Chapter 33 Geological structure of the ground from Durness and Eireboll to Loch More

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The district to be described in the present chapter extends from the northern coast-line of Sutherland, between the Kyle of Durness and the ground east of Loch Eireboll, southward to the line of valley in which Loch More lies, and is represented on Sheets 107, 108, 113, and 114 of the one-inch map. It exhibits with great clearness the main tectonic features in the complicated structure of the North-West Highlands. Among these features, the following are typically displayed:

1. The reduplication of the Cambrian strata by means of reversed faults and folds in advance of the great lines of displacement.
2. The occurrence of two powerful thrusts, the more westerly one on Ben Arnaboll, bringing forward a slice of the old floor of Lewisian gneiss, together with the overlying unbroken Cambrian sequence from the basal quartzites to the Eilean Dubh dolomite (Group II. of the Calcareous Series), and the more easterly or Moine thrust ushering in the " Eastern or Moine schists".
3. The remarkable overlap of the Moine thrust, whereby the materials which rest upon that plane pass transgressively across all underlying displaced masses till they come to repose directly on the highest division of the Calcareous Series in the Durness basin.
4. The existence of a double system of normal faults affecting the strata and thrust-planes alike, one set trending N.N.E. and S.S.W., while the other, which appears to be newer, runs more or less at right angles to the first series. By these two systems of later dislocations the thrust-planes, lying at gentle angles, have been intersected and shifted precisely as if they had been boundary-planes between two geological formations. By means of two normal step faults, the Cambrian basin of Durness and the mass of Eastern schists which lies upon it have been isolated from the main belt at Eireboll, and have been brought down to the sea-level.

(a) The Durness Basin

The general structure of this important district is illustrated by the sections in (Figure 20) and (Figure 23). The western portion of ground represented in (Figure 20) shows the slightly uneven surface of Lewisian gneiss (A) on which the Torridon Sandstone (Bb) was laid down, the unconformability between these red sandstones and the overlying Cambrian quartzites (Ca), and the isolation of portions of these sedimentary systems by denudation. On Meall Sgribhinn, the -basal quartzites (Ca) and part of the pipe-rock (Cb) dip to the south of east at angles varying from 12° to 18° while the underlying red sandstones are almost flat or gently inclined to the north-west. Passing eastwards to the shore of the Kyle of Durness at Dail, we find an example of the double unconformability, for the basal beds.of the Arenaceous Series (Ca) rest partly on the red sandstones (Bb) and partly on the Lewisian gneiss (A, (Figure 20)). Beyond a small fault that repeats the base line at Dail, the transgression is complete, for the false-bedded Cambrian grits there rest directly on the ancient floor of Lewisian gneiss (A in Figure).

Though the normal sequence from the pipe-rock sub-zones to the fucoid-beds and *Salterella*- (Serpulite-) grit is not exposed near Dail, the outcrops of the members of the Middle Series being concealed by the waters of the Kyle, it is found in the southern portion of the basin, as already mentioned, at Rudh' a' Ghrudaidh. Between the east shore of the Kyle and the village of Durine, the seven groups of the Calcareous series (Ce I.–VII.) succeed each other in natural order, although their outcrops have been shifted by several faults. It is noticeable, however, that cleavage begins to appear in the more fine-grained members of the Balnakiel sub-division, and becomes more pronounced in the overlying zones. The outcrops of the higher zones of dolomite and limestone are repeated by a series of strike-faults, some of which can be proved to be normal, others may possibly be reversed.

East of the village of Durine, the highest members of the Calcareous series are overlain by shattery quartzite, striped fissile schist, frilled schist, and deformed gneiss (M■ λ A), which together form part of the series above the Moine thrust-plane (T_1). Their superposition is clearly displayed in the cliff west of Sango Bay, to the south of Creag Chearbach, where the rocks beneath and above the thrust-plane are alike affected by small normal faults. The development of these ancient displaced rocks in this part of the basin is limited, for they stretch southwards only for about a mile, and along their eastern margin they are abruptly truncated by a powerful dislocation (f_2 in (Figure 20)), which lets them down against the Sailmhor dolomites. (Ce III.) The apparently conformable sequence from the Calcareous series into an overlying series of schists is entirely deceptive, for the schists can be linked with the corresponding section at Fair-aird Head, north-west of Durine village, and with the sequence overlying the Moine thrust-plane east of Loch Eireboll. (See (Figure 23))

On the further side of the limestone plateau east of Sangomore the dolomites and limestones of Group IV., there broadly developed, are bounded by a fault (f_3 in (Figure 20)), which successively brings them in contact with the pipe-rock (Cb) and basal quartzites (Ca) skirting the shore west of Sangobeag. On the western slope of Meall Meadhonach, about the level of the 900-feet contour line, a small outlier of the basal quartzites (Ca) with part of the pipe-rock (Cb) rests on the Lewisian gneiss, and is cut off along the eastern margin by the first of the two great step faults that bring down the Durness basin (Sheet 114).

(b) Loch Eireboll

The platform of Lewisian gneiss (A) on the eastern slope of Meall Meadhonach is covered unconformably by a thin cake of basal quartzites (Ca), followed on the west shore of Loch Eire-boll by the pipe-rock (Cb). Crossing the loch to Heilim, the observer immediately encounters the belt of complication in advance of the Arnaboll thrust. Nowhere in the Eireboll region is the development of imbricate structure ("Schuppen-struktur") so clearly displayed as in the fine coast-section from Heilim northwards to the mouth of the Hope River. For about a third of a mile north of the ferry-house the two lowest groups of the Calcareous series are repeated, but further north for a distance of a mile and a half there is a constant reduplication of fucoid-beds, serpulite-grit, and basal dolomite in thin lenticular masses, repeated by reversed faults. The inclination of these displacements is at a slightly higher angle than the dip of the strata, the difference varying from 10° to 15°, and a similar relationship is observable between the planes of cleavage and of stratification in the fucoid-beds. Both the strata and the reversed faults are inclined to the E.S.E. at rather high angles. At Cailleach a 'Mhuilleir, the headland about a mile west of the mouth of Hope River, these piled-up beds are cut off by a thrust inclined to the E.S.E. at 50°, which brings up the pipe-rock to the east. Beyond this dislocation the Cambrian strata are repeated by folds as well as by reversed faults, as may be seen round Beinn Heilim, where the beds consist chiefly of pipe-rock, though some of the hill-tops are capped by fucoid-beds with infolds of serpulite-grit.

