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## Chapter 6 The Carboniferous rocks

### Introduction

One of the most remarkable results of the geological survey of Arran is the restricted area now assigned to the Carboniferous rocks which were formerly supposed to cover a large part of the island, and it may be as well before entering into details about these strata to remove certain misapprehensions as to their position, distribution, and thickness. The Carboniferous series, it has long been known, is typically developed and best studied along the eastern coast, where it forms a narrow strip which stretches for about 3 miles between the Cock and the Fallen Rocks. Its thickness here has been much exaggerated because no account has been taken of numerous faults by which the strata are repeated. A narrow band of the formation, 200 yards in width, also occurs on the north shore near the mouth of the burn east of North Newton. This strip lies between two large faults. Along the shore at Corrie, Carboniferous strata stretch for two-thirds of a mile, with a dip of 20° to 25°, until they are overlapped by the New Red Sandstone 250 yards south of the Corrie Hotel. The total thickness of the Carboniferous rocks on this shore may be as much as 1200 or 1500 feet, inclusive, as at Laggan, of a volcanic group 300 or 400 feet thick. Several thin red limestones occur near the upper part of the series, but the most prominent members are the volcanic group, the thick Corrie limestone, and the white sandstones immediately above that bed. It is by these well-marked bands that the series can be followed inland and recognized among the numerous faults, some of which bring up the Old Red Sandstone and confine the Carboniferous rocks to a comparatively narrow belt. One of these north-north-west dislocations, with a throw greater than the total thickness of the series, shifts the base of the volcanic group into the burn north of Maol Donn, and another large fault running along the west side of that hill has moved the main body of the Carboniferous rocks southward again for more than a mile. The strata reappear in the Merkland Burn, whence they can be traced to the south-west through the wood, and behind Brodick Castle, in a steeply-dipping band altogether not more than 200 to 300 yards in width. Though they disappear under the Brodick alluvium, some of the sandstones and shales are visible in the Rosa Burn about the bridge, and the thick white sandstones are a conspicuous feature about the manse and church. Behind the churchyard the thick Corrie limestone was formerly worked. A little farther west a large fault throws the rocks up to the hillside where the thick white sandstone forms a marked feature, and the limestone immediately below has been worked. The Carboniferous band here is 200 yards wide only, and dips steeply to the south-east; the New Red rocks, extremely false-bedded as usual, forming the high bank above. The volcanic group crops out here and there at the base, and the whole series can be followed south-west to Windmill Hill, where it becomes entangled among intrusive masses of various kinds, which, along with faults, have displaced the rocks so that they do not occur again till the south side of Glen Dubh is reached. This locality is more than a mile south-east of Windmill Hill, where they were lost sight of.

From Glen Dubh the Carboniferous formation may be traced in a number of detached outcrops separated by faults southwards by Benlister Glen, and Cnoc a' Chapuill, to near the Clauchan Glen, being recognizable by the presence of the volcanic group, after the Corrie limestone has been overlapped by the New Red Sandstone. There is no trace of these rocks on the west coast, the New Red Sandstone reposing directly on the Old Red Sandstone without the interposition of any Carboniferous strata. W. G.

The Carboniferous formation thus undergoes attenuation from north-east to south-west. The greatest thickness is in the north-east at Laggan; south of the Central Ring Complex the strata become very thin; whilst on the coast north of Machrie Bay the Carboniferous was probably not deposited at all.

The Carboniferous formation in Arran includes representatives of the Calciferous Sandstone with their intercalated lavas, the Carboniferous Limestone Series, and the Coal Measures with an indeterminate amount of Millstone Grit, and a contemporaneous volcanic series. According to Gunn's estimate (p. 48), the total thickness is only between 1300 feet and 1400 feet, except at Laggan, where the thickness may be 2650 feet (Gunn, *Geology of North Arran, etc.*, *Mem. Geol. Sun.*, 1903, p. 46); and, therefore, the Arran succession is attenuated or telescoped as compared with that of the Scottish mainland. The prevalent pink and red colours of the strata are regarded by Mr. E. B. Bailey as due to oxidation during New Red Sandstone times, and not to the downward percolation of iron-bearing solutions from that formation. *Geol. Mag.*, vol. lxiii., 1926, pp. 276–281.

The Carboniferous outcrops lie almost entirely within the semicircular zone of adjustment-faulting consequent upon the development of the two igneous centres of the northern granite and the Central Ring Complex; and therefore comprise narrow faulted strips placed in echelon around the eastern and southern margins of the igneous masses. The dip is usually steep, and varies from due east to due south, in harmony with the view that the attitude of the formation is consequent upon the doming of the igneous centres. G.W.T.

## The Calciferous Sandstone Series

The Calciferous Sandstone sediments and lavas occur in practically all the above-mentioned Carboniferous outcrops. The only outcrop from which they are believed to be absent is that occurring at the head of the southern branch of the Slidery Water (p. 70). The sedimentary rocks consist of variously-coloured sandstones, red, purple, and white in colour, often calcareous, pebbly, or conglomeratic; red shales; and grey to pink cementstones and cornstones. It should be noted that Mr. E. B. Bailey considers that the cornstones frequently found towards the base of the Calciferous Sandstone Series in Arran should be relegated to the Upper Old Red Sandstone (*Geol. Mag.*, vol. lxiii., 1926, p. 277).

