Chapter 3 Formations and terms

Tabular statement of formations

The following classification has been adopted in the index of Sheet 53:

POST-GLACIAL

Peat

Landslips

Glacial and Post-Glacial

Fresh-Water Alluvium:

Lowest Terrace

High Terrace

Higher Terrace

Alluvial Cone

Fluvio-glacial Gravel (only separately mapped at Corran [NN 016 636])

POST-GLACIAL

Marine Alluvium:

Present Beach

Low Raised Beach

"25-Ft" Raised Beach, about 35 ft above O.D.

Raised Marine Deltas

Raised Sea Margins are also shown

GLACIAL

Morainic Drift

Boulder Clay

TERTIARY AND DOUBTFUL

Dolerite Dykes, mostly N.W. or W.N.W.

Monchiquite W.N.W. Dyke (Glen Coe) (treated as Permian in the sequel)

Breccia Vent with Nepheline Basalt (treated as Permian in the sequel)

(Allt Coire na Bà [NN 188 650] [NN 190 640])

Doubtful Middle Old Red Sandstone

Rudha na h-Earba Conglomerate

LOWER OLD RED SANDSTONE AND DOUBTFUL

Sediments:

Conglomerates, Sandstones, and Shales

Minor Intrusions:

Porphyrite Dykes, mostly N.E. (some with slight foliation near Starav Granite are distinguished by a symbol)

Fine-grained Diorite N.E. Dykes, sometimes porphyritic (Glen Etive District)

Andesite W.N.W. Dykes (Glen Coe District)

Lamprophyre Dykes and Sheets

Quartz-Porphyry, Felsite, and Rhyolite Dykes

Plutonic Intrusions:

Biotite-Granite, Porphyritic Granodiorite and Tonalitic Granodiorite of the Morvern-

Strontian Complex

Granite and Quartz-Diorite, including much of the "Fault-Intrusion" of Glen Coe

Porphyrite Facies of "Fault-Intrusion"

Porphyrite Facies of "Early Fault-Intrusion"

Augite- and other Diorites, including two outcrops of "Early Fault-Intrusion" at east margin of map

Kentallenite and Cortlandtite

Contemporaneous Igneous Rocks:

Agglomerates, including some Sedimentary Breccias

Rhyolite Lavas

Andesite Lavas separated locally into Hornblende- and Augite-Andesites (includingBasalts)

METAMORPHIC ROCKS OF UNCERTAIN AGE NORTH-WEST OF LOCH LINNHE

Stratigraphical Relations of the Sediments are doubtful

Intrusions

Epidiorite and Hornblende-Schist (much of the Glen Scaddle intrusion might be classed as Diorite)

Augen Gneiss (Sgùrr Dhomhnuill [NM 890 679]); see p. 116.

Of mixed Origin:

Felspathised Sedimentary Gneiss

Sediments of "Moine Series":

Limestone

Quartzite

Psammitic Gneiss

Pelitic Gneiss

METAMORPHIC ROCKS OF UNCERTAIN AGE SOUTH-EAST OF LOCH LINNHE

Intrusions:

Hornblende-Schist (S.E. of Glen Creran) probably later than main folding

Sediments in stratigraphical sequence from Cuil Bay Slates (youngest) to Linnhe Quartzite (oldest):

Cuil Bay Slates (with Lismore Limestone of Shuna [NM 920 490] probably younger still, but not indexed)

Appin Phyllites and Limestones

Appin Quartzite

Ballachulish Slates

Ballachulish Limestone

Leven Schists

Glen Coe Quartzite

Binnein Schists

Binnein Quartzite

Eilde Schists

Eilde Quartzite

Eilde Flags (with Linnhe Quartzite and Dark Schist)

Sediments near Blackwater Reservoir [NN 250 605], of doubtful Stratigraphical Position:

Stob Quartzite

Reservoir Schists

Reservoir Quartzite

Reservoir Flags

MINERAL VEINS

Haematite (E.N.E. of Glenure House [NN 043 481]); see also p. 288

In addition to giving the position of the various rock groups, the map carries signs to show how the inclination of the bedding and cleavage, or foliation, of the sedimentary and schistose rocks varies from place to place. Faults and slides (fold-faults) are distinguished from unbroken junctions, while a device is employed in certain cases to indicate which of two adjacent igneous intrusions is the later. Glacial striae are indicated by special arrows pointing in the direction of ice-flow.

