Chapter 6 Metamorphic rocks Ballachulish Recumbent Syncline

D. Stob Bàn to Callert

Introduction at Stob Bàn

The district that now falls to be described lies between Allt Coire a' Mhusgain [NN 150 670], which drains from Stob Bàn into Glen Nevis near Polldubh [NN 141 686], in the north, and Callert House on Loch Leven, in the south. Most of it, but not Stob Bàn, is included in (Figure 8). It is specially important as its interpretation provides a key to the tectonics of a large tract of country on the south, as well as on the north, of Loch Leven (cf. (Figure 7), E–H; (Figure 14), C,D; and Sheet 53). Other key localities might be cited, but this is the simplest.

As shown on Sheet 53, the Aonach Beag recumbent synclinal fold-core, refolded into a secondary synform at the north end of the Stob Bàn ridge (chap. 5), is followed a quarter of a mile to the south-east on the same ridge by another recumbent synclinal fold-core, refolded into another equally obvious secondary synform. This other synclinal fold-core (still half a mile north-west of the summit of Stob Bàn) consists of both Ballachulish Limestone and Ballachulish Slates. It is therefore fuller in a stratigraphical sense than the Aonach Beag recumbent fold-core lying to the north-west. Accordingly we treat the two fold-cores as closely related, rather than identical, since, as will be more fully understood presently, the recumbent synclines of the district gape towards the north-west and as a rule take in more and more stratigraphical groups in that direction. We therefore give the fuller recumbent syncline, involved in the more south-easterly secondary synform, a name of its own — it is the great Ballachulish Recumbent Syncline; and we treat the Aonach Beag Recumbent Syncline as a digitation at a slightly lower level ((Figure 17), p. 112). The distinction between these two recumbent synclines does not, however, involve any important matter of principle, which is fortunate since the criterion employed to separate them is not altogether trustworthy. This difficulty will be apparent when we come to describe Glen Creran (p. 65), where the Ballachulish Core is, very locally, fuller towards the close than towards the gape — a result, presumably, of complicated sliding.

As explained in chapter 3, the same convention is used in the stratigraphical definition of the Ballachulish Core as has been employed in regard to the Appin and Aonach Beag Cores: the Ballachulish Limestone (6) and younger formations are classed as core-rocks; while the Leven Schists (7) and older formations are treated as envelope-rocks.

The section of the Ballachulish Fold as exposed on the steep face of the Stob Bàn ridge overlooking Allt Coire a' Mhusgain [NN 150 670] reads as follows:

(7) Cover of thick Leven Schists (hornfelsed) in the heart of the secondary synform

(6) Core: Upper layer of Ballachulish Limestone (calc-silicate-hornfels), 100 ft

(5) Core: Black Ballachulish Slates (hornfelsed), 100 ft

(6) Core: Lower layer of Ballachulish Limestone (calc-silicate-hornfels), 100 ft

(7) Basement of thick Leven Schists (hornfelsed) in contact at both sides with Glen Coe Quartzite (8)

Both the cover and the basement Leven Schists belong to the envelope.

The correlations involved in our table admit of no doubt. The Ballachulish Slates (5), for instance, can be picked up south-west of the Mullach nan Coirean Granite in the Lairigmòr valley of (Figure 8), and can be followed thence to the Ballachulish slate quarries at Ballachulish village (Laroch) south of Loch Leven.

For any young geologist who enjoys a scramble the Stob Bàn [NN 146 654] section of the refolded Ballachulish Fold is the most rewarding of any in the one-inch map. Let us imagine that such a one has satisfied himself of the reality of the

secondary synform, and has then climbed back to the summit of the ridge to consider the consequences. The map (Sheet 53) shows him at once that this little secondary synform necessitates a secondary synformal interpretation affecting the Ballachulish Fold in all the district to the south as far as the Cruachan "Granite".

To begin with, its continuation can be recognised with certainty in the Lairigmòr valley of (Figure 8). Beyond this it is joined by two other secondary synforms pitching south-west off the slopes of Mam na Gualainn [NN 116 625]. Next, crossing Loch Leven, it expands mightily, as shown by the increasing separation of the two outcrops of what we have called the basement Leven Schists of the Stob Bàn exposure. One of these outcrops crosses the loch east of Ballachulish Ferry [NN 053 598] and then, after interruption by the Ballachulish Pluton, continues south-westwards through Fraochaidh [NN 029 516] and Beinn Mhic na Ceisich [NN 016 493]. The other crosses the loch east of Callert, at the same time turning at right angles to the south-east where it can be followed along the lower reaches of Glen Coe. In the great basin-shaped depression within the angle separating these divergent outcrops, the Ballachulish Core, consisting of Ballachulish Limestone and younger formations, is covered by a broad spread of overlying Leven Schists. These latter correspond with the cover of Leven Schists occupying the heart of the secondary synform at Stob Bàn; but south of Loch Leven pitch extends their outcrop eastwards to reach from Sgòrr a' Choise [NN 084 552] and Salachail [NN 056 512] to the lavas of the Cauldron-Subsidence of Glen Coe. At three localities in this broad spread, Beinn Fhionnlaidh [NN 100 500], Beinn Maol Chaluim [NN 140 520] and Stob Dubh (Section B of one-inch map and Sections G, H, (Figure 7) of p. 48) the Leven Schists carry conspicuous caps of Glen Coe Quartzite, belonging in a broad sense to the upper limb of the Ballachulish Fold. Coupled with this, in Gleann Chàrnan [NN 135 500], Gleann Fhaolain [NN 150 520] and Glen Etive, the so-called Windows, they are cut through by erosion to give glimpses of underlying Ballachulish Limestone resting on basement Leven Schists, which in turn rest on Glen Coe Quartzite belonging to the lower limb of the Ballachulish Fold.

In the windows just mentioned, Ballachulish Limestone alone separates basement from cover Leven Schists, which is one less formation than at Stob Bàn; but in the district reaching three miles west of the mouth of Glen Coe the core of the Ballachulish Fold, separating basement from cover Leven Schists, includes Ballachulish Limestone, Ballachulish Slates, Appin Quartzite, Appin Limestone and Appin Phyllites, the same great assemblage as we have described in the Appin Fold-Core at Onich.

South of Mullach nan Coirean Granite

It is time now to leave Stob Bàn, and, crossing the Mullach nan Coirean Granite, to examine outcrops on the north-east face.of the Lairigmòr valley of (Figure 8). The secondary synform of Stob Bàn here includes baked Ballachulish Slates as its central formation, without any of the cover of Ballachulish Limestone and Leven Schists present on Stob Bàn. In fact, the cover Leven Schists of the envelope are not to be seen again north of Loch Leven.

The Ballachulish Slates are thicker than at Stob Bàn, and on either side the underlying layer of Ballachulish Limestone (calc-silicate-hornfels) is strongly developed on the hill-top near the granite margin. The basement Leven Schists beyond are also thick. Exposures are intermittent, but on crossing the Lairigmòr valley (Figure 8) one realises a great change in the development of the Ballachulish Fold: the lower limb shows marked attenuation, leading in many cases to total disappearance of one or more recognisable horizons.

Ballachulish Slide

Thisattenuation is connected with the most interesting slide in the whole district, to wit the Ballachulish Slide. On the one-inch map and in (Figure 8) this slide is shown by a heavy line starting south of the Lairigmòr valley. No doubt the slide continues north-east to the Stob Bàn ridge [NN 146 654], cutting out, for instance, all the dark pure portion of the Ballachulish Limestone expected next the Ballachulish Slates; but its effects in this direction are much less conspicuous than they are south of the Lairigmòr valley.

A brief examination demonstrates that the Ballachulish Slide must have developed before the Ballachulish Fold was bent into the secondary Stob Bàn Synform. It is found, in fact, that the eastern and western outcrops of the lower limb of the Ballachulish Fold show precisely similar phenomena of attenuation (Figure 8), (Figure 9). In keeping with this, in the

hollow west of Mam na Gualainn [NN 116 625], where the Stob Bàn Synform is joined by two others of like type, the attenuated lower limb with the Ballachulish Slide has a corresponding zig-zag outcrop.

Three great formations are affected by attenuation in connection with the Ballachulish Slide in this district, namely the Ballachulish Slates (5), Ballachulish Limestone (6) and Leven Schists (7). The next four paragraphs are written for those who propose to use (Figure 8) as a guide to their thoughts rather than their feet. The remainder of our account of the Callert district will then be devoted to those who can give a day to its exposures and thus attain conviction in the field.

Naturally one can appreciate the attenuation of the Ballachulish Slates (5) in the lower limb of the Ballachulish Fold only where Appin Quartzite is present in the heart of the Appin Fold — elsewhere one cannot distinguish the slates in the lower limb from those in the upper. The requisite condition is fulfilled for a mile and a half on the north-western side of the Stob Bàn [NN 146 654] secondary synform, where Appin Quartzite has been mapped as a strip east of Tom Meadhoin [NN 085 624]; and also for a short space on the eastern side of the expanded Stob Bàn Synform, in the Loch Leven shore section east of Callert House. On the north-western side, the Ballachulish Slates (5) and Ballachulish Limestone (6), which might be expected to intervene between the Appin Quartzite (4) and the Leven Schists (7), are in some exposures reduced to a few feet in thickness, and in others cut out altogether. In like manner on the east side of the synform, at Loch Leven, both formations are entirely missing.

Marked reduction is sometimes easier to realise than complete elimination, for the presence of a remnant reassures us that we are searching the right place. Eight localities are marked in (Figure 8) with a heavy little cross to indicate exposures of a few feet of Ballachulish Limestone (often calc-silicate-hornfels, (Figure 39), p. 237) in the anticipated position. The contrast between attenuation in the lower limb and thick development in the upper limb of the recumbent Ballachulish Fold is most striking. A damaged, but representative outcrop of Ballachulish Limestone in the upper limb has been preserved from erosion in the central part of the secondary synform, and stretches from Callert House for about a mile and a half inland. The borders of this outcrop consist of limestone, pure or micaceous. The central tract, seen in streams north-east of Callert House [NN 092 604], is made up of slightly calcareous silvery-grey quartzose schists — correlatable with the impure part of the stratigraphical group covered by the name Ballachulish Limestone, as defined elsewhere.

Passing now to the envelope, we find particularly instructive phenomena of attenuation furnished by the basement or foundation Leven Schists (7). On the north-west of the expanded Stob Bàn secondary synform, west of Mam na Gualainn [NN 116 625], lies a thoroughly well exposed antiform of Glen Coe Quartzite (8) forming Tom Meadhoin [NN 085 624] (Figure 8). On its south-east side the quartzite is separated from outcrops of Ballachulish Limestone and Slates (6 and 5) and Appin Quartzite (4) by a narrow belt of Leven Schists in one extreme case reduced to 30 ft in thickness; and yet the Leven Schists, when followed round the nose of the Tom Meadhoin Antiform, are found to make an uninterrupted band a mile wide, in spite of marked dissection into hills and valleys. The Leven Schists (along with the Glen Coe Quartzite) belong to the combined envelope of the Ballachulish and Appin Cores: the thinned-out development serves as basement to the Ballachulish Core; the thick development, as cover to the Appin Core. Clearly a slide, the Ballachulish Slide, accounts for the thinning that is so obvious close to the south-east margin of the quartzite in the Tom Meadhoin Antiform. In passing we may note that current-bedding in the Glen Coe Quartzite at Tom Meadhoin [NN 085 624] shows that Glen Coe Quartzite is older than Leven Schists.

Two facts of first class importance emerge from examining the Tom Meadhoin [NN 085 624] exposures. The first is that the Tom Meadhoin Antiform, unlike the Stob Bàn Synform, is contemporaneous with the formation of the Ballachulish Fold and Slide. The second is that, as the Tom Meadhoin Antiform closes towards the north-west (Figure 9), the complementary Ballachulish Fold must close towards the south-east. This conclusion is supported by the much greater prominence of Appin Quartzite on the western than on the eastern side of the secondary Stob Bàn Synform as expanded in the Callert district (Figure 8), (Figure 9). Across the loch in the Ballachulish (Laroch) district the south-eastward close of the Ballachulish Fold may be said to be self-evident, since the core at Ballachulish is much fuller than at Glen Coe (*cf.* (Plate 3) and (Figure 10)).

Callert excursion

The following is an itinerary suitable for an individual or party seeking confirmation of the main structural features of the Callert district (Figure 8), (Figure 9). We assume a start from the Onich–Kinlochleven coastal road.

A convenient beginning is made with the Ballachulish Slide on the shore of Loch Leven opposite Eilean Choinneich [NN 070 593], 1½ miles west of Callert House. The slide outcrops about 200 yd S.E. of a band of Glen Coe Quartzite (8), quarried at the roadside. In this space the shore shows intermittent exposures of Leven Schists (7) consisting of grey phyllites with some black seams, quartzite ribs and slightly calcareous beds. The whole is a typical representative of the banded portion of the Leven Schists expected near the Glen Coe Quartzite. Close to the eastern limit of the phyllitic exposures there is an outcrop of black slate, 12 ft wide, beyond which, to the east, we find the following: grey phyllite, 36 ft; gap, 45 ft; grey limestone, banded to east with black slate, 6 ft; striped quartzite and black slate, soon followed by good black slates.

In considering this coast section we may neglect the 12 ft of black slate interposed among the grey phyllites. Its interpretation is ambiguous: it may either be an exaggeration of the black seams commonly found in the banded edge of the Leven Schists near Glen Coe Quartzite, or it may be a tectonic slice of Ballachulish Slates. In either case it is an irrelevant detail.

Leaving this point unsettled, we have what seems to all local appearance to be a straightforward stratigraphical succession starting from banded Leven Schists (7) and ending up with Ballachulish Slates (5). There is no repetition of outcrop to suggest a fold but looking across the loch, with Sheet 53 or (Plate 3) to help us, we see that the striped quartzite and black slate of our shore belongs to the transition half of the Appin Quartzite (4), and that this, three quarters of a mile to the south, behind St. John's Church [NN 067 586], opens up synformally to enclose in its gape the massive half of the Appin Quartzite followed by Appin Limestone (3) and Appin Phyllites (2). We can now interpret our northern shore section opposite Eilean Choinneich [NN 070 593] with confidence as follows from west to east:

Lower Limb of Ballachulish Fold (West): Banded Schists (7); slide omitting most of the Leven Schists and most of the Ballachulish Limestone; remnant of Ballachulish Limestone (6); slide omitting Ballachulish Slate (5).

Heart of Ballachulish Fold: Striped zone of Appin Quartzite (4).

Upper Limb of Ballachulish Fold (East): Ballachulish Slate (5).

The banded Leven Schists (7) of the lower limb of the Ballachulish Fold correspond with what we have called basement Leven Schists at Stob Bàn, and form part of the envelope of the Ballachulish Core — to which latter all the younger formations (6,5,4) are to be assigned. The two slides enumerated are branches of the Ballachulish Slide. The Ballachulish Slates (5) of the eastern, upper limb of the Ballachulish Fold as seen in this shore section belong manifestly to the northern continuation of the quarried type-outcrop across the loch. They are well exposed again close at hand near the road and in burns west of Callert House.

Ballachulish Limestone (6), which, like the slates just mentioned, must belong in the upper limb of the Ballachulish Fold, is seen further east at two places on the shore indicated by notes on (Figure 8). In the more westerly of these, the limestone is dark and pure, such as normally comes against Ballachulish Slates (more particularly in the relatively simple country of the Appin Fold). In the more easterly, though still grey, it is highly micaceous and impure. It must, therefore, be separated from the black phyllites (Ballachulish Slates) immediately to the east (see below) by a slide. In the greater part of the Ballachulish, Cretan and Glen Coe districts (Plate 3), (Plate 4) and (Figure 10)), a corresponding slide has been found, and it has been named the Sgòrr- a' Choise Slide (S.A.C.S. of (Figure 14); S■ of (Figure 7)) from a mountain two miles south of Loch Leven (Plate 3).

The Sgòrr a' Choise Slide differs from the Ballachulish Slide in that it thins the upper, instead of the lower, limb of the Ballachulish Recumbent Syncline. It is therefore a thrust rather than a lag. It has, however, been affected very clearly, for instance at Loch Creran [NM 940 420] (Plate 4), by the secondary synformal folding that we have discussed on the Stob Bàn ridge. In agreement with this we find a double outcrop at Callert [NN 092 604]. The more westerly separates the calcareous quartzose schists, noted on (Figure 8), from the pure grey limestone on the north-west. It is almost certain that the stratigraphical position of these calcareous quartzose schists (seen in a little stream north-east of Callert House)

is between the grey micaceous limestone on the south-east and the Leven Schists.

East of the grey micaceous limestone on the coast, that is immediately across the Sgòrr a' Choise Slide, we find from west to east:

Upper limb of Ballachulish Fold	Black graphitic phyllites, mostly covered by beach (Ballachulish Slates, 5, much reduced by movement)	120
	Intensely sheared rusty graphitic phyllites with quartzite and quartzose bands — pyrites common (striped transition zone of of Appin Quartzite, 4, much reduced by movement)	40
	Intensely sheared white quartzite, with gritty texture very seldom preserved (massive part of Appin Quartzite, 4, marking the centre of the Ballachulish Fold — the foundations of a summerhouse serve as a landmark)	100
	Intensely sheared rusty interbedded quartzite, quartzose bands and graphitic phyllite — pyrites common (striped transition zone of the Appin Quartzite, 4, much reduced by movement, but retaining more of the quartzitic portion than is found in the western outcrop)	40
Lower	Ballachulish Slide (very well exposed and marking the base of the Ballachulish Core)	—
	Grey non-rusty, very thin-bedded, massive mica-schists, with biotite porphyroblasts (typical Leven Schists, 7, belonging to the basement position in the Ballachulish Envelope)	45

The Ballachulish Slide indicated above cuts out the greater part of the striped zone of the Appin Quartzite, the whole of the Ballachulish Slates and Limestone, and the greater part of the Leven Schists, since what remains of these latter is only about 300 ft thick before Glen Coe Quartzite is reached. A very moderate estimate places the total omitted, at 2500 ft. The precise position of the slide on the shore is easy to find, as it is marked by a strong contrast in lithology. Moreover the sea waves, while developing little ridges and hollows along the greatly disturbed bedding of the striped Appin zone, have left the adjacent Leven Schists with smooth joint faces.

It will be noted that attenuation and special shearing has affected the upper limb of the Ballachulish Fold east of Callert House, though it has not reduced it nearly so much as the lower limb. If time permit, a visitor should satisfy himself beyond doubt that the thin black graphitic phyllites, classed as Ballachulish Slates of the upper limb in our table, are stratigraphically Ballachulish Slates. All that is necessary is to follow the crumpled black phyllite inland along what is virtually a continuous exposure (Figure 8) till at three quarters of a mile from the coast it is seen in much less disturbed condition, and unmistakably of Ballachulish Slate type. Half a mile further north the black slate outcrop thus reached is separated from Leven Schists by a thin representative of the Ballachulish Limestone indicated by three heavy crosses west of Mam na Gualainn [NN 116 625] on (Figure 8).

Having got so far a visitor should certainly go west to the well-exposed antiform of Tom Meadhoin [NN 085 624], showing re-emergence of envelope in the basement position. With the help of the map and section (Figure 8), (Figure 9) and the

description already given, a geologist should have no difficulty in realising the great tectonic contrast between the south-east and north-west sides of this antiform.

Before reaching Tom Meadhoin [NN 085 624], special shearing is obvious along the Ballachulish Slide in a small gorge at the head of Allt a' Choire Dhuibh. Here a section is afforded from massive Appin Quartzite, through much-diminished representatives of the striped zone and Ballachulish Slates to what remains of the Leven Schists, with Ballachulish Limestone omitted. There is evident smashing, but whether contemporaneous with the slide or later is uncertain.

From Tom Meadhoin [NN 085 624] a traverse of a mile somewhat south of east takes us across Leven Schists undiminished by the Ballachulish Slide. Beyond, it is easy to find the crag, west of Leac Mhòr [NN 069 616] on the one-inch map, where Ballachulish Limestone of the south-east limb of the Appin Fold looks down upon North Ballachulish [NN 052 603]. We here reach the equivalent (along strike) of the north-western end of (Figure 9). Comparing this figure with Section A at the foot of the one-inch map, it is easy to realise that the Glen Coe Quartzite of Tom Meadhoin [NN 085 624], the oldest rock of the district, belongs to the core of a great complex recumbent anticline, and that this anticline which is named after Kinlochleven in chapter 7 separates the Ballachulish Recumbent Syncline above from that of Appin below. It is clear too that the Ballachulish and Fort William Slides are homologous, both of them lags developed in the lower unreversed limbs of recumbent synclines.

E. Ballachulish to Sgòrr A' Choise

Introduction

The Ballachulish district, mostly included in (Plate 3), extends from near the ferry eastwards along Loch Leven to the mouth of Glen Coe (see Sheet 53). Its western boundary is marked by the Ballachulish Pluton; and its southern extremity by a broad outcrop of hornfelsed Ballachulish Slates east of the southern tip of this intrusive complex. Access is easy, and evidence regarding the gape of the Ballachulish Fold is spectacular. Among other features is a roadside demonstration of the Ballachulish Slide at St. John's Church [NN 067 586] (Plate 3). It is noteworthy, however, that the district, taken in isolation, affords no evidence whatever of the essentially recumbent character of the Ballachulish Fold and Slide. Most of the rocks as exposed stand steeply and constitute a complex synform including within its limits a succession of subsidiary steep synforms and antiforms ((Figure 7), F, G).

The Ballachulish Slide (B.S., (Figure 7)) at St. John's Church [NN 067 586] is seen on the west side of the Ballachulish Fold. It here goes underground, as shown west of Beinn Bhàn [NN 069 575] in (Figure 7), F, G, to reappear to the east outside of (Plate 3) in Glen Coe (Figure 10) and the Windows of Etive [NN 160 510]. Visitors with limited time should concentrate on the St. John's exposure followed by examination of the type section of the reappearance 2¼ miles to the east-north-east at a boathouse on Lochlevenside due north of Glencoe House (p. 72). The connection between what is seen at these two localities is supplied by the invaluable evidence already considered in the Callert district (D, p. 47).

The complementary Sgòrr a' Choise Slide (S■ on (Figure 7)) is best demonstrated by climbing Sgòrr a' Choise, which is highly to be recommended to those who are young and active.

The secondary synformal distribution of the Ballachulish Fold, with its attendant slides, as illustrated in (Figure 7), has already been realised by our hypothetical young geologist standing on the Stob Bàn ridge with his back to Glen Nevis (p. 49).

The stratigraphy of the Ballachulish district is the same as that described in the Appin district (chapter 4), extending from Appin Phyllites (2, youngest), through Appin Limestone (3), Appin Quartzite (4), Ballachulish Slates (5), Ballachulish Limestone (6) to Leven Schists (7). According to our convention the Ballachulish Limestone and younger formations are referred to the core of the Ballachulish Recumbent Fold, and the Leven Schists to the envelope.

The Leven Schists, just as on the Stob Bàn ridge, occupy two contrasted positions in respect of their associates: they function as a foundation or basement, outcropping west of the Ballachulish Slide in the north-west corner of (Plate 3); and also as a cover, spreading out east of Sgòrr a' Choise ((Figure 7), G).

