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## Chapter 7 The Carboniferous rocks (*continued*)

### Carboniferous Limestone Series and Coal Measures

As the Carboniferous Limestone Series and the Coal Measures (with the Millstone Grit) <ref>The question as to how much of the Millstone Grit is involved in these sections must be deferred pending further investigation. Mr. G. V. Wilson, however, has found the bauxitic clays of the Millstone Grit horizon in North Ayrshire, in the Merkland Burn section (see The Ayrshire Bauxitic Clay, *Mem. Geol. Surv.*, 1922, pp. 5, 8, 24).</ref> are inseparably associated in Arran, it becomes advisable to describe the two together. Rocks belonging to these series are found in the north-eastern coastal exposures; in the sections at and near Corrie; in the group of outcrops from the Merkland Burn north of Brodick to Windmill Hill south of the String Road; in the Benlister Burn, west of Lamlash; and in the exposures at the head of the southern branch of the Sliderry Water. There is almost certainly an offshore occurrence to the north of Catacol (p. 69).

#### The Laggan sections

The main or Hurllet limestone is here considerably thicker than elsewhere in the island, and is overlain at some distance by two other dark calcareous bands which are not represented at Corrie, and may be the equivalents of the Hosie limestone. The highest of these three limestones occurs nearly a quarter of a mile northwest of the shepherd's house, at a point where the shore-line bends westwards, and coincides with the strike of the beds. The section of these three limestones is as follows, in descending order:

	feet
Black, hard calcareous shale and shaly limestone	10 to 12
White sandstone, some of it coarse and pebbly	About 60
Black, hard, calcareous shale with limestone in middle	10 to 12
Coarse sandstone with a little black shale	30
Thick Corrie Limestone with calcareous shale below	35
Blocky sandstone	

These beds all dip northward at 40°. All the limestone contains many fossils belonging to the following:

Crinoid stem	<i>P. longispinus</i> ? J. Sow.
<i>Archaeocidaris urei</i> (Flem.)	<i>P. cf. pugilis</i> Phill.
<i>Rhombopora</i> sp.	<i>Schizophoria</i> sp.
<i>Polypora</i> sp.	<i>Spirifer</i> aff. <i>bisculatus</i> J. de C. Sow.
Athyrid	<i>S. aff. trigonalis</i> (Mart.)
<i>Chonetes laguessiana</i> de Kon.	<i>Spiriferina octoplicata</i> ? (J. de C. Sow.).
Orthotetid	
<i>Productus</i> aff. <i>giganteus</i> (Mart.) [no furrows]	

The shale pavement of the limestone, though fossiliferous, has not yielded fossils of diagnostic value such as would point to the presence of the Hurllet Fauna ' of Central Scotland. *Strepsodus portlockii* (Portl.) was obtained here.

The black shales above have yielded:

<i>Archaeocidaris urei</i> (Flem.)	<i>E. pentonensis</i> Hind
<i>Rhabdomeson</i> sp.	<i>Myalina flemingi</i> (M'Coy)
<i>Camarotoechia pleurodon</i> (Phill.)	<i>M. verneuilii</i> (M'Coy)
<i>Orbiculoidea nitida</i> (Phill.)	<i>Pinna flabelliformis</i> (Mart.)
<i>Lingula mytiloides</i> J. Sow.	<i>Protoschizodus axiniformis</i> (Portl.)
<i>Productus</i> cf. <i>concinnus</i> J. Sow.	<i>Sanguinolites variabilis</i> M'Coy
<i>P. cf. longispinus</i> J. Sow.	<i>Sedgwickia gigantea</i> M'Coy

*P. sp.*, finely striated form  
*Spirifer semicircularis* Phill.  
*Spiriferina octoplicata* (J. de C. Sow.)  
 ? *Amussium concentricum* Hind  
*Aviculopecten dissimilis* (Flem.)  
*A. clathratus* (M'Coy)  
*Edmondia josepha* de Kon.

*Syncyclonema sowerbyi* (M'Coy)  
*Conularia quadrisulcata* J. Sow.  
*Naticopsis globosa* (Hoeningh.) [de Kon.]  
*Nautiloid*  
*Orthoceras*  
*Elonichthys robisoni* (Hibb.).

The upper bed of black shale and shaly limestone referred tentatively in the section above to the Hosie limestone contains the following assemblage:

*Cardiopteris nana* (Eichwald)  
*Archaeocidaris urei* (Flem.) Cf.  
*Ambocelia urei* (Flem.)  
*Composita ambigua* (J. Sow.)  
*Hustedia radialis* (Phill.)  
*Lingula mytiloides* J. Sow.  
*L. squamiformis* Phill.  
*Orbiculoidea nitida* (Phill.)  
*Productus longispinus* J. Sow.  
*P. pugilis* Phill.  
*P. cf. concinnus* J. Sow.  
*Actinopteria persulcata* (M'Coy)  
*Allorisma variabilis* (M'Coy)  
*Aviculopecten clathratus* (M'Coy)  
*A. knockonniensis* (M'Coy)  
*Edmondia josepha* de Kon.  
*E. laminata* (Phill.)  
*E. rudis* ? M'Coy

*Lithodomus lingualis* (Phill.)  
*Nuculana livistriata* (M. and W.) [Hind]  
*Pinna flabelliformis* (Mart.)  
*Sanguinolites variabilis* M'Coy  
*S. striato-lamellosus* de Kon.  
*S. tricostatus* (Portl.)  
 ? *Scaldia fragilis* de Kon.  
*Syncyclonema sowerbyi* (M'Coy)  
*Euomphalus carbonarius* J. de C. Sow.  
*Euphemus urei* (Flem.)  
*Macrocheilina acuta* (J. de C. Sow.)  
*Naticopsis*  
 ? *Coelonautilus subsulcatus* (Phill.)  
*Goniatite*  
*Orthoceras*  
*Megalichthys*  
 Paloniscid scales

