
6 The Dalradian rocks of the northern Loch Awe district

By G. J. Borradaile

Maps

Ordnance Survey, 1:50,000 sheets 55 and 49.

Geological Survey, one inch to one mile: 36 (Kilmartin), 37 (Inverary), 44 (Mull) and 45 (Oban).

Introduction

In this guide accessible exposures of Middle and Upper Dalradian rocks (now respectively classified as the Argyll and Southern Highland Groups [Harris and Pitcher 1975]) in the northern Loch Awe district are described. The localities have been chosen so as to allow examination of each of the major lithological components of the succession. Furthermore, the outcrops allow the major structures of the region to be detected.

Examination of the localities described requires two days. The best centre on which to base an excursion is Oban although Kilchrenan, Taynuilt and Connel also provide accommodation within the area.

General geology

Within the present area (Figure 2) the outcrop pattern of the Dalradian stratigraphy is controlled by the Loch Awe Syncline, a structure which was first described by Bailey (1913). The most north-easterly part of this structure is shown by the synclinal distribution of stratigraphic units shown in (Figure 2). In detail the Loch Awe Syncline is a compound structure consisting of two synclines and an intervening anticline. These quite tight folds are slightly overturned to the south-east (Borradaile 1973) in contrast with the single broad, open, upright syncline indicated by Bailey. The axial traces of the component folds to the Loch Awe Syncline strike NE–SW and the more prominent syncline is the Kilchrenan Syncline. Its axial trace passes just to the west of Kilchrenan and the syncline appears to continue as the Tayvallich Syncline in the area to the southwest of that indicated in (Figure 2). The Loch Awe-Tayvallich district provides the type areas for parts of the Upper and Middle Dalradian, and the stratigraphic sequence is given in (Table 1).

Our knowledge of the large scale structure of the Dalradian of the South-West Scottish Highlands stems mainly from papers by Bailey (1913, 1917), Shackleton (1958), and Rast (1963). Rast presented the first synthesis of the major Dalradian structures which, with more recently described minor modifications, is sketched in the cross-section (Figure 1). The principal structures are the Islay Nappe, Loch Awe Syncline and Tay Nappe. These are F_1 folds (Borradaile 1973) accompanied by a slaty cleavage (S_1). The latter fold dominates the structure of the Dalradian from Loch Fyne to the Highland Border. These major F_1 folds have NE–SW axial traces and although the component folds of the Loch Awe Syncline do have plunge culminations and depressions, the major F_1 fold hinges are sub-horizontal on a regional scale. The axial planes and axial planar cleavage (S_1) of the major F_1 folds diverge upwards from their upright attitude in the west of the Loch Awe District. This divergence is at least partly attributable to the monoforms which affect the limbs of the Islay and Tay Nappes (Roberts and Treagus 1964; Borradaile 1970). The sequence of other post-primary deformation episodes does not sufficiently affect the regional structure (Figure 1) to warrant discussion here. The structural levels represented at the localities and groups of localities ((Figure 3), (Figure 4) and (Figure 5)), which are referred to below, are indicated in (Figure 1). All the localities provide opportunities for testing the relation of the outcrops to the local and major (Figure 1) structures by the use of cleavage-bedding relationships, vergence of minor folds, way-up criteria and facing. The term 'facing' is here used strictly in the sense of Shackleton (1958) (see Borradaile (1976) for a recent discussion of the use of facing).

Description of localities

The three principal groups of localities are described below in ascending stratigraphic order. Two localities which occur low in the stratigraphic sequence are mentioned at the end of the guide.

Locality 1 [NM 835 135]

Locality 1 (minimum time thirty minutes) occurs on the part of the Loch Melfort foreshore which runs almost north-south (Figure 3). Its accessibility is not affected by the state of the tide and it lies adjacent to a minor road which can be used by a minibus. The locality is best approached through a small clearing in the foreshore wood which has been used as a small caravan site in recent years. This locality provides excellent exposures of the Ardrishaig Phyllite, in which the nonpelitic bands show ripple currentbedding and sole marks.

Tectonic minor structures are also excellently displayed. At the small point at the south end of this exposure a folded metadolerite sill can be examined. The sill has ellipsoidal chloritic patches (deformed vesicles) aligned within the cleavage. A subhorizontal crenulation cleavage can be identified in the pelites in the same outcrop. Small scale F_1 folds are refolded by secondary folds which have this crenulation cleavage as an axial-planar structure.