The facies of the various formations is as at Onich (A), so that only a few local notes on stratigraphy are required.

Stratigraphical detail

Appin Phyllites (2)

The Appin Phyllites (2) are grey phyllites with, in many exposures, a very large proportion of flaggy fine-grained quartzite intercalations. There is a good display on the western slopes of Gleann an Fhiodh [NN 080 560] (Plate 3). In the valley west of Beinn Bhàn, owing to proximity of the Ballachulish Pluton, the phyllites are altered to massive spotted cordierite-hornfels, and, where banded with quartzite, resemble baked representatives of the striped zone of the Appin Quartzite.

Appin Limestone or Dolomite (3)

The Appin Limestone or Dolomite (3) presents both types met with in the Onich and Appin district. The cream or pink, dark-banded type, Tiger Rock, has been unsuccessfully quarried as an ornamental stone in a " Marble Quarry [NN 080 574]" a little west of the River Laroch [NN 080 560] in Gleann an Fhiodh [NN 080 560], 700 yards up from the bridge in Ballachulish village. Much purer white dolomite is seen close at hand against Appin Quartzite in the important tributary that drains the south slopes of Beinn Bhàn [NN 069 575]. Some of the purer variety weathers in gritty fashion through loosening of dolomite crystals following solution of calcite matrix. The massive pure variety is also exposed on the top of Sgòrr a' Choise, again close to Appin Quartzite; it weathers with the faintest of blue-white tints.

In the Allt Giùbhsachain [NN 062 570] valley west of Beinn Bhàn [NN 069 575], and again (beyond (Plate 3)) two miles south-west of Sgòrr a' Choise summit, the Appin Limestone is greatly altered by the Ballachulish Pluton. In the last-named exposure dedolomitisation has produced a grey limestone, studded with innumerable little crystals of forsterite, usually serpentinised.

The half of the Appin Quartzite (4) next to the Appin Limestone is massive gritty felspathic quartzite. The other half (4′ in (Figure 7)), next the Ballachulish Slates, is the usual striped transition zone, showing endless intercalations of quartzite and black slate. The combined thickness is 1000 ft. The massive quartzite, as exposed in Allt Giabhsachain above St. John's Church [NN 067 586], intervenes between exposures of Appin Limestone on the south and the striped transition zone on the north; and it shows repeated current-bedding, consistently younging towards the Appin Limestone.

The Ballachulish exposures of the striped transition zone are especially good. Interfolded isoclinally with the Ballachulish Slates they are seen for a quarter of a mile along the shore and road at St. John's Church [NN 067 586]; and east of this they give an excellent uninterrupted exposure for 200 yards upstream from the Laroch bridge at the entrance to Gleann an Fhiodh [NN 080 560]. In Sgòrr Dhearg [NN 056 558] again they build the greater part of a cliff which makes a very conspicuous object as seen from Ballachulish village. A few calcareous layers are found in the heart of the striped zone; and abundance of pyrites makes the whole group prone to rusty weathering — emphasised where the pyrites has been converted to pyrrhotite near the Ballachulish Pluton (p. 251).

Ballachulish Slates (5)

The black Ballachulish Slates (5) are opened up in huge quarries by the roadside. They afford a few instances of graded bedding.

Ballachulish Limestone (6)

The Ballachulish Limestone (6) is a big and varied formation. A good exposure along the road immediately east of the slate quarries begins with dark grey, tolerably pure, sandy limestone, corresponding with the dark pure outcrop half a mile W.S.W. of Callert House across Loch Leven (Figure 8). At Bridge of Coe [NN 104 589], a mile to the east, what is seen in the river can still be called grey limestone, but it is paler and very impure and micaceous. It corresponds in turn with the grey micaceous limestone noted in (Figure 8) on the shore south-east of Callert House. In between these outcrops is a mass of slightly calcareous schist or phyllite, obviously an exaggerated continuation of the calcareous

quartzose schists of (Figure 8). This mass of slightly calcareous schist makes the wooded slopes leading down from the rounded Leven Schist summit of Meall Mòr to the bottom of Glen Coe, where it affords several characteristic exposures along the new road of (Figure 10). One of these, opposite Leacantuim [NN 117 577] and the Youth Hostel, Glen Coe [NN 117 577], shows some white limestone, probably very close to Leven Schists.

Although in a sense the country from the slate quarries to Bridge of Coe [NN 104 589] is the type locality for the Ballachulish Limestone, it is so complicated tectonically that it is not nearly as satisfactory for this purpose as the hilltop exposure east of Onich. It suffers especially from the presence of the Sgòrr a' Choise Slide ((Plate 3); S■ of (Figure 7)). However, when all the available evidence is assembled, the Ballachulish district agrees with the Onich district in giving the Ballachulish Limestone: (a) a dark pure development against Ballachulish Slates; (b) a great mass of calcareous schist as a middle member; and (c) a white or cream-coloured limestone against Leven Schists. The Bridge of Coe [NN 104 589] exposure probably belongs to the passage from (a) to (b). Group (a), already noted just east of the Ballachulish slate quarries, reappears excellently exposed, a mile further south in Allt Socaich [NN 086 560] at the foot of Sgòrr a' Choise. It is here succeeded to the east by Group (b), much curtailed by the Sgòrr a' Choise Slide. Beyond the slide follows Group (c), and then the Leven Schists.

The Leven Schists (7) on the west side of the outcrop of the Ballachulish Fold, between Loch Leven and the Ballachulish Pluton, are grey phyllites or micaschists with numerous small porphyroblasts of biotite, and sometimes garnet — altered to cordierite. They carry many interbedded thin black seams and, in the eastern part of the section, numerous bands of fine-grained quartzite too. These Leven Schists, we have already pointed out, are part of the basement or foundation, upon which the Ballachulish Limestone and later formations of the district lie in complicated folds.

The corresponding cover of Leven Schists, overlying the Ballachulish Limestone, etc., makes Meall Mòr and other mountains east of Sgòrr a' Choise. It was reached in the Allt Socaich [NN 086 560] section when we crossed the cream-coloured edge of the Ballachulish Limestone; but its further consideration belongs to the Glen Coe and Glen Etive district (I).

Tectonic detail

We may now turn to tectonic relations. The gape of the Ballachulish Fold is highly complex, and includes within itself three minor synforms called after Beinn Bhàn, Gleann an Fhiodh [NN 080 560], and Sgòrr a' Choise (Figure 7). As these synforms have cores of relatively young formations, they can be called synclines, and this term is used in (Plate 3).

The synformal nature of the Beinn Bhàn Fold is self-evident above St. John's Church [NN 067 586]. The dip of the Appin Quartzite is almost vertical in the north-west limb, whereas it is directed towards the north-west at much more moderate angles in the south-east limb. Moreover the pitch of the fold is clearly, though steeply, towards the south-west, in which direction additional formations are taken on. E. B. B.

The synformal nature of the Gleann an Fhiodh Fold is inferred because an observed antiform intervenes between it and the Beinn Bhàn Synform. This anti-form, with cleavage developed parallel to its axial plane, is seen to good advantage in the striped transition zone of the Appin Quartzite laid bare in an easily accessible semi-cliff due east of the summit of Sgòrr Dhearg [NN 056 558] and south of the precipice which is so conspicuous from the village. It should be visited by anyone who wishes to check the structural interpretations given in (Figure 7), F, G. The regularity of the antiform, as exposed in the cliff, is broken somewhat by a slide marked by a conspicuous hollow with discordance of dip on its two sides. This slide is shown on the map, but is of trivial importance. A more important slide is indicated on the map a little to the south-east and lettered S′ in (Figure 7), G; it does not, however, in any way impair the regular development of the antiform as exposed in the cliff. E. B. B., H. B. M.

The synformal nature of the Sgòrr a' Choise Fold is merely inferred on analogy with that of the Beinn Bhàn and Gleann an Fhiodh Synforms.

The two main complementary slides (lag and thrust) of the district, generally spoken of as the Ballachulish and Sgòrr a' Choise Slides respectively, will be dealt with in the accounts that immediately follow of excursions to St. John's Church

[NN 067 586], Gleann an Fhiodh [NN 080 560] and Sgòrr a' Choise.

St. John's Church [NN 067 586] excursion

Before actually starting our excursion from Ballachulish village, let us mention two features of the Beinn Bhàn Synform, which most visitors will be prepared to accept without leaving the road (Plate 3). The mapping of the Appin Phyllites (2), Appin Limestone (3) and Appin Quartzite (4) of Beinn Bhàn [NN 069 575] and Allt Giùbhsachain [NN 062 570] shows that these rocks have a perfectly regular arrangement, except in the two following particulars:

It has not been found possible to trace the outcrop of the Appin Limestone completely round that of the Appin Phyllites in the valley of Allt Giùbhsachain [NN 062 570]. Exposures are bad, but locally the limestone can be proved to be absent probably as a result of minor sliding.

The junction of the massive quartzite and the striped zones of the Appin Quartzite on the east face of Beinn Bhàn [NN 069 575] is certainly a minor slide as shown in (Plate 3) and (Figure 7). There is a discordance of dip and strike on the two sides of this slide, so that its presence is easily recognised at a distance, for instance in the view from Ballachulish railway station.

Now we come to the excursion proper:

The regularity of the Beinn Bhàn Synform breaks down altogether near St. John's Church [NN 067 586] when we pass outwards from the striped zone of the Appin Quartzite. One need scarcely leave the roadside to realise this important feature. At the west end of Ballachulish (Laroch) village there are large quarries in Ballachulish Slates (5). These quarries are opened near the centre of the antiform separating the Beinn Bhàn and Gleann an Fhiodh Synforms. With neighbouring exposures they indicate beyond doubt that the Ballachulish Slates are represented in full force on the east side of the Beinn Bhàn Synform ((Figure 7), F, G). Two hundred yards west of the quarries the striped rocks of the Appin Quartzite put in a first roadside appearance. Thereafter for about half a mile Ballachulish Slates and striped Appin Quartzite alternate, all dipping steeply north-west. This must be due to zig-zag interfolding of slates and stripes, for on the hill face above the road the junction between striped and overlying massive Appin Quartzite follows a uniform line descending north-westwards until it reaches the axial plane of the syn form, near Allt Giabhsachain. It then sweeps up almost vertically; but the Ballachulish Slates (5) which have gone out to sea do not reappear. Instead, on the shore and for three-quarters of a mile inland, the striped rocks are bounded on the north-west by a thin representative of the grey pure part of the Ballachulish Limestone (6), followed by the banded transition group that elsewhere links Leven Schists (7) with Glen Coe Quartzite (8).

Here is easily examined detail:

The best section to show the elimination of Ballachulish Slates is afforded in a little promontory west of St. John's Church [NN 067 586]. The most westerly outcrop of Ballachulish Slates here makes a small skerry called Sgeir Uaine [NN 068 586] on (Plate 3). West of this for 50 yards the foreshore is occupied by part of the striped zone of the Appin Quartzite, including a thin bed of sandy limestone. Then follows typical, rather pure, grey Ballachulish Limestone, 12 yards across. Beyond this, immediately, come banded Leven Schists, undoubtedly marginal to Glen Coe Quartzite. The latter does not come to the surface here; but, as we have seen already, it outcrops on the same line, north of the loch (Figure 8).

The exposure is complicated by the presence of non-schistose lamprophyre dykes that flank the Ballachulish Limestone on either side; but the more northwesterly of these allows the slide between Ballachulish Limestone and banded Levens to be examined for a foot along its outcrop. Both dykes are considerably shattered, which shows that some of the obvious disturbance affecting the striped Appin Quartzite may be much later than the Ballachulish Slide.

Let us summarise what we learn from this locality:

1. The Ballachulish Slide is in two main branches either side of the Ballachulish Limestone: on the south-east side it cuts out all the Ballachulish Slates; on the north-west it cuts out much the greater part of both the Ballachulish Limestone and the Leven Schists.

2. The Beinn Bhàn Synform does not fold the Ballachulish Slide and must therefore be contemporaneous with it.
3. The Beinn Bhàn [NN 069 575], Gleann an Fhiodh [NN 080 560] and Sgòrr a 'Choise Synforms are synclinal in the sense that they have cores of younger formations.
4. Together they are incidents in the gape of the Ballachulish Fold in the manner indicated in (Figure 7).
5. Coupled with what is seen in Glen Coe and Glen Etive (p. 83) they teach us that the Ballachulish Fold is a recumbent syncline closing towards the south-east.
6. The Ballachulish Slide reducing the lower, normal limb of the Ballachulish recumbent syncline is therefore a lag, not a thrust. E. B. B.

Gleann an Fhiodh [NN 080 560] and Sgòrr a' Choise excursion

For those who have the time the following excursion is recommended from Ballachulish village up Gleann an Fhiodh [NN 080 560] and Allt Socaich [NN 086 560] (1½ miles); then ascent and traverse of Sgòrr a' Choise (2 miles); and return by Gleann an Fhiodh [NN 080 560] (3 miles). Such an excursion, even if Sgòrr a' Choise is not climbed, will greatly help anyone furnished with the one-inch map and (Plate 3) to appreciate the minor folds of Gleann an Fhiodh [NN 080 560] and Sgòrr a' Choise as illustrated in (Figure 7).

For completeness one may start with a visit to the grey, relatively pure portion of the Ballachulish Limestone (6) in the upper limb of the Ballachulish Fold, exposed by the roadside east of the village (an extra half mile). This is followed to the west by Ballachulish Slates (5) opened in an immense quarry. Still keeping to the road one next meets with the striped transition zone of the Appin Quartzite in its natural position bordering the slates. This thick zone is more fully exposed in the River Laroch [NN 080 560] upstream from the bridge in Ballachulish village. Here it occupies the bed of the burn as far as the Established Church, when gritty Appin Quartzite puts in an appearance. Appin Limestone (3) is wanting in the river section at the eastern margin of this quartzite outcrop, for a slide of small importance brings the latter into direct contact with green-grey Appin Phyllites (2), interbanded with thin ribs of cream-coloured limestone — unfortunately the slide itself is not exposed. Part of the missing outcrop of Appin Limestone is well seen in a " Marble Quarry [NN 080 574]" on the west side of the river. It is here cream and pale pink in colour with dark stripes (Tiger Rock). The marginal portion, a much purer white dolomite, is exposed interfolded with Appin Quartzite in an important tributary stream just a little to the north of the quarry.

The phyllites, mentioned above as slid against Appin Quartzite in the main river, mark the centre of the Gleann an Fhiodh Syncline at this locality. Soon to the south a return outcrop of Appin Limestone appears, and furnishes the river bed for 400 yards. Then, above a waterfall, Appin Quartzite, at first massive and gritty, later striped and transitional, follows with marked attenuation. This attenuation, which is maintained along strike for three miles, is the evidence for the slide S" of Sections F and G (Figure 7).

The attenuated Appin Quartzite, well exposed in the river, shows the following signs of disruption:

1. the face of quartzite over which the water tumbles at the fall is slickensided;
2. the quartzite a little farther upstream is in a crushed condition and is crossed by wlill-defined planes of movement;
3. the striped succession beyond the quartzite is, like the quartzite proper, of greatly diminished thickness and is crossed by planes of movement which cut the bedding structures at so small an angle that their presence is only revealed by careful scrutiny.

Beyond the striped zone of the Appin Quartzite there is, especially in Allt Socaich [NN 086 560], a fine exposure of Ballachulish Slates (5), belonging to the same outcrop as carries the great quarry near the coast. Next in this tributary, just as at the quarry, comes dark-grey, pure, banded Ballachulish Limestone (6). This is followed by a succession of slates, both black and grey, with numerous bands of limestone, mostly dark, but some cream-coloured — a mixed assemblage referable to the preponderant, very impure, middle member of the Ballachulish Limestone series Immediately to the east is cream-coloured limestone, several feet thick, still belonging to the Ballachulish Limestone and followed by a great uninterrupted outcrop of Leven Schists (7).

Let us recall that the Leven Schists west of St. John's Church [NN 067 586] on Lochlevenside belong to the foundation which, at Stob Bàn (p. 47), supports the Ballachulish Limestone and later formations assigned to the core of the Ballachulish Recumbent Syncline. Now our two Ballachulish excursions have taken us right across the outcrop of this complex core; and we, at Allt Socaich [NN 086 560] at the foot of Sgòrr a' Choise, stand on Leven Schists, which function as its cover ((Figure 7), G). The further consideration of this cover will be reserved for descriptions of Glen Creran, Glen Coe and Glen Etive (District I, p. 83).

Here for completeness we must interpolate an explanation regarding the ground north of Allt Socaich [NN 086 560], which we shall not have time to visit during this excursion. It will be seen that (Plate 3) shows the Sgòrr a' Choise Slide (S" ', (Figure 7)) as continuing across the two miles which separate Allt Socaich [NN 086 560] from Loch Leven; whereas Sheet 53 shows the same slide as terminating a very short distance north of the stream. The difference of expression is due to a desire not to overload the one-inch map. It so happens that the Sgòrr a' Choise Slide shows in very dramatic fashion south of Allt Socaich [NN 086 560] (see sequel), and to omit it there would often render the one-inch map unintelligible. To the north its effects are more subdued. They exist, however. Thus the dark pure portion of the Ballachulish Limestone is confined to those portions of the formational outcrop which bulge westward at Allt Socaich [NN 086 560] and again at the coastal slate quarry. In between, Ballachulish Slates, for more than a mile along their east margin, make direct contact with impure calcareous schist or pale limestone. H. B. M., E. B. B.

In Allt Socaich [NN 086 560], to resume our excursion, the main effect of the slide is greatly to curtail the outcrop of the mixed calcareous schist division which normally separates the grey and cream-coloured margins of the Ballachulish Limestone. In addition some black slate in this mixed division, immediately west of the cream-coloured marginal limestone, shows signs of special disturbance.

Climbing now out of Allt Socaich [NN 086 560] we follow the crop of the cream-coloured limestone to the top of Sgòrr a' Choise. At the summit a steep pitch introduces Appin Quartzite, striped and massive, and Appin Limestone, of the unbanded white type (presumably pure dolomite). The effect of the Sgòrr a' Choise Slide here becomes exceedingly obvious, for, whereas on the north-west side of the Sgòrr a' Choise Fold Ballachulish Slates and Appin Quartzite are developed in force, on the south-east side these two formations are reduced to 3 ft each in thickness; and at the same time all of the Ballachulish Limestone Series as exposed in Allt Socaich [NN 086 560] is cut out except for the cream-coloured margin. Accordingly we find this latter, south-east of the slide, separated from white Appin Limestone, in the heart of the Sgòrr a' Choise Fold by a mere 6 ft of strata. The attenuation can be followed in its various stages of accomplishment along the line marked in (Plate 3) as a subsidiary slide running north of west 30 yd S. of the Sgòrr a' Choise cairn. Bands in the steeply pitching striped zone of the Appin Quartzite are broken into a series of lenticles.

If the traverse be continued south-westwards along the ridge of Sgòrr a' Choise so as to reach the path leading back into Gleann an Fhiodh [NN 080 560], it will be found that the Appin Quartzite on its north-west side is bounded by yet another slide. This has resulted in a severely "scrubbed" face of quartzite on the hillside south-east of the point at which the path crosses the River Laroch [NN 080 560]. The quartzite here is in the condition of the Durness Quartzite of the North-West Highlands where crossed by one or other of the well-known thrusts of the region.

Half a mile upstream from where the path just mentioned crosses the River Laroch [NN 080 560], exposures, partly in tributaries entering from the south, show the termination of the Appin Phyllite outcrop that further north, half a mile wide, marks the heart of the Gleann an Fhiodh Synform. The structures involved are highly complex, and the available evidence is insufficient to elucidate them in detail. The return journey by path down Gleann an Fhiodh [NN 080 560] is sufficiently illustrated in (Plate 3).

F. Glen Creran

Allt Eilidh [NN 067 530] South to Ellerie [NN 039 489]

This sub-district starts a little south of (Plate 3) and reaches for a short distance into (Plate 4). Allt Eilidh [NN 067 530] is a tributary of Glen Creran draining the south-eastern slopes of the Sgòrr a' Choise ridge. Ellerie [NN 039 489] is a house a little north of the junction of Glen Creran and Glen Ure [NN 070 475]. Both are named on Sheet 53, and the latter also

on (Plate 4). The geology continues south-westwards that of the Ballachulish district (E), as may be seen from examination of Sheet 53, and that part of (Figure 7), H, which crosses Glen Creran south of Salachail [NN 056 512].

Ballachulish Limestone (6) and the younger formations, Ballachulish Slates (5), Appin Quartzite (4), Appin Limestone (3) and Appin Phyllites (2), mark the core of the Ballachulish Fold. To the north-west, from Fraochaidh [NN 029 516] to Beinn Mhic na Ceisich [NN 016 493], Leven Schists (7) of the envelope emerge as foundation to this core. To the south-east, from Meall an Aodainn [NN 080 525] to Leac Bharainn [NN 065 495], they follow on as cover.

The Leven Schists of the foundation-outcrop, right up to their eastern contact with Ballachulish Limestone, are of the banded type characteristic on a large scale of the older part of the formation south-west of the Ballachulish Pluton (p. 44). The non-banded younger portion, seen further west in Meall Bàn [NN 003 533], is cut out eastwards by the Ballachulish Slide, here generally double as at St. John's Church [NN 067 586] on Loch Leven. In contrast, the Leven Schists of the cover start with a great thickness of the unbanded younger portion, making unbroken contact with Ballachulish Limestone as in Allt Socaich [NN 086 560] (p. 60).

The dissimilarity between the two sides of the Ballachulish Fold is even more marked when we consider the representation of the Ballachulish Limestone. On the west side the only part of the Ballachulish Limestone to be recognised is the pure, dark-grey portion that is expected against Ballachulish Slates. On the east the only part is the cream-coloured edge, or corresponding calc-silicate-hornfels, expected against Leven Schists.

Here are a few details:

On the west, for the first quarter of a mile south of the Ballachulish Pluton, the Ballachulish Slide can be traced as dividing the banded Leven Schists of Fraochaidh [NN 029 516], at first, from Ballachulish Slates and, further south, from Appin Phyllites. Where the Appin Phyllites occur, the slide is followed by thin discontinuous outcrops of very pale limestone, perhaps Appin Limestone. After quarter of a mile, however, the slide becomes manifestly double, with anything up to 300 yd separating its two branches. In between is dark, pure Ballachulish Limestone, often accompanied by important bands of Ballachulish Slates.

On the other side of the gape of the Ballachulish Fold we find the Sgòrr a' Choise Slide (S■. (Figure 7), H) strikingly displayed. Let us start where the present district overlaps the Ballachulish District south of a small pluton, one and a half miles S.W. of Sgòrr a' Choise and half a mile S.W. of (Plate 3). Sheet 53 indicates that the slide here greatly reduces the Ballachulish Slates (5) and Limestone (6) that intervene between Appin Quartzite (4) on the north-west and Leven Schists (7) on the south-east. Two tributaries of Allt Eilidh [NN 067 530] cross the Gleann an Fhiodh [NN 080 560] path, coming from (Plate 3) and now descending towards Salachail [NN 056 512]. In the more northerly stream the attenuated groups are represented by a very few feet of black slate and calc-silicate-hornfels. In the more southerly, conditions are probably the same, but there is a small gap in the exposures where the calc-silicate might be expected.

