3 The Dalradian rocks of the west coast of the Tayvallich peninsula

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Maps

Ordnance Survey, 1:50,000 sheet 55.

Geological Survey, one inch to one mile: 28 Jura.

Introduction

The west coast of the Tayvallich Peninsula provides a continuously exposed section through the Crinan Grit, Tayvallich Limestone and Tayvallich Lava formations, and therefore straddles the boundary between the Middle and Upper Dalradian (Rast 1963), and possibly the base of the Cambrian (Downie *et al*. 1971).

The section is reached by following the road southwards from Tayvallich Village and taking the right fork signposted KIELS. Follow this road for five miles to Kiels House (Figure 1) where there is a gate across the road [NR 696 806] and park on the grass verge. The road and turning places are inadequate for coaches. The geological traverse to be followed from this locality is approximately six miles and the return walk (along the road) four miles. By parking a vehicle at Tighavullin [NR 729 853] (Figure 1) on the way to Kiels House from Tayvallich the return walk can be avoided.

General geology

The peninsula was mapped by Peach for the Geological Survey (Peach *et al.* 1911). By discovering pillow lavas in Tayvallich, Peach established the existence of extrusive basic rocks in the Dalradian of the South-West Highlands, and also by observing pipe amygdales and using flow morphology, established the stratigraphic sequence of the area, *i.e.* that the Crinan Grit is the oldest formation exposed on the peninsula. The rocks of the area are folded into a syncline (Tayvallich Syncline) whose hinge plunges 200–500 SSW. Associated with the axial plane of this structure there is a strong slaty cleavage. Subsequent episodes of deformation have locally overprinted this cleavage with a crenulation cleavage which is locally strongly developed in bands of carbonaceous pelite. A detailed map of the northern part of the area has recently been published by Wilson and Leake (1972).

The excursion starts on the eastern limb of the syncline, where the Tayvallich Limestone and Kells Grit are examined, before crossing to the western limb to study the Tayvallich Lavas on the west coast. Northwards along this coast, successively older members of the lava formation are encountered, then the *Tayvallich Limestone* and finally Crinan Grit. From the coast the excursion follows the outcrop of Tayvallich Limestone inland around the closure of the Tayvallich Syncline and finishes at the road near Tighavullin.

Description of localities

Locality 1 [NR 697 805]

From the parking place, walk down to the shore by the jetty and examine exposures along the high-water line. The rock here is an agglomerate composed of pillow and vesicular lava fragments in a limestone matrix. Some of the lava fragments contain parallel, arcuate vesicle trails, having once formed part of a pillow. Possibly this agglomerate was produced by broken pillow fragments slumping off a lava flow and mixing with underlying unconsolidated sediment as it was disturbed at the leading edge of the flow.

The fragments are all flattened in the main cleavage and the principal strain directions of the deformation which produced the Tayvallich Syncline and its cleavage can be determined by measuring the orientation of the deformed fragments.

Locality 2 [NR 696 806]

From the jetty walk 50 m westwards along the road and turn right up the drive to Kiels House. Immediately on the right of the drive, across a small burn, vertically dipping beds of arkosic sandstone are exposed. These are the youngest rocks of the area and lie on the south-east limb of the Tayvallich Syncline, above the Tayvallich Limestone and Lava formations. Mineralogically they are distinct from Crinan Grit in that they contain detrital epidote and more feldspar and mica. The name Kells Grit (Gower 1973) has been proposed for these previously unrecorded sandstones and they have been correlated with Loch Avich Grit (Borradaile 1973) further north-east.

Locality 3: Loch na Cille Boulder Bed [NR 688 803]

Walk westwards along the main road to the northern end of Rudha na Cille [NR 688 803] (Figure 1) and examine the rocks exposed on the peninsula as far south as 200 m south of the point where the submarine power cable from Jura comes ashore. The Loch na Cille Boulder Bed crops out down the centre of the peninsula. pillow lavas lie stratigraphically below the boulder bed and are exposed on the west coast. Limestone charged with fragments of epidiorite rests with a sharp contact on top of the boulder bed and crops out along the east coast. All the beds dip uninverted east-southeast at approximately 80°.

