south in many examples on either side of the Little Cumbrae and near Ardscalpsie in Bute. Sometimes there is a deviation towards the east as on the rock called Miller's Thumb in Millport Harbour, where the direction is about 15° E. of S., and near Barr Buidhe, South Bute, where it is S.S.E. In other cases it is west of south, as in Bute to the east of Barefield (S.S.W.).

It is clear, then, that the ice-sheet from the north moved over the comparatively low ground of Bute and the Cumbraes without let or hindrance, but the high hills of Arran divided the stream of ice as a rock in a running stream divides its current. For along the western side of the high ground south of Catacol we find almost universally the direction of the striae parallel to the edge of the granitic mass. At first the direction is nearly S.W., as near Lochan a' Mhill. From Penrioch to Imachar the general trend of the ice-markings gradually changes from S.S.W. to almost due south, and about Balliekin it becomes east of south. Thus we have clear evidence that the ice-sheet *coasted* the high ground instead of going over it. The striae on the granite inland to the west of the Iorsa valley have the same southerly tendency, but as the direction of these coincides with that of the valleys there it is not clear whether they are due to the great ice-sheet or to local glaciation. Portions of the great sheet may have gone over the watersheds at the heads of Catacol Burn and Easan Biorach, which are both under 1200 feet in height, and been augmented by local ice shed from the neighbouring hills.

The larger granitic mass east of the Iorsa caused a much greater deviation in the direction of the ice-sheet, for from Torr Meadhonach, in the north of the island, all along the skirts of the mountains we find the general direction of glaciation to have been between E.S.E. and due east. This continues at least as far as Farchan Mòr on the south side of Glen Sannox. It now becomes pretty clear that the high mountains of Arran were not overridden by the general ice-sheet, but they must, both before and at the time of greatest glaciation, have been covered by a local ice-cap which shed material all round to increase the general mass of ice. The high ground south of Gleann an t-Suidhe may have formed a local ice-sheet also. At all events we have evidence that to the south of this the general ice-sheet moved south-westward over Arran towards Kintyre. It may be mentioned that glacial striae are particularly numerous and good on the west side of Arran near the road between Whitefarland and Imachar; a particularly fine example of a grooved and polished surface of schist may be observed by the roadside at the former place.

To the east-south-east of Auchencar ridges of drift or drumlins which are parallel to the general direction of the glacial striae are very prominent. They trend somewhat to the west of south, and in several cases are evidently examples of the phenomenon called crag and tail, for each of them is under the lee of a crag behind which the glacial material has accumulated. W.G.

In his uncompleted MS. on Sheet 13 Gunn listed some notable localities for well-preserved glacial striae in the southern part of Arran as follows:

Striae are most numerous and best preserved on the quartz-porphyry of Brown Head and Cnocan Doun. They all run nearly N.N.W. A hundred yards east of Ballymeanochglen west of Dippin there is a strong set striking E. 40° N., and a faint set striking E. 10° N. North-west of Clauchog Farm the stria run nearly due south, while east of Smuraig the direction is north-east. North of Glenscorrodale the striae trend 30° E. of N., and north-east of Cnoc a' Chapuill there are many striae running N.N.E. In the Slidderly Water south-east of Cnoc na Dail, and at the head of the Slidderly Water they strike E.N.E. On the north side of Monamore Glen there are striae running N.E. and E.N.E., whereas in the burn itself the direction is east and west parallel to the stream course. On the island of Pladda off the south-east coast of Arran the striae run E.N.E.

Erratics — Most of the erratic blocks and boulders of Arran are of local origin, a phenomenon no doubt due to the protecting influence of the local ice-cap. Some examples of foreign boulders are given below. G. W. T.

A well-rounded boulder of coarse granite with large crystals of pink felspar is on the shore about half a mile west of the Cock of Arran. It is probably an example of the granite of Glen Fyne which has been carried from the north. About three-quarters of a mile west of Lochranza pier there is, at a height of about 200 feet above the sea and reposing on the schists, a large boulder of brecciated conglomerate very like the kind so common in the Upper Old Red rocks of Bute. Its dimensions are 12 feet long by 9 feet broad, and it is 4 feet high. This block of coarse rock is composed mainly of fragments of quartz and schist. It may have travelled across from Bute. Rock of much the same character occurs also in Arran, but it would not be easy to account for its position here unless it came from outside the island.