A fault trending north with a downthrow west crosses these limestones, the lowest of which can be traced as far as the footpath to the westward, but beyond this it is unknown. On the shore where the coast-line again trends north-west there is a pretty example of a sharp syncline in sandstone with thin, dark shale bands. This extends for about 50 yards, and appears to be bounded by a north-east fault. North of this the dip increases from 30° to 60°. The rocks are mostly sandstones with some bands of black shale and flags, and in one place there is a thin ironstone. South of the ruins of the old salt pans we come upon the crop of the coal or coals worked on this coast, and which have no representatives at Corrie. The coal was worked here upwards of a century ago, and there have been somewhat different accounts given of it. All agree, however, that it was a kind of blind or glance coal, which burned without much smoke or flame — an anthracite, in fact. Headrick, who first described these workings<ref>See his View of the Mineralogy, etc., of the Island of Arran, 1807, pp. 212–219.</ref> in detail, states — 'there are three or four seams of coal running parallel from north to south, the principal or main seam being 14 feet in thickness'; but this statement is hardly credible, especially when compared with an account of a working which he got from a Mr. Cowie who had wrought the coal. Mr. Cowie's description was as follows: 'The seam of coal at the Cock of Arran, wrought by James Cowie, is first about 10 inches, then 8 or 10 inches of a dauchy till, then 20 inches of coal... the till between the two seams of coal seems to burn lime.' The dauch or till was always mixed with the blind coal in burning lime. It seemed to kindle more readily than the coal; and the only difference was that the dauch always left a large *quest* (cinder), whereas the coal burnt into a fine white ash of very small quantity. The thicknesses above given are very much less than 14 feet, when added together, and in fact do not amount to 4 feet, which thickness we may confidently give as the utmost it attained. Two outcrops have been traced, but it seemed probable these were two sets of workings in one and the same coal separated by a fault. Near the salt pans *Lepidodendron veltheimianum* (?) was collected, and 140 yards north-west of the old ruins there is a hard, brown weathering, argillaceous limestone in the position apparently of the Index or *Productus latissimus* limestone. This bed appears to be 5 or 6 feet in thickness, and has yielded:

*Archaocidaris urei*, a *Polypora*, *Lingula mytiloides*, and *L. squamiformis*, an Orthotetid, a doubtful *Productus latissimus*, and a small gasteropod.

The section above this is a good deal obscured, but some 70 yards farther along the shore, where the dip is N.W. at 50° or 60°, there is obscurely seen a thin band of dark-coloured limestone associated with hematite bands. Some 450 yards, or a quarter of a mile north-west of the salt pans, in a small bay, are tessellated ferruginous beds with an ironstone band where were collected:

<i>Camarotoecnia pleurodon</i> (Phill.)	<i>Nucula gibbosa</i> Flem.
<i>Giganteid Productus</i>	<i>Streblopteria ornata</i> (R. Eth.)
<i>Aviculopecten</i> aff. <i>knockonniensis</i> (M'Coy)	<i>Sanguinolites striato-granulatus</i> Hind
<i>Edmondia</i> ?	<i>Protoschizodus axiniformis</i> (Portl.) ?
? <i>Eumicrotis</i>	<i>Bucanopsis decussata</i> (Flan.)
<i>Myalina verneuillii</i> (M'Coy)	<i>Euphemus urei</i> (Flem.), large
	<i>Orthoceras</i>

At the same spot, in bands overlying the ironstone, were collected:

<i>Allorisma sulcata</i> (Flem.)	<i>S. ornata</i> (R. Eth.)
<i>Edmondia rudis</i> M'Coy	<i>Euphemus urei</i> (Flem.)
<i>Nucula gibbosa</i> Flem.	<i>Orthoceras</i>
<i>Nuculana attenuata</i> (Flem.)	<i>Cladodus striatus</i> Ag.
<i>Streblopteria laevigata</i> (M'Coy)	

The beds here dip northward at 20° to 25°. Beyond these we pass over an alternating series of sandstones and clays on to a thick blocky sandstone which forms a kind of headland. The coast now trends more westerly, and we soon come upon a fault running at right angles to the shore which throws down on the east 20 to 30 feet. Beyond this we get a portion of the beds repeated, and soon we arrive at a red limestone in which *Productus latissimus* is abundant. This is more than a quarter of a mile south-east of the junction with the New Red rocks. It is bounded by a fault on the west side, which must be an upcast to the east, and is apparently some 15 feet in thickness. It has yielded:

Chaetetid, laminar form	<i>P. latissimus</i> J. Sow., rather narrow form
? Zaphrentid, indet.	<i>P. pugilis</i> Phill.
<i>Crinoid joints</i>	<i>P. aft. lobatus</i> J. Sow.
<i>Archaocidaris urei</i> (Flem.)	<i>Schizophoria resupinata</i> (Mart.)
<i>Fenestella</i>	<i>Spirifer triradialis</i> Phill.
<i>Tabulipora scotica</i> Lee	<i>Spirifer</i> sp.
<i>Chonetes laguessiana</i> de Kola.	<i>Spiriferina octoplicata</i> (J. de C. Sow.)
<i>Composita ambigua</i> (J. Sow.)	<i>Nucula gibbosa</i> Fleur.
<i>Leptaena analoga</i> (Phill.)	<i>Nuculana attenuata</i> (Flem.)
<i>Productus antiquates</i> J. Sow.	<i>Phillipsia mucronata</i> M'Coy

Nearly 100 yards west from this spot and 375 yards south-east of the New Red junction occurs a thin 'cephalopod limestone' about 2 feet in thickness, which yielded:

*Composita ambigua* (J. Sow.), a bisulcate *Spirifer*, a small giganteid *Productus* similar to the form occurring in the Upper Limestone group of Central Scotland, and two indeterminable Nautiloids; one a large, smooth form, while the other is strongly tuberculated (? *Pleuronautilus*).

A few yards west of this, in bands overlying the cephalopod limestone and 365 yards south-east of the New Red junction, there were got:

Cf. <i>Amboccellia urei</i> (Flem.)	<i>P. scabriculus</i> ? (Mart.)
? <i>Composita ambigua</i> (J. Sow.)	? <i>Schellwienella crenistria</i> (Phill.)

*Dielasma* ?

*Productus muricatus* Phill.

*P. pugilis* Phill.

*Nucula gibbosa* Flem.

*Nuculana attenuata* (Flem.)

*Orthoceras*

A few yards farther west and 350 yards south-east of the New Red rocks, there were collected:

?*Edmondia*, *Sanguinolites clavatus* (Eth.) and *Solenomorpha parallela* (Hind).

Above these beds comes a brecciated-looking limestone of considerable thickness, which is repeated by a fault ranging N.N.E. This only yielded a compound coral. It has been called the Coral limestone.

Some of the upper limestones crop out on the hillside a quarter of a mile west of Cock Farm, and from one of these were obtained:

Chaetetid, cast of

Crinoid ossicles

*Fenestella*

*Productus latissimus* J. Sow.

Cf. *Schellwienella crenistria*

*Allorisma sulcata* (Flem.)

*Myalina verneuillii* (M`Coy)

*Macrocheilina*

*Deutaliid*

Trilobite, indet.

A thin limestone occurs in the faulted strip of Allt Mòr, between North Newton and the Cock of Arran.

Above the Coral limestone on the shore the beds consist largely of shales and red clays, with some rough and irregular sandstones. The highest marine band noticed was 100 yards south-east of the New Red junction, and here were obtained:

*Lingula mytiloides* J. Sow., *Productus muricatus* Phill., *Schellwienella crenistria* (Phil.), *Spirifer semicircularis* Phill., and crinoid ossicles.