The Loch na Cille Boulder Bed was initially described in Peach *et al.* (1911, p. 71) as follows: "An extraordinary conglomerate has been traced along the west shore of Loch na Cille, and is well exposed at the roadside to the north. It is extremely full of fragments of slaggy epidiorite, but also contains numerous pebbles of white felsite and syenite rather sporadically distributed."

With reference to the matrix, he says: " ... it contains crystals of feldspar and strongly resembles a decomposed, sheared, porphyritic epidiorite full of carbonates."

The Geological Survey offered two possibilities for the origin of this conglomerate, either as a result of tectonic crushing, or from a conglomeratic mud-flow. A glacial origin for the boulder bed was later proposed by Elles (1935), whilst Allison (1941) claimed that the acidic boulders are xenoliths in a porphyritic lava flow.

Silvestri (1963) has proposed a genetic classification ofhyaloclastites based on studies in Sicily and his descriptions are relevant to the genesis of the various lithologies of the Tayvallich Lava formation including the Loch na Cille Boulder Bed. He describes (*op. cit.,* p. 316) the formation of "initial hyaloclastite breccias" from a submarine fissure eruption and the Loch na Cille Boulder Bed may have been formed by this process.

All the boulders in the boulder bed are highly altered and epidotized. From a study of tubular" coralline" structures which occur in the vicinity of the submarine power cable marker post, Borradaile, Roberts and Scrutton (1971) have suggested that some epidotization may be related to the formation of the boulder bed.

Locality 4

Continue north-westwards along the road, past the derelict houses at Keillmore to the jetty [NR 688 807] (Figure 1). Examine the rocks exposed along the coast between the jetty and [NR 69 3817]. Here the coastline is parallel to strike and it is possible to study lateral variations in pillow lavas and associated hyaloclastite breccias and tuffs. The following volcanic types may be recognized in this section, nomenclature after Silvestri (1963):

1. Initial hyaloclastite breccia, formed immediately after the opening of the fissure.
2. Massive, structureless lava.
3. Pillow lava, composed of whole pillows in contact with each other.
4. pillow breccia, lying immediately above the flow and formed from the breakdown of pillows during palagonization.
5. Common hyaloclastite, constituted exclusively of glassy fragments, formed from further degradation of pillow breccia.
6. Stratified hyaloclastite, found *in situ* at the top of formations and along their margins. Graded bedding is a common bed-form.

7. Reworked hyaloclastite, is well bedded and often mingled with sedimentary materials. It may occur far from the locus of eruption.

This sequence of volcanics is ideal and is not fully developed with each extrusion. Laterally, parallel to the direction of the lava flow a similar sequence develops and can be used to determine the direction of dip of the slope on which the lava was extruded (Figure 2). Within this sequence of rocks is a bed of "porphyry breccia" (Peach *et al.* 1911) which is 8 m thick, thinning northwards and which is exposed in the ancient cliffs at the back of the raised beach · [NR 690 813]. It is composed of boulders up to 60 cm in diameter of pink feldspar porphyry in a tuffaceous epidiorite matrix. This bed is probably an initial hyaloclastite breccia, composed of fragments from the wall of a fissure which has penetrated a sub-volcanic intrusion of porphyry (see Locality 5). Attention is also drawn in this section to excellent pillows [NR 693 817]. The lava from which these pillows were formed was porphyritic and phenocrysts of feldspar have settled to the lower portions of some pillows. Other features to note about these pillows are:

- Concentric zoning.
- Chilled margins.
- Their shape relative to their immediate neighbours.