Between Heilim and the base of Arnaboll Hill (Beinn Poll Ath roinn in one-inch Sheet 114), all the zones, ranging from the Eilean Dubh dolomites to the pipe-rock, are repeated by a complicated system of 'reversed faults and folds, the higher zones occurring to the west and the lower ones to the east. Round the western slope of that hill the arrangement of the fucoid-beds, serpulite-grit, and basal dolomite admirably illustrates the piling-up of the rocks in advance of the more powerful lines of disruption. At length this system of faults and folds culminates in the Arnaboll thrust, by which a mass of Lewisian gneiss, in places upwards of 400 feet thick and presenting features similar to those west of Eireboll, has been driven over the Cambrian strata. The detailed mapping of the displaced gneiss on Beinn Arnaboll proves it to rest transgressively on all the Cambrian zones from the basal quartzites to the *Salterella* dolomite (Group I. of the Calcareous series). This discordance was recognised by Nicol, who regarded the gneisses as granulites intrusive in the Cambrian sediments.

The effects of this disruption on the quartzites is well seen on Beinn Arnaboll. (Figure 20) On the north slope, where the pipe-rock (Cb) underlies the gneiss (A), the vertical worm-tubes are flattened and bent over in the direction of the plane of movement; and on the eastern declivity, where the basal quartzites are covered by the Archaean rocks, they develop a finely-banded and streaky appearance, due to the compression of the felspar fragments and grains of quartz. On the surface of the divisional planes a series of parallel lines indicates the direction of movement, and is accompanied by a slight development of white mica. In like manner the Lewisian gneiss (A), while preserving its original structures in the

heart of the mass, is highly sheared in places near the plane of disruption. The production of pseudo-rhyolitic structure in the pegmatites, and the conversion of the hornblendic gneiss into a green micaceous schistose rock, are displayed on the eastern slope where the Lewisian rocks overlie the basal quartzites.

The former further north-westward extension of the displaced gneiss is proved by the occurrence of a small outlier, about 100 yards long, on the crest of a hill (Sithean-na-Cuag) about half a mile north-west of Beinn Arnaboll and 300 yards west of Loch Creagach, where the thrust materials consist of sheared gneiss and rest on the fucoid-beds, serpulite-brit, and dolomite. (Shown on (Figure 20)) The mass of Lewisian gneiss on Beinn Arnaboll is abruptly cut off by the Moine thrust (T_1 in Figure) which ushers in the Eastern schists. The peculiar green platy mylonised rocks, the frilled schists, marble, deformed gneiss, and siliceous Moine schists (M′, λ, A, M) which occur in Sango Bay and round Fair-aird Head (Durness) are here conspicuously developed.

The evidence being thus clear for the complete discordance between the thrust Lewisian gneiss and the underlying piled-up sedimentary strata on Beinn Arnaboll, we proceed to show that all the Cambrian strata on the east side of Loch Eireboll between Heilim and Creag-na-Faolinn lie in a synclinal fold, and have been driven westwards in front of the anticline of Lewisian gneiss along the Arnaboll thrust-plane. (Figure 21)

About a mile south of Heilim Pier, a promontory named An t-Sron forms the western headland of Camas an Buhl, where a Complete sequence can be traced from the pipe-rock to the Eileen Dubh dolomites and limestone as represented in the vertical table already given. (Chapter 24) The hill-slope east of the promontory towards Bealach Mhairi presents a descending section from the highest sub-zone of the pipe-rock to the basal pebbly grit resting unconformably on the gneiss. -

This section has figured largely in the literature bearing on the order of succession of the rocks in the North-West Highlands, for while Murchison maintained that it proved the existence of an upper quartzite, Nicol contended that the evidence confirmed his belief that the lower quartzite was brought up to the east by means of folding. The horizontal section given by Nicol<ref>*Quart. Journ. Geol. Soc.,* vol. xvii., p. 88, fig. 3.</ref> correctly represents, in broad outline, the sequence and relations of the Cambrian strata at Camas-an-Duin. He clearly saw that, in Camas Bay, where the pipe-rock dips eastwards apparently below the igneous mass of the hill (Lewisian gneiss) the openings of the annelid-tubes and the ripple-marks are there on "the lower faces, showing that there has been a complete reversal of the strata".<ref>*Ibid.,* p. 89.</ref> While accurately interpreting the sequence and relations of the Cambrian sediments at this locality, he regarded the Lewisian gneiss as intrusive granulite throwing off the strata on each side of the hill and involving large fragments of the mica-slate to the east. Hence he inferred that the mica-slate is the lower and older rock.

Subsequently, in 1883, Professor Lapworth described this section in detail, confirming Nicol's conclusions regarding the sequence of the sediments<ref>The Secret of the Highlands. *Geol. Mag.,* 1883, p. 126.</ref> He added certain evidence of great moment, viz., that on the eastern margin of the quartzite there rises from beneath the lower division of the arenaceous series the thin basal conglomerate, with its quartz pebbles and fragments of coloured shales. He further showed that this conglomerate rests on the highly crystalline or so-called "igneous rock" of the Sutherland gneiss, on the platform above the ridge (Bealach Mhairi), where a narrow island of quartzite is surrounded by the crystalline "igneous rock", and is separated from it by the basal conglomerate, the visible phenomena affording very clear evidence of a distinct unconformity between the two series. Professor Lapworth therefore inferred that this place affords a complete demonstration of the identity of the so-called lower and upper quartzites, and proves that the lower quartzite (and of necessity the whole of the fossil-bearing series) is of newer age than the "igneous rock" of the Sutherland gneiss.

