NO. XV.—NOTES ON THE GEOLOGY OF SOUTH-EAST ARRAN.

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THE rocks exposed along the shores of S.E. Arran belong to the upper member of the lower division of the Trias. The red sandstones of Clauchland shore and Holy Isle are seen to pass upwards into a series of yellow and white sandstones, the latter being in places highly calciferous, and, consequently, weathering into very irregular forms through the solution of the contained carbonate of lime. On the inland hill slopes these rocks are seen to pass conformably upwards into a great series of red, mottled, and olive green, marly sandstones and shales, which are classed as Upper Trias, and are probably the equivalents of the Keuper series. The whole of these rocks dip westward at low angles, and the Upper Trias alone, unless repeated by faults, must attain a thickness of about 1000 feet. With the possible exception of a few occasional markings like worm tracks, the whole series appears to be destitute of any evidence of organic existence.

An outstanding feature of the geology of this district is the numerous basic sills intruded among the sandstones, which do not seem to have reached the surface at the time of intrusion, but have been laid bare by subsequent denudation.

One of the best exposures of these sills occurs at the south end of the Holy Island and along the shore westward of King's Cross Point. Tracing the sill from the east, it rises from under the waters of the Firth, and passes upwards across the horizontally bedded sandstones, till at the south end of the Holy Island the base of the sill is about 150 feet over sea-level. It then as rapidly descends till, on the western shore of the island, it again dips under the waters of the strait which forms the southern entrance to Lamlash Bay. The lighthouses on opposite sides of the island are both built on the sill, which must here considerably exceed 100 feet in thickness, its upper surface being nowhere seen.

On the other side of the strait the sill reappears at King's Cross Point, the base not being laid bare at low water, while it is distinctly in evidence on both the 50-feet and 100-feet beaches, which are here prominent features. Traced further west, it is seen to split up into several branches within 200 yards of the point. The lowest of these, which is about 10 feet thick, occupies the foreshore for a considerable distance from below low-water mark. Being columnar in structure, it forms a fine Giant's Causeway, but, owing to the disintegration of a strip of sedimentary rock entangled within it, the upper part has been undermined by the surf, and a large area of the beach is encumbered by its ruined columns. Further west the foreshore is occupied by an extensive tract of white calciferous sandstone, hardened in places to quartzite by a branch of the sill, which at low water can be seen to underlie it. Meantime, the great bulk of the sill has invaded higher and higher strata, until it disappears altogether from the old coast line, leaving the shore encumbered with rounded blocks, as evidence of its presence further inland. Numerous ramifications of the sill appear at various levels in both branches of the burn which crosses the sands to the north of Whiting Bay, and one branch forms a long, prominent platform on the hill slopes behind Auchencairn, at an elevation of about 350 feet over sea-level.

Where comparatively thin, the material of the sill may be termed a compact basalt. This is also the texture of the base of the sill before it subdivides. Further up, the sill becomes more acid in its composition, and is intersected by numerous strings and veins of basic material, which appear to be segregations during the process of cooling. Still further up, the central parts of the sill become coarsely crystalline, and resemble a gabbro. Having cooled down after the external surfaces of the sill had solidified, contraction has, in places, resulted in the formation of cavities, which have been subsequently infilled with zeolitic minerals.

A similar sill, or series of sills, occurs at the south end of Arran. At Dippen Head the whole height of the sea cliff presents a fine section of a great sill, except at one point, where the sandstones may be seen to extend about half-way

up the cliff, the sill bending over them like a great arch. This sill must exceed 200 feet in thickness, and, like that at King's Cross, it also invades higher and higher platforms of the sandstones, and subdivides and thins out as it is traced towards the west. From below sea-level at Dippen it attains an elevation of 400 to 500 feet in Glenashdale, and the terraced outlines of the hills of this district, which, from a distance, greatly resemble a series of bedded lavas, appear to be due to the numerous ramifications of this sill.

The sources from which these sills have been intruded would therefore appear to have been situated to the east or south-east of the present coast line, and to be now concealed by the waters of the Firth. Enormous denudation has taken place, and it is probable that, but for the protection afforded by the sills, the whole of the soft Triassic sandstones of this part of Arran would long since have disappeared.

Subsequently to the consolidation of the sills, the plutonic forces have broken out afresh, and have rent both them and the sedimentary rocks among which they had been injected into numerous fissures, between whose gaping walls molten rock has again arisen from the same deep-seated reservoir, and consolidated into the basaltic dykes which are now seen to traverse sandstones and sills alike.

A still later, and probably the concluding phase of the great early Tertiary period of volcanic activity, appears to have resulted in the intrusion of numerous acid sheets and bosses in the southern part of Arran. It is noteworthy that none of the basic sheets or dykes are seen to invade the felsite bosses of the Holy Isle, Dundhu, or Drumadoon, although basic dykes are not uncommon in the granite of the northern part of the island. Not only is this the case, but at the south end of the Holy Island, where the King's Cross sill is exposed in the coast cliff, resting on the red sandstones, the felsite is seen coming up in a broad band (200 to 250 feet) from below sea-level, and traversing both sandstones and sill; it appears to be the pipe, or one of the pipes, through which the intrusion of the felsite was effected. These felsite sheets and bosses would, therefore, appear to be the very latest results of plutonic action in this part of Scotland.

Both basic and acid sills have greatly altered the sedimentary strata into which they have been injected. This is shown in a marked degree in the case of the felsite of the Holy Island, and is probably due to the bulk of the intrusion and consequent length of time during which it was slowly cooling down. The red sandstones are converted into white quartzites for a very considerable distance below the surface of contact, and in places are rendered highly columnar. The felsite itself is, for the most part, of a platy structure, though in places showing rows of vertical or slightly inclined columns. An extensive sheet of similar felsite, which occurs near the summit of the hills to the west of King's Cross, displays, where sections are cut by the hill streams, a very perfect columnar structure.

The surface of the sill at King's Cross Point and on the shores of the Holy Isle opposite, up to the 25-feet beach, still bears the marks of intense glaciation. The channel between is quite in the path of the ice as it streamed down from the hills on the north, and the ice must have been tightly jammed between the Holy Isle and King's Cross Point. To the consequent severe erosion of the sill at this point, the formation of the southern entrance to Lamlash Bay is probably due. Previous to the glacial period the northern entrance was probably part of the valley of the streams which now debouch into Lamlash Bay.

The summit of the hills to the west of King's Cross forms an irregular plateau at an elevation of 1100 to 1200 feet, which has been covered with a deposit of peat to a thickness of from 3 to 5 feet. In many places this is now being rapidly denuded away, leaving exposed a thin soil of clay and coarse sand, with many boulders of granite from the Goat Fell Hills, and a few others which appear to be foreign to the island. Where the peat still remains it is frequently honeycombed with deep moss-hags. The present rapid denudation of the peat from extensive areas where it formerly grew must be due to some change of climatic conditions, and may point to a recent increase in the rainfall of the district.