Intercalated with the sediments there are the products of a considerable volcanic episode, which has given rise to tuffs, agglomerates, and basaltic lavas of types familiar in the Lower Carboniferous of Scotland (p. 57).

The principal sections will be described in order from north to south. G.W.T.

### Details of sections

The remarkable junction of schists, and cornstones of the Calciferous Sandstone Series, on the shore at North Newton is one of the classic sections of Arran, and has often been described. It seems to have first been noticed by the celebrated James Hutton in the year 1785, and his description of it appears first in the third volume (p. 235) of his *Theory of the Earth*, which remained in MS. till edited by Sir Archibald Geikie in 1899. It may be worth while to quote a part of this description: 'Lochranza, at the north end of the island, is properly within the alpine schistus; but, in tracing the shore, upon the east side of the loch or bay, we come to the extremity of this schistus district. Here the first thing that occurs is the immediate junction of the inclined strata of schistus and the other strata, which here appear to be a composition of sandstone and limestone; these strata are equally inclined with the schistus, but in the opposite direction. Those two different kinds, of stratified bodies rise to meet each other; they are somewhat confused at the immediate junction; but some of the sandstone or calcareous strata overlap the ends of the alpine schistus.' Hutton made a drawing of the junction, which has been lost. Its place is supplied in the volume by a sketch from Sir A. Geikie.

The exact locality of the section is on the foreshore about one-third of a mile north-east of the most northerly farm in North Newton, on the eastern side of a stile and wire fence. The rocks consist of beds of red and yellowish sandstone with lenticular calcareous bands, and distinct beds of white cornstone. They stretch along the shore for nearly 400 yards, and project nearly half-way across the raised beach. At the south end they dip N.N.W. at 30°, and at the north end W.N.W. at 25°, so that the strike describes a curve of 45°. The schists on which they rest unconformably dip S.S.E. at 40°.

### Sections on the north-east coast

The Laggan section of the Carboniferous stretches along the north-eastern shore of Arran, from the Fallen Rocks, near Corloch, for a distance of three and one eighth of a mile to within 600 yards of the Cock of Arran. The shepherd's house at Laggan is 2 miles from the Fallen Rocks, while Millstone Point is a like distance from the northern end of the strip, the length of which, however, is only 3½ miles, as the coast-line is not straight. The width of the strip varies, but in general is not more than a quarter of a mile; it widens to half a mile at Cock Farm, but in two places south of Millstone Point it does not exceed 200 yards.

The dip is everywhere high, and nearly in the same direction; lowest at the north end, where it is about 30°, but for the greater part of the distance it is 40° or 50°, and even 60° in places. This high dip suggests an enormous thickness of beds, but it must be remembered that the general dip is in a direction to the east of north, while the trend of the coast is

about 40° north of west, and is only 30 or 40 degrees removed from the general strike of the beds. In fact, there are parts of the coast-line where its direction coincides very nearly with the strike for some distance. In addition to this consideration it must be borne in mind that there are several large faults, especially in the lower part of the section, which repeat many hundred feet of the strata. Still, there is no doubt that we have here a much greater development of Carboniferous rocks than we have at Corrie; probably the thickness of the whole is twice as great, and if we confine our attention to the sedimentary beds alone the disproportion is still greater. The increased thickness is not confined to one part of the section. All the limestones are thicker than they are at Corrie, and they are more in number — there are coals which are absent at Corrie, and naturally there is a much greater development of sandstone and shale. The following is a comparative estimate of the thicknesses of the various subdivisions in the two sections:

	Corrie	Laggan
	feet	feet
Coal Measures	150	250
Limestone Series	425	750
Calciferous Sandstone Series above and below traps	75	575
Calciferous Sandstone Series above and below traps	275	700
Total	925	2275
Add thickness of Volcanic Series	450	375
Grand total	1375	2650

The greatest difference is in the thickness of that part of the Calciferous Sandstone Series below the volcanic zone, which is less than 300 feet at Corrie contrasted with 100 feet in the Laggan section. It has been suggested that the trap at Corrie is a great dyke which conceals a very large fault, and that this accounts for the differences between the two sections; but the fault at Corrie, if it existed, would not explain why we have increased thicknesses at Laggan in all the sedimentary beds. Besides, we know that the thinning of the Carboniferous beds at Corrie as compared with those at Laggan is continued southward, so that in the neighbourhood of Brodick Castle and in Glen Shurig the total thickness is about 600 feet.