Although the F_1 profiles are often gently curving or ptygmatic, extreme pressure resolution across the S_1 planes has produced step-like discontinuities in F_1 profiles and a secondary carbonate banding in places. A mineral lineation can often be recognized in the pelites as an alignment of micaceous minerals, deformed pyrite or mimetic pyritous overgrowths on the S_1 cleavage surfaces.

If further time is available the minor structures in the exposures adjacent to Melfort Pier [NM 832 141] should be examined. Amongst other structures pre- F_1 boudins can be seen there.

Locality 2 [NM 852 137]

Locality 2 (minimum time one hour) can be reached by leaving vehicles in the lay-by in a small quarry on the east side of the A 85 near the south end of Loch nan Druimnean (Figure 3). Walking east a series of metadolerite sills is crossed. These sills represent feeders to the lavas of the Tayvallich Lavas, and between them small outcrops of Ardrishaig Phyllites can be examined en route. Some of these outcrops show ripple current-bedding, and facing on the slaty cleavage is upwards to the west. Locality 2 exposes the Shira Limestone in two old lime quarries on a gentle slope north of the burn flowing out from Loch Phearsain. The limestone is black, sandy and brecciated and, in the upper quarry, shows current-bedded units. Although the Shira Limestone is often thin (5–10 m) it is a persistent marker horizon just above the Ardrishaig Phyllite. If further time is allowed the Crinan Grit quartzites can be examined in the crags east of Loch Phearsain. The best approach from Locality 2 is around the south end of the loch, crossing the burn which flows out of the loch near the outlet, and then following the footpath around the south shore.

Localities 3 to 7

These localities (see (Figure 4)) are accessible by coaches coming south towards Kilchrenan from the main Oban-Dalmally road (A85) on the shore of Loch Etive. The road (B845) south to Kilchrenan provides an awkward exit from the A85 unless the approach is made from the Oban direction. If the initial approach is from the east long vehicles should proceed to the village of Taynuilt to the west of the Kilchrenan turn-off and there turn around allowing an approach from the west. Localities 4 to 7 require a minimum time-allocation of two-and-a-half hours.

Locality 3 [NN 044 255]

(Minimum time forty-five minutes) This locality exposes graded quartzites of the Crinan Grits, the lithostratigraphic unit which underlies the Tayvallich Slates and Limestones. The exposure occurs on the north-eastern shore of Loch Tromlee and the best route from the B845 is to approach the northern end of the loch from the west, along the foot of the wooded slopes.

Locality 4 [NN 036 247]

This locality is on the west side of the B845 just to the south of a lay-by, and to the north of, and in sight of, the quarry buildings. It provides exposures of Tayvallich Limestone. The exposures occur against a small knoll, and exhibit excellent slump-breccia and pebbly varieties of the black limestone. There is also an exposure of the pebbly lenticular quartzites which occasionally occur within the Tayvallich Slates and Limestones.

Locality 5 [NN 038 244]

The exposures comprising this locality begin just south of the quarry which was worked in the Tayvallich Limestone (parking space is available by the quarry buildings). This locality is the small group of exposures and quarries which occur on the west side of the B845. There the Tayvallich Limestone is the thinly bedded slaty variety or the pebbly variety. The quartz pebbles in the limestone have been more resistant to deformation than the black limestone and cone-like strain shadows around the pebbles have been infilled with white carbonate. These elongate strain shadow structures indicate the direction of maximum extension within the St cleavage.

A quartzite crops out above the limestone and their contact may be traced parallel to the road. At the southern end of this locality, near the track leading to Achnacraobh and near the foot of an electricity pylon, well developed angular secondary folds may be examined in a quarried exposure of Tayvallich Limestone.

Locality 6 [NN 032 239]

This locality can be approached along the track which rises to the west from the B845. Beyond the end of the track at Achnacraobh croft, Tayvallich Limestone and Slate are exposed in the burn. The quartz pebbles in the limestone are graded, and the limestones show ripple current-bedding. These sedimentation structures show that the beds are overturned but consideration of the orientation of S_1 indicates that the facing is upwards to the south-south-east.

