Chapter 2 Historical review

Highland Schists

Early work

In 1810 T. Macknight (1811, pp. 307–357) traversed a considerable portion of the Western and Central Highlands of Scotland, and visited many points of interest in the district dealt with in this memoir. He viewed all geological phenomena from the standpoint of Wernerian doctrine, and found no evidence in favour of Hutton's theories regarding the metamorphism of the schists or the igneous origin of granite. Thus he thought that the schistose strata had been precipitated from a primitive ocean, and that their quartz veins, high dips, crinkling, and contortion were all developed during the process of accumulation. He expresses keen satisfaction in having been able to trace a succession from the clay-slate of Ballachulish, through the mica-slate of the Fort William shore of Loch Linnhe and the gneisses of Ardgour, to the "granite"<ref> The term "granite" between inverted commas covers in this memoir both granite and granodiorite.</ref> of the western end of Glen Tarbert [NM 910 600]. This he evidently regarded as a normal downward sequence of deposit; in Glen Coe, however, and Ben Nevis, he found a development of "granite", and other rocks classed in this memoir as igneous, which he assigned to an overlying formation of later date than the surrounding schists. Macknight also recorded the association of limestone with the slates at Ballachulish, and the occurrence of both granular quartz and limestone at Onich.

J. Macculloch's writings at once strike a different note (1814). He showed that the quartzites of Jura [NM 700 010], Ballachulish, and Assynt are, in large measure at any rate, true mechanical deposits, since they contain worn and blunted pebbles of quartz and felspar. He further drew attention to various sections in which the Jura [NM 700 010] and Ballachulish quartzites are overlain by, or interbedded with, clay-slates and mica-slates; and on the basis of this association he argued that the slates, like the quartzite (granular quartz), had originated as detritus, and not as crystalline precipitates from Werner's primitive ocean.

Incidentally, in the presentation of his evidence, Macculloch has given an excellent account of the transition zone linking the quartzite of Ballachulish, that is the Appin Quartzite, with the well-known Ballachulish black slates (1814, p. 483). We quote the following:

33. Fine sandstones, not to be distinguished from the floetz sandstones, and, like many of them, striped in endless alternations by black clay. From the series at Ballachulish. These belong to the quartz rock, which alternates with clay slate, and show the transitions between these two substances.

The term "floetz sandstones" used in this description merely signifies normal sandstones of such formations as the Carboniferous System.

Later, Macculloch (1817, p. 126) drew attention to the fact that the Ballachulish "granite" metamorphoses the schists in its vicinity, and sends veins into them, and, further, that it contains innumerable fragments of these schists as inclusions. But Wernerian theories still dominated Macknight (1821) who, returning to the district, described the contact-altered rocks round the Ballachulish "granite" as gneisses occupying their normal position in his imaginary granite, gneiss, mica-slate, clay-slate succession. Macknight now regarded the Ben Nevis "granite" as probably part of a great underlying mass, forming the foundation of the Scottish Highlands; the rocks of the upper portion of the mountain (the lavas) he correlated as before with the Glen Coe complex, and interpreted them as an overlying formation.

Both Macculloch (1819, p. 265) and Macknight refer to the limestone of Lismore [NM 870 440], which extends into the southern edge of the present map, and is continued northwards into Shuna [NM 920 490]. Macculloch rightly points out the resemblance of this limestone to that of Islay. In 1836, a year after his death, Macculloch's geological map of Scotland was published (*cf.* Eyles 1937; 1939). In this he indicated in a generalised manner the positions of many of the limestone, quartzite, and clay-slate outcrops of the district, especially in the neighbourhood of Loch Leven and

Portnacroish [NM 926 474] (Appin railway station).

The igneous origin of the Ben Nevis complex had been confidently denied by Macknight. C. von Oeynhausen and H. von Dechen (1830; 1834), however, pointed out that the "granite" has forced its way through the surrounding gneiss and schists, and that it extends laterally into these rocks in the form of veins. It is interesting to find them referring in their descriptions of Glen Nevis to "a rock composed of alternate laminae of white felspar and green mica" which occurs, for a considerable distance, bordering the granite margin. This curious rock has since been shown by J. S. Grant Wilson and J. J. H. Teall to be a calcsilicate-hornfels produced by thermal metamorphism from a thick mass of schistose limestone (Sum. Prog. 1898, p. 66); but for many years its nature was not understood, and in the earlier maps of the district it is always classed as "gneiss". Von Oeynhausen and von Dechen also drew attention to the grey, granular limestone of the Spean section, which is situated not far north of the limit of the district at present under discussion.

Nicol (1844, p. 165) recognised, probably from the summit of Ben Nevis, that quartzite plays an important role in the geology of the country lying between Glen Nevis and Glen Coe. He expressed the opinion that the quartzite here forms the tops of many of the hills, and we find this theory of an overlying quartzite constantly recurring in his later writings. Thus he groups together the quartzites of Islay, Jura [NM 700 010], and Loch Linnhe, and maintains that they "cannot be older than the Lower Silurian Period" (1858, p. 5) and that they are associated with mica-slate upon which they appear to rest. On reading paragraphs *f* and *g* of Nicol's note, there can be no doubt that he correlated the quartzites mentioned above with those of the North-West Highlands.

Murchison (1859, p. 420) adopted similar views in that he provisionally classed the quartzites and limestones of the Loch Linnhe district with the fossiliferous deposits (now known to be Cambrian and Ordovician) of north-west Sutherlandshire. Later he elaborated this interpretation in conjunction with Archibald Geikie (1861, pp. 171–240). Finding opposing dips on the two sides of Loch Linnhe near Fort William, they postulated an anticline along the line of the loch, bringing up the Sutherlandshire series from beneath the general gneiss and schists of the Highlands. It is strange to find that Nicol's hypothesis of an overlying quartzite is here turned upside down without involving any change in his correlations. It is now acknowledged, however, that it was quite impossible, either for Nicol or for his successors, to arrive at any true conception of the structure of this district as a result of brief visits. This latter-day caution is, in fact, foreshadowed in Murchison and Geikie's own paper, for in it they insist on the presence of isoclinal folds as an important factor in the structure of the Highlands (1861, pp. 201, 203, figs. 17, 18). It must be added that the correlation put forward both by Nicol and Murchison of the Loch Linnhe quartzites with those of Sutherlandshire carries very little weight at the present day. In this matter also the need for caution has been increasingly recognised.

Harkness followed with a paper inspired by Murchison's generalization regarding the age and position of the Highland schists. He draws a section across the Ardsheal [NM 995 574] peninsula, north of Cuil Bay, showing schist (Cuil Bay Slates and Appin Phyllites) lying in a syncline above quartz-rock (Appin Quartzite) with locally a band of limestone (Appin Limestone) intervening (1861, fig. 8, p. 266). It is probably no more than a coincidence that this interpretation agrees with the views at present in vogue, for it is doubtful whether Harkness found sufficient local evidence to indicate the synclinal structure of this peninsula.

In a final paper on the district, Nicol regarded the clay-slate, limestone and quartzite of Appin and Ballachulish as unconformable to the mica-slate, and as probably belonging to an overlying formation. In bad weather he visited sections in Glen Nevis, and these again led him to suspect the presence of an unconformable overlying quartzite (1863, pp. 205–206). Apart from this question, Nicol gives an interesting account of the schistose beds — partly "clay-slate", partly "mica-slate" — which intervene between Loch Leven and the southern edge of the map (1863, p. 202). He draws special attention to the frequent cross-foliation of these rocks, and, led astray by definite segregation of quartzose material along cleavage planes in the more micaceous layers, he concludes that the foliation must have originated under the same conditions as the bedding.

Cuil Bay Slates to Glen Coe Quartzite

The Geological Survey entered the district in 1895, and published a succession of brief notes in Annual Reports for 1895–6 and in Summaries of Progress for 1897–1908 and 1912 (see List of References). At first the field work on the

schists was wholly in the hands of J. S. Grant Wilson, with petrological support from J. J. H. Teall. Wilson's task was to block out the main features of the geology in a minimum of time. In 1902, when Teall became Director, B. N. Peach's responsibility as District Geologist was strengthened; and next year he had three Geologists placed under his leadership, with H. B. Maufe (Muff) and E. B. Bailey joining Wilson. More detail was expected, and less stress was laid on rapid accomplishment. In fact eventually much of what may be called the preliminary survey was given a quick revision in the light of later discoveries. In 1904 C. T. Clough took over from Peach, and G. W. Grabham was added to the group, followed in 1906 by W. B. Wright.

We shall defer discussion of Ardgour till chapter 9, and of the Lismore Limestone outcropping in the island of Shuna [NM 920 490] till p. 42. Also, to begin with, we shall confine our attention to schist groups lying between the Cuil Bay Slates and the Glen Coe Quartzite inclusive. The succession in this sequence is now known to be:

Cuil Bay Slates, black — youngest

Appin Phyllites, grey

Appin Limestones, white

Appin Quartzite, gritty

Ballachulish Slates, black

Ballachulish Limestone, dark limestone against the Ballachulish Slates, calcareous schist in the middle, thin cream-coloured limestone against the Leven Schists

Leven Schists, grey

Glen Coe Quartzite, fine — oldest

The names used above are all chosen from Sheet 53 (Geol.) and in what follows will be substituted for alternative names employed in early descriptions, some of which were based on faulty correlations.

In 1895 Grant Wilson was able to show the Director General, A. Geikie, several interesting geological features between Fort William and Onich. We read in the latter's account (Ann. Rep. 1896, p. 25) that a "grey normal" limestone (Ballachulish) is associated with black schist (Ballachulish) which is folded with quartzite (Appin) north of Gleann Seileach [NN 048 631]; and that "between this glen and the shore [at Onich] a white limestone [Appin], folded with the quartzite, but without any associated black schist, may be a distinct band", different, that is, from the grey band noted above. This account gives us a preview, as it were, of the succession now accepted from Appin Phyllite to Ballachulish Limestone.