Coal Measure plants were obtained from a spot 72 yards south-east of the New Red rocks:

*Calamites* sp.

*Cordaites principalis* (Germar)

*Lepidostrobus* ?

A larger and more important set was collected from a locality 20 yards south-east of the New Red junction, and these are the following:

*Calamites ramosus* Artis

*Calamites varians* Sternb.

*Cordaites principalis* (Germar)

*Mariopteris muricata* (Schloth.)

*Neuropteris gigantea* Sternb.

*Neuropteris* sp.

*Sphenophyllum myriophyllum* Crépin

*Sphenophyllum* sp.

## Sections at and near Corrie

The Corrie Limestone (Figure 1), which occupies the old harbour, is probably the equivalent of the Hurlet. It is said to be 20 feet in thickness, and is crowded with innumerable specimens of *Productus giganteus*, well exposed on the under surfaces of many of the beds in the old quarry to the westward, which extends for nearly a quarter of a mile up the hillside. The beds of limestone are separated by thin partings of reddish shale, and from the calcareous shale immediately overlying the limestone were obtained by the fossil-collector of the Survey, Mr. Tait, a number of species the list of which is:

*Rhabdomeson*, casts of

*Pinnatopora*

*Chonetes laguessiana* de Kon.

*C.* sp. (larger than *C. laguessiana*)

*Lithodomus lingualis*

? *Modiola*

*Myalina flemingi* (M`Coy)

*M. peralata* de Kon.

? <i>Cleiothyridina roissyi</i> (L'Ev.)	? <i>Pinna mutica</i> M'Coy
? <i>Dielasma</i>	<i>Protoschizodus obliquus</i> (M'Coy)
<i>Productus costatus</i> J. de C. Sow.	<i>Euphemus urei</i> (Flem.)
<i>P. giganteus</i> (Mart.) [furrows do not reach umbo]	<i>Naticopsis globosa</i> ? (Hoeningh.) [de Kan.]
<i>P. latissimus</i> J. Sow.	Pleurotomariid
<i>P. productus</i> (Mart.)	Cf. <i>Porcellia mosana</i> de Kon.
<i>P. scabriculus</i> (Mart.)	<i>Gasteropod</i> indet.
<i>P. aff. longispinus</i> J. Sow.	<i>Actinoceras</i>
<i>P. (Pustula) cf. elegans</i> M'Coy	<i>Orthoceras sulcatum</i> Flem.
<i>Schellwienella crenistria</i> (Phill.)	<i>O. sp.</i>
<i>Spirifer all. trigonalis</i> (Mart.)	Nautiloid
<i>S. cf. semicircularis</i> Phil.	<i>Phillipsia mucronata</i> M'Coy
<i>Spiriferina octoplicata</i> (J. de C. Sow.)	<i>Megalichthys</i>
<i>Aviculopecten dissimilis</i> (Flem.)	<i>Polyrhizodus magnus</i> M'Coy
<i>Aviculopecten</i> sp., finely striated	<i>Rhadinichthys ornatissimus</i> (Ag.)
Cf. <i>Crenipecten semicircularis</i> (M'Coy)	<i>Xystrodus striatus</i> (M'Coy)
? <i>Leiopteria</i>	

Two basic dykes cross the limestone in a north-north-west direction. One of these, just above the old lime-kiln, is 5 feet wide, and the other, nearly 50 yards higher up, is 4 feet in width. Several small faults also cross the quarry. One of these above the kilns coincides with one of the dykes just mentioned, and it throws down east 7 to 8 feet. A second fault a little farther up, throws down 2 feet to the west, and a third fault is down east 3 to 4 feet. Near the top of the quarry there is the following section:

	feet
Sandstone	6
Shale and shaly sandstone	3
Sandstone to	to 12
Shale and shaly sandstone (red)	3 to 5
Limestone, upper bed	at least 16

There are slight calcareous shale partings where *Producti* are very numerous.

Between the two upper faults the *bearing* above the limestone is much less, being only 10 to 15 feet, but east of this there is probably 30 feet of sandstone and shale in the artificial cliff above the limestone. The two shale bands are variable, but the intermediate sandstone is not so thick and massive as near the top of the quarry, while 10 to 12 feet of the upper sandstone appears.

Headrick (*op. cit.*, p. 344) gives some analyses of limestone at Corrie, from which it appears that the proportion of carbonate of lime varies from 90½ to 97 per cent. He also gives the following for South Corrie Quarry:

Carbonate of Lime	98½
Clay	1½

This is probably the old quarry at An Sgriob, north of Maol Donn, which is in the same bed as the Corrie Quarry, and which has also yielded a numerous suite of fossils. W. G., G.W.L.

The An Sgriob quarry appears to be an enlargement of a cliff-section in a small stream. It has not been worked for many years, but still shows the section illustrated on top of next page.

Bed 6 probably belongs to the Coal Measures. It rests on the limestone in the eastern part of the quarry (Figure 3), then successively on the sandstone (bed 4), and on bed 5. This junction may represent an unconformity between the Coal Measures and the Carboniferous Limestone Series. Bed 4 is lenticular, and fades out in a distance of a few feet. A thin dyke of crinanite cuts the series in the western part of the quarry. The shale (bed 1) is calcareous towards the top of the

bed, and contains one or two thin limestone bands, and numerous red-stained limestone nodules which are very fossiliferous. The thick limestone (bed 3) is crowded with large *Productids*.

The shales below the limestone have yielded the following suite of fossils:

Crinoid stems	<i>Nucula gibbosa</i> Flem.
<i>Archaeocidaris urei</i> (Flem.)	<i>Pinna flabelliformis</i> (Mart.)
<i>Fenestella</i>	<i>Protoschizodus axiniformis</i> (Portl.)
<i>Rhabdomeson</i> ?	<i>P. obliquus</i> (M`Coy)
<i>Cf. Camarotcechia pleurodon</i> (Phill.)	<i>Pseudamussmm ellipticum</i> (Phill.)
<i>Chonetes laguessiana</i> de Kon.	<i>Pterinopecten radiatus</i> (Phill.)
<i>Dieslasma hastatum</i> (J. Sow.)	<i>Sanguinolites striato-granulatus</i> Hind
<i>Productus concinnus</i> J. Sow.	<i>Syncyclonema sowerbyi</i> (M`Coy)
<i>P. productus</i> (Mart.)	<i>Bucanopsis decussata</i> ? (Flem.)
<i>P. scabriculus</i> (Mart.)	<i>Euomphalus</i>
<i>P. sp.</i> , giganteid	<i>Euphemus urei</i> (Flem.)
<i>P. sp.</i> , small, finely striated	<i>Loxonema</i>
<i>Spirifer grandicostatus</i> M`Coy	<i>Macrocheilina</i>
<i>S. aff. duplicosta</i> Phill., with finer ribbing	<i>Cf. Naticopsis planispira</i> de Kon. [non Phill.]
<i>S. sp.</i> , elongate form	<i>Zygopleura</i>
<i>Allorisma sulcata</i> (Phill.)	Dentaliid
<i>Aviculopecten</i>	<i>Orthoceras cylindraceum</i> Flem.
<i>Edmondia sulcata</i> (Phill.)	<i>O. sulcatum</i> Flem.
<i>Leiopteria squamosa</i> (Phill.)	? <i>Temnocheilus</i>
<i>Myalina flemingi</i> (M`Coy)	<i>Paloniscid scales</i>