A mile to the south-west, in another burn, running down the hill slope to pass close to Salachail [NN 056 512], the Sgòrr a' Choise Slide is laid bare at a small waterfall. Its effect here has been to bring an extensive outcrop of Ballachulish Slates on the north-west into contact with the cream-coloured edge of the Ballachulish Limestone (no longer hornfelsed) followed by Leven Schists on the south-east. The cream-coloured limestone is traversed by obliquely convergent planes of movement. The exposure is particularly clear. Its main features are repeated to the south-west in the River Creran [NN 060 510], but they are confused by subsequent faulting.

This takes us into (Plate 4). For the next half mile to Allt Coire Mulrooney [NN 034 500] west of Ellerie [NN 039 489], the Sgòrr a' Choise Slide brings Ballachulish Slates into direct contact with Leven Schists. Meanwhile the Ballachulish Core, measured from the basement to the cover outcrop of the Leven Schist envelope, is narrowing. In Easan Diblidh [NN 020 485], west of Ellerie [NN 039 489], it is less than 300 yards wide. This contrasts strongly with the 3-mile measurement north-west of Sgòrr a' Choise in (Plate 3). The contents of the core in Easan Diblidh [NN 020 485] dip steeply north-west and are from west to east as follows:

	Outcrop width in feet
*Ballachulish S*lide (*W. branch*) at structural base	—

Ballachulish Limestone (pure part of 6) and Slates (5): both black	400
Ballachulish Slide (*E. branch*)	—
Appin Phyllites (2): grey with quartzitic and calcareous beds	150
Appin Limestone (3): typical white	50
Appin Quartzite (4): unstriped portion	50
Sgòrr a' Choise Slide	—
Ballachulish Limestone (6): highly impure, pale portion — at structural top	300

It is safe to assume that the small outcrop widths of the individual formations are all due to mechanical thinning.

Looking back northwards, the one-inch map shows us how the gape of the Ballachulish Fold continuously widens towards and at the Ballachulish Pluton. It is already a mile wide, where it meets the great intrusion. The formations involved in this direction are the same as are listed above in Easan Diblidh [NN 020 485]; only they are often developed on a much more ample scale.

Exposures are excellent in Allt Coire Mulrooney [NN 034 500] and its tributaries, north-east of Easan Diblidh [NN 020 485]. The only lithological feature that need be noted is that the Appin Phyllites in several places contain thin black seams suggesting a passage to the Cuil Bay Slates (1) that are represented in the Appin Core.

The various formations are disposed in three main folds which probably correspond with the Sgòrr a' Choise, Gleann an Fhiodh [NN 080 560] and Beinn Bhàn Synforms of the Ballachulish district. The structural connexion, however, is not quite certain, because, where the two districts meet east of the southern tip of the Ballachulish Pluton, no formation younger than the Ballachulish Slates has been spared by erosion; and in the slate outcrop structural details cannot be traced.

If we confine attention to rocks younger than the Ballachulish Slates, we may provisionally assign outcrops in the Allt Coire Mulrooney [NN 034 500] drainage basin as follows from east to west:

· The Sgòrr a' Choise Synform probably includes all the Appin Quartzite and Limestone (4 and 3), with associated Appin Phyllite (2), which are mapped at the northern margin of (Plate 4).

·The Gleann an Fhiodh [NN 080 560] Synform, north of (Plate 4), probably includes the Appin Quartzite where crossed by the 1500 ft contour shown on Sheet 53 and the conspicuous Appin Limestone and Phyllite outcrop to the north-west.

· The Beinn Bhàn Synform, still further north, probably includes the outcrop of Appin Quartzite half a mile east of Fraochaidh [NN 029 516], and the tongue of Appin Phyllite that separates this outcrop from the eastern branch of the Ballachulish Slide. C. T. C., E. B. B.

Lower Glen Creran and Glen Ure [NN 070 475]

Thissub-district corresponds with the area mapped in (Plate 4), overlapping with the previous sub-district in regard to Easan Diblidh [NN 020 485] and Allt Coire Mulrooney [NN 034 500]. As shown on its margin, (Plate 4) extends from Taravocan [NN 020 463] southwards into one-inch Sheet 45 (Geol.). Unfortunately the Geological Survey Sheet 45 is only available in an uncorrected edition, first printed in 1907.

Before proceeding to detail let us take note of the outstanding structural features presented in this plate. We have on previous pages traced the outcrop of the core of the Ballachulish Fold, as marked by Ballachulish Limestone (6) and younger formations (5–2), from the Stob Bàn ridge above Glen Nevis (p. 47) to where it enters (Plate 4) north of Ellerie [NN 039 489]. South of this, (Plate 4) shows how the core outcrop on reaching Loch Creran [NM 940 420] swings back to the north-east until cut off by the Cruachan Pluton in Glen Ure [NN 070 475]. It also shows that the Ballachulish Slide swings round in exactly the same manner always separating the Ballachulish Core from a great outcrop of banded Leven Schists. These latter, as we have already seen, connect northwards (apart from disruption by the Ballachulish and

Mullach nan Coirean Plutons) with the basement Leven Schists of the Stob Bàn secondary synform (p. 49).

Let us give a local name, Loch Creran [NM 940 420] Fold, to the fold responsible for the sharp deflection of outcrops, shown in (Plate 4). It must be a secondary fold, in the sense that it is obviously later than the Ballachulish Slide. A glance at Sheet 53 suggests that it is essentially identical with the secondary Stob Bàn Synform, so clearly exposed 16 miles to the north-north-east. We propose to show that this correlation is correct. All that is required is to demonstrate that the Loch Creran [NM 940 420] secondary fold is synformal.

The only alternative is to suppose that the Loch Creran [NM 940 420] Fold does not have a gently inclined axis, but is a torsional fold about a steep axis; in which case it has no analogy with the Stob Bàn Synform.

We shall first give strictly local evidence under headings (1) to (3); and this proves highly suggestive though not conclusive. We shall then, under heading (4), supplement our local evidence by looking eastwards, when all becomes clear. The Loch Creran Fold is undoubtedly a synform.

1. Let us start with the upper limb outcrop of Ballachulish Limestone (6), which reaches south-south-west from Allt Coire Mulrooney [NN 034 500] past Fasnacloich [NN 020 478] and the post office. On reaching Loch Creran [NM 940 420] it turns to go by Taravocan [NN 020 463] and the mapped sheepfold further east, and so reaches Glen Ure [NN 070 475]. On both sides of the Loch Creran Fold, dips are directed more or less north-westwards, but on the north-west side they seem to be significantly steeper than on the south-east. If this appearance is not misleading, the Loch Creran [NM 940 420] Fold must obviously be a synform.
2. In the limestone outcrop we are considering, the appearance of dips on the north-west side of the Loch Creran Fold being steeper than those on the south-east is strengthened by the relative narrowness of the outcrop on the north-west side compared with the south-east. This argument would be conclusive in simpler country, but not here where the thickness of formations is largely influenced by slides.
3. The Leven Schists in the heart of the Loch Creran Fold are seen just west of Taravocan [NN 020 463] to pitch gently north-eastwards. This affords very strong confirmatory evidence that the Loch Creran Fold is a synform. On the other hand, in complicated ground half a mile south of Taravocan [NN 020 463], pitch is very steep and more often than not towards the south. Taken by itself appearances here suggest that the Loch Creran Fold is a torsional fold with a very steep axis. There is, however, no need to regard this last evidence as more than a symptom of irregular complexity.
4. The evidence set out under heading (1) in favour of the synformal nature of the Loch Creran Fold becomes conclusive if it can be demonstrated that the Ballachulish Limestone between Taravocan [NN 020 463] and Glen Ure [NN 070 475] is passing on a regional scale under the Leven Schists that outcrop to the north-west. Fortunately there is no doubt whatever that such is the case. The Leven Schists concerned form part of a great spread, furnishing what we have often called the "cover", which, as Sheet 53 shows, reaches eastwards, through Leac Bharainn [NN 065 495], Sgòr na h-Ulaidh [NN 111 518], Meall a 'Bhuiridh and Beinn Maol Chaluim [NN 140 520] to the lavas occupying the cauldron-subsidence of Glen Coe (Section BB, foot of Sheet 53; and (Figure 7), G,H). In this extensive area, which measures several miles whether considered from west to east or from north to south, the Leven Schists function as a thick moderately inclined layer. The top of this layer is defined by caps of Glen Coe Quartzite on Beinn Fhionnlaidh [NN 100 500] and Beinn Maol Chaluim [NN 140 520], north-west of Glen Etive, and Stob Dubh, south-east of the same. The bottom of the layer is defined by the emergence of Ballachulish Limestone between Taravocan [NN 020 463] and Glen Ure [NN 070 475], and again in the Windows of Etive [NN 160 510], that is in Gldann Chàrnan, Gleann Fhaolain [NN 150 520] and Glen Etive. As (Plate 4) and Sheet 53 show, before the band of Ballachulish Limestone we are considering reaches the Cruachan Pluton in Glen Ure [NN 070 475], it has come to rest directly on the Ballachulish Slide. In the more easterly exposures, furnished by the Windows of Etive [NN 160 510] ((Figure 7), G,H), this relationship continues; but more information must be reserved for our discussion of the Glen Coe to Glen Etive district (1, p. 83).

Before proceeding to detail there is another important structural feature of (Plate 4) to which attention may be drawn. We have already explained that from the northern limit of this map south to Easan Diblidh [NN 020 485] the Ballachulish Fold-Core is represented by outcrops which follow one another from west to east as follows: Ballachulish Limestone and Slates (6, 5, between two branches of the Ballachulish Slide); Ballachulish Slates, Appin Quartzite, Limestone and

Phyllites (5, 4, 3, 2, between the eastern branch of the Ballachulish Slide and the Sgòrr a' Choise Slide); and Ballachulish Limestone (6, between the Sgòrr a' Choise Slide and the cover Leven Schists). We have also pointed out that in this locality, everything lying between the east branch of the Ballachulish Slide and the Sgòrr a' Choise Slide may with fair certainty be referred to the Sgòrr a' Choise Fold. Now if we look at (Plate 4) south of Taravocan [NN 020 463] we recognise exactly the same succession of outcrops from south to north as we have just detailed in the Easan Diblidh [NN 020 485], or better in the Allt Coire Mulrooney [NN 034 500] area, from west to east. It is, however, remarkable that the Ballachulish Core in these south-easterly exposures should be stratigraphically fuller than it is to the north-west between Easan Diblidh [NN 020 485] and Loch Creran [NM 940 420]. It will be remembered that the Ballachulish district shows clearly that the Ballachulish Fold closes towards the south-east. It therefore seems necessary to admit that the extra formations, as we may call them, south-east of Taravocan [NN 020 463], have squeezed through the core rocks exposed north-west of Fasnacloich [NN 020 478], the post office and Loch Creran [NM 940 420].

The difficulty just described is purely local. In all outcrops of the Ballachulish Core from Allt Coire Mulrooney [NN 034 500] northwards to Loch Leven there is a fuller stratigraphical complement than in Glen Ure [NN 070 475], Glen Coe and the Windows of Etive [NN 160 510].

We now turn to local detail:

All the foundation Leven Schists (7′) of the north-west corner of (Plate 4) are of the banded type characteristic on a large scale of the older part of the formation in the Kentallen-Appin district, p. 44. They are in fact largely composed of bands of impure quartzite. Across Loch Creran [NM 940 420], eastwards, their character is considerably blurred by contact-alteration; but it is clear that in this direction, as they approach the Cruachan Pluton, they contain an increasing proportion of grey mica-schist hornfels.

Glen Coe Quartzite (8) is mapped in (Plate 4) as splitting the basement Leven Schists south of Glen Ure [NN 070 475]. Its structural position with reference to the Ballachulish Slide corresponds with what is found at Tom Meadhoin [NN 085 624] and Mam na Gualainn [NN 116 625] (Section A, Sheet 53; (Figure 8), (Figure 9), pp. 50, 51) and the Windows of Etive [NN 160 510] ((Figure 7), G, H, p. 48); but its lithological character is different. Elsewhere in Sheet 53 (but probably not in Glen Strae [NN 150 300] to the south-east, see Bailey and Macgregor, 1912, p. 172) the Glen Coe Quartzite is always fine-grained. Here, however, it is gritty with large and abundant grains of quartz and felspar. On character alone it might be correlated with the Appin Quartzite, but this is ruled out by a banded passage zone linking with the Leven Schists alongside. There can be no question of a misleading mechanical admixture, for many of the semipelitic layers are thickly strewn with big detrital grains.

The cover Leven Schists (7) of the north-east corner of (Plate 4), reaching southwest to Taravocan [NN 020 463], are very different from the basement or foundation Leven Schists (7′) in that they are of the purely pelitic type characteristic on a very large scale of the younger portion of the formation in the type outcrop north of Loch Leven (p. 40). The dissimilarity is of course due to displacement along the Ballachulish Slide.

Once more the contrast between the lower and upper limbs of the Ballachulish Fold also affects markedly (though not everywhere) the representation of the Ballachulish Limestone (6): in the lower limb the dai k pure portion is generally all that is preserved, often in association with Ballachulish Slates (5); in the upper limb the pale impure portion is practically universal. The contrast here depends upon the conjoint operation of the Ballachulish and Sgòrr a' Choise Slides.

Let us start with the lower limb. Where this enters (Plate 4) from the north, the Ballachulish Slide is double and its two branches embrace two bands of dark pure Ballachulish Limestone separated by an outcrop of Ballachulish Slates. This arrangement clearly continues with minor changes for a mile and a half. Further south-east, Ballachulish Limestone is very seldom seen along the north-west branch of the Ballachulish Slide, though three narrow strips, dark and pure, have been mapped in this position at localities numbered (6) on (Plate 4). The Ballachulish Slates continue; but in a stream that flows down past the post office they join with a more south-easterly outcrop of the same formation, and this renders the south-east branch of the Ballachulish Slide temporarily unmappable.

It is thought, however, that the Ballachulish Slide continues double right down to Loch Creran [NM 940 420]. The succession of outcrops from west to east, crossed obliquely by the coastline, is as follows:

Banded basement Leven Schists — at structural base

Lower branch of Ballachulish Slide

Ballachulish Limestone, dark, pure, very thin

Ballachulish Slates, quarried for wall-building

Ballachulish Limestone, dark, pure, thicker, burnt for lime

?Upper branch of Ballachulish Slide

?Appin Phyllites, non-calcareous schist, very thin

?Appin Limestone, white limestone, very thin

?Sgòrr a' Choise Slide

Ballachulish Limestone, pale calcareous schist, thick — *at structural top*

In (Plate 4) the above queried interpretations are accepted; but, owing to scale, no attempt can be made to represent the thin strip of probable Appin Phyllite and Limestone, so that the upper or south-east branch of the Ballachulish Slide is shown by the same heavy line as the Sgòrr a' Choise Slide.

To the east, across Loch Creran [NM 940 420], the Ballachulish Slide is essentially single for about a mile, without any certain outcrop of Ballachulish Limestone or Slates along its course — a narrow local strip of calc-silicate-hornfels, though numbered 3 on (Plate 4), may perhaps be Ballachulish Limestone. Then turning east the slide resumes its double character, and encloses outcrops of Ballachulish Limestone and Slates with, at first, just the same arrangement as at the northern margin of (Plate 4). Exposures are excellent between a right-angle bend in a wall half a mile south of Taravocan [NN 020 463] and a fault that runs north-east to the sheepfold shown in the map: the limestone is dark marble, looking very like the dark pure portion of the formation as seen elsewhere outside contact aureoles; the slates are represented by black pelitic hornfels spotted with cordierite.

East of the sheepfold fault things are different, for Ballachulish Limestone is mostly confined to the impure older portion of the formation (altered to calcsilicate-hornfels), and, in sympathy, Ballachulish Slates are wanting. The mapping in (Plate 4) of Allt Buidhe is only approximate. Valley bottom exposures are poor except in the stream bed, and secondary folding is unusually complex. It is almost certain that Appin and Ballachulish Limestones are here slid together, as indeed they are in the relatively simple ground west of the fault. The apparent conjunction of the two limestones along Allt Buidhe [NN 030 440] is seen 200 yards upstream from the fault, where a second sheepfold, not shown on (Plate 4), serves as a useful landmark. Less than 100 yards to the south-east, unmistakable dark Ballachulish Limestone (marbled) outcrops in a hollow, while in the stream itself there are exposures of pale marble which have the appearance of contact-altered Appin Limestone. (Plate 4) includes both occurrences (ornamented as Ballachulish Limestone) as lying between two branches of the Ballachulish Slide; and six hundred yards further upstream undoubted Ballachulish Limestone is seen again. The outcrop allotted to this formation in (Plate 4), northwards from Allt Buidhe [NN 030 440] to the margin of the Cruachan Pluton, consists of a great thickness of calc-silicate-hornfels with minor outcrops of dark-grey marble. Its correlation as Ballachulish Limestone cannot be questioned; and it obviously lies between two branches of the Ballachulish Slide.

These two branches must have come together again where for a short space cut off by the Cruachan Pluton, since the slide on reappearing for a couple of miles is either single or substantially so. Ballachulish Limestone has only been recognised along the slide in this part of its course in confluent streams draining towards Glen Ure [NN 070 475] House. It here consists of calc-silicate-hornfels and is about 40 feet thick, and its position is merely indicated by the number 6 on

(Plate 4).

The Ballachulish Limestone of the upper limb of the Ballachulish Fold west of Glen Creran can readily be traced from Allt Coire Mulrooney [NN 034 500], near Ellerie [NN 039 489], to the head of Loch Creran [NM 940 420]. In this part of its course it is, owing to the Sgòrr a' Choise Slide, almost entirely represented by pale grey, very impure calcareous schist with occasional outcrops of pale limestone. The pure dark portion has in general been entirely cut out.

A trifling exposure of pure dark limestone does, however, occur on the eastern border of a phyllite outcrop mapped west of the post office in (Plate 4). The locality is 200 yards north of where this phyllite border reaches the road, half a mile south of the post office. The phyllite is problematical. It is grey with black streaks, and resembles part of the Appin Phyllites; but it is difficult to believe that it is anything but a stratigraphical intercalation in the impure Ballachulish Limestone.

The Ballachulish Limestone in the upper limb of the Ballachulish Fold east of Loch Creran [NM 940 420] is practically always in the condition of calc-silicate-hornfels. Beds too pure to yield this product are almost completely absent, cut out here again by the Sgòrr a' Choise Slide.

Let us now turn our attention to the formations younger than the Ballachulish Limestone, whose outcrops intervene between the upper branch of the Ballachulish Slide and the Sgòrr a' Choise Slide; and let us start on the west side of Glen Creran.

At the northern edge of (Plate 4) the formations concerned are Ballachulish Slates (5), and Appin Quartzite (4), Limestone (3) and Phyllite (2). We have already seen how the outcrop of these formations narrows in Easan Diblidh [NN 020 485], with omission of the Ballachulish Slates (p. 63). A mile further south-west, as shown in the post office stream, the diminution continues, and all three Appin formations have disappeared, though Ballachulish Slates have come in again. Another mile to the south-west, at Loch Creran [NM 940 420], we think we can identify Appin Limestone and Phyllite in a strip too narrow to show on (Plate 4); but that is all (p. 66).

East of Glen Creran an almost continuous outcrop of Ballachulish Slates (5) borders the Sgòrr a' Choise Slide, corresponding exactly with the outcrop due north of Ellerie [NN 039 489]. It is very narrow near the alluvium at the head of Loch Creran [NM 940 420], and about half a mile further north-east it temporarily disappears, evidently as a result of sliding. When, a little further east, it comes in again its black slates have been transformed to black hornfels spotted with cordierite. East of the fault that crosses by the sheepfold of (Plate 4) this black hornfels is extremely prominent and gives rise to a sombre row of crags, conspicuous even from a distance.

The striped transition zone of the Appin Quartzite (4) which follows is much less definite in its characters, and one cannot, in the contact aureole, always distinguish it with certainty from parts of the Appin Phyllites or the banded portion of the Leven Schists. Its outcrop, however, in most cases is limited by hornfelsed black slate on the one side and gritty quartzite on the other. In the burn flowing north-west to the sheepfold the striped zone is shown in (Plate 4) as terminating somewhat abruptly against banded Leven Schists. The mapping naturally becomes rather difficult in this case, but fortunately the banded Levens here no longer closely approach the striped division of the Appin Quartzite in character, for they contain a large proportion of grey pelitic mica-schist hornfels.

The massive gritty division of the Appin Quartzite (4) is of great assistance to the mapper, for it retains its normal characters even close to the Cruachan Pluton. It is a massive pure-white quartzite with big detrital grains of quartz and felspar. The value of the quartzite is particularly evident in the Allt Buidhe [NN 030 440] glen, where its outcrop, taken in conjunction with that of the hornfelsed Ballachulish Slates, very clearly defines the essential features of an unusually intricate bit of structure. It is noteworthy that almost all the dips seen in the Allt Buidhe [NN 030 440] district are extremely steep, and that the form of outcrops is not appreciably influenced by topographic features of the magnitude of the Allt Buidhe [NN 030 440] valley.

The Appin Limestones (3) and Phyllites (2) come next in order. Narrow outcrops of calc-silicate-hornfels have been noted at the eastern margin of the Balliveolan [NN 008 448] outcrop of Appin Quartzite, and are referred with some hesitation to the Appin, rather than the Ballachulish, Limestone position. Along the southern margin of the next outcrop of Appin

Quartzite, about half a mile south of Taravocan [NN 020 463], a band of marble, or a corresponding hollow, is constantly seen. In colour this marble may be white, pinkish or grey. A grey specimen, taken from close to the fault which leads down to the sheepfold, was found to contain forsterite (S17310) [NN 0276 4552], indicating its original dolomitic character. Another specimen, however, from the same band further west showed no forsterite (S17309) [NN 0219 4572]. Across the fault the gritty Appin Quartzite is again frequently bounded on the side remote from the striped zone by a band of marble, as shown in (Plate 4). A grey marble, from the edge of the quartzite at the top of the declivity leading down to the stream that flows north-east to the sheepfold, has proved on examination to be particularly rich in forsterite and green spinel (S17311) [NN 0465 4672]. There can be no doubt whatever as to the correctness of the correlation of all these marginal outcrops of marble with the Appin Limestone. We shall return in a minute to what we regard as Appin Limestone separated by a stratigraphical intercalation (numbered 2 on (Plate 4)) from this marginal band.

The Appin Phyllites east of Glen Creran belong almost wholly to this supposed intercalation. Here in the aureole of the Cruachan Pluton they are practically indistinguishable from the striped zone of the Appin Quartzite just as at Kentallen and in Allt Giùbhsachain [NN 062 570] on the two sides of the Ballachulish Pluton. There is a further difficulty in that the banded Leven Schists near Loch Creran [NM 940 420] are also of very similar appearance. In fact in mapping certain hornfelses with quartzite ribs as Appin Phyllites one has to be guided to a large extent by their relations to more easily recognisable formations on either side. There is, however, good internal evidence for assigning the banded hornfelses half a mile south of Taravocan [NN 020 463] to the Appin Phyllites, for various exposures show alternating beds of impure calc-silicate-hornfels, phyllite-hornfels and quartzite, an assemblage very reminiscent of parts of the Appin Phyllites elsewhere.