In 1898 Wilson in the same area seems to have realised, though with some confusion, the synformal disposition of Ballachulish Slate over Ballachulish Limestone (Sum. Prog. 1899, p.46), well displayed in the south wall of Glen Nevis overlooking Glen Nevis. House ((Figure 3), p. 39); and later he drew attention to spectacular recumbent folding on a moderate scale affecting Glen Coe Quartzite at Stob Bàn, four miles to the south-east (Sum. Prog. 1902, p. 123).

Peach after one season's work with his staff of three offered a tentative appraisal of the schist succession in the Ballachulish district (1904, p. 66). This recognised that the Appin and Glen Coe Quartzites are distinct, an important point contributed by Wilson. Otherwise the statement was sorely muddled by misco rrelation of Appin Limestone with the cream-coloured edge of the Ballachulish Limestone, and of Appin Phyllites with Leven Schists. Peach had not found time to visit previously-mapped ground, including that lying north-east of Onich. Moreover, both he and Wilson started with the preconception that the Appin Quartzite was unconformable and might be folded in among outcrops of associated formations almost promiscuously.

If, however, we exclude all thought of the Appin Phyllite and Limestone, Peach's summary of 1904 does give an easily recognisable account of the lithology of the normal stratigraphical succession connecting the Appin and Glen Coe Quartzites (Plate 3), p. 55. In addition Maufe reported in some detail on a very special succession with Glen Coe

Quartzite at its base, which outcrops along Glen Coe from Bridge of Coe [NN 104 589] to Clachaig Hotel (1904, p. 67). This succession owes its peculiar character to the Ballachulish Slide, as yet unsuspected ((Figure 10), p. 70).

The exceptional Glen Coe succession passes south under a great cover of Leven Schist in Meall Mòr and Allt na Muidhe [NN 110 550], to reappear four miles away, with minor modifications, in what have since been called the Windows of Etive [NN 160 510]. Here Gough began mapping it (1905, p. 65), though unaware of its underground connection with Glen Coe. Here too, Maufe, in completing Clough's survey, came to a wonderful realisation of great recumbent movements (1906, p. 91). He found that the Glen Coe Quartzite exposed at the base of the Glen Coe succession in the bottom of the local glens is repeated above the thick Leven Schist cover so as to cap the neighbouring mountains. This discovery will be farther discussed on p. 87.

Next year, 1906, two important revisions were undertaken, the results of which were practically unrecorded at the time, though they greatly influenced later developments. In one day the writer remapped the Ballachulish district between the River Laroch [NN 080 560] and Beinn Bhàn [NN 069 575], and in doing so established the stratigraphical succession of Appin Phyllite, Appin Limestone, Appin Quartzite, Ballachulish Slate, that had been suggested ten years before in the Onich region. Another result was the vindication of Macculloch's transition zone between the two last-named formations; and still another, the tracing of three fold-faults; but the site of the Ballachulish Slide was not visited on this occasion.

Later in 1906, Clough and Wilson carefully revised the continuation of the same belt of complications southwards past Loch Baile Mhic Chailein [NN 023 475] to the edge of the map. They were unable to resolve some of the statigraphical puzzles, but they refined the mapping of outcrops and recognised certain fold-faults, among them one that has since been called the Sgòrr a 'Choise Slide. The evidence investigated in 1906 by the writer and by Clough and Wilson does not, in isolation, suggest large-scale tectonics; but it is of prime importance when considered in relation to what is found in neighbouring districts.

In 1908, when the mapping of both schists and igneous rocks in Sheet 53 (Geol.) was all but completed, the writer spent a fortnight visiting key exposures. The Callert district ((Figure 8), p. 50) was taken first, and, along with a geological manuscript copy of Sheet 53 as a whole, it gave a complete picture of the Ballachulish Recumbent Fold and Slide, both of them refolded. This was supplemented, in company with Maufe, by a comparison of the Ballachulish and Onich exposures, which disposed of the still lingering miscorrelation between Appin Limestone and the cream-coloured edge of the Ballachulish Limestone. Incidentally almost, the special Glen Coe succession, both in Glen Coe and the Windows of Etive [NN 160 510], now stood revealed as an eviscerated product due to the Ballachulish Fold-fault or Slide.

Horne and Clough came to check the new hypotheses. The latter started with the conviction that Glen Etive could not be interpreted from Callert; but as soon as he actually saw the Callert evidence he realised that it, with the intervening mapping, left no doubt regarding the continuation of the Ballachulish Slide through the Windows of Etive [NN 160 510]. Horne, on the other hand, faced with unfamiliar rocks and ideas in steep mountainous country, suspended judgment. So Clough, left alone, took the writer to see the Windows and also his 1906 mapping from Ballachulish southwards past Loch Baile Mhic Chailein [NN 023 475]. Everywhere the evidence fitted into place.

In a first note the connection between the Callert and Etive evidence was stressed (Sum. Prog. 1909, p. 51), and promise was given of further field study. Various excursions followed, during which the Cuil Bay Slates, for instance, were added to the stratigraphical column. The most helpful trip of all was made along with Maufe in the autumn of 1909. It resulted from a conversation in which Maufe had explained to Horne that he doubted whether some of the postulated slides had been sufficiently closely located to be shown by heavy black lines on Sheet 53 which was preparing for publication. The traverse was extensive and cleared up a number of uncertainties. The most important item was the establishment of the antiformal disposition of the Ballachulish Slates that separate the Beinn Bhàn and Gleann an Fhiodh [NN 080 560] synforms (Plate 3). There soon followed a paper in the Quarterly Journal of the Geological Society (1910) entitled " Recumbent Folds in the Schists of the Scottish Highlands".

Since then there has been one very important advance, in which the Cuil Bay Slates have been shown to be the youngest rocks of the succession listed on p. 18. This most welcome discovery was made by three young overseas visitors, T. Vogt, S. Buckstaff and O. N. Rove in 1924, though not published till 1930 (Vogt 1930; see also Tanton 1930,

and Bailey 1930). It was based upon the reading of current-bedding in the Appin and Glen Coe Quartzites, and has in after years been abundantly confirmed.

In the 1910 paper noted above, and again in the 1916 first edition of this memoir, the present writer had emphasised that no local evidence known to him indicated whether the Cuil Bay Slates were the oldest or youngest members of the succession. In 1922, however, in a general discussion of "The structure of the South-West Highlands" he had "ventured to suggest" that they were the oldest, an inference based mainly upon "tentative" stratigraphical correlations with other districts (1922, p. 195). Naturally these correlations have had to be abandoned in the light of the discovery made by Vogt and his friends. It has also followed that the movement registered in the local schists has been towards the north-west and that the two most important fold-faults of the district, the Ballachulish and Fort William, but not the Sgòrr a' Choise, Slides, have been developed in the lower limbs of recumbent synclines (Bailey 1930, p. 81; 1938).

Apart from such matters as depend upon age-orientation, the writer has on occasion been able to improve in detail upon his 1910 presentation of the evidence; and if the reader desires to follow up some particular point he will find guidance in the List of References. Here too are recorded certain criticisms under the names of G. L. Elles and C. E. Tilley (1930), J. F. N. Green (1931) and J. W. Gregory (1931) — to which replies have been given (Bailey 1934a, pp. 404, 511–522).

Leven Schists to Eilde Flags

Letus now turn to an extensive region, roughly bounded on the north-west by a line drawn from Callert on Loch Leven to the north-east corner of the map, and on the south by the broad limestone outcrop of Lower Glen Coe and the volcanic rocks further east to Altnafeadh [NN 222 563]. The sequence, in so far as it concerns us here, is as follows:

Leven Schist — *youngest*

Glen Coe Quartzite

Binnein Schist

Binnein Quartzite

Eilde Schist

Eilde Quartzite

Eilde Flags — *oldest*

Most of the mapping of this district was done by the writer, who thought when he wrote his 1910 paper that he had proved the repetition of rock types to be due to folding. In other words he correlated the Leven, Binnein and Eilde Schists as one formation, and the Glen Coe, Binnein and Eilde Quartzites as another. The evidence, until current-bedding was called in to help, was very difficult to read; but in spite of this R. G. Carruthers, after re-examining the whole region, successfully disentangled the true sequence (Sum. Prog. 1913; Carruthers 1923, pp. 25–30). The writer was given generous opportunities for further research, but for long could not reach a definite conclusion, as is explained in the first edition of this memoir (Bailey 1916, pp. 64–72) and in the memoir on the adjoining Sheet 54 (Geol.) (Bailey 1923b, pp. 30–33). At last in 1929, during a visit of the Princeton Summer School, T. L. Tanton and others demonstrated to him the trustworthiness of current-bedding. Next day the party saw the new method dispose of the old uncertainties, and posted to Carruthers a round robin carrying twelve signatures, which acquainted him of a unanimous verdict in his favour (Bailey 1930, p. 80).

This has of course, radically altered the reading of the detail of the tectonic pattern ascribed to the district outlined above. A full re-investigation was soon undertaken, and the result published in a paper entitled "West Highland Tectonics: Loch Leven to Glen Roy [NN 300 880]" (Bailey 1934a). Here we find an elaboration of a statement which was published after the Princeton excursion, namely: "The new criterion of original order of succession makes it child's play to recognise the essential structure of the district as recumbent folding, miles in extent, followed by steeply packed folding, thousands of

feet in extent" (Bailey 1930, p. 81).

Two recent papers on the quartzites and mica-schists of the Loch Leven–Glen Nevis district by W. G. Hardie (1955) and G. S. Johnstone (1955) trace additional slides with the help of current-bedding.

Schist metamorphism is touched upon in the Geological Survey Annual Reports and Summaries of Progress mentioned above; and is dealt with more fully in the first edition of this memoir and in papers by Bailey (1923a) and Elles and Tilley (1930).

Addendum

Since the preparation of the present edition of this memoir L. E. Weiss and D. B. McIntyre (1957) have attacked the structural problems of the Loch Leven district by methods which of late have found much favour among active researchers. As a result they have reached conclusions very different from those adopted in these pages.