The beds between the Corrie Limestone and the Index Limestone are well exposed on the shore for 220 yards south of the old harbour, and consist mainly of alternations of thick white sandstones and flags, with occasional shale bands. The dip continues much the same in amount and direction, 20° to 30° towards the south-east. The sandstones have been much quarried for building material in the wood above the houses, and at the landing place. There is an ironstone band in one place, and fireclays, such as often underlie coal-seams, occur, but there are no coals, though we are on the horizon of the coals worked at the north end of the island near the Cock. There are traces of coal plants however. The thickness of this part of the series must be about 250 feet.

A thin red limestone with *Productus latissimus* occurs about 25 yards south of the Ferry rock, and not far to the south of it occur two others, as in the following section in descending order:

		Feet
3	Red limestone, in one place	1
	Shale and sandstone, some of the sandstone fine and like Ganister	About 20
2	2. Red limestone	1
	Red shale	7 to 8
2	Red limestone	2-3
	Shale, argillaceous, with red and mottled sandstone	5

No. 1 of this section is the Index or *Productus latissimus* Limestone. It contains few brachiopods apart from *Prod. latissimus* J. Sow. The most characteristic element of the poorly-preserved fossil assemblage consists of small gasteropods of which the most widespread are a form resembling *Macrocheilina polyphemoides* de Kon., but narrower, and small Murchisonids; others may be referred to *Bucanopsis decussate* (Flem.), *Euomphalus carbonarius* J. de C. Sow., and *Loxonema* sp. Imperfectly preserved lamellibranchs may belong to *Edmondia* and to *Sanguinolites*. Cephalopods are represented by an indeterminable Nautiloid.

No. 2 band has yielded almost exclusively minute gasteropods difficult of determination, belonging to *Macrocheilina* and to Murchisonids, the latter of which include *Murchisonia* and *Aclisina*. It is doubtful whether the specific names given to these small fossils on p. 41 of the first edition of this Memoir would stand to-day. A tooth of *Strepsodus striatulus* Traq. was also obtained.

Lamellibranchs, among which the more conspicuous are *Nucula scotica* Hind, *N. luciniformis* Phill., *Nuculana attenuata* (Flem.) and *Allorisma sulcata* (Flem.), give a slightly different faunal aspect to No. 3 band, where the small gasteropods mentioned above still occur. G.W.L.

There are numerous small faults about this part of the shore which in the main run parallel to the coast-line, crossing the beds nearly at right angles, and shifting their outcrops again and again for a few feet. A mass of sandstone now projects into the sea and south of this, in front of the hotel, is a little bay in which occur two or three thin red limestones, from 1 to 2 feet thick, which are probably separated by shale, but the section is not clear. To the south of this bay there is a mass of sandstone with irregular shale bands. One of the shale bands, 8 to 10 feet thick at the shore-

line, gradually thins away seaward, till at low-water mark it has almost disappeared. The thick sandstone underlies a mass of red and mottled clays, red and purplish shales, with occasional thin sandstones which occupy the larger bay south of the hotel. The beds in this bay are classed with the Coal Measures as they contain organic remains of Upper Carboniferous facies, but they and the equivalent beds elsewhere may possibly be Millstone Grit. About 25 yards south of the northern boundary of Cromla gardens, and near high-water mark, there was obtained a specimen of *Neuropteris gigantea* Sternb., and opposite the Cromla House the beds yielded *Lepidodendron* sp., *Carbonicola acuta* (J. Sow.), *C. aquilina* (J. de C. Sow.), and *Naiadites modiolaris* (J. de C. Sow.).

These Coal Measures strata also crop out in the lower part of Locherim Burn 200 yards from the sea, where in fine red shale 15 yards from the faulted New Red junction there were obtained:

*Mariopteris muricata* (Schloth.)

*C. aquilina* (J. de C. Sow.)

*Neuropteris heterophylla* Brongt.

*Naiadites* sp.

*Carbonicola acuta* (J. Sow.)

Another locality near Corrie where these beds occur is on the north-west side of the Maol Donn cliff. In red sandy shale above the limestones were found:

*Artisia approximata* (Brongt.)

*Calamites ramosa* Artis

*C.* sp.

*Neuropteris gigantea* Sternb.

*N.* sp.

*Stigmaria* sp.

There is another fossiliferous band up the Locherim Burn the existence of which was first made known by Prof. W. Ivison Macadam, <ref>See his paper entitled Notice of a New Fossiliferous Bed in the Island of Arran, *Trans. Geol. Soc. Edinburgh*, vol. v., 1887, p. 316.</ref> but it is in the Upper Limestone Series some 330 yards from the sea, where the stream forks at a waterfall, and it is separated by a fault from the Coal Measures strata previously mentioned. Alternations of shale and sandstone occur with a thin limestone band. The beds above the limestone yielded the following plants to the Geological Survey collectors:

*Asterocalamites scrobiculatus* (Schloth).

*Carpolithes sulcata* L. & H.

*Lepidodendron veltheimianum* Sternb.

*Lepidostrobus* sp.

*Rhodea* sp.

*Sigillaria taylori* Carr.  
*Sphenopteridium dissectum* (Gopp.)  
*Stigmaria*

The limestone and calcareous shale band underlying the plant bed afforded:

*Schizophoria resupinata* (Mart.) Cf.  
*Schellwienella crenistria* (Phill.)  
*Productus* sp.  
*Allorisma sulcata* (Flem.)  
*Edmondia unioniformis* (Phill.)  
*Myalina verneuilii* (M'Coy)  
*M.* sp.  
*Nucula gibbosa* Flem.  
*Nuculana attenuata* (Flem.)  
*Protoschizodus axiniformis* (Portl.)  
*P. obliquus* (M'Coy)  
*Bellerophontid*  
*Macrocheilina* sp.

