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## Chapter 11 Rocks of Lower Old Red Sandstone age

### Volcanic Series of Glen Coe

The volcanic rocks of the Glen Coe district occupy a roughly oval area, situated in the south-east corner of the map and measuring nine miles in length by five in breadth (Figure 19). They form the centre of the mountainous district about Glen Coe and the upper part of Glen Etive, giving rise to about a dozen peaks over 3000 feet in altitude. On the north side of Glen Coe they constitute the jagged ridge of Aonach Eagach [NN 160 583], whence a south-easterly dip brings them down into the central portion of the glen. On the south side they reach a height of 3766 feet in Bidean nam Bian [NN 140 543] (Figure 20), and form the northerly spurs of this hill, which are known as the "Three Sisters of Glen Coe" (Aonach Dubh, Garr Aonach, and Beinn Fhada [NN 170 550], (Plate 4). Thence they extend eastwards into the two "Herdsmen of Etive" (Buachaille Etive Beag [NN 192 548] and Buachaille Etive Mòr [NN 210 538], of which latter Stob Dearg [NN 225 543] is the main peak, (Plate 8), p. 146). South of this they cross Glen Etive, to build the northern and eastern ridges of Clach Leathad [NN 240 493] and the shoulder of Beinn Ceitlein [NN 176 490] above Dalness [NN 168 512].

The area thus defined is surrounded for four-fifths of its circumference by a fault which throws down the volcanic rocks and the underlying schists some thousands of feet. On the south side, where the fault is wanting for a distance of 4 to 5 miles, the volcanic rocks have been invaded by a lobe of the Cruachan Pluton which has penetrated into the heart of the volcanic region.

#### A. Standard sequence: Loch Achtriochtan to Buachaille Etive Beag [NN 192 548]

A traverse up Coire nam Beith, between An t-Sròn and Aonach Dubh [NN 155 560], to the top of Bidean nam Bian [NN 140 543], and thence to the southern summit of Beinn Fhada [NN 170 550], furnishes the best introduction to the study of the volcanic series ((Figure 20) and Sections II, IV, of (Figure 21)). A condensed account will suffice for most readers, while further detail is given elsewhere (Clough, Maufe and Bailey 1909, p.615).

The full sequence encountered is as follows, in descending order:

7	Andesites and Rhyolites	300
6	Shales and Grits	50
5	Rhyolites	250
4	Hornblende-Andesites	900
3	Agglomerates and Shale	250
2	Rhyolites	450
1	Augite-Andesites and Basalts	1500
Total		3700

#### Group 1. Augite-Andesites and Basalts

About 17 flows of augite-andesite and basalt occur in Group 1, and are well exhibited in the precipitous lower crags of Aonach Dubh. In the stream of Coire nam Beith (Figure 20) they are separated from the underlying phyllites by a couple of feet of purple sandy shale containing flakes of phyllite.

The lavas closely resemble the more basic flows constituting the greater portion of the Lorne Series. They are dark grey, almost black when fresh, and become purple, reddish and greenish on decomposition. Small black phenocrysts of augite and red pseudomorphs after olivine can often be detected.

They are only sparingly amygdaloidal, and their vesicles are filled with calcite, agate, red jasper, and sometimes epidote. They are often much brecciated, with red shale bedded into the interstices between the blocks. Breccias of this type must not be confounded with agglomerates. Good examples are exposed near the summit of the group in Coire nam Beith [NN

140 550] and between the Coe and the road 400 yards south of east of Achtriochtan [NN 157 571] farm (Figure 22). Occasional beds of shale and grit intervene among the lavas, as may be seen to advantage 200 yards east of the upper fall in Coire nam Beith.

The upper surfaces of some of the flows are reddened in a manner suggesting contemporaneous weathering.

The lavas of Group 1 outcrop without material change south-eastwards along the Boundary-Fault from An t-Sròn [NN 134 550] to Dalness [NN 168 512] in Glen Etive; and in the other direction they cross the Coe in force between Achtriochtan [NN 157 571] farm and the Queen's Cairn [NN 183 565] (Figure 22), as will be described in the following section.

## **Group 2. Rhyolites**

There are three rhyolite lavas in Aonach Dubh of (Figure 20), each about 150 feet thick. They all show fluxion structure, and the uppermost flow-brecciation in addition.

The local variations of Group 2, represented by rhyolites alone in the type section, are extremely interesting. Traced into the western peak of Bidean nam Bian [NN 140 543], where the rocks stand on end near the Boundary-Fault (Figure 20), the rhyolites die out entirely. Followed to the east, on the other hand, from Aonach Dubh through the other two "Sisters of Glencoe" (Gearr Aonach [NN 160 555] and Beinn Fhada [NN 170 550]), the group expands, and in the last-named, and also in the opposite slopes of Buachaille Etive Beag [NN 192 548], it includes a very large proportion of andesite flows (Section II, (Figure 21)). Among these latter both augite- and hornblende-andesites occur, and their intercalation with the rhyolites, which they more or less replace in the succession, can clearly be traced in Beinn Fhada [NN 170 550]. The thickness of the group in this locality must be about 2000 feet.

Farther east again, the andesite-lavas of Group 2 disappear even more suddenly than they came. Not one of them extends round the northern face of Buachaille Etive Beag [NN 192 548], for this consists entirely of rhyolite.

## **Group 3. Agglomerates**

The next group in (Figure 20) is a mass of agglomerate made up of blocks of augite-andesite and rhyolite and underlain by about 20 feet of greenish sandy shale.

This agglomerate marks an important period during which few if any lavas were erupted. The accumulation is of variable character, and often gives place to green shales and grits. The latter are well bedded and show that the structure of the central portion of the Glen Coe area is characterised by a prevalent southerly dip of varying amount. The fine-grained sediments are 100 feet thick in Allt Coire Gabhail [NN 162 550]. In the western slope of Beinn Fhada [NN 170 550] they are much thinner, and in the eastern slopes are lost sight of. They reappear, however, at the head of Allt Lairig Eilde [NN 173 540], and connect north-eastwards with agglomerate, just as in the type section of Stob Coire nan Lochan.

## **Group 4. Hornblende-Andesites**

The hornblende-andesites of Bidean nam Bian [NN 140 543] weather with a pale crust, though dark greenish-grey to black on a fractured surface. They carry small but fairly conspicuous phenocrysts of plagioclase feldspar and hornblende in a compact base, which often exhibits flow-banding. This is the youngest division included in (Figure 20). Its outcrop reaches continuously from Stob Coire nan Lochan to Buachaille Etive Beag [NN 192 548].

## **Group 5. Rhyolite**

A black vitreous rhyolite, rich in phenocrysts of feldspar, succeeds the hornblende-andesites of Bidean nam Bian [NN 140 543]. Though a thick mass it may be a single flow. It encloses numerous xenoliths of rhyolite and hornblende-andesite, and occasional pieces of quartzose schist.

Rhyolites in this position extend along Beinn Fhada [NN 170 550], and also form an outlier on Buachaille Etive Beag [NN 192 548]; and they probably enter into the contact-altered mass forming the southern end of Buachaille Etive Mòr [NN

210 538]. Their base dips at moderately high angles towards the south.

## **Group 6. Shales and Grits**

Well stratified greenish-grey shales and grits now interrupt the volcanic sequence. They vary considerably in thickness and seem to have collected on a lake bottom. Their outcrop, with that of the following Group 7, is limited to the southern shoulder of Beinn Fhada [NN 170 550].

## **Group 7. Andesites and Rhyolites**

The topmost group preserved consists of rhyolites and hornblende-andesites accumulated in very irregular fashion (Section IV, (Figure 21), p. 134). H. K., H. B. M.

## **B. Road excursion: Loch Achtriochtan to Altnafeadh**

In the locality map (Figure 22) the new Glen Coe road is drawn with firm boundaries, while the old road is only shown west of Loch Achtriochtan. The following account of roadside geology extends eastwards from this loch to Altnafeadh [NN 222 563], and includes other interests besides those directly concerned with the volcanic rocks. In a previous excursion starting from the mouth of the glen we reached the Boundary-Fault of the Cauldron-Subsidence of Glen Coe (p. 77), and described it as seen in An t-Sròn (Figure 20) and in the River Coe [NN 155 569]. Let us start here and work our way inwards into the cauldron, that is towards the left in our picture.

The groups of lava and agglomerate numbered in (Figure 20) will be referred to constantly as we proceed; but the standard account of their development along the deeply-indented precipitous southern slopes of the glen has already been given in the preceding section.

The underlying phyllites, though well exposed in (Figure 20), are in most of their outcrop south of the road covered by the water and alluvium of Loch Achtriochtan. This, however, does not prevent the eye from following, just south of the Coe, their approximate junction with augite-andesites and basalts of Group 1; though, in the broad bottom of the glen north of the river, erosion has removed for a space all trace of escarpment.

North of the road, the lavas of Group 1 soon reassert their position in the topography and furnish a conspicuous cliff running obliquely up the hill-slope to meet the Boundary-Fault midway along the craggy summit ridge of Aonach Eagach [NN 160 583] (Jagged Ridge). Close to the fault the lavas are tilted vertical, but at a little distance they dip away from it with a regular, fairly steep, south-easterly inclination.

Proceeding east along the road one soon comes to the furthest north point of Loch Achtriochtan, beyond which its shoreline leaves the road turning abruptly to the south-east. Here, on the north side of the road, one can hammer convenient exposures of the little-altered phyllite (Leven Schists). Here too, looking northeastwards up the steep face of the glen, one can realise that the phyllite tract terminates within a distance of about a mile. Rock exposures are frequent on the slope above the road, though isolated by thin glacial drift and more still by impressive chutes of debris, which latter increase to a maximum just before Achtriochtan [NN 157 571] farm is reached. Where the hillside exposures show phyllite they are distinguished by a slabby smoothness. The eye can thus trace the phyllite outcrop, which is clearly bounded north-eastwards by the lava escarpment already mentioned; while north-westwards it is limited, much more obscurely, by rough rocky slopes, due to Fault-Intrusion just outside the Boundary-Fault. It is almost startling to note how faintly this fault manifests itself in the scenery here, on the north side of the glen, as compared with its diagrammatic showing in An t-Sròn across the way.

Andesite of Group 1 first appears at the roadside in a knob upon which Achtriochtan [NN 157 571] farm is built ([S39706](#)) [NN 1565 5714]. This may well be the lowest flow; but to hammer the basal sediments described in the following section (p. 142) one has to go one or two hundred yards north of the road.

From Achtriochtan [NN 157 571] farm onwards for the next mile and a half there are frequent roadside exposures of Group 1 andesites or basalts. They are all very fine-grained, and it is often impossible to discern their crystalline texture with a pocket lens — though they are not flinty like the overlying rhyolites. Amygdaloidal developments are very restrained.

While traversing these lavas the road, between half and three-quarters of a mile east of Achtriochtan [NN 157 571] farm, crosses two more very impressive chutes of debris. These have been fed by intermittent streams that have etched the face of the Chancellor [NN 167 578] (an English name replacing Am Bodach, 'The Old Man'). The streams have been guided by shatter-belts and porphyrite dykes. It is clear that some at least of these shatter-belts are of quite early date, for two of them running N.–S. have persuaded porphyrite dykes to forsake temporarily their normal north-east direction.

A quarter of a mile past the more easterly of the major debris chutes descending from the Chancellor [NN 167 578], the road bears to the right at a rock cutting. There can be no mistaking the position, for east of the cutting there is a milestone reading 25 miles to Tyndrum and 12¼ to Kinlochleven. The cutting shows basalt in part reddened, possibly by contemporaneous weathering, and traversed by a characteristic north-east porphyrite dyke, 10 feet wide. The exposure has a special interest in that the lava affords specimens of the rare pink manganese epidote called withamite (Brewster 1825; Heddle 1898, p. 355). The mineral occurs in small crystals occupying a central position both in amygdales and in the infillings of narrow cracks. Maufe traced this withamite-bearing lava ([S11615](#)) [NN 1729 5662] down to the River Coe [NN 155 569], and noted a good exposure where the old deserted road runs for 200 yards in a south-easterly direction, aiming directly at the mouth of Allt Coire Gabhail [NN 162 550].