Weiss and McIntyre discard all reference to original stratigraphy, and pay practically no attention to structural results previously obtained — beyond speaking hazily of big recumbent folds and slides having been recognised, in part correctly. In fact, they explain that the procedure adopted up to date has been "philosophically unsound... because it does not include a study of structural geometry in three dimensions". Their own main concern has been with the attitudes of bedding planes, foliation planes and fold axes, coupled with certain aspects of tectonic sequence. They divorce their observations of attitude from field and map context, grouping them instead as representative of what they consider to be tectonically homogeneous sub-areas. They next subject each group to simple geometrical analysis, and, having reassembled the resultant statistics on a vague, or one may say diluted, geographical background, they boldly draw conclusions.

Weiss and McIntyre carry their antipathy to stratigraphical control so far as to avoid any assistance from the abundant current-bedding of the district — they cover the subject with a statement that "all observations of cross-bedding made during the present investigation serve only to confirm his [Bailey's] observations". Accordingly they do not distinguish between normal and inverted dips. A dip of 160° (French style) goes into the hat as 20° (British style); which presumably explains why no mention is made of the fact that almost everywhere the beds in the eastern half of their district are upside down (Kinlochleven Inversion), while those in the western half are as consistently right way up (*cf.* our (Figure 15), p. 99). As their paper is called "Structural Geology of Dalradian Rocks at Loch Leven" it is well that readers should be forewarned that its methods offer no hope of proving, or disproving, the presence of large-scale recumbent folds. (It may be retorted that Sheet 53 does not distinguish between normal and inverted dips; but a dip on a geological map is read in its structural context, whereas a dip in a list is likely to be taken at face value.)

I may add that I have considered carefully the 85 graphs in which Weiss and McIntyre summarise their sub-areal statistics derived from thousands of observations; and I have found nothing to suggest the desirability of change in the structural reading of the district offered in 1934 (and reproduced in the present volume). This is scarcely surprising, since both their graphs and my interpretation are based upon careful examination of identical exposures; but it does not in itself imply that my 1934 interpretation is correct. To realise this important point one has only to remember that in 1909 I put forward a substantially different interpretation, which was, of course, just as carefully planned to conform with the data under consideration. (The 1934 corrections are based on additional evidence, furnished by current-bedding in a multitude of exposures, which distinguishes between normal and inverted successions.)

Before attempting to read the remainder of this addendum anyone unfamiliar with the subject should look through chapters iii, v, vi D, vii and viii in conjunction with Sheet 53. He will then realise that the Aonach Beag and Ballachulish Cores, north of Loch Leven, have been for a long time interpreted as refolded at a relatively late date into four secondary synforms (Figure 17), p. 112. The Ballachulish Core is preserved in the three more south-easterly of these synforms, which are shown in more detail in (Figure 8), p. 50. All three, pitching<ref>See p. 34 for definition of pitch.</ref> S.W., cooperate to develop the great pitch-depression of Glen Creran south of the loch ((Figure 17)). That these three synforms, and, along with them the Glen Creran Pitch-Depression as a whole, are later than the formation of the Ballachulish Core is emphasised by their folding of the Ballachulish Slide as a pre-existent structure.

The most south-easterly of the three synforms may be named for ready reference the Mam na Gualainn Synform — it is No. 1 Fold of Weiss and McIntyre (1957, p. 590). To the south-east it is succeeded by what has been interpreted in the past as a complementary antiform with blunt crest pitching very steeply S.W. under lower Glen Coe — where it mightily increases the scope of the Glen Creran Pitch-Depression. This S.W.-pitching antiform may be called the Loch Leven Antiform. It is replaced in Weiss and McIntyre's interpretation by a very different structure, their No. 2 Fold (1957, p. 590).

This has brought us to a crucial difference of interpretation concerning the contrasted attitudes of the Glen Coe Quartzite north and south of Loch Leven (within a couple of miles of lnvercoe). On the north the dip is steeply N.W., whereas on the south it is steeply S.W.

Bailey. — The N.W. dip N. of the loch corresponds with the N.W. limb of the Loch Leven Antiform. The S.W. dip S. of the loch corresponds with the S.W. pitch of the blunt front of this antiform.

Weiss and McIntyre*.* — The N.W. dip is a pitch-dip shown by the upper limb of the Loch Leven (No. 2) Fold, reinterpreted as a recumbent fold striking N.W. The S.W. dip corresponds with partial exposure of the hinge of the same, supposedly recumbent, Loch Leven Fold.

Both interpretations accept the view that there are two phases of folding involved; but even here there is local disagreement:

Bailey*.* — The Mam na Gualainn Synform and the Loch Leven Antiform, both belong to the later phase, since both fold the Ballachulish Slide.

Weiss and McIntyre*.* — The Mam na Gualainn Synform is relatively late because it strikes S.W. and observation often shows S.W.-striking structures crossing earlier structures that are otherwise oriented. The supposedly recumbent No. 2 Fold striking N.W. is relatively early.

One is left with the impression on reading Weiss and McIntyre that they recognise sliding as omnipresent, but that they do not think of the Ballachulish Slide as a definite structural entity that can be traced through later folds — they do not even allude to its possible existence! I must leave readers to form their own judgment in this matter and to ponder on the consequences.

As a connected issue it may be pointed out that there are two opinions regarding other irregularities of strike that are characteristic of the Loch Leven district away from the immediate neighbourhood of Invercoe [NN 098 593]:

Bailey*.* — These irregularities are mostly relatively late date diversions dependent upon the development of the Glen Creran Pitch-Depression.

Weiss and McIntyre. — These irregularities are relatively early residuals from a phase of recumbent folding with N.W. strike.

Let us pass on. In the first description given of the district (Bailey 1910, p. 604) we find the following:

"The secondary folding of the Aonach Beag Core has been accompanied by production of a very striking vertical strain-slip cleavage, which affects a belt of country about a mile wide [a later account adds that it is conveniently exposed in Glen Nevis gorge]. The strain-slip cleavage cuts and displaces quartz-veins in the schists which it traverses,.... it would seem that the quartz-veins in the present instance were formed in connexion with the development of the Aonach Beag Core and were buckled and broken when the latter suffered its subsequent corrugation".

The temptation was resisted to extend this conclusion to cover a wide area, and to distinguish between foliation phenomena connected with the development of the great recumbent folds (which latter may themselves be far from contemporaneous) and others connected with the subsequent development of the Glen Creran Pitch-Depression. Need for caution was emphasised by failure to find in the West Laroch [NN 080 580] quarries, or in the exposures further south, any criterion of attitude which would preferentially allot the cleavage of the Ballachulish Slates there displayed either to

the movement responsible for the Ballachulish Slide or, alternatively, to that responsible for the Glen Creran-Pitch-Depression — it is probably a very mixed phenomenon.

Weiss and McIntyre have given much more attention than I have to this difficult subject, and have decided that the Loch Leven district furnishes a widespread record of two main phases of foliation development. I am much impressed by their findings, and am prepared to attach the two phases of Aonach Beag to their time-scale. The Aonach Beag phenomena are exactly similar in appearance to the Loch Leven phenomena illustrated in photographs by Weiss and McIntyre (1957, pl. 2).

I must, however, add one more word of caution. Weiss and McIntyre think, probably quite rightly, that the early foliation of the district is accompanied by, and sometimes "recumbently folded" into, little "B-folds" that are apparently "syngenetic" (1957, p. 579). These foldlets they illustrate in three photographs (1957, pl. 1). I think the following is a fair description. In one photograph, lettered D, the foldlets reproduce miniature Jura [NM 700 010]-Mountain structures, the whole tilted. In another, C, the foldlets are compressed parallel with the regional. early foliation, and are disposed as typical dragfolds with orthodox relation to larger, but still very small, antiforms and synforms. In still another, A, the hinges of the foldlets are only seen occasionally, and the tightly appressed limbs are inseparable from the accompanying early foliation.

The point which two of these photographs, and also the accompanying text, quite clearly makes is that the B-foldlets tend to be parallel with the regional, early foliation; and everybody knows that the early foliation of the district is very variously inclined, generally at steep angles. Accordingly to speak of these foldlets as "recumbent" is to use the word recumbent "in an unusual sense; and to argue from their presence that large-scale"recumbent" folds are to be expected in the district is apt to confuse the unwary. (The obvious retort is that the main fold of the district, the Kinlochleven Recumbent Anticline, has already been described as recumbent in spite of the obvious abundance of steep dips.

The answer is that this fold is an up-and-down structure; it is recumbent only on a very large scale; it is steep in its smaller, but still large, ups and downs. For instance, in its widely spread inverted limb, the Kinlochleven Inversion, all antiforms have cores of younger rocks, and all synforms have cores of older rocks. This signifies very large-scale inversion, and therefore very large-scale recumbent folding; but the limb-dips of the antiforms and synforms are generally steep, vertical or even reinverted.) See also King and Rast (1959).

Igneous rocks

Early work

Between 1810 and 1820 the presence of "granite" at Ben Nevis, Glen Coe, Ballachulish and the Moor of Rannoch, and of associated "porphyry" (now known to be lavas and ashes) at the two first-named localities, had been reported by J. Williams (1810, pp. 409, 469), R. Jameson (1811, p. 115), T. Macknight (1811, pp. 307–357; 1821, pp. 113–5), J. Macculloch (1817) and A. Boue (?1820, pp. 21, 66–7). Williams at Ben Nevis, standing on the "granite" floor of the Allt a' Mhuilinn [NN 161 730] corrie, and looking up at the great cliff of "porphyry" reaching to the summit of the mountain (Plate 10), naturally, though mistakenly, thought that the "granite" passed under the "porphyry". We have already seen how the Wernerian Macknight agreed with this interpretation, and how, at first, he extended it outwards, thinking that the surrounding schists passed in turn under the "granite". Macculloch's Huttonian observations on contact-metamorphism and schist-inclusion by the Ballachulish "granite" have also been noted.

The structure of Ben Nevis was wonderfully clearly appreciated by C. von Oeynhausen and H. von Dechen (1830; 1834). They saw that the "granite" "has forced its way through [the schists]: the granite traverses these also, in the form of veins". Moreover they considered it "fully established" that the shape of the "porphyry" making the mighty cliff above Allt a' Mhuilinn [NN 161 730] "is that of an oblique four-sided pyramid, irregular and truncated, rising on the east and south, through the granite; and not merely overlying it, as M. Boué supposed". This constituted a thoroughly good field-appreciation of shape, though now one would say four-sided prism with rounded angles rather than pyramid.