In the Merldand Burn about three-quarters of a mile north of Brodick Castle there is a fairly continuous outcrop of the Carboniferous rocks, except that the section is obscured where the Corrie Limestone should appear. The thick sandstones above it appear, and lower down the burn two of the Upper Limestones. From the lowest of these were collected:

Crinoid ossicles  
? *Cleiothyridina roissyi* (L'Ev.)  
*Composita ambigua* (J. Sow.)  
Orthotetid  
*Productus* cf. *muricatus* Phill.  
*Allorisma sulcata* (Flan.)  
*Edmondia josepha* de Kon.  
*Lithodomus lingualis* (Phill.)  
*Pectiniform shell*

The limestone a few yards still lower down the stream yielded *Productus latissimus*. The more shaly beds still farther down the stream are similar to the highest beds on the Corrie shore, and from them were obtained the following Coal Measures forms:

*Anthracomya modiolaris* (J. de C. Sow.)  
*Carbonicola acuta* (J. Sow.)  
*C. acuta* var. *rhomboidalis* Hind  
*Naiadites quadrata* (J. de C. Sow.)  
*Megalichthys hibberti* Ag.  
*Rhizodopsis sauroides* (Will.)

The same beds in a parallel burn nearly a quarter of a mile to the south-west of this gave *Carbonicola acuta*, *C. aquilina*, *Rhizodopsis*. sp All these beds have a steep dip to the E.S.E., and the dip increases towards Brodick Castle. The Corrie Limestone was at one time quarried at the edge of the wood about half a mile north of the Castle, and there are traces of small limestone quarries west of the Castle. In the Sawmill stream 300 yards south-west of the Castle the beds are practically vertical. Here, a few yards above a foot-bridge, were collected the following:

*Productus latissimus* J. Sow, [small]  
*P. scabriculus* (Mart.)



*Aviculopecten cf. dissimilis* (Flem.)

Bellerophontid

*Zygopleura rugiferum* (Phill.)

*Z. aff. murchisonianum* (de Kon.)

Gasteropods, with low spire, 2 forms

Gasteropod, conical with spirally striated base

*Orthoceras* indet.

They must belong to the Upper Limestone Series. In the mill-lade *Lingula squamiformis* Phill. was found. Shelly ironstone bands associated with shales and sandstones are found in the Rosa Burn on either side of the bridge near Brodick Manse, and from one of these, a few yards above the bridge, a 'musselband ironstone', there were obtained a Lycopod branch and a species of *Carbonicola*. Here we have the Coal Measures again.

The Corrie Limestone was formerly quarried north-west of the church, just beyond the boundary wall of the kirkyard; and on the hillside a quarter of a mile south-east of the String Road and half a mile and upwards west of the wood. The beds are nearly vertical in both localities and they yielded *Productus giganteus* (Mart.). The Carboniferous rocks here have diminished to a thickness of not more than 600 feet, and yet we have the Coal

Measures above and the volcanic series below; but there is no trace in Glen Shurig of the Upper Limestones. In the Memoir on Sheet 21 (1903) it goes on to state here that Carboniferous sediments are involved in the felsite of Windmill Hill. A discovery of Mesozoic fossils in 1925 makes it certain that the brick-red and tea-green marls at this locality are Keuper and not Calciferous Sandstone, as stated in the Memoir. It is practically certain that all the sediments entangled with the felsite intrusions of Windmill Hill are Mesozoic (see p. 104).

The next exposure of Carboniferous rocks is found about a mile to the south of the above locality, on the south side of Glen Dubh, where it forms a triangular patch bounded on the east and west by faults (see p. 55). In the southern angle of the triangle massive white sandstone, which probably overlies the Corrie Limestone, is seen, but the limestone itself does not crop out, and no other beds are to be observed. Near the west end of Creag nam Fitheach another and still smaller Carboniferous patch occurs which is faulted on either side, but no other rock is visible than the volcanic zone.

South of this small isolated patch and beyond Brisderg, two other detached areas of Carboniferous rocks occur in Benlister Glen, on either side of a synclinal, the centre of which is occupied by Trias. It would seem that the unconformity between the two formations is more marked here than in any other part of the island yet described, for in one place beds containing plants and animals of Coal Measures age occur, while elsewhere the New Red rocks rest directly upon the Corrie Limestone or even overlap that bed and repose on the shales below. On the western side of the synclinal the Corrie Limestone may be seen at Benlister Burn, nearly half a mile south-south-west from Brisderg. It appears to be repeated by a fault on the north side of the burn, but must be several feet in thickness, and from it have been collected numerous fossils. all in a Poor state of Preservation:

Crinoid joints

*Archaeocidaris urei*

*Fenestella*

*Cleiothyridina roissy* (L'Ev.)

*Composita ambigua* (J. Sow.)

? *Dielasma*

? *Hustedia radialis* (Phill.)

*Productus concinnus* J. Sow.

*P. giganteus* (Mart.)

*P. latissimus* J. Sow.

*P. scabriculus* (Mart.)

*P. cf. muricatus* Phill.

? *P. fimbriatus* J. de C. Sow.

Cf. *Schellwienella crenistria* (Phill.)

*Schizophoria* ?

*Spirifer bisulcatus* J. de C. Sow.

*S. semicircularis* Phill.

*S. trigonalis* (Mart.)

*S. cf. duplicicosta* Phill.

*S. cf. humerosus* Phill.

? *Spiriferina octoplicata* (J. de C. Sow.)

? *Macrocheilina*

*Megalichthys* sp.

*Poecilodus jonesi* Ag.

This limestone is overlain by New Red sandstone and conglomerate, while a few yards away, on the south side of the burn, the conglomerate rests immediately on red shaly clay, and the limestone has disappeared. However, nearly 300 yards farther to the south-west the *Productus* limestone appears again for a short distance, but in a very attenuated form (only 3 feet thick) under the conglomerate, but not immediately, and overlying a thick series of red shales and clays, with a few thin tuffaceous bands.

The dip is high, being 50° to 60° towards the south-east, and to the westward comes on the volcanic zone which underlies the red shales. All these rocks are pierced by many acid and basic dykes.

On the eastern side of the synclinal the limestone appears in the southern bank of a small burn 400 yards due south of Brisderg. It is of considerable thickness, and is overlain by several feet of white blocky sandstone, on which rests the Triassic conglomerate. To the westward the conglomerate appears to overlap both the sandstone and limestone, and rests immediately on the red shales below. The greater part of the small valley to the eastward seems to be occupied by these red shales, though not many sections occur in them, owing to a thick deposit of drift, and the Triassic conglomerate appears to form the feature on the west side, which runs southward to a waterfall in the Benlister Burn, where it dips westward. No limestone here appears below the conglomerate, though red shales and sandstone, probably of Carboniferous age, are visible, dipping westward at 35°. However, by following the base of the conglomerate, some 200 yards to the southward, where a small stream occurs, we come upon the limestone again, with the usual *Productus giganteus*. The rocks here are much disturbed however. Lower down the main stream below a fall called Eas Geal (white water), at the bend of the stream there occur some shales and sandstones of a red colour, with a bed of shelly ironstone, dipping steeply to the south-east. This locality is 2¼ miles west of Lamlash Bay, and half a mile south-south-east from Brisderg. These beds have yielded Coal Measures forms like those of Corrie, etc. There were collected here:

*Calamites suchowii* Brongt., *Calamites* sp., and *Carbonicola acuta* (J. Sow.)