Discussion of terms

Highland Schists

A bed or formation is said to young in the direction towards which it presents its younger side. An uninverted bed youngs upwards and in the direction of dip; but an inverted bed youngs downwards and away from the direction of dip. The direction of younging is often determinable from current-bedding ((Figure 13), p. 92).

The folding of the schists within Sheet 53 is extremely complex, and it may be helpful to explain the terminology employed in its description. The idea of an isoclinal fold is sufficiently familiar to form a starting-point. In an isoclinal fold the two limbs of the fold and the intervening axial plane of the same have assumed a rough parallelism, for a lesser or greater distance; the inclination of the parallel limbs we take as defining the inclination of the fold itself; and experience teaches us that the isoclinal folds of some of the better known mountain chains often lie at low angles, and such prostrate folds are said to be recumbent.

Recumbent folds, where well-developed, frequently attain to surprising dimensions, and can be traced for miles as more or less flat sheets in a direction at right angles to the strike of the folding. These large-scale folds generally occur in groups, in which the apices of the recumbent anticlines all point in one direction and the apices of the complementary synclines in the opposite direction. The direction in which the apex of a fold, whether anticline or syncline, points, defines the direction in which that particular fold closes. In the other direction the fold is said to open or gape (cf fold of Glen Coe Quartzite, (Figure 9), p. 51, which closes to the N.W. and gapes to the S.E.).

When we deal with a region unaffected by recumbent folds it is easy to define an anticline as a fold that closes upwards, or what is the same thing under the circumstances as a fold with a core of older formations (and a syncline, vice versa). When, however, we enter a region affected by recumbent folding we get into difficulties. This is partly because the axial plane of a recumbent fold may undulate, so that we may find a recumbent anticline closing upwards at one locality and downwards at another. At the same time, if the recumbent folding has affected strata previously uninverted, it remains true that a recumbent anticline contains a core of older formations — and, as always, vice versa for a recumbent syncline. For example, we are reasonably certain that the main recumbent folds of Sheet 53 were not preceded by regional inversion. Accordingly, once we learnt that the cores of the great homologous Ballachulish, Aonach Beag and Appin recumbent folds consist of younger formations, we accepted them as recumbent synclines separated by complementary recumbent anticlines ((Figure 17), p. 112).

Another difficulty is that later, often called secondary folds, which for convenience we shall assume to be non-recumbent, frequently affect earlier recumbent folds. Where such secondary folds involve an inverted recumbent limb they will close upwards, if they possess a core of younger formations, and downwards vice versa. Altogether, it is sometimes helpful to call a fold which closes upwards an antiform rather than an anticline, if one wishes to state its form without fear of suggesting that its core consists of older formations. Synform is the complementary term. It is interesting to recall that the Appin recumbent fold, where its core outcrops between Glen Nevis and Onich (compare one-inch map with (Figure 2), p. 37) was recognised as a synform long before relative dating of its affected formations proved that it has a core of younger rocks.

Sometimes, where an isoclinal fold crosses a cliff, the natural section provides a clear picture of the direction of close. This is the happy position where the Appin Fold, just mentioned, is sectioned by the steep south-western face of Glen Nevis ((Figure 3), p. 39). The view from near Glen Nevis House [NN 126 721] shows that the fold has here a core of Ballachulish Slates clearly resting upon the purer part of the Ballachulish Limestone.

Observation is rarely such an easy matter. Isoclinal folds, where strictly recumbent, close towards some point of the compass without any upward or downward component, so that for them the words antiform and synform have no application. Of course, strictly recumbent folds do not occur on a large scale in nature; but the uncertainties introduced by undulation of the axial plane have already been noted.

Even in non-recumbent folds the determination of upward or downward close may present difficulty in the field, for topographic assistance such as is provided in Glen Nevis, is rarely forthcoming in Scotland.

