Chapter 21 Faults

Introduction

Chapter 12 has been devoted to the Boundary-Fault of the Glen Coe Cauldron-Subsidence and chapter 14 has dealt incidentally with the corresponding fault that encircles the lavas of Ben Nevis. In addition a subsection of chapter 13 has been given to the Allt Buidhe Fault connected with the "Granite" Complex of Etive. This fault enters Sheet 53 from the south, across a broad belt of calc-silicate-hornfels, and can be easily identified in (Plate 4), p. 63. Its northward continuation is responsible for much shattering of rocks in the bed of the River Creran [NN 060 510] above Barnamuc [NN 048 499].

Such shattering has again and again guided subsequent erosion on a large or small scale, as set out in chapter 1 and in programmes for road excursions in Glen Coe, chapters 6 and 11.

Many faults recorded on the Survey's six-inch field-maps are accompanied by very minor displacement of adjacent rocks. Most of these have been intentionally omitted from the published one-inch Sheet 53, or have been indicated there merely by the words SHATTER BELT. This policy has been adopted to avoid obscuring other data presented on the map. At the same time one must remember that a shatter-belt along a fault, even if accompanied by very small displacement, may well be of considerable economic as well as scenic importance. It may, for instance, render a particular site unsuitable for a reservoir dam or even a reservoir floor; or it may let water into or out of a tunnel; or it may add difficulty to the regular shaping of a tunnel; or, worse still, it may lead to fatalities as a result of roof-falls. Accordingly in many cases advance location of shatter-belts is of high importance to engineering projects.

In what follows special attention will be paid to the Great Glen or Loch Linnhe Fault, which rivals in scientific interest the boundary-faults of Glen Coe and Ben Nevis. Then a few other individual faults will be selected as noteworthy for one reason or another. Finally a more minute account will be offered of faults met with in a sample area, the Alltchaorunn [NN 196 509] district, Glen Etive.

Great Glen Fault

The Great Glen Fault runs north-east and south-west right across Scotland. It is accompanied by much shearing and shattering, which has guided the erosion of a continuous large-scale hollow. This is the Great Glen with its series of fresh-water lochs connected by the Caledonian Canal. At its two ends the hollow is filled by the sea to give the Moray Firth, on the east coast, and Loch Linnhe in Sheet 53, on the west.

In the Moray Firth the fault brings Jurassic rocks on the south-east into contact with schists and Middle Old Red Sandstone on the north-west. In Mull, beyond Loch Linnhe, its effect upon Jurassic rocks is much less obvious. The main movements along the fault are certainly pre-Mesozoic.

At the head of the Moray Firth, in the Inverness district, Middle Old Red Sandstone is exposed on both sides of the fault; and at one point Horne has estimated that this great sandstone formation extends 6000 ft deeper on the southeast side than on the north-west (in Horne, Hinxman and others 1914, p. 68). This is a matter that particularly affects Sheet 53 since the conglomerate at Rudha na h-Earba [NM 912 555] (chapter 19) seems to be part of a series of strips of Middle Old Red Sandstone reaching south-west from Inverness along Loch Ness [NN 400 100], Loch Oich [NN 320 010] and Loch Lochy [NN 230 900]. The local evidence will be considered presently.

In Sheet 53 as a whole the influence of the Great Glen Fault upon schist distribution is unusually striking. The schists that lie to the south-east of the fault are very much less highly metamorphosed than those of Ardgour to the northwest.

The effect of the Great Glen Fault upon the Jurassic of Moray Firth, the Middle Old Red Sandstone of Inverness and the Schists of Sheet 53 has been very generally ascribed to downthrow towards the south-east (including in this term steep over-thrusting from the north-west favoured by George Barrow). Apparently the only hint of an early appeal to wrench- or tear-faulting is found in a description of a fault at Allt Mòr in the Loch Ness [NN 400 100] area, a fault which Cunningham-Craig has claimed to belong to "the same system" as the neighbouring Great Glen Fault. "Horizontal slickensides", he goes on to say, "prove that lateral movement took place along this [Allt Mòr] line of disruption, as was the case with most, if not all, of the north-east and south-west fault lines" of the Highlands in general (*in Horne*, Hinxman and others 1914, p. 70). Later Kennedy, quite independently and much more emphatically, came to the same conclusion. He based on various lines of evidence, of which four are selected for discussion below (*in* Geikie, J., 1940, pp. 169–171; Kennedy 1946; 1948; 1949).