These rocks on the west side appear to be faulted against the contemporaneous volcanic zone elsewhere described (see latter part of this chapter), and on the east they are thrown against Triassic rocks by a large fault which passes east of Brisderg. Another fault with a throw in the opposite direction passes west of Brisderg, and brings down the Triassic rocks on that side against the Lower Carboniferous zone, which is also bounded on the south side by a fault running eastward, throwing the red shale down against the traps. W.G., G.W.L.

## Catacol Cairn

The coping of the wall in front of the police station, Lochranza, near the pier, is made of white Carboniferous freestone collected on the foreshore nearly a quarter of a mile north of Catacol, and the coping of the wall round the most easterly house in Catacol is from the same locality and of the same character. At first it seemed possible the materials might have been derived from ballast blocks or from scattered boulders on the shore, but on examining the ridge below high-water mark (called a 'cairn'), whence the stones were obtained, it was found there were still remaining numerous large and not rounded blocks of the white Carboniferous sandstone, and also many blocks of red fossiliferous limestone belonging to the same formation. The sandstone blocks are much too large to have been used for ballast, and if there is not an outcrop of Carboniferous rock near, the ridge must be regarded as a kind of moraine. But the latter explanation does not appear very probable when we consider that the nearest place where rocks of this kind occur *in situ* is more than 2 miles

away to the east of North Newton. It seems more likely that the blocks have been cast up by storms from an outcrop not far away, beneath the sea.

There are many limestone blocks in the old dyke by the roadside between Catacol village and the bridge over Catacol Burn, which must also have been derived from the foreshore.

Mr. D. Tait has obtained the following suite of organic remains from the limestone blocks of the 'cairn'

Coral, rugose

*Lithostrotion*, indet.

*Crinoid ossicles*

*Composita ambigua* ? (J. Sow.)

*Lingula*

*Productus latissimus* J. Sow.

*P. sp.*, small *giganteid*

*P. cf. antiquatus* J. Sow.

? *Schizophoria resupinata* (Mart.)

*Spirifer*

*Aviculopecten*

*Nucula gibbosa* ? Flem.

*Nautiloid*, indet.

*Phillipsia mucronata* ? M'Coy

**Sections in Slidery Water Head, South Branch**<ref>This account is somewhat summarized from Mr. Gunn's MS. on Sheet 13. A long detailed account is to be found in a paper by Mr. Gunn, On the Old Volcanic Rocks of the Island of Arran, *Trans. Geol. Soc. Glasgow*, vol. xi., part ii., 1900, pp. 174–191.</ref>

The Carboniferous area in this locality consists principally of dull-red slaggy lavas and red tuffs, the latter, which vary from fine muds to coarse agglomerates, predominating. Two bands of sandstone and shale, which have yielded plants, shells, and fish remains having a Coal Measures aspect to the fossil-collectors of the Geological Survey, are included. The area over which these rocks extend is roughly triangular, nearly three-quarters of a mile in length from N.E. to S.W., with a breadth of 600 yards at its widest part. It is found in the southern headwaters of the Slidery Water on the south side of the Ross Road, about 4 miles south-west of Lamlash Pier. These rocks may extend some 200 or 300 yards farther than the most northerly outcrops noticed, and may occupy the drift-covered ground between the main stream and the road.

The rocks, for the most part tinged a deep red or purple, are arranged in an anticlinal form, the axis of which is directed from E.N.E. to W.S.W. Only the southern side of this structure is, however, well exposed, the northern being much obscured by glacial drift. The principal sections are found in three unnamed parallel branch streams which rise in the higher ground to the south, and run north-west across the area. They are here named Burns A, B, and C, for convenient reference. The longest of these is Burn C, which rises on the west side of Cnoc Dubh; Burn B, the next to the east, is not shown on the One-inch Map and the most easterly is Burn A. Sections are exposed in still smaller intermediate streams, and in the main burn which runs parallel to the road, especially in that part of it near the foot of Burn C. The sections are much obscured by the abundance of Cainozoic intrusions.

The general stratigraphical succession in descending order is as follows:

Base of New Red Sandstone

Lavas, very slaggy and amygdaloidal, with occasional tuff bands

Coarse felspathic grit

Shales and ironstone bands, with a sheet of intrusive felsite

Flaggy sandstones and shales passing westward into fine volcanic mudstones. This is the band which has yielded most of the organic remains

Alternations of fine red volcanic mudstone and tuff, with coarse volcanic ash and ashy sandstone, with sometimes beds apparently of lava

The base of the series is nowhere seen

### Burn A

The section in this burn is much obscured by drift. Beds of purplish-red tuff are seen in the lower part of its course, and dip down stream or to the W.N.W. at a low angle. Higher up the burn these rocks are abruptly truncated by a mass of coarse intrusive dolerite, which here bounds the volcanic series on the eastern side. To the south-west, between this burn and the next, there crops out on the hillside a massive red rock, which, in places, resembles a tuff, and in others, a fine-grained lava.

### Burn B

A felsite intrusion occupies the burn for 100 yards or so above its junction with the main stream. Tuffs and fine-grained lava occur above the felsite, and dip north at angles varying from 20° to 10°. In the next 150 yards an undoubted slaggy lava occurs, with intercalated beds of shale and sandstone, and about the waterfall fine red mudstone and shale probably of volcanic origin. The dip lessens to horizontality, and then inclines in the opposite direction, *i.e.* towards the south-east. The most important part of the section is reached 250 yards up the stream from its foot. The fossiliferous bands are partly involved with a mass of intrusive Cainozoic felsite. As far as can be made out, the section is as follows in descending order:-

- |   |   |
|---|---|
| 1 | Shale with bands of ironstone, mostly included within the felsite. <i>Carbonicola</i> abundant.   |
| 2 | Sandstone, white, flaggy, and quartzose, with <i>Stigmaria</i> .<br>Thickness, 12 to 15 feet.   |
| 3 | Shale with ironstone band full of shells in places. 8 to 10 feet thick.   |
| 4 | A thin sheet of grey (? intrusive) basic igneous rock, <ref>This rock ( <a href="#">S7740</a> ) [NR 98 28] is a fine-grained quartz-dolerite identical with some members of the suite described in Chapter 12.</ref> amygdaloidal at top. About 2 feet thick. |
| 5 | Shale, reddish and dark-coloured, some of it towards the base slightly tuffaceous. It contains some ironstone nodules, and seems to pass down into fine red tuffaceous mudstones or shales. Thickness, 8 to 10 feet.  |

These beds dip to the south-east at an angle of 12°.