It is often helpful to limit the use of the word core by assigning to it an arbitrary stratigraphical boundary. In the unlimited sense, any fold, wherever found, has an inner portion of which we have already spoken as the core, and a corresponding outer portion which may be called the envelope. As folds close towards a particular direction, formations furnishing envelope at one place must function as core at another, and vice versa. If, however, we consider a fold in its entirety, we can give its core a statigraphical limit and a correspondingly definite name. This procedure has been adopted in the sequel in regard to the recumbent synclines of Ballachulish, Aonach Beag and Appin. The Ballachulish, Aonach Beag and Appin Cores are defined as the cores of these three synclines in so far as they consist of Ballachulish Limestone (with or without later formations). The older formations, Leven Schists, etc., involved in the folding, are then classed as envelope. Over wide areas the envelope formations must of course occupy core positions, but this involves no logical contradiction. Also it need lead to no confusion, for it is easy to drop the limited-core terminology wherever it ceases to be convenient.

An even more important term is fold axis, though it happens that it can only be given an approximate definition unless the particular fold has a well marked. apex or angular close or hinge. Where such an apex affects a bed, the fold axis for that bed follows the line of the apex. While there is generally some looseness in the definition of a fold axis, axial direction is what really matters, and it is unambiguous in an ideal cylindroid fold. It is in fact the one direction shared by all positions of the folded bed. In other words, it is the direction along which any two non-parallel positions of this bed will intersect if produced. The inclination of the axial direction of a fold is what is called in the index of Sheet 53 the pitch of the fold. This practice is followed in the present memoir although, of recent years, the word plunge has to a large extent replaced pitch in this sense and pitch has been given a different meaning.

As a working rule we may treat dips as giving pitch if they are observed along the axial belt of a fold outcrop and if they are directed roughly parallel with the general strike of the fold. If the core disappears under the envelope in the direction of pitch, then clearly the fold is an antiform, and vice versa in the case of a synform. Search for information is helped by the fact that large and small folds in any particular district often have the same direction of pitch — but this cannot be taken as a universal rule.

Pitch may in certain cases be deduced. We have seen that a natural cross-section of the Appin Fold at Glen Nevis shows that the fold there is a synform. A glance at the behaviour of outcrops to the south-west as far as Onich allows us to deduce that the pitch of this synform is south-westwards.

Now, as may readily be imagined, the rocks included in recumbent folds have very commonly broken. The immense extent of many of these folds is due, in large measure, to the rupture of the folding rocks, and their displacement along fold-faults or slides, which as a rule lie approximately parallel to the folds themselves. Slides do not belong all to one category. Some are developed in, and more or less replace, the lower, reversed limbs of anticlines; these are known as thrusts. Others are developed in, or replace, the lower unreversed limbs of synclines, and are called lags. Thrusts and lags are complementary to one another in the sense that anticlines and synclines are said to be complementary. When Sheet 53 was mapped the order of stratigraphical succession had not been discovered. All that could be said was that the slides of the district included examples of both thrusts and lags, and that it was impossible to say which were which.

When the stratigraphical succession was determined it was surprising to find that the two most prominent slides of the district, the Fort William Slide in the lower limb of the Appin Fold ((Figure 2), p. 37) and the Ballachulish Slide in the lower limb of the Ballachulish Fold ((Figure 8), (Figure 9), pp. 50, 51) are both lags. This is surprising, because thrusts are much better known in other parts of the world and are much easier to picture in course of development. The lags of our district are associated with unusually extensive unthinned inversions.

Before leaving this subject it is interesting to recall that, when the recumbent fold paper (Bailey 1910) was presented at the Geological Society, slip was used as a short synonym for fold-fault. This was, however, exchanged for slide at the request of Charles Lapworth, who had originally used slide in the sense that thrust is now employed in descriptions of the North-West Highlands.

Igneous rocks, etc

The term pluton is freely used in the sequel, because of its convenient vagueness, to denote a mass of coarse-grained igneous rocks, irrespective of composition or shape. Thus the Ballachulish Pluton south of Ballachulish Ferry [NN 053 598] is half quartz-diorite, half granite.

It has already been explained (p. 28) how the Cauldron-Subsidence of Glen Coe came by its name. The investigation of this occurrence supplied a group of ideas which, in English, are rendered by such terms as ring-fracture, ring-fault and ring-dyke; but the actual introduction in our country of ring-terminology awaited the recognition of Glen-Coe-like ring-features in the Tertiary volcano of Mull (ring-bosses, Bailey in Sum. Prog. 1914, p.51; ring-dykes, Bailey and Richey in Sum. Prog. 1915, p. 36). T. Thoroddsen, however, had already drawn attention to ring-fractures, or as he called them "Kreisbrüchen", in Iceland (for a review see Bailey 1919). The Glen Coe ring-fault is very often spoken of as the Boundary-Fault of the Cauldron-Subsidence. At some localities it has more than one branch, and movement along it can sometimes be shown to have been intermittent.

