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THE SCOTTISH GEOGRAPHICAL

MAGAZINE.

THE SCULPTURE OF NORTH ARRAN.

By FREDERICK MORT, D.Sc., M.A., F.G.S., F.R.S.G.S.

(With Sketch-map, Illustrations and Diagrams.)

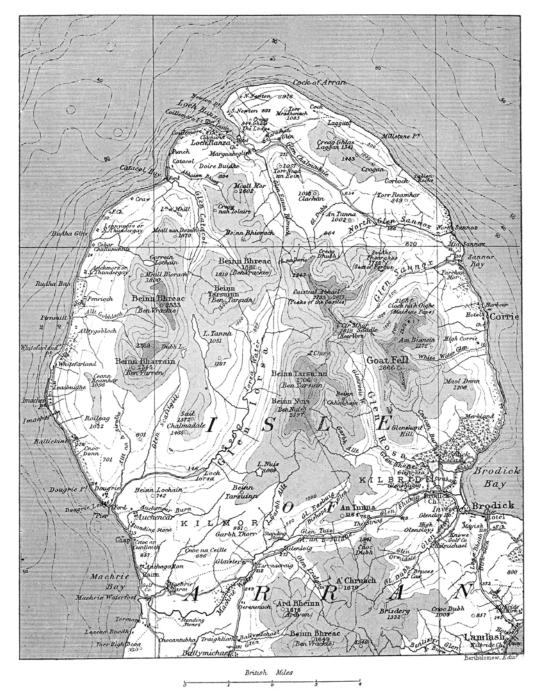
IN a former article in this $Magazine^{1}$ the present writer discussed a number of physiographic problems presented by the Goat Fell group of mountains in North Arran. Evidence was led controverting the usually accepted view that the marked difference in appearance between east and west Arran is due to the fact that the eastern mountains are composed of coarse granite while the western mountains are composed of fine granite. Jointing and igneous dykes were shown to have an effect on the scenery, but this effect is a secondary one. The prime cause is the glaciation of the region.

A plateau varying from 900 to 1100 feet above sea-level was shown to be well developed about the Goat Fell group. This plateau (called the thousand-foot platform) was formed in late Tertiary times, and a marine origin is suggested. The valleys of the Goat Fell group present several abnormal features, which are attributed to glaciation. By a consideration of the sections along the thalwegs or river-beds of Glen Rosa and its tributary the Garbh Allt the conclusion is reached that Glen Rosa has been deepened by ice not more than 800 feet and not less than 500 feet.

The orientation of the corries of the Goat Fell group is significant. There are about ten in this area, only one of which faces west; the others face north-east or east, that is, the direction away from the sun and the warm winds, and most favourable to the accumulation of snow and ice. A somewhat similar phenomenon is exhibited by many of the ridges. One side is steeper than the other, and the steep side almost

VOL. XXX.

¹ "The Sculpture of the Goat Fell Mountain Group," vol. xxvii. p. 632.



MAP OF NORTH ARRAN.

The lighter shading shows land over 1000 feet in height, the deeper that over 2000 feet.

invariably faces in a direction between north and east. The conclusion of the paper is "that a large-featured, round-shouldered, full-bodied mountain of pre-glacial time had been converted by erosion during the Glacial Period—and chiefly by glacial erosion—into the sharp-featured, hollow-chested, narrow-spurred mountain of to-day."

Since 1911 the writer has extended his investigations over all the northern part of Arran, and the following pages give a summary of the main results of this work. The thousand-foot platform has been found well developed round all the mountains of North Arran. It forms a broad, flat shelf from which the central mountains rise steeply. The appearance of this peneplain in the Goat Fell area has been described in



FIG. 1.—Meall nan Damh from Catacol. A mountain of coarse granite yet presenting smooth outlines.

the paper referred to above. In the west of the island it is best developed south of Beinn Bharrain. This part of the platform can be traced for over six miles to the north until it is cut through by Glen Catacol. The belief that this ancient base-level of erosion is of marine origin is supported by the fact that similar lower plateaux can occasionally be detected, although much smaller and more fragmentary. For example, a platform about 500 feet above sea-level can be seen in certain parts of North Arran. This of course cannot be reconciled with the sub-aerial origin of the lower platform, for during the formation of the lower peneplain the thousand-foot platform would have been dissected to a considerable degree, which is not the case. If the platforms are sea-cut, however, this difficulty does not arise.