Bryce, it may be added, also closely followed the junction between lavas (he called them greenstone instead of porphyry) and "granite" at Ben Nevis. He did not rightly appreciate the mutual relations of the two rocks, but he did notice "in places

portions of siliceous slate, sometimes of conglomerate structure entangled in the greenstone, or dividing it from the granite" (1864, p. 105). He was probably referring to a strip of schist and basal breccia that is exposed between the lavas and the "granite" on the corrie floor of Allt a' Mhuilinn [NN 161 730].

Passing to Glen Coe, we find W. Stevenson giving a fairly accurate account of phenomena of permeation which are there locally important. "Near the granite and porphyry", he writes, "where the metamorphism becomes extreme, flesh-coloured felspar is added chiefly between the slaty and quartzose laminae" (1867, p. 167). The value of this description is much reduced by the extravagance of some of the accompanying speculations.

In 1874 J. W. Judd wrote an account of the "Newer Palaeozoic volcanoes" of the Highlands (1874, p. 276). He pointed "to the very marked similarity in petrological characters between the vestiges of the lava rocks preserved in Beinn Nevis and Glen Coe on the one hand, and those which make up the large areas, as of Lorn and central Scotland on the other" (1874, p. 295); and by "lava rocks", he meant the "porphyry" or "greenstone" of earlier authors, which he had no hesitation in recognising as lavas and agglomerates.

Most of the Newer Palaeozoic volcanoes of central Scotland are shown by fossiliferous associates to be of Old Red Sandstone and Lower Carboniferous date; and Judd prefers not to make any closer approximation in regard to the lavas of Lorne, Glen Coe and Ben Nevis. A strange misstatement may be noted in this connection. Judd says "in the map of Scotland published in 1861 [it is dated 1862] by Sir R. Murchison and Prof. Geikie the 'traps' of Lorn are indicated as being of Old Red Sandstone age" (1874, p. 277). Actually this map miscorrelates the Lorne traps with those of the Hebrides, and groups both as Oolitic. Geikie's map of 1876 does show the Lorne lavas as of Upper Old Red Sandstone age, but this was two years after Judd had published his paper. The matter was finally settled by the finding of Lower Old Red Sandstone fossils in Lorne by A. Macconochie (Geikie 1897b). Stems and a *Pachytheca* were later found in Glen Coe by D. Tait and B. N. Peach (Sum. Prog. 1903, pp. 78, 130). They were for some years referred to known Lower Old Red Sandstone types; but redeterminations have since rendered their age-significance less definite (p. 145).

Judd interpreted the great "granite" masses of our area as the eroded stumps of mighty volcanoes, a view that may come very near to the truth. He also, like others previously, called attention to the multitude of dykes characteristic of parts of the region. He clearly recognised that the "granites" had been "protruded" through the schists. At Ben Nevis, however, he repeats Williams' structural mistake, for he thinks that the lavas and agglomerates furnish a "great cap" to underlying "granite" — and this in spite of his knowledge of von Oeynhausen and von Dechen's claim that the "masses of porphyry ' had been forced through the midst of an earlier-formed mountain of granite" (Judd 1874, pp. 293–4). All the same, a plug, or neck, theory of the centrally exposed volcanic rocks continued popular until Maufe in 1910 cleared up the whole matter. It is illustrated, for instance, in sections accompanying Geikie's geological map of Scotland, both in 1892 and 1910. On the other hand Ben Nevis is not mentioned in Geikie's "Ancient Volcanoes of Great Britain" (1897a), and the Glen Coe lavas are briefly dismissed as "picturesque outliers" of the Lorne series. All this goes to show how little was known of the structure of the district when the Geological Survey undertook its detailed investigation.

Meanwhile, between 1874 and 1910, the volcanic character of the central rocks of Ben Nevis was emphasised by descriptions of hornblende-andesite (Teall 1888, p.287, p1. 37, 1) and of fine tuff (Mackie 1907). Teall's description of the Ben Nevis hornblende-andesites, given in his "British Petrography" (1888) established "the only good instance of a hornblende-andesite known in the British Isles" up to date; though now the type is widely recognised from Glen Coe and elsewhere.

Teall also referred in "British Petrography" to the Ballachulish and Ben Nevis "granites" and to an unusual "plagioclase-augite-olivine-mica rock" at Kentallen, west of Ballachulish (1888, pp. 268, 325, pl. 16, 1). The Ballachulish "so-called granite" is carefully described as illustrating the great difficulty of drawing a line between quartz-mica-diorites and granitites.

Geological Survey and later

As for the Kentallen rock, Teall did not in 1888 recognise its orthoclase; but later, when as Petrographer of the Geological Survey he examined specimens collected by Wilson, he drew special attention to the presence of this mineral and

enriched a full description of the rock with a chemical analysis. He further made comparison with Brogger's olivine-monzonite type, though careful to point out that the Kentallen quarry rock "is far richer in olivine than any rock hitherto recognised as belonging to the monzonite group" (Ann. Rep. 1897, pp. 22–3). Teall's notes in the Annual Report of the Geological Survey for 1896 and in Summaries of Progress for 1897 to 1899 furnish a much abbreviated record of the foundations he laid for future petrological work on the plutonic rocks and the associated contact-metamorphism of the district. As an obvious superstructure we may note a very able paper by J. B. Hill and H. Kynaston introducing the name kentallenite as soon as it had become apparent that the Kentallen type reappeared at a number of widely separated localities in Argyll (1900).

Kynaston entered Sheet 53 (Geol.) after mapping Lorne lavas and Cruachan "Granite" in Sheet 45 (Geol.) to the south; and he undertook much of his own petrology as he went. In Sheet 53 he mapped a considerable part of the Glen Coe lavas and of the northward extension of the Cruachan "Granite", which latter he found to intrude and bake the lavas (Sum. Prog. 1901, pp. 82–3). Before leaving Sheet 45 he had already established two main features closely affecting the geology of Sheet 53, namely: the presence of what is now called the Etive Swarm of parallel north-east dykes (Sum. Prog. 1898, p. 88); and the fact that the Cruachan "Granite" is pierced by a central, more acid granite — called after Glen Etive by Kynaston, but later renamed after Ben Starav (Sum. Prog. 1899, pp. 78, 80). He pointed out that this Starav Granite is apparently (we now know really) later than the Etive Swarm.

Kynaston's year by year descriptions include certain structural mistakes, but these are mostly cleared up in a note to the British Association meeting of 1902.

Here we find a statement of what is still accepted as the standard succession of the Glen Coe volcanics (basic andesites, rhyolites, agglomerates and hornblende-andesites, (Figure 20), p. 133) and also a recognition of eastward overlap in this succession upon the schist floor. Further, while rightly maintaining that the Cruachan "Granite" intrudes the Glen Coe lavas, he records the presence of boulders of granite and diorite, from some other source, in the basal conglomerates of the Glen Coe volcanic pile (1903).

The above announcements were amplified in manuscript notes left by Kynaston on his departure for South Africa in 1903 — notes that were later incorporated in the first edition of this memoir. Moreover, these notes include a first description of the boundary-fault of the Glen Coe cauldron as exposed in An t-Sròn (Figure 20). Kynaston could not, of course, foresee that the fault he mapped in An t-Sròn would presently be found to turn round and encircle a sunken area; but he did realise, so far as was possible from a single section, the fundamental relation existing between it and the An t-Sròn "Granite", which is part of what has since been called the Fault-Intrusion. The following is taken from his manuscript:

"On the south side of Glen Coe, south-south-west of Loch Achtriochtan, a well-marked line of fault, indicated by a deep cleft on the north-east slopes of An t-Sròn, cuts off abruptly the andesites which are seen on the east side. On the west side occurs a mass of granite which shows a marginal facies along the line of the fault, so that it is possible that the fault may be older than the granite".

Although we now claim that faulting and intrusion were contemporaneous, it remains true that at any particular point the fault must have started before the first arrival of magma.

Kynaston's mapping of the Glen Coe lavas was in the main completed by Maufe, as also his mapping of the Boundary-Fault, usually in two branches, in its course between An t-Sròn and Glen Etive. South of Glen Etive, Clough traced a branch of the Boundary-Fault with flinty crush-rock along it, which latter he compared with flinty crush-rock he had already brought to notice in the Cheviot Hills and in the North-West Highlands (Sum. Prog. 1905, p.. 68). This observation was soon to be extended along much of the line of the Glen Coe Boundary-Fault elsewhere.

North of An t-Sròn Maufe and Peach traced the Boundary-Fault past Loch Achtriochtan to near the west end of Aonach Eagach [NN 160 583] ((Figure 19), p. 132). It was not realised at the time that the fault here suddenly turns through a right angle; in fact Peach, on finding a contact of quartzite and lava at the east end of Aonach Eagach [NN 160 583], attributed it to unevenness of the floor upon which the volcanic rocks had accumulated (Sum. Prog. 1904, p. 70). Yet it was clearly recognised that the fault was definitely arcuate, running N.N.W. from Glen Etive, N. at An t-Sròn and N.N.E.

past Loch Achtriochtan to Aonach Eagach [NN 160 583].

While Maufe was working on the volcanic rocks from Clachaig Hotel, the writer, stationed at Caolasnacon and later at Altnafeadh [NN 222 563], was assigned the predominantly schistose country to the north and north-east. This by accident led to my mapping the boundary-fault for the six miles between Aonach Eagach [NN 160 583] and Stob Beinn a' Chrillaiste beyond Altnafeadh [NN 222 563], thus virtually completing the main Glen Coe story (Sum. Prog. 1906, pp. 96–8, fig. 2).