Flinty crush-rock is a name applied by Clough to crush-rock which has a very compact black matrix with subvitreous lustre — flinty in appearance, not in composition. Clough first met what he called "flinty-like streaks [which] occur along the lines of greatest crushing" in the Cheviot Hills (1888, p. 23); and later he found many examples in the North-West Highlands (1907, index, 18 refs. — commoner still in the Outer Hebrides). Meanwhile T. Holland independently investigated instances, called trap-shotten bands, in southern India (1900, pp. 198, 248); while S. J. Shand's pseudotachylyte, later described from the Orange Free State (1917), would certainly be called flinty crush-rock if it occurred in Scotland. In the Glen Coe region flinty crush-rock is only found along or near to the Boundary-Fault. It is a product of partial melting, and much of the heat which it records is attributed to friction connected with rapid displacement.

Fault-Intrusion means in this memoir an intrusion contemporaneous with some phase of the Boundary-Fault of the Glen Coe Cauldron. On this understanding the terms Main and Early Fault-Intrusions are self-explanatory.

Great Glen Fault

A wrench- or tear fault is a fault along which the relative displacement of the two sides has been horizontal. Along a dextral wrench the far side has moved relatively to the right, and along a sinistral wrench, the far side has moved relatively to the left. According to Kennedy the Great Glen Fault is an unusually powerful sinistral wrench with a relative displacement of 65 miles. E. B. B.