Locality 5 [NR 695 822]

At this locality an intrusion of pink feldspar porphyry is exposed between tide levels (Figure 1). Flett (*in* Peach *et al.* 1911, pp. 94–95) has described the detailed mineralogy of this porphyry and published a chemical analysis. The large feldspar crystals are chessboard albite which occur in a matrix of quartz, muscovite, epidote, chlorite and calcite. 'Attention is drawn by Flett to the unusually high sodium content of the porphyry (6.8%) and low potassium (0.3 %). Rocks of this composition occurring in association with pillow lava are termed "quartz-keratophyres" (Hatch, Wells and Wells 1961). A poorly developed mineral banding of more mafic and felsic layers is present in parts of the intrusion, parallel to its upper contact. This contact is concordant with bedding in the overlying tuffs and local traces of chilling are present along it.

Locality 6 [NR 695 822] to [NR 703 833]

Further examples of pillow lava and hyaloclastite occur northwards along the coast between Locality 5 and [NR 703 833]. Good exposures of stratified hyaloclastite with graded beds occur along this traverse for a distance of approximately one kilometre south from [NR 703 833]. The beds vary in thickness from 1–60 cm and constituent tuff particles from 0.05–2.00 cm. Grading fines upwards, reversed grading being very rare. Certain beds fme from the centre upwards and downwards. Graded hyaloc1astite probably formed from a cloud of tuff which was swept upwards into the overlying water by convection currents above a hot lava surface. The marked lack of cross-lamination in these beds suggests that the particles settled from suspension in water unaffected by lateral bottom currents and that they were not therefore deposited from a turbidity current.

Locality 7: An Aird [NR 704 838]

From the northern end of the traverse in the previous section, walk westwards across the small bay to the peninsula of An Aird. The peninsula is composed of a laccolith intrusion of epidiorite. pillow lavas occur on the west coast of An Aird and are gradually replaced northwards by pillow breccia and hyaloclastite. The laccolith may have been a magma chamber which fed the pillow lavas of the west coast of An Aird peninsula. The An Aird locality has been designated a Site of Special Scientific Interest.

Locality 8: Port an Sgadain [NR 707 846] and Port nan Clach Cruinn [NR 709 848]

At these two localities it is possible to examine the base of the Tayvallich Lava formation and also the underlying Tayvallich Limestone. The lava flows here are characterized by pipe amygdales at their base and by a scoriaceous top, often with rusty coloured limestone veins penetrating between the blocks of lava. Peach (1911, figure 4) used these particular exposures of lava to demonstrate that the succession here dips uninverted south-south-eastwards.

The lowermost lava flow rests on calcareous phyllite which in places was deformed by forward movement of the lava flow at the time of eruption. Wood (1964) has described push folds and load structures of this horizon at Port nan Clach Cruinn, and from their orientation has deduced that the lava flowed northwards. As it advanced the toe of the flow pushed forwards and downwards into underlying soft sediment producing push folds. On stagnation, bulbous masses at the base of the lava loaded downwards into the sediment, in places becoming completely detached to form balls of lava surrounded by sediment.

Beneath the lava, Tayvillich Limestone (35 m) is exposed in a section which extends northwards from 200 m along the coast from Port nan Clach Cruinn. Details of the beds exposed within this section are given in (Figure 3). The sequence consists of a series of conglomeratic and graded, turbidite limestones.

Locality 9: Port Bealach nan Gall [NR 712 852]

From the lowest beds of limestone at the northern end of the section described in (Figure 3), cross westwards on to the small promontory formed by a sill of epidiorite intruded into Crinan Grit and then follow the high water mark northwards for a further three hundred metres to where graded beds of coarse sandstones crop out. These beds occur at the top of the Crinan Grit, which here is very coarse grained and locally conglomeratic. Excellent examples of flute casts are present at this locality and can be examined on the overhanging under-surfaces of beds.

Also at this locality in a more pelitic bed at the high water mark, occur large (2 m diameter) rusty weathering carbonate nodules (?siderite).