Locality 7 [NN 032 236]

Locality 7 exposes some of the lithologies which occur within the uppermost Tayvallich Slates and Limestones. The Kilchrenan Grit is exposed in the low crags on the north side of a small burn, and is a poorly graded feldspathic grit containing black mudstone fragments. Black Tayvallich Slates are exposed in the burn and to the south-west, near an electricity pylon, the Kilchrenan Boulder Bed crops out. The boulder bed is a slumped deposit of rounded quartzite pebbles and boulders in a black slate matrix which occurs just below the base of the Tayvallich Lavas. If further time is allowed better exposures of the boulder bed can be examined at a point [NN 034 228] in the burn west of Kilchrenan or on the shore [NN 034 215] of Loch Awe near the Old Manse. This excursion could also be extended by examining the Tayvallich Volcanic rocks which are exposed adjacent to the minor road leading to Dalavich, by Fernoch [NN 013 198] and in the quarry at [NN 006 188].

Localities 8 to 10

These localities (see (Figure 5)) are accessible by minibus from Kilmelford or Kilchrenan and require a minimum time allocation of one hour. Vehicles may be parked in the lay-by on the north side of the road at the north-eastern end of Loch Avich.

Locality 8 [NM 952 156]

This locality, at the roadside, exposes slightly calcareous black slates at the top of the Loch Avich Grit sequence. Bedding, slaty cleavage and a crenulation cleavage can be recognized in this lithology.

Locality 9 [NM 954 158]

Locality 9 is reached by walking 200 m uphill to the NE. through a small natural wood. Here cleaved basic lavas of the Loch Avich Volcanic sequence outcrop. Some outcrops show pillow structure, with vesicular zones within the pillows and secondary epidote rims around their outer margins. Near the deer fence the pillow shapes indicate way-up.

Locality 10 [NM 954 165]

Locality 10 occurs near the junction of two burns to the North of locality 9. There the more usual Loch Avich Grit lithologies are exposed; graded feldspathic grits and green or green-gray slate. If further time is allowed the epiclastic volcanic rocks which belong to the top of the Tayvallich Volcanic sequence can be examined at a point [NM 954 168] higher up the main burn.

Localities 11 and 12

These are en route localities, one or both of which will be passed by any party visiting the area described in this guide. Both localities are coastal but their accessibility is barely affected by the state of the tides.

Locality 11 [NM 850 298]

(Minimum time half-an-hour). From the centre of Oban this locality is reached by going SW down Albany Street (signposted to Gallanach) from the traffic island near the railway terminus. This road crosses over the railway at the end of Albany Street and curves to the right to pass the South Pier and become the Gallanach Road, a promenade along the Sound of Kerrera.

Black slates and limestones of the Late Precambrian (Downie et al 1971) Easdale Slate Group are exposed along much of this foreshore, showing several cleavages and occasionally small sedimentation structures such as load-casts and grading in siltstone units. Features of particular interest are: slump-folded fine sandstones by the wall at the N. end of Gallanach Park; an outcrop-size refolded fold immediately adjacent to the SW corner of the Oban Sailing Club building (at the SW end of Gallanach Park); graded silty limestones 10 m south of Oban Sailing Club building; and, 150 m SW of the Sailing Club building there are excellently exposed load-casts in siltstones which outcrop beneath a massive loose block of Old Red Sandstone conglomerate on a pebbly beach.

Locality 12 [NN 115 088]

(Minimum time ten minutes) occurs immediately adjacent to a fenced and tarmacadam-surfaced lay-by which is on the south side of the A83 one third of a mile to the east of Strone Point (Figure 2). The lay-by is approximately three miles from Inverary, which is to the west, and approximately two miles west from Dundarave Castle.

In the vicinity of the lay-by, on the foreshore on the South side of the road, tight and isoclinically folded Ardrishaig Phyllites are exposed. The comparison in F_1 fold style in the same lithologies at Loch Melfort (Locality 1) qualitatively illustrates the contrast in the degree of deformation across the Loch Awe Syncline. Several large F_1 fold pairs show a sense of vergence consistent with their being on the lower limb of the recumbent Tay Nappe.