A couple of rhyolite flows, both belonging to Group 2, are interbedded among andesites in the Chancellor [NN 167 578], and in certain lights they can be recognised from the road. The upper one, or another in like position, reappears in a conspicuous comrade crag, called A' Chailleach [NN 184 572] (The Old Woman), a mile to the south-east. It is pink or red and can as a rule be easily identified even at a distance.

The lower of the two Chancellor [NN 167 578] rhyolites marks the base of Group 2. It has been traced for a mile and a half along the north face of the glen until, due south of A' Chailleach [NN 184 572], it reaches the valley bottom to join with the exposures of the more spectacular mountains across the glen.

The Three Sisters of Glen Coe, Aonach Dubh (Black Ridge) [NN 155 560], Geàrr Aonach (Short Ridge) [NN 160 555] and Beinn Fhada [NN 170 550] (Long Mountain) dominate the view to the south. All three are spurs of Bidean nam Bian [NN 140 543] (Peak of Hides or Deer Skins). Their main features, outlined in the previous section, can easily be followed in the scenery with the help of the geological one-inch map coupled with (Figure 19). Above all, one recognises the special grandeur of the thick rhyolite flows of Group 2 (Plate 6), p. 133 and the ease with which their junction with the augite-andesites of Group 1 can be traced, if we disregard very minor instances of interdigitation.

Among other points of interest in the view to the south we note that several porphyrite dykes of the Etive Swarm can be recognised. A good example of such a dyke cutting through the rhyolites of Aonach Dubh has for a stretch fallen away in blocks thus producing in the cliff a conspicuous cleft, the mythical Ossian's Cave [NN 153 563], sometimes visited by climbers (Figure 22). Again at the foot of Gearr Aonach [NN 160 555], west of Allt Coire Gabhail [NN 162 550], the rhyolite crags are traversed by half a dozen grassy lanes floored by porphyrite dykes (Plate 6), (Plate 7).

Allt Coire Gabhail [NN 162 550] (Stream of the Corrie of Capture) is itself guided by a porphyrite dyke, and has for some distance disappeared under a considerable landslip precipitated from Gearr Aonach (Plate 7). An alluvial strath has formed behind the landslip, and in the days of clan warfare served as a convenient hiding place for captured cattle.

Allt Coire Gabhail [NN 162 550], directed as we have seen by a porphyrite dyke, drains north-eastward; and, downstream from the landslip, it has cut a deep gorge. The Coe (left bottom corner of (Plate 7) in its general westward course has also met this particular dyke (which crosses the old road just beyond the cottage), and has eroded its course for a short distance south-westwards along it. Thus two about equally matched currents meet head on, and their combined torrent escapes at right angles, west-north-westwards along a transecting gorge that is guided by a monchiquite dyke, of probable Permian date. This monchiquite (lettered C on Sheet 53) has been recognised at intervals for five miles; and at

the collision juncture of Allt Coire Gabhail [NN 162 550] with the Coe it has located a third incoming stream, called Allt Doire-bheith [NN 175 563] (Stream of the Birchwood), entering from the east-south-east (that is from the left in (Plate 7)). Thus Nature, taking advantage of two intersecting dykes, has arranged what has come to be known as the Meeting of Three Waters [NN 175 563].

At about this point a great upward step affects the bottom of Glen Coe, a step corresponding with the crossing of the lowest persistent rhyolite of Group 2 that extends on the one side to Aonach Dubh and on the other to the Chancellor [NN 167 578].

Though for half a mile above the Meeting of Three Waters [NN 175 563] the Coe still flows over andesites of Group 1, the influence of the resistant cover of rhyolite is already obvious. Broadly speaking the bed of the river, from Loch Leven to a point a quarter of a mile downstream from the Meeting of Three Waters [NN 175 563], rises 400 feet in 5½ miles. From here to the fourth of a succession of bridges, which we shall soon be crossing (Figure 22), it rises four and a half times as quickly, 500 feet in 1½ miles. Upstream from this bridge to the watershed west of Lochan na Fola [NN 210 560] (Bloody Lochan, named after a brawl) it rises much more gently again, 100 feet in one mile.

At the step, the Coe has incised itself into the bottom of the glen, cutting a gorge along intersecting zones of weakness; and it has already succeeded in eliminating all falls and cataracts along its own course. In doing so, however, it has outstripped its tributary Allt Lairig Eilde [NN 173 540] that enters upstream beyond Beinn Fhada [NN 170 550] (Figure 22). Accordingly this important tributary is left hanging, and discharges as a picturesque waterfall into the post-glacial part of the chasm excavated by the Coe. This affords a favourite spectacle for tourists, and special laybys have been arranged for buses.

The new road, which we are following (Figure 22), by means of cuttings and bridges keeps close by the line of the river, so that, starting with an initial advantage of about 100 feet, it is able to maintain an easy uniform gradient, combined with fairly long limbs, between three almost rectangular bends. The manner in which the upstep of Glen Coe has been negotiated, and the precautions taken further back where fans of debris have been crossed, afford fine examples of civil engineering.

Welcome as are the close views of the river mentioned above, they are on the whole less impressive than what can be seen, hereabouts, at a higher level from the old road, now only available to walkers. Anyone with time to spare should make a point of visiting both, and the laybys at the fall make this easy for motorists. The high-level view is best approached from the east, by leaving the new road for the old between the closely adjacent second and third bridges upstream from the Allt Lairig Eilde [NN 173 540] fall. Both roads are here on the north side of the Coe, the new road a little lower than the old. Having reached the latter, one proceeds westward for quarter of a mile to the foot of An t-Innean Mòr (Great Anvil or Stiddy [NN 183 565], now commonly corrupted to Study [NN 183 565]). Here a cairn, shown on (Figure 22), by the side of the old road marks a view-point chosen for Queen Victoria's lunch during a visit to the West Highlands. The advantage of approach from the east is that at first the old road, at a little over 800 feet approximates to the general level of the bottom of what may well be called Upper Glen Coe. Then at the Queen's Cairn [NN 183 565] it brings one suddenly into view of Lower Glen Coe, 300 feet below. It is argued in chapter 1 that Upper Glen Coe still owes much of its character to an initial eastward-draining river, while Lower Glen Coe has been profoundly transformed by reversed drainage making for the west.

Though approach to the Queen's Cairn [NN 183 565] from the east is recommended because of its specially dramatic quality, approach from the west is very easy, again on foot. The old road cannot be missed where it climbs up above the new road along a ramp ¼-mile N.E. of the Meeting of Three Waters [NN 175 563]. In a quarter of a mile it rises 130 feet to the Queen's Cairn [NN 183 565].

Other items in the view from this cairn are tracks of north-east porphyrite dykes crossing the lower slopes of Beinn Fhada [NN 170 550] and Buachaille Etive Beag [NN 192 548], exactly comparable with those already noted at the foot of Gearr Aonach [NN 160 555].

Still another reason for visiting this locality is afforded by the intensely corrugated fluxion-banding of the rhyolite on which the Queen's Cairn [NN 183 565] stands. This is the basal rhyolite of Group 2, in large measure responsible for the preservation of Upper Glen Coe.

Let us now return to the new road by descending the ramp ¼-mile N.E. of the Meeting of Three Waters [NN 175 563]. At the bottom, let us turn eastwards towards the Allt Lairig Eilde [NN 173 540] fall. For 300 yards there are good roadside exposures of an andesite lava that serves as top to Group 1, until it passes in clear section under the Queen's Cairn rhyolite of Group 2. A first glance at the road cutting may give the false impression that the rhyolite is filling pockets on an uneven surface of the andesite, here somewhat amygdaloidal; but the illusion is due to the dark-grey andesite having been bleached white in patches where until recently it has been overlain by peaty soil. Close examination shows that the plane between andesite and rhyolite dips evenly and gently, reaching the road surface opposite the most westerly of the laybys arranged for views of the river gorge. Here the exact line of demarcation is emphasised by a two-inch bed of fine-grained black volcanic sandstone, fairly rich in minute detrital flakes of muscovite in addition to plentiful volcanic debris. Slices [\(S39698\)](#) [NN 1809 5639]; [\(S39699\)](#) [NN 1809 5639] show this interesting sediment to be slightly disturbed by the overlying rhyolite, here a crypto-crystalline devitrifying glass.

For the next 150 yards the road cutting exposes the rhyolite as a breccia, presumably a basal flow-breccia rather than an independent ash. Slices [\(S39697\)](#) [NN 1809 5639]; [\(S39700\)](#) [NN 1809 5639] from near the base have patches rich in epidote; while [\(S39701\)](#) [NN 1809 5639] from near the top is a much cracked mosaic of feldspar and quartz. There has probably been a lot of strewing immediately after eruption. Then follows in the road cutting and in the river gorge a magnificent show of gently and evenly inclined flow-banding, contrasting strongly with the corrugated display higher up in the same flow at the Queen's Cairn [NN 183 565]. About a dozen north-east dykes, porphyrite and lamprophyre, are seen in the half mile of cutting that traverses the rhyolite outcrop.

Exposures of the Queen's Cairn rhyolite continue past three bridges that carry the road to and fro across the Coe and end near an imposing cairn, between river and road, which stands at the start of a path that leads through Lairig Eilde [NN 183 560] (Pass of the Hind) to Dalness. Here the rhyolite is followed by overlying andesite which extends along the road for the next quarter of a mile until the fourth and final bridge of the series is reached. This andesite belongs to one of the numerous andesite intercalations characteristic of the Beinn Fhada [NN 170 550] development of Group 2 (p. 135); and it connects these with the andesite flows that separate the Queen's Cairn rhyolite from that of A' Chailleach [NN 184 572] to the north.

We have now come approximately to the flat axial region of a syncline determined by the tendency of the lavas to dip away from the curved course of the Boundary-Fault of the Cauldron-Subsidence. So far along the road, all the way from Achtriochtan [NN 157 571], the prevalent dip of the volcanics has been south-easterly. Before long, however, we are to enter a belt with pronounced south-westerly dip, which, combined with drastic overlap, brings Moine Schists (Eilde Flags) to view at Cnoc nam Bocan (Goat Hillock) [NN 213 561]. Deficient exposures, a certain confusion of dips, and irregularities in the succession make it doubtful where exactly the centre of the syncline lies. Maufe, who mapped the ground, thought that the andesite we have just mentioned is the highest volcanic rock preserved anywhere in the bottom of Glen Coe. The writer, after re-examining the evidence since the making of the new road, is of a slightly different opinion. He thinks, without being quite certain, that, immediately east of the fourth bridge, this andesite passes under agglomerate followed in turn by porphyritic rhyolite, and that the latter, which outcrops conspicuously along the road for the next three-quarters of a mile, is really the highest rock encountered in our traverse. It is remarkable, therefore, that, where last seen at the roadside, this porphyritic rhyolite comes within a quarter of a mile of the Moine Schists (Eilde Flags) exposed at Cnoc nam Bocan — a consequence of overlap.

Agglomerate, with one short interruption by andesite, is the first rock seen north of this porphyritic rhyolite in its west to east course along the road. It would seem to be the same agglomerate as that noted above east of the fourth bridge; and its continuation south-eastwards from Lochan na Fola [NN 210 560] has been mapped across the River Coupall [NN 210 554] to Stob Dearg [NN 225 543] (Red Peak).