The recurrence of Appin Limestone some little way in from the Appin Quartzite margin of the Appin Phyllites is a feature often noted further north. Near the southern margin of the Appin Phyllite outcrop just described there is a thick bed of irregularly weathering white marble (sometimes grey), with dark streaks. It is first seen north-west of a wall half a mile due south of Taravocan [NN 020 463], and can readily be followed thence to the fault about a mile further east. Two specimens (S17307) [NN 0173 4573] (S17308) [NN 0173 4573] examined contain no forsterite, but this does not in any way disprove the Appin correlation. Across the fault, as already explained, the white marble is conspicuous in Allt Buidhe [NN 030 440] (p. 67). Both east and west of the fault, it often contacts undoubted Ballachulish Limestone on the side remote from the Appin Phyllite outcrop.

One point remains. East of Glen Creran there are very numerous small sheets of compact hornblende-schist. Only a small proportion of them are shown in Sheet 53, and none at all in (Plate 4). Scattered examples occur as far east as Beinn Fhionnlaidh [NN 100 500], where a narrow porphyritic example cuts Glen Coe Quartzite near a small lochan close to the margin of the Cruachan Pluton. The main concentration is near Glen Creran, and straddles the outcrop of the Ballachulish Slide. It is clear from this that their intrusion post-dates the development of the slide. Their foliation, which is often very pronounced, is quite possibly connected with the secondary folding responsible for the Loch Creran [NM 940 420] Synform. E. B. B.

G. Glen Coe

Introduction

The schist geology of Glen Coe is the counterpart of that just described east of Glen Creran (*cf.* (Figure 10) and (Plate 4)), in that it shows the outcrop of the Ballachulish Core and Slide, in the south-east limb of the Stob Bàn — Loch Creran [NM 940 420] secondary synform, swinging eastwards cross-country under the influence of pitch. The pitch direction at Glen Coe is south-west and at Loch Creran [NM 940 420] north-east. Between lies the great pitch-depression of Glen Creran ((Figure 17), p. 112).

Moreover the schist geology of Glen Coe is the direct continuation of that exposed between Callert House and Callert Cottage, just across Loch Leven ((Figure 8), (Figure 9), pp. 50, 51). Stated in terms of shore exposures, its outstanding feature is the reappearance of the Ballachulish Slide at a boathouse north of Glen Coe House [NN 103 594] (Figure 10), two and a half miles east of where this slide goes underground at St. John's Church [NN 067 586] ((Plate 3); (Figure 7),

F, pp. 55, 48). This corresponds precisely with the reappearance of the same slide east of Callert, one and a half miles east-north-east of where it goes underground in the promontory marked by a black cross in (Figure 8). It will be remembered that recognition of the synformal disposition of the Ballachulish Slide in the Callert district follows from consideration of the Stob Bàn Synform — or alternatively of the Tom Meadhoin Antiform; and that a similar conclusion is deducible in the Glen Creran district from consideration of the Windows of Etive [NN 160 510]. Altogether the reader is advised to turn to the discussions starting on pp. 47, 64. More local, but less direct, evidence on the same point is afforded in the exposures of the Beinn Bhàn Synform and of the antiform separating this structure from the Gleann an Fhiodh Synform (p. 58). E. B. B.

Below is given a brief account of the geology of the Glen Coe district as a whole, such as can be followed at home with the help of Sheet 53. Then comes detail regarding the Loch Leven shore section north of Glencoe House [NN 103 594], to be followed by rather elaborate notes of an excursion up Glen Coe by the old road to Loch Achtriochtan and back by the new (Figure 10). After this, separate descriptions are supplied of exposures at Meall Dearg and Coire Mhorair, further east and iust across the ridge that bounds Glen Coe to the north.

General

On the shore north of Glencoe House [NN 103 594] banded Leven Schists (7) are brought by the Ballachulish Slide (B.S.) into contact with Appin Quartzite (4), which includes partial representatives of both its massive and its striped zones. Next westwards follows a thin band of Ballachulish Slates (5); and then, through the intervention of the Sgòrr a' Choise Slide, comes very slightly calcareous schist belonging to the middle part of the Ballachulish Limestone series (6) — for detail see p. 72.

The Appin Quartzite does not continue far inland along the Ballachulish Slide, while at the same time a less impure portion of the Ballachulish Limestone inserts itself along the Sgòrr a' Choise Slide. This is the general state of affairs for two miles south-east from Bridge of Coe [NN 104 589]. The less impure part of the limestone series corresponds with the grey micaceous limestone mapped in (Figure 8) south-east of Callert House.

At Clachaig Hotel the thin band of Ballachulish Slate fails, and banded Leven Schists (7) come into direct contact with impure Ballachulish Limestone (6), here in the condition of calc-silicate-hornfels (S11048) [NN 1246 5702]; (S11049) [NN 1280 5667]; (S15871) [NN 125 567]; (S15872) [NN 125 567]. The omitted unbanded portion of the Leven Schists is estimated at a couple of thousand feet thick. The section is an exact foretaste of what will be described in the Windows of Etive [NN 160 510] (p. 85), except that at Clachaig the Ballachulish Limestone (calc-silicate=hornfels) is considerably thicker.

East of Clachaig and north of Loch Achtriochtan, in the vicinity of the Cauldron-Subsidence of Glen Coe, the Ballachulish Core climbs up to the very summit of the ridge confining the glen, and is represented on its slopes by two large isolated outliers. The average inclination of the underlying Ballachulish Slide is 20° S.E., whereas, from Loch Leven to Clachaig, it is probably steeper and is consistently directed S.W. The swerve of strike may be partly due to sinking towards the cauldron-subsidence, but mainly it marks the S.E. limb of the Loch Leven Antiform of p. 23. A third, minor outlying patch has been located north of Meall Dearg [NN 163 585] (p. 80). In all three, marginal Ballachulish Slates are generally wanting; and banded Leven Schists below are more or less cut out. Accordingly the core-rock is almost wholly calc-silicate-hornfels (often little more than baked phyllite), and it rests very closely upon Glen Coe Quartzite except that, on the Glen Coe slopes, coarse porphyrite (Fault-Intrusion of Glen Coe) usually follows the plane of junction. The Meall Dearg [NN 163 585] exposure, though outside the main Boundary-Fault, lies just south of a subsidiary branch ((Figure 23), p. 156).

On crossing the main Boundary-Fault into the Cauldron-Subsidence we find in Coire Mhorair (p. 80) that Ballachulish Slates reappear, furnishing a narrow outcrop, while Ballachulish Limestone is developed in force, emerging from beneath unconformable lavas of the Glen Coe series ((Figure 24), p. 158). Without doubt the Ballachulish Slates and Limestone of Coire Mhorair belong to the Ballachulish Core, and equally certainly they pass (while hidden by later lavas) beneath greenish-grey phyllites that are well displayed to the south-west either side of Loch Achtriochtan ((Figure 7), E, F; (Figure 10)). It is obvious that these phyllites, thrown down by the Boundary-Fault of the Cauldron-Subsidence, must structurally

overlie the Ballachulish Limestone of the outlying patches outcropping just across this fault to the north-west. Obviously too, they form part of the great cover-spread of Leven Schists, which, outside the Cauldron, follows to the south of Ballachulish Limestone towards Glen Etive and Glen Creran. H. B. M., E. B. B.

Two facts of first class importance follow from examination of the metamorphic condition of these phyllites. The first is that they have escaped the contact-metamorphism characteristic of all neighbouring schists surrounding the cauldron-subsidence — this is a matter to be discussed in chapter 12. The second is that (making abstraction of contact-metamorphism) their regional metamorphism is manifestly lower than that of the Leven Schists belonging to the same great structural layer in its exposures close at hand outside the Cauldron-Subsidence. The safe inference is that regional metamorphism in this district decreased upwards, and that the great downthrow of the cauldron-subsidence has juxtaposed markedly different grades of regional metamorphism. The local detail, easily checked, is reserved for pp. 78–9. H. B. M.

A word of personal explanation is required. In the first edition of this memoir no mention is made of the contrast of regional metamorphism described above. Actually Maufe fully recognised its reality and significance, and often referred to it in conversation. Unfortunately he left for South Africa without supplying full notes for the memoir. The writer, to whom it fell to make good the deficiences, had no opportunity to check this particular point in the field; and, fearing the possibility of a mistake in a locality where contact-metamorphism complicates the issue, he left Maufe's views unrecorded in print. Confirmation, however, has been supplied in a paper by G. L. Elles and C. E. Tilley, to whom Maufe's observations had been communicated. They found the field relations as stated, though their own interpretation of evidence in neighbouring districts led them to expect the exact opposite (1930, p. 641); and the writer has since satisfied himself on the ground that Maufe was right. For similar evidence at Ben Nevis, see p. 179. E. B. B.

All that remains in this general account of Glen Coe is to say a few words about the relations of the Ballachulish Limestone of the glen to what we have called the cover-spread of Leven Schists. This cover-spread is divided for four miles south-westwards from Glen Coe by a tongue of Ballachulish Limestone (calcareous schist) constituting the upper half in this neighbourhood of the Ballachulish Core. Above lie the Leven Schists of Meall Mòr (Figure 10), while below come those of Allt na Muidhe [NN 110 550], resting in turn quite clearly on the lower half of the Ballachulish Core as developed east of Leacantuim [NN 117 577]. (Figure 10) supplies minor rectifications of mapping, not available for the 1948 edition of Sheet 53, and these serve to emphasise the tectonic beauty of the recumbent fold displayed between Clachaig and Meall Mòr with its limestone core outcropping in the north-west slopes of the glen holding Allt na Muidhe [NN 110 550]. H. B. M., E. B. B.

Now let us turn to detail.

Loch Leven Shore North of Glencoe House [NN 103 594]. — Thesection to be described lies close to, or along, the south-bank road to Kinlochleven, shown in (Figure 10), p. 70. The road here is, for half a mile, winding and wooded, and motorists visiting the section should park at one or other end, for traffic includes buses and lorries. The landmark is a boathouse about midway in the danger zone. The following measurements were made with a tape along the road from east to west. Very roughly they correspond to cross-strike figures:

	Yards
Boathouse stands on twisted and broken banded quartzite and mica-schist belongingto the banded edge (here quite broad) of the basement Leven Schists (7)	—
Gap through which, according to inland exposures, the *Ballachulish Slide* must run	53
Gritty Appin Quartzite (4), best seen on shore	8
Striped zone of Appin Quartzite (4)	30
Gap	55
Black Ballachulish Slates (5), well seen at road but not on shore	29
Gap including *Sgòrr a' Choise Slide*	32

Impure, grey, slightly calcareous schist belonging to the middle part of the Ballachulish Limestone (6), exposed for a long distance along both road and shore —

Road excursion, Glen Coe to Loch Achtriochtan

Since Glen Coe is so often visited the following roadside description is not confined to schist geology, so that to appreciate the significance of some of the topics introduced a reader may have to consult later chapters.

Lower Glen Coe has two roads, both maintained in good condition until they meet at Loch Achtriochtan (Figure 10). The old road, north-east of the river, follows approximately the course of the Ballachulish Slide, so that along it one has plenty of opportunity to hammer rocks near this critical position. On the other hand it hugs too closely the north-eastern slope of the glen, and is too thickly wooded, to do full justice to the geological landscape. In this respect the new road is exceptionally happy, and the views it affords of major structures are wonderfully impressive. The main schist groups concerned, Glen Coe Quartzite (8), Leven Schists (7) and Ballachulish Limestone (6), have sufficiently distinctive scenic expression to enable outcrops and field relationships to be followcd from a distance with the help of the one-inch geological map or (Figure 10) (which includes some minor corrections).

The excursion, as outlined, starts from and returns to Loch Leven, which helps in the appreciation of a very complicated stretch between Clachaig Hotel and Loch Achtriochtan. Visitors arriving at this loch in the opposite direction, from the east, should be able to grasp the main features of the Cauldron-Subsidence with its Boundary-Fault and associated Fault-Intrusion as illustrated in (Figure 20), p. 133; but they may easily lose themselves if they attempt, without further introduction, to disentangle the local schist story, the evidence for which has been cut to pieces by the Glen. Coe Fault-Intrusion and by somewhat later north-east dykes. They are therefore advised, after a halt at the west end of Loch Achtriochtan, to pass on fairly quickly beyond scattered outcrops of the Fault-Intrusion to a foot-bridge across the Coe close to the new road south-south-east of Clachaig Hotel, and to begin their detailed examination with Stage 2 (p. 75) followed by Stages 3–7.

First stage

The first stage of the excursion, as planned from the west, lies between Bridge of Coe [NN 104 589] and Clachaig Hotel; but the coastal exposure described above (p. 72) at the boathouse north of Glencoe House [NN 103 594] (County Maternity Horne) should, if possible, be studied in advance, along with the closely connected Callert evidence across Loch Leven (p. 50).

Bridge of Coe [NN 104 589] lies at the east end of Càrnach, often called Glencoe village, situated on a delta which the Coe built out post-glacially into the sea when high water stood at what is now 35 ft above O.D. The river beneath the bridge shows Ballachulish Limestone (6) in the form of a contorted phyllitic grey limestone, a good deal purer than anything seen at the boathouse (p. 72). On the east, hill slopes rise to the summit of the Pap of Glen Coe [NN 125 595], 2430 ft. Much of the intervening steep hillside is thinly covered by moraine, but it is clear that the greater part is fashioned out of quartzite, the Glen Coe Quartzite (8). This latter dips S.W. at about 75°, furnishing a complicated example of pitch (p. 23).

The limestone is separated from the quartzite by a narrow composite belt consisting of black schist, measuring about 50 yards across, followed to the northeast by grey phyllite (or mica-schist) with quartzite bands, about 400 yards wide. The black schist just mentioned is well seen at the roadside, 250 yards E. of the gate into the grounds of Glencoe House [NN 103 594]. The boathouse and Callert evidence proves conclusively that it is a reduced representative of the great Ballachulish Slates quarried in force only two miles to the west. Also, the boathouse, Tom Meadhoin [NN 085 624] (p. 52) and Stob Bàn (p. 47) evidence proves equally surely that the accompanying grey phyllitic mica-schist belongs wholly or almost wholly to the banded portion of the Leven Schists.

In their original mapping Peach and Maufe traced the Glen Coe black schist as a narrow band persisting almost to Clachaig Hotel; and Maufe, at any rate, rightly regarded it as a possible reappearance of the Ballachulish Slate formation.

He entertained this supposition at a time when as yet no one had dreamt of the existence of the Ballachulish Slide; he approached the subject of correlation through his recognition of the problem presented by the three-sided nature of the type outcrop of the Ballachulish Limestone. This latter is bounded at Ballachulish (Plate 3) by the great Ballachulish Slates, at Meall Mòr by the even greater Leven Schists, and at Bridge of Coe [NN 104 589] itself by the miniature Glen Coe black schist (Figure 10). The writer remembers the incredulity with which he first heard from Maufe of the possible correlation of black Ballachulish Slates and Glen Coe black schists. He can therefore sympathise with newcomers to the district, who may feel inclined to dismiss it as absurd.

The black schist (Ballachulish Slate) seen 250 yards E. of the gate to Glencoe House [NN 103 594], is in contact on its north-east margin with a banded group of grey phyllite or mica-schist, which carries some black seams and many interbeds of quartzite. It has not been possible as yet to decide whether this all belongs to the banded Leven Schists or whether a strip close to the black schist should be interpreted as part of the striped zone of the Appin Quartzite — undoubtedly present at the boathouse. In other words it is as yet uncertain whether the Ballachulish Slide lies exactly along the north-east margin of the black schist or a few yards further north-east. What is easy to appreciate is that the whole of the Ballachulish Limestone and of the immense unbanded portion of the Leven Schists is here missing between the Glen Coe black schists (Ballachulish Slates) and the Glen Coe Quartzite of the Pap.

The Coe runs close alongside the road at this point and furnishes further exposures of the black schist. Upstream an alluvial strath intervenes between river and road. At first the latter traverses thin moraine with a very few exposures of banded Levens. Then it crosses two great rubble cones discharged by tributary streams. Such cones are a characteristic feature of the north slopes of Glen Coe. The two of the present locality have come from gorges initiated along shatter-belts due to unimportant faulting — another common circumstance.

Beyond the deltaic cones the road for a short distance is bounded to the north by well-exposed banded Leven Schists. Very soon, however, at a gentle curve to the left, it runs for 250 yards at the foot of a dark wooded slope, mapped as black schist. Specimens can be collected from two small neighbouring intrusions of appinite. The more southerly lies in the black schist, and is crossed by a wall that runs up the hillside close to a minor stream. The more northerly (S11036) [NN 1152 5810]; (S11037) [NN 1158 5810], with aplitic veins (S11906) [NN 1162 5817] and associated "granite" (S11038) [NN 1164 5806], has intruded banded Levens and is exposed 50 to 300 yards E. of the wall. The hornblendes of the more northerly appinite are sometimes three inches long.

At the next gentle bend, this time to the right, the road passes on to an exposed continuation of the phyllitic limestone (Ballachulish Limestone) last seen at Bridge of Coe [NN 104 589], now a mile distant. The exposures of the calcareous group form picturesque mounds and are no more than openly wooded. They are at first confined to the north of the road, but soon extend to the south, where we find Leacantuim [NN 117 577] farm and a Scottish Youth Hostel, Glen Coe [NN 117 577], and, further on, two artificial fish-ponds. The famous Signal Hill [NN 125 567], marked by a triangle on (Figure 10) just S.W. of Clachaig Hotel, is the most conspicuous of these calcareous knolls. Upon it, according to unconfirmed tradition, a fire was kindled to advertise zero hour for the 1692 massacre.

Walkers, as soon as they realise they have reached the Ballachulish Limestone, should temporarily leave the road and follow instead the margin of this formation, which for the next mile lies a little to the north. Even those who are tied to transport should park and carefully examine the rocks of the locality. A minor point of interest is that there is some impure grey carbonaceous limestone studded on its weathered surface with roughly isometric crystals of albite, measuring half a centimetre across and packed poecilitically with calcite granules (S39694) [NN 1171 5794] — a very unusual mineral development for Scotland. This albitic limestone carries rather smaller porphyroblasts of phlogopitic biotite. The neighbouring banded Levens occasionally show garnet.

Of much more importance is the fact that the Ballachulish Limestone is separated from banded Leven Schists on the north-east by a shallow hollow in which exposures of the black or dark grey mica-schist (Ballachulish Slate horizon) can readily be found, sometimes containing garnet (Elles and Tilley 1930, p. 640). About a quarter of a mile east of the beginning of its exposures, this black schist can be seen firmly welded on to banded Leven Schist. Mere examination of the junction would not justify anyone in affirming, or denying, the presence of the great Ballachulish Slide, which must here separate the two formations. Three hundred yards west of Clachaig Hotel the Ballachulish Limestone crosses wholly

to the south side of the road. Just about this point the Ballachulish Slate outcrop fails. It must reach the road, since it is represented by dark grey mica-schist on both sides of a fence immediately to the north; but south of the road, exposures soon show that it no longer separates Ballachulish Limestone from banded Levens. The Ballachulish Limestone is here in the condition of calc-silicate-hornfels owing to the proximity of the Glen Coe Fault-Intrusion.

Second stage

We have now reached the second stage where the geology of the glen centres naturally on Clachaig Hotel. The hotel itself stands on Glen Coe Quartzite dipping west at about 45°. In this direction the quartzite passes under banded Leven Schists whose outcrop measures some 75 yards across. They are mostly seen in a ragged plantation, where they are cut by an unusually large porphyrite dyke running for the time being north and south.

Back along the road, at a hundred yards north-west of the hotel, the plantation is bounded by a wall running S.W. If, leaving the road, one follows this wall for 75 yards, one traverses nothing but banded Leven Schists, until, just before reaching a gentle bend to the left, one finds these banded Levens passing under the calc-silicate-hornfels representative of the Ballachulish Limestone. See chapter 18 for description of unusual specimens, (S11048) [NN 1246 5702]-(S11049) [NN 1280 5667]; (S15871) [NN 125 567]; (S15872) [NN 125 567]. Here then we have one of the most easily located exposures of the Ballachulish Slide, cutting out the pure portion of the Ballachulish Limestone and the great unbanded portion of the Leven Schists.

The Clachaig exposures are duplicated at and near a foot-bridge over the Coe 300 yards S.S.E. of the hotel. We shall give this locality further attention in the sixth stage of our excursion, when we pass close by on the return journey along the new road. Meanwhile north of the hotel we see descending from the quartzite mountain of Sgòr nam Fiannaidh [NN 137 584], 3168 ft, a stream that has etched a gorge, for long unclimbed. Here again is an example of the ease with which erosion can attack smashed rock along a minor fault. Debris, swept down to form a spreading fan, extends to the margin of the road.

East of the debris chute are crags of Glen Coe Quartzite, with perhaps some little that might be ascribed to banded Levens. The bedding is often obvious, and, in a general way, has an antiformal disposition with steep south-westerly pitch. Thus, while along the north slope of Glen Coe from the mouth of the glen to Clachaig dip has been steeply S.W., at Clachaig it swings round to the S.E. and continues so to the Boundary-Fault of the Cauldron-Subsidence.

The crags of quartzite overlooking the debris chute are surmounted by obviously softer rocks. These are calc-silicate-hornfels and represent Ballachulish Limestone riding on the Ballachulish Slide. What is seen from the hotel is merely the start of an extensive cake which reaches half a mile uphill and for the same distance eastwards to the mouth of Loch Achtriochtan. Superposition of the calc-silicate-hornfels on the quartzite is very clear in the view from the hotel; but the actual junction is obscured by the fact (recognised by Peach) that it has on this, the north side of the glen, located an important irregular sill of the Glen Coe Fault-Intrusion. The Fault-Intrusion hereabouts is a coarse porphyrite, pink or grey, and it has flooded the quartzite (and banded Leven Schists) below the Ballachulish Slide, whereas it has scarcely entered the overlying calc-silicate. The probable cause of this relative impermeability is the felted texture of the calcsilicate, held together by minute needles of tremolite.

The irregular flooding of the quartzite by Fault-Intrusion is illustrated in an easily visited small quarry 200 yards E. of the hotel. A more interesting exposure is afforded by a pronounced little antiform seen 300 yards N.E. of the hotel (at Creag nan Gobhar, the Goat's Crag, on the 6-inch map). Here there are several irregular intrusions of Fault-Intrusion, which Peach (almost certainly correctly) held responsible for the antiform; but to do justice to the evidence one must be prepared to spend a couple of hours and undertake a definite scramble.

Third stage

The third stage is the final outward part of the excursion. It begins where the old road comes to the river bank a quarter of a mile east-south-east of Clachaig Hotel; and it ends at Loch Achtriochtan [NN 145 566]. Until the Boundary-Fault of the Cauldron-Subsidence is reached the northern face of the glen is mainly occupied by calc-silicate-hornfels (Ballachulish Limestone) in two closely adjacent cakes that measure respectively half a mile by half and three-quarters of a mile by a

quarter. These two cakes are plastered, as it were, on the steep hill side. We have already viewed the western margin of the more south-westerly cake when we stood in front of Clachaig Hotel. The northern tip of the more north-easterly extends to over 3000 feet above sea level where it reaches the summit ridge of Sgòr nam Fiannaidh [NN 137 584]. With a geological map to help, it is easy to recognise these two cakes in the local scenery (especially if one looks from the new road across the river). Both present what seems in the local setting a strangely smooth surface, due to the nature of their material uninterrupted by Fault-Intrusion. The surrounding ground occupied by Fault-Intrusion ramifying among quartzite and banded Levens offers strongly contrasted irregularity.