The considerable plunge variation shown by the early minor folds in these outcrops has been discussed by Borradaile (1972). A consistently oriented mineral lineation can be observed on the cleavage surfaces at this locality.

References

- BAILEY, E. B. 1913. The Loch Awe Syncline. *Q. J. geol. Soc. Lond.* 69, 280–305. , 1917. The Islay Anticline. *Q. J. geol. Soc. Lond.* 72, 132–59.
- BORRADAILE, G.J. 1970. The west limb of the Loch Awe Syncline and the associated cleavage fan. *Geol. Mag.* 107, 459–67.
- BORRADAILE, G.J. 1972. Variably oriented co-planar primary folds. *Geol. Mag.* 109, 89–98. *Trans. R. Soc. Edinb.* 69, 1–21.
- BORRADAILE, G.J. 1973. *Dalradian Structure and Stratigraphy of the Northern Loch Awe District, Argyllshire.*

BORRADAILE, G.J. 1977. "Structural facing" (Shackleton's rule) and the Palaeozoic rocks of the Malaguide Complex near Velez Rubio, SE. Spain. *K. Nederl. Akad. Wet. Proc.* 79B, 330–336.

DOWNIE, C, LISTER, T.R., HARRIS, A.L. and FETTES, D.J. 1971. A palynological investigation of the Dalradian rocks of Scotland. *Rep. No. 71/9. Inst. geol. Sci.* 30 pp.

HARRIS, A.L. and PITCHER, W.S. 1975. The Dalradian Supergroup. In Harris, A. L. et al. (eds), A correlation of the Precambrian rocks of the British Isles *Spec. Rep. no. 6, Geol. Soc. Lond.*

RAST, N. 1963. Structure and Metamorphism of the Dalradian rocks of Scotland. In Johnson, M. R. W. and Stewart, F. H. (eds), *The British Caledonides* Edinburgh. Oliver and Boyd.

ROBERTS, J.L. and TREAGUS, J.E. 1964. A Re-interpretation of the Ben Lui Fold. *Geol. Mag.* 101, 512–16.

SHACKLETON, R.M. 1958. Downward-facing structures of the Highland Border. *Q. Jl geol. Soc. Lond.* 113, 361–92.

Figures and tables

(Table 1) Stratigraphic sequence for the northern Loch Awe District after Borradaile (1973). + = Lower Cambrian, ++ = Late Precambrian, from the micropalaeontological evidence of Downie et al. (1971).

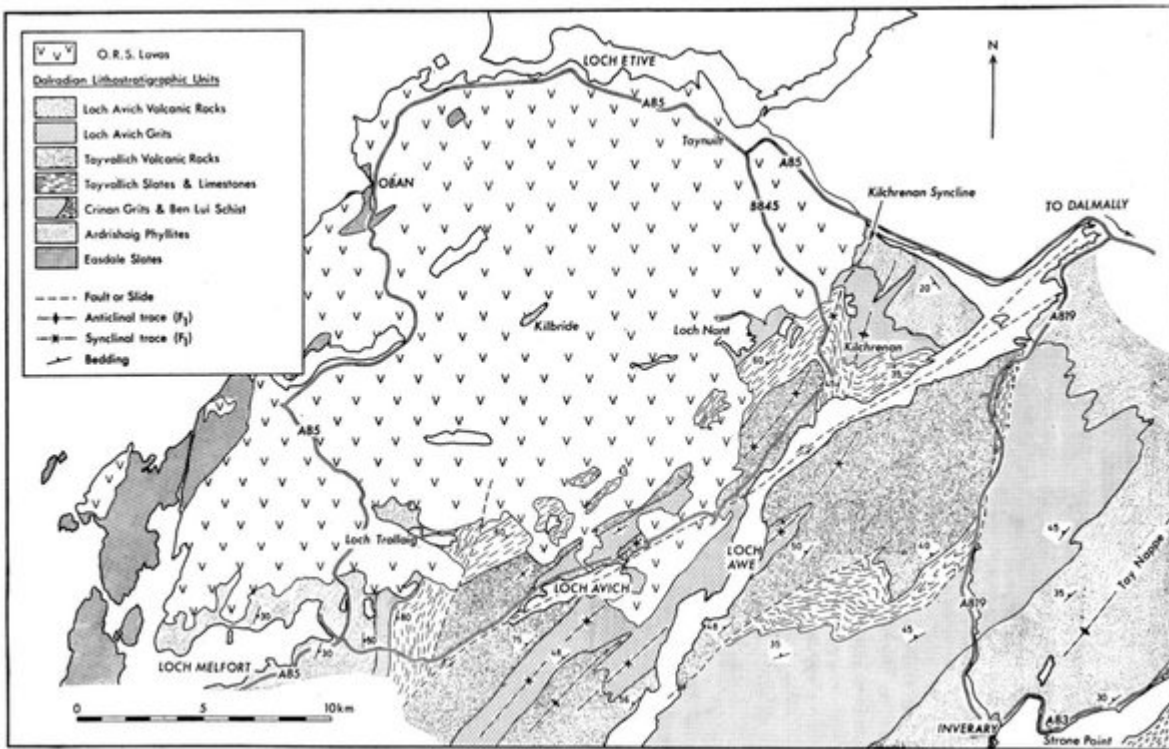
(Figure 1) Diagrammatic cross-section of the major structures of the Illtay Nappe Complex on which are indicated the approximate structural positions of the localities described in this guide. The stippled regions in this cross-section correspond to the areas illustrated by geological maps in (Figure 3) (Kilmelford), (Figure 4) (Kilchrenan) and (Figure 5) (Loch Avich). The localities at Oban and Strone Point are, respectively, localities 11 and 12.