Exposures are fairly good along and beyond the old road which lies a little to the north of the new road, and they show conclusively that the Lochan na Fola [NN 210 560] agglomerate crosses it with a steep south-westerly dip. The following

succession emerges from beneath the agglomerate within a distance of about 500 yards measured along the new road: rhyolite, andesite, rhyolite. The last-named has been excavated in a large shallow quarry on the south side of the road, an ideal place to park or turn a bus. Just beyond is a notice-board, reading: Cnoc nam Bocan Summit 1,024 ft. [NN 213 561]

The quarried rhyolite may quite possibly be the same as the Queen's Cairn flow at the base of Group 2 in the standard sequence of the west. At any rate it occupies approximately the same position in the volcanic pile; yet here it rests on Moine Schists that make the actual hillock of Cnoc nam Bocan [NN 213 561] immediately to the north. The juxtaposition is not due to faulting. Maufe found thin basal conglomerate intervening on the old road, and, though this particular evidence has since been covered, basal sediments can easily be followed for about a mile where the unconformable contact continues north-west obliquely up the valley side.

The overlap recognised at Cnoc nam Bocan [NN 213 561] is characteristic of all the northeastern margin of the Glen Coe volcanics. It is, for instance, diagrammatically seen at the base of the magnificent Stob Dearg [NN 225 543], which stands full in view a mile to the south-east (p. 146).

Looking in the opposite direction one can grasp that Cnoc nam Bocan lies well within the Cauldron-Subsidence. The Boundary-Fault passes at the foot of Stob Mhic Mhartuin [NN 207 575] (p. 160) a mile to the north-west, and then continues without special features, to cross the road three-quarters of a mile beyond Altnafeadh [NN 222 563].

One last point. While the summit post at Cnoc nam Bocan [NN 213 561] marks the summit of the road, the flat inconspicuous watershed of the valley itself lies half a mile further east, the other side of Lochan na Fola [NN 210 560], at almost exactly 1000 feet. Looking east past Altnafeadh [NN 222 563] along the Moor of Rannoch (R. in (Figure 1); also (Figure 18)) we can easily restore in imagination the supposed eastward-draining river that has now had its waters redistributed to the westward-flowing Coe and the southwestward-flowing Etive.

## **C. North side of Glen Coe: especially basal sediments**

### **Introduction**

The road traverse just described, supplemented by Sheet 53 or (Figure 19), allows us to realise the main features of the volcanic succession displayed north of the Coe, except that it does not cross exposures of basal sediments. These sediments are quite thin and are probably of different dates in different exposures owing to the marked overlap from west to east. To clarify matters, the present section, though devoted primarily to the basal sediments, starts with a concise summary of their volcanic associates which alone reveal the rather confusing overlap. Some repetition from Section B is unavoidable, but additional facts are introduced.

### **Volcanic rocks**

Owing to sharp upward tilt of the volcanic series in the neighbourhood of the Boundary-Fault (Figure 21), only Groups 1 and 2 of the standard sequence are found on the northern flanks of Glen Coe. Moreover, the distinction between the two groups is not always clear, for Group 2, instead of being all rhyolite, as in Aonach Dubh (Figure 20), is a mixed assemblage of rhyolite and andesite, as in Beinn Fhada [NN 170 550] (p. 135), and its andesites sometimes directly overlie others belonging to Group 1.

A rhyolite lava in the basal portion of Group 2 is traceable for a mile and a half from the Queen's Cairn [NN 183 565] to the lower slopes of the Chancellor [NN 167 578] ((Figure 19), (Figure 22)). All the andesites outcropping between it and Achtriochtan [NN 157 571] farm obviously belong to Group 1; but in Aonach Eagach [NN 160 583] these same andesites are overlain by others which further east, in the Chancellor [NN 167 578], lie above the Queen's Cairn rhyolite and therefore belong to Group 2.

On top of the Chancellor [NN 167 578] andesites, that is some way up in Group 2, a second rhyolite appears. Westward it caps the Aonach Eagach andesites at Meall Dearg [NN 163 585]. East-south-eastwards it, or another in approximately

the same position, is responsible for the crag A' Chailleach [NN 184 572] where it is interbedded among andesites.

The upturned base of the volcanic series is seen north of A' Chailleach [NN 184 572] in Coire Mhorair and Coire Odhar-mhòr [NN 196 583] ((Figure 21), (Figure 23), (Figure 24), (Figure 25), pp. 134, 156, 158, 159). The lavas are all andesites without any sign of the Queen's Cairn or A' Chailleach rhyolites; but hornblende-andesites appear near the bottom and are more likely to belong to Group 2 than to Group 1.

Where the base of the volcanic series reappears to run obliquely down the hillside from west of Stob Mhic Mhartuin [NN 207 575] towards Cnoc nam Bocan [NN 213 561] (Figure 22) it consists for three-quarters of a mile of agglomerate with locally an underlying andesite. Half a mile before reaching the road this agglomerate seems to unite with another on a slightly higher horizon. The combined agglomerate, crossing the road at Lochan na Fola [NN 210 560], then runs south-eastwards well up among the rhyolites of Stob Dearg [NN 225 543].

At the road the downward succession from the Lochan na Fola [NN 210 560] agglomerate to the emergence of Moine Schists (Eilde Flags) at Cnoc nam Bocan [NN 213 561] is: rhyolite, andesite, rhyolite. As may be gathered from the account already given of the road traverse, this last rhyolite resting on the Moine Schists is, at any rate approximately, on the horizon of the Queen's Cairn flow at the base of Group 2.

It is thus clear that basal sediments near Achtriochtan [NN 157 571] farm are likely to date from an early stage of Group 1, whereas basal sediments near Cnoc nam Bocan [NN 213 561] are more likely to represent the latest stage of this group. At the same time it is possible that basal sediments anywhere may be considerably older than immediately overlying lavas or ashes. H. B. M., E. B. B.

### Basal sediments

Thin basal sediments are seen at a number of places at the foot of the precipitous crags that mark the oncoming of andesites of Group 1 on the slope north-west of Achtriochtan [NN 157 571] farm. One of the most interesting lies between the 1000-ft and 1250-ft levels half a mile from the farm. The following succession dips at 30° to the south-east:

	feet
Andesites	—
Fine grit	2½–3
Green shales	1–3
Coarse conglomerate	About 30
Green micaceous shales with plant remain	Not more than 20

These sediments are of a local character and are not traceable far in either direction. A short distance further up the hill towards the left the section in the basement beds is:

	feet
Compact banded green shale passing down into green sandstone	12
Coarse pebbly grit	10
Red and green shales with sandstone bands	8
Fine grit	5
Conglomerate	20
Silvery greenish phyllites	—

A thin felsite sill is here intrusive along the plane of unconformity between the conglomerate and phyllites (Leven Schists). The conglomerates consist of well-rounded boulders and pebbles of quartzite, phyllite, andesite, and "granite", and an occasional pebble of quartz-porphyry, in a gritty matrix, which is often very felspathic. The shales are mostly purple and sandy, but occasionally contain bands of darker and more argillaceous material.



Sections from the "granitic" boulders were examined and found to be quartz-diorites rather than granites. One section shows (S10285) [NN 1594 5870] much idiomorphic plagioclase, altered biotite, calcareous patches after another ferromagnesian mineral, and some interstitial quartz. In some there is altered green hornblende, and augite may also have been originally present (S10286) [NN 1594 5870]; (S10287) [NN 1594 5870]. Another section is from a biotite-granite (S10288) [NN 1594 5870]. These rocks are of types common among the unfoliated "granites" of the Highlands, and would appear to have been derived from one or more closely associated plutonic masses. The boulders are often large and always well rounded. They do not resemble any of the varieties of "granitic" rocks (Fault-Intrusion) found in the immediate neighbourhood, nor could they possibly have come from any portion of the Ben Cruachan — Ben Starav Pluton, since this, as will be shown in the sequel, is of later date than the volcanic rocks overlying the conglomerates. The most abundant boulders are those consisting of white quartzite; they reach a length of 3 ft. The larger ones are well rounded, the smaller more sub-angular, and many of them have their surfaces stained red. Two boulders of a basic plutonic rock much decomposed but resembling the kentallenite of Aonach Dubh a' Ghlinne [NN 120 530] were noticed. Boulders of pyroxene-andesite are fairly plentiful, and a few pebbles of hornblende-andesite were found, but none of rhyolite or porphyrite. The matrix of the conglomerate is generally a coarse grit, but in some places a sandy shale. Altogether the conglomerate resembles the boulder-gravel in the bed of a torrential stream. H. K., H. B. M.

A small patch of basement conglomerate is seen again with like characters in Coire Càrn [NN 154 585] at the foot of Meall Dearg [NN 163 585], where it is overturned at an angle of 70° in close proximity to the Boundary-Fault ((Figure 23), p. 156). There is a further exposure of the base of the group in the stream-bed of Coire nan Lab [NN 167 584], but the conglomerate is absent here and the sedimentary beds consist mostly of shale. The base is also seen in Coire Mhorair and Coire Odhar-mhòr [NN 196 583] situated further to the east ( (Figure 23) Figure (Figure 24), (Figure 25), pp. 158, 159, and Section III, (Figure 21), p. 134). In the immediate vicinity of the Boundary-Fault the beds are locally overturned; elsewhere they dip steeply away from the Boundary-Fault towards Glen Coe. From the southern flank of Sam a' Choire Odhair-bhig a band of ashy grits, shale and conglomerates, resting unconformably on the schists and succeeded by coarse agglomerate and lavas, may be followed fairly continuously down to the Glen Coe road half a mile west of Altnafeadh. Along this line the dip, in conformity with the change of trend of the Boundary-Fault, is directed towards the south-west at various angles. E. B. B.

## D. Sequence on Buachaille Etive Mòr [NN 210 538]

The volcanic series in ascending order consists of: (1) basement breccia, with intercalated flows of andesite; (2 and 3) rhyolites and rhyolitic flow-breccias, with intercalated and overlying agglomerate and sediment; and (4) hornblende-andesites. These together attain a thickness of at least 2500 ft (Sections I, II, (Figure 21), p. 134).

### Group 1

The breccias at the base of the series are usually coarse and made up largely of angular fragments of quartzite and quartzose schists. These may have been derived quite locally, and rarely attain 6 in. in diameter. Here and there throughout the breccias thin beds of finer material are met with, and as they are well bedded it appears they must have been laid down under water. The general characters of these deposits are well seen beneath rhyolite lavas on the north face of Stob Dearg [NN 225 543], where they form smooth rock-slopes towards the base. The best section occurs beneath a conspicuous overhanging slab which can be easily recognised in the photograph ((Plate 8), p. 146) at the lower limit of the rocky portion of the hill. The sequence, where the beds are thickest, is as follows, in descending order:

	feet
Bedded breccia often resembling conglomerate, with fragments of quartzite, micaceous schist, and some of felsite— in a gritty matrix	
Red shales with cornstones	14
Purple shales	4
Greenish and black shales, showing alternations of coarser and more sandy layers with finer bands	10

Conglomerate, with angular and subangular boulders of quartzite and quartzose schists (Eilde Flags) in a green sandy matrix	20
Green shales, some red, and irregular bands of conglomerate	18
Fine greenish basement breccia containing quartzite fragments	1–2
Quartzite, much shattered at the surface	—

A band of dark shales at the base of the same overhanging crag a little farther to the north yielded Tait and Peach several remains of plants. Among these are stems of which R. Kidston and W. H. Lang have written as follows: "They are not *Psilophyton* but narrow, linear, dichotomously-branched axes without hairs or spines; many of the branches end in what appear to be hemispherical sporangiumlike bodies" (1924, p. 608). Along with these are numerous, exceptionally well preserved *Pachytheca*, which these authors place in a new species *P. fasciculata*. They point out that the genus *Pachytheca* is probably algal, and that it is abundantly represented in the Lower Old Red Sandstone of Scotland, England and Wales, but is also found in the Downtonian and Wenlock of England. The Wenlock species is certainly not *fasciculata*, while the Downtonian specimens and most of those from the Lower Old Red Sandstone are too poorly preserved to allow of close comparison. The genus is not known from either the Middle or Upper Old Red Sandstone of Scotland (1924, pp. 610–612).