The pronounced south-easterly dip of the calc-silicate cakes would, if uninterrupted, provide a valley-bottom outcrop connecting with the broad band of Ballachulish Limestone that has been traced from Bridge of Coe [NN 104 589] to Clachaig. Actually, however, a gentle east-west antiform must run along the bottom of the glen, for most of the river exposures show rocks a little below the Ballachulish Slide. These consist of banded Leven Schists along with Glen Coe Quartzite, both irregularly cut by and impregnated with Fault-Intrusion. There are in addition later porphyrite dykes. The Glen Coe Fault-Intrusion here is coarse porphyrite or plutonic equivalent, grey (S10307) [NN 129 565] or pink. At, and west of, a conspicuous salmon ladder it is grey; while further upstream, 150 yards W. of the bridge that brings the new road across the Coe, it is pink and much resembles common types of the later N.E. porphyrite dykes. At the salmon ladder the grey Fault-Intrusion is seen in contact only with banded Levens; whereas the more easterly pink outcrop separates banded Levens, downstream, from calc-silicate-hornfels, upstream. This last belongs to the first of the two hillside cakes. The following four exposures of the calc-silicate can easily be identified: (1) 100 yards downstream from the road-bridge, between the pink Fault-Intrusion of the river bed and the adjacent road (S39692) [NN 1352 5663]; (2) immediately downstream from the bridge and east of the pink Fault-Intrusion of the river bed; (3) in a roadside quarry facing the bridge where the old and new roads meet (S39693) [NN 1384 5665]; (4) just above the road on the loch side, 300 yards N.E. of the bridge.

The quarry at the bridge exhibits a variety of rocks: at its east side is calcsilicate-hornfels; further west, there is a broad pink porphyrite dyke which to the south furnishes the foundation of the bridge; further west again is pink Fault-Intrusion, xenolithic and ramifying, the obvious continuation of the pink Fault-Intrusion of the river bed just across the old road. At one point in the quarry the Fault-Intrusion cuts a dark hornfelsed mica-schist, which is not calcareous and yet is unlike Leven Schist — it is probably much-altered Ballachulish Slate just above the Ballachulish Slide.

South of the river, hornfelsed mica-schist (S39695) [NN 1387 5664], exactly like the probable much-altered Ballachulish Slate of the quarry, is seen in a cutting of the new road 50 yards W. of the bridge. This is followed westward by a 50-yard exposure of pink Fault-Intrusion on the southward continuation of the quarry and river outcrop. To the west again in the road cutting, as in the river, come banded Leven Schists. It is obvious that the quarry, river and new road exposures of pink Fault-Intrusion, separating, as they do, the more south-westerly cake of calc-silicate=hornfels from banded Leven Schists, must belong to the irregular sill that Peach mapped below the calc-silicate on the steep hillslope to the north.

Fourth and furthest east stage

The fourth and furthest east stage of our road excursion is located approximately at the western end of Loch Achtriochtan. Here we obtain the wonderful view of the south slopes of the glen depicted in (Figure 20), p. 133. We have reached the Boundary-Fault of the Cauldron-Subsidence of Glen Coe, and are looking at a natural cross-section, truly impressive. To the east are preserved down-thrown Devonian volcanic rocks resting unconformably on much older phyllites (Leven Schists). Together these have sunk deep within the Cauldron-Subsidence. To the west we see An t-Sròn, made of a "granitic" Fault-Intrusion which in molten condition rose outside the Boundary-Fault as the rocks inside went down thousands of feet. We leave the Devonian lavas for later consideration in chapter 11; but the Fault and Fault-Intrusion require further attention here, as also the schists.

The gorge marked "fault" with "chilled margin of granite" in (Figure 20) is easily identified. This gorge has been guided by shattering, which is of later date than the main faulting since it has broken the smooth chilled edge of the "granite" into fragments.

An independent point of interest is that the Boundary Fault changes course appreciably where the firm line representing it in the sketch (Figure 20) passes downhill into an interrupted line. With the help of an air photograph it is easy to see that the attendant later shatter-belt continues downhill without this deviation, and crosses the old road just west of the bridge quarry, thence to continue for a mile up the north face of the glen, a conspicuous feature-maker. Similarly, shattering along the deviated line of the Boundary Fault, shown by a broken line in (Figure 20), continues uphill and is responsible for the erosion of the minor gorge appearing above the word "granite" in our sketch.

Mapping indicates that the deviated Boundary-Fault must pass through the River Coe [NN 155 569] practically where the latter leaves Loch Achtriochtan; and actual fault-rock is here exposed just downstream from a foot-bridge. It is a dark, almost flinty rock, totally unlike anything else in the neighbourhood. Microscopic examination reveals that it (S39696) [NN 1383 5663] has probably been derived by baking from flinty crush-rock (p. 160). Much of its substance seems to have been provided by comminution of the very impure Ballachulish Limestone that here margins the fault, but it retains no textural vestige of schistose antecedents. Minute grains of quartz are easily recognised, either in trains or more often isolated. An abundant matrix can be largely resolved by a high power into unorientated flakes of biotite and prisms of tremolite.

The "granite" that represents the Fault-Intrusion in An t-Sròn ((Figure 10), (Figure 20)) has behaved very differently from the much more dispersed porphyrite versions of the same exposed in the River Coe [NN 155 569] and on the north slopes of the glen. Instead of being confined below the layer of calc-silicate-hornfels, it has burst through, high into the great cover of Leven Schists. It is full of quartzite xenoliths, and may perhaps have blasted its way explosively. Its eastern margin, let us repeat, is smooth and chilled against the downthrown lavas and phyllites within the cauldron, while its western margin is irregular and unchilled. In keeping, its contact-metamorphism is almost wholly restricted to the rocks outside the Boundary-Fault. This is easily checked by comparing the hornfelsed condition of the various groups of schist seen downstream from the road-bridge with the unhornfelsed state of the phyllites (Leven Schists) within the cauldron. The latter are conveniently sampled a quarter of a mile to the north-east, where the combined road leaves the shore of Loch Achtriochtan (S39688) [NN 1437 5699].

The Loch Achtriochtan basin, two-thirds choked with alluvium, lies wholly on the phyllite outcrop. It is a shallow rock basin, overdeepened, as Maufe first pointed out, by selective glacial erosion. As a rule the phyllite has behaved as the most easily eroded rock of the vicinity. (Figure 20), however, shows a local contradiction, where phyllite knobs overlook adjacent fault-intrusion. In this case it is probable that with increasing bulk in An t-Sròn [NN 134 550] the Fault-Intrusion has succeeded in indurating a narrow belt of phyllite without notably changing its general appearance.

The effect of the Boundary-Fault on the distribution of regional metamorphism has already been discussed rather fully (p. 71). To appreciate it in the field one should compare the condition of the downthrown phyllites (S39688) [NN 1437 5699], mentioned above, with that of garnetiferous mica-schists to be described below along the new road 500 yards W. of the footbridge S.S.E. of Clachaig Hotel (S39690) [NN 1244 5634] and again at Achnacon [NN 119 566] farm (S39689) [NN 1179 5663].

Fifth stage

The fifth stage finds us going homeward by the new road as far as the foot-bridge over the Coe, S.S.E. of Clachaig Hotel [NN 128 567]. It repeats points already dealt with in stage (3) of the excursion — d, p. 79.

Sixth stage

The sixth stage is based on the foot-bridge just mentioned. This lies close to the new road, and is built on Glen Coe Quartzite dipping 45° S.W. under banded Leven Schists. These in turn pass under calc-silicate-hornfels well exposed in a road-cutting, at the east end of which stands a conspicuous boulder. With these guides and with the help of (Figure 10), a geologist will probably be able to read the view spread out before him for a couple of miles. It affords one of the most spectacular illustrations of recumbent folding coupled with sliding that Scotland has to offer, in descending order as follows:

f. In the distance, unbanded Leven Schists (7) of Meall Isar summit

e. Impure Ballachulish Limestone (6) of Meall Mòr slopes stretching S.W. from Achnacon [NN 119 566]

d. Unbanded Leven Schists (7) of Allt na Muidhe [NN 110 550]

c. Impure Ballachulish Limestone (6) of the road-cutting 300 yards from where we stand; here it is calc-silicate-hornfels, but it continues as impure, unbaked limestone past Leacantuim [NN 117 577] to Bridge of Coe [NN 104 589]

Ballachulish Slide

b. Banded Levens (7) at our feet, crossing to the old road at Clachaig and continuing thence to the boathouse on Loch Leven

a. Glen Coe Quartzite (8) also at our feet, providing foundation to the foot-bridge and extending past Clachaig into the Pap of Glencoe

Seventh stage

7. In the seventh stage a traverse from this foot-bridge S.S.E. of Clachaig along the new road past Achnacon [NN 119 566] to Loch Leven will allow us to sample all but the topmost item (f) of the above structural succession.

(a) The Glen Coe Quartzite a little downstream from the bridge shows current-bedding, almost certainly right-way-up, as might be expected.

(b) Banded Leven Schists are very poorly exposed between the foot-bridge and the new road, but sufficiently to justify the assumption that they form part of a continuous outcrop reaching north through the ragged plantation west of Clachaig. The dip is S.W. at 35°.

(c) The cutting exposure on the new road showing talc-silicate-homfels is excellent. Only a few of its beds retain mica dating from the regional metamorphism. The dip is westerly at 45°, with contortions. South of the road this talc-silicate outcrop can be followed for 300 yards south of east until cut off by the An t-Sròn "Granite". North of the road it crosses the Coe at a gorge to join the Signal Hill [NN 125 567] exposures leading north-westwards past Leacantuim [NN 117 577] to Bridge of Coe [NN 104 589]. Signal Hill [NN 125 567] is shown by a triangle in (Figure 10).

The gorge just mentioned has other interests. Its eastern beginning is eroded in a large porphyrite dyke, already mentioned in the plantation west of Clachaig. Its greater part, however, follows for a quarter of a mile an east-north-east dyke of hornblende-lamprophyre, sometimes 10 feet thick. A specimen collected by Peach is so coarsely crystalline that it might be classed with the appinites (S11612) [NN 1126 5486]. In fact, before the name appinite was introduced it had been suggested to call the rocks concerned clachaigite on the strength of this specimen. Detailed examination is difficult unless the Coe is exceptionally low. It has, however, been found that the dyke is often a normal hornblende-lamprophyre, sometimes veined and sometimes cut to pieces by aplite (S39702) [NN 1240 5643]; (S39703) [NN 1247 5647]; (S39704) [NN 1247 5647]; (S39705) [NN 1247 5647], presumably cognate. The reaction phenomena are as might be expected.

(d) On emerging from the cutting in calc-silicate-hornfels the road runs west on a low parapet; but to the north, especially along the continuation of the Coe gorge (here spanned by a tourist foot-bridge leading to Signal Hill [NN 125 567]), there are excellent exposures of typical unbanded Leven Schist, somewhat garnetiferous (S39690) [NN 1244 5634]. To begin with, the schist is clearly affected by contact-alteration; but its garnets undoubtedly belong to the regional metamorphism of the district. Other good exposures with garnets easy to see occur where the road crosses Allt na Muidhe [NN 110 550] and in a cutting near Achnacon [NN 119 566] farm (S39689) [NN 1179 5663].

By the time it has reached Achnacon [NN 119 566] this Leven Schist outcrop (d) is seen to separate the Signal Hill [NN 125 567] — Leacantuim [NN 117 577] band (c) of Ballachulish Limestone from its fellow (e). The latter is of identical stratigraphical material, but is mounted at a higher level on the structural ladder, so that from the slopes of Meall Mòr[NN 100 560] it overlooks the farm. Admittedly the north-westerly continuation past Achnacon [NN 119 566] of the Leven Schists in the (d) position is largely obscured by valley-bottom alluvium; but there is a small typical exposure beside a

rough track, 250 yards N. of the farm. It lies 150 yards N.E. of the new road, along which for a space no solid rock is found.

(e) The great tongue of calcareous schist (Ballachulish Limestone) outcropping along the south-eastern slopes of Meall Mòr can readily be appreciated in the view; but N.W. of Achnacon [NN 119 566], for 800 yards, no rocks are seen at the roadside. Then at frequent intervals until Loch Leven is reached there are numerous rather poor exposures of greatly contorted impure calcareous schist. The most interesting of these lies almost due W. of Leacantuim [NN 117 577] farm which stands on the other side of the river. Here in a stream that passes under the new road, and also in the bank of the road, Maufe found the impure calcareous schist to contain a band or bands of white limestone such as is commonly seen elsewhere at unbroken contacts of Ballachulish Limestone and Leven Schist. It is therefore probable that the Leven Schist outcrop (d) extends under alluvium very nearly to this spot. There is no chance of a further extension, except as a very narrow band, for nearby the Coe gives exposures referable to the Leacantuim [NN 117 577] belt (c). Approximately, therefore, the Meall Mòr(e) and Leacantuim [NN 117 577] (c) outcrops of Ballachulish Limestone unite east of Leacantuim [NN 117 577].

To avoid breaking the continuity of theme, no mention was made when we passed Allt na Muidhe [NN 110 550] and Achnacon [NN 119 566] of three important geological views well seen from these localities. The first centres on a cap of Glen Coe Quartzite resting on Leven Schist in Beinn Maol Chaluim [NN 140 520] beyond the head of Fionn Ghleann [NN 124 550], 3 miles S.S.E. of Achnacon [NN 119 566] (p. 87). The second is focussed on a craggy summit ridge called Aonach Dubh a' Ghlinne [NN 120 530] (Black Ridge of the Glen) composed of Leven Schists baked by the An t-Sròn "Granite" on the west side of Fionn Ghleann [NN 124 550], one mile S. by E. of Achnacon [NN 119 566]. The third is of glacial interest and concerns deposits near the junction of the river of Fionn Ghleann [NN 124 550] with Allt na Muidhe [NN 110 550], half a mile south of Achnacon [NN 119 566]. For half a mile upstream from the junction, the bottom of Fionn Ghleann [NN 124 550] displays three remarkably fine fluvioglacial fans, developed preferentially on the south-west of the stream; while the combined river is paralleled, this time on its east side, by an uncommonly continuous morainic ridge carrying a footpath which joins the road near a sheepfold. The detailed position of the various ice-fronts involved has not yet been worked out.

In addition to these more or less localised views, the new road affords an excellent chance of following in the scenery the various outcrops that accompany the old road together with the backing of Glen Coe Quartzite in the ridge connecting the Pap with Sgòrr nam Fiannaidh [NN 137 584]. Also, looking north-west across Loch Leven, one can easily pick out the rounded summit of Tom Meadhoin [NN 085 624]. Here, it will be remembered, the Glen Coe Quartzite rises antiformally from under Leven Schist ((Figure 9), p. 51) in marked contrast with its cap-relationship in Beinn Maol Chaluim [NN 140 520].

Mean Dearg

The Meall Dearg [NN 163 585] outcrop of the Ballachulish Core and Slide is illustrated in (Figure 23), p. 156. The core, consisting of talc-silicate-hornfels, is seen as a strip north of a felsite dyke that is earlier than the porphyrite Fault-Intrusion making Meall Dearg [NN 163 585]. Undoubted "cover" Leven Schists are exposed to the south just across this dyke (lettered PH. for phyllite).

The geology north of the talc-silicate strip is very confused by outcrops of Fault-Intrusion, all of which are not strictly synchronous. Exposures are sometimes poor. There is, however, practically no doubt but that the talc-silicate lies on the downthrow side of a branch of the main fault bounding the Glen Coe Cauldron-Subsidence. It also seems to be sharply downfolded by secondary folding earlier than this subsidence. Exposures east of the Meall Dearg [NN 163 585] ridge show what is interpreted as banded Leven Schists (phyllites) followed by Glen Coe Quartzite. The short outcrop of Ballachulish Limestone indicated in (Figure 23) north of the banded Leven Schists has been drawn through ground covered by glacial drift.

Coire Mhorair

Metamorphic sediments emerge in Coire Mhorair [NN 185 585] from below uptilted Devonian lavas within the Cauldron-Subsidence of Glen Coe, and exposures are all that could be desired (Figure 24). Dips throughout are very steep, and the strike is roughly east and west. The succession of outcrops from south to north is as follows: (a) Devonian lavas; (b) thin Devonian shales; (c) unconformity; (d) thick, pale grey, very micaceous limestone, not contact-altered, belonging to the middle part of the Ballachulish Limestone (6); (e) Sgòrr a' Choise Slide — S.A.C.S.; (f) black Ballachulish Slates (5) (as schists) along with striped zone of Appin Quartzite (4), together 60 feet thick; (g) Ballachulish Slide — B.S.; (h) crags of Glen Coe (or older) Quartzite (8, 10 or 12 of chapter 7); (i) southern branch of Boundary-Fault of Cauldron-Subsidence, succeeded by porphyrite as Fault-Intrusion.

The striped Appin Quartzite, grouped with the black slates, or schist, in (Figure 24), can be seen gradually creeping across successive bedding planes of the Glen Coe (or older) Quartzite, clearly marking the course of the Ballachulish Slide. The locality can be recommended to all who wish to walk for a considerable distance along a bare, obviously transgressive, major slide. A party may well visit it in conjunction with neighbouring exposures of the Boundary-Fault of the Cauldron-Subsidence (p. 158). The Ballachulish Slates are really schists, much more metamorphic, for instance, than the Leven Schists at Loch Achtriochtan, and carry garnet (S12924) [NN 204 577].

The quartzite listed as (h) north of the Ballachulish Slide (g) is shown as Glen Coe Quartzite in Section BB of Sheet 53, but is more guardedly called Glen Coe or older in the account just given. Caution is required, for there are three fine-grained quartzites in the Loch Leven succession, namely Glen Coe (8), Binnein (10) and Eilde (12), that cannot be safely distinguished in isolated exposures. It is natural to think of the Coire Mhorair [NN 185 585] outcrop as belonging to the Glen Coe Quartzite if one approaches from the west, where the Ballachulish Slide is almost always separated from the Glen Coe Quartzite by a layer of banded Leven Schists; but when presently we consider the district from Altnafeadh [NN 222 563] to Coire an Easain [NN 250 496] we find that other possibilities must be admitted.

Immediately east of Coire Mhorair lies Coire Odhar-mhòr [NN 196 583], from which two streams drain northward (Figure 24). Here we find quartzite occupying the whole space between two branches of the Boundary-Fault of the Cauldron-Subsidence. It may be the same quartzite as in Coire Mhorair. At any rate it is certainly of Glen Coe, Binnein or Eilde age. The Coire Odhar- mhòr quartzite dips steeply more or less south-west. Beyond to the north the country-rock consists of quartzo-felspathic micaceous flags (Eilde Flags, 13, of chapter 7), with a band of quartzite — infolded or interstratified, we do not know.

This broken succession of outcrops brings home to us very vividly that the Ballachulish Limestone of Coire Mhorair [NN 185 585], within the Cauldron-Subsidence, structurally overlies the Eilde Flags exposed outside in Coire Odhar-mhòr [NN 196 583]. Turn now to one-inch Sheet 53, and our view expands. Clearly the Ballachulish Limestone from the mouth of Glen Coe all the way to Coire Mhorair overlies the quartzite, mica-schist, flag assemblage that crosses Loch Leven and River Leven from the mouth of the Coe to at least two miles upstream from Kinlochleven.

Also it is clear that the quartzite or quartzites of Coire Mhorair [NN 185 585] and Coire Odhar- mhòr [NN 196 583] intervene structurally between the Ballachulish Limestone of Coire Mhorair and the Eilde Flags of Coire Odhar-mhòr [NN 196 583].

H. Altnafeadh [NN 222 563] South-east by Càm Ghleann to Coire An Easain

Proceeding east for half a mile from the outcrop of Ballachulish Limestone at Coire Mhorair, and keeping south of the southern branch of the Boundary-Fault of the Glen Coe Cauldron-Subsidence, one crosses the Devonian volcanics of (Figure 19), eventually reaching their margin. Unfortunately on the summit ridge this is hidden under drift; but down the slope, a mile east-south-east of the Coire Mhorair limestone, Devonian sediments underlying agglomerate are seen resting unconformably on Eilde Flags — micaceous quartzo-felspathic flags of psammitic "Moine" type (13 of chapter 7. *Cf.* Barrow 1904).

From this point sufficient exposures show that Eilde Flags emerge from under the Devonian volcanic pile all the way downhill to the Glen Coe road; and that, apart from igneous interruptions, these flags extend along the latter past Altnafeadh [NN 222 563] until the volcanics meet the Boundary-Fault of the Cauldron-Subsidence. The strike of the flags

is south-east, roughly parallel with that of the quartzite of Coire Odhar-mhòr [NN 196 583]; and dips are steep, perhaps more often southwest than north-east.

Within the flag area, just outlined north of the road, there is an important quartzite outcrop at Stob Mhic Mhartuin [NN 207 575] (2300 ft, (Figure 19), (Figure 26)). Its beds also strike south-east and stand about vertical. Downhill this quartzite is lost sight of under drift; and as it does not reappear in exposures nearer the road it is mapped in Sheet 53, diagrammatically, as folded out.

Across the road the Eilde Flag belt can be traced by exposures in stream courses to about a mile beyond Càm Ghleann [NN 247 515], always with south-east strike and steep dips (Figure 29). The Ballachulish Limestone and associated quartzite of Coire Mhorair [NN 185 585] must lie on the south-west side of this belt, though the limestone for half a dozen miles is hidden by the Devonian lavas. In keeping with this, fine-grained quartzite with south-east strike emerges from beneath the lavas at the foot of Stob Dearg [NN 225 543] and continues for two miles south-eastwards to Glen Etive.

The maximum cross-strike width of the steep Stob Dearg [NN 225 543] quartzite is 400 yards; that of the Coire Odhar-mhòr [NN 196 583] quartzite is 300 yards; and that of lava-covered space through which the Coire Mhorair quartzite can be expected to run to separate the Coire Mhorair limestone, seen to the west, from the Eilde Flags, seen to the east, is also 300 yards. It follows that the Stob Dearg [NN 225 543], Coire Odhar-mhòr [NN 196 583] and Coire Mhorair quartzites appear to be identical. They all belong to the Glen Coe — or older — category. The direct association with Eilde Flags (13) at Stob Dearg [NN 225 543] suggests that all of them are Eilde Quartzite (12). In this case the Ballachulish Slide at Coire Mhorair has cut out everything between the striped zone of the Appin Quartzite (4) and the Eilde Quartzite (12). This, however, is not established. E. B. B.