These conclusions were independently confirmed by Dr. Callaway, who further pointed out the evidence for a small reversed fault in the bay near the Pictish Tower east of An t-Sron.<ref>*Quart. Jour. Geol. Soc.,* vol. xxxix., p. 398 *et seq.*</ref>

On referring to (Figure 21), it will be seen that, for about one-third of a mile between An t-Sron and the Pictish Tower, south of Camas an Duin, the strata are arranged in a gentle compound anticline, the lowest members being the highest beds of the pipe-rock Cb), followed by the various sub-zones of the fucoidshales (Cc). About 200 yards south-west of the promontory the soft cream-coloured shale appears at the top of the zone, from which, as already stated, fragments of

Olenellus were obtained. Southwards along the shore the *Satterella*- (serpulite-) grit (Cd) follows in natural order, succeeded by the sub-divisions of the Ghrudaidh dolomites (Ce I.) and by the members of the Eilean Dubh group (Ce II. in (Figure 22)). On the east side of the compound anticline, near the old Pictish Tower, the lowest beds of the Ghrudaidh dolomites are cut off by a reversed fault (shown in (Figure 21)), which brings up the fucoid-shales, arranged in a double syncline, each fold containing a, small outlier of serpulite-grit. Eastwards the latter sub-zone is brought into contact with the pipe-rock by a small thrust, and as the observer ascends the hill-slope to the east he encounters both divisions of the quartzite, usually in inverted order and arranged in one or more isoclinal folds. At the junction with the Lewisian gneiss the false-bedded grits with the thin basal conglomerate dip to the E.S.E. in inverted order at 80°. About 200 yards to the east a small patch of basal quartzite lies in a fold in the gneiss, which is truncated on the south-east side by a reversed fault (Figure 21); and about 30 yards further up the hill the outlier (Ca) described by previous observers appears, measuring 700 yards in length and 150 yards in breadth. In this outlier the strata, belonging wholly to the lower division of the arenaceous series and including the basal fine conglomerate, are isoclinally folded and dip to the E.S.E. The adjacent Lewisian rocks consist of crushed hornblendic gneiss with veins of granite and pegmatite. Eastwards strips of highly-sheared and rolled-out quartzite may be observed close to the Moine thrust-plane which may probably be lenticles of the basal quartzite.

The mass of Lewisian rocks on Bealach Mhairi is merely the southward prolongation of that on Beinn Arnaboll, for one can walk continuously on the old Lewisian platform for a distance of a mile and a half from the one point to the other. (Sheet 114) Further, the unconformable junction between the gneiss and the Cambrian strata can be traced for about a mile on one line along the west slope of Bealach Mhairi north to Druim na Teanga, where both the gneiss and the inverted quartzites come in contact with the piled-up fucoid-beds, serpulite-grit, and dolomites to the north and east. Again, a patch of the basal quartzites resting unconformably on tke Lewisian gneiss is found above the Arnaboll thrust-plane on the west face of Beinn Arnaboll, as shown in (Figure 20).

The difficulty in explaining these complicated relations at once disappears, if we follow the outcrop of the Arnaboll thrust-plane. Owing partly to its gentle inclination and partly to folding and denudation, its outcrop forms a remarkably sinuous line. It is clearly seen on the east and north slopes of Beinn Arnaboll, whence it can be followed round the west face of the hill, descending into the hollow on the west, then bending back on itself, winding round the north margin of the quartzites on. Drum Teanga and entering Loch Eireboll in Heilim Bay.

From that point it traverses the floor of the loch southwards and reappears at the base of Creag-na-Faoilinn. This structure accounts for the inversion of the quartzites east of Camas an Duin and for the occurrence of the lower groups of dolomites at Eireboll House, which will now be described.

As shown in (Figure 22), the Cambrian strata from their base up to the Eilean Dubh limestone rest undisturbed on the floor of Lewisian gneiss along the west side of Loch Eireboll.

But on the east side of the loch the structure at once becomes greatly complicated. The broad features at An t-Sron are continued southwards to the low plateau at Eireboll House, with this modification that the folds in the latter area are now represen ed in the two lowest groups of the Calcareous series (Ce I., II.) South of An t-Sron a passage is traceable upwards from the *Olenellus* zone to the dolomites of the Ghrudaidh and Eilean Dubh groups, which cover the low ground bordering the loch for two and a half miles to a point beyond Rudh Ard Badanach and within a mile of the base of Creag-na-Faoilinn. The dolomites are arranged in a gentle compound anticline, the Eilean Dubh beds (Ce II. in (Figure 22)) extending inland from the shore to near the high road beyond Eireboll House, where the underlying dolomites of the Ghrudaidh sub-division come to the surface and form a sharp syncline, followed by the serpulite-grit, fucoid-beds, and pipe-rock, sometimes in inverted order. Here neither the basal quartzites nor the unconformable junction with the Lewisian gneiss are exposed, as the section is interrupted by a thrust which brings forward highly-sheared materials. But the conclusion is obvious that the Cambrian strata on either side of Eireboll House are the southern prolongations of those which at An t-Sron and in Camas-an-Duin overlie the Arnaboll thrust-plane. Hence this line of displacement is represented in (Figure 22) as lying beneath the thrust limestones at Eireboll and coming to the surface between An Corr Eilean and the eastern shore of the loch. This small island about a mile W.S.W. of An t-Sron is composed mainly of dolomites of the Eilean Dubh group, dipping to the E.S.E. at angles varying from 10° to 15°. From the absence of any indications of reversed faulting or other disturbance, it is highly probable that the limestones here are in natural sequence

with the undisturbed Cambrian strata on the west side of the loch.