Some 300 yards south of the Fallen Rocks the cornstone base of the Carboniferous rocks occurs in two places separated by a small fault. The cornstone is pebbly and adheres to the conglomerate below in an unconformable manner, like that described in the junction north of Corrie. This is separated by a considerable north-trending fault with a downthrow eastward from the main mass of the Carboniferous section which commences on the north side of the Fallen Rocks. The beds here have a fairly steady dip of 30° to 40° to the northward, often inclining east of north sometimes as much as 15° or 20°. There are two cornstones of the usual light-coloured concretionary character, which are sometimes pebbly, and irregular in thickness. They are separated by a few feet of sandstone. There succeed to the northward a series of red clays with some lenticular calcareous bands, and red sandstone with quartz pebbles. These are bounded on the north by a fault which crosses the foreshore in an easterly direction, and throws down on the north an alternating series of grey shales, thin sandstones, and calcareous bands. Among these Mr. James Thomson<ref>On the stratified rocks of the shore-line from Clachland Point to the Cock of Arran, *Trans. Geol. Soc. Glasgow*, vol. xi., part i., 1898, pp. 12–30.</ref> discovered a brecciated or tuffaceous rock from which he obtained remains of plants and fish. At this locality, about 300 yards north of the Fallen Rocks, Mr. Tait, the collector for the Survey, obtained the following species:

<i>Cordaites</i> sp.	<i>Rhizodus ornatus</i> Traq.
Fern rachis	<i>Strepsodus striatulus</i> Traq.
<i>Sphenopteris</i> sp.	Fish-head plate
Paloniscid scales (indet.)	Various bones and plates (indet.).
<i>Rhizodus hibberti</i> (A g.)	

Above these grey beds there come about 150 feet of an alternating set of white sandstones and red clays or shales, the clays containing several small lenticular cornstone bands, the uppermost of which are fairly good continuous limestones, 1 to 2 feet thick, of the same character as the basal cornstones. These beds are surmounted by thick-bedded white

sandstone, which continues for but a short distance, and then the section is lost for several hundred yards. Some 200 yards, however, beyond the most northerly Laggantuin Burn, white sandstones, with a northerly dip of 60°, appear in the old sea-cliff, and these strongly resemble the pebbly sandstones of Millstone Point, a long way to the northward. In fact, there is not much doubt this is their position in the series. To the west of these is a large fault with a downthrow east of several hundred feet. On the west side of this the upper beds of the Old Red Sandstone, and all the lowest beds of the Carboniferous, including the cornstones, are exposed in a precipitous hill. The fault runs northward along the east side of this hill, but on reaching the shore it, or a branch of it, runs along the foreshore in a north-west direction for 250 yards and then passes out to sea. On the inner side of this fault, along the foreshore, we again come upon the Millstone Point grits, but we do not find a continuous section up to the base of the volcanic series, for the beds immediately underlying that series are cut out by two parallel faults along the strike. Nearly a mile from the Fallen Rocks there is exposed on the shore a good section of the volcanic series, consisting of alternations of basic lavas with coarse and fine tuffs, the whole amounting in thickness to between 350 and 400 feet. These, which are elsewhere described in some detail (see latter part of this chapter), occupy the shore for a distance of over 200 yards, dipping steeply northward at 50° to 60°, but they do not appear in the old sea-cliff to the west, being cut off on that side by a large fault which runs in a northerly direction across the foreshore. This brings up again the beds below the trap, which are seen at intervals on the shore, the highest beds being grey cementstones like those underlying the trap near Laggan. Above these comes a portion of the volcanic series again, which is bounded on the west by another large fault bringing up against it sandstones and shales of a much lower horizon.

To the northward come white sandstones, some of which are coarse, alternating with red shale and clay bands, and in one place some cementstones and grey beds. These continue as far as the bay, south of Millstone Point, where there is a gap in the section. The rocks, however, are almost continuously exposed on the hillside to the south of this bay, and there can be no doubt whatever about the general order of succession. The dip is almost everywhere to the east of north, and between 50° and 60°. On the north side of the little stream called the Garbh Allt, white pebbly grits are well exposed at Millstone Point. In places the quartz pebbles in the rock are large, some being as much as 4 inches in length. We cross a small and unimportant fault, and pass upward into alternations of white sandstone and dark shale with traces of coal. These are succeeded by grey sandstones and blue and grey cement stones alternating with thin tuff bands, and in the upper part with two thin beds of lava. This is the spot, some 750 yards south-east of Laggan cottage, where Wiinsch discovered trees and plant-remains, imbedded in trappean ash, <ref>On the occurrence of fossil trees imbedded in Trappean Ash in Arran, *Trans. Geol. Soc. Glasgow*, vol. ii., part ii., 1866, p. 97.</ref> in the year 1865. It is interesting to note that these plant-remains, which are accompanied in this locality by thin coal-seams, occur on the same geological horizon as the coal which was formerly worked at Ambrisbeg, and at Ascog in the island of Bute, but in no other place within this Sheet is a coal known to occur at the base of the volcanic series.