The largest of the local erratics are of granite. The heaviest is probably the Clach Mhòr, on the highest raised beach south of the Corrie Burn and about three-quarters of a mile south of the hotel. It is 30 feet square at the base, about 15 feet high, and must weigh about 400 tons. A block still longer than this (36 feet), but probably not so heavy, occurs among the moraines north of Ceum na Caillich. Clach an Fhionn, a split boulder north of Corrie by the roadside, measures 17 feet by 10 by 7, and Clach a' Chait, 600 yards farther north, is 18 feet long, 6 to 9 feet wide, and about 15 feet high. There is a large granite boulder on the Corrygills shore, and large blocks of granite are numerous on the Clauchland shore on the north side of Lamash Bay, and a few occur high up on the northern slopes of Holy Island. They are abundant on the Old Red Sandstone slope east of Monyquill, where one was measured 17 feet by 8 feet 6 inches; and on the hill-slopes north of Dougrie and on the seashore to the west, where several are as much as 20 feet long. The numerous large boulders of granite and schist that encumber the shore for a distance of a mile and a half north-west from the lorsa Water have been derived from the denudation of the boulder-clay during the process of cutting back the cliff to form the present raised beach, and the Clauchland shore boulders have probably in like manner been derived from the denuded till of the neighbourhood. W. G. Boulders of the northern granite are scattered rather generally over the southern part of Arran. Gunn lists some of the more notable occurrences as follows:—Many large granite boulders on north shore of Whiting Bay; in Glen Ashdale region numerous granite boulders, especially south of Glen Ashdale Wood. Other localities are: on hillside south of Largymeanoch 1000 yards east of Cnoc na Comhairle; on the scarp of the Dippin crininite near Dippin; 300 yards N.N.W. of the keeper's lodge at Kildonan at a point 500 feet above the sea, between the Allt Mòr and Easa Cumhang, Auchenhew; and large boulder 400 yards north of Drumadoon Farm.

A granite boulder, 4 feet by 3 feet by 3 feet, is perched on the edge of the Cnoc na Garbad scarp near 890 feet O.D.

These occurrences bear testimony to the general southward dispersal of blocks of the northern granite. They were prevented from travelling east or west by the pressure of the ice-sheets which filled Kilbrennan Sound and the Firth of Clyde. Although Arran granite has been recorded from Ayrshire, by Mr. John Smith, *Trans. Geol. Soc. Glasgow*, vol. xi., Supplement, 1898, p. 112. on the authority of a local collector, it must be of extreme rarity of occurrence, as many other observers have failed to find it in the drift deposits. J. W. Gregory, *Trans. Geol. Soc. Glasgow*, vol. xvii., part iii., 1926, p. 364. G.W.T.

Glacial deposits — Till or Boulder-clay — This well-known irregularly accumulated deposit is often tinged of a red colour and is very unevenly distributed, being mostly confined to the valleys and low-lying ground. Probably the best exposure

of it in this area is on the north side of Ballymichael Burn, nearly half a mile above the road, where reddish till or stony clay appears from 40 to 50 feet in thickness. Thick masses of grey till may be seen in the banks of the Cnocan Burn, Brodick, about half a mile above the wood, and compact red till appears in the south bank of Glenclay Burn near Knowe. The general drift of the granite area is less clayey and more loosely aggregated, sometimes much like morainic material in character, though not in form. Thick masses of loosely-constructed brownish drift, with large blocks in it, are exposed in the banks of Allt Gobhlach, Pirnmill, half a mile from the sea, and fine exposures of this loose granitic drift are found by the stream called Allt an t-Siorraim which issues from Loch Tanna. In places on the west side of the stream the drift would appear to be from 50 to 100 feet thick. W. G.

The southern half of Arran is largely smothered under a thick sheet of boulder-clay, which is generally some shade of red in colour, owing to the prevalence of the New Red Sandstone country-rocks in this part of the island. The drift is often somewhat sandy, as, for example, in the region south of Tighvein, and Gunn records beds of red sand in the till east of Port na Feannaiche, near Corriecravie. The thickness of the boulder-clay is especially great in the valleys of the principal streams, as Glen Ashdale, the Kilmory Water, and the Slidderly Water. Thick till caps the cliff at Torn nan Uain, west of Bennan Head, and its denudation has supplied the numerous boulders on the foreshore at that locality.