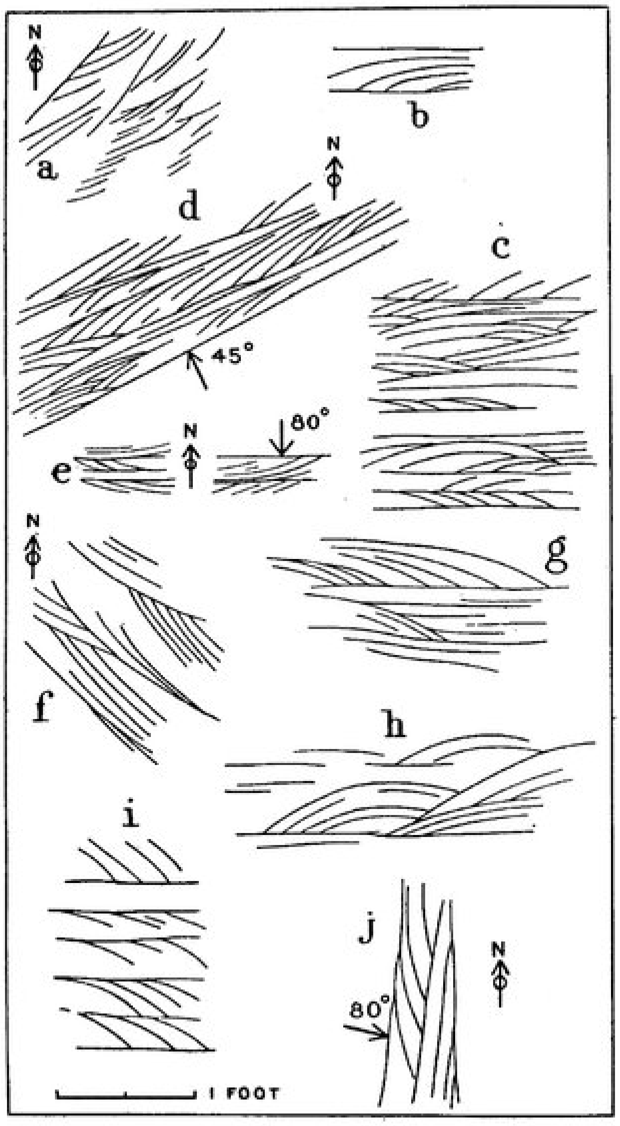

FIG. 13. Sketches of current-bedding

(Figure 13) Sketches of current-bedding. Explanation of Figure. 13 — Sketches of Current-Bedding Sketches a, d, e, f and j, which represent current-bedding on a fairly flat surface, are treated as maps with the north point at the top. The remaining sketches, of current-bedding on fairly steep faces, are treated like strike-sections with the main bedding represented horizontally. a. Glencoe Quartzite youngs north-westward, away from Binnein Schist. Eastern side of the mouth of quarry at Rudha Cladaich [NN 122 610], north shore, Loch Leven ((Figure 15), west). b. Glencoe Quartzite youngs downwards, away from Binnein Schist. Southern side of Glen Nevis, almost in a line with a shatter-belt or smash shown on Sheet 53 and (Figure 16). c. Binnein Quartzite youngs downwards towards Binnein Schist. Near northern shore, Loch Leven, half a mile east of Allt Nathrach [NN 160 631] ((Figure 15), east). d. Binnein Quartzite youngs south-eastward, away from Eilde Schist. Northern shore, Loch Leven, three-quarters of a mile west of Allt Nathrach [NN 160 631] ((Figure 15), east). e. Binnein Quartzite youngs northward, away from Eilde Schist. At junction of these formations, southern shore, Loch Leven opposite Eilean nam Ban [NN 159 619] ((Figure 15), east). f. Binnein Quartzite youngs north-eastward, away from Eilde Schist. Same junction as (e), but half a mile inland along strike and just outside (Figure 15), east. g. Eilde Quartzite youngs downwards towards Elide Schist. Roadside, half a mile northeast of Caolasnacon ((Figure 15), east). h. Eilde Quartzite youngs downwards towards Eilde Schist, but at some distance from the contact. Roadside, 1¼ miles east-north-east of Caolasnacon ((Figure 15), east). i. Eilde Quartzite youngs downwards towards Eilde Schist. Near western junction, a little above deer-stalkers' path, 1½ miles north-east of Am Bodach and 3 miles north of Kinlochleven. j. Eilde Quartzite youngs eastward, towards Eilde Schist. Near eastern junction, close to same deer-stalkers' path as (i), but only one mile north-east of Am Bodach.

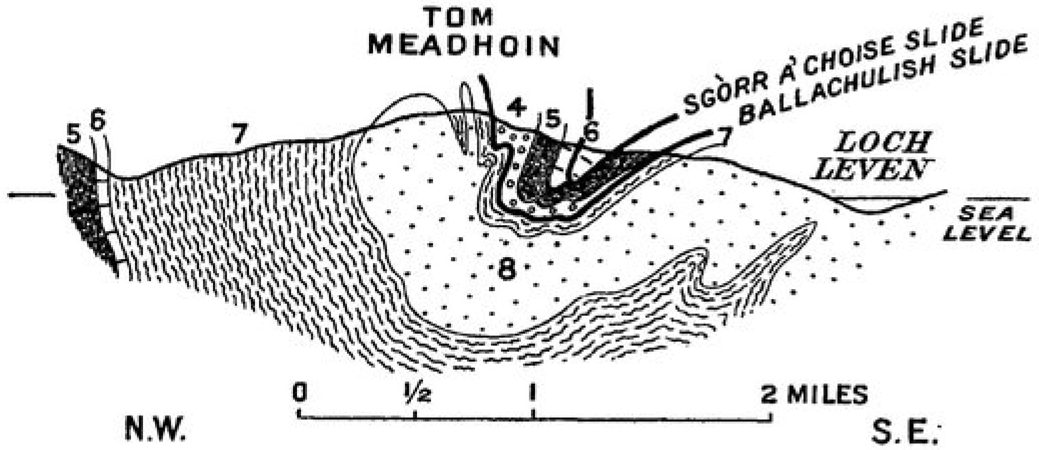

FIG. 9. Section across Fig. 8 showing the relation of the Ballachulish Slide to the Tom Meadhoin Antiform