At the north-eastern end of Buachaille Etive Mòr [NN 210 538], lava-flows of andesite intercalated with the basement breccia, and with them representing Group 1, are so thin that they cannot be shown on Sheet 53. They are seen on the banks of the stream flowing down past Lagangarbh [NN 222 560] cottage south of Altnafeadh [NN 222 563], and again near the river Etive on the south-east slopes of Stob Dearg [NN 225 543]. They appear to represent the north-eastward thinning of the andesites so well developed in Aonach Dubh [NN 155 560] and about Dalness [NN 168 512]. The rocks are sometimes vesicular, show specks of pyrites but no conspicuous phenocrysts, and may be dark grey or light grey. Under the microscope ([S12490](#)) [NN 2185 5564]; ([S12772](#)) [NN 2312 5323] they are seen to be very much decomposed: pseudomorphs after some ferromagnesian mineral are set in a ground-mass of cloudy felspar laths, with interstitial epidote and iron-ores. Vesicles are frequent, and are filled with calcite and pyrites.

In the area about Dalness [NN 168 512], that is at the south-west end of Buachaille Etive Mòr [NN 210 538], a greater development of andesite lavas is accompanied by breccias which in the main consist almost entirely of fragments. These andesitic breccias could not be separated from the lavas in mapping; but, intercalated near the top of the series, is a mappable bed of quartzite breccia, which runs round the south-west spur of Buachaille Etive Mòr [NN 210 538] and dips gently to the north-east.

## Group 2

Resting on the basal sediments and andesites are the rhyolites and rhyolitic flow-breccias of Group 2, which attain a thickness of about 1500 ft on the north face of Stob Dearg [NN 225 543] (Plate 8). The precipitous character of this peak is entirely due to these rocks. The rhyolites tower up in huge vertical walls and precipices, while numerous joint planes often form a series of step-like ledges, and sometimes give the rock a rudely columnar appearance. The scenery formed by these flinty-textured masses cannot fail to impress anyone who has seen the imposing and precipitous eastern face of Stob Dearg [NN 225 543], the highest point (3345 ft) of Buachaille Etive Mòr [NN 210 538] Here the lower rhyolites are free from fragments, but throughout the rest of this area they are of the nature of flow-breccias containing abundant fragments of other rhyolites, hornblende-andesites, and, frequently, of schists as well. On Stob na Bròige [NN 190 523], the south-westerly summit of Buachaille Etive Mòr [NN 210 538] overlooking Alltchaorunn [NN 196 509] cottage, these flow-breccias, although their basal portion has been cut off by the Cruachan "Granite", attain a thickness of over 1500 feet without reaching their upper limit.

Marked metamorphism has been induced by the Cruachan "Granite" throughout much of the district. The altered rhyolites assume a red colour with partial obliteration of their characteristic flow structure.

It is considered probable that a red felsitic rock which forms the top of Stob Dearg [NN 225 543] may really be intrusive although it is grouped with the rhyolitic lavas in the published map. It has a well-defined fluxion edge without any accompaniment of fragmental material.

Intercalated with the rhyolites are beds of agglomerate, flows of andesite, and an occasional parting of shale. The most important bed of agglomerate is mapped as continuous with the band exposed at Lochan na Fola [NN 210 560] on the Glen Coe road, and forms a large part of the floor of the corrie west of Stob Dearg [NN 225 543]. Local beds of red sandstone and shale occur along with it, and one of them, situated near its base, is well seen on the ridge forming the western margin of the corrie. To the east the agglomerate thins out until represented by only a few feet of dark purplish and greenish shales. These run diagonally down the eastern face of Stob Dearg [NN 225 543] and have given rise to the feature known to mountaineers as the "Crowberry Traverse [NN 225 545]". The shales here are less steeply inclined than in the corrie west of Stob Dearg [NN 225 543], on the west side of which they are sometimes vertical. A thin parting of shaly beds, though much shattered by lines of fault and crush, is well seen in a gully immediately to the south-east of the "Crowberry Traverse [NN 225 545]", and is accompanied by a bed of ash about 2 ft thick. Other bands of ash occur among the lavas south of the peak, and are seen in thin slices under the microscope to consist chiefly of comminuted glass fragments, with typical ash-structure, and accompanied by a few recognisable pieces of rhyolite and hornblende- and pyroxene-andesites. Slices of the agglomerate show fragments of igneous and metamorphic rocks in varying proportions, set in a matrix of quartz grains and comminuted igneous rocks ([S12477](#)) [NN 2075 5423]; ([S12487](#)) [NN 2166 5305]. In cases where there is only a small proportion of schist, and the agglomerate consists almost entirely of igneous matter, the distinction between it and rhyolitic flow-breccia becomes very difficult, and, in fact, impossible once the rocks have been even slightly altered ([S12470](#)) [NN 2068 5415]; ([S12487](#)) [NN 2166 5305]; ([S12784](#)) [NN 210 535].

The andesite intercalations, met with occasionally throughout the group, are most numerous near its base in the Dalness area [NN 168 512]. Where the junctions are well seen, it sometimes appears as though the andesite was of the nature of an inclusion in the rhyolite, since there is no vesicular margin between the two, while the general outline of the junction does not always agree with the strike of the surrounding beds. The andesite which occurs along the "granite" margin, south of Stob Dearg [NN 225 543], is regarded as one of these intercalations among the rhyolites of Group 2. The slices prepared from these intercalations show the results of contact-alteration by the neighbouring "granite". They were originally hornblende-andesite flow-breccias, but the hornblende phenocrysts are now only represented by magnetite skeletons and matted aggregates of biotite or, more rarely, of green hornblende in ragged prisms. Phenocrysts of feldspar do not occur. The ground-mass consisted originally largely of feldspar and granules of some ferromagnesian mineral, but is now a mosaic of feldspar, some quartz, and scales of biotite or prisms of green hornblende ([S12511](#)) [NN 2116 5283]; ([S12762](#)) [NN 180 525]; ([S12764](#)) [NN 189 519].

### Group 3

A bedded breccia full of fragments of the schists represents Group 3 of (Figure 20). It is exposed on the summit ridge of Buachaille Etive Mòr [NN 210 538], where it thins out in a southerly direction, just as in Buachaille Etive Beag [NN 192 548] and Stob Coire nan Lochan.

### Group 4

A small outlier of hornblende-andesites of Group 4 forms the mid peak of Buachaille Etive Mòr [NN 210 538], rising to a height of 3325 ft. It includes thin intercalations of rhyolite, but the predominating rock is a dark hornblende-andesite, containing needles of hornblende visible to the eye. Under the microscope the effects of contact-alteration are very marked. The original rock is seen to have contained phenocrysts of hornblende, plagioclase, and sometimes mica. H. K., G. W. G.

## E. Sequence in Càrn Ghleann and Sròn Na Crèise

In this, the most easterly part of the volcanic district (Figure 29), the sequence is similar in many respects to that described on the northern end of Buachaille Etive Mòr [NN 210 538]. In ascending Càrn Ghleann from the position of the

Boundary-Fault we encounter several detached outcrops of rhyolite and andesite, and also patches of breccia consisting of angular fragments of schist and rhyolite.

### Group 1

A short distance farther up the glen we come to a coarse conglomerate underlying the main mass of the volcanic rocks. As exposed in the stream it contains, in addition to schist fragments, large masses of various igneous rocks, conspicuous among which are boulders of a red "granite", which attain a diameter of 2 or 3 ft. This "granite" is particularly interesting as it shows some of the characters which distinguish the Moor of Rannoch rock from those later "granites" which are intrusive in the volcanic series. In the hand specimen the quartz is seen to occur in large blebs, and a foliation can sometimes be made out. Under the microscope ([S12788](#)) [NN 2488 5191] the quartz appears in composite areas such as are characteristic of the Moor of Rannoch rock; while the plagioclase is near oligoclase. The fact that in slices these boulders show biotite as their only ferromagnesian mineral ([S12788](#)) [NN 2488 5191]; ([S12789](#)) [NN 2488 5191] indicates that if they have been derived from the Moor of Rannoch mass, they must have come from its marginal portions as its interior contains hornblende in addition. G. W. G.

Overlying the conglomerate comes a dark basic andesite which is all that remains to represent the thick basic andesites (Group 1) of the Coire nam Beith section (Figure 20).

### Group 2

The andesite is succeeded by several feet of shale overlain in turn by thick rhyolitic lavas belonging to Group 2. Except in the floor of the glen, where the andesite is present, the rhyolites form the local base of the series. Their junction against schists is well seen on the northern slopes of Sròn na Crèisee [NN 240 522], where a thin layer of breccia usually intervenes — Sròn na Crèisee [NN 240 522], see Sheet 53, is the northern summit of the ridge marked Stob Glas Choire [NN 240 515] in (Figure 29). On Sròn na Crèisee [NN 240 522], as on Buachaille Etive Mòr [NN 210 538], the volcanic series dips at high angles to the south-east, but in Càrn Ghleann and further east it is lying approximately flat and abuts against a steeply sloping surface of schist.

### Group 3

Agglomerates and breccias of Group 3 cap the rhyolites in the large corrie at the head of Càrn Ghleann, whence they sweep round to the northwest and cross the Sròn na Crèisee [NN 240 522] ridge until they meet intrusive Cruachan "Granite" (Section I, (Figure 21), p. 134). Eastwards they extend round the head of Càrn Ghleann into Meall a' Bhùiridh (Sheet 54, Geol.), to come into direct unfaulted contact with the schists, thus emphasising the remarkable overlap. This also is the condition of affairs in Coire an Easain [NN 250 496], where extremely clear exposures illustrate the uneven nature of the floor upon which the breccia accumulated.

The breccias often consist almost entirely of fragments of rocks derived from the quartzose and micaceous schist of the neighbourhood; but it is impossible to draw any hard and fast line between this breccia and the coarse agglomerate with which it is associated, consisting mainly of fragments of rhyolite and andesite. In some places the breccia is comparatively fine-grained, and full of small angular fragments of quartzose schist and rhyolite, averaging half an inch or less in diameter; but more usually the main mass of the rock is a confused agglomeratic mixture of angular fragments of all sizes, consisting of quartzose and micaceous schist, rhyolite and occasional blocks of andesite. The fragments of quartzose schist are sometimes two yards or more in length. As the andesites of Group 4 are approached the agglomerate becomes more and more andesitic, and sometimes consists mainly of andesite fragments. The finer-grained portions of the breccia are well bedded, and good indications of bedding are seen on both the east and west slopes of the head of Càrn Ghleann. These finer-grained portions are very rich in quartz grains, and sometimes appear to pass into zones of grit. In two or three places on the west side of Càrn Ghleann angular fragments of a rather acid biotite-"granite" were observed in the breccias. These fragments are not unlike the "granite" which is exposed further west in Glen Etive, but they cannot possibly have been derived from any portion of the Cruachan or Starav "Granites" since the Cruachan "Granite", the earlier of the two, is in the immediate neighbourhood clearly intruded into the breccias. They must have been derived either from some older mass bared by erosion, or from some quasi-contemporaneous intrusion, fragments

of which have been ejected during explosions. The occurrence of "granite" blocks in the conglomerates and breccias of this part of the district may be paralleled with that of Tertiary granophyre and gabbro in the agglomerates of the Cuillin Hills of Skye (*cf.* Harker 1901b, p. 507).

#### **Group 4**

The hornblende-andesites of Group 4 in their normal types succeed the agglomerates, and are remarkably well exposed along the sharp east and west ridge of Meall a' Bhùiridh, and again along the north and south ridge between Sròn na Crèisee [NN 240 522] and Clach Leathad [NN 240 493]. The rocks weather with a pale greyish or whitish crust, but on fracture they are dark grey or almost black; and small plagioclase phenocrysts and prisms of hornblende may usually be detected with the naked eye. Flow-structure is also well seen, especially on the Meall a' Bhùiridh ridge. The Cruachan "Granite" has invaded these andesites and sends many veins into them. The junctions with the "granite" in the field are clear and well defined, and decided contact-alteration has been produced. This will be described in chapter 18.

