
2 Ardschalpsie Point

[NS 043 580]–[NS 045 576]

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2.1 Introduction

The Ardschalpsie Point GCR site is situated on the west coast of the Isle of Bute, just to the north of Scalpsie Bay. It consists of a narrow rock platform backed by a steep rock face that forms an almost straight, 400 m-long, section north-west of Ardschalpsie Point (Figure 4.6). The immediate hinterland, which consists of a raised beach backed by an ancient sea cliff, also provides some excellent exposures.

The metasedimentary rocks exposed in this section are some of the youngest in the Southern Highland Group. They were formerly assigned to the Bullrock Greywacke (*sensu* Clough, in Gunn *et al.*, 1897) and have also been referred to as the ‘Lower Leny Grits’ (Anderson, 1947a) and the Innellan ‘Group’. They are now assigned to the Toward Quay Grit Member of the St Ninian Formation, which overlies the Bullrock Greywacke Member stratigraphically (i.e. on the BGS 1:50 000 Sheet 29E, Dunoon and Millport, 2008). Immediately east of the GCR site, the Toward Quay Grit Member is overlain by the Ardschalpsie Formation, which is assigned to the Trossachs Group. The GCR site lies well south of the outcrop of the Dunoon Phyllite Formation, which contains the closure of the Tay Nappe (see the *Cove Bay to Kilcreggan* site report), and has a splay of the Highland Boundary Fault as its southern limit.

This GCR site is of national importance as it provides a unique opportunity to examine a virtually continuous, and clean, coastal section across part of the top limb of the Tay Nappe. The closure of the Tay Nappe can be traced across Scotland but the upper limb of the structure is seldom well exposed. It is seen, for example, to the north-east of this site between Toward and Dunan on the Dunoon peninsula (where it is named the Aberfoyle Anticline: Roberts, 1974) and at the *Cove Bay–to Kilcreggan* GCR site, but is not as readily studied as at Ardschalpsie Point. Here, the inland exposures, deeply etched by weathering due to their slightly calcareous nature, complement those on the coast and reveal in detail the relationship between the spaced S1 cleavage and the bedding (Figure 4.7). The contact between the uppermost Dalradian and the much younger, Devonian to Lower Carboniferous strata, seldom seen in the 250 km between Arran and Stonehaven, is well exposed at the south-east end of the rock platform.

Surprisingly, considering the pioneering work carried out in the neighbouring Cowal peninsula, no details of the Dalradian rocks were given in the Geological Survey memoir covering this part of Bute (Gunn *et al.* 1903). It was left to McCallien (1938) to provide the first general account of the Dalradian of Bute. Anderson (1947a) published a more-detailed account and map of Scalpsie Bay, and concluded, from the dip of the beds combined with way-up evidence, that the Dunoon Phyllites farther north on Bute lie in the core of a ‘normal’ (i.e. *upward-facing*) anticline. Conversely, Shackleton (1958) suggested that the Tay Nappe structure is probably a *downward-facing* anticline, based on an admittedly small number of observations of the geometrical relationship of bedding to cleavage, combined with way-up evidence. The only detailed, modern study of this section was by Simpson and Wedden (1974) who confirmed Shackleton’s interpretation, and recorded the three-dimensional relationship of the L1 stretching lineation to the local fold hinges in these rocks.

2.2 Description

The coastal section trends at about 60° to the general strike of the beds, and is excellent for cross-section construction (Figure 4.8). The only drawback is that, despite almost continuous rock exposure above the high-tide mark, many of the rock surfaces in the intertidal zone, which would normally yield the finer detail, are completely covered with a dense mat of barnacle and algal growth.

The rocks consist of beds of grey-green metagreywacke, generally 1–2 m thick in the northern part of the section, but reaching 3 m thick at the southern end. They are separated by thin layers of metasilstone and/or slaty metamudstone (generally less than 10 cm thick), or form amalgamated units. The metagreywackes, formerly referred to as 'grits', are fine to coarse grained, and many of the beds show normal grading.

Over thirty examples of graded bedding have been recorded from the section shown in (Figure 4.8) and, as previously reported by McCallien (1938), they show younging to the south-east. Beds are generally right-way-up throughout the section, only becoming overturned on the middle limbs of mesoscopic F1 folds ((Figure 4.8), localities a and b). As a result of the bonding effect of penetrative deformation and cleavage development, the bottoms of beds are very rarely exposed. However, flame structures are seen on the bases of a few beds, and cross-lamination (showing younging to the south-east) is seen in the uppermost, finer grained parts of some beds; Simpson and Wedden (1974, plate 1a) illustrate an example from 450 m north of the GCR site.