The following set of fossils was obtained 750 yards south-east of Laggan cottage:

<i>Lepidophloios wiinschianus</i> Will.	<i>Sphenopteris</i> sp.
<i>Lepidophloios</i> sp.	<i>Stigmaria</i> .
<i>Rhacopteris</i> sp.	<i>Allorisma sulcata</i> Flem.
<i>Zeilleria moravica</i> (E.H.)	<i>Edmondia pentonensis</i> Hind
<i>Diplothemema patentissimum</i> (E.H.)	<i>Sedgwickia gigantea</i> M'Coy.

These beds, which dip at a somewhat smaller angle, from 35° to 40°, are succeeded by the principal mass of trap, elsewhere described (see latter part of this chapter), and above this there is a thin cement-stone series again, alternating bands of grey beds, shales, corn-stones, and sandstones with some tuffaceous bands. A thick series of white blocky sandstones, alternating with thin bands of red shale, forms marked features west of the shepherd's house, and these continue till we reach the Corrie or Hurllet limestone, nearly 250 yards north-west of the house.

From a place 100 yards south-east of the cottage *Sphenopteridium erassum* (L. and H.) and another species were obtained, and a few yards north of the cottage *Sph. crassum* ? and a species of *Stigmaria*.

Lavas and tuffs of the Calciferous Sandstone Series occur three times between Corloch and the shepherd's house at Laggan. These rocks are all of basaltic composition (p. 57). The most northerly exposure occupies the shore for nearly a

quarter of a mile, its southern boundary being nearly half a mile from Laggan. The greater portion of the outcrop consists of massive, fine-grained grey trap in which no dip is visible, but the whole series is inclined to the north at an angle between  $30^{\circ}$  and  $40^{\circ}$ , so that the total thickness must be over 300 feet. There are two fine tuff bands in the lower portion of the mass, and between these the rock is very scoriaceous, while the part below these fragmental bands is soft. Below the main mass are alternations of thin lava beds and fine shaly tuffs, in some of which Wünsch was the first to discover remains of Carboniferous plants (see *Trans. Geol. Soc. Glasgow*, vol.ii., pp. 97 and 160, On the Occurrence of Fossil Trees imbedded in Trappean Ash in Arran).

The ordinary Calciferous sandstones and shales underlying the traps succeed to the southward, but owing to large faults we find repetitions of the volcanic series to the south of Millstone Point, where the lavas again occur, but the tuffs are much coarser than in the last section and form a large proportion of the whole series, so that here we are probably nearer the site of a volcanic vent. Nearly half a mile south of Millstone Point we find the following section on the foreshore:

- The upper portion is for the most part a slaggy and amygdaloidal lava with a little tuffaceous material, about 150 feet in thickness. This is succeeded in descending order by well-bedded greenish and red tuffs, 75 feet thick.
- Lava — slaggy above and with pillowy structure below, often an irregular mass in which are several red and dark flinty bands apparently filling up cracks in the lava-flow-75 feet.
- Finer tuffs with some lava — a few feet, perhaps 10.
- Coarse volcanic agglomerate-75 feet.

The dip is slightly east of north at a high angle,  $50^{\circ}$  to  $60^{\circ}$ , and the total thickness must be near 400 feet.

These beds only appear on the foreshore and on the raised beach, being cut off on the west by a large fault running nearly due north with a downthrow east of some 500 feet. Some distance to the north, therefore, we find the volcanic zone again on the foreshore resting on the cementstone series. It has the same steep northerly dip, but we only see a portion of it, the lower agglomerate band about as thick as before but intercalated with some finer tuff bands, and surmounting it a portion of the grey trap bed; and then another northerly-running fault with a large downthrow east destroys the continuity of the section.

### Sections at Corrie

It will be advisable to describe the Corrie shore-section in some detail, as it is easy to examine at low water, and is comparatively little faulted. (See (Figure 1)). From the schoolhouse northward there is exposed on the shore, for a distance of 350 yards, the lower volcanic series, made up mainly of massive lavas, with a thick band of coarse volcanic agglomerate at the base or northern end. To the north of this for a distance of about 35 yards are various members of the Lower Carboniferous rocks, including three limestones or cornstones, and below these projects a mass of red conglomerate which is the highest bed of the Old Red Sandstone. This is the locality called the March of Achag Farm by the older writers. The red conglomerate itself is 50 feet broad at high-water mark, but considerably less at low water, and the junction between it and the Carboniferous beds is peculiar. A joint or crush at the shore-line, running N.N.E., appears to die out towards the sea, or is overlapped by sandstone and limestone, which abut against a nearly vertical face of the conglomerate, so that this is clearly an unconformable junction. This mass of calcareous sandstone and pebbly cornstone, several feet thick, may be faulted along a north-north-east line against a few feet of overlying white sandstone which dips to the south-east at  $25^{\circ}$  to  $30^{\circ}$ . Above this lies red shale, and then comes a nodular cornstone, about 15 feet thick, with a red argillaceous matrix. A gap of a few feet separates this from the uppermost cornstone, which is a whitish, irregular, calcareous sandstone somewhat mixed with reddish sandstone, and shaly below. It may be 3 feet thick. The 15 yards of distance between this and the base of the agglomerate is almost entirely occupied by white sandstone, the beds of which dip S.E. at  $25^{\circ}$  or more, so that it is probably as much as 20 feet thick. The whole thickness of strata between the volcanic rocks and the conglomerate cannot, however, be more than 45 feet.