On the north and east sides of the highest point on the ridge north of Clach Leathad [NN 240 493], 20 to 30 ft of dark grey laminated shales and grits occur intercalated in the lower portion of the hornblende-andesite series. These beds are considerably indurated by the "granite", and no signs of fossils were observed in them. H. K.

### **F. Sequence around Dalness [NN 168 512], Glen Etive**

#### **Irregular floor**

The schistose floor on which the rocks of Old Red Sandstone age rest is seen in several places, both near the River Etive and some distance above it, and is evidently very uneven. On the north bank of the Etive a breccia about 2 ft thick, inclining steeply south-west, separates the andesites from the schists, which here are less siliceous than usual in the adjoining localities. Further up on the south side of the river various inliers of quartzite are exposed at different levels within the andesitic rocks. The surface of the quartzite is generally a good deal broken and frequently partially covered with a skin of breccia. C. T. C.

In a bed of breccia cropping out round the S.W. end of Buachaille Etive Mòr [NN 210 538] large masses of quartzite appear, and are well seen in Allt Gartain [NN 197 540], half a mile up from Dalness, and also on the slope about half a mile E.N.E. of the house. The smaller of these masses, associated with a bed composed of quartzite fragments, appear at first sight to be merely particularly large boulders; but one very large mass in Allt Gartain [NN 197 540] is evidently in place. It is probable then that they are all stacks surrounded by the volcanic rocks, and that the breccia-bed is scree-material showered down upon and finally covered by the advancing lavas.

#### **Group 1**

The basic andesites of Group 1 may be traced continuously from the type section of Coire nam Beith (Figure 20) along the south-western flanks of Bidean nam Bian [NN 140 543] to the neighbourhood of Dalness [NN 168 512]. Though not so thick as in the type section, they present a greater development here than in the district to the north-east. As already mentioned in describing Buachaille Etive Mòr [NN 210 538], these andesite lavas are accompanied by andesitic breccias, so similar in appearance as to be inseparable for mapping purposes. G. W. G.

The andesites exposed in the river Etive between 200 yards and three-quarters of a mile east of Dalness have suffered considerable contact-alteration. Weathered surfaces are usually very knobby, with prominences greener and more epidotic than the rest. Perhaps these represent the parts which were the most decomposed at the time of the intrusion of the neighbouring "granite". Exposures sometimes show conspicuous oval forms rather like the pillows of pillow-lavas, the outer rims of which for the breadth of half an inch or so project a little, but the vesicles show no arrangement parallel to these rims.

Many parts of the rock have a brecciated aspect, the angular pieces frequently fitting into one another very exactly, with hardly any matrix between. In numerous cases cracks penetrate pieces of andesite for a certain distance and then come

to an end as if they had been developed during violent rolling or on falling. It is not clear that any true ash is present.

The amygdales often project considerably on the weathered face. They are usually much elongated and consist of epidote, or epidote and a pale green hornblende. Other vesicles are filled with quartz, apparently in a granular or granulitic condition, and to a less extent with plagioclase ([S11488](#)) [NN 1741 5093].

In one locality a number of thin veins which cross the local trend of the vesicles almost at right angles were also seen to contain a pale hornblende in considerable abundance.

The development of hornblende and felspar in the vesicles, and of hornblende in the veins, is doubtless due to contact-metamorphism, probably exerted by the neighbouring "granite", and it may be concluded that the lavas were considerably decomposed and crossed by strings of carbonate before the metamorphism was effected (*cf.* Harker and Marr 1891, p.297).

On the hillside three-quarters of a mile W.S.W. of Dalness an important band of elastic material, sometimes perhaps 300 ft thick, intervenes between the andesites and the overlying rhyolitic rocks of Group 2. The character of the elastic beds varies rapidly from place to place. In the burn rather more than three-quarters of a mile E.S.E. of Dalness the group is almost entirely composed of coarse breccias of quartzite and andesite, and it is noticeable that the pieces of andesite are often more porphyritic than the underlying andesite lavas. At the very top of these beds there is a little fine-grained highly-altered sandstone containing pieces of quartzite. In the adjacent crags the following succession in descending order can be made out, but the middle group appears to die out rapidly in a westerly direction:

	Thickness feet
Breccias composed of quartzite and andesite, with occasional bands of sandstone, sometimes ashy	50
Grey and pink sandstone with fragments of quartzite	60
Breccia composed of angular pieces of quartzite from 5 in. to 12 in. in length:very little fine matrix	50

The above beds are in some places almost horizontal, but in others inclined at gentle angles to the S. or S.S.W. They are often greatly altered, being close to the "granite".

## Group 2

The highest members of the volcanic series preserved on the slopes of Beinn Ceitlein are composed of 1000 ft or so of rhyolitic rocks belonging to Group 2. In certain weathered exposures many of them show included fragments; but no vesicles or distinct flow-structures are seen. Ashes as well as lavas may be present, but a separation has not been attempted owing to the masking of original differences by contact-alteration. C. T. C.

## G. Fissure-fillings or outliers

Reference may now be made to certain breccia patches, found in the vicinity of the Glen Coe Boundary-Faults, which have given rise to differences of interpretation. Clough and Maufe regarded the examples which occurred in their ground as outliers preserved in hollows of a very irregular erosion surface; whereas the writer thinks that the majority, if not all, have formed in volcanic fissures, extending in some cases far below the land surface of the day, and filled in part from above, in part from the depths. Here are examples.

1. In the corrie at the head of Gleann Chàrnan [NN 135 500] (nat. grid [NN 122 517]) Kynaston mapped a small mass of appinite piercing a breccia shown as c1 on Sheet 53. This breccia is made up of large subangular blocks of the adjoining Leven Schist mixed with a few fragments of quartzite. The writer considers that it choked an explosion vent up which appinite subsequently rose. He recalls how in the island of Colonsay (Sheet 35, Geol.) a suite of basic intrusions, very similar to the Gleann Chàrnan [NN 135 500] appinite, is associated in like manner with breccias which seem to include material that has tumbled down explosion pipes (Wright and Bailey 1911, p. 34); and he extends just



such an interpretation to a patch of breccia intruded by related augite-diorite in Lismore [NM 870 440] (Sheet 45, Geol.). On the other hand Maufe (*in* Kynaston, Hill and others 1908, p. 80) has interpreted both the Gleann Chàrnainn [NN 135 500] and the Lismore [NM 870 440] breccias as superficial deposits still *in situ*.

2. A larger breccia patch, also shown as c1 on Sheet 53, has been mapped at a height of 2500 to 3000 feet on Sgòr nam Fiannaidh [NN 137 584], north of Glen Coe (nat. grid [NN 137 581]). Maufe describes it as resting against a steep slope of quartzite, and as consisting of quartzite fragments, together with small pieces of red felsite and porphyritic andesite, set in a siliceous matrix. It is pierced by Glen Coe Fault-Intrusion.
3. Four miles further east, a small patch of breccia occurs surrounded by quartzite between two branches of the Glen Coe Boundary-Fault near the foot of Sròn a' Choire Odhar-bhig ((Figure 24), p. 158; see also (Figure 26), p. 160).
4. From half to three-quarters of a mile in front of the highly tilted lavas of Stob Dearg [NN 225 543] there is a belt extending from the Devil's Staircase [NN 216 574] to Glen Etive and Càrn Ghleann, along which exposures of rhyolite and breccia are constantly making an appearance. The belt for the most part passes through ground much obscured by glacial deposits, and often its existence can only be recognised in isolated stream sections. Careful examination of that part which passes south-west of Stob Beinn a' Chrillaiste, above Altnafeadh [NN 222 563] ((Figure 28), p. 163), shows various irregular outcrops of rhyolite, often separated from the adjacent schists by thin breccias, and therefore allied in their behaviour to the lavas of the district rather than the intrusions. The breccias here consist of small angular fragments of schist. In the Coupall River [NN 210 554], along this line, pieces of rhyolite are also common.
5. Clough found small patches of sandy breccia in contact with quartzite at several places across the River Etive from Dalness [NN 168 512]. One set at the north end of Beinn Ceitlein, a mile south-east of Dalness, is closely associated with rhyolitic bands, some of which are clearly intrusive. Another set, midway to Dalness, is free of rhyolite. Both lie south-west, that is outside, of the main branch of the Boundary-Fault, which introduces the continuous volcanic outcrop of Dalness and Glen Coe; but they are included within an outer, comparatively gently inclined branch exposed on the western slopes of Beinn Ceitlein. E. B. B.

## H. Summary of volcanic history

1. The Glen Coe volcanic rocks are in all probability of Lower Old Red Sandstone age.
2. They accumulated on an uneven floor carved by erosion in the Highland Schists, and show strong overlap from south-west to north-east.
3. In a few cases patches of breccia and rhyolite seem to mark the sites of volcanic fissures.
4. The lavas are basic andesites (including basalts), hornblende-andesites, and rhyolites. Their extremely irregular arrangement *inter se* indicates that they were supplied from neighbouring independent vents. The basic flows frequently show reddened tops as if affected by contemporaneous weathering.
5. The agglomerates of the period cannot be distinguished with certainty from scree-breccias.
6. The sediments accompanying the volcanic rocks are of quite restricted occurrence. They include screes and torrential conglomerates, along with shales and grits which appear to have gathered in temporary lakes. Plant remains including *Pachytheca fasciculata* have been found in shale at the foot of Stob Dearg [NN 225 543]. Shale sometimes fills the crevices of the lavas of the bottom group consisting of basic andesites.
7. Away from the faulted margin of the area the volcanic rocks dip at varying angles towards the south. H. B. M.

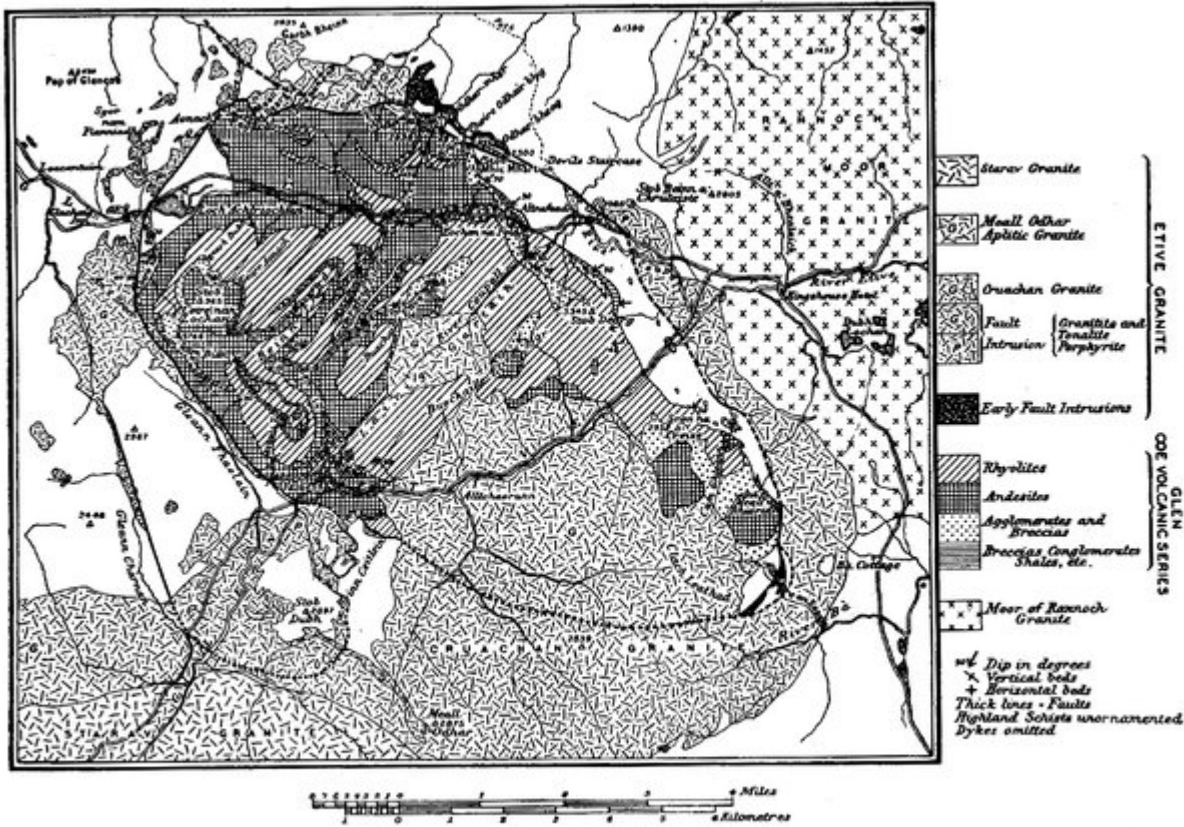


FIG. 19. Map of the Cauldron-Subsidence of Glen Coe and associated igneous phenomena  
For new road see Fig. 22