The sharp syncline in the limestone east of Eireboll House and the inversion of the underlying Cambrian strata were noted by Nicol and represented in his section of that area,<ref>*Quart. Jour. Geol. Soc.,* vol. xvii., p. 92, Fig. 5.</ref> and his observations were subsequently confirmed by Dr. Callaway. Nicol further noted the thinning-out southwards of the igneous rock of Arnaboll Hill (Lewisian gneiss) and the occurrence of mica- and talc-slates with innumerable fine threads or lines of igneous material, in association with the quartzites.

Continuing the section east of Eireboll House, we find, on the west slope of Meall a' Bhaid Tharsuinn, that the inverted pipe-rock is succeeded by highly-sheared gneiss, the twobeing separated bya well-marked thrust. Along this declivity and about the same level strips of flaser gneiss are interleaved with bands of mylonised quartzite, the planes of schistosity being parallel to the powerful thrust-planes. That these siliceous zones are in all probability deformed basal quartzites of the Cambrian sequence is supported by the fact that in this line of section, about the 700-feet contour line, a lenticle of sheared dark-blue limestone with black chert nodules appears, which may probably be a portion of the Balnakiel group of the Durness dolomites. On the one-inch Sheet 114, these strips of sheared gneiss, quartzite, and limestone are represented as occurring in the materials overlying the Moine thrust-plane, but it is not improbable that their appearance is due to intermediate thrusts in advance of that great line of disruption, as shown in section. (Figure 22)

(c) From the Hope River to Ceann, Geal Mor (Whitten Head).

This tract of ground west of the Moine thrust is occupied partly by Cambrian strata, chiefly quartzites, repeated by faults and folds, as in the area round Beinn Heilim, and partly by displaced masses of Lewisian gneiss. The outcrop of the Arnaboll thrust-plane, which descends the east slope of Beinn Arnaboll to Loch Hope, is then shifted northwards to Inverhope by a fault which runs along the lower part of the lake. Thence, the thrust-plane, overlain by a mass of Lewisian rocks, can be followed north to Cnoc na Uilt Tharsuinn, where it is overlapped by the Moine thrust. The two patches of gneiss shown on Sheet 114 near the eastern headland of Loch Eireboll — one S.S.E. of Freasgeal and the other forming Cnoc Ard an Tionail — are probably outliers of the materials above the Arnaboll thrust-plane, which have been let down to the west by normal faults (Figure 23). The outcrop of this line of displacement beneath the Cnoc Ard an Tionail mass is well seen on the top of the cliff at Whitten Head, Ceann Geal Mor, and on Mol Mohr. The piled-up strata, which there underlie the plane, consist of basal quartzites, which have been driven on to the pipe-rock in the bay termed Mol Mohr. Southwards in Geodh' a' Bhathaich the fucoid-shales and the uppermost zone of the arenaceous series are repeated by minor reversed faults.

The unconformable junction of the lower division of the quartzite with the Lewisian gneiss is displayed on the cliff a quarter of a mile south-west of Ceann Geal Mor, where it dips to the west at 80°, with the thin pebbly conglomerate at its base. On the sea-stack to the north it is inclined to the north-east. Another exposure is met with in a small stream draining Loch na Beiste, about a mile and a half south of the Whitten Head, where the basement breccia or conglomerate is inverted- and dips to the E.S.E. at 45°. The triangular mass of Lewisian rocks lying to the east of this unconformable strip of basal quartzite occupies the lofty sea-cliff for about a mile east of Ceann Geal Mor, where the rocks consist of crushed hornblendic gneiss traversed by veins of granite and pegmatite. Along the eastern margin of this mass it is overlain unconformably on the top of the cliff by a thin patch of basal quartzites, which is truncated by the Moine thrust.

The structures just described near Ceann Geal Mor are represented in the accompanying section (Figure 23), which has been prepared to show the relations of the strata north of the Durness basin to those in the north-east part of the Eireboll region. In the double system of normal faults which have been alluded to as traversing the Durness area, one set trends north-east, while the other; of later date, cuts these nearly at right angles. By means of one of the later north-west dislocations, which truncates the Durness basin along its northern margin, the dolomites of the Croisaphuil zone (Ce VI.) have been thrown five miles to the north-west, as far as An 'Garbh-eilean (Sheet 114). This displacement has likewise shifted the outcrop of the Moine thrust-plane from Sango Bay to the west of Fair-aird Head. Though not exposed at the surface, the position of the thrust-plane must be close to the western base of the headland, as the islets in the north part of Balnakiel Bay are composed of Cambrian dolomite and limestone which underlie that plane. The shore-section from Fair-aird south-east to Seanachaisteal (Bishop's Castle) displays a fine development of the Eastern schists, including the

platy mylonised rocks, frilled schists, sheared gneiss, and siliceous Moine-schists (M■, λ, *x*, A, M, in (Figure 23)), which were correctly correlated by Murchison and Nicol with the schists in the neighbourhood of Beinn Thutaig, east of Loch Eireboll.