Two facts of historical importance may here be introduced. The first belongs to the very outset of my investigation, when Maufe explained to me that he had already found that the quartzite-lava contact at the east end of Aonach Eagach [NN 160 583] (ascribed by Peach to an irregularity of the pre-lava floor) was really due to an abrupt turn of the Boundary-Fault. To this Maufe added that his experience between Glen Etive and Aonach Eagach assured him that the Boundary-Fault, when followed eastwards, would be found again and again flanked exteriorly by Fault-Intrusion, smoothly chilled against it. I answered that, if all this proved true, we must be dealing with a cauldron-subsidence, around which magna had contemporaneously spurted up. The phrase ' cauldron-subsidence ' was used because of Suess' descriptions, as rendered in the English translation of his "Antlitz der Erde", of the Ries and Hohgau cauldrons, at first interpreted as regions of subsidence (Suess 1924, index references).

The second point to be noted came after I had almost finished the mapping of my share of the fault-zone, and was leading Clough and Maufe along its course. On coming to Stob Mhic Mhartuin [NN 207 575], in some ways the type exposure of the Boundary-Fault (Plate 9), Clough noticed that I had overlooked a one-inch layer of flinty crush-rock immediately adjoining the chilled margin of fault-intrusion. This proved to be Clough's major contribution to the study of the Glen Coe Cauldron; for recognition of flinty crush-rock at a number of other places enabled me to improve materially my understanding of exposures in my own ground, and, in company with Grabham, to continue with certainty the tracing of the boundary-fault from Stob Beinn a' Chrùlaiste [NN 232 564] to Coire an Easain [NN 250 496] ((Figure 29), p. 164). In this eastern district, it may be added, Grabham made the independent very important discovery that the Moor of Rannoch "Granite" is earlier than the Fault-Intrusion of Glen Coe.

The standard account of "the Cauldron-subsidence of Glen Coe and its Associated Igneous Phenomena" is by Clough, Maufe and Bailey (1909), and to this readers are referred. Among other things they will find in it the first suggestion that some plutonic intrusions occupy subterranean cauldron-subsidences (1909, fig. 14, p. 670), and also the first explanation offered of swarms of parallel dykes (1909, pp. 673–5). It may be added that subaerial calderas of subsidence have been claimed at a number of modern volcanoes from very early days of geological interpretation; but Glen Coe probably affords the first deeply eroded example to be thoroughly appreciated. It should, however, be recalled that J. Schetelig, at about the same time as the Geological Survey was working in Glen Coe, independently investigated similar instances in the Oslo district — he briefly mentions the Baerum caldera in an excursion guide of 1916, but he died in 1935 without having published anything that might be called a description (*cf.* Holtedahl 1943). It would take too long even to list papers on similar subjects that have since appeared at home and abroad.

Maufe went from Glen Coe to Ben Nevis, where he found the same general style of intrusion-tectonics, though with interesting variations. His standard account is entirely his own work (Sum. Prog. 1910). It has been modified by J. G. C. Anderson (1935b) in relation to the marginal portion of what Maufe had separated as the Outer "Granite", but otherwise remains intact.

Anderson (1937a) has also published a very important paper on the Etive Complex (including the Cruachan, Starav and other "Granites"); but his new conclusions mostly concern Sheet 45 (Geol.). In addition T. R. M. Lawrie has subdivided the Ballachulish Pluton as shown in the 1940 and 1948 editions of Sheet 53.

Anderson's papers on Ben Nevis and Etive carry valuable petrographical data, especially in regard. to gravitational differentiation; while two by F. Walker (1924, 1927) are concerned with various intrusions in the neighbourhood of Kentallen. Moreover, as might be expected, the rocks of the district figure prominently in modern textbooks of petrology.

Two more petrological papers may be selected for special notice, for though they deal with the geochemistry of the Devonian (or Caledonian) rocks of Scotland as a whole, these rocks are better represented in Sheet 53 than anywhere else. The first supplies a comparison of the major constituents of the Devonian rocks with those of their neighbours of Carboniferous and Tertiary age. It establishes, among other things, a relatively high content of MgO (Elder 1935). The second concentrates on trace elements, a field that has been but little explored (Nockolds and Mitchell 1948). See also Nockolds and Allen (1953; 1954).

Great Glen Fault

A wonderful claim has been put forward by W. Q. Kennedy (1946) that the Great Glen Fault, along which Loch Linnhe has been eroded, is a sinistral wrench- or tear-fault with a horizontal displacement of 65 miles. The evidence for the most part lies outside Sheet 53 (Geol.), but will be summarised in chapter 21.

Glaciation and Recent deposits

Reference to the bibliography of this Memoir will show that the Boulder Committee of the Royal Society of Edinburgh from 1878 to 1884, under the convenorship of David Milne Horne, issued several reports, which touched upon its glaciology. It is interesting to find that kentallenite and augite-diorite boulders in Glen Creran, and along the shore south from Kentallen, early attracted attention. At the time there was a great tendency to look for a westerly or north-westerly source for all erratics, and accordingly specimens of the "black granite" boulders were dispatched to Prof. Judd for identification with the gabbros of Mull; it is not surprising considering the date, 1877 or 1878, that Prof. Judd considered it "certain they were derived from the Western Isles".

On general grounds this conclusion was immediately disputed by James Geikie (1878, p. 867), who stated that he had never seen Hebridean erratics upon the mainland of Scotland. In fact, local evidence might have been adduced to throw doubt upon the suggestion, for, thirty years before, Charles Maclaren (1849, pp. 169–172) had illustrated a masterly account of the glaciation of Scotland by a detailed description of certain conspicuous *roches moutonnées* at Ballachulish, and had shown, it now seems conclusively, that these rocks had been moulded by land ice moving from east to west.

M. F. Heddle (*in* Boulder Com. 1880b, p. 630) strengthened James Geikie's position immensely by finding kentallenite or, as he described it, a rock "identical in composition with the boulders", occurring *in situ* above the path which leads between Glen Creran and Ballachulish, a couple of miles north of Salachail [NN 056 512]. In spite of this discovery, however, the idea that the "black granite" boulders came from Mull was not finally relinquished for years. It is now known, of course, thanks to Grant Wilson's mapping and the petrographical descriptions of Teall, Hill, and Kynaston, that "black granite" (kentallenite and augitediorite) is represented by several outcrops in the district, and that it has an individuality of composition which entirely distinguishes it from the Tertiary gabbros. This later work is dealt with in chapter 17.

It may be stated that, although ice-rafts are frequently invoked by the reporters of the Boulder Committee, many of the phenomena of transport were correctly attributed to local glaciers, especially in the later reports. Colin Livingston of Fort William and Heddle were both particularly clear on this point.

While dealing with the subject of erratics, it is convenient to direct attention to a pebble found by J. Currie in far-away Iona, since he claims that it has been transported by ice from Glen Coe (1899). One of the lavas of Glen Coe contains a beautiful red epidote, first found by H. Witham in 1824 and described, under the name "withamite", by D. Brewster (1825). The Iona erratic is said to be identical with this Glen Coe lava, both in its general characters and in its containing a considerable quantity of withamite. It is quite probable from the direction of ice flow that Currie is right in deriving this pebble from Glen Coe, sixty miles distant, but it also seems possible that it may have come from some unknown source in Mull; this possibility is suggested owing to Harker's description of rosy epidotes which "may be termed withamite" occurring in some of the lavas of Skye (1904, p. 52).

An analysis of the Glen Coe withamite has been given by Thomson (1836, p. 377) and another, much more complete, by Heddle (1898, p.355).

The raised beaches of the district have not attracted very much notice. R. Chambers (1848, p. 92) has referred to them, and has figured the problematical terraces of Corran [NN 016 636] (wrongly called Connel in his description).

J. Gwynn Jeffreys (1863) has also published an exceedingly valuable list of fifty-nine marine species of Scandinavian facies from a bed found by Captain Bedford at Fort William. The significance of these shells, and of certain mosses found by Wright and Maufe beneath the "25-ft beach" of the same locality, and described by H. N. Dixon (1910), will be discussed in chapter 22.

Although not rich in lakes the district has shared in the advantages of the great Scottish fresh-water loch survey, carried through under the direction of John Murray and Laurence Pullar during the years 1897 to 1909. The results have been published in collected form (1910), and a reference to the bibliography of this memoir will enable the reader to find details regarding six small lochs which have been sounded in Sheet 53. E. B. B.