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

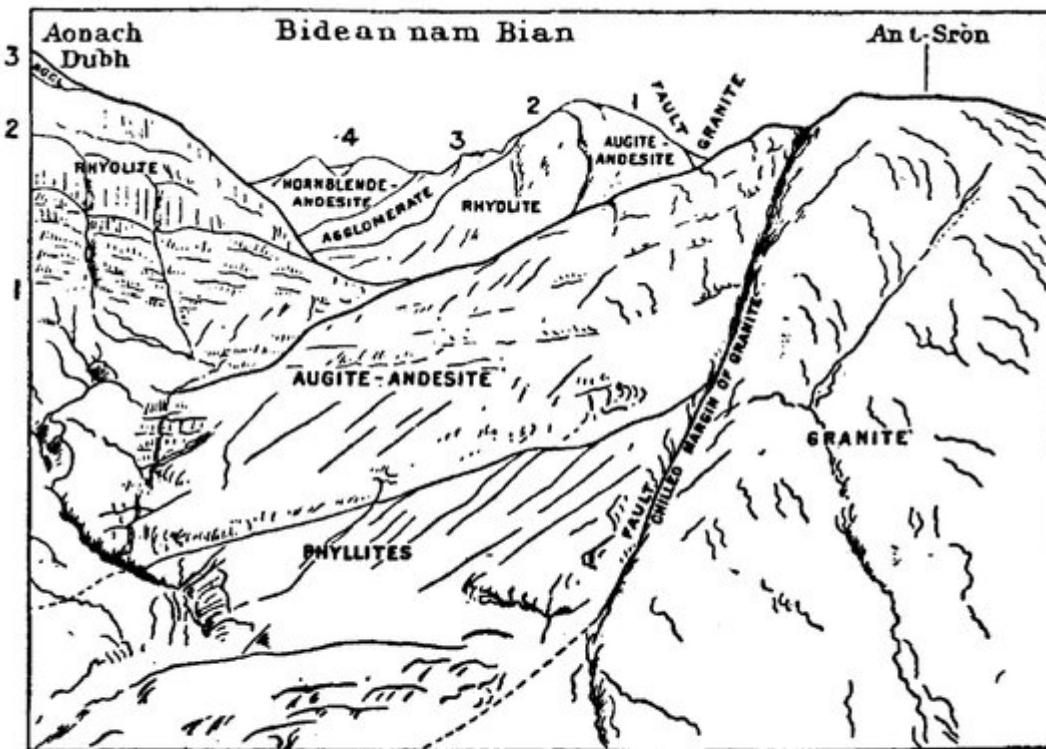
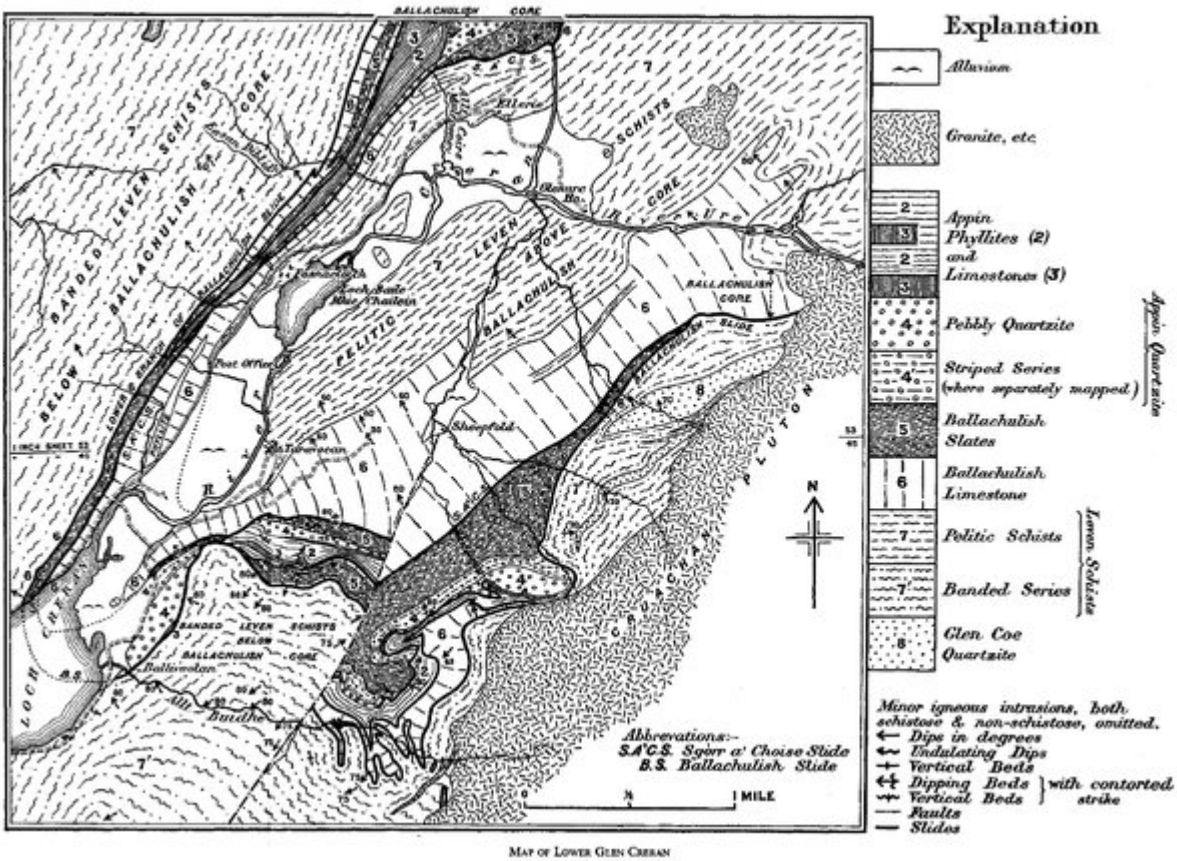


FIG. 20. View of Boundary-Fault of the Cauldron-Subsidence of Glen Coe  
as exposed in An t-Sròn

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





(Plate 4) Map Of Lower Glen Creran.



(Plate 8) Stob Dearg Rhyolite lavas (crag) on schists (grass covered). Fossils at +.

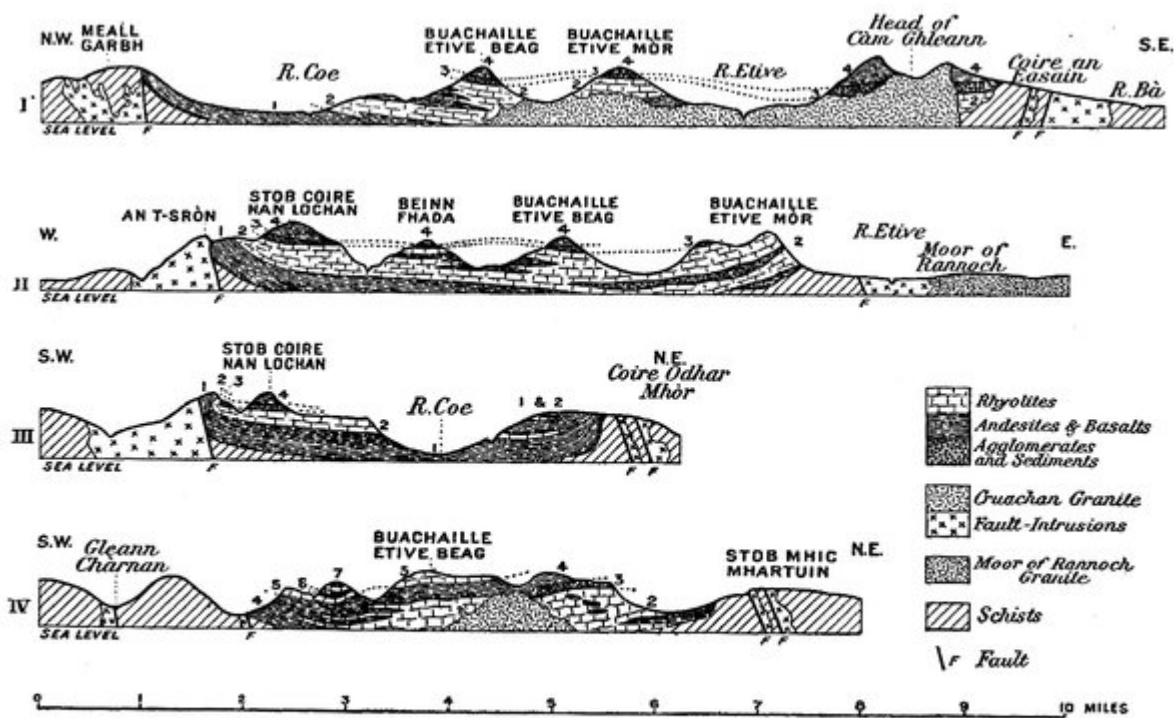


FIG. 21. Sections across the Cauldron-Subsidence of Glen Coe  
The numbers 1-7 refer to groups discussed in the text

(At Coire an Easain the boundary-faults incline outwards to S. E., not inwards as shown above)

(Figure 21) Sections across the Cauldron-Subsidence of Glen Coe The numbers 1-7 refer to groups discussed in the text  
(At Coire an Easain the boundary-faults incline outwards to S. E., not inwards as shown above).

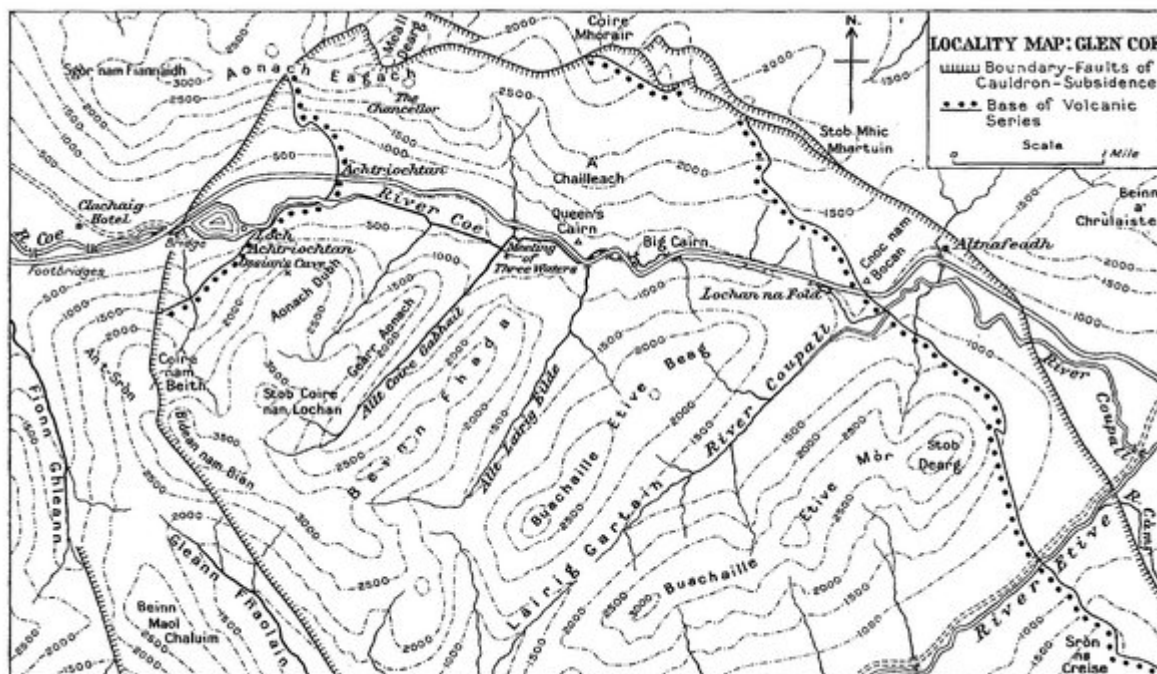


FIG. 22. Locality map: Glen Coe

(Figure 22) Locality map: Glen Coe.