The Stob Dearg [NN 225 543] outcrop of quartzite disappears under Devonian lavas in Glen Etive in the north-west corner of (Figure 29). When, much diminished, it reappears two miles further south it soon turns to run south-westwards across the burn that drains Coire an Easain [NN 250 496]. Here the stream section maps south-eastwards as follows:

Devonian agglomerate (called breccia in (Figure 29))

Unconformity

Thick hornfelsed garnetiferous mica-schist (Leven Schist, 7, cover of Ballachulish Core)

Thin calc-silicate-homfels (Ballachulish Limestone, 6, of Ballachulish Core)

Ballachulish Slide (only indicated by a note in (Figure 29))

Thin quartzite (reappearance of Stob Dearg [NN 225 543] outcrop of Glen Coe, or older, Quartzite)

Eilde Flags (13)

North-west branch of Boundary-Fault of Cauldron-Subsidence (heavy line, (Figure 29))

Narrow Early Fault-Intrusion

Eilde Flags (13)

South-east branch of Boundary-Fault (heavy line, (Figure 29))

Broad Main Fault-Intrusion

Eilde Flags, very extensive along River Bà [NN 240 472]

The general dip is westerly so that the Leven Schists appear on local evidence to be the highest schist member here exposed within the Cauldron-Subsidence; and this appearance is emphasised by the great spread of Eilde Flags outside

the subsidence. Mica-schist shown in (Figure 29) at the south end of the Moor of Rannoch Pluton, although of similar character to the mica-schist listed above, clearly belongs to the Reservoir outcrop (p. 108) which, further north, emerges from below Stob Quartzite and Eilde Flags. C. T. C., E. B. B.

If instead of taking a local view we look back to Coire Mhorair and Glen Coe, we get the same answer. We are certainly dealing with Ballachulish Limestone in one and the same structural position all along the line, though connecting links are hidden under Devonian lavas. We have already realised that from the mouth of the Coe to Coire Mhorair this layer of limestone overlies the assemblage of quartzite and mica-schist that outcrops to the north. It follows of necessity that from Coire Mhorair to Coire an Easain [NN 250 496] the limestone overlies the predominantly flag assemblage that outcrops to north-east and (at Coire an Easain [NN 250 496]) to southeast.

In keeping with this, six miles to the south-east, what is taken to be Ballachulish Limestone with the same tectonic setting has been described as outcropping at a low angle well up in the escarpment of Beinn Doirean [NN 326 379] (Bailey and Macgregor 1912, pl. x, where the scale should have been drawn $_{z}$ inch to 1 mile). Similarly, eighteen miles to the north-east in the Ben Alder country beyond Loch Ossian [NN 390 680], Carruthers has shown that the well known Loch Laggan [NN 480 860] Limestone is disposed in a synform overlooking Moine surroundings. He does not call this limestone Ballachulish Limestone, but he does say that it and its immediate associates seem "to represent a reappearance of some members of the Lochaber Series", which amounts practically to the same thing (1923, p. 34). J. G. C. Anderson has recently continued the mapping of this limestone, and has published a very valuable map extending north-east to the Monadhliath Mountains. Readers are recommended to study his paper very carefully (1956).

Returning to Sheet 53 we may note that Coire an Easain [NN 250 496] lies six miles southeast of Coire Mhorair, but only four miles east of the Windows of Etive [NN 160 510], whither we now go.

1. Glen Coe to Glen Creran and Glen Etive

Introduction

Our present district is roughly triangular in shape, and mostly falls within the drainage basin of Glen Creran. Its north-westerly portion is limited by a complicated outcrop of Ballachulish Limestone (described under the Ballachulish and Glen Coe headings, E, G), which reaches from Glen Coe to Glen Creran and Glen Ure [NN 070 475]; while its eastern angle is bounded by the Cauldron-Subsidence of Glen Coe and the Cruachan Pluton, these two meeting in Glen Etive.

In previous pages we have defined the core of the recumbent Ballachulish Syncline as the part which consists of Ballachulish Limestone and younger formations. We have then traced the outcrop of this core, and found that it constitutes a polygonal ring which, in spite of being breached by the Cruachan Pluton, in large measure surrounds our district. Commencing in the south-west at the margin of the pluton, the. following localities may be recalled as markers: Glen Ure [NN 070 475] and Loch Creran [NM 940 420] ((Plate 4), reaching S. of Sheet 53), Gleann an Fhiodh [NN 080 560] (Plate 3), Bridge of Coe [NN 104 589] and Loch Achtriochtan (Figure 10), Coire Mhorair (Figure 24), Coire an Easain [NN 250 496] ((Figure 29), E. margin of Sheet 53).

In our accounts we have continually emphasised that this ring-outcrop has two contrasted sides. The formations outcropping outside the ring serve as a foundation to the core in a big sense, that is they underlie it if we disregard steep secondary inversions; while the formations (in large measure stratigraphically identical) that outcrop inside the ring function as a cover to the core similarly interpreted. The reader is referred to discussions already given in connection with Stob Bàn (p. 47), Glen Creran [NN 030 480](p. 64), Coire Mhorair (p. 81) and Coire an Easain [NN 250 496] (p. 82).

There is only one fairly large-scale complication in this connection, and it is due to the Ballachulish Core in Glen Coe locally dividing into a lower and an upper portion, in the (c) and (e) positions of p. 78.

The Leven Schist cover just referred to is responsible for much the greater part of the surface of our present district stretching from Glen Coe to Glen Creran [NN 030 480] and Glen Etive. After describing it in some detail, we shall take

the following subjects in order: the Windows of Etive [NN 160 510], opened by erosion in this wide-spread cover; caps of Glen Coe Quartzite, locally surmounting the same; and a problematical quartzite at Beinn Ceitlein, outcropping in the angle between two branches of the Boundary-Fault of the Glen Coe Cauldron and cut across by an offshoot of the Cruachan Pluton, where this advances northward into the sunken area.

Since the Ballachulish Limestone round the Glen Creran area seems everywhere to make essentially unbroken contact with the Leven Schist cover, and since current-bedding elsewhere in both Appin and Glen Coe Quartzites proves Ballachulish Limestone to be younger than Leven Schists, the district affords a splendid example of large-scale inversion. This inversion, however, does not affect the Glen Coe Quartzite of the caps, so far at least as they have been examined for current-bedding. The quartzite here is right-way-up and is separated by slides from the Leven Schists below, Nor, of course, does the Glen Creran Inversion affect the Glen Coe Quartzite exposed below the Ballachulish Slide in the Windows of Etive [NN 160 510]. E. B. B.

Leven Schist cover

The Leven Schist cover in the heart of the great pitch-depression of Glen Creran shows a certain amount of variety from point to point; but it has not been found possible to subdivide it into groups, and such local differences as do occur are largely effects of metamorphism. The prevailing type is a homogeneous greenish-grey quartzose mica-schist, with alternating layers of somewhat more and somewhat less sandy nature. Bright little flakes or porphyroblasts of biotite are highly characteristic, just as in the eastern part of the type outcrop of Leven Schists at the mouth of Loch Leven north of Ballachulish Ferry [NN 053 598]. Anyone wishing to confirm this comparison should visit the cover Leven Schists as exposed in Allt Socaich [NN 086 560] (Plate 3). Not only are the schists themselves identical in character with those of the type area, but also the adjoining portion of the Ballachulish Limestone is exactly like that seen in corresponding position in the hill-top crag above North Ballachulish [NN 052 603].(p. 39).

Additional minerals are found in the eastern part of the district. Small blades of actinolite occur up Allt na Muidhe [NN 110 550], and towards Glen Etive large crystals of the same mineral are frequently encountered. Garnets also are found in Allt na Muidhe [NN 110 550] all the way to Glen Coe, particularly along the edges of quartzose bands. In the district south of the An t-Sròn Pluton and east of Beinn Fhionnlaidh [NN 100 500] garnets come to be so abundant that much of the deposit assumes the character of a garnetiferous mica-schist.

Contact-alteration is very marked in the neighbourhood of the An t-Sròn Pluton, and on the west side of Fionn Ghleann [NN 124 550] the baked mica-schists stand out as a craggy ridge well seen from Glen Coe. The development of actinolites and garnets is in no way connected with this contact-metamorphism. It belongs to the earlier, regional metamorphism of the district. H. B. M.

The garnetiferous mica-schist is also strongly hornfelsed in the neighbourhood of the Cruachan Pluton. On the slopes of Beinn Ceitlein, south-east of Glen Etive, the garnets are usually surrounded by dark rims, partly composed of biotite, and elongated in a definite direction, showing that the rock has been considerably sheared since the garnets were developed. This confirms distributional and microscopic evidence that the garnets are pre-pluton, for the rocks of the pluton are very rarely sheared. On the same north-western slope of Beinn Ceitlein the garnetiferous mica-schist sometimes includes thin seams containing dark green actinolite, occasionally arranged in radiate forms, in a matrix of mica-schist with abundant flakes of mica. C. T. C.

Windows of Etive [NN 160 510]

The great layer of Leven Schists just described is two or three thousand feet thick, and out of it a whole series of hills and valleys has been carved. In Glen Etive and its tributaries, Gleann Fhaolain [NN 150 520] and Gleann Chàrnan [NN 135 500], erosion has cut sufficiently deep to lay bare the foundation upon which the Leven Schists rest ((Figure 7), G, H; Section BB, Sheet 53). The openings thus pierced by erosion have come to be known as the Windows of Etive [NN 160 510], and in them the following sequence of rocks is revealed in descending order beneath the great covering of garnetiferous mica-schist:

	Thickness in feet
Calc-silicate-hornfels (Ballachulish Limestone)	15–400
Ballachulish Slide (heavy line on Sheet 53)	–
Banded margin of Leven Schists	0–100
Fine-grained Glen Coe Quartzite	–

The smaller measurements are from Beinn Ceitlein east of Glen Etive. The calc-silicate-hornfels (south of Dalness, (S11485) [NN 1711 5032]; (S11486) [NN 1716 5023]; Allt Fhaolain, (S11625) [NN 1504 5208] is a fine-grained greenish-white rock in which little prisms of tremolite can often be recognised. The other important constituents are granular diopside (malacolite) and felspar. Calcite is rare. The banded Levens are an alternating series of mica-schist and quartzite. In keeping, the top of the underlying Glen Coe Quartzite is finely banded with mica-schist. C. T. C., H. B. M.

For the most part the bedding of the quartzite, as exposed in Gleann Fhaolain [NN 150 520], west of Dalness, is straight, but two instances of uninverted current-bedding have been noted. This was in accordance with expectation. E. B. B.

The Ballachulish Slide was recognised in the Windows as a result of the interpretation of the Callert district north of Loch Leven (p. 50). Upon revisiting the Gleann Chàrnan [NN 135 500] exposures it was found that the talc-silicate-hornfels is separated by a discernible plane of discordance from the underlying banded Leven Schists (Figure 11). This plane is less marked by any appearance of disruption than the well known thrust-planes of the North-West Highlands. It only occasionally transgresses the bedding and foliation of the schists above and below. Sometimes, in addition to such transgressions, one finds small, flat, isoclinal folds affecting the schists above or below without involving the plane itself. In other cases, however, the plane seems to be folded along with the schists it separates. C. T. C., E. B. B.

It is instructive to compare the Window succession, revealed by erosion in the heart of the great Glen Creran Pitch-Depression, with the rim successions that have already been described. One is struck at once with the practical identity of the Etive sections with those exposed 2–1- miles to the north by the roadside west of Clachaig Hotel, Glen Coe (p. 75), and again 4 miles to the west-south-west in Glen Ure [NN 070 475] (p. 64). The only noteworthy difference is that the calc-silicate-hornfels of the Windows is a good deal thinner. The thinning of the talc-silicate is particularly marked in the most easterly Window exposures, on Beinn Ceitlein [NN 176 490]; and this, along with concomitant reduction of underlying banded Levens, strongly recalls what is seen at Coire an Easain [NN 250 496] that lies another 6 miles to the east (p. 82). There is, however, a much stronger development everywhere in Glen Etive of underlying quartzite than at Coire an Easain [NN 250 496].

The Windows of Etive [NN 160 510] can be sampled cross-country from Glen Coe starting from Achnacon [NN 119 566] farm (Figure 10). The route lies up Fionn Ghleann [NN 124 550] and crosses Bealach Fhionnghaill [NN 130 525] into Gleann Chàrnan [NN 135 500]. On the way Fionn Ghleann [NN 124 550] affords interesting exposures of the An t-Sròn outcrop of Fault-Intrusion; but to do justice to the Windows it is necessary to begin in Glen Etive, which is served by a second-class road. C. T. C., H. B. M., E. B. B.

Caps of Glen Coe Quartzite

The common practice in this memoir is to relegate history of research to chapter 2, but in the present case it seems desirable to present the facts rather fully in their proper context as they were successively appreciated. In the *Summary of Progress* for 1904 Cough gave the first description of the schist succession exposed in the Windows of Etive [NN 160 510] (1905, p. 65). His account deals with what is seen east of a north-to-south tongue of Fault-Intrusion on the south-east side of the glen, opposite Dalness. It includes a reference to quartzite that reaches up to the summit of Beinn Ceitlein. This is the problematical quartzite to be described presently, and Clough pointed out, quite correctly, that it is separated from the Window exposure by a fault. No mention is made of an obvious cap of quartzite on neighbouring Stob Dubh, because it lay beyond the area actually mapped.

Next year Gough could not continue field work in the Highlands, and Maufe completed the mapping of the Windows, both sides of Glen Etive. In the course of his work he mapped not only the Stob Dubh cap (2897 ft), but also another (2967 ft)

on the Beinn Maol Chaluim [NN 140 520] ridge (Section BB, Sheet 53). Caps on Beinn Fhionnlaidh [NN 100 500] (3139 ft) further west had already been mapped with some little confusion by Kynaston before Maufe's advent, and did not for the time being enter into the story.

Maufe's reaction is expressed in the *Summary of Progress* for 1905 as follows: "The structure of the district is evidently that of a huge overfold, the limbs of which dip gently westwards and are at least three miles in length (from trough to crest). The quartzite which caps the hills also forms the floors of the glens" (1906, p. 91). This is the first announcement of what later has come to be called the Recumbent Fold, or Recumbent Syncline, of Ballachulish.

Much has happened since 1905, when the stratigraphical succession of the district was very imperfectly known, and when complications due to slides were not suspected; but the fact remains that Maufe was justified in claiming that the quartzites above and below the great Glen Etive mica-schist are stratigraphically one and the same, and that they owe their relative position to large-scale tectonics. Maufe quite properly assumed that the mica-schist had only two strati-graphical sides. One of these, he said, was bounded by the great complex of limestone, black slate and gritty quartzite, at the time only partially understood, which outcrops between Ballachulish and Glen Creran. Therefore the mica-schist is not interbedded between two different fine-grained quartzites. In other words the summit and valley-floor quartzites of Glen Etive are stratigraphically identical.

In 1905 Maufe naturally thought that the axial plane of his recumbent fold lay in the middle of the 3000-ft mica-schist. The band of calc-silicate-hornfels, occurring a little above the lower quartzite, was interpreted as a local impersistent intercalation, and was looked for (in vain) a little below the upper quartzite. Its recognition as Ballachulish Limestone core resting on Ballachulish Slide had to await the interpretation of the Callert district north of Loch Leven (Bailey 1909, p. 51).

A further complication later followed the realisation that current-bedding can often distinguish between right-way-up and upside-down. In 1930 Beinn Maol Chaluim [NN 140 520] was revisited, and in 1932 Beinn Fhionnlaidh [NN 100 500] was remapped (Bailey 1934a, p. 504). In both cases the quartzite was confirmed as of Glen Coe type; but in both cases, contrary to expectation, it was found to be uninverted.

The Beinn Maol Chaluim [NN 140 520] cap of quartzite has a normal dip of about 50°, while the plane separating it from underlying Leven Schist is much more gently inclined. This plane therefore is an obvious slide.

The Beinn Fhionnlaidh [NN 100 500] quartzite has two outcrops. In both there is a more or less eastern margin which acts on the whole as base, and a more or less western margin which acts on the whole as top. There is a great deal of small-scale folding, and the top of the western outcrop is packed into isoclines with steep westward inclination. Current-bedding at a number of places shows that in both outcrops the quartzite is interbedded between an older mica-schist below and a younger mica-schist above. The interpretation offered on Sheet 53 is that the older mica-schist is on the Binnein horizon of chapter 7, while the younger mica-schist is Leven Schist. The Cruachan Pluton has greatly altered the mica-schists, and there seems no chance of distinguishing between Binnein and Leven horizons on the score of lithology. It appears certain, however, that the older mica-schist must be separated from the Leven Schists of the main underlying spread by slides ((Figure 7), H, p. 48).

The quartzite cap of Stob Dubh has not been revisited in search of current-bedding, so that we do not know whether or no it is inverted. Maufe mapped it as resting on a zone of banded mica-schist and quartzite, which suggests a normal passage to the underlying Leven Schists — but the same appearance is furnished at Beinn Fhionnlaidh [NN 100 500] where, as we have seen, the quartzite is uninverted. E. B. B.

Problematical quartzite of Beinn Ceitlein

The upper part of Beinn Ceitlein [NN 176 490], facing Dalness from the east side of Glen Etive, is composed of a very considerable outcrop of Glen Coe Quartzite. From north to south this measures two miles, and from east to west three-quarters of a mile. Its boundaries are as follows: to the south, an arcuate dyke of acid granite named after Meall Odhar — this is a post-Cruachan member of the great Etive plutonic complex; to the east, an important offshoot of the Cruachan member of the same complex, which here penetrates the Cauldron-Subsidence of Glen Coe; to the north, the

main branch of the Boundary-Fault of the Cauldron-Subsidence, introducing rhyolite lavas; and, to the west, another branch of the Boundary-Fault. This western branch has a general north-westerly or westerly inclination of about 50°, and may conveniently be called the Beinn Ceitlein Fault.

The strike of the quartzite within the above limits is northerly with a tendency to swing to north-west in the north. The dip is westerly at angles of from 30° to 50°. This attitude contrasts with that of the Window succession seen across the Beinn Ceitlein Fault on slopes leading down to the River Etive and up to the summit of Stob Dubh. Here dips are usually gentler, 10° to 30°, and are commonly directed south-west.

It is almost certain that the Beinn Ceitlein quartzite corresponds with the valley-bottom outcrops of Glen Coe Quartzite exposed to the west in Glen Etive, Gleann Fhaolain [NN 150 520] and Gleann Chàrnan [NN 135 500]. The evidence is supplied by a very restricted outcrop of fine-grained green tremolitic schist or calc-silicate-hornfels (S11449) [NN 1818 5005] found in close association with the quartzite. This tremolitic rock agrees in character with (S11486) [NN 1716 5023]; (S11625) [NN 1504 5208], talc-silicate-homfelses framing the Windows of Etive [NN 160 510], close at hand, and with (S15439) [NN 1235 7122]; (S15440) [NN 1235 7122] of the same stratigraphical horizon in Glen Nevis. It is shown on Sheet 53 as a minute dot of blue, with national grid reference 182500, at the north-east end of the summit ridge of Beinn Ceitlein. Useful landmarks to help in its location are provided by a small lochan to the south and rhyolite lavas within the main Cauldron to the north. The distance from lochan to lavas is about 80 yards, and the green schist passes midway between as a narrow strip traceable W.N.W. for 100 yards. It is overlain by a sheet of fine-grained lamprophyre (S11448) [NN 1818 5005], while to the north it is cut off by an extremely inconspicuous fault, probably of much the same age as the main Boundary-Fault. On the south, it seems steeply to overlie a thin set of semipelitic beds alternating with quartzite. These may well represent the banded Leven Schists below the Ballachulish Slide of the Window succession.

It was thought in early days that the Beinn Ceitlein Fault probably threw down to the east, because northwards it converges on the main branch of the Boundary-Fault of the Cauldron, which here unmistakably throws down to the north-east. In fact, before the significance of the associated patch of green schist was realised, the Beinn Ceitlein quartzite was referred to the cap, rather than the valley-bottom, position of Glen Coe Quartzite in the Window succession. In other words, the Beinn Ceitlein quartzite was supposed to be a down-faulted continuation of the Stob Dubh band (Clough, Maufe and Bailey 1909, p. 628 and fig. 2, p. 627). This last item of interpretation was afterwards abandoned; but in the first edition of the present memoir it was pointed out that since the Beinn Ceitlein quartzite and fault have roughly the same inclination, it is still possible to suppose that the fault may throw down to the east in spite of valley-bottom quartzite rising to outcrop in that direction.

Here it may be pointed out that if the Beinn Ceitlein Fault throws down to the east it is a reversed fault of rather low inclination. This, however, does not present any special difficulty, for the Boundary-Fault of the Cauldron-Subsidence has reversed inclination all along the northern and north-eastern sectors of its course. C. T. C.

When the first edition of this memoir was prepared, the writer thought with Clough that the Beinn Ceitlein Fault threw down to the east. Now, however, he thinks it much more probable that it throws down to the west, and that it is a normal fault merging into a broken monocline. According to this view, the Beinn Ceitlein Fault is likely to be the curved continuation of the outer branch of the Boundary-Fault which, after interruption by the Cruachan Pluton, reappears along Gleann Chàrnan [NN 135 500] (*cf.* (Figure 17), (Figure 18)).

The downthrow side of the Beinn Ceitlein Fault may perhaps some day be identified more certainly by reference to accompanying Fault-Intrusion. According to experience branches of the Glen Coe Boundary-Fault lie on the down-throw side of associated Fault-Intrusion. Clough has evidently found it very difficult to decipher the local evidence, for in some places he maps the fault as occurring on the one side of the intrusion, and in other places on the other side. It is quite possible that the relationship is not regular, since here two branches of the Boundary-Fault meet and each has a Fault-Intrusion accompaniment. E. B. B.

Dalness

The presence of quartzite caps on Beinn Maol Chaluim [NN 140 520] and Stob Dubh, a little outside the main Boundary-Fault of the Glen Coe cauldron, renders it practically certain that the same quartzite, faulted down, is locally preserved under the lavas of the Dalness district. A few minute quartzite inliers are described later as jutting up irregularly through andesite lavas in the Glen Etive hollow. They all fall within a mile east, and half a mile north-east, of Dalness (p. 149). C. T. C.

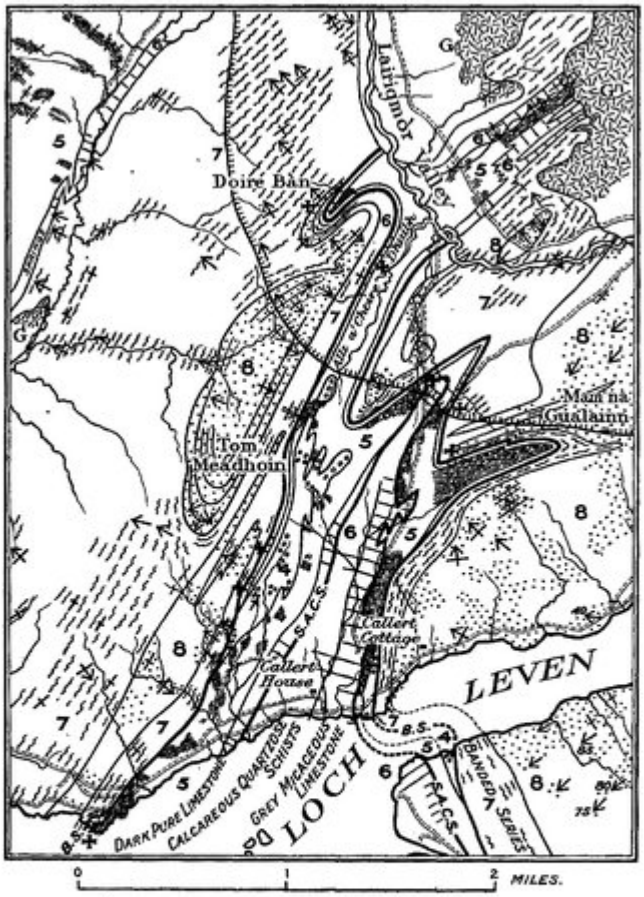


FIG. 8. Map showing outcrops in Callert district

4, Appin Quartzite (youngest); 5, Ballachulish Slates; 6, Ballachulish Limestone; 7, Leven Schists; 8, Glen Coe Quartzite; G, Granite

(Figure 8) Map showing outcrops in Callert district 4, Appin Quartzite (youngest); 5, Ballachulish Slates; 6, Ballachulish Limestone; 7, Leven Schists; 8, Glen Coe Quartzite; G, Granite.