In the Ice Age North Arran was a centre of independent glaciation. The eastern area is higher than the western, and ice-erosion was therefore more vigorous in the east than in the west. This is shown by the

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fact that the western glens less frequently cut deeply into the thousandfoot platform, but generally debouch on to the platform. In the cycle of glacial erosion the eastern area has reached a more mature stage than the western. The narrow, branching arêtes, the serrated outlines of the ridges, the valleys heading into wide amphitheatres, the cols, the large cirques,—all these features indicate maturity. In the west the valleys are U-shaped, but do not head in amphitheatres; valley heads are rounded and corrie-like, but of the same width as the valleys; the ridges are generally round-backed and broad; the original upland is clearly manifest; cirques are much rarer; there is no example of a col formed by two cirques.

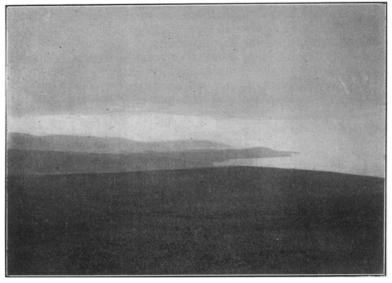


FIG. 2.—The Thousand-Foot Platform from hills south of Pirnmill. Machrie Bay in background. The immature dissection of the platform is well shown.

W. H. Hobbs in his *Characteristics of Existing Glaciers* has attempted to classify the stages in the process of glacial erosion. He recognises four stages:

- 1. The initiation of the cirque. The valleys begin to show a "grooved" effect.
- 2. The "grooved upland." Valleys are U-shaped, but the head cirques are the same width as the valleys. Ridges are not strongly denuded.
- 3. Early maturity. Valley heads are widened into amphitheatres. Ridges are narrow, but part of the original rounded surface can be recognised.
- 4. Full maturity resulting in the "fretted upland." The valleys are straight and wide, and are separated by jagged ridges. None of the original plateau is left.

In North Arran the eastern area and the western area are at different stages in the cycle of glacial erosion. In the east the "fretted upland" stage has been almost, although not quite, attained. In the west the stage reached is just past the "grooved upland" stage, with indications in places of very early maturity. This contrast in stage between east and west is of the utmost importance, and in this contrast lies the only satisfactory explanation of the marked difference of topographic features between the east and the west of North Arran.

The glens of North Arran have a marked individuality. They are all of the same type—deep, broad, barren, lonely, and stern. Trees are rare, and the glens owe none of their charm to richness of foliage.



FIG. 3.—The Thousand-Foot Platform from the summit of Torr Nead an Eoin. The sudden rise to the mountains of the interior can be plainly seen.

They impress the imagination by their sweeping curves, their imposing size, the fine contours of their bounding ridges, the harmony and proportion of their shapes, and by a general effect of grandeur and austerity. They present studies in form and in light and shade rather than in colour.

Examination of a section along the thalweg of the Rosa Water shows that near the mouth of the stream the gradient increases, instead of decreasing as we should expect. It is a remarkable fact that the thalweg of every large stream in North Arran shows this increase of gradient near the mouth of the river. The heights at which this increase begins are as follows:—in Glen Rosa about 300 feet above the sea, in Glen Sannox 100 feet, in Glen Chalmadale 200 feet, in Glen Catacol 200 feet, in Glen Iorsa 150 feet. There can be little doubt that the increase in gradient of all the thalwegs may be attributed to a slight rejuvenation of the streams, caused by the very recent uplifts that gave rise to the raised beaches of the Clyde area.