The volcanic agglomerate itself is 45 yards in width on the shore, and must be 50 feet thick or more. It is a very coarse rock, made up of fragments of basic trap, sometimes as much as 6 feet in length. The lower beds of the lavas are massive, bluish, and fine grained, and some of the upper are purplish in colour, but the whole is similar in composition, being a porphyritic olivine-basalt. This mass of Carboniferous lavas, which are certainly contemporary with the

sedimentary rocks adjacent, is probably 300 feet in thickness.

South of the school, for a distance of 75 yards, we find sandstones and shales that overlie the lavas. The dip is in the same direction as before, but only about 20°. Most of the rocks here are of a red colour, and the shales are specially so, and some are tuffaceous. Among these occurs a thin red limestone from 1 to 2 feet in thickness.

On the shore opposite the Established Church is a projecting mass of purplish and much-veined trap 10 yards across. This is a lava bed, about 10 feet thick, and the last outflow from the old volcano in this locality. Above this is a gap of 20 yards or so, probably occupied by shales; to which succeed thick beds of white and pinkish sandstone, which have been quarried both on the shore and up the hillside to the westward. There is probably a thick mass of red shale above this and underlying the Corrie limestone, but it is poorly exposed on the shore.

The basaltic lavas on the shore near the big boulder called Clach an Fhionn exhibit a very fine spheroidal jointing giving rise to a pseudo-pillow structure.

There are numerous sections of the Calciferous Sandstone lavas and tuffs, with the accompanying sediments, in the burns that drain the steep hillside west and south of Corrie. The beds seen near the Established Church are exposed in the burn that flows past the church, but the base of the lower volcanic mass is not seen here, for a large fault cuts off the outcrop 600 yards from the sea. This fault shifts the rocks to the southward, and both beds are exposed again in the Locherim Burns, where some intercalations of tuff occur in the lower and larger bed. Another large fault, which must have a throw of over 1000 feet, shifts the volcanic rocks again to the south, this time a distance of three-quarters of a mile to the burn called Uisge nam Fear, which is the first stream north of Maol Donn. W.G.

A good section of the Calciferous Sandstone lavas and sediments is exposed in the Church Burn. The exposures begin about three-quarters of a mile from the sea, where the quartz-conglomerate of the Old Red Sandstone, dipping steeply to the south-east, is followed by a thick series of soft, red, crumbling sandstones, intersected by four basalt dykes. There are occasional harder bands containing small pebbles of quartz and chips of shale. Between the third and fourth dykes alternations of quartz-conglomerate and sandstone are seen. The fourth dyke appears to have risen along a fault-line, which brings coarse agglomerate against the quartz-conglomerate. Only a few feet of thickness of the agglomerate is seen, and it is succeeded by a thick flow of porphyritic basalt. Then comes decomposed amygdaloidal material representing the junction between two flows, followed by a second flow with well-marked spheroidal jointing like that of the shore-section. Another band of decomposed material separates a third lava flow, also with spheroidal jointing. This is overlain by soft, green and red, sandy shales, intercalated with well-bedded tuff. Then comes 4 feet of cream, red, and grey compact limestone or cornstone, followed by more tuff. As the stream now runs nearly along the strike of the rocks, this limestone and tuff are seen in the bed of the stream until near its mouth. In one place a few feet of bright red shale succeeds the cornstone. Close to the shore a decomposed, veined, highly amygdaloidal lava appears, which is correlated with the upper lava band on the Come shore. This lava is overlain by mottled red and green shale, followed by red sandstone.

A very similar section is seen in the North Locherim Burn, with the exception that tuff and agglomerate here greatly predominate over lavas.

An excellent section of the Calciferous Sandstone Series is exposed in the Uisge nam Fear (Figure 2). The rocks are first exposed a little west of the 282 feet O.D., about half a mile from the sea, and consist of coarse white and pink mottled sandstone dipping about 30° to south-east. Upstream, after a short blank interval, the lavas are seen, and their base can be well followed in the gorge west of the 341 feet O.D. The section in the gorge is as follows:

	feet
Basalt lavas	—
Tuffaceous sandy shales and tuffaceous sandstones	30
Bright red shale, with green patches	1
Coarse sandy tuff	1½
Bright red shale with green spots	3

The section in the upper part of the gorge is rather obscure and confused owing to many small faults (see section, (Figure 2)).

The falls at the head of the gorge are in coarse white and pink mottled sandstone, with thin bands of conglomerate. Above this a strong fault brings in the sandstones and conglomerates of the Upper Old Red Sandstone for some distance, after which there is another stretch of Calciferous Sandstone lavas and tuffs let down by trough-faulting (Figure 2).