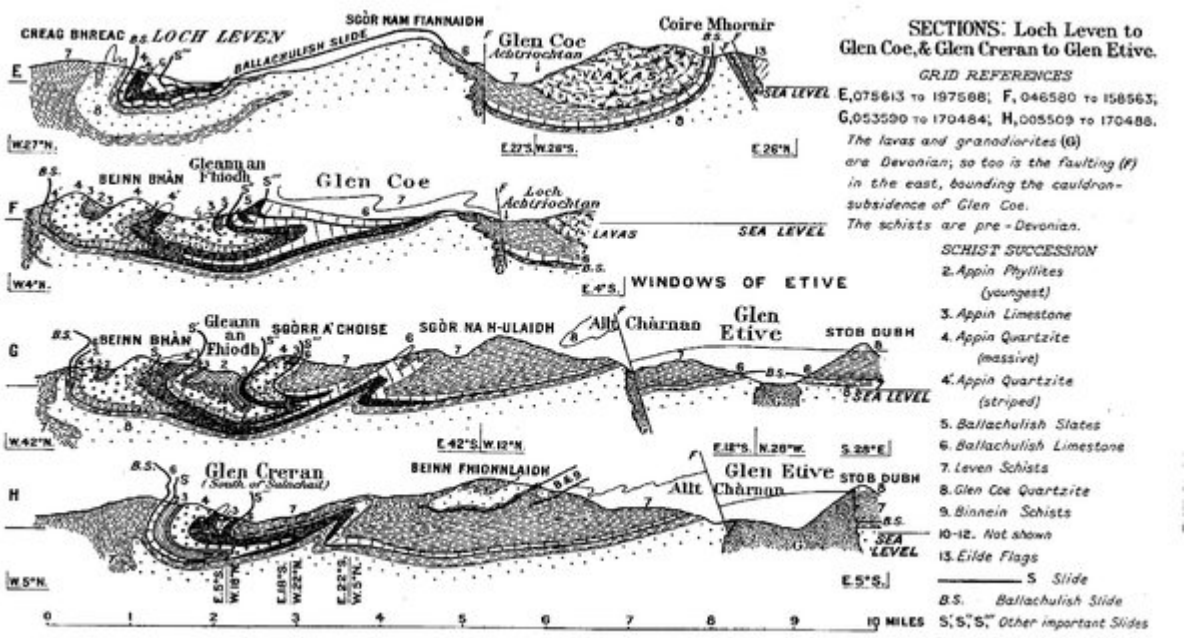


FIG. 7. Sections: Loch Leven to Glen Coe, and Glen Creran to Glen Etive

(Figure 7) Sections: Loch Leven to Glen Coe, and Glen Creran to Glen Etive. E, [NN 075 613] to [NN 197 588]; F, [NN 046 580] to [NN 158 563] G, [NN 053 590] to [NN 170 484] H, [NN 005 509] to [NN 170 488].

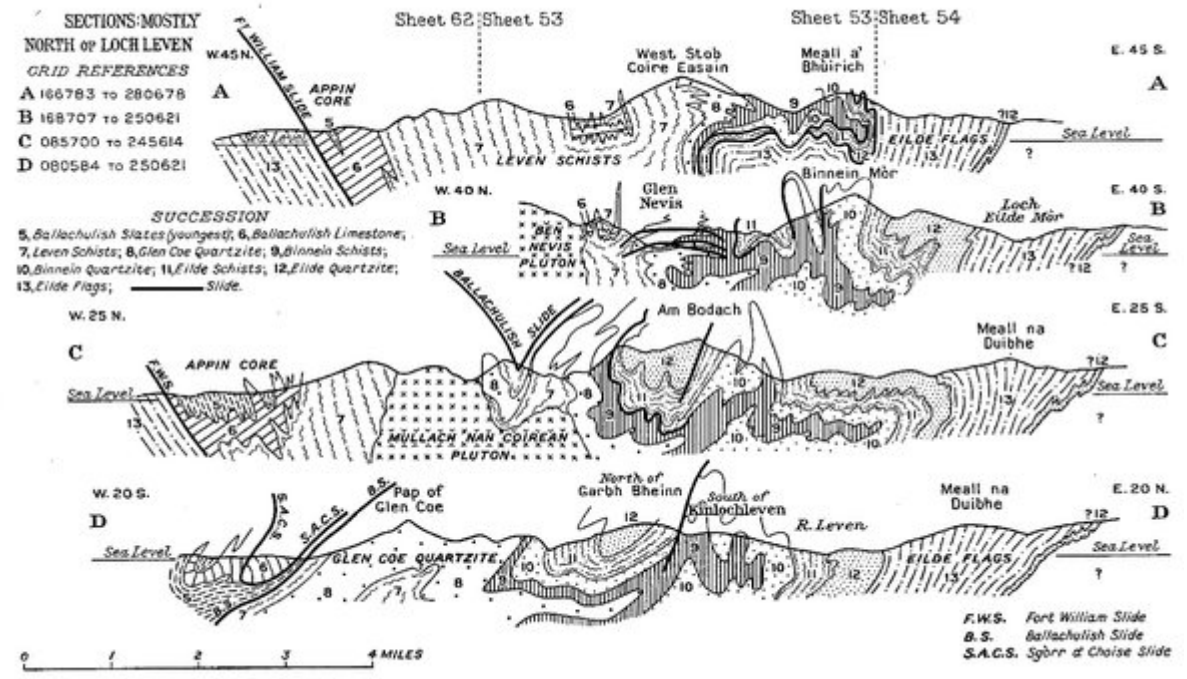


FIG. 14. Sections: mostly north of Loch Leven

(Figure 14) Sections: mostly north of Loch Leven A [NN 166 783] to [NN 280 678]; B [NN 168 707] to [NN 250 621]; C [NN 085 700] to [NN 245 614]; D [NN 080 584] to [NN 250 621].

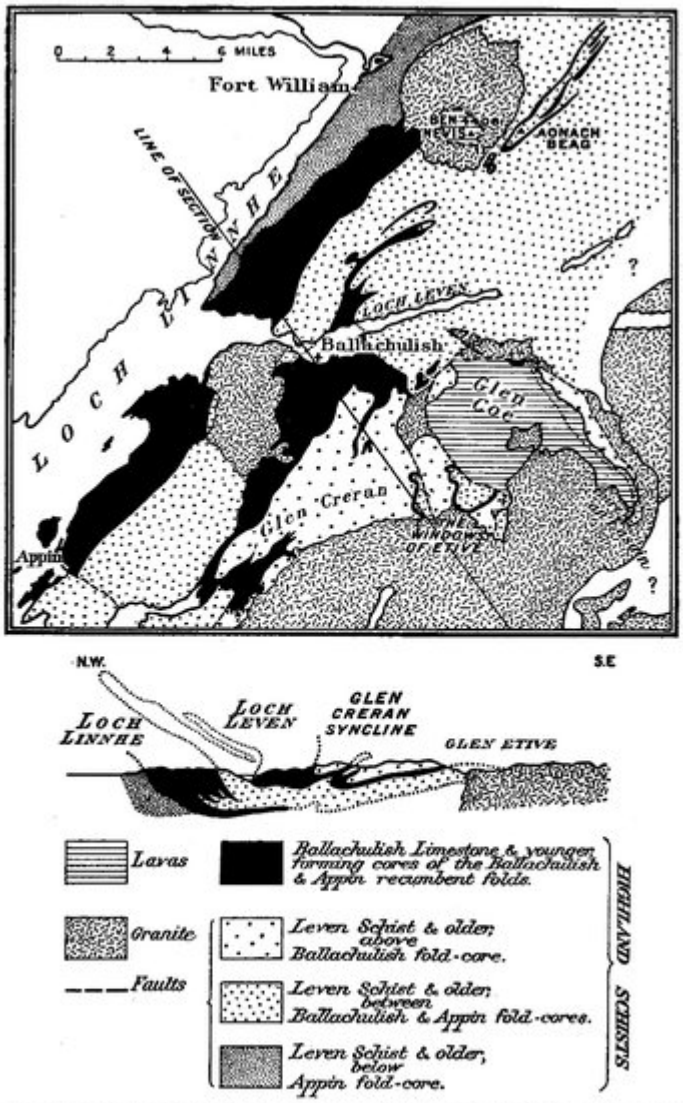


FIG. 17. Map and Section showing the structure of the Highland Schists and the positions of the cauldron-subsidences of Glen Coe and Ben Nevis

(Figure 17) Map and Section showing the structure of the Highland Schists and the positions of the cauldron-subsidences of Glen Coe and Ben Nevis.

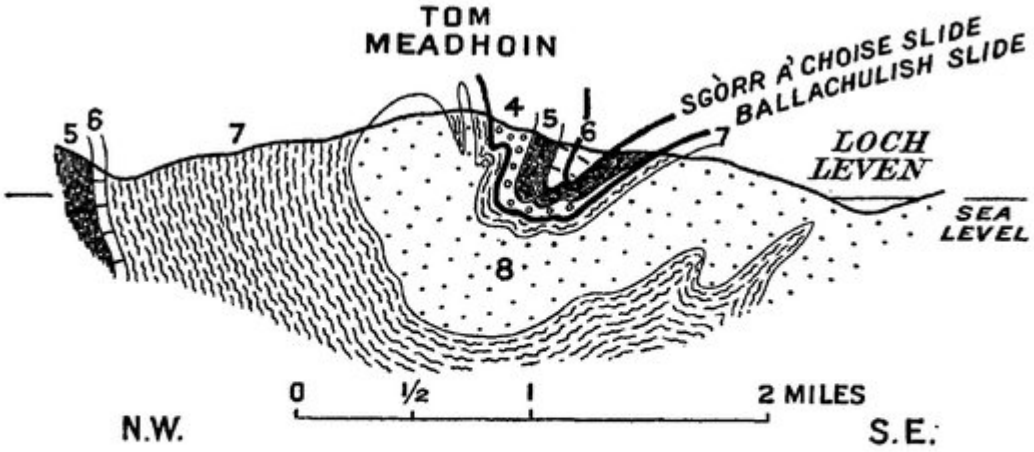


FIG. 9. Section across Fig. 8 showing the relation of the Ballachulish Slide to the Tom Meadhoin Antiform

4, Appin Quartzite (youngest); 5, Ballachulish Slates; 6, Ballachulish Limestone; 7, Leven Schists; 8, Glen Coe Quartzite

(Figure 9) Section across (Figure 8) showing the relation of the Ballachulish Slide to the Tom Meadhoin Antiform 4, Appin Quartzite (youngest); 5, Ballachulish Slates; 6, Ballachulish Limestone; 7, Leven Schists; 8, Glen Coe Quartzite.

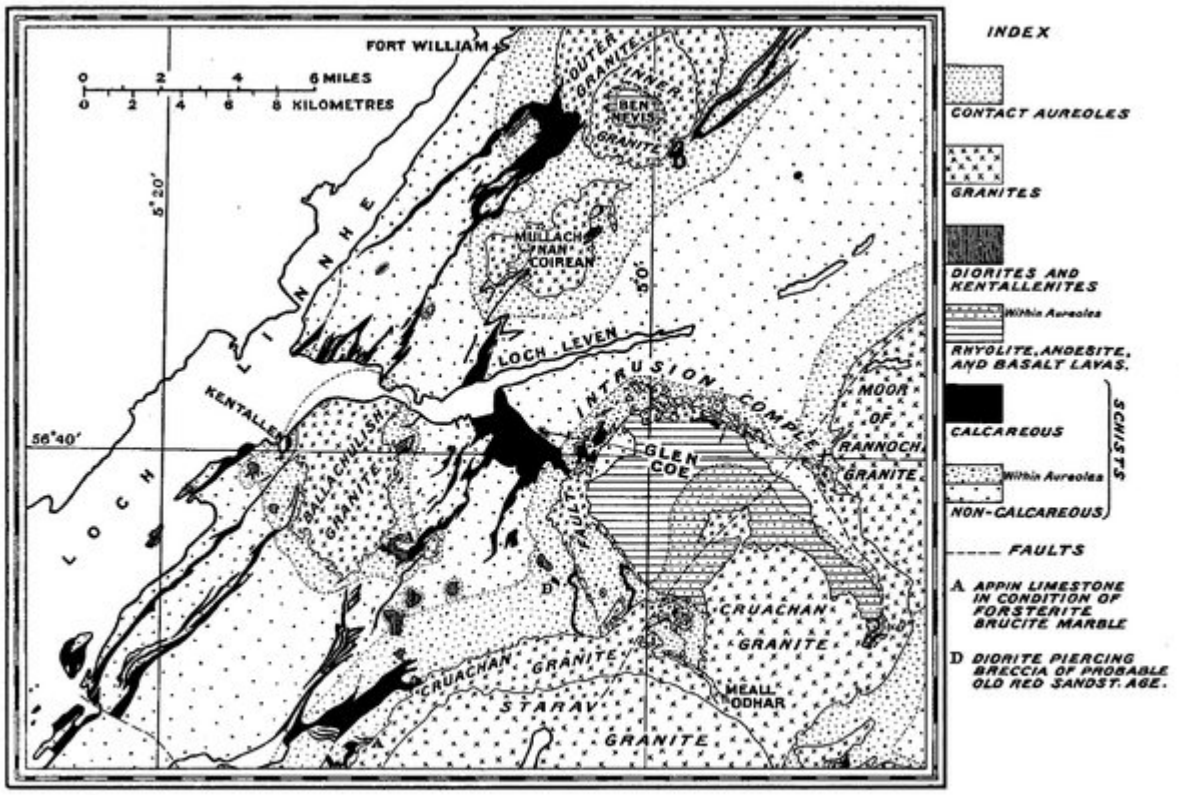
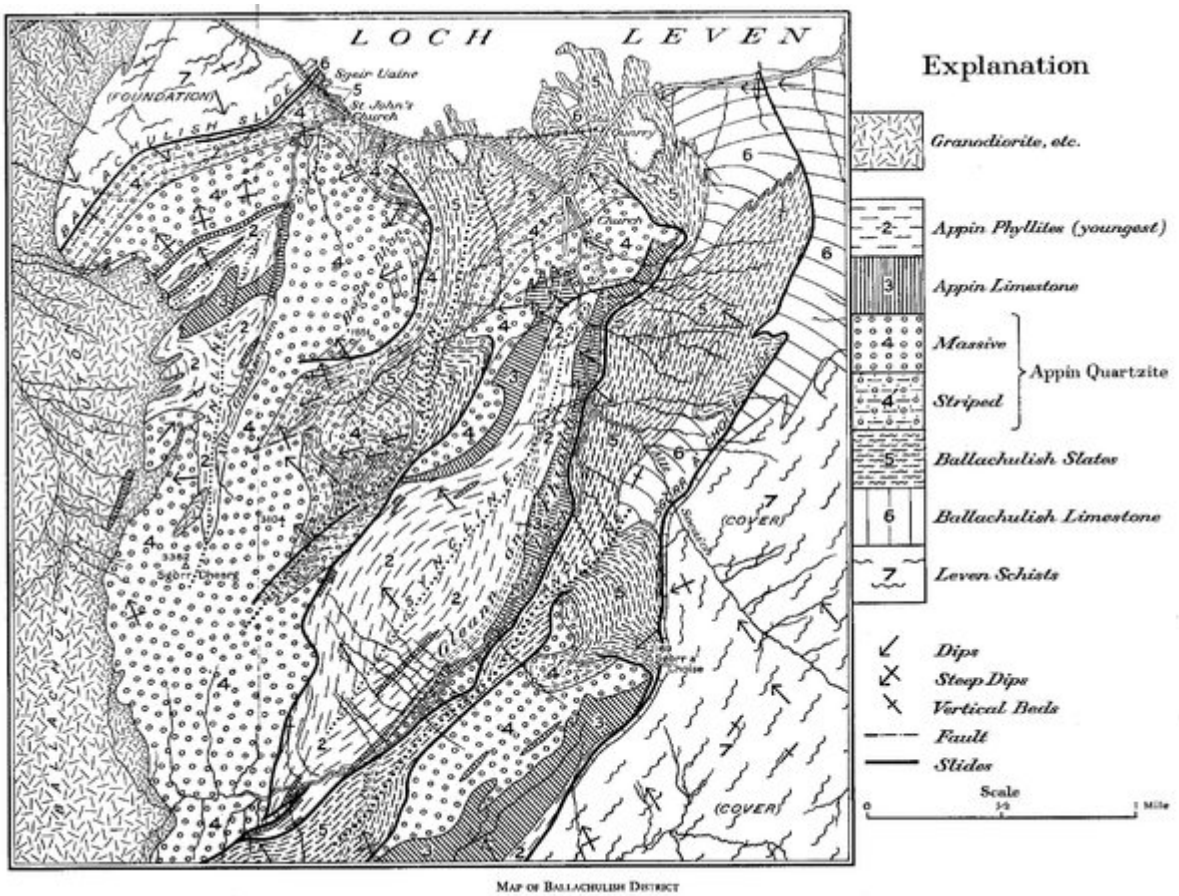


FIG. 39. Map of contact-aureoles south-east of Loch Linnhe
The limits drawn include alteration sufficiently intense to convert impure limestone into calc-silicate-hornfels

(Figure 39) Map of contact-aureoles south-east of Loch Linnhe. The limits drawn include alteration sufficiently intense to convert impure limestone into calc-silicate-hornfels.



MAP OF BALLACHULISH DISTRICT

(Plate 3) Map of Ballachulish District.

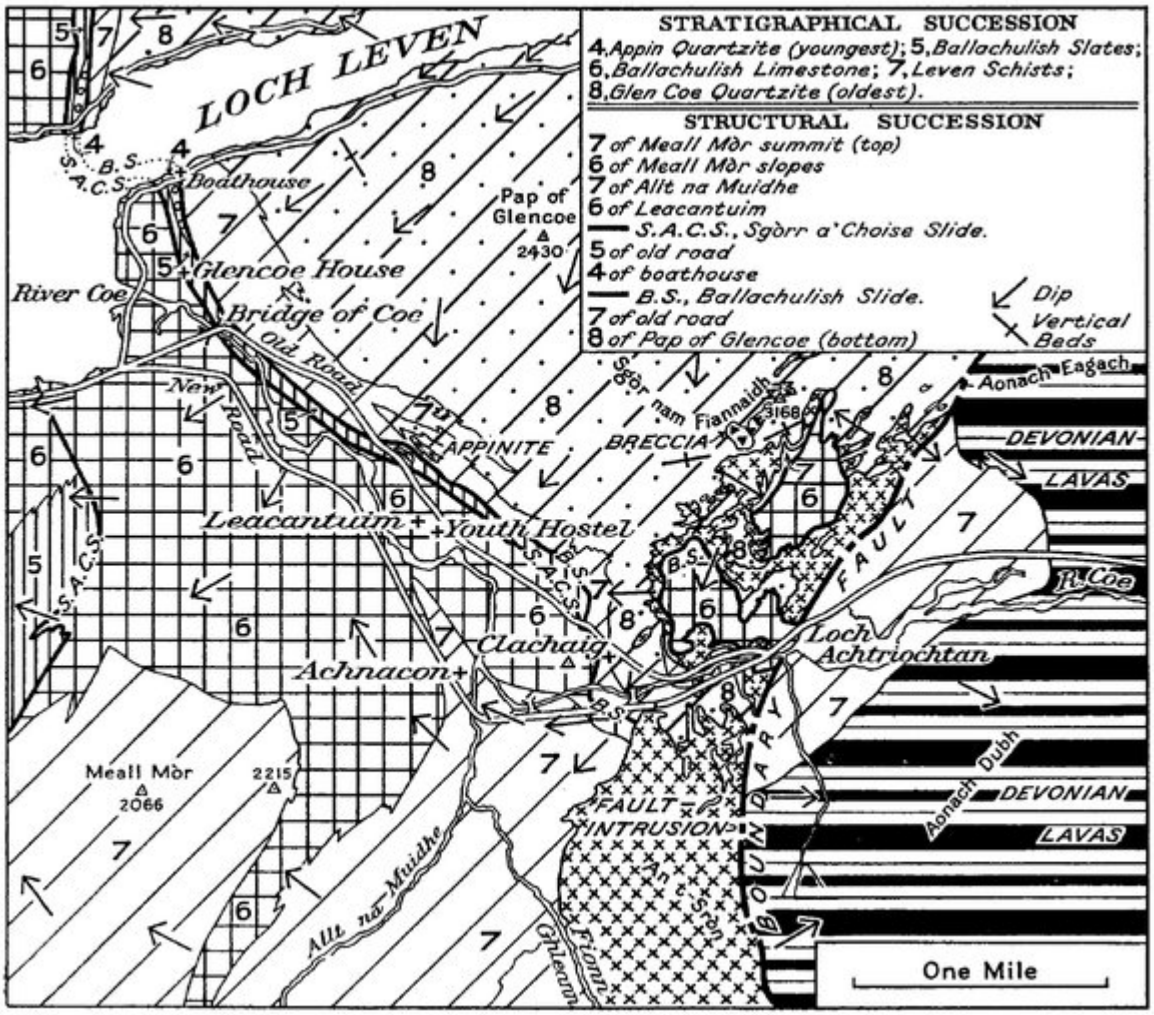
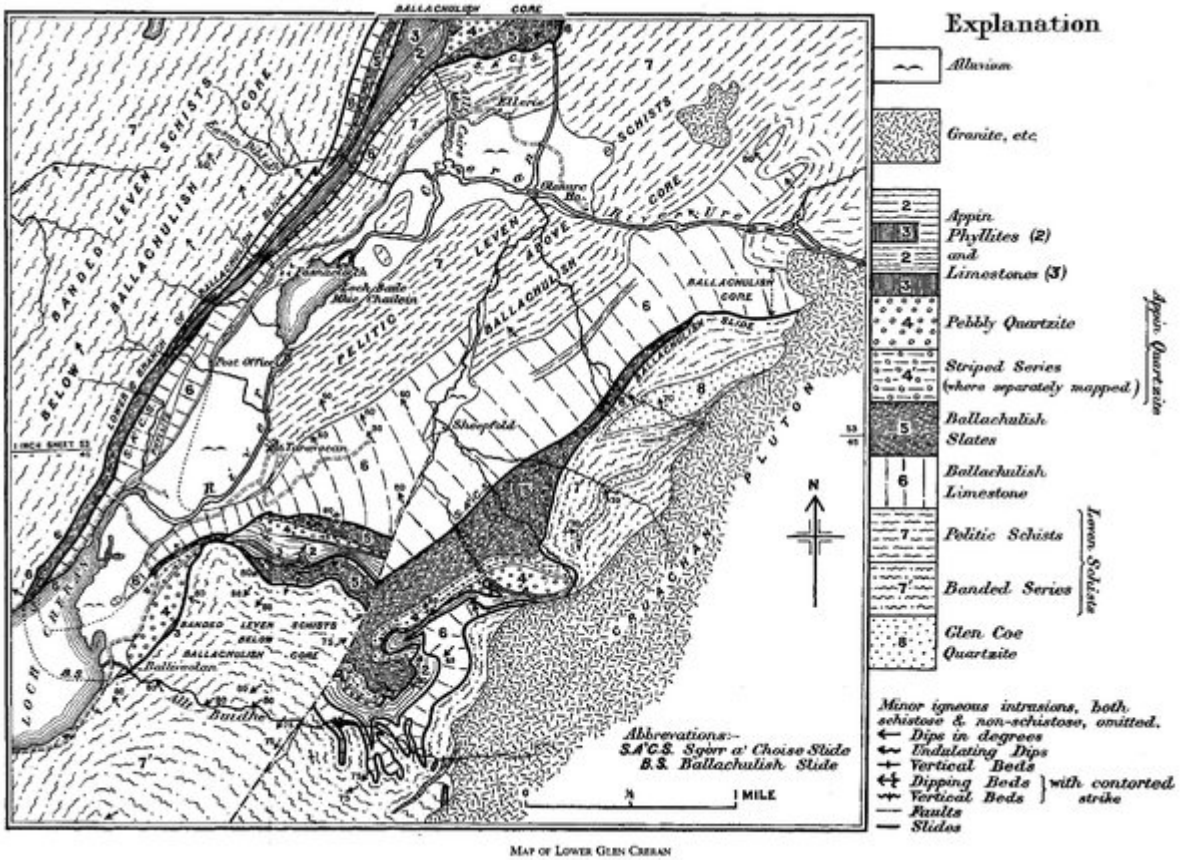


FIG. 10. Map of Lower Glen Coe

(Figure 10) Map of Lower Glen Coe.