1. The Great Glen Fault, as Cunningham-Craig first pointed out, seems to belong to a series of great wrench-faults, some of which have been interpreted as such since quite early in the present century. Kennedy lists the Strathconon, Strath Glass, Laggan, Ericht–Laidon, Tyndrum and Loch Tay Faults (1946, fig. 4, p. 56). He points out that all these faults are sinistral, that is, if one looks across their course one sees a relative displacement to the left. Also, this displacement is considerable — up to 4–5 miles in the case of the Ericht-Laidon Fault. The displacement Kennedy claims for the Great Glen Fault is also sinistral, and it amounts to 65 miles. It is the exceptional magnitude of this figure that impresses one with the need for caution.
2. A great belt of regional injection affects the Moine Schists near Strontian and to the north-east (Figure 40); and another extends east from Foyers. Kennedy correlates these two belts as really one and the same, displaced by the Great Glen Fault. Most people regard injection zones as fed from an underlying source. Accordingly, truncation of the Strontian injection zone by subsidence along the Great Glen Fault would imply subsidence to the south-east at the site now occupied by Loch Linnhe; whereas truncation of the Foyers injection zone by subsidence along the Great Glen Fault would imply subsidence to the north-west in the present Foyers locality. Such a contrast of downthrow direction, where downthrow is on a large scale, is very difficult to accept. It appears more probable that the displacement indicated has been horizontal rather than vertical. The horizontal distance involved is about 65 miles and is sinistral.
3. In Sheet 53 Kennedy considers that the difference of metamorphism on the two sides of the Great Glen Fault is too great to be reasonably explained by downthrow towards the southeast. Admittedly, the downthrow would have to be immense; but marked differences of metamorphism are apparent on the two sides of the boundary-faults of the Glen Coe and Ben Nevis Cauldron-Subsidences, where only vertical movement can be invoked (pp. 71, 179).
4. After realising the implications of the evidence considered under heading (2), Kennedy wondered if the Strontian "Granite", which he knew well, might not have been originally united with the comparatively unknown Foyers "Granite" (Figure 40) to form a single complex. He therefore undertook a rapid examination of the Foyers "Granite", and found in it the same association of types as at Strontian with the same time-sequence and with a complementary arrangement of outcrops (1946, fig. 6, p. 62). He has summarised his comparison as follows: The Great Glen Fault "truncates the Strontian Granite, the southern portion of which, according to the detailed structural evidence, is missing. The missing portion, moreover, can be identified in the Foyers mass which outcrops on the other side of the fault-line some 65 miles to the north-east and is similarly truncated by the fault. These two major Caledonian intrusions consist of identical rock types and are structurally homologous". It will be noted that the Strontian–Foyers "granite" evidence is exactly similar to the injection-zone evidence, only more appealing. Even if we are sufficiently cautious to refuse to accept as proved the correlation of the two "granite" complexes we still must admit that the evidence which they afford against a subsidence explanation is extremely strong. Truncation of the Strontian "Granite" by subsidence would almost certainly entail subsidence to the south-east, whereas truncation of the Foyers "Granite" would equally strongly imply subsidence to the north-west. In all the circumstances Kennedy's interpretation seems probable; and we may note that it has been somewhat strengthened through detailed investigation of the Foyers outcrop undertaken by Mould (1946). Her map differs in some important respects from that quickly drawn by Kennedy, but it is the same in essence. "The present detailed study of the Foyers complex has," she says, "shown its likeness to the Strontian mass in many particulars, but has also revealed some differences" (1946, p. 264). When she enumerates these differences one finds them surprisingly slight.