It is from the upper part of No. 3 that most of the fossils have been obtained. Some thin bands are crowded with specimens of *Carbonicola*; and the same horizon has yielded plants and various species of fish. Two species of *Carbonicola*, *C. acuta* (J. Sow.) and *C. robusta* (J. Sow.), and seven of fishes (see list below) have been obtained here. The plants were submitted to the late Dr. Kidston, but only one, *Lepidodendron*, could be specifically identified. The following is a complete list of the fossils obtained by the Survey collectors, Messrs. Macconochie and Tait, in 1897, from bed No. 3:

*Lepidostrobus* sp.

*Stigmaria* sp., abundant

*Calamites* sp.

*Carbonicola acuta* (J. Sow.)

*C. robusta* (J. Sow.)

C. sp., indet.

*Diplodus* sp., teeth

*Pleuroplax* sp., teeth

*Helodus* sp., teeth Ag.

*Megalichthys hibberti* ? Ag., teeth and scales

*Rhizodopsis sauroides* ? (Will.), scales

*Strepsodus sauroides* (Binney), teeth

*Platysomus parvulus* Young, scales

*Lepidodendron veltheimianum* Sternb.

Subsequently, in 1899, Mr. Tait obtained plants, chiefly *Calamites*, from the red tuff below and near the waterfall, the most abundant form being *Asterocalamites scrobiculatus* (Schloth.), a characteristic Lower Carboniferous form. *Sphenopteris* sp. ? and *Anthropalaemon* were also obtained.

The section in the upper part of Burn B above the felsite is very poor. It shows red micaceous shale and sandstone underlying a strong band of light-grey, rather coarse, feldspathic grit. In 1899, however, Mr. Tait discovered fossils in fine red mudstones, including numerous specimens of *Neuropteris heterophylla* Brongt., a characteristic Coal Measures form, and a specimen of *Spirangium carbonicum* Schimper. This form had previously only been recorded from one other locality in Scotland, Woodhead Quarry, Kilmaurs, Ayrshire, in strata belonging to the lowest member of the Coal Measures.

The grit band mentioned above does not appear in the stream gorge, but forms a conspicuous feature on the hillside, especially to the north-east, where it can be traced for 250 yards. It dips south-east, and, with the whole of the accompanying series, is cut off on the east side by an intrusive felsite mass. Above the grit a slaggy lava, with perhaps one band of tuff, is poorly exposed. The burn at this place is occupied by an interesting composite dyke. The south-eastern boundary of the volcanic series appears to be unfaulted in this place, as a feature strewn with blocks of a whitish sandstone probably marks the oncoming of the New Red Sandstone above.

### **Burn C**

The most significant section occurs about a quarter of a mile above the main stream. The New Red Sandstone here dips south at 15°, and is followed below by a slaggy lava about 30 feet thick, although the junction is obscured by a felsite dyke. The upper grit and shale band, which comes on beneath the lava, may likewise be about 30 feet thick. A fault occurs here along the burn throwing down about 30 feet to the west. The purple and dark shales yield *Stigmaria* fragments, and from an ironstone band there was obtained by the fossil-collector a small shell (? *Myalina*). Subsequently Mr. Tait obtained *Neuropteris heterophylla* Brongt., *Calamites* sp., *Lepidophloios*, and some lamellibranchs.

Below this shale comes the intrusive felsite of Burn B; but instead of the fossiliferous shales and sandstones of that stream a mass of barren red shales and volcanic mudstone appears below the intrusive rock. These beds are at first horizontal, but they soon roll over, with a gentle dip to the W.N.W., and then at a high angle. The purple ash in the lower part of the stream appears nearly vertical in places, but the section is much confused by Cainozoic basalt intrusions. These also cut through massive red tuffs and breccias in the main stream, just above its junction with Burn C. Below the junction the dip is very irregular, and vertical in places. It may be that the disturbance is due to a volcanic vent. Farther down the volcanic series is cut off by a basic Cainozoic intrusion, which forms the boundary all along the north-west side. Poor exposures of the lavas and accompanying sediments occur at various places to the west and south-west of Burn C for a distance of a little over 600 yards.

The volcanic series of Slidery Water Head (south branch) is thus seen to be bounded by a basic intrusion on the north-west side, which probably comes up along a line of fault downthrowing to the north-west. On the east it is bounded by intrusive masses of dolerite and felsite, except for a short distance immediately south of the Ross Road, where glacial drift obscures all the relations. Only along its southern border, therefore, can anything be learnt as to its relations to the overlying New Red Sandstone. These succeed to the south, and are presumed to rest unconformably on the volcanic series, but the evidence is not conclusive, and the data for the general unconformity between the Carboniferous and the

New Red Sandstone has been obtained from other Arran localities. To account for the fact that the New Red Sandstone rocks are here reposing on beds of Coal Measures age, while a mile away to the north-west they rest on Lower Carboniferous rocks, it must be supposed that in the intermediate area the unconformity between the two formations is much more decided than it has been found to be elsewhere in the island, or that there is concealed here a post-Carboniferous fault which threw down these higher rocks (Coal Measures) against the Carboniferous Limestone Series before the deposition of the New Red Sandstone. W.G. (MS.)

Three slices of the Upper Carboniferous lavas of Arran are available in the Survey collection. These are all from the exposures at the head of the Slidery Water described in the preceding section; two are from Burn B ([S7051](#)) [NR 98 28], ([S7740](#)) [NR 98 28], and one from Burn C ([S7739](#)) [NR 98 28]. The last-named is the freshest and most typical rock. It shows numerous serpentinized microphenocrysts of olivine in a ground-mass of straight-extinguishing plagioclase laths (oligoclase), and iron-ores (magnetite and haematite). The groundmass possesses a poorly-developed flow texture through the sub-parallel arrangement of the felspar microlites. The other two rocks are entirely similar, except that they are more decomposed with a more profuse development of secondary iron-ores. The affinities of these rocks are clearly with the mugearites.

Four slices of the tuffs from Slidery Water Head have also been examined. Three of these ([S6994](#)) [NR 980 280], ([S7738](#)) [NR 97 28], ([S7742](#)) [NR 98 28] show about equal admixtures of quartz grains and volcanic fragments. The latter are all of mugearitic characters, and are often rounded, although some large fragments (1 cm. diameter in ([S7738](#)) [NR 97 28] have extremely irregular embayed shapes. While some of the lava fragments are still comparatively fresh, the majority of them are more or less limatized. The matrix in which both quartz grains and lava fragments are embedded is a decomposed aggregate of fine volcanic detritus. The remaining specimen ([S6371](#)) [NR 98 28] is well bedded, and is so rich in quartz that it is best regarded as a tuffaceous sandstone. G.W.T.