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

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

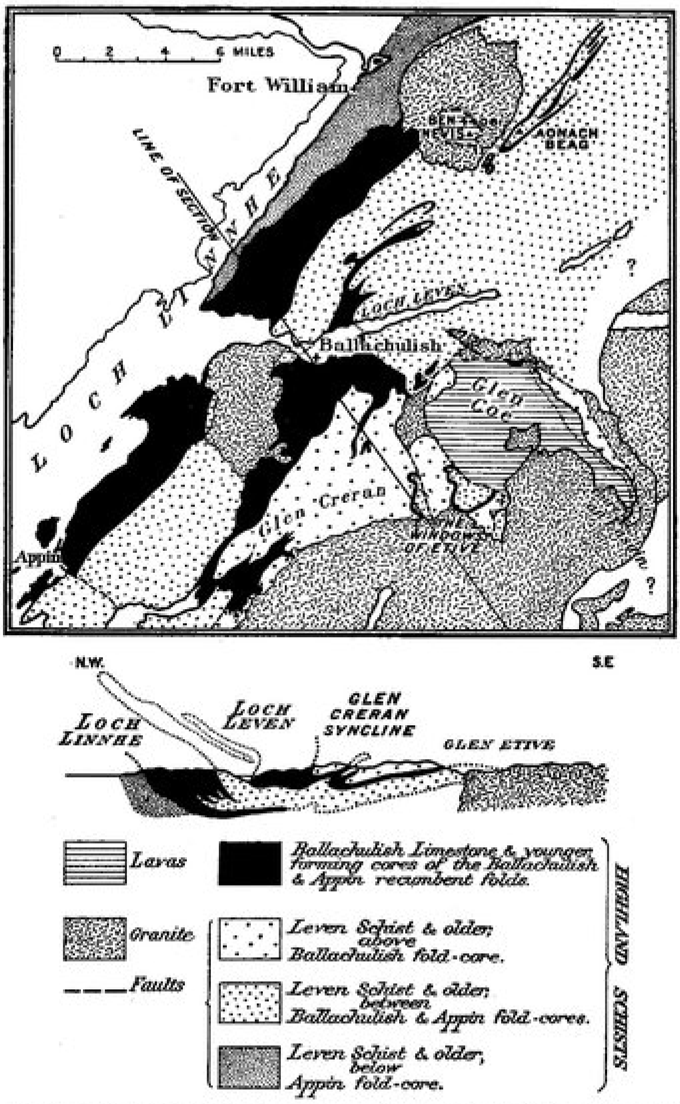

FIG. 17. Map and Section showing the structure of the Highland Schists and the positions of the cauldron-subsidences of Glen Coe and Ben Nevis

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

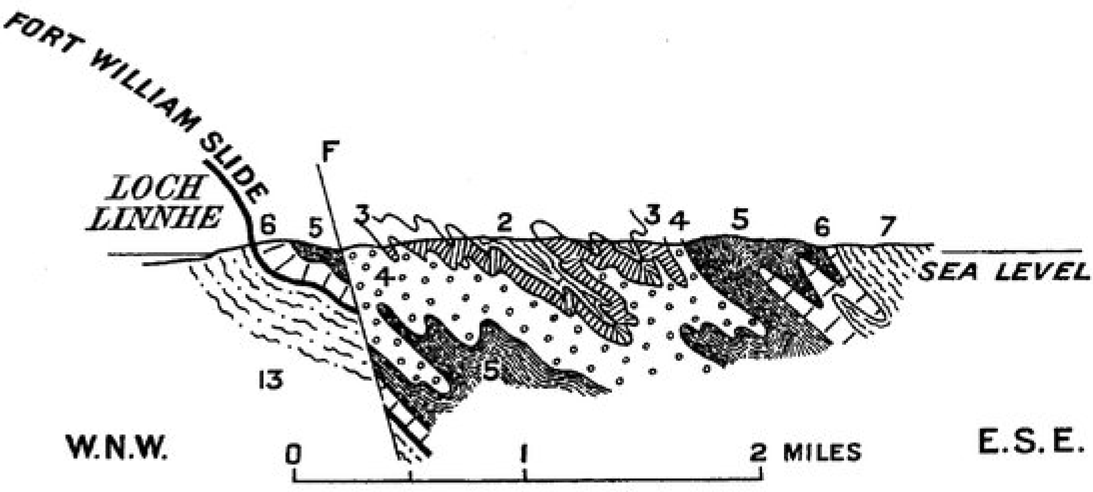

FIG. 2. Section across Appin Fold : Onich shore

2, Appin Phyllites (youngest) ; 3, Appin Limestone ; 4, Appin Quartzite ; 5, Ballachulish Slates ; 6, Ballachulish Limestone ; 7, Leven Schists ; 13, Eilde Flags

(Figure 2) Section across Appin Fold: Onich shore. 2, Appin Phyllites (youngest); 3, Appin Limestone; 4, Appin Quartzite; 5, Ballachulish Slates; 6, Ballachulish Limestone; 7, Leven Schists; 13 Eilde Flags.