Thin beds of metamudstone and/or metasilstone occur commonly between the metagreywacke beds in the northern half of the section, whereas thick, amalgamated beds of metagreywacke with no intervening mudrock predominate in the younger rocks to the south. The metamudstone occurs in several guises: as grey-green slaty metamudstone with 1–5 mm-thick bands of black metamudstone; as grey slaty metamudstone with centimetre-scale green bands; and as purplish grey, slaty metamudstone. The latter variety is more common at the southern end of the section.

The matrix of the metagreywackes consists of detrital grains of quartz, feldspar, and muscovite, accompanied by flakes of chlorite and white mica, which grew during the regional metamorphism (Simpson and Wedden, 1974). The granule- to medium-pebble-sized clasts found at the bases of graded beds are mainly of quartz, with pink feldspar being common in some beds. Rip-up slabs and angular fragments of dark mudstone, a few centimetres long, occur in a number of the beds.

The beds forming the long limbs of the F1 minor folds are right-way-up, and represent the regional orientation of the upper limb of the 'Tay Nappe'. They dip consistently to the south-east at about 60°, at a steeper angle than the first cleavage (S1; dip 42°SE) throughout the section (Figure 4.6), (Figure 4.7) and (Figure 4.8). An L1 stretching lineation, plunging at 33° to the east-south-east, is present as a silky striation on slaty-cleavage surfaces, mainly in the northern part of the section (Simpson and Wedden, 1974).

The penetrative slaty cleavage (S1) developed in the metamudstones is fanned in mesoscopic fold closures and is continuous, via cleavage refraction, with the centimetre-scale microlithons making up the spaced cleavage that affects most of the metasilstones and metagreywackes (Figure 4.7)b. This spaced cleavage is even seen in some of the 2–3 m-thick metagreywacke beds. Evidence of later ductile deformation is given by a few late, open structures that fold the main cleavage ((Figure 4.8), localities c, d and e), and by an unrelated, gently dipping, crenulation cleavage that occurs locally. Faults with varying orientations occur at regular intervals throughout the section, becoming more significant and marked by massive quartz veins or fault-breccia up to a metre thick, as the Highland Boundary Fault is approached.

The faulted relationship between the Dalradian rocks and red sandstones of the Lower Carboniferous, Kinnesswood Formation is fully exposed at beach level in the intertidal zone at locality f on (Figure 4.8). It is marked by a zone of brecciated Dalradian rock up to 14 m thick, south-east of which major rectilinear fractures separate the Dalradian from the Carboniferous rocks. A 45 cm-thick, deeply weathered, dyke runs parallel to the fault zone (Hill and Buist, 1994). Reddening of the Dalradian rocks along joints and fractures at this locality suggests that the Old Red Sandstone-facies Carboniferous rocks once lay unconformably on the Dalradian north of the branch of the Highland Boundary Fault, prior the final displacement on the fault.

The Dalradian rocks are weakly metamorphosed, and occur within the chlorite zone of regional metamorphism; detrital white mica is still present in the mineral assemblage, but is accompanied by a felt of smaller, aligned, white mica crystals making up the S1 fabric.

2.3 Interpretation

The St Ninian Formation, and in particular the Bullrock Greywacke Member, have been correlated with similar pebbly metagreywackes found south of the Dunoon Phyllite Formation on the Toward peninsula, Rosneath peninsula (Tanner, 1992; *Cove Bay to Kilcreggan* GCR site), and west of Loch Lomond, as well as north of the putative Highland Border Complex at North Glen Sannox, Isle of Arran. At all of these localities the Bullrock Greywacke is right-way-up and dips to the south-east on the upper limb of the Tay Nappe.

At the *Ardscalpsie Point* GCR site, right-way-up beds dip consistently to the south-east at a steeper angle than the first cleavage (S1) (mean difference=19°; (Figure 4.6) and (Figure 4.8)). This agrees with the minor fold vergence and confirms that the D1 facing direction is down-to-south, and that the 'Tay Nappe' here is a synformal or downward-facing anticline (Shackleton, 1958; Simpson and Wedden, 1974).