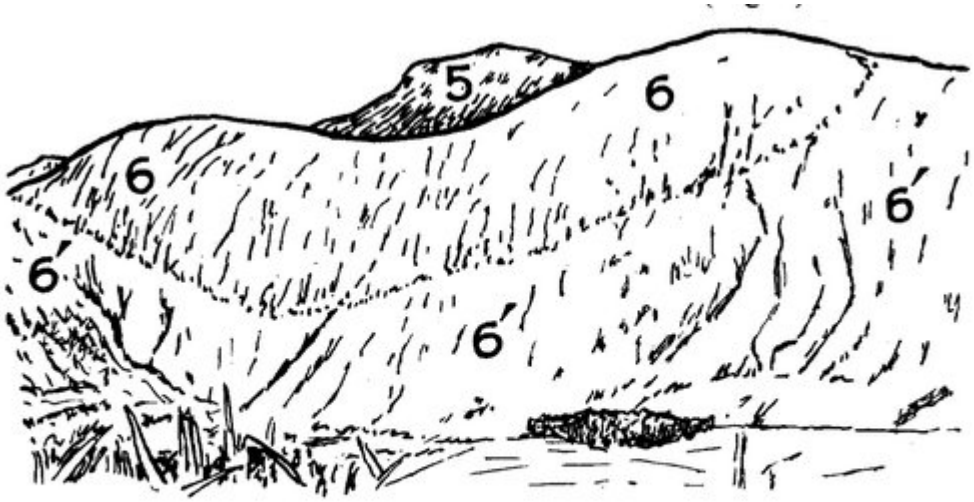
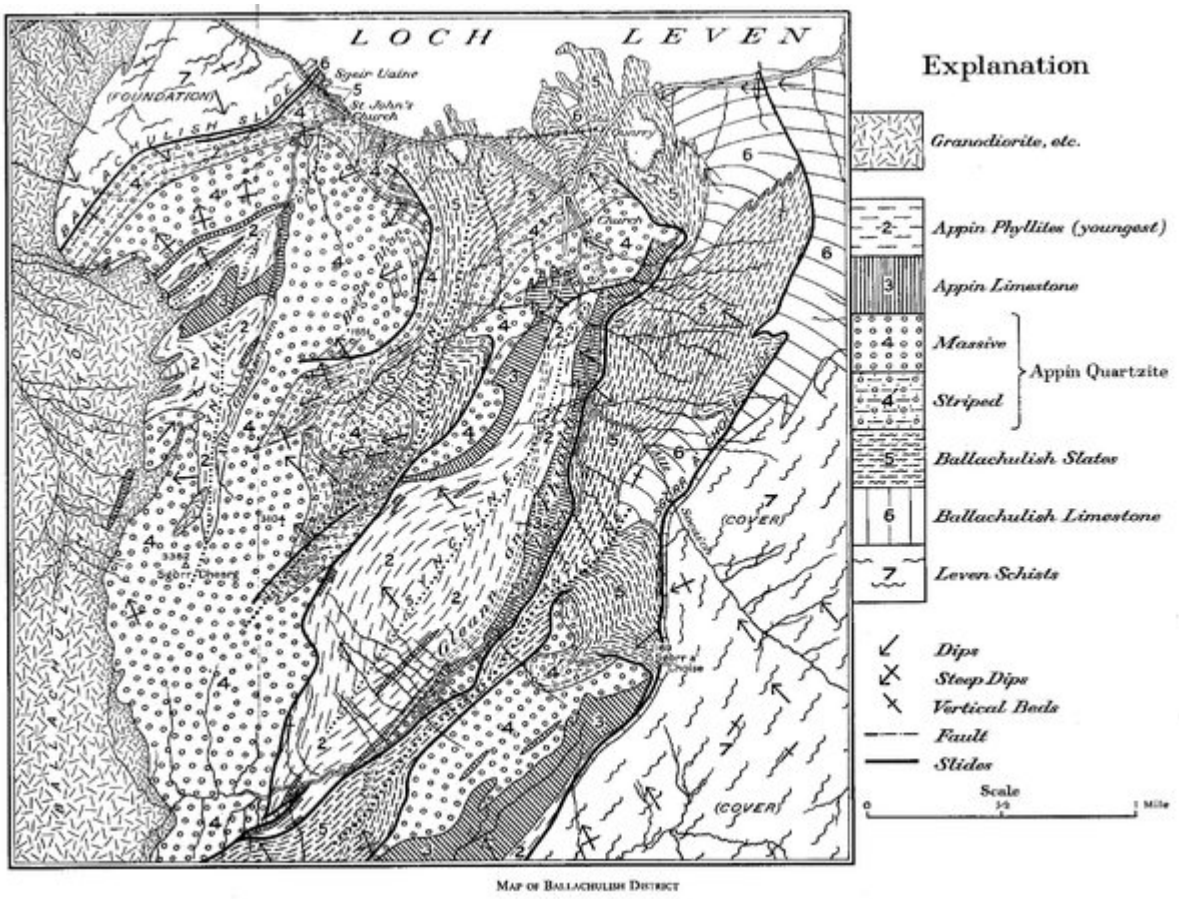


FIG. 3. Sketch of Appin Fold sectioned in S.W. wall of Glen Nevis

5, Baked Ballachulish Slates (youngest) ; 6, Marble of Ballachulish Limestone ; 6′, Calc-silicate-hornfels of Ballachulish Limestone

(Figure 3) Sketch of Appin Fold sectioned in S.W. wall of Glen Nevis 5, Baked Ballachulish Slates (youngest); 6, Marble of Ballachulish Limestone; 6′, Cale-silicate-hornfels of Ballachulish Limestone.



(Plate 3) Map of Ballachulish District.

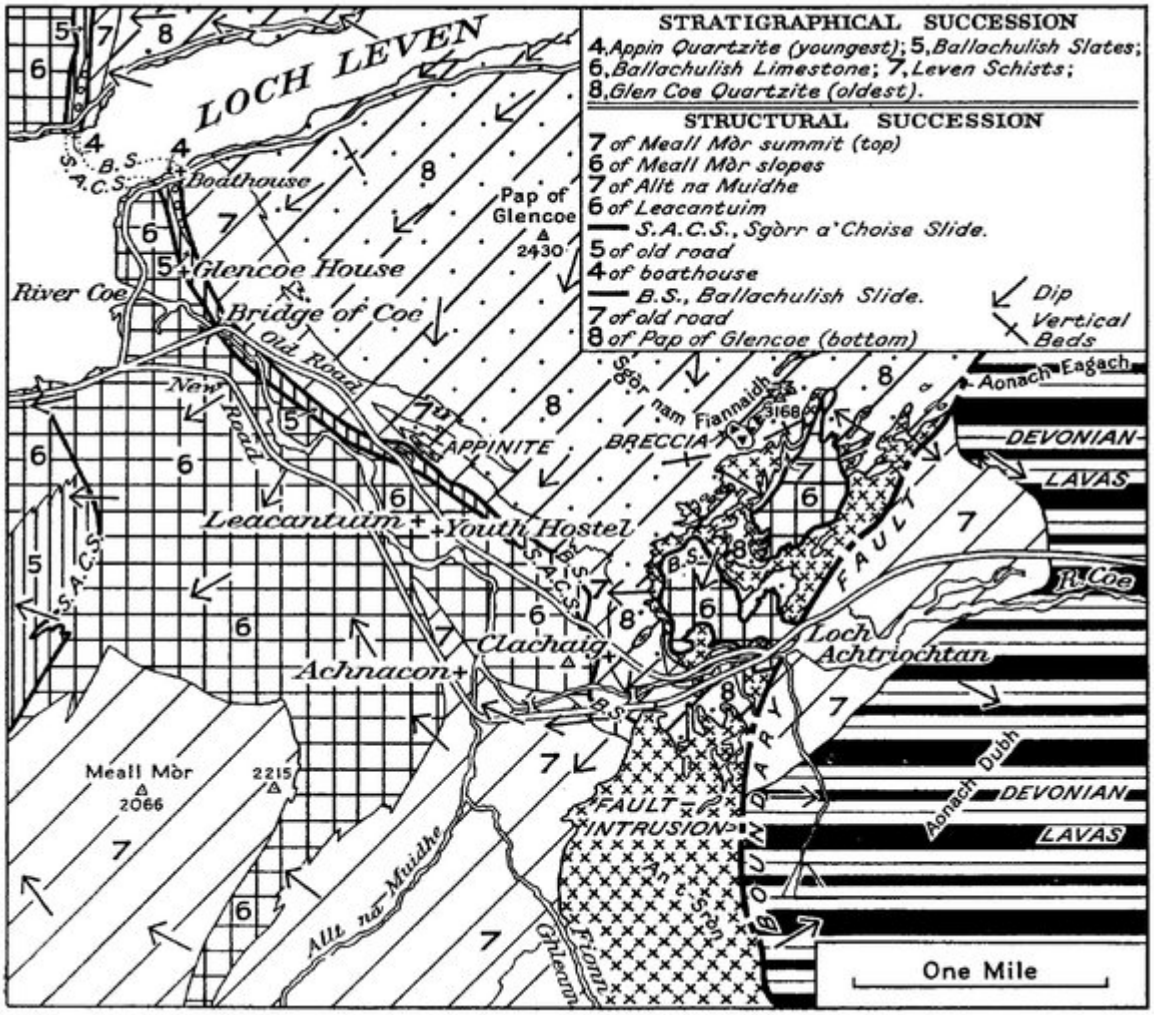


FIG. 10. Map of Lower Glen Coe

(Figure 10) Map of Lower Glen Coe.

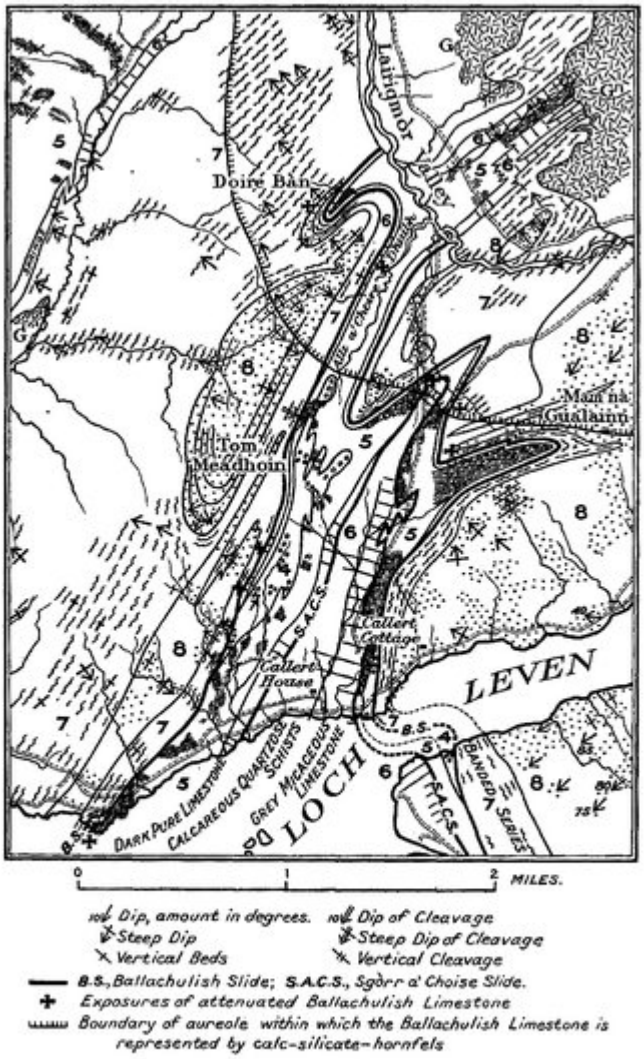


FIG. 8. Map showing outcrops in Callert district

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.