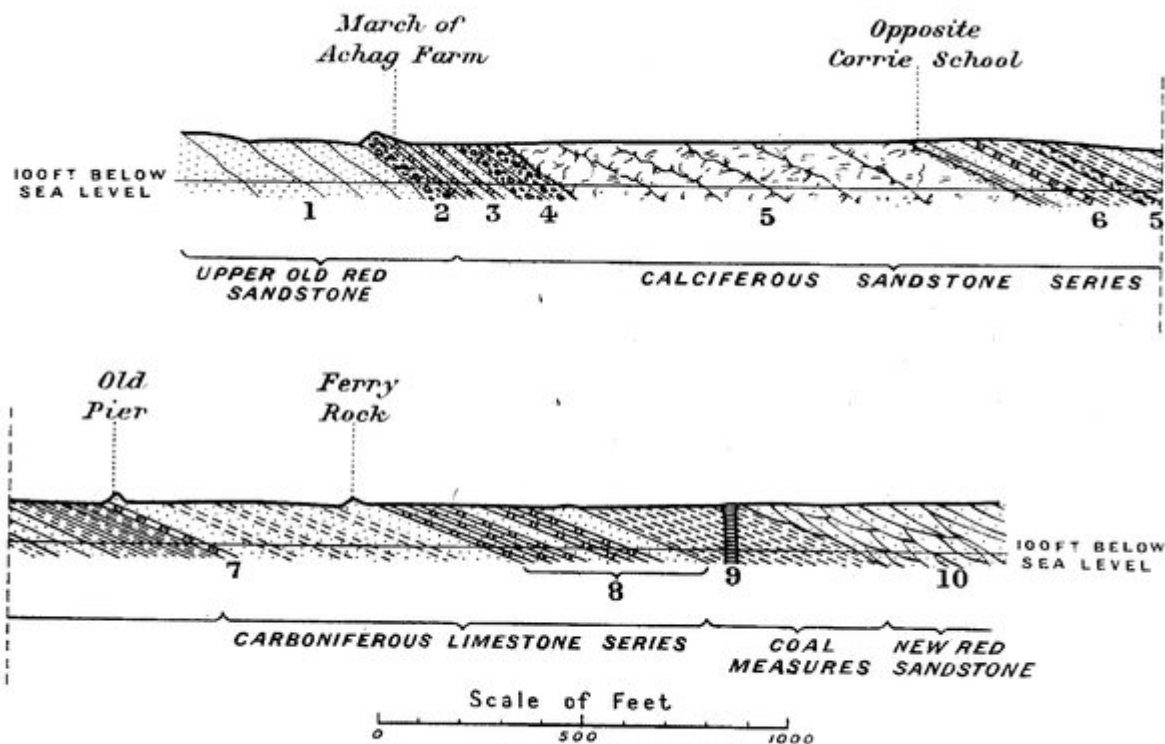


FIG. 1.—Section along shore opposite Corrie.

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.

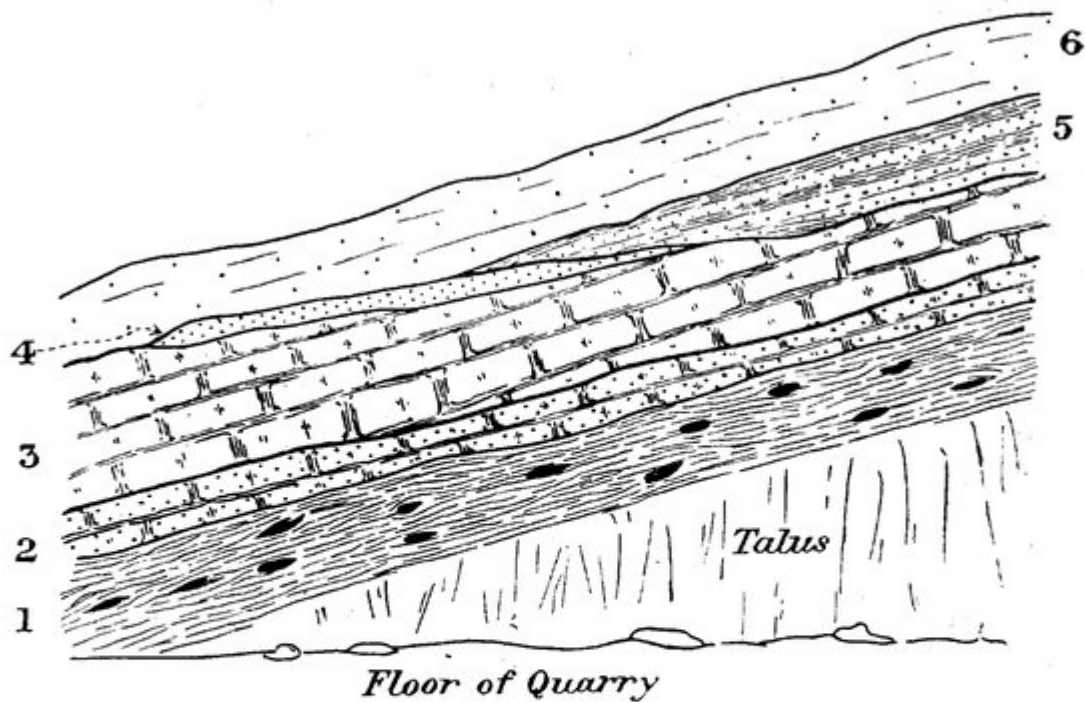


FIG. 3.—Section in An Sgriob Quarry, Corrie.

- 6. Red sandstone, with plant remains (Coal Measures and Millstone Grit).
- 5. Thin-bedded red sandy shale with ribs of sandstone,  $7\frac{1}{2}$  feet.
- 4. Lens of coarse red gritty sandstone,  $3\frac{1}{4}$  feet.
- 3. Limestone with partings of shale, 14 feet.
- 2. Sandy red limestone, with shale partings ; thickness uncertain.
- 1. Red and grey shale, calcareous at top, 17 feet.

Carboniferous  
Limestone  
Series.

G.W.T.

(Figure 3) Section in An Sgriob Quarry, Corrie. 6. Red sandstone, with plant remains (Coal Measures and Millstone Grit). 5. Thin-bedded red sandy shale with ribs of sandstone,  $7\frac{1}{2}$  feet.) 4. Lens of coarse red gritty sandstone,  $3\frac{1}{4}$  feet 3. Limestone with partings of shale, 14 feet. 2. Sandy red limestone, with shale partings thickness uncertain. 1. Red and grey shale, calcareous at top, 17 feet. 1–5 is carboniferous Limestone Series