Kennedy's suggested Strontian — Foyers displacement may perhaps be parallelled by a possible Colonsay — Ballachulish displacement of like apparent direction and magnitude. In Colonsay, named on (Figure 40), a typical kentallenite, appinite, augite-diorite association matches exactly in lithology, though not in country-rock, the Ballachulish concentration illustrated in (Figure 18). It is tempting to attribute the present separation to movement along the Great Glen Fault; if so, the fault must run south-east of Colonsay, not north-west as shown by Kennedy in (Figure 40). There is independent evidence that such is its true position.

Let us now return to Sheet 53 and consider the outlier of supposed Middle Old Red Sandstone conglomerate at Rudha na h-Earba [NM 912 555]. It rests unconformably on felspathised, highly metamorphosed Moine Schists with granite veins. Accordingly it lies on the north-west side of the main branch of the Great Glen Fault, for this runs along Loch Linnhe to introduce the slightly metamorphosed schists of Rudha Mò, Shuna Island [NM 920 490] and the Appin mainland. Thus it is practically certain that the main branch of the Great Glen Fault has not moved with important downthrow to the south-east since the deposition of the Rudha na h-Earba conglomerate. If it had, one would expect to have found an extensive south-eastern outcrop of the Rudha na h-Earba formation. This argument does not, of course, preclude important south-east downthrow prior to Rudha na h-Earba conglomerate times; and so it must not be taken as a demonstration of the emplacement of the conglomerate by wrench-faulting. A possible alternative is that the rocks forming the Rudha na h-Earba [NM 912 555] peninsula occupy a narrow trough-fault, or graben, developed after the main faulting episode. Such a strip would give no clue as to the nature of previous movements, vertical or horizontal. In Mull, further south-west, a narrower strip includes Kimmeridgian which appears to have escaped pre-Ceriomanian erosion through subsidence into a graben following the course of the Great Glen Fault (Bailey *in* Lee and Bailey 1925, p. 114; Manson *in* Sum. Prog. 1934, pp. 83–4).

The Rudha na h-Earba conglomerate has been correlated with strips of Middle Old Red Sandstone seen intermittently at Loch Lochy [NN 230 900], Loch Oich [NN 320 010] and Loch Ness [NN 400 100] further north-east along the Great Glen, and there is no doubt at all that the Middle Old Red Sandstone has suffered intense movement along the Great Glen Fault. Kennedy has proposed that the initiation of the faulting dated from Carboniferous times. The writer, however, thinks that the fault was already active in Lower Old Sandstone times. This is suggested in Sheet 53 by the manner in which a zone of granite-veins and elongated granite-bosses flanks Loch Linnhe as far south-west as Inversanda Bay b[NM 940 595] (p. 189). It looks as though ascending magma, presumably of Lower Old Red Sandstone age, was guided by the Great Glen Fault. In Druim na Maodalaich [NM 875 535] this same alignmentappears in an offshoot of the Strontian "Granite" Complex. Accordingly it is probable that the Great Glen Fault has to some extent functioned as a guide to Strontian magma, even though later it may have cut the resultant Strontian-Foyers Pluton into two.

When Kennedy wrote of Foyers he thought that the strip of Middle Old Red Sandstone, which is shown in (Figure 40), was essentially dipping unconformably off the Foyers "Granite". Mould has since shown that the relationship is considerably more complex. The Foyers "Granite" is often separated at outcrop from the Middle Old Red Sandstone by schists. These are partly Moines, corresponding with the normal country-rock of the "granite"; but for two miles they consist of a narrow strip of problematical "Gleann Liath Series". The latter consist of "coarse gneisses, with associated limestones, intruded by basic hornblende-diorite and veins of pegmatite and granite" — a description that suggests comparison with the Glen Scaddle rocks of Sheet 53. The Gleann Liath Series is faulted against the country-rock Moines on the south-east, and is covered by north-west-dipping unconformable Middle Old Red Sandstone on the north-west. As Mould has traced the unconformity from Moines to Gleann Liath Series (1946, p. 263) it seems clear that some of the important faulting of the district is earlier than the local Middle Old Red Sandstone. Mould herself clearly expresses this opinion when she says: "The Foyers Granite ' is traversed by many crush zones and movement lines related to the Great Glen Fault. The movements have evidently spread over a long period of time; some appear to be earlier than the Middle Old Red Sandstone" (1946, p. 256).