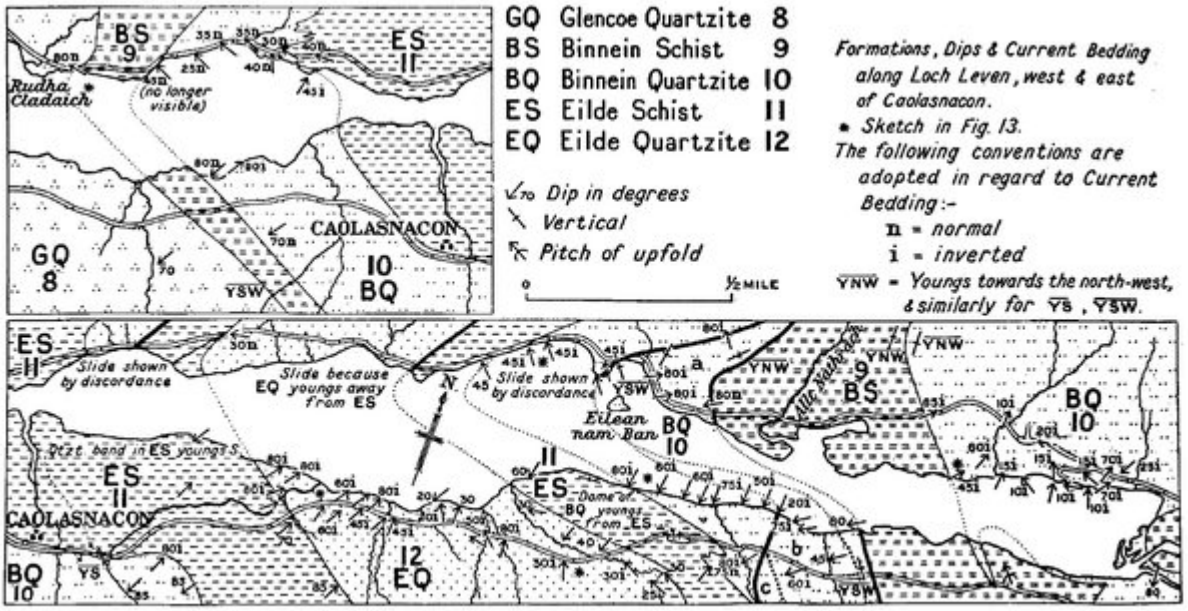


FIG. 15 (West above, east below). Formations, dip and current-bedding west and east of Caolasnacon

(Figure 15) (West above, east below). Formations, dip and current-bedding west and east of Caolasnacon.

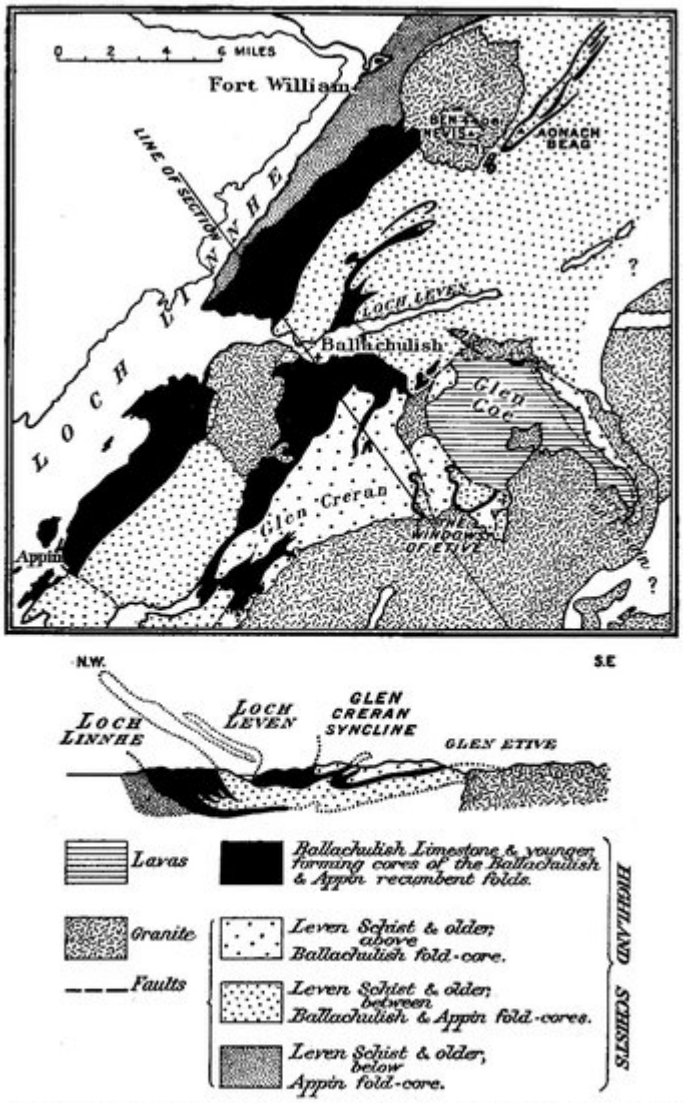
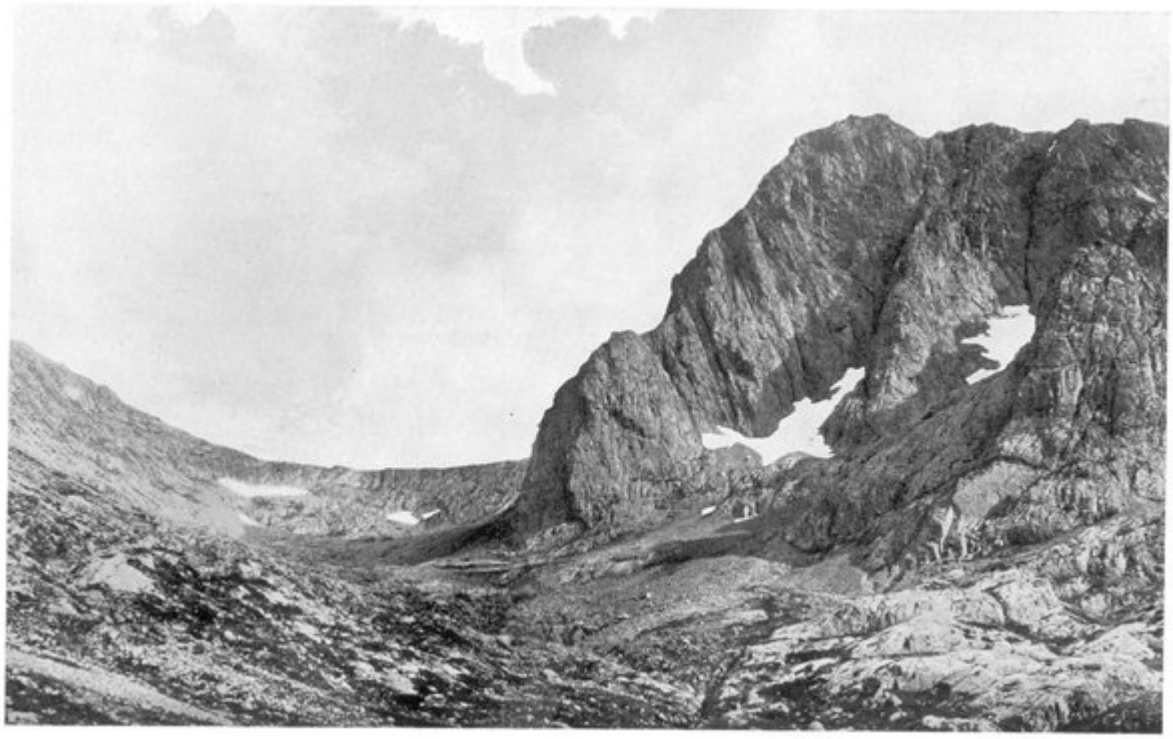


FIG. 17. Map and Section showing the structure of the Highland Schists and the positions of the cauldron-subsidences of Glen Coe and Ben Nevis

(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.



(Plate 10) Allt a' Mhuilinn [NN 161 730]: Ben Nevis Volcanics on right, and Inner "Granite" on left, meeting in stream.

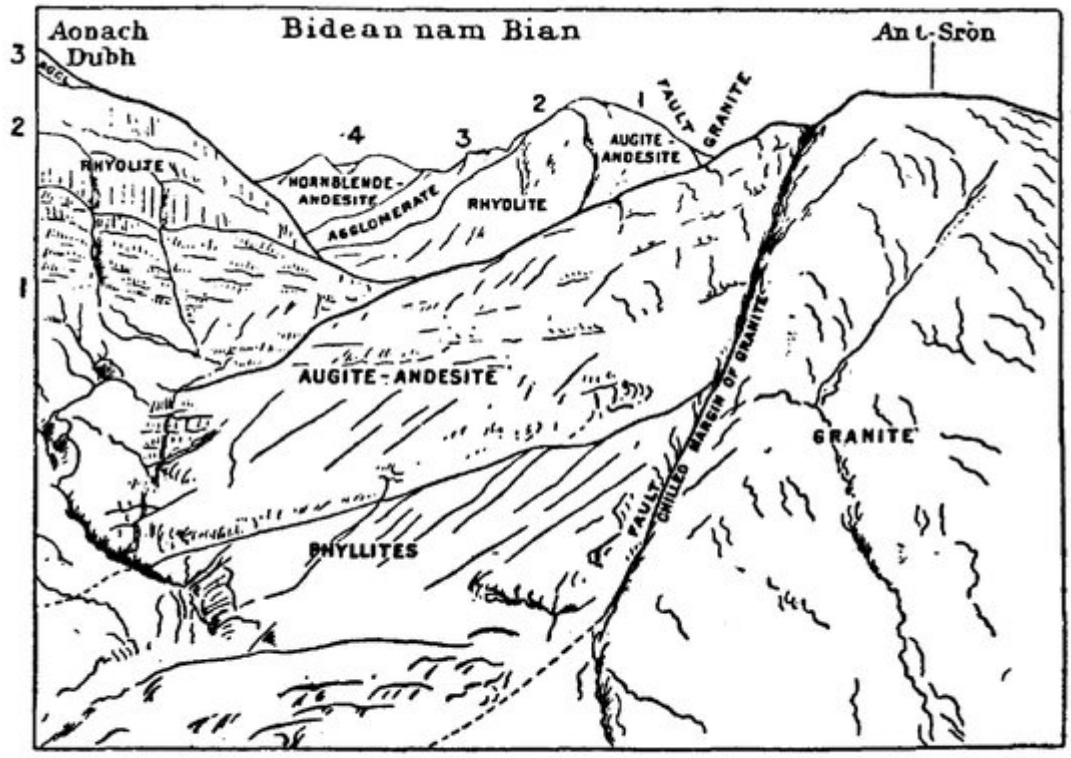


FIG. 20. View of Boundary-Fault of the Cauldron-Subsidence of Glen Coe as exposed in An t-Sròn