**Sections north and west of Brodick** — A large fault extending to the south on the west side of Maol Donn results in the displacement of the Calciferous Sandstone outcrop of the Uisge nam Fear to the region near Merkland, north of Brodick Castle. From here the outcrop runs S.S.W. until it is lost under the alluvium of Brodick Bay. It reappears in a faulted strip which extends in a west-south-west direction from Brodick Church to Windmill Hill, to the south of the String Road. The Merkland Burn gives a section in basaltic lavas and tuffs north-west of the Summer House in the Brodick Castle policies; and this strip, faulted once to the southeast, can be traced down to the west of Brodick Castle.

On the slopes to the south of the String Road a small crag and terrace is first encountered on the ascent, which consists of red-stained Calciferous Sandstone basalt lava, very splintery and much crushed. Surmounting this is a thick, well-defined crag and terrace, consisting of coarse white sandstone with occasional pebbly layers. All these beds appear to dip steeply into the hill, *i.e.* to the south-east. It is difficult to say whether the red and white coarse sandstones which succeed the above belong to the Calciferous Sandstone or to the Carboniferous Limestone Series. G.W.T.

**Sections in the central area from Glen Dubh to the Clauchan Glen** — By the disruptive action of igneous rocks and of faults the Carboniferous rocks are shifted more than a mile to the southward of the above exposures, and next occur on the south side of Glen Dubh above a wood, and north of a fine set of scars called Creag nam Fitheach. They form a triangular area bounded on the east and west by faults. That on the east side throws down against them the New Red sandstones and conglomerates of Creag nam Fitheach; that on the west brings up the Upper Old Red Sandstone. The volcanic series of the Carboniferous, dipping southward at angles of 25° to 30°, rests on the Upper Old Red beds at the top of the wood.

South of Brisderg two detached patches of Calciferous Sandstone sediments and lavas occur in Benlister Burn, on either side of a synclinal, the centre of which is occupied by New Red Sandstone. They are associated with small exposures of Carboniferous Limestone Series and Coal Measures (p. 68). W. G.

The much-broken strip of Carboniferous rocks which lies south of the Central Ring Complex, in the tract about Cnoc a' Chapuill, belongs entirely to the Calciferous Sandstone subdivision, *i.e.* to beds below the Corrie Limestone. This limestone crops out in Benlister Glen; but in the present locality it is overlapped by the New Red Sandstone rocks, which rest unconformably on the red shales and mudstones below the limestone. These red shales, dipping south-east at 40°, are visible in the highest part of the northern branch of the Slidderly Water, <ref>This higher part of the stream is omitted from the Ordnance maps.</ref> and are probably underlain by the volcanic series of the Calciferous Sandstone. A large fault with a downthrow to the north and a direction about E.S.E., shifts both shales and volcanic rocks a considerable distance eastward, so that the former crop out in the same burn where its course is towards the south-west. It runs nearly along the strike, and exposes beds of red sandy clay or shale, purplish red sandstone, and red arenaceous tuffs, the whole much invaded by dykes and sheets of basalt and felsite. The dip of these rocks is generally to the south-east at angles of 30° to 40°, the direction changing to nearly due south at the junction of the two streams south-east of Cnoc a' Chapuill. Just above the junction in the lower part of the other branch stream red mudstones and reddish and grey shale may be observed, with rootlets of plants in places.

Almost the only exposure of the volcanic series occurs in the Allt Mòr, which runs southward on the east side of Cnoc a' Chapuill. A northwardly-running fault appears to shift the Carboniferous rocks farther to the north, and in the stream upward to the west of this, there are found many traces of ash and lava, which appear to alternate several times. The

whole section is, however, much obscured by intrusive dykes and sheets, as in the more easterly burn. The tuffs and the massive rocks are nearly always stained a red or purplish colour, as are also the shales and sandstones which are occasionally met with. The dip is south, so that the stream crosses the strike nearly at right angles, and the amount varies from 20° to 40°.

All these beds strike at the hill of Cnoc a' Chapuill, on which there is no trace of them, nor can they be seen on the north of the hill; and though there is fair evidence that this hill is faulted on both sides, it seems also very probable that the Carboniferous rocks are here overlapped by the newer formation. On the western side of the hill, and about 200 yards south of the O.S., there are found traces of the volcanic series in the form of red tuff and ashy red clay, which dip to the south. Westward from this point there are wide spreads of thick peat, and the boundary between these rocks and the overlying New Red Sandstone becomes very obscure. The volcanic zone is no more seen, and the strip of Carboniferous rock, if any exist, is probably shifted about, as represented on the map, by the faults which appear to throw the New Red rocks. To the south of the Clauchan Glen, high upon the hillside, and about 1½ miles west of Cnoc a' Chapuill, a limestone has been quarried in several places. This is a cherty and pebbly rock which dips south at about 20°, and is presumed to be identical with that which occurs as a cornstone at the base of the Carboniferous to the north of Corrie and near the Fallen Rocks. In the most westerly of the quarries the limestone is light in colour and massive, and the more siliceous parts project on a weathered surface. But the whole appears so pebbly that it must be difficult to find any part pure enough for lime-burning. It is overlain by some shales, and 5 to 6 feet of carious sandstone and limestone. Some beds of conglomerate, which come above these, have been classed with the Carboniferous rocks.