It is now time to warn readers that Kennedy's views have been strongly contested by Shand (1951). The latter found that at one point in the glen the width of concealed rock, due to surface deposit (presumably covering fault-shattered material) measures only a third of a mile. He concluded therefore that available exposures along the glen are close enough to give the essential features of the shatter-belt between. In these exposures he failed to find horizontal slickensidesthis in spite of his visiting Cunningham-Craig's record at Allt Mòr, which he describes as unsatisfactory owing to rock weathering and cover by brush wood.

He also failed to find mylonite; but he explains that by mylonite he means flinty crush-rock, or pseudo-tachylite, with which he was very familiar in the Parys Mountain of South Africa. As the development of flinty crush-rock presumably depends rather upon rapidity than upon integrated extent of movement, this is not necessarily significant. In regard to one or two specimens, collected by Eyles as showing minute veins of flinty crush-rock, he remarks that "they can hardly be considered to throw any light on the problem of the Great Glen". Taken by themselves they certainly do not.

Shand's statements regarding dearth of horizontal slickensiding along the Great Glen do constitute an obvious difficulty for Kennedy's interpretation; and it is to be hoped that they will lead to further intensive study.

On the other hand his disrespectful treatment of the crush phenomena along the glen and his insistence upon flinty crush-rock as a necessary accompaniment of extensive wrench-faulting came as a surprise to many Scottish geologists. A carefully documented reply was soon furnished by Eyles and MacGregor (1952).

In so far as Sheet 53 is concerned considerable shatter phenomena are a general feature of the north-west shore of Loch Linnhe and also of the south-east shore in the narrow section between Fort William and Rudha Cuilcheanna [NN 013 615]; and at one place, but only one, a sample is exposed of the altogether exceptional shearing that is thought by most geologists to be truly characteristic of the fault zone. The locality is the foreshore for about a mile south-west of Fort William as exposed at low tide. The following account was published long before Kennedy had thought of a wrench interpretation of the Great Glen Fault (Bailey 1934a, p. 471).

Here we see "a pale grey set of schists with what appear at first sight to be beds and lenticles of rusty-weathering sedimentary calcareous schist, the whole affected by terrific breaking and mylonization hading steeply, as a rule, towards the north-west. Careful search and comparison show that these grey schists have been derived for the most part from bedded semi-siliceous rock of more or less Eilde Flag type, and that the associated calcareous bands and lenticles are foliated calcitized (or dolomitized) lamprophyres of Devonian age; there are also a few porphyrites. In places, the mashed mylonized assemblage develops into a foliated crush-breccia that might even be mistaken for boulder bed" with porphyrite pebbles.

Great Glen subsidiaries

Let us now turn to what may be termed subsidiary branches of the Great Glen Fault. To the north-west of the Corran Narrows [NN 0183 6342] of Loch Linnhe one such subsidiary is indicated on Sheet 53 as reaching north-east past Rudha Dearg [NN 026 668]. In the other direction it very likely connects with the branch that passes north-west of the Rudha na h-Earba peninsula [NM 912 555] between Inversanda Bay b[NM 940 595] [NM 940 595] and Camas Chil Mhalieu [NM 905 555].

Across, that is south-east of, Corran Narrows [NN 0183 6342] another subsidiary is mapped behind Druim na Birlinn [NN 032 643]. It has caused notable displacement of schist outcrops, and also has guided the erosion of considerable hollows. Hidden under raised beach (and therefore not coloured on the map) it is responsible for a north-south low-level pass, followed for half a mile by the main road west of Onich. North of this it has located the excavation of a stream gorge draining past Inchree [NN 030 635].

Fault crossing Glen Nevis

As shown on Sheet 53 by the words SHATTER BELT (see also (Figure 16)) a fault crosses Glen Nevis a little above the mouth of the tributary Allt Coire na Gabhalach [NN 202 680]. It has determined the course of the River Nevis [NN 200 680] for three-quarters of a mile, and is known to continue both to north-east and southwest.