Glen Sannox in its "architecture" is the simplest of all the glens of North Arran. It is merely a great groove scored from the heart of the mountains to the sea. Upper North Glen Sannox impresses one more strongly than any other glen in Arran with the disproportion between the actual stream and the great valley in which it runs.

In several respects Glen Chalmadale differs from all the other glens of North Arran. The other valleys are all approximately radial, as one would expect from the denudation of a dome, but Chalmadale shows no obvious relation to the orographical features of the area. Neither does



FIG. 4.—A typical eastern ridge. The arête running from Suidhe Fhearghas to Caisteal Abhail. Cir Mhor on left.

it lie in the direction of the main ice-stream. Along with lower North Glen Sannox it forms a profound and continuous depression that cuts right across the island from north-west to south-east. The Chalmadale water rises in flat ground that really forms the floor of a big, continuous valley, the north-west part of which is called Glen Chalmadale, and the south-east North Glen Sannox. The present writer suggests that the Chalmadale-Sannox depression was initiated when Arran was joined to the mainland, and the present Firth of Clyde did not exist as an arm of the sea. The Chalmadale-Sannox stream may have been the tributary of a big river flowing down Loch Fyne, and then southeast across the Southern Uplands.

Gleann Easan Biorach is a tributary of Glen Chalmadale. There are several interesting features in this glen, but space prevents detailed

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description. Reference must be made to one point, however, the origin of the fine waterfall above Lochranza at the junction of Easan Biorach and Chalmadale, for the writer does not agree with the accepted explanation of the origin of this fall. In the Geological Survey Memoir the late Mr. Gunn explains it as the result of river action on a schist belt hardened by contact with the granite. The objections to this view may be stated briefly as follows :---

- 1. The supposed hard band of schist makes no feature on the smooth contours of the sides of the glen.
- 2. The schist band should produce a fall in Glen Catacol, less than two miles away, but there is no fall of any kind there.



FIG. 5.—A typical western ridge. Beinn Bhreac from north ridge of Beinn Bharrain.

- 3. We should find waterfalls of similar origin all round the periphery of the granite, but they do not exist.
- 4. Lateral corrasion should be plainly marked above the hard band, for the hard band would establish a temporary base-level of erosion. Of such widening in Gleann Easan Biorach there is not a trace.
- 5. On Gunn's hypothesis the location of the fall just at the junction of the Easan Biorach and the Chalmadale is merely a remarkable coincidence.

The waterfall of the Easan Biorach is of the same type as all the other large waterfalls in North Arran. They are of the hanging valley type which are found at the junction of a tributary with its main valley, and are characteristic of all glaciated regions. We find a similar waterfall in Glen Catacol at the junction of its tributary Gleann Diomhan with the main stream (Fig. 7). Gleann Easan Biorach and Gleann Diomhan are hanging valleys, and the waterfalls mark the discordant junctions. Glen Iorsa is the longest glen in North Arran, and the Iorsa Water

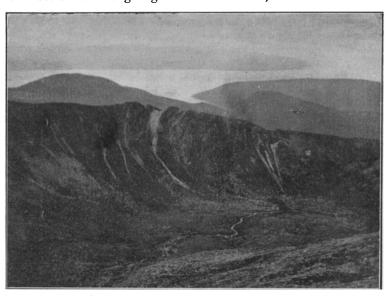


FIG. 6.—A misfit. Upper North Glen Sannox. The stream is quite out of proportion to the valley. The valley has been deepened and widened by ice.

(doubtless because of its greater volume) has much more of a graded character than any other stream in North Arran. From Loch Iorsa to the sea the river is fairly straight and free from bends. For a mile or

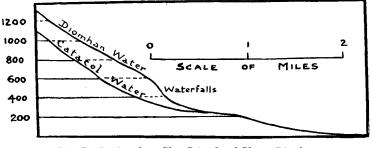


FIG. 7.—Section along Glen Catacol and Gleann Diomhan. Gleann Diomhan is a hanging valley.

two above the loch, however, the stream winds about in a series of well-developed meanders. A meandered middle course and a straight lower course are certainly remarkable features to find possessed by any river. The explanation is that the rejuvenated part of the stream below Loch Iorsa, as one result of its renewed youth, has straightened its course. No other river in North Arran shows this feature, because no other river is maturely graded enough to have developed similar meanders.