At several places in the Kilmory and Slidderly Waters a glacial shell-bed is found intercalated in the boulder-clay. Accounts of these beds are given by R. Boog Watson<ref>On the Great Drift Beds with Shells in the South of Arran, *Trans. Roy. Soc. Edinburgh*, vol. xxiii., 1864, pp. 523–546</ref> and J. Bryce.<ref>*Quart. Journ. Geol. Soc.*, vol. xxi., 1865, pp. 204–213; see also *Geology of Arran and Other Clyde Islands*, 4th edition, 1872, pp. 44–48, 180–192.</ref> The most accessible section is in the Cloined Burn, a tributary of the Kilmory Water, about three-quarters of a mile north-east of Lagg Hotel. Bryce gives the following section at this locality:

7. Surface soil.
6. An upper drift, similar to No. 4.
5. A compact bed of stones, with less sand, forming a marked line on the cliff, but not easily reached. Thickness, 5 or 6 feet.
4. An upper drift of sand and stones; thickness variable.
3. Dark sandy bed with open texture, 4 or 5 feet, apparently local.
2. Clay bed with shells, 7 to 10 feet.
1. Boulder-clay [very hard and tough]. 12 to 20 feet thick.

The shell-bed is seen again on the west bank of the Kilmory Water, opposite Kilmory Church; and in the Allt na Pairce, near its confluence with the Slidderly Water. The fossils found in these shell-beds are given by R. Boog Watson and J. Bryce as follows:

<i>Balanus crenatus</i>	<i>Modiola modiolus</i>
<i>Purpura norvegica</i>	<i>Leda pygmaea</i>
<i>Tellina baltica</i>	<i>Leda pernula</i>
<i>Cyprina islandica</i>	<i>Pecten islandicus</i>
<i>Astarta elliptica</i>	<i>Pecten opercularis</i>
<i>Astarta arctica</i>	<i>Littorina littorea</i>
<i>Astarta compressa</i>	<i>Turritella communis</i>
<i>Astarta striata</i>	<i>Natica</i> sp.
<i>Cryptodon sarsii</i>	

Many of these shells are in a perfect state of preservation, and indicate quiet deposition on the sea-floor. G.W.T.

Moraines — Relics of a later and more local glaciation also occur in nearly all the valleys in the shape of moraines. They are especially conspicuous in the valleys at the head of the North Sannox stream on the north side of Caisteal Abhail, and in the upper part of Glen Cloy in both its branches, Glen Dubh, and Glen Ormidale. In the three valleys into which the North Sannox stream divides the moraines are generally an irregular assemblage of small mounds composed of huge blocks of granite, but in addition to this there is a fine example of a lateral combined with a terminal moraine on the eastern and north-eastern sides of the heaps south-east of Creag Dhubh. There is also a linear moraine in the eastern valley Coire nan Ceum — in addition to the formless heaps. In South Glen Sannox there is a well-formed lateral moraine, more than half a mile in length, which forms a sloping ledge nearly parallel to the stream on the north side of the valley, under Ceum na Caillich. In Coire nan Larach to the north of Am Binnein there is a beautifully-formed lateral moraine strewn with granite blocks, and there is another in Coire Làn at the head of the White Water. A well-marked linear moraine, which is at a low level to the north of Maol Donn; can be easily discerned from the high road south of Corrie. It has a north-east trend. Moraines are common in the Iorsa valley, and there are fine examples near the head of the Garbh Choire Dubh west of Cir Mhòr. In Glen Rosa they are found less than half a mile west of the wood and below the upper limit of the 100-ft. beach, and they are prominent again two miles farther up the valley where it divides into three. The upper part of the Garbh Allt branch glen, for a distance of a mile from the head of the valley, is almost one sea of moraines. In Glen Dubh (Glen Cloy) there is a magnificent series arranged for the most part in concentric curves round an alluvial flat at the foot of the crags which must at one time have been a glacial lochan, or a tarn, dammed by moraines.