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

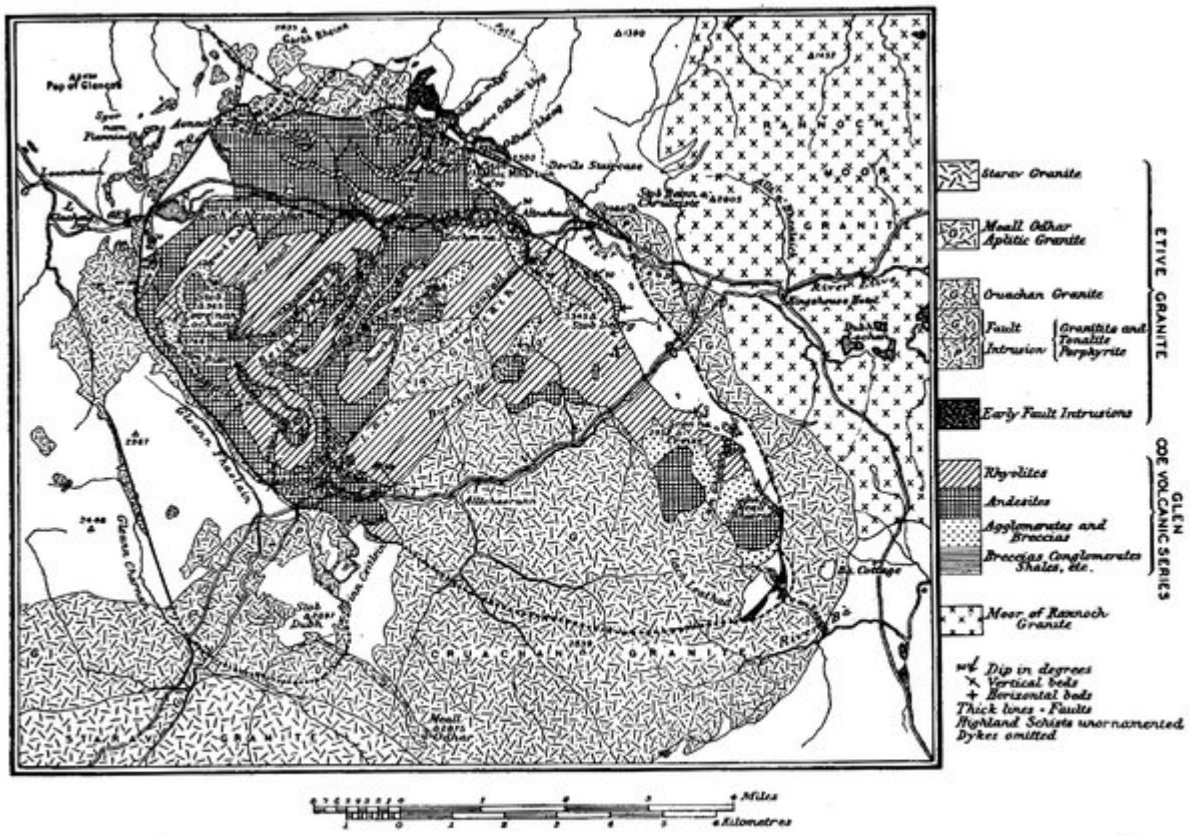
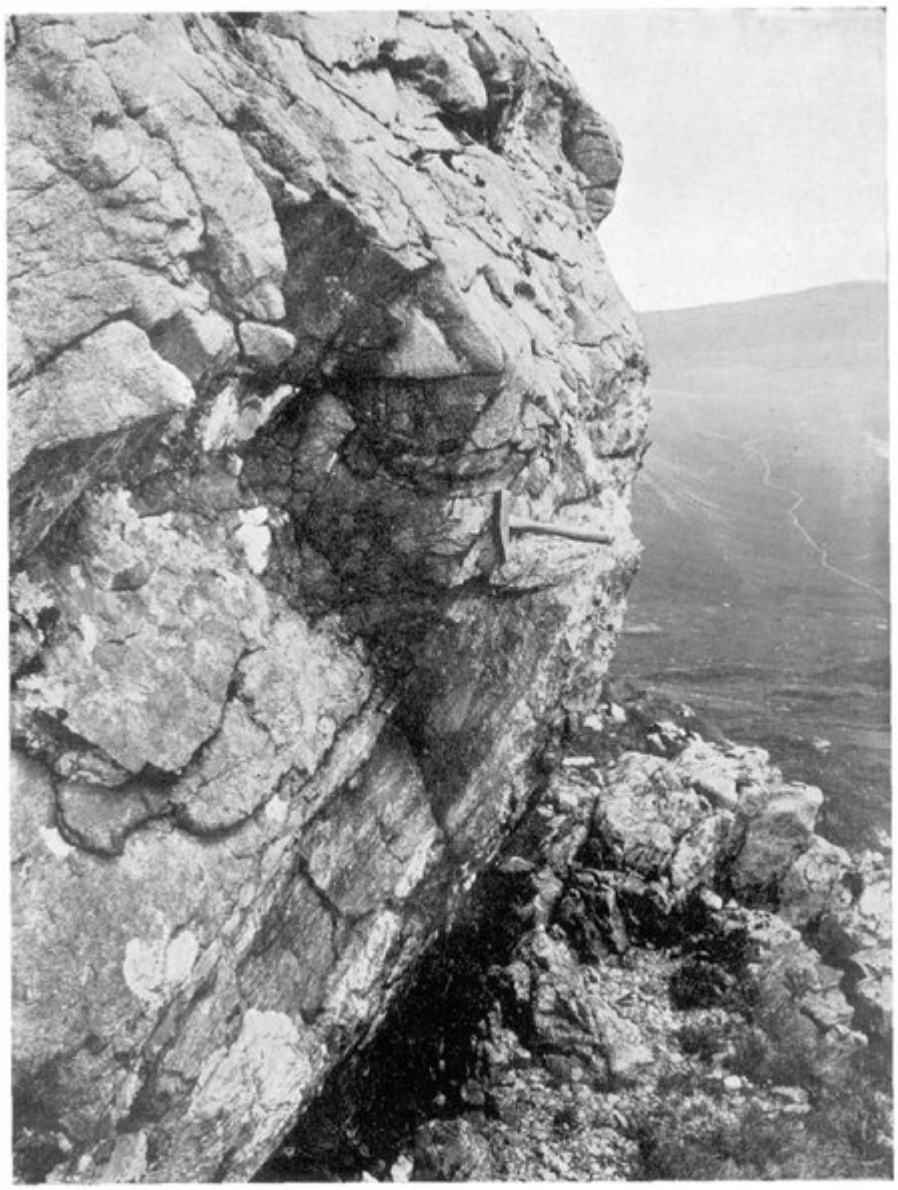


FIG. 19. Map of the Cauldron-Subsidence of Glen Coe and associated igneous phenomena
For new road see Fig. 22

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



(Plate 9) Glen Coe Fault, Stob Mhic Mhartuin [NN 207 575].

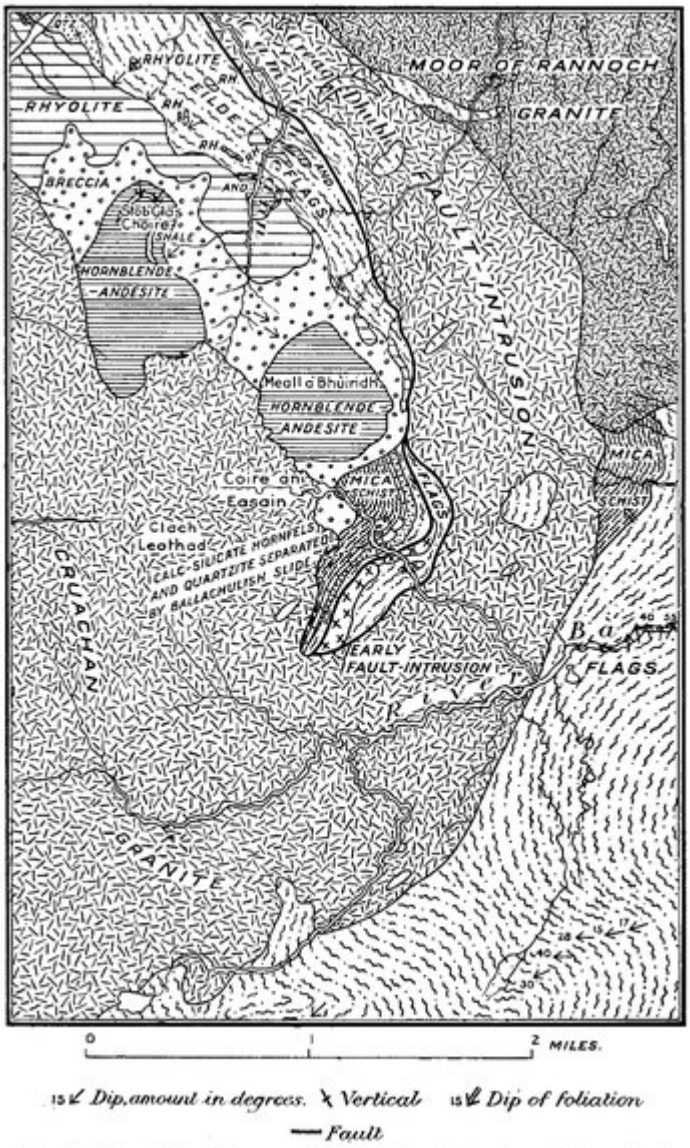


FIG. 29. Map of Càm Ghleann and Coire an Easain. North-east dykes omitted

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