The tributary of Glen Iorsa from Loch Nuis is a good example of a hanging valley. Fig. 9 shows a section along the Iorsa Water and this tributary, from which we

can estimate the amount of glacial deepening of the The figure main glen. shows that a sudden increase in the gradient of the tributary occurs between 700 feet and 200 feet. This drop of 500 feet is due to over-deepening of the main valley by glaciation, and measures the *minimum* amount of ice-deepening. But the platform, thousand - foot

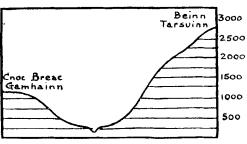


FIG. 8.—Section across Glen Iorsa from Cnoc Breac Gamhainn to Beinn Tarsuinn. Vertical scale double the horizontal. The catenary outline is well seen.

which is well developed here, is a pre-glacial feature. This platform, therefore, fixes a *maximum* value of 800 feet (1000 minus 200) for the glacial deepening of Iorsa glen at this point (Fig. 9). It is remarkable that the same maximum and minimum values should be obtained by applying this method to Glen Rosa. (See previous paper.)

The headwaters of several of the main streams of Arran rise in valleys that cut right through the island. The divide is often imperceptible. Although at a divide normal stream corrasion has a zero

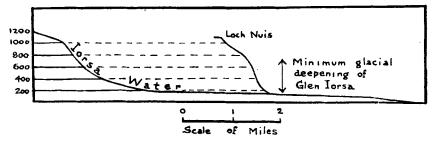


FIG. 9.-Section along Glen Iorsa.

value, yet a stream may rise in a valley, the walls of which rise hundreds of feet on either side. The Loch na Davie divide is one of the most interesting. It is situated in a valley that furrows right across the island from Lochranza to the mouth of the Iorsa. A section of the valley at the divide is shown in Fig. 10.

The name Loch na Davie, i.e. Loch of the Two Streams, indicates another peculiarity. The loch is situated on the divide between Easan Biorach and Iorsa, and is generally believed to flow into both these valleys. The Ordnance Survey maps of all scales mark a stream emerging at each end of the loch. We may assume, then, that this was the

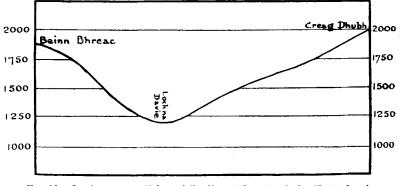


FIG. 10.—Sectiou across a "through" valley at the watershed. Vertical scale double the horizontal.

state of affairs in 1864 when North Arran was surveyed. At the present time, however, the divide is a few yards north of the loch. We have thus an example of the sensible migration of a divide within a comparatively short period of time.

The formation of a deep, "through" valley connecting Easan Biorach

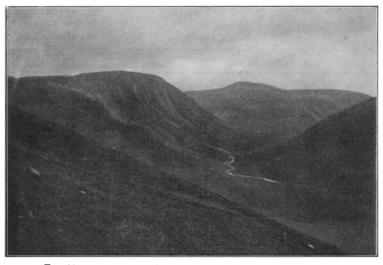


FIG. 11.-A typical North Arran glen. Looking up Glen Catacol.

and Iorsa is due (in the writer's opinion) to the action of ice. At the time of maximum glaciation the ice-sheet moving down the Firth of Clyde probably sent an arm up Gleann Easan Biorach, across the divide, and down Glen Iorsa. It was this ice that produced the marked valley at the divide and also the shallow pan in which Loch na Davie lies.