In the valley of the Machrie Water, about Monyquill and Glaister, and also up the Machrie Burn, mounds of detritus occur which at a distance might be mistaken for moraines, but which when closely examined are found to consist of washed sand and gravel. They are, therefore, more of the nature of eskers or kames. On the Machrie Burn they are conspicuous to the west of Cnoc na Ceille, where they form an irregular group stretching for a quarter of a mile parallel to the burn on its east side. On the west side, a line of them, almost a continuous ridge, may be traced to the northwestward for nearly half a mile. On the Machrie Water the best examples of them are found between Monyquill and Machrie Bridge on the west side of the river, and mounds of much the same character are found near the road which runs past Derenenach and Ballymichael to Shiskine. East of Ballymichael these mounds are very striking, and pits have been opened in them in several places for gravel and sand. Pits have also been made in the long mound between Machrie Bridge and Glaister. One of these mounds of a curved shape, south-west of Monyquill, is known as 'The Serpent Mound', and is supposed to be artificial. W.G.

According to Prof. J. W. Gregory, *The Scottish Kames, and Their Evidence on the Glaciation of Scotland*, *Trans. Roy. Soc. Edinburgh*, vol. liv., part ii., 1926, pp. 404–405. the banks of sand and gravel east of the main road north of Shedog are surface washes of sand and gravel down the steep slope of boulder-clay on which they rest. The 'Serpent Mound' south-west of Monyquill, is a bank of denuded morainic material, a remnant of a terminal moraine. The mounds in the Machrie Burn are regarded by the same authority as clayey moraines. Prof. Gregory also describes a line of mounds at Driminigar, east of Blackwaterfoot, which are the remnants of a curved moraine. A small hillock of sand and gravel occurs at the end of the long mound, and is due to a fan formed by a stream that had cut through the moraine. G. W. T.

Post-Glacial and Recent

Raised beaches — The 25-ft. raised beach is a marked feature on the coast-line of Arran. Though often very narrow it is very persistent. It may disappear for a time at a rocky promontory but shortly reappears. Sometimes it is but a shelf cut in the rocky shore with no deposit of gravel on it, and occasionally, as in the case of the Scriden and the Fallen Rocks in Arran, the original shelf has been obliterated by a comparatively recent landslide. The marine shells found in the sand and gravel of this lower raised beach or lying loose on its surface, appear all to be of species now living in adjoining seas, and are a testimony to the recent elevation of the land. A list of some found in a field about a mile south of Corrie is given by Sir A. C. Ramsay. *Geology of the Island of Arran from Original Survey, 1841*, p. 77. A separate beach at the height of the '40 feet' seldom occurs, except at the mouths of the large streams or in sheltered bays. In fact, both the 25-ft. and 40-ft. beaches are represented by the continuous marine terrace above described, which is often bounded by high sea-cliffs in which water-worn caves occur at various levels. These latter are conspicuous between Brodick and Corrie on the eastern side of Arran in the New Red Sandstone; and several are found hollowed out of the schist on the north-west coast. A remarkable group is associated with the King's Cave near An Cumhann on the Tormore shore.

The higher and older marine terraces have evidently suffered much denudation by the action of the sea along the exposed part of the coast, and by streams at their mouths, and in the bays of Brodick and Lamlash, where several burns enter the sea. In these latter situations the marine and freshwater alluvia are mingled so that it is difficult to class them separately. We have evidence, however, of several beaches at different levels rising from 40 or 50 feet to over 100 feet above the sea, which are beautifully exhibited near the mouths of the Iorsa and Machrie streams in Arran. At the time of greatest depression the sea penetrated far up into many of the valleys; Glen Rosa and Glen Cloy were sea lochs, each $\frac{1}{2}$ miles in length; Loch Ranza was lengthened by one mile, and Lamlash Bay extended one mile farther to the west. North Glen Sannox was a long narrow sea loch, and at Catacol and South Sannox there were broad, short lochs. Perhaps the greatest changes in Arran would be on the western coast, where not only was there a sea loch at the mouth of the Iorsa but in the plain of Shiskine the sea penetrated in an irregular way to more than 2 miles eastward of its present boundary, and the hilly ground of Torr Rìgh Beag and Torr Rìgh Mòr formed a separate island. Good sections of the gravel and sand of the higher beaches are exposed in the north bank of the Rosa Burn one mile from the sea, the south bank of Sannox stream opposite Mid-Sannox House, the east side of the Iorsa Water above Dougrie Lodge, and in a gravel pit at Lochranza above the junction of the two main streams and west of Ballarrie.