The excursion moves eastwards from Locality 9 to the scarp formed by the basal lava flow as its outcrop extends inland from Locality 8 and follows this scarp around the northern flanks of Barr na h-Iolaire. The limestone beneath the lava is mainly obscured by grass-covered scree debris. However, it is possible to follow the base of the lava round the minor folds associated with the closure of the Tayvallich Syncline and to determine their orientation.

From the north-east end of Barr na h-Iolaire walk south-eastwards to meet the road in the vicinity of Tighavullin.

The geology of the latter part of this excursion is well illustrated by the geological map published by Wilson and Leake (1972).

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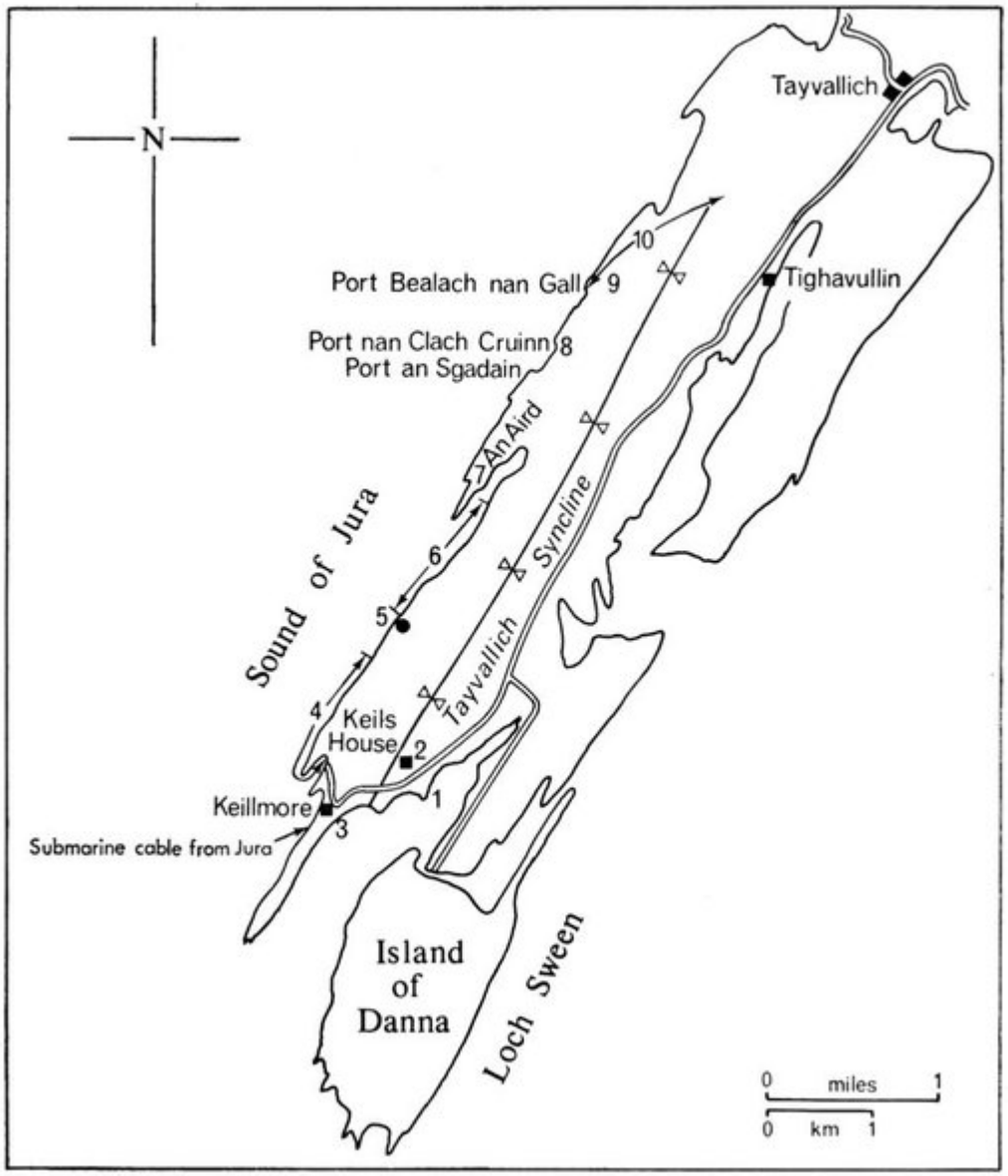
Figures

(Figure 1) Guide to the localities described in the text.