Loch Leven–Loch-Eilde Mòr Fault

An east-north-east shatter-belt has guided the erosion of Loch Leven and Loch-Eilde Mòr. It is often connected with a right-angle bend of the strike of the schists; and it is argued on p. 95 that it may have been located by this bend. Broken rock along its course is especially well seen in streams at the head of Loch Leven, where SHATTER BELT is printed on the map; and what is probably a continuation of the same smash is exposed in the bluff west of St. John's Church [NN

067 586], Ballachulish. Displacement along this fault is unrecognisably small.

Glen Etive — Lairig Gartain [NN 200 544] Fault

A great shatter-belt, parallel with Loch Linnhe, has been traced from the lower reaches of Glen Etive through Lairig Gartain [NN 200 544] and across the Blackwater Reservoir [NN 250 605] a little above the dam. It is shown on Sheet 53 by a dark brown line. Broken rock is visible at many places along its course. It is not possible, however, to determine precisely any displacement which it may have produced in the schists, lavas and "granites" that it traverses, for it has given rise to a broad hollow wherein exposures are poor and discontinuous. It is clear, however, that such displacements as occur must be comparatively trifling.

Faults West of Glenceitlein [NN 148 479], Glen Etive

A SHATTER-BELT is marked on Sheet 53 leading east from the head of Allt Bealach na h-Innsig [NN 070 484]. It affects both Leven Schists and Cruachan "Granite".

Another crush-zone runs along the lowest reaches of Allt nan Gaoirean [NN 130 477] where the map shows Cruachan and Starav "Granites" in contact. E. B. B.

Faults of Alltchaorunn [NN 196 509] District, Glen Etive

All the faults considered below are later than the north-east porphyrite dykes of the Etive Swarm. They mostly follow the direction of these dykes, or else run at right angles to the same. The north-easterly set of faults may be the earlier; and the north-westerly may perhaps be of Tertiary — or Permian — age. Suggestive evidence is afforded in a burn about a mile west-south-west of Alltchaorunn [NN 196 509] House. Here a crush-band with calcite strings strikes north-north-east within a porphyrite dyke, and is cut by a somewhat similar crush-band striking north-west, or west-north-west, nearly parallel to a dyke of supposed Tertiary age. The latter can be easily identified on Sheet 53.