Stretching lineations were first described from Dalradian rocks by Clough (in Gunn *et al.*, 1897), from the Cowal peninsula to the north-east of the Isle of Bute. When plotted on an equal area stereographic projection, the F1 fold hinges and intersection lineations from this GCR site are seen to be dispersed along a great circle that contains the mean orientation of the stretching lineation. This result is consistent with the curvilinear nature of some minor folds observed in the field and indicates that a considerable rotation of fold hinges towards the stretching direction (X) has taken place (see the *Strone Point* and *Glen Orchy* GCR site reports in Tanner *et al.*, 2013a and Treagus *et al.*, 2013 respectively).

Late warps of the bedding and early cleavage have the step-like geometry characteristic of minor structures congruous with the F4 Highland Border Downbend (see the *Portincaple* GCR site).

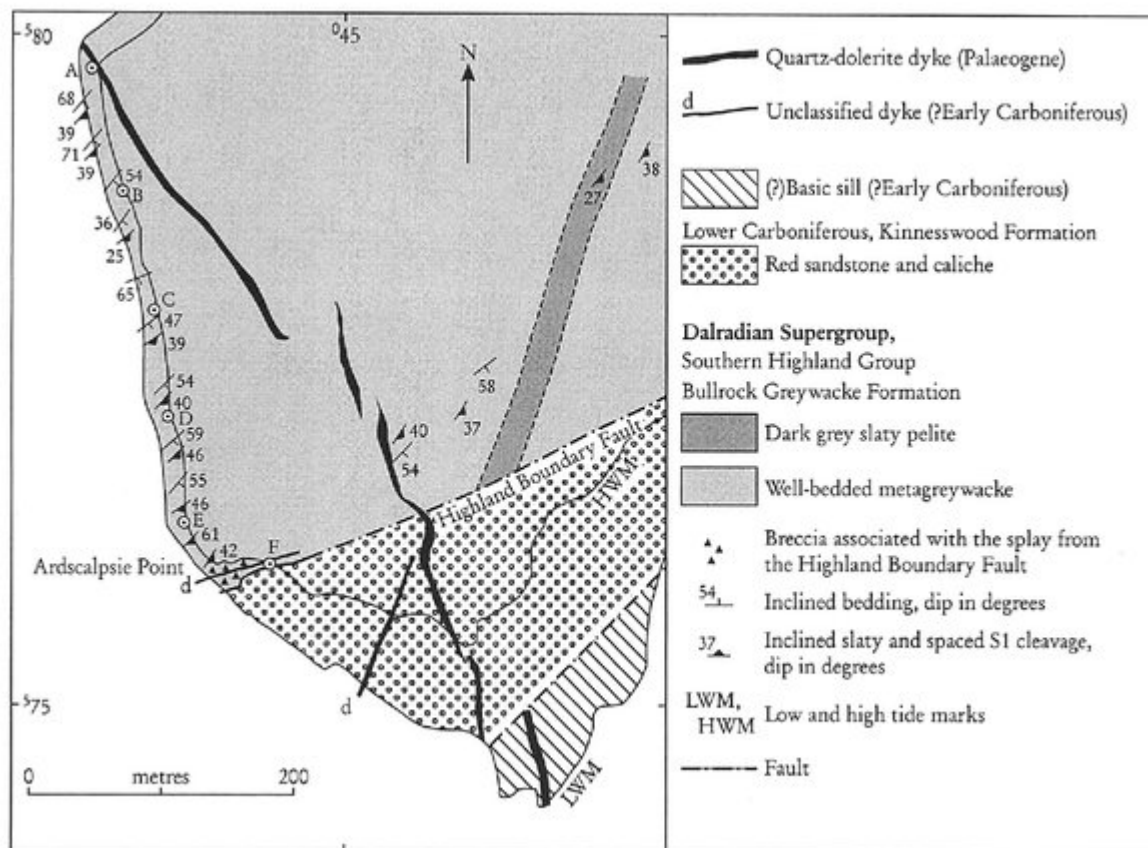
2.4 Conclusions

The Tay Nappe is one of the largest fold structures in Scotland. It was excised south-east of the Highlands by movement on the Highland Boundary Fault, leaving the upper limb of the Nappe exposed only in a relatively narrow SW–NE-trending outcrop across Scotland. The importance of the *Ardscalpsie Point* GCR site lies in the fact that it is probably the best place for studying in detail this limb of the structure, to check whether the field relationships accord with the proposed structural model for the nappe (for details of the evolution of the Tay Nappe, see the *Cove Bay to Kilcreggan* GCR site report).