(Figure 2) Distribution of the principal lithologies of the Dalradian rocks in the Northern Loch Awe District (after Borradaile, 1973). N.B. The maximum number of passengers that may be carried in one vehicle on certain roads is, as follows: (a) the road along the north shore of Loch Melfort: 15 persons. (b) The road from Loch Melfort to Loch Awe passing Loch Avich: 15 persons. (c) The road along the West shore of Loch Awe, south from Kilchrenan: 21 persons. No restrictions exist for the other roads illustrated.

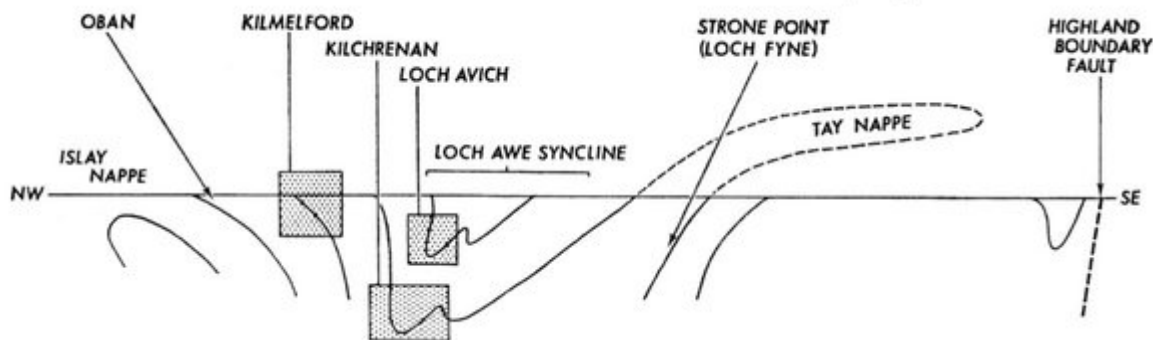
(Figure 3) Geological map of the Kilmelford district with localities 1 and 2 indicated. Areas in which the Dalradian rocks are less well exposed have been left unornamented and outcrops of posttectonic igneous intrusions have been omitted.

(Figure 4) Geological map of the Kilchrenan district with localities 3, 4, 5, 6 and 7 indicated. Areas in which the Dalradian rocks are poorly exposed have been left unornamented and outcrops of many minor post-tectonic igneous intrusions have been omitted.