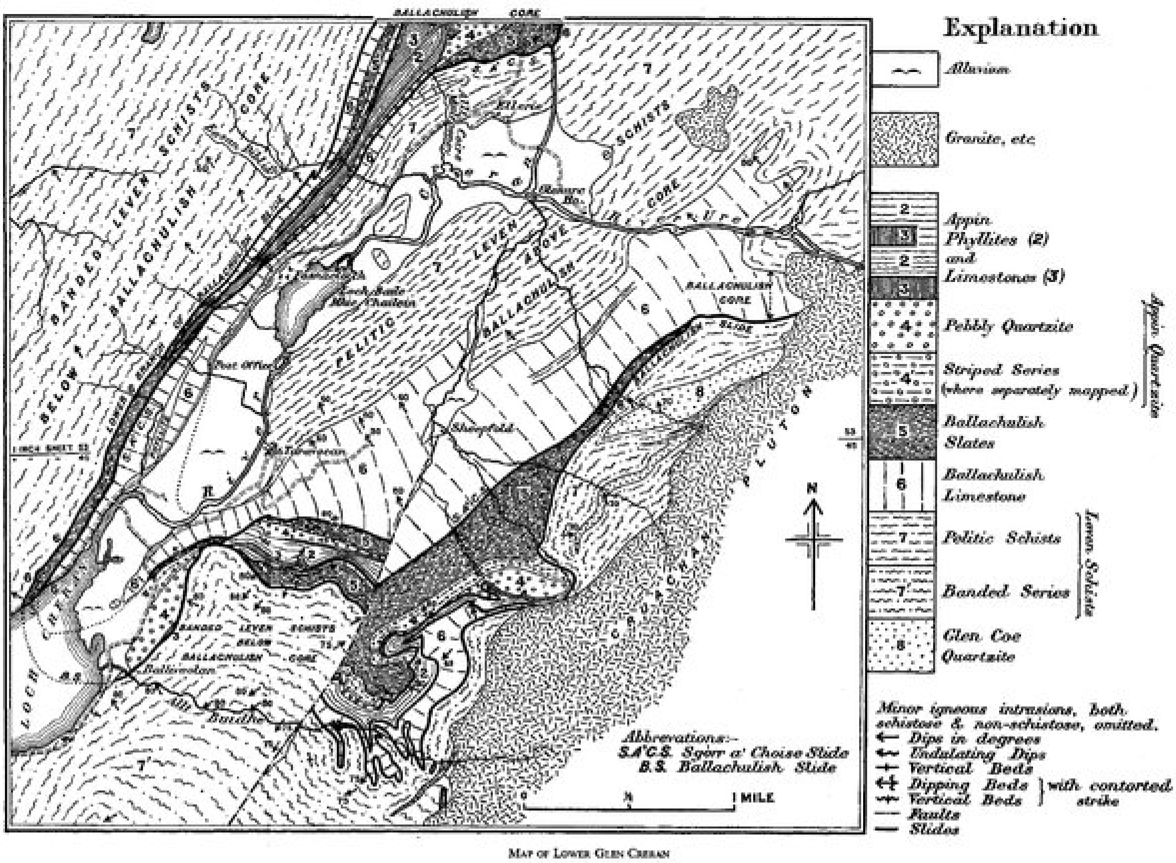
Let us now turn to the middle course of Allt a'Chaoruinn [NN 190 490], where SHATTER BELT is printed on Sheet 53. The long reaches of the stream which run north-east or north-north-east mostly follow crush-planes; and these, like the dykes of the neighbourhood, incline steeply south-east. The crushes are accompanied by many strings of calcite and some of quartz; while the adjacent rocks have developed close parallel joints. In one example, a mile slightly west of south of Alltchaorunn [NN 196 509] House, a quartz vein attains a breadth of four feet.

Some north-north-east shatter-belts, crossing the two tributaries that enter this part of Allt a'Chaoruinn [NN 190 490] from the west, seem to be nearly vertical; while an east-north-east fault that traverses the south end of Beinn Ceitlein [NN 176 490] inclines south. In places this last has effected considerable crushing; but it has produced only very slight displacement of porphyrite dykes.

The most prominent of the north-westerly crushes of the district crosses Glen Etive half a mile west of Alltchaorunn [NN 196 509] House, and for five miles is marked by a dark brown line on Sheet 53. Just south of the glen its position is indicated by a deep erosion cleft on the hillside. Crushed rock is seen at one place in the bottom of this cleft, and porphyrite dykes have suffered a dextral displacement of 9 ft. Similar dextral displacement of 9 ft affects a quartz-porphyry dyke (the one that terminates further south a little before reaching the Meall Odhar Granite, p. 173). On the other hand, south-south-east of Alltchaorunn [NN 196 509] House, what appears to be the same crush-plane is accompanied by minor sinistral displacement of porphyrite dykes. This disagreement is not surprising as the shifts involved are in all three cases very small. The fault at the locality just cited is vertical, but more often it inclines to the south-west.

About a mile east of the quartzite summit of Stob Dubh a north-west crush, not indicated on Sheet 53, crosses the quartz-porphyry dyke mentioned above. Again there is dextral displacement, here measuring 9 ft.

A burn running slightly west of north joins the Etive about a quarter of a mile below Dalness. Various crush-bands and calcite veins keep nearly along its course. They do not displace dykes to any appreciable extent. C. T. C.



(Plate 4) Map Of Lower Glen Creran.