Freshwater Alluvia — As might be expected from the small size of the streams the patches of freshwater alluvium are generally small and unimportant. The largest are found in the plain of Shiskine, on the Machrie Water above the old bridge, and stretching south-westward along the valley of the Black Water to Drumadoon Bay; in the Iorsa valley above Iorsa Loch, and at the mouths of the Iorsa, Catacol Burn, Easan Biorach, the two Sannox Burns, those which enter the bays of Brodick and Lamlash, Glen Ashdale, Kilmory Water, and Slidery Water. The alluvium at the debouchure of the streams has been to a great extent formed from the denudation and rearrangement of the material forming the raised beaches. In the Shiskine district the alluvium of the swift-running streams on the east side has been spread out in fan-like or delta forms over the marine material. The alluvial sand and gravel of the Machrie is 2 miles in length and nearly half a mile broad in places, and has been accumulated by several swift-running streams of considerable size. At first sight it might be supposed that the material has filled up an old loch, but the fact that there is a rise of quite 100 feet between the foot and the upper end rather militates against this view. The patch of alluvium in Glen Iorsa is nearly as broad as the last and is 3 miles long, and here there must have been at one time an extensive sheet of fresh water which, including the present Loch Iorsa, may have been $3\frac{1}{2}$ miles in length. For a distance of more than a mile above the last-named loch the alluvial flat is studded with small lochans, and the rise in level is but 7 or 8 feet. Even at a distance of more than 2 miles above Loch Iorsa the alluvial flat is only 30 feet higher than the loch. A beautiful example of a filled-up lochan, an old moraine-dammed tarn, occurs at the head of Glen Dubh at the foot of the steep crags. The present extent of the alluvial flat shows this lochan was about 400 yards long and 300 broad. Old lochans or tarns which have been filled up are now generally peat-bogs. It is evident that several of the streams have changed their courses in the low-lying ground near the sea. In an old manuscript map of the latter part of the eighteenth century the Rosa Burn is represented as taking a sweep round to the eastward in what is now the deer-park, and the Cnocan Burn came southward towards it. The marked bank in the park south-west of the cottages shows where the old stream ran. At that time there was a project to make an artificial channel connecting the Rosa Burn with the mouth of the Cnocan in order to form a harbour opposite the castle. The lower part of the Cnocan Burn is now an artificial cut. There is still trace of a large bend, an old course of the Rosa, west of Strabane. The mouth of this stream has undergone several changes. At one time it ran along the sands towards the Cnocan, and afterwards changed to a straight course out to sea.

Then it turned to the north again and its outlet, when the Ordnance Survey was made, must have been nearly 700 yards north of what it is now. The present run straight out to sea is, however, said to be owing to an artificial cut having been made. It has been in existence many years, but is not on the revised Ordnance map. The greater part of the water of Ballymichael Burn is now carried by an artificial channel into the Machrie Water, to the east of the Stone Circles of Tormore.

Peat — *See also p. 269.* — The high ground on which peat accumulates is mostly in the southern half of the island. It covers most of the Central Ring Complex from Beinn Bhreac to A' Chruach, and is thick over the greater part of the region south of Tighvein, and in the valleys of the Slidery and Kilmory Waters. The higher granite hills are almost bare of vegetation, but there is a good deal of peat, however, on the lower granite area from Glen Catacol eastward to An Tunna, and it is abundant on the high plateau-like or gently-sloping ground formed of schists, nearly all round the granite

district. It is found, in fact, over the rocks of all formations in Arran, from the oldest to the boulder-clay of the Glacial period.