On the west this limestone and the associated rocks appear to be cut off by a large fault running N.N.W. Eastward the limestone can be traced by small quarries and swallow-holes for a quarter of a mile, when it is shifted 100 yards to the south by a fault with a north-easterly trend; which has a downthrow to the north-west. The limestone, which everywhere preserves its usual character, has been worked a little on the eastern side of this fault in a long narrow quarry, but all trace of it to the eastward disappears. W.G. (MS.)

Examination of the slices of the Calciferous Sandstone lavas of Arran in the Survey collection shows that they are all olivinebasalts of Craiglockhart and Dalmeny types. Craiglockhart basalt is represented by five specimens, all from the shore section north of Corrie ([S9396](#)) [NS 023 439], ([S9397](#)) [NS 023 439], ([S9398](#)) [NS 023 439]; ([S5658](#)) [NS 020 430], ([S5659](#)) [NS 020 430]. Some of these rocks are beautifully fresh; others have undergone extensive serpentinisation and hematization ([S9397](#)) [NS 023 439], ([S9398](#)) [NS 023 439]. The fresh rocks show phenocrysts of purplish augite and olivine, up to 0.5-cm. in diameter, in an inter-granular groundmass consisting of labradorite laths with augite and magnetite granules. The latter are wedged in between the feldspars which exhibit a marked flow texture. The augite phenocrysts are frequently zoned, and have narrow exterior bands of a slightly darker tint than the interiors, which are often spongy with inclusions of groundmass material. While a few crystals are sharply euhedral, the majority are of irregular embayed outline, and have obviously suffered some magmatic corrosion. The olivines are usually serpentinised, but are occasionally found fresh. The phenocrysts of this mineral are more numerous, but are generally much smaller than the pyroxene.

Dalmeny basalts are to be found in the Uisge nam Fear section south of High Corrie ([S2148](#)) [NS 020 420]; in the exposures north of the String Road, 500 yards north of Windmill Hill ([S6997](#)); and from east of Lag na Croise, Benlister Glen ([S6995](#)) [NR 980 310]. All of these rocks show numerous serpentinized and hematized microphenocrysts of olivine, in an intergranular groundmass consisting of labradorite, augite, and iron-ores. The Uisge nam Fear rock contains a few small microphenocrysts of augite in addition to olivine, and may be merely a fine-grained type of Craiglockhart basalt.

A well-bedded tuff of this volcanic horizon from a tributary to the Benlister Burn a quarter of a mile south-east of Brisderg ([S25049](#)) [NR 988 317] is a bright red rock which, in thin section, shows numerous, sharply-angular grains of quartz embedded in an opaque, richly-ferriferous matrix, consisting of hematized debris of basaltic lava. In this tuff are found hard concretions ([S25075](#)) [NR 988 317] of a red-and-pink mottled rock, in which the hematite has segregated into small irregular masses, whilst the rounded lava fragments, of which the rock is mainly composed, are thoroughly bauxitized. Another specimen from the exposures north of Creag nam Fiteach, Glen Dubh ([S6996](#)) [NR 990 330], is of much the same character, but is richer in quartz and sandstone debris. G.W.T.