(Figure 2) Vertical and lateral variations in a basic submarine lava flow.

(Figure 3). Stratigraphic column at Port nan Clach Cruinn. Key

1. Vesicular lava with basal pipe amygdales. Load structures cause sediment to be squeezed upwards into lava. Toes of lava project downwards and northwards into the sediment causing minor fold disturbances.
2. Interbedded cream limestone (1–3 cm) and cream calcareous phyllite (0.5–1 cm).
3. Channel filled by limestone containing boulders of grey limestone in a matrix charged with angular fragments of quartz. Whole unit is cross-bedded, indicating derivation from south.
4. Pure grey limestone with beds 1–10 cm thick.
5. Parallel laminated(0.5–1 cm) limestone.
6. Graded limestone with fragments of quartz (1–1.5 cm) and black calcareous slate. Channelled base trending 110°. Intruded from below by a sedimentary dyke of 7.
7. Laminated (0.2–2 cm) limestone with sand-sized quartz fragments.
8. Conglomerate with boulders of dark grey limestone.
9. As 7.
10. Conglomerate of rusty weathering black limestone with largest fragments measuring 100 × 50 cm.
11. As 7.
12. Grey limestone with fragments (0.5–1 cm) of malachite and quartz.
13. As 7 with ripple marked base.
14. Massive limestone with quartz (0.5–1.5 cm) and black slaty limestone (1–3 cm) fragments. Flute casts at base indicate current from south-east.
15. Conglomerate with fragments up to 50 of rusty weathering black limestone, 1–1.5 cm of quartz and saccharoidal quartzite and 0.5 cm of malachite.
16. Cream phyllitic limestone.
17. Black limestone with quartz fragments (0.5–1.5 cm).
18. Rusty weathering black limestone boulders.
19. As 17.
21. As 18.
22. Black limestone with quartz fragments up to 2 cm and grey calcareous slate fragments up to 3 cm.
23. Beach deposit, no rock exposed.
24. Coarse-grained epidiorite. All thicknesses quoted are post-deformation.



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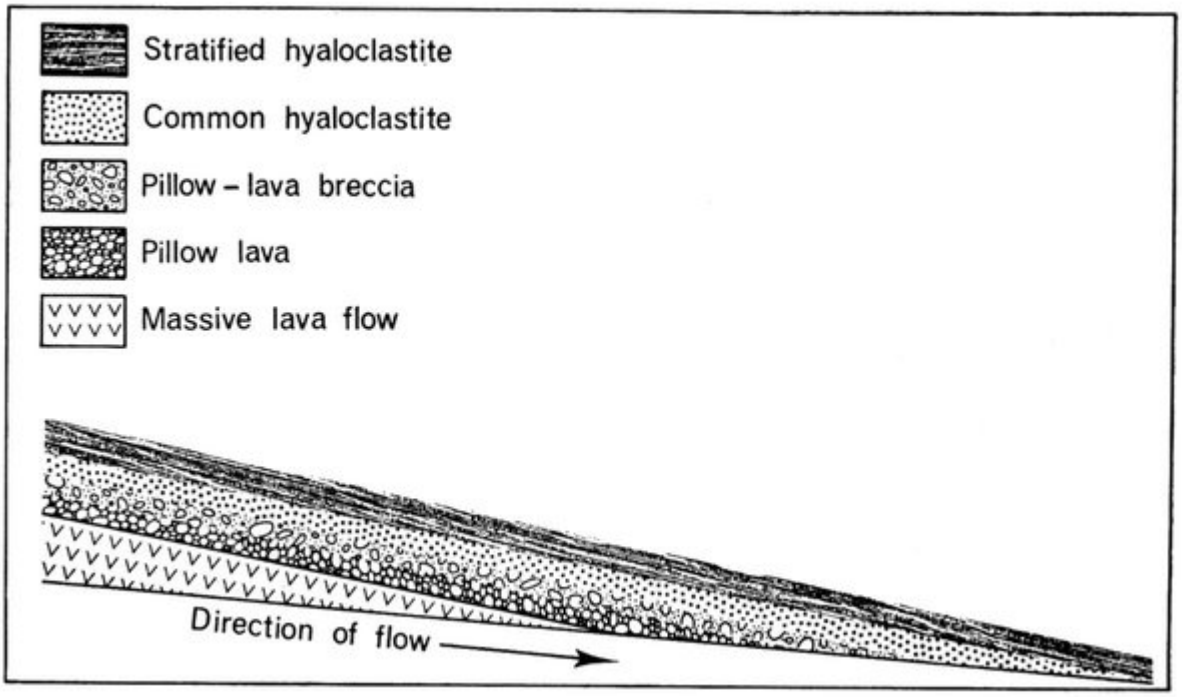