MAP OF LOWER GLEN CREran

(Plate 4) Map Of Lower Glen Creran.

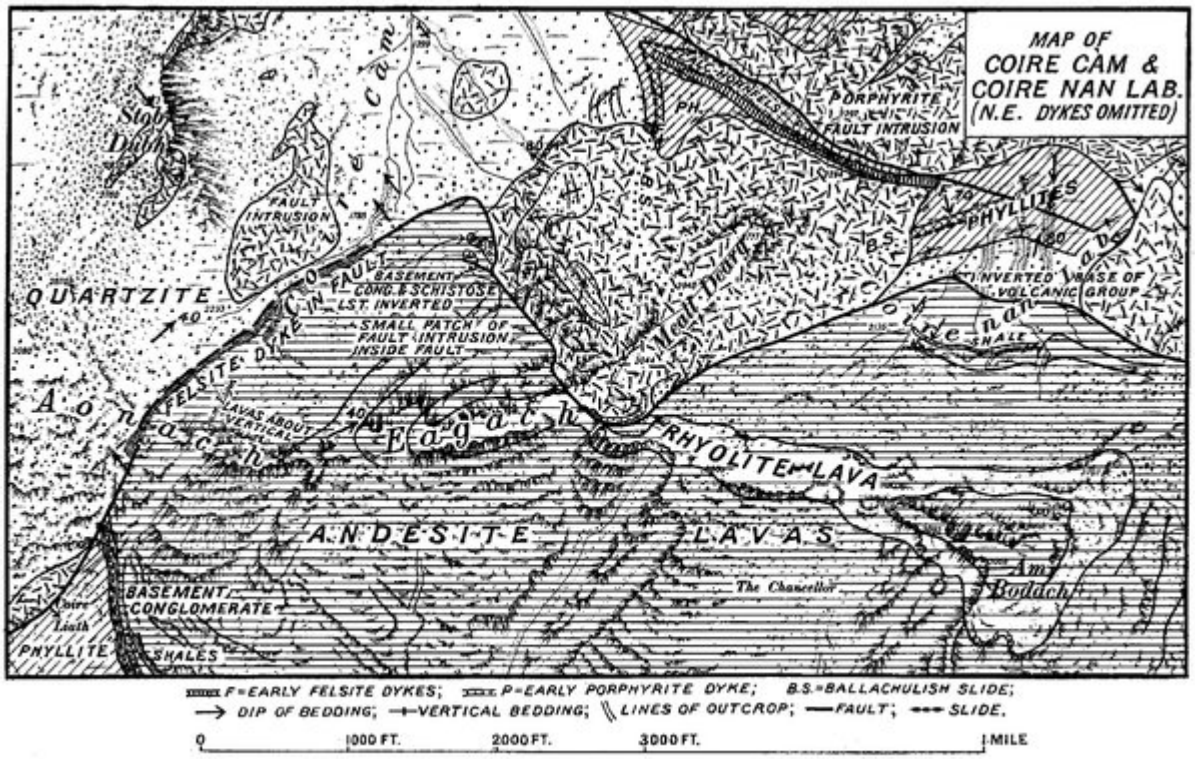


FIG. 23. Map of Coire Càm and Coire nan Lab. North-east dykes omitted. (The Fault-Intrusion is chilled at its contact with the early dykes north of Meall Dearg)

(Figure 23) Map of Coire Càm [NN 154 585] and Coire nan Lab [NN 167 584]. North-east dykes omitted. (The Fault-Intrusion is chilled at its contact with the early dykes north of Meall Dearg [NN 163 585]).

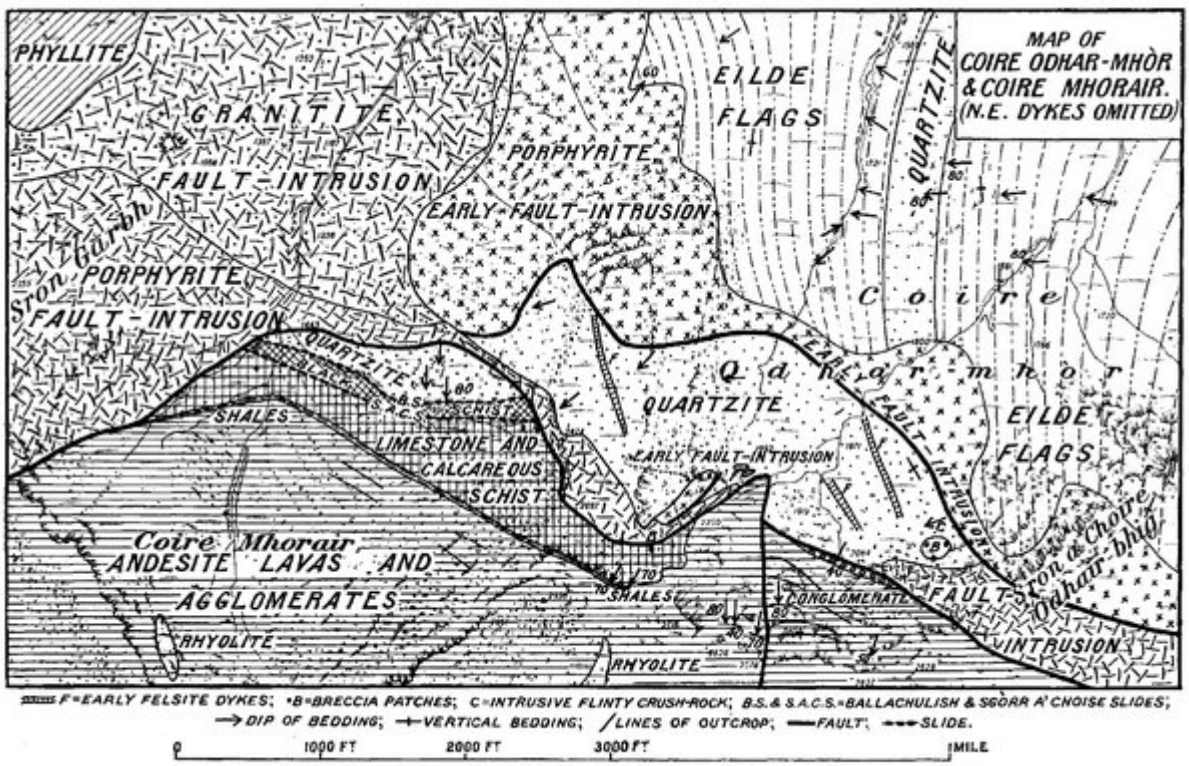


FIG. 24. Map of Coire Mhorair and Coire Odhar-mhòr

(Figure 24) Map of Coire Mhorair and Coire Odhar-mhòr [NN 196 583].

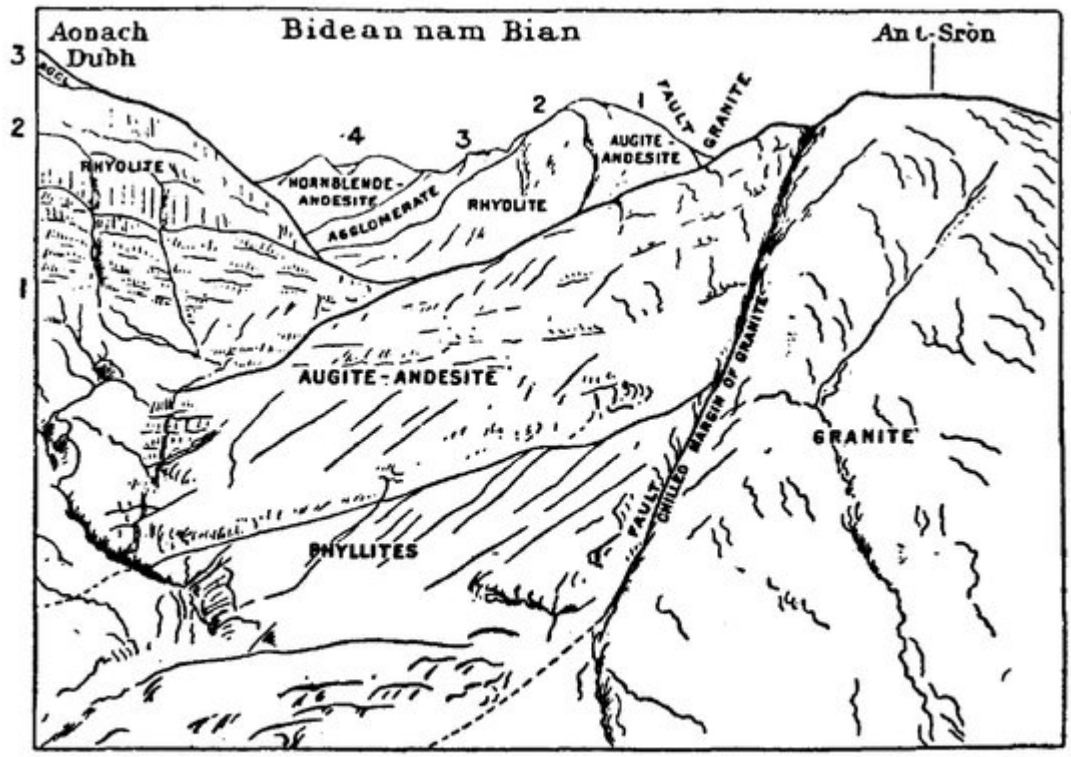


FIG. 20. View of Boundary-Fault of the Cauldron-Subsidence of Glen Coe as exposed in An t-Sròn

(Figure 20) View of Boundary-Fault of the Cauldron-Subsidence of Glen Coe as exposed in An t-Sròn.

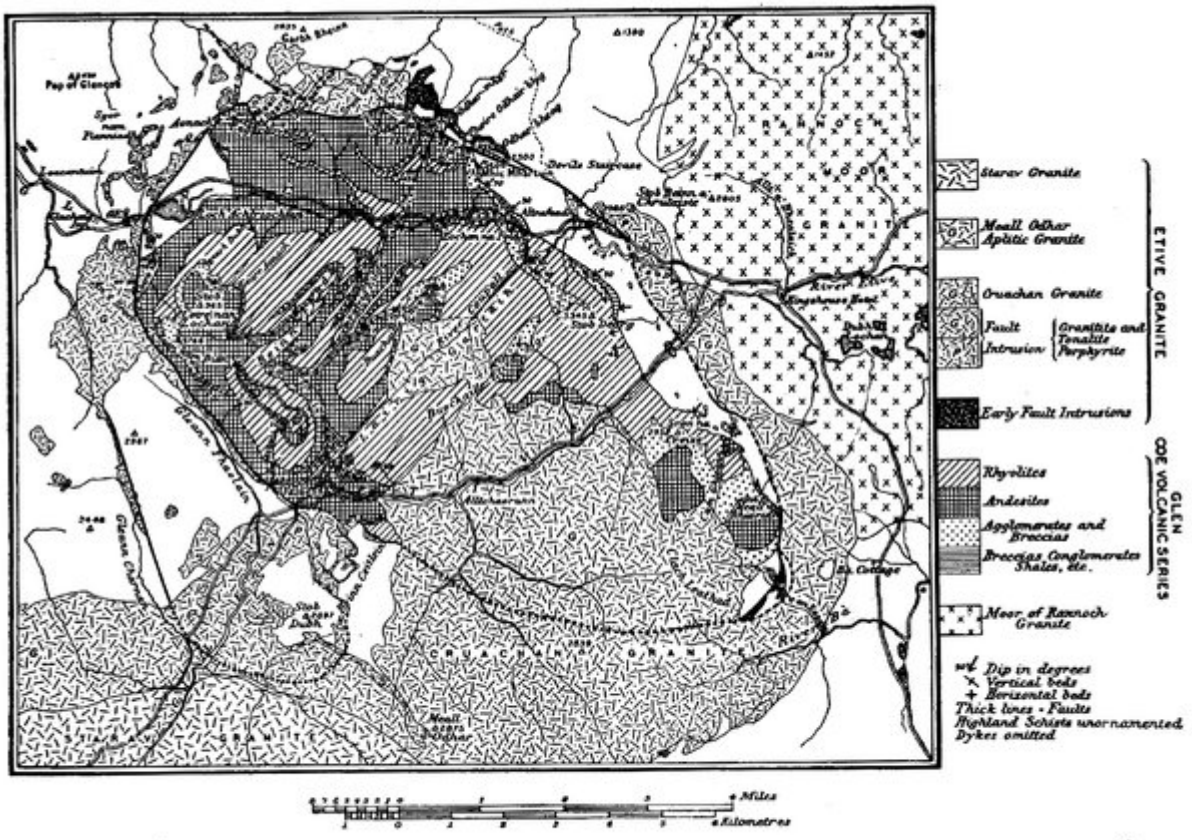


FIG. 19. Map of the Cauldron-Subsidence of Glen Coe and associated igneous phenomena
For new road see Fig. 22

(Figure 19) Map of the Couldron-Subsidence of Glen Coe and associated igneous phoenomena. For new road see (Figure 22).

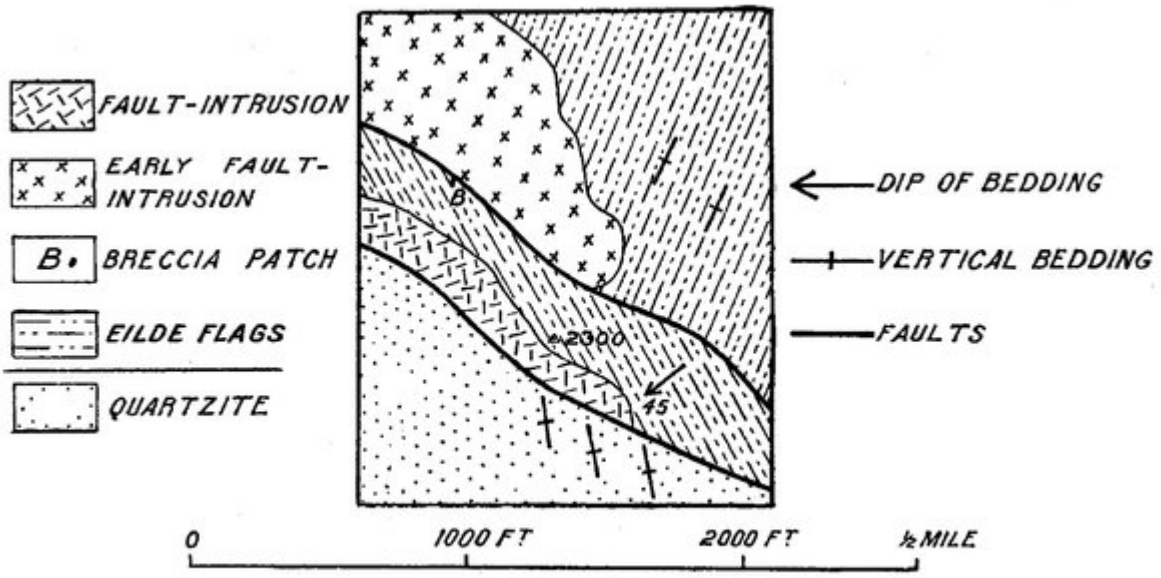


FIG. 26. Map of Stob Mhic Mhartuin. North-east dykes omitted

(Figure 26) Map of Stob Mhic Mhartuin [NN 207 575]. North-east dykes omitted.

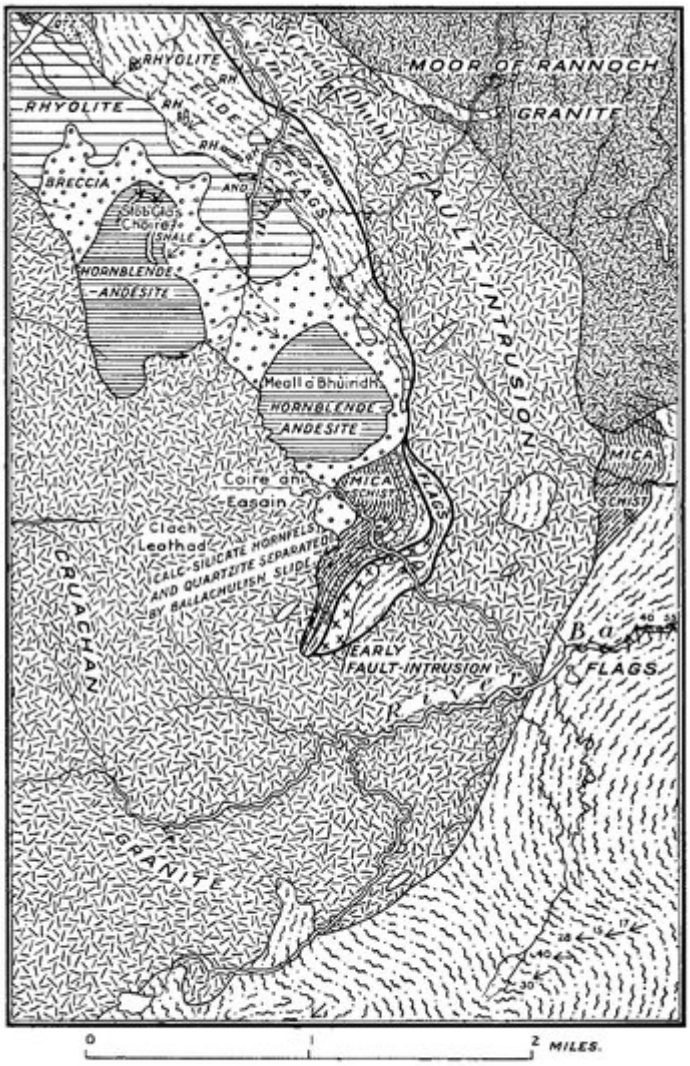


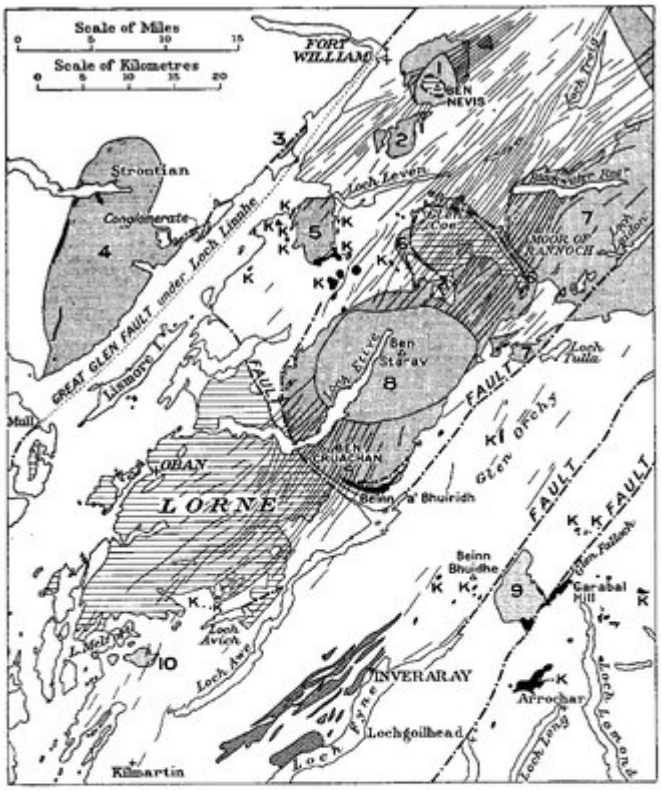
FIG. 29. Map of Càm Ghleann and Coire an Easain. North-east dykes omitted

(Figure 29) Map of Càrn Ghleann and Coire an Easain. North-east dykes omitted.

FIG. 11. Sketch of Ballachulish Slide on S.W. side of Gleann Chàrnan

Calc-silicate-hornfels (Ballachulish Limestone) lying discordantly, through the intervention of the Ballachulish Slide, upon banded Leven Schists

(Figure 11) Sketch of Ballachulish Slide on S.W. side of Gleann Chàrnan [NN 135 500] Calc-silicate-hornfels (Ballachulish Limestone) lying discordantly, through the intervention of the Ballachulish Slide, upon banded Leven Schists.



VOLCANIC ROCKS: *Ben Nevis, Glen Coe, Lorne*
BASALT, ANDESITE, RHYOLITE.

DYKES: *Mostly of Nevis and Etive Swarms.*
PORPHYRITE, MICRODIORITE, LAMPROPHYRE, PORPHYRY.

INCLINED SHEETS: *Loch Fyne.*
QUARTZ-PORPHYRY.

ULTRA-ACID, ACID and INTERMEDIATE PLUTONS.
GRANITE, QUARTZ-DIORITE: 1 *Ben Nevis*; 2 *Mullach nan Coirean*; 3 *Loch Linnhe*; 4 *Strontian*; 5 *Ballachulish*; 6 *Glen Coe*; 7 *Rannoch*; 8 *Etive*; 9 *Garabal*; 10 *Loch Melfort.*

BASIC and ULTRA-BASIC PLUTONS, *including a few giant xenoliths*
APPINITE, MONZONITIC AUGITE-DIORITE, ETC., including
K = *KENTALLENITE.*

FIG. 18. Map of igneous rocks of South-West Highlands referred to Lower Old Red Sandstone Period

(Figure 18) Map of igneous rocks of South-West Highlands referred to Lower Old Red Sandstone Period.