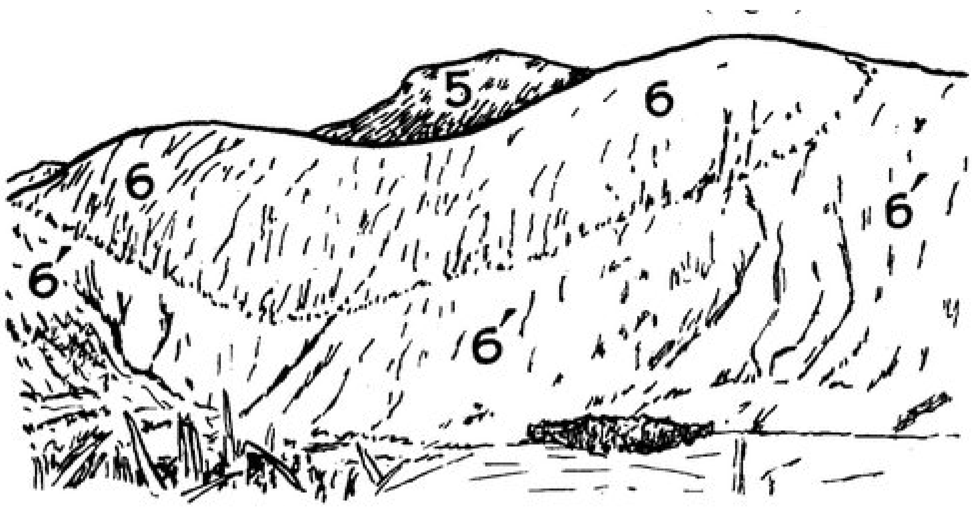

FIG. 3. Sketch of Appin Fold sectioned in S.W. wall of Glen Nevis

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

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

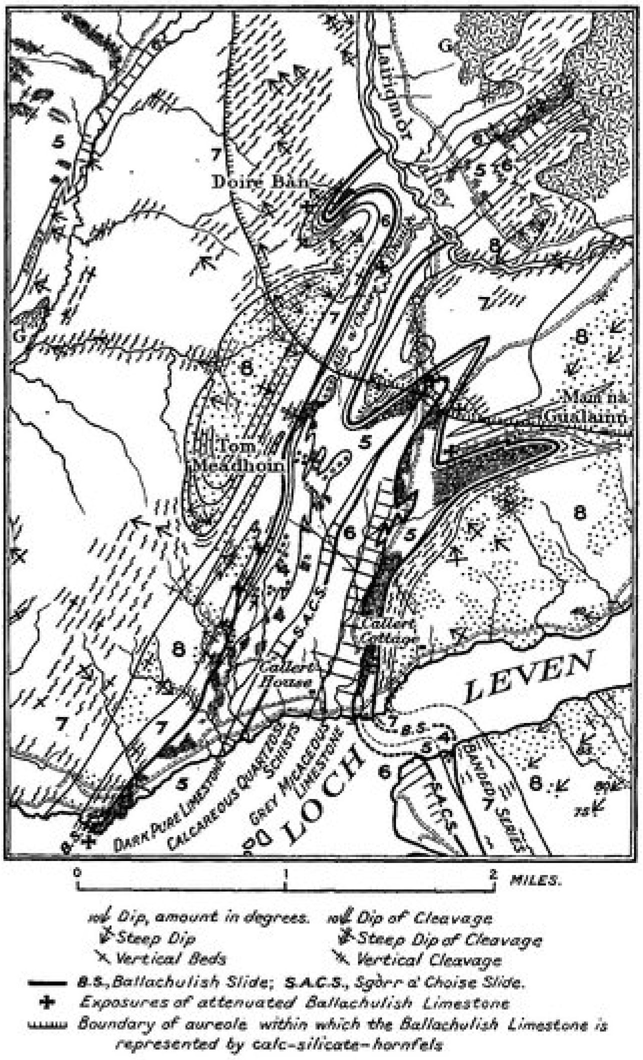

FIG. 8. Map showing outcrops in Callert district

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

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