The divide at Loch Tanna presents the same features as that just described. Another deep "through" valley joins Glen Iorsa with Gleann Diomhan, a tributary of Glen Catacol. The sides of this "through" valley are steep and smooth, and the profile is U-shaped. For part of its way there is no stream at all in this valley. There is little doubt that it has been cut by ice. Between Glen Catacol and the sea on the west there is a "through" valley of the same type, and evidence can be brought forward to show, not only ice-action, but the

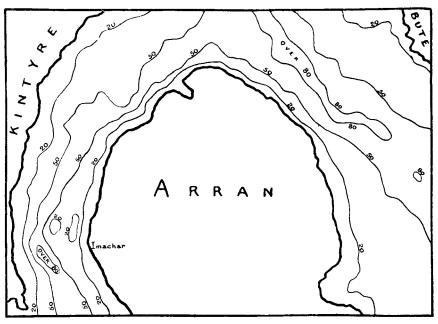


FIG. 12.—Sketch-map showing depth of sea-floor around North Arran. Depths are in fathoms.

direction in which the ice moved. Without going into details we may say that the distribution of granite boulders shows that the ice came from Glen Catacol, and moved in a north-west direction.

Most of the lochs of North Arran lie on the thousand-foot platform. The lochs of this type are not very picturesque, nor do they present any specially interesting geographical problems. They are simply accumulations of water in hollows on the surface of the plateau. These hollows generally occur among the drift deposits left by the Ice Age. Some of the lochs are drying up. Another type of lakes includes those lying in rock-hollows, but drift-dammed. Loch Tanna is the best example of this type. It is over a mile long with an average width of a furlong, and occupies the "through" valley between Glen Catacol and Glen Iorsa. Loch na Davie affords clear evidence of shrinkage. Since it lies on a watershed its affluents are negligible. Since Loch na Davie was surveyed in 1864 its length seems to have shrunk at an average rate of about half a yard a year.

The only really good example of a true rock basin is Coirein Lochain. It is easily the most picturesque loch in Arran, being situated at the base of a deep corrie, backed by dark cliffs. Tradition says that the loch is fathomless. It is certainly fairly deep, for its shores slope very rapidly down on all sides. East, west, and south of the loch the corrie rises in steep walls with rough, cliffy outcrops of rock. On the north-west there are deposits of drift, but they are not deep, and the loch must therefore lie in a true rock basin.

Dubh Loch, which lies half a mile west of Loch Tanna, may also be a rock basin. It lies in a distinct hollow of the rock. Bare granite crops out to the east, south-east, and west. On the other sides the morainic covering is not very thick. If its thickness is less than the depth of the loch then Dubh Loch is a true rock basin. On the whole one is inclined to think that it is.

Finally, let us glance briefly at the configuration of the sea-floor immediately bordering North Arran, paying special attention to the position and depth of any pronounced trenches or hollows. Fig. 12 shows contours at 20 fathoms, 50 fathoms, and 80 fathoms. South of Arran the Firth of Clyde stretches between Kintyre and Ayrshire, with a maximum depth of 30 fathoms. The sketch-map shows that there is a distinct furrow in Kilbrennan Sound, the depth of which is over 50 fathoms. Off the extreme north-west shores of the island this furrow is close to the Arran coast. It gradually recedes westwards, until it is nearer Kintyre than Arran. The deepest part of this trench is an elongated hollow opposite Imachar, that is, exactly at the narrowest part of the sound.

The same phenomena recur off the eastern shores. The furrow deeper than 50 fathoms first skirts the Arran coast, and then gradually recedes. In this case also the deepest part of the furrow is found where the channel is narrowest. It would be rash to draw conclusions with any confidence from this rather scanty basis of data, yet it may be pointed out that the observed facts are in harmony with the theory of erosion by ice flowing from the north, and pressed outwards by radial streams from Arran.

A VISIT TO THE PANAMA CANAL AND CUBA.

By Esther M. Downie.

(With Illustrations.)

1. PANAMA.

TIMES have changed on the isthmus of Panama since, in the seventeenth century, the pirate Morgan marched across it, following the old gold road through one of the most pestilential countries on earth. I suppose