(d) From the Head of Loch Eireboll to Loch More

At the head of Loch Eireboll the conspicuous escarpment of Creag na Faolinn on the east side of the valley, composed partly of a slice of Lewisian gneiss about 600 feet thick, presents with great clearness the tectonic relations of the rocks. On the west side of Strath Beag, between Crann Stacach and Polla, the thin cake of Cambrian quartzite having been partly removed (Ca, Cb), the platform of Lewisian gneiss (A) has been laid bare, presenting there its normal lithological characters and its usual north-west strike. At the head of Loch Eireboll, to the west of the outlet of the Strath Beag River, the false-bedded grits_ and pipe-rock follow in normal order, but in the centre of the valley the evidence is concealed by alluvial and morainic deposits. Crossing the river to the south-east base of the crag, we find lenticular masses of the top zone of the pipe-rock, fucoid-beds, and serpulite-grit (Cb, Cc, Cd) repeated by reversed faults, until they are abruptly cut off by the Arnaboll thrust, which brings forward a mass of the basal quartzites (Ca) resting unconformably on the Lewisian gneiss (A). The piled-up members of the Middle Series, and especially the *Olenellus* zone, can be followed round the base of the crag to near the bend in the high road. There they are directly overridden by the Lewisian rocks, which form the northern half of the crag, and consist of hornblendic gneiss with veins of pink granite and pegmatite. Though somewhat crushed, these rocks closely resemble Lewisian types seen to the west. The unconformability of the basal quartzites on the gneiss above the Arnaboll thrust-plane can be traced up to the top of the crag, where both the gneiss and quartzites are truncated by the Moine thrust. (T■ in (Figure 24)) Special interest attaches to the exposure here of this upper disruption-line, for on the northern slope of the hill the plane of the Moine thrust, composed of sheared gneiss, is laid bare and shows its lines of stretching, trending E.S.E. and W.N.W. Immediately above the plane, green, platy, fissile mylonitic rocks are followed by a great development of epidotic flaser-gneiss and pegmatite, with a fine parallel banded structure containing knots and lenticles, in which the original lithological characters have not been effaced. The planes of schistosity in these deformed materials dip generally to the E.S.E. — that is, more or less parallel with the plane of the Moine thrust. Eastwards a considerable mass of deformed gneiss, in which the original structures are well preserved, is followed by a series of the Eastern or Moine schists.

A still more conspicuous example of a lenticular mass of displaced Lewisian rocks overlying the Arnaboll thrust plane occurs about a mile further up Strath Beag on the east side of the valley at Creag Earail. Measuring about a mile and a half in length and three - quarters of a mile in breadth, it rises from the 100-feet level to a height of over 1000 feet. It consists mainly of green hornblendic gneiss with veins of pink granite and pegmatite. A noteworthy feature is the occurrence of the northwest strike throughout this mass, though signs of crushing are discernible and numerous veins of epidosite have been developed. The tectonic structure precisely resembles what is seen at Creag na Faoilinn, for the Arnaboll thrust can be traced round the base of the crag, with the piled-up pipe-rock, fucoid-beds, and serpulite-grit lying beneath that plane, while the crag is capped with an outlier of the sheared rocks above the Moine thrust. The outcrop of this great displacement is to be seen further east. A striking characteristic of the mylonised materials accompanying this dislocation is the presence of a zone of shattery quartz-schist immediately above the thrust-plane.

The mountainous region stretching southwards by FoinneBheinn and Beinn Arcuil to Loch More furnishes two important links in the chain of evidence relating to the tectonics of this northern region. In the first place, it demonstrates in the clearest manner that the piled-up Cambrian strata in advance of or west of the Arnaboll thrust have themselves been driven westwards along a plane or "sole", separating the displaced materials from the underlying undisturbed strata. In the ground above described the proofs of this structure are concealed under the waters of Loch Eireboll. In the second place, *we* learn that the first thrust-plane or "sole", along which the heaped-up Cambrian strata have been driven, appears here on a lower level than in the tract north of Heilim — viz., on the horizon of the lower division of the quartzites. Hence the zones, repeated by reversed faults above this plane or "sole", consist chiefly of a small part of the basal quartzites (Ca), all the subdivisions of the pipe-rock, together with the fucoid-beds and serpulite-grit where these have escaped denudation.

(Figure 25), which gives a section of the ground from Fionne Bheinn to Sabhal Mor — a distance of five and a half miles — supplies a typical illustration of the structure of the whole region from Strath Beag to Loch More as regards the belt to the west of the great disruption-lines. On Ceann Mor (2980 feet — the highest peak of Foinne-Bheinn — the undisturbed quartzites appear in force, including the lower division (Ca), about 300 feet thick, and the lower zones of the pipe-rock (Cb), 150 feet, inclined to the south-east at about 15°. Following the ridge towards Creag Dionard and Plat Reidh, the observer finds that the members of the arenaceous series are suddenly tilted at higher angles, and that, for a long distance, the sub-zones are constantly repeated in the same definite order by reversed faults.

In the unravelling of this type of structure between Strath Beag and Loch More, the sub-divisions of the pipe-rock, and particularly Sub-zone III., with the "trumpet" pipes and the band of quartzite containing *Salterella* associated with it, have been found to be of great service. The minor displacements are clearly exhibited in many cliff sections, notably in the great precipices overlooking Strath Dionard (Sheet 114), in the lofty crag above Loch na Tuaidh on the north-east side of Beinn Arkle (or Arcuil), and on the ridge between Strath Dionard and Strath Beag, where the relation of the reversed faults to the undisturbed strata beneath is apparent. A careful examination of the last of these sections shows these minor displacements to be branches of an underlying thrust, whose plane approximately coincides with the bedding planes of the basal quartzites. The outcrop of this major thrust-plane follows a . very sinuous course. Ascending the hill-slope west of Strath Beag, it crosses the ridge north of Conamheall, thence to the foot of Loch Dionard, and across Foinne-Bheinn to Loch na Tuaidh. From that point it curves round the northern face of Beinn Arkle, thence south-eastwards by Allt a Chuirn above Lone, till it is concealed under a covering of peat and turf. Its position near the top of the basal quartzites is remarkably constant, and, as might be expected, it has given rise to a prominent structural feature which not only interrupts the continuity of the quartzites, but has influenced the denuding agents in their operations. At certain localities the piled-up strata lying at an oblique angle to the plane have been stripped off and the surface of the plane of disruption has been laid bare — as, for example, in the deep corrie of Am Bathaich, on the south side of Beinn Arkle, and on the floor of Coire na Lurgainn between Cir Gorm and Creag Dionard. (Figure 25)

Immediately above this major thrust-plane or " sole", thin wedges of basal quartzite appear in the piled-up materials, but on the top of the Plat Reidh (Figure 25), on the ridge of Conamheall, and on Beinn Arkle the pipe-rock alone is exposed with strips of Fucoid-beds at intervals. The outcrops of the reversed faults on these lofty plateaux are usually indicated by long narrow hollows occupied by the remnants of the dolomitic shales.