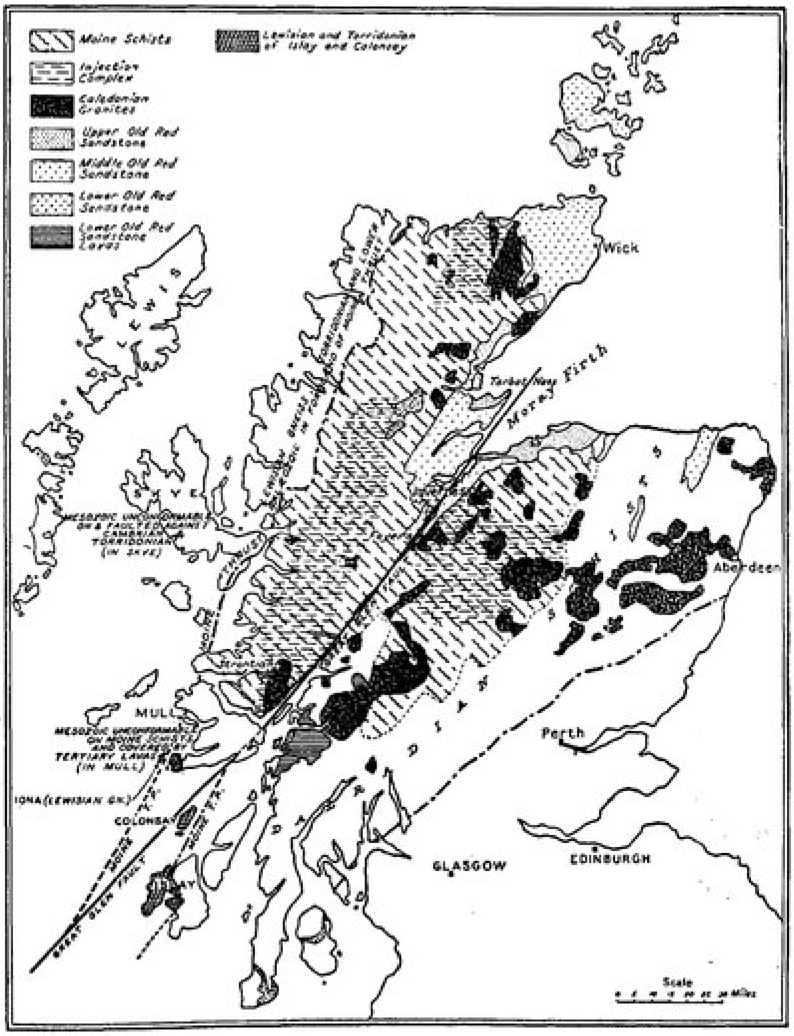


FIG. 40. Geological map of the Scottish Highlands to show the present position of the Moine injection complexes, the Strontian and Foyers granites, and the Moine Thrust-plane, after W. Q. Kennedy

(Reproduced, by permission, from *Quart. Journ. Geol. Soc.*, vol. cii, pt.i, 1946, fig. 2)

(Figure 40) Geological map of the Scottish Highlands to show the present position of the Moine injection complexes, the Strontian and Foyers granites, and the Moine Thrust-plane, after W. Q. Kennedy (Reproduced, by permission, from Quart. Joum. Geol. Sot., vol. cii, pt.i, 1946, fig. 2).