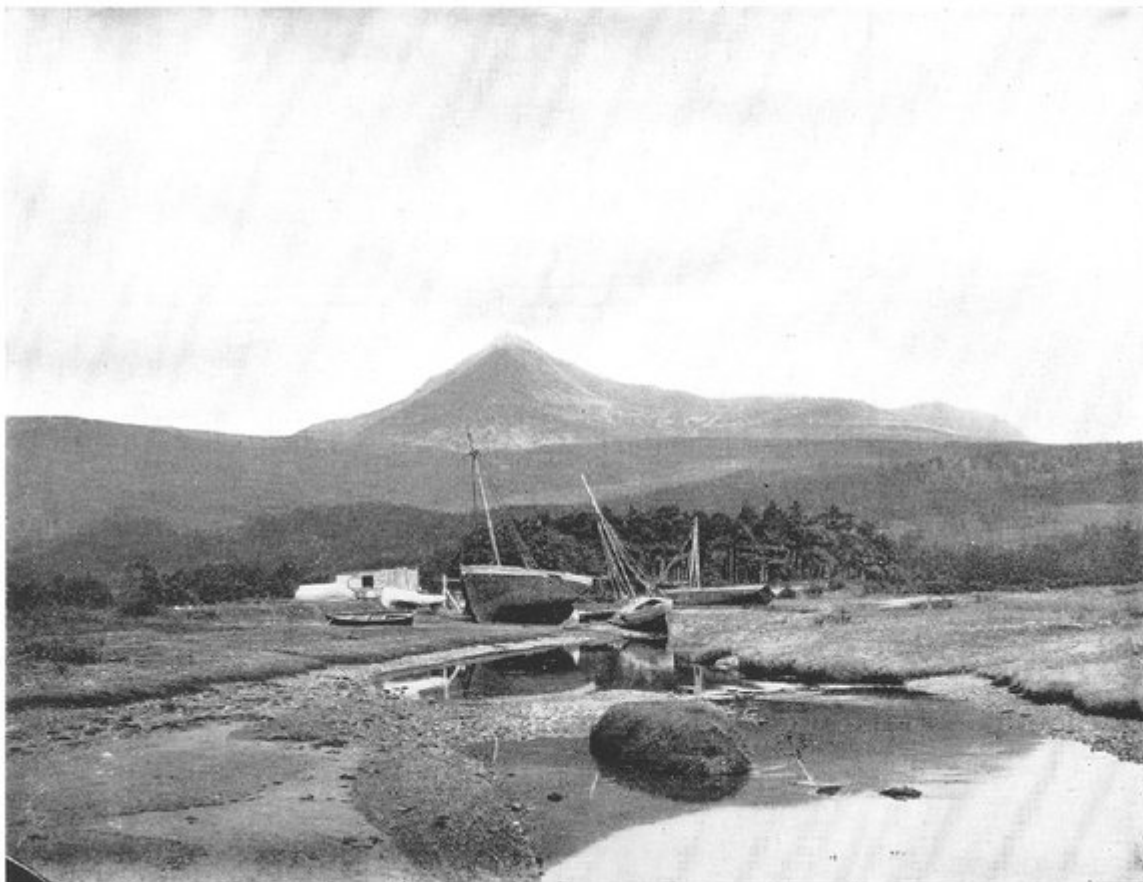
Blown Sand — Blown sand is not common around the coasts of Arran. The most extensive areas are on the west side of the island, at Machrie Bay, and on either side of the Black Water at Blackwaterfoot, where it forms typical seaside links — mounds of loose and shifting sand interspersed with rolling grassy hollows. The only other place where blown sand occurs is on the shore at Eilean Mairi, three-quarters of a mile south-east of Lagg Hotel.

Landslip — Probably the largest area covered by a landslip in Arran is that which is found in the hollow north of Maol Donn, between it and An Sgriob. Large masses both of Carboniferous and Permian rocks are scattered over an area which is 600 yards in length from south-west to north-east, and on an average more than 200 yards in breadth. The extent of this slip must be quite 25 acres. Other notable landslips, which have often been described, are those which form the Fallen Rocks and the Scriden. The former make a striking debacle of large blocks, from a height of 500 or 600 feet down to the sea-level between North Glen Sannox and Millstone Point. The slipped masses are all of Upper Old Red conglomerate. The Scriden covers a larger area at the most northerly part of the island. It is formed of large blocks of New Red sandstone and conglomerate which fell, it is said, some two hundred years ago. The concussion shook the earth, and the fall was heard in Argyllshire and Bute. In addition to the masses which have actually fallen, several parts of the hill above have moved slightly from their position and left deep and narrow rents, one of which is known as the Fairy Dell.

In the south of Arran, while there is a considerable rock fall at Dippin, most of the landslips represent slides of boulder-clay over solid rock. There are notable examples of this type of landslip on the north side of Clauchan Glen, in Monamore Glen, Glen Ashdale, and near High Clauhog. W.G.