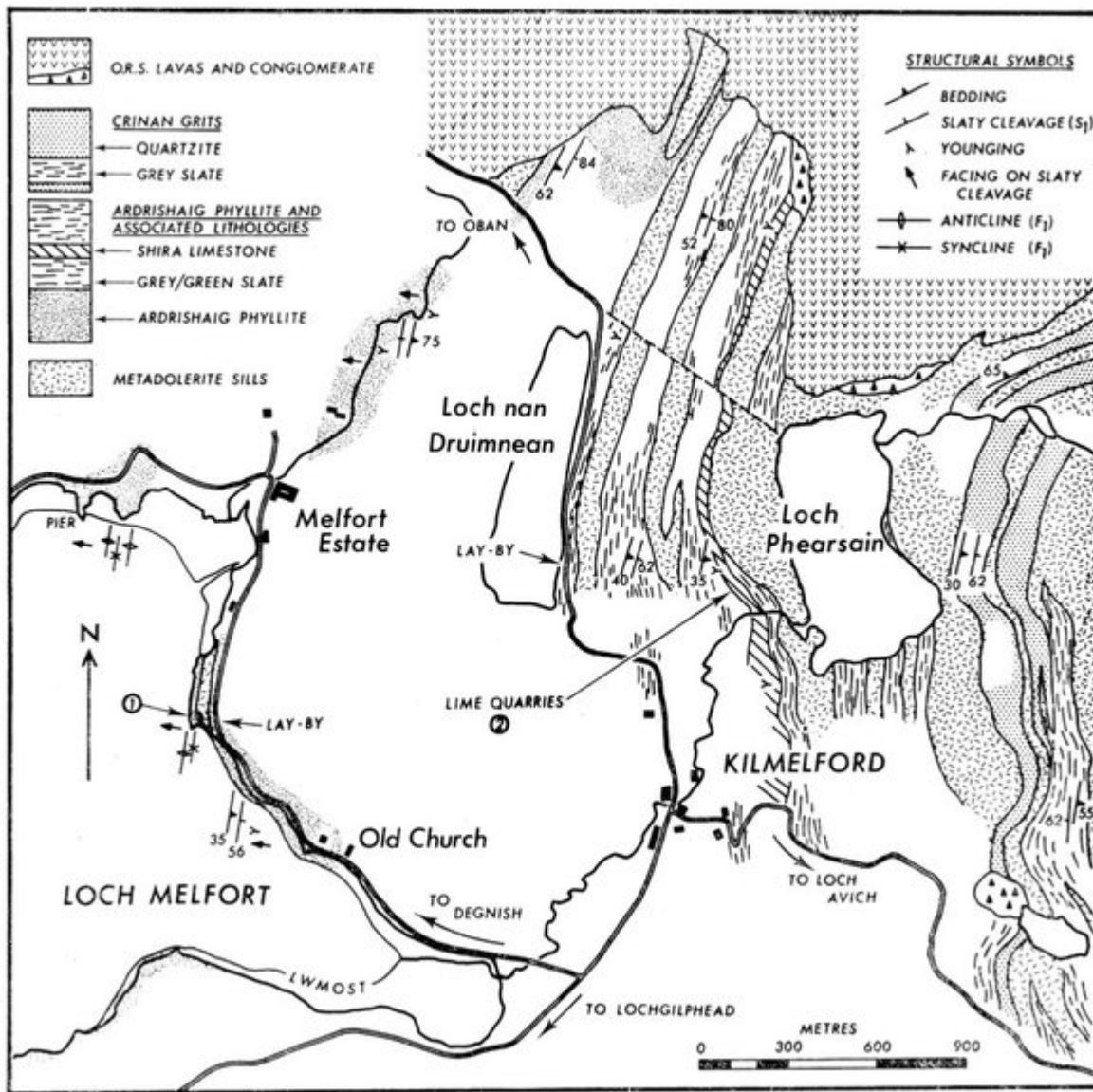
(Figure 5) Geological map of the ground to the North-East of Loch Avich with localities 8, 9 and 10 indicated. Areas in which the Dalradian rocks are poorly exposed have been left unornamented and outcrops of minor post-tectonic igneous intrusions have been omitted.