At certain localities this system of reversed faults is accompanied by folding — as, for example, on the face of Creag Dionard (Figure 25), which becomes more pronounced eastwards near the Arnaboll or Moine thrusts. It is worthy of note that by this system of reversed faults and folds the quartzites on the Plat Reidh and on Ben Arcuil are reduplicated till they appear to be about two and a half times their normal thickness.

Eastwards from the Plat Reidh at An Dubh Loch (Figure 25) the piled-up Cambrian strata are truncated by the Arnaboll thrust, which has brought forward a mass of Lewisian gneiss. Beneath this thrust-plane the fucoid-beds, serpulite-grit, and occasionally the basal dolomite, with an imbricate structure similar to that at Heilim (Figure 20), are exposed, particularly on the south and west sides of An Dubh Loch. It is not improbable that the comparatively even surface of the Plat Reidh may be due to the former westward continuation of the Arnaboll thrust at a comparatively small height above its present level. The displaced gneiss overlying this plane, which is traceable for two miles from Loch an Ulabhith to Loch Fir Dhurinnis, is more deformed than the mass occupying the same relative position on Creag Earail in Strath Beag, already described. The original strike has been nearly obliterated, and the hornblendic rocks, associated with much pink pegmatite, are traversed by numerous veins of epidorite.

East of these displaced Lewisian rocks lies the Moine thrust, whose outcrop in this region usually gives rise to a prominent feature in the landscape. Here it appears at the base of a steep slope of green schist, in which the foliation planes dip south-eastwards at low angles. First in order above the "sole" come green platy and frilled schists, the latter being highly crumpled, and forming a well-marked zone on the west face of Meall a' Chuirn. These are succeeded by the normal siliceous granulitic schists, which have been traced southwards from the ridge east of Eireboll.

One final feature regarding the tectonics of this northern district remains to be noted, in the behaviour of the Moine thrust relatively to the underlying strata, when followed along the strike southwards from the Eireboll region. Evidence has been

adduced to show the irregular distribution of the masses of Lewisian gneiss above the Arnaboll thrust-plane, a feature which was noted by previous observers. These masses appear as narrow belts or lenticles, which are overlapped by the materials above the Moine thrust-plane, pointing to a complete discordance between the two. Hence we find, at various localities between Loch Eireboll and Loch More, that the Eastern schists, driven westwards by the Moine disruption, are frequently placed directly above the displaced Cambrian strata, both having a common dip in a south-easterly direction.

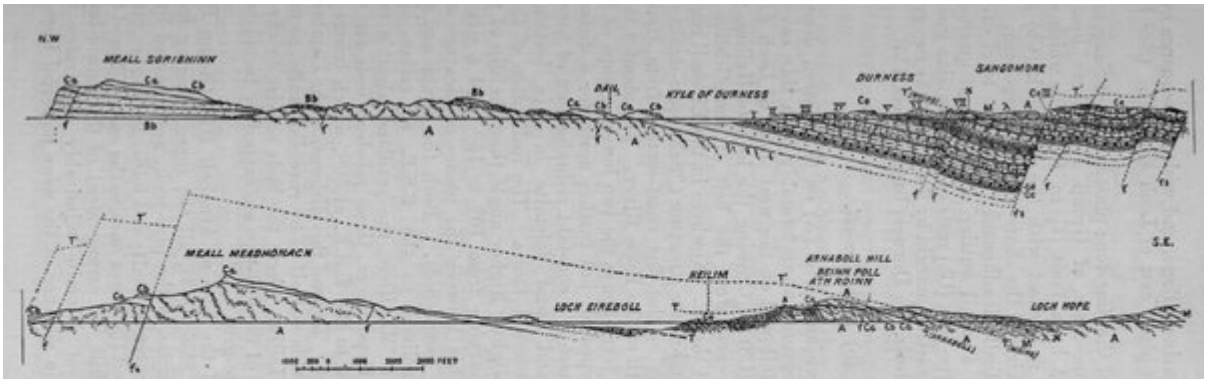

FIG. 20.—Section from Meall Sgribhinn by Durness, Sangomore, and Meall Meadhonach to Arnaboll Hill and Loch Hope.

A. Lewisian Gneiss. Bb. Torridon Sandstone. Ca. Basal Quartzite (Cambrian). Cb. Pipe-rock. Cc. Fucoid-beds.
Cd. Serpulite Grit. Ce. Limestone. Ce I. to Ce VII. Cambrian Dolomite and Limestone.
M'. Mylonized Rocks, Green Schists, and Phyllites. M. Moine-schists. x. Quartz Schist. λ. Marble.
T. Thrusts. T'. Moine-thrust. f. Faults.

(Figure 20) Section from Meall Sgribhinn by Durness, Sangomore, and Meall Meadhonach to Arnaboll Hill and Loch Hope. A. Lewisian Gneiss. Bb. Torridon Sandstone. Ca. Basal Quartzite (Cambrian). Cb. Pipe-rock. Cc. Fucoid-beds. Cd. Serpulite Grit. Ce. Limestone. Ce I. to Ce VII. Cambrian Dolomite and Limestone. M′. Mylonized Rocks, Green Schists, and Phyllites. M. Moine-schists. x. Quartz Schist. λ. Marble. T. Thrusts. T′. Moine-thrust. f. Faults.