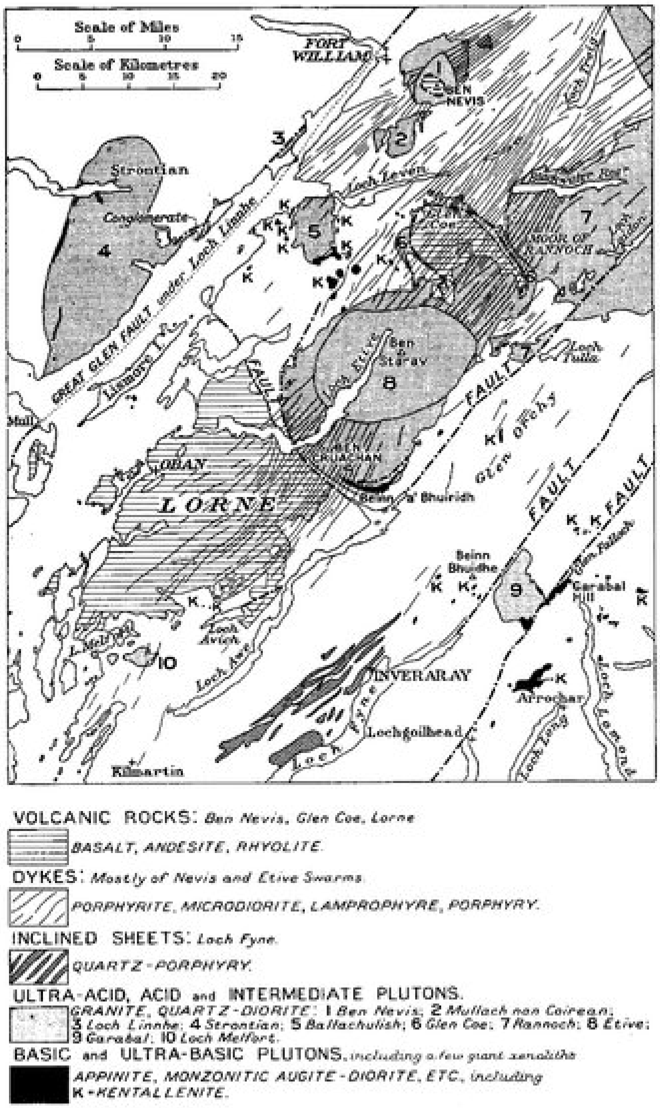


FIG. 18. Map of igneous rocks of South-West Highlands referred to Lower Old Red Sandstone Period

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

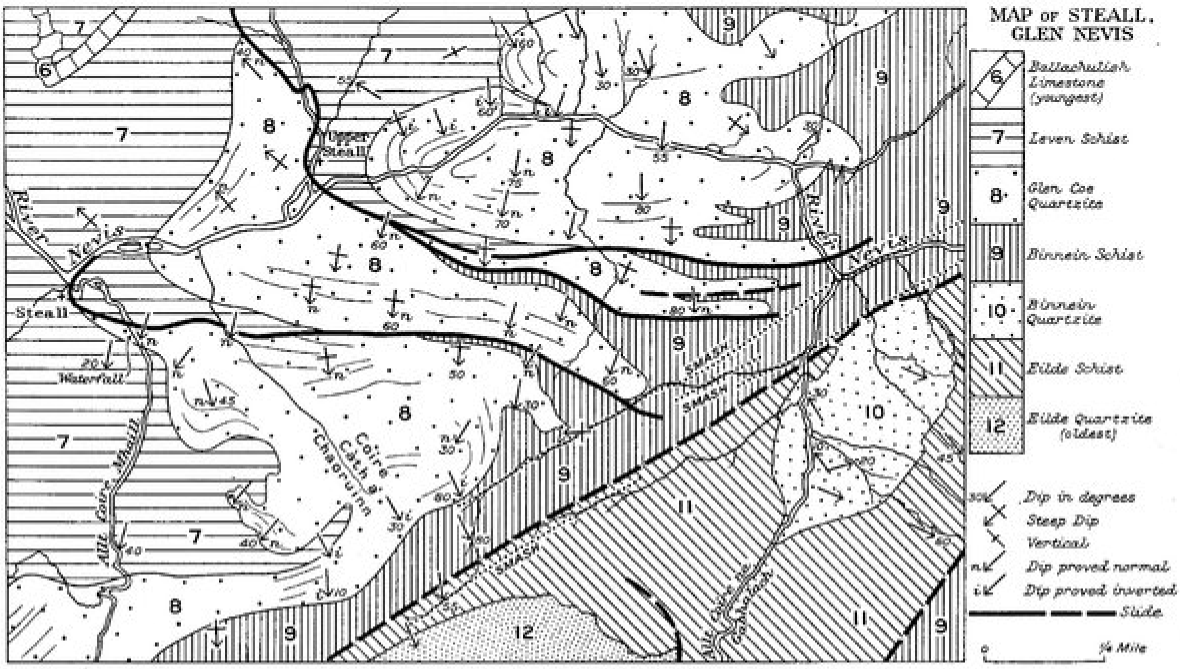


FIG. 16. Map of Steall, Glen Nevis

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