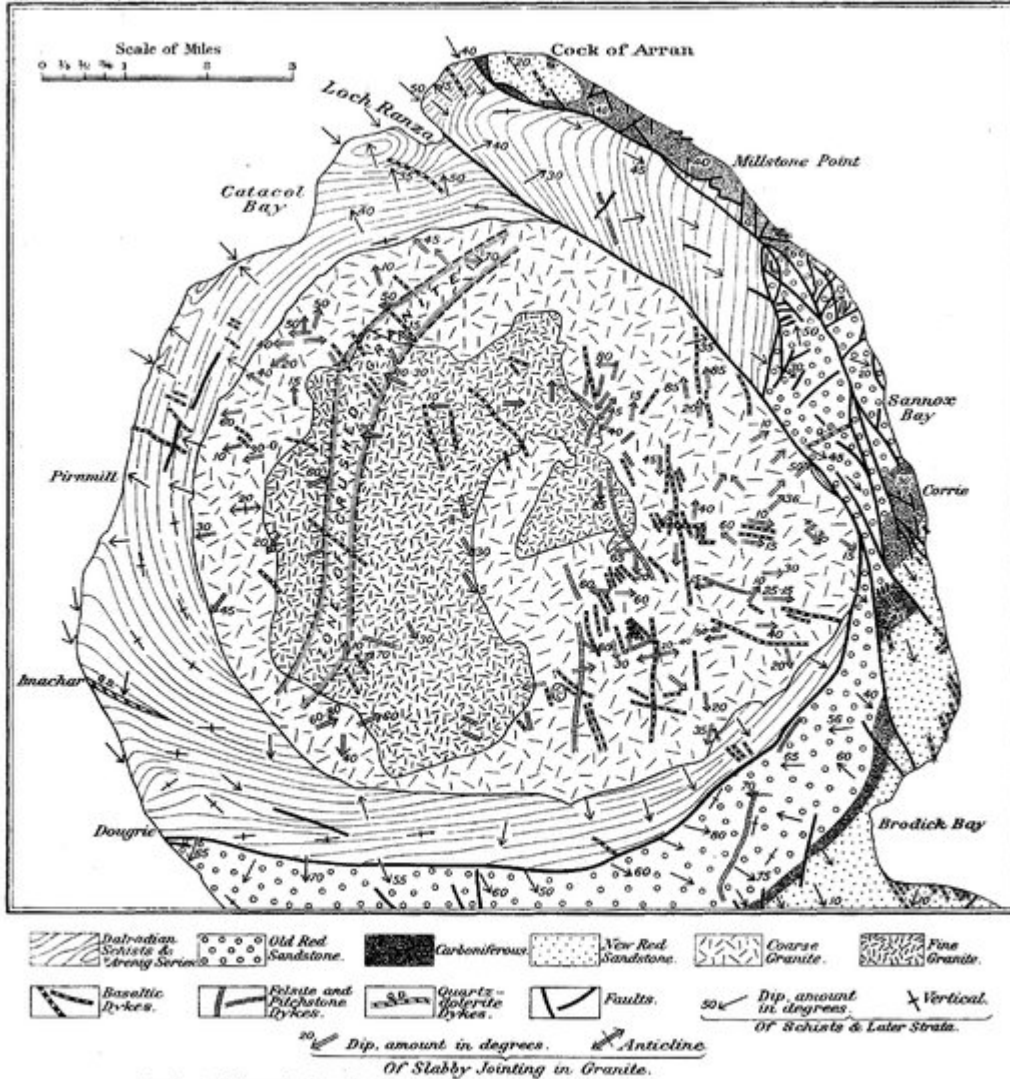
Geology of Arran.
(*Mem. Geol. Surv.*)

PLATE I.



View of '1000-Foot Platform' around Goatfell, from Brodick Bay. [Frontispiece.]

(Plate 1) *View of 1000-Foot Platform around Goatfell from Brodick Bay. Frontispiece.*



(Plate 3) Tectonic map of North Arran.



U-shaped valley of Glen Rosa, looking north ; Cir Mhòr at head of valley, and Ceum na Caillich (or Witch's Step) seen over the divide of The Saddle,

(Plate 6) *U-shaped valley of Glen Rosa, looking north; Cir Mhòr at head of valley, and Ceura na Caillich (or Witch's Step) seen over the divide of The Saddle.*