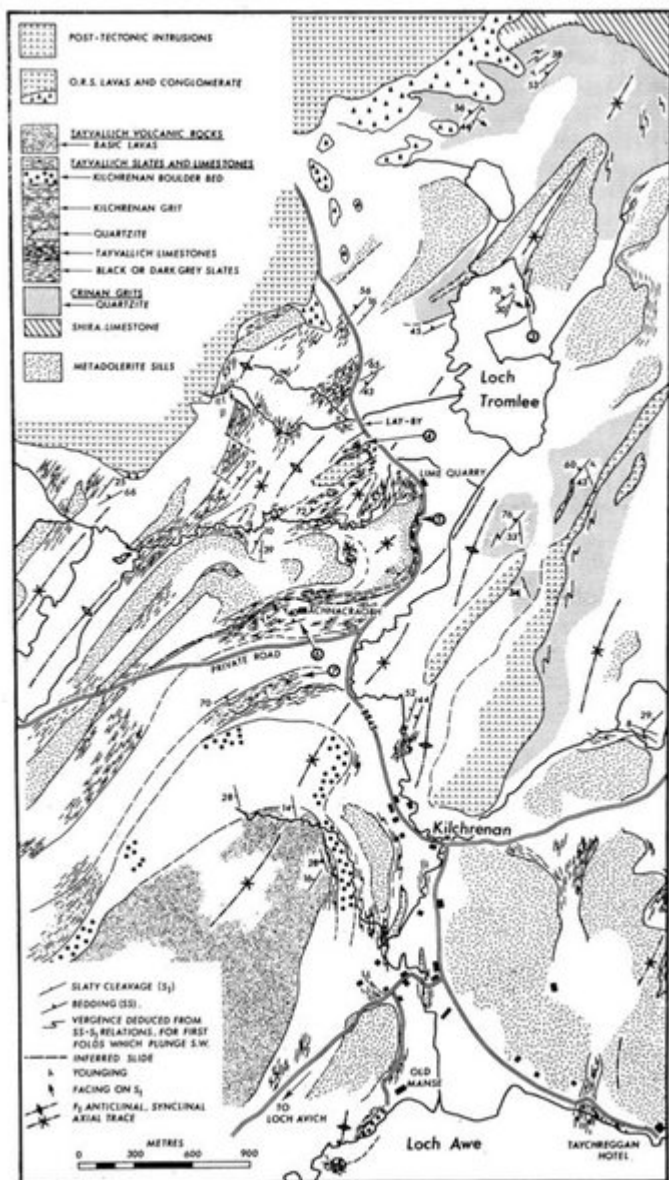
(Figure 2) Distribution of the principal lithologies of the Dalradian rocks in the Northern Loch Awe District (after Borradaile, 1973).