*(Plate 6) Gearr Aonach [NN 160 555] And Aonach Dubh: Glen Coe "sisters" Largely rhyolite lavas.*



*(Plate 7) Melting of Three Waters, Glen Coe; and Rock-Fall, Allt Core Gabhail.*

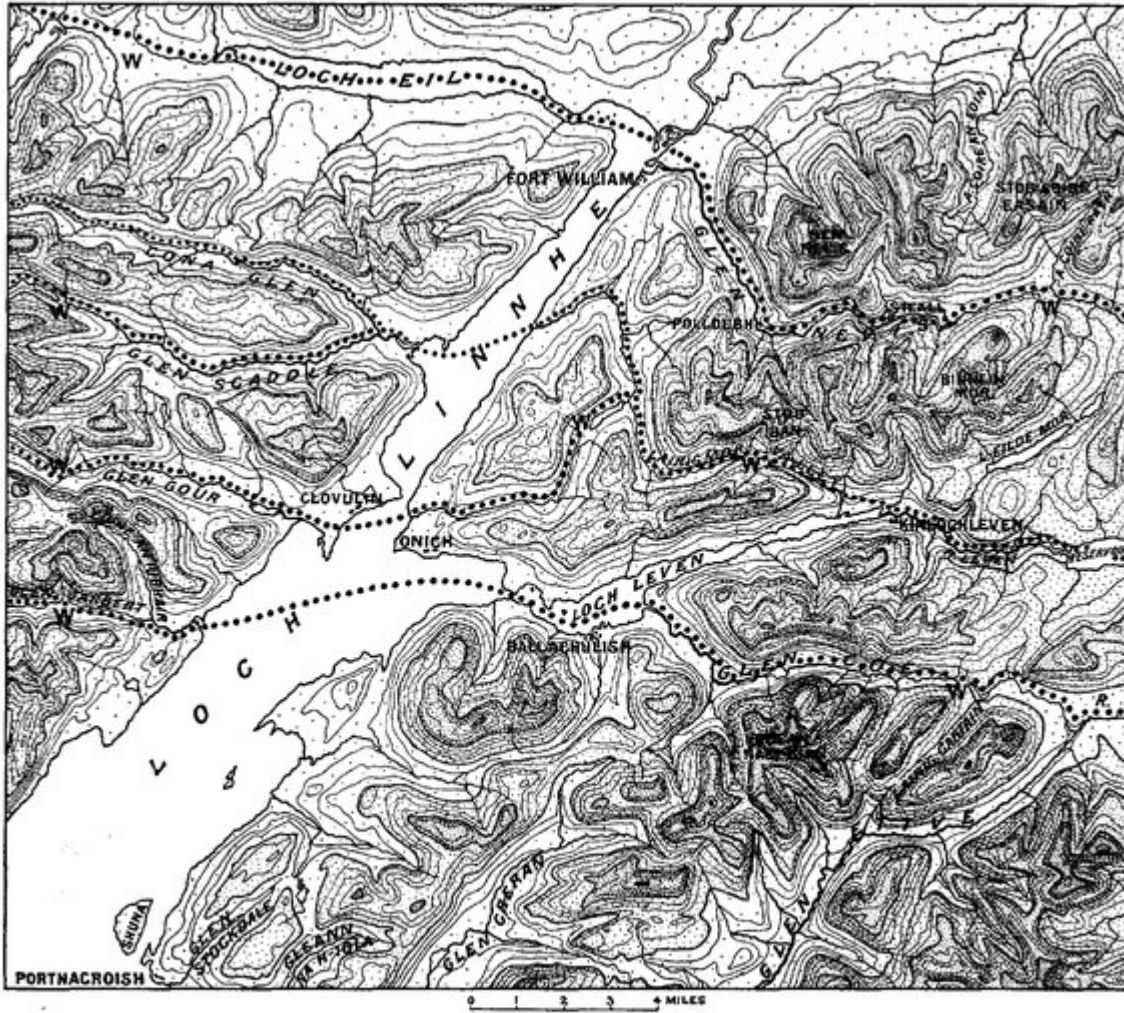
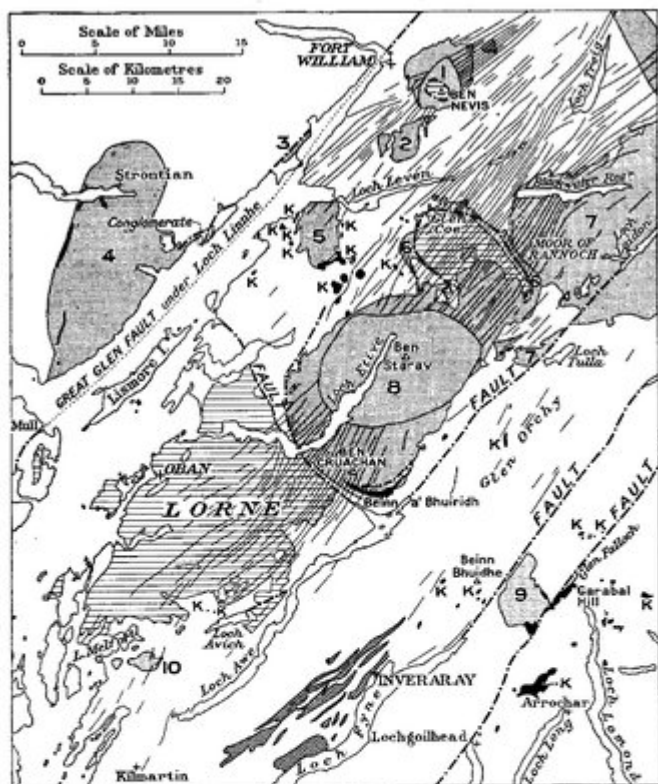


FIG. 1. Map of inferred original Tertiary drainage system (shown in heavy dots)

Shatter-belts guide Loch Linnhe, Loch Leven and Lairig Gartain.  
 Contour-interval 250 ft, with change of ornament every thousand feet.  
 W, Secondary Watersheds. R, west end of Rannoch Moor

(Figure 1) Map of inferred original Tertiary drainage system (shown in heavy dots) Shatter-belts guide Loch Linnhe, Loch Leven and Lairig Gartain [NN 200 544]. Contour-interval 250 ft, with change of ornament every thousand feet. W, Secondary Watersheds. R, west end of Rannoch Moor.



**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 Meallan.  
 ■ **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.



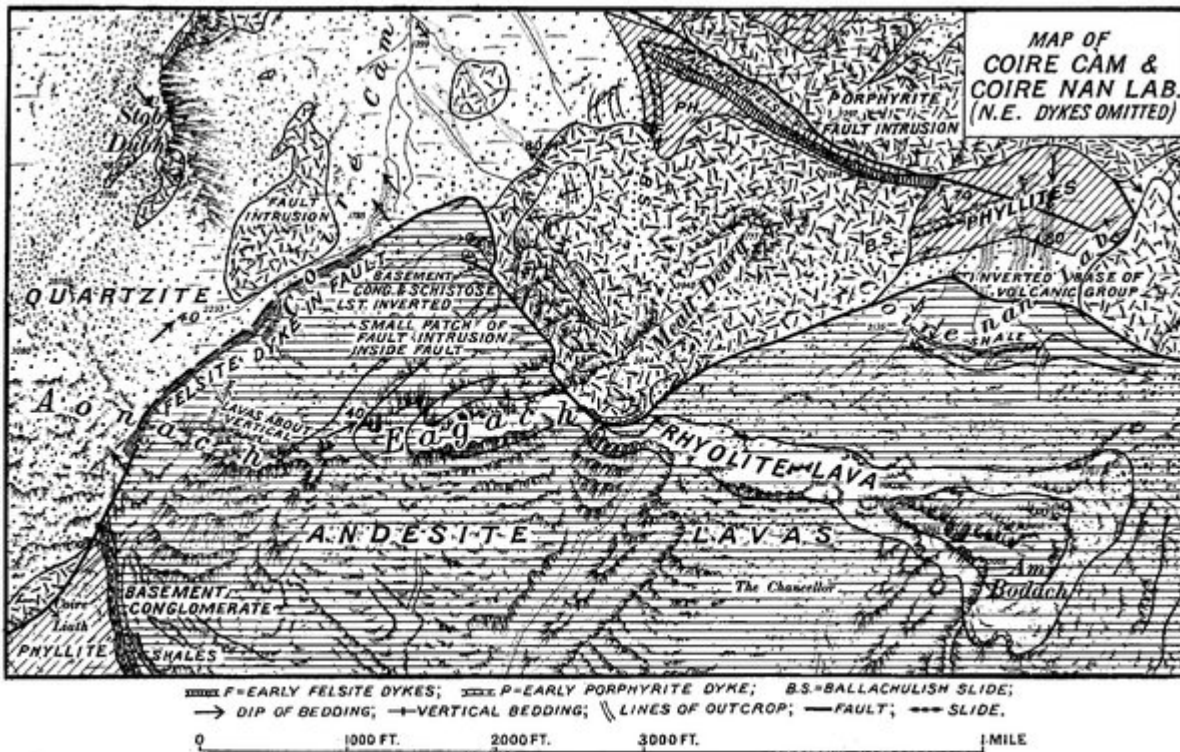


FIG. 23. Map of Coire Càrn and Coire nan Lab. North-east dykes omitted. (The Fault-Intrusion is chilled at its contact with the early dykes north of Meall Dearg)

(Figure 23) Map of Coire Càrn [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]).