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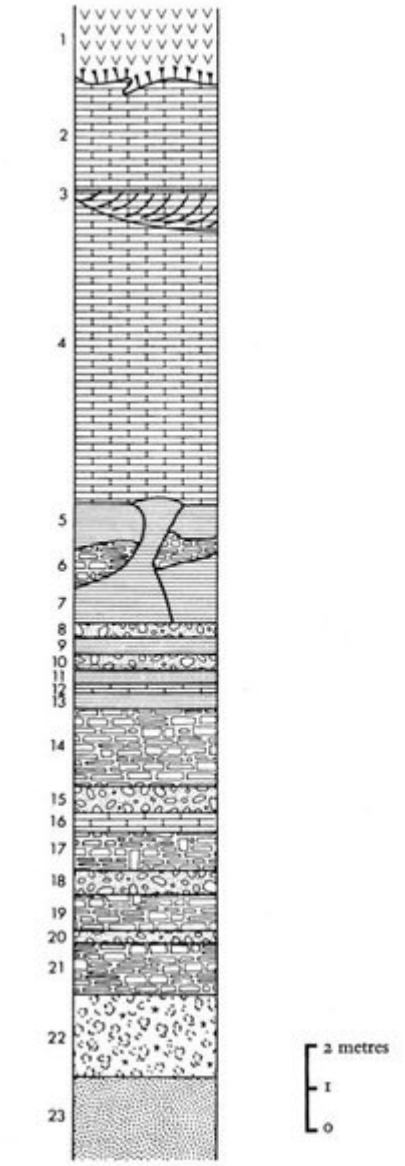

(Figure 3) Stratigraphic column at Port nan Clach Cruinn. Key 1 Vesicular lava with basal pipe amygdales. Load structures cause sediment to be squeezed upwards into lava. Toes of lava project downwards and northwards into the sediment causing minor fold disturbances. 2 Interbedded cream limestone (1–3 cm) and cream calcareous phyllite (0.5–1 cm). 3 Channel filled by limestone containing boulders of grey limestone in a matrix charged with angular fragments of quartz. Whole unit is cross-bedded, indicating derivation from south. 4 Pure grey limestone with beds 1–10 cm thick. 5 Parallel laminated (0.5–1 cm) limestone. 6 Graded limestone with fragments of quartz (1–1.5 cm) and black calcareous slate. Channelled base trending 110°. Intruded from below by a sedimentary dyke of 7. 7 Laminated (0.2–2 cm) limestone with sand-sized quartz fragments. 8 Conglomerate with boulders of dark grey limestone. 9 As 7. 10 Conglomerate of rusty weathering black limestone with largest fragments measuring 100 × 50 cm. 11 As 7. 12 Grey limestone with fragments (0.5–1 cm) of malachite and quartz. 13 As 7 with ripple marked base.