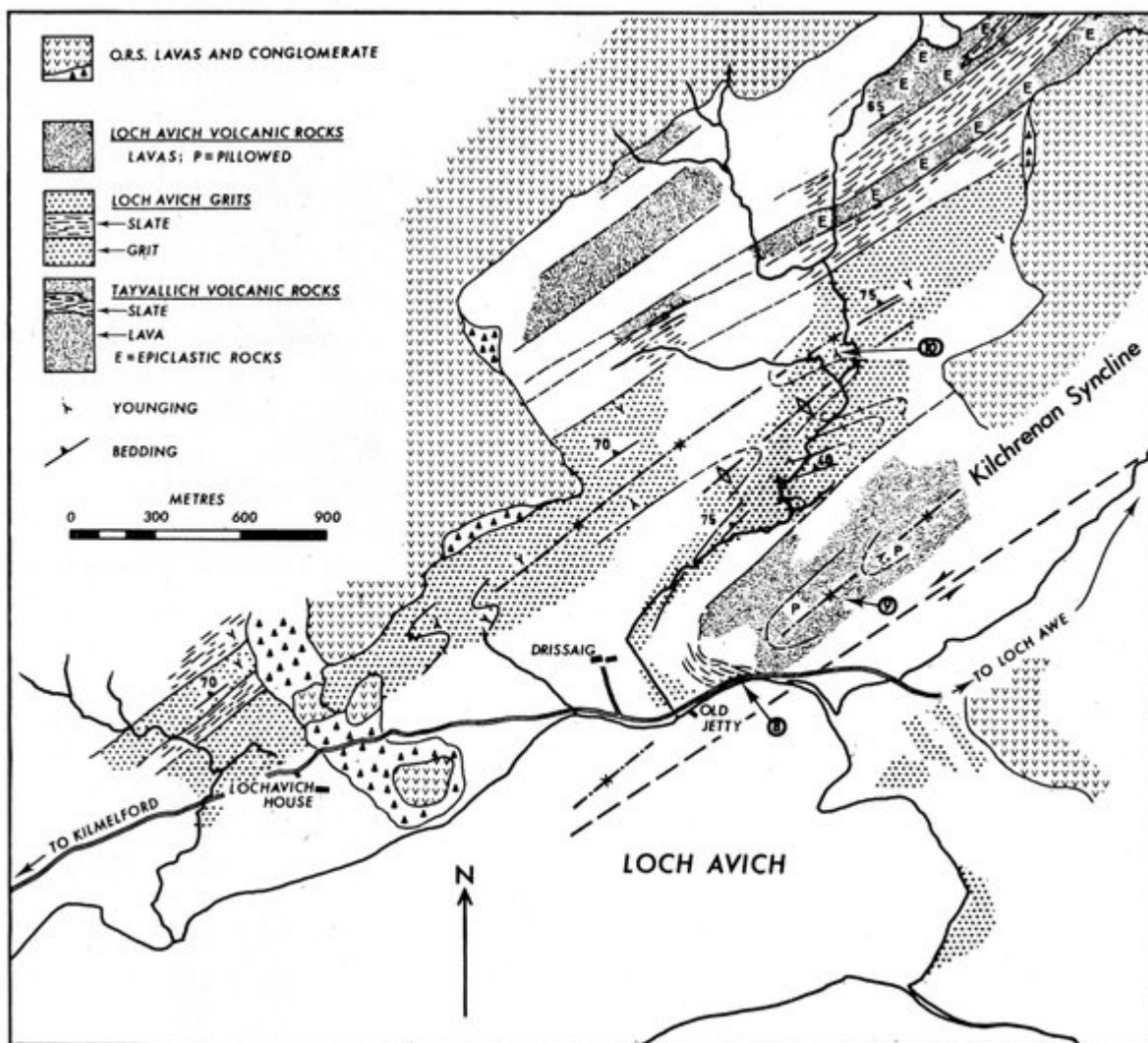
(Figure 1) Diagrammatic cross-section of the major structures of the Illay Nappe Complex on which are indicated the approximate structural positions of the localities described in this guide. The stippled regions in this cross-section correspond to the areas illustrated by geological maps (Kilmelford), 4 (Kilchrenan) and 5 (Loch Avich). The localities at Oban and Strone Point are, respectively, localities 11 and 12.



(Figure 3) Geological map of the Kilmelford district with localities 1 and 2 indicated. Areas in which the Dalradian rocks are less well exposed have been left unornamented and outcrops of post tectonic igneous intrusions have been omitted.



(Figure 4) Geological map of the Kilchrenan district with localities 3, 4, 5, 6 and 7 indicated. Areas in which the Dalradian rocks are poorly exposed have been left unornamented and outcrops of many minor post-tectonic igneous intrusions have been omitted.



(Figure 5) Geological map of the ground to the North-East of Loch Avich with localities 8, 9 and 10 indicated. Areas in which the Dalradian rocks are poorly exposed have been left unornamented and outcrops of minor post-tectonic igneous intrusions have been omitted.

Lithostratigraphic units		Principal lithologies	Observed thicknesses (km)
UPPER DALRADIAN (Southern Highland Group)	Loch Avich Volcanic Rocks	Basic pillow lavas.	0.3–0.5
	Loch Avich Grits	Graded felspathic grits with green and black slates.	0.65–1.1
	Tayvallich Volcanic Rocks	Basic lavas, some pillowed. Epilastic volcanic material.	2.0
	+Tayvallich Slates and Limestones	Black slates and black limestones (slumped and graded in places).	1.0–1.2
	Crinan Grits	Quartzites, graded in places.	0.1–3.0
MIDDLE DALRADIAN (Argyll Group)	Ardrihaig Phyllites and associated lithologies	Black sandy Shira Limestone and grey slates at top. 'Phyllites' are well bedded sandy limestones and fine-grained quartzites interbedded with green-grey pelite. Degnish Limestone at base.	4.0–4.5
	++Easdale Slates	Black slates with black limestones and silty horizons.	

(Table 1) Stratigraphic sequence for the northern Loch Awe District after Borradaile (1973). + = Lower Cambrian, ++ = Late Precambrian, from the micropalaeontological evidence of Downie et al. (1971).