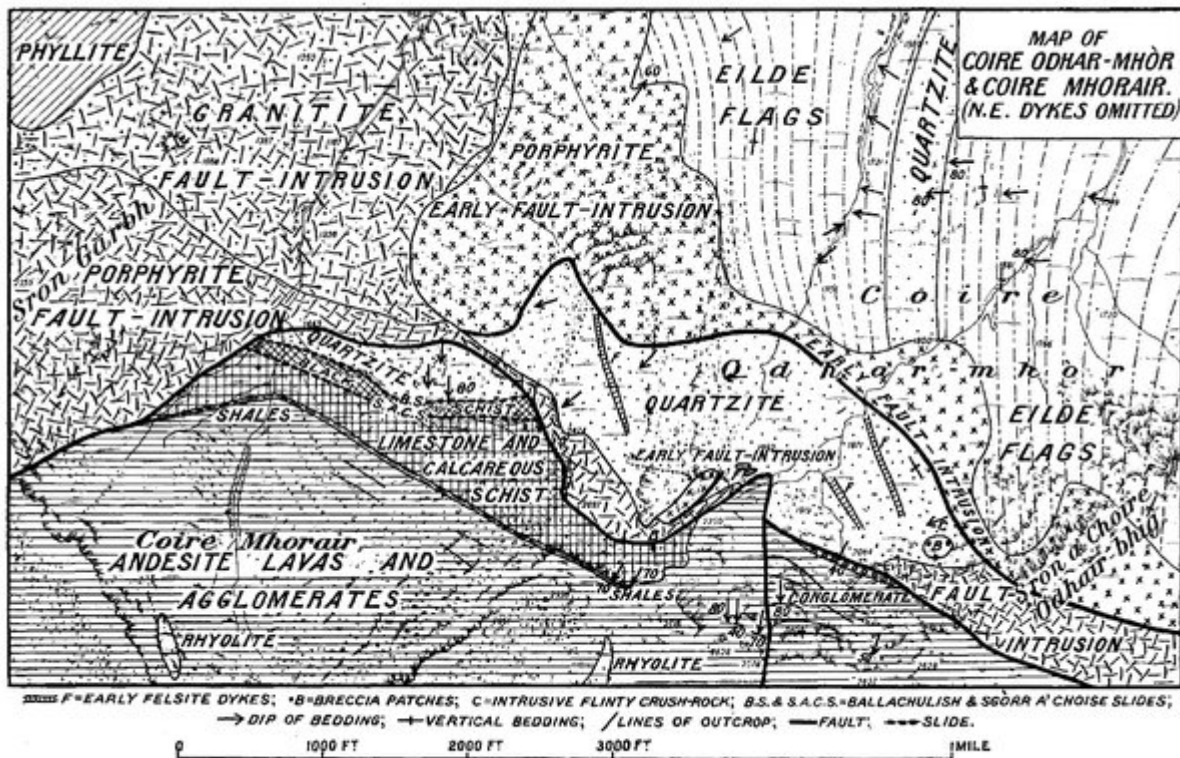


FIG. 24. Map of Coire Mhorair and Coire Odhar-mhòr

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

S.W.

N.E.

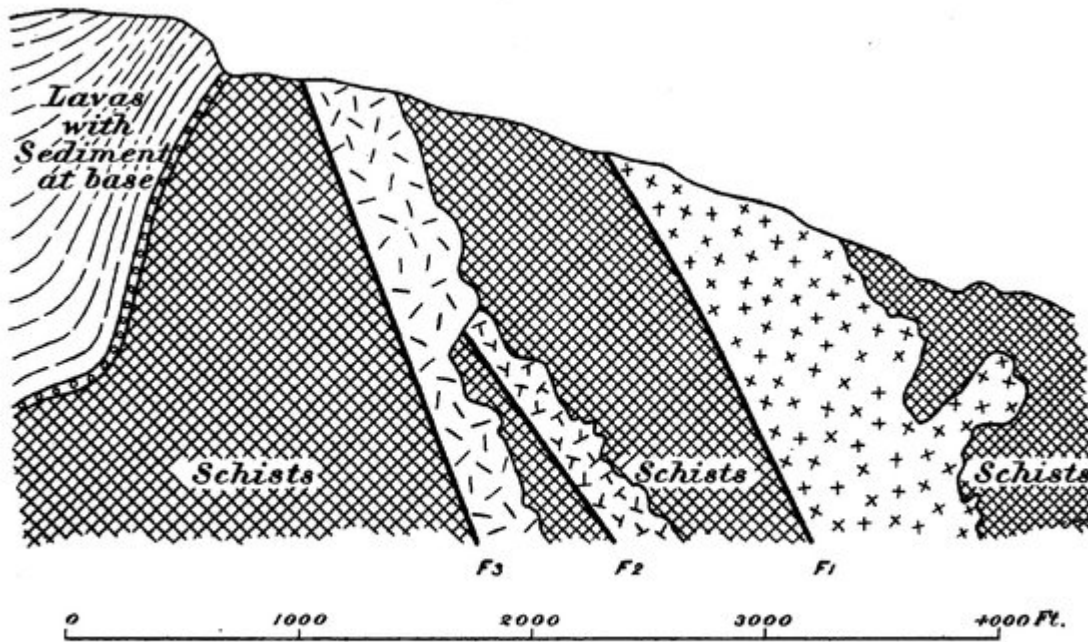


FIG. 25. Section through ridge W. of Coire Odhar-mhòr

F1 and F2 Early Boundary-Faults accompanied by Early Fault-Intrusions. F3 Main Boundary-Fault with Main Fault-Intrusion

(Figure 25) Section through ridge W. of Coire Odhar-mhòr [NN 196 583] F1 and F2 Early Boundary-Faults accompanied by Early Fault-Intrusions. F3 Main Boundary-Fault with Main Fault-Intrusion.



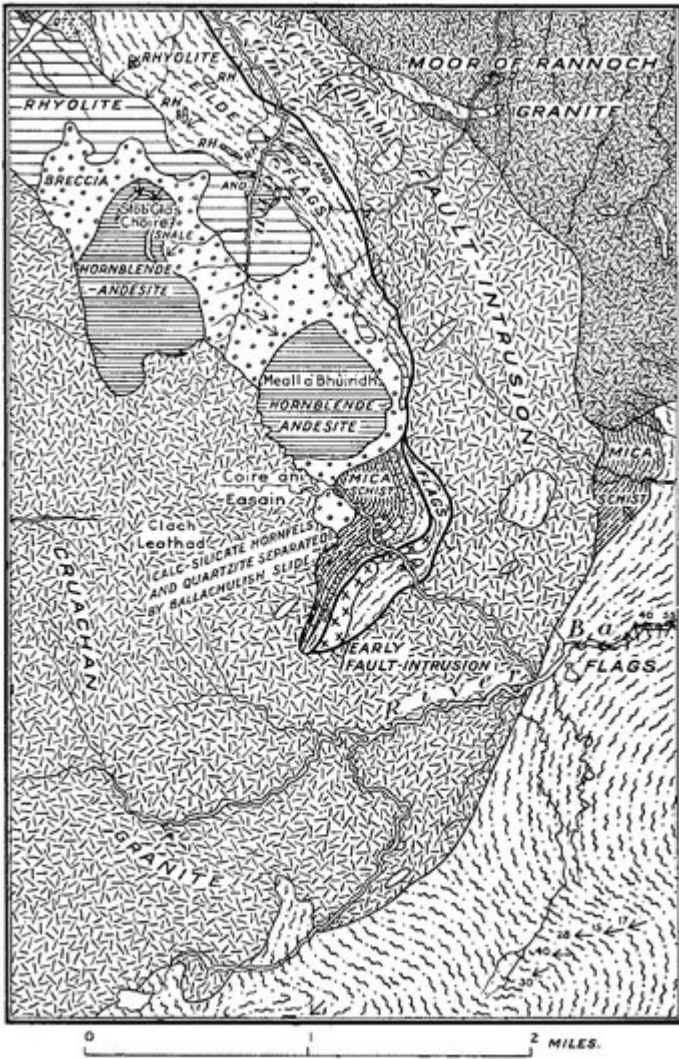


FIG. 29. Map of Càrn Ghleann and Coire an Easain. North-east dykes omitted

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

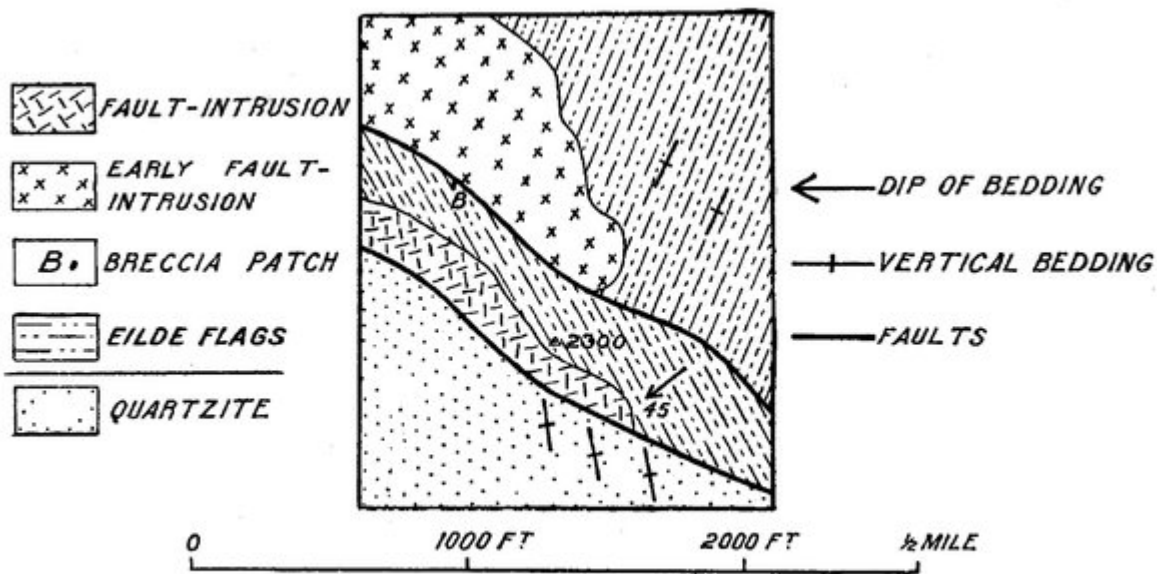


FIG. 26. Map of Stob Mhic Mhartuin. North-east dykes omitted

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

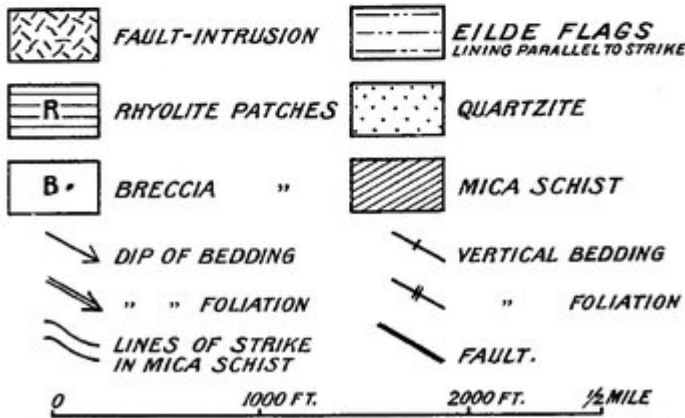
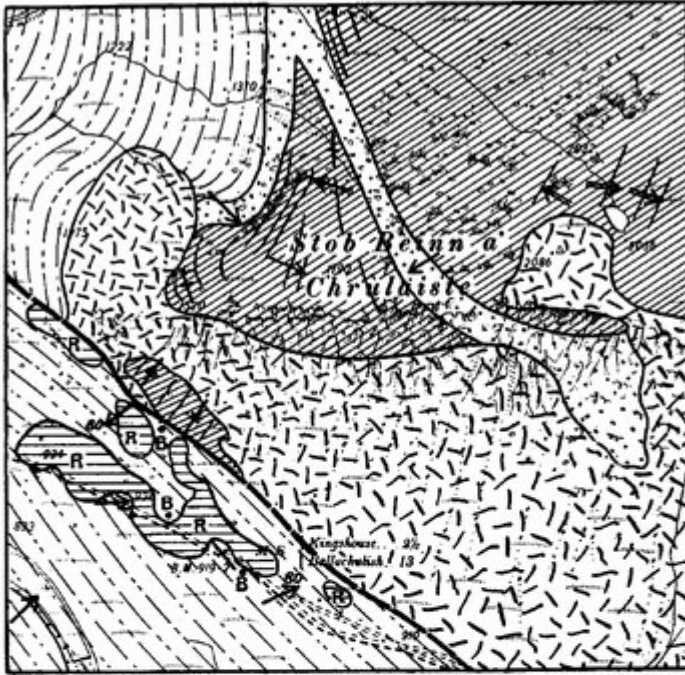


FIG. 28. Map of Stob Beinn a' Chrùlaiste. North-east dykes omitted

(Figure 28) Map of Stob Beinn a' Chrtilaiste. North-east dykes omitted.