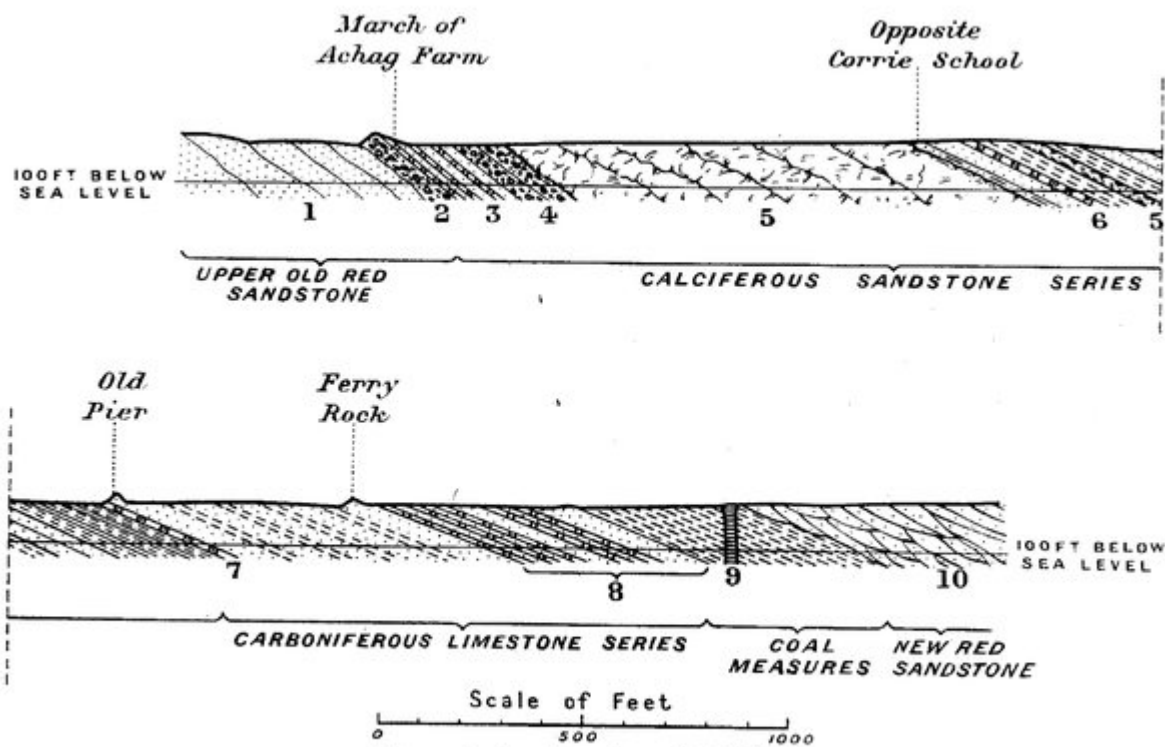


FIG. 1.—Section along shore opposite Corrie.

1. Sandstones ; 2. Conglomerate ; 3. Cornstones ; 4. Tuffs ; 5. Lavas ; 6. Limestone (red) ; 7. Limestone ('Corrie') ; 8. Upper Limestones ; 9. Basalt ; 10. Red Sandstone.

(Figure 1) Section along shore opposite Corrie. 1. Sandstones, 2 Conglomerate 3. Cornstones 4 Tuffs, 5 Lavas, 6. Limestone (Red) 7. Limestone ('Corrie') 8. Upper Limestones 9. Basalt 10. Red Sandstone.

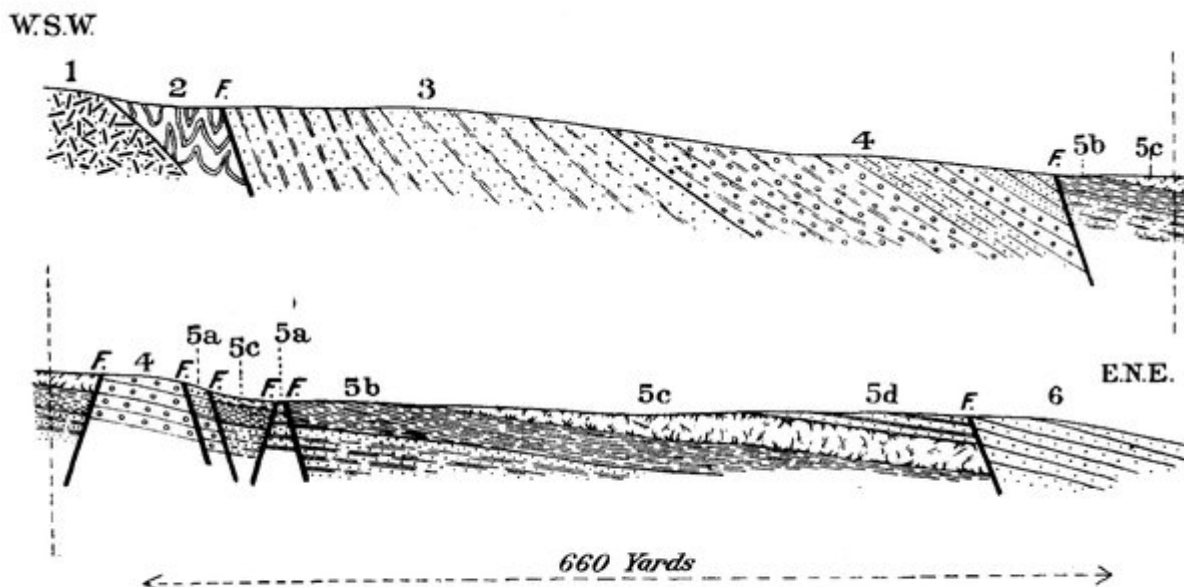


FIG. 2.—Section along the Uisge nam Fear, half a mile south of High Corrie.

1. Granite ; 2. Dalradian schists ; 3. Lower Old Red Sandstone ; 4. Upper Old Red Sandstone ; 5. Calciferous Sandstone Series ; 5a. Lower group of sandstones ; 5b. Basaltic tuffs and red shales ; 5c. Basalt lavas ; 5d. Upper sandstones and marls ; 6. New Red Sandstone (Corrie Sandstone) ; F. Fault.

(Figure 2) Section along the Uisge nam Fear, half a mile south of High Corrie. 1. Granite 2. Dalradian schists 3. Lower Old Red Sandstone 4. Upper Old Red Sandstone 5. Calciferous Sandstone Series 5a. Lower group of sandstones 5b. Basaltic tuffs and red shales 5c. Basalt lavas 5d. Upper sandstones and marls 6. New Red Sandstone (Corrie Sandstone) F. Fault.