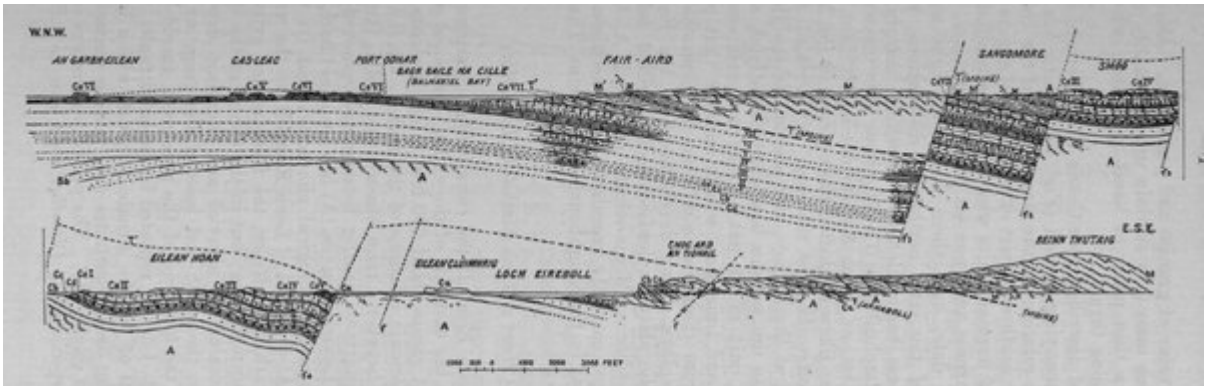

FIG. 23.—Section from An Garbh Eilean by Fair-aird Head and Eilean Hoan to Cnoc Ard an Tionail and Beinn Thutaig.

A. Lewisian Gneiss. Bb. Torridon Sandstone. Ca. Basal Quartzite (Cambrian). Cb. Pipe-rock. Cc. Fucoid-beds.
Cd. Serpulite-grit. Ce. I.—Ce VII. Sub-divisions of Cambrian Dolomite and Limestone.
M'. Mylonised Rocks, Green Schists, and Phyllites. M. Moine-schists. x. Quartz-schist. λ. Marble.
T. Arnaboll-thrust. T'. Moine-thrust. f. Faults.

(Figure 23) Section from An Garbh Eilean by Fair-aird Read and Eilean Hoan to Cnoc Ard an Tionail and Beinn Thutaig. A. Lewisian Gneiss. Bb. Torridon Sandstone. Ca. Basal Quartzite (Cambrian). Cb. Pipe-rock. Cc. Fucoid-beds. Cd. Serpulite-grit. Ce. I. — Ce VII. Sub-divisions of Cambrian Dolomite and Limestone. M′. Mylonised Rocks, Green Schists, and Phyllites. M. Moine-schists. x. Quartz-schist. λ. Marble. T. Arnaboll-thrust. T′. Moine-thrust. f. Faults.

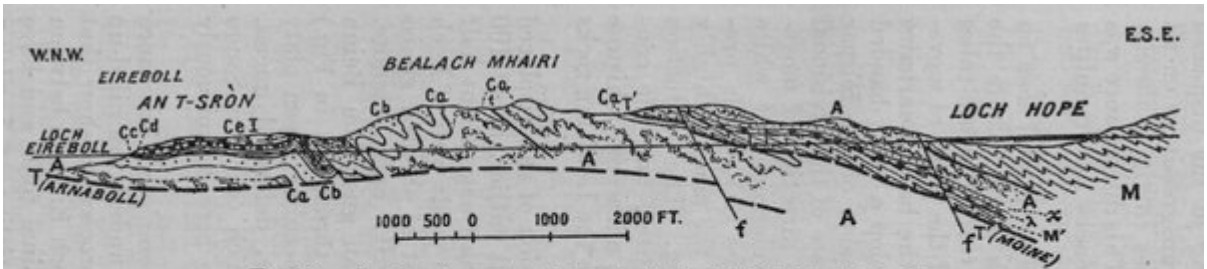

Fig. 21.—Section from An t-Sron by Bealach Mhairi to Loch Hope.

A. Lewisian Gneiss. Ca. Basal Quartzite (Cambrian). Cb. Pipe-rock. Cc. Fucoid-beds.
Cd. Serpulite-grit. Ce I. Limestone (Ghrudaidh group).
M'. Mylonised Rocks, Green Schists and Phyllites. M. Moine-schists. x. Quartz-schist.
λ. Marble. T. Arnaboll-thrust. T'. Moine-thrust. t. Minor-thrust. f. Faults.

(Figure 21) Section from An t-Sron by Bealach Mhairi to Loch Hope. A. Lewisian Gneiss. Ca. Basal Quartzite (Cambrian). Cb. Pipe-rock. Cc. Fucoid-beds. Cd. Serpulite-grit. Ce I. Limestone (Ghrudaidh group). M′. Mylonised Rocks, Green Schists and Phyllites. M. Moine-schists. x. Quartz-schist. λ. Marble. T. Arnaboll-thrust. T′. Moine-thrust. t. Minor-thrust. f. Faults.

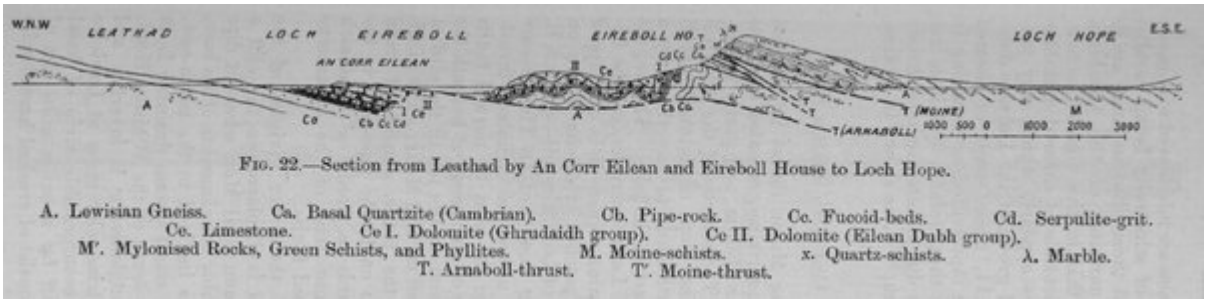

Fig. 22.—Section from Leathad by An Corr Eilean and Eireboll House to Loch Hope.

A. Lewisian Gneiss. Ca. Basal Quartzite (Cambrian). Cb. Pipe-rock. Cc. Fucoid-beds. Cd. Serpulite-grit.
Ce. Limestone. Ce I. Dolomite (Ghrudaidh group). Ce II. Dolomite (Eilean Dubh group).
M'. Mylonised Rocks, Green Schists, and Phyllites. M. Moine-schists. x. Quartz-schists. λ. Marble.
T. Arnaboll-thrust. T'. Moine-thrust.

(Figure 22) Section from Leathad by An Corr Eilean and Eireboll House to Loch Hope. A. Lewisian Gneiss. Ca. Basal Quartzite (Cambrian). Cb. Pipe-rock. Cc. Fucoid-beds. Cd. Serpulite-grit. Ce. Limestone. Ce I. Dolomite (Ghrudaidh group). Ce II. Dolomite (Eilean Dubh group). M′. Mylonised Rocks, Green Schists, and Phyllites. M. Moine-schists. x. Quartz-schists. λ. Marble. T. Arnaboll-thrust. T′. Moine-thrust.

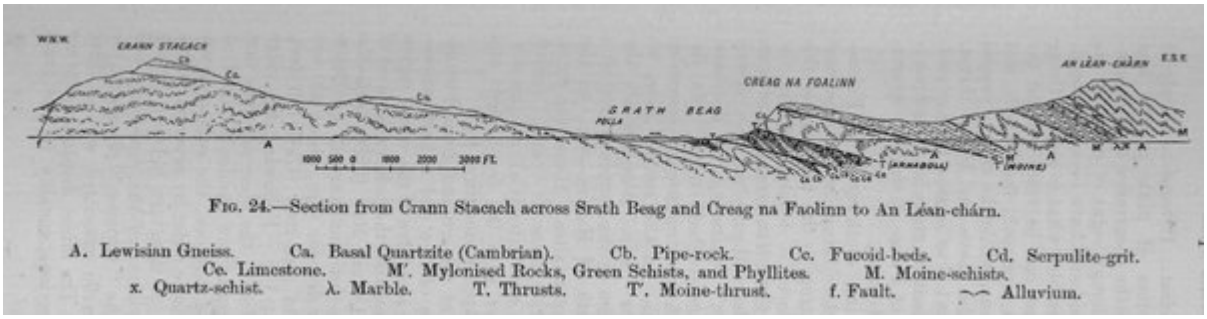

Fig. 24.—Section from Crann Stacach across Srath Beag and Creag na Faolinn to An Léan-chárn.

A. Lewisian Gneiss. Ca. Basal Quartzite (Cambrian). Cb. Pipe-rock. Cc. Fucoid-beds. Cd. Serpulite-grit.
Ce. Limestone. M'. Mylonised Rocks, Green Schists, and Phyllites. M. Moine-schists.
x. Quartz-schist. λ. Marble. T. Thrusts. T'. Moine-thrust. f. Fault. ~~ Alluvium.

(Figure 24) Section from Crann Stacach across Srath Beag and Creag na Faolinn to An Lean-charn. A. Lewisian Gneiss. Ca. Basal Quartzite (Cambrian). Cb. Pipe-rock. Cc. Fucoid-beds. Cd. Serpulite-grit. Ce. Limestone. M′. Mylonised Rocks, Green Schists, and Phyllites. M. Moine-schists. x. Quartz-schist. λ. Marble. T. Thrusts. T′. Moine-thrust. f. Fault. [symbol] Alluvium.

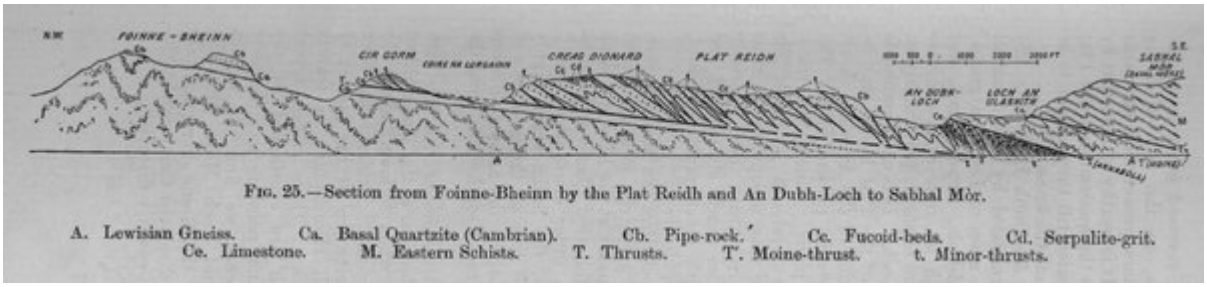

Fig. 25.—Section from Foinne-Bheinn by the Plat Reidh and An Dubh-Loch to Sabhal Mòr.

A. Lewisian Gneiss. Ca. Basal Quartzite (Cambrian). Cb. Pipe-rock. Cc. Fucoid-beds. Cd. Serpulite-grit.
Ce. Limestone. M. Eastern Schists. T. Thrusts. T'. Moine-thrust. t. Minor-thrusts.

(Figure 25) Section from Foinne-Bheinn by the Plat Reidh and An Dubh-Loch to Sabhal Mòr. A. Lewisian Gneiss. Ca. Basal Quartzite (Cambrian). Cb. Pipe-rock. Cc. Fucoid-beds. Cd. Serpulite-grit. Ce. Limestone. M. Eastern Schists. T. Thrusts. T′. Moine-thrust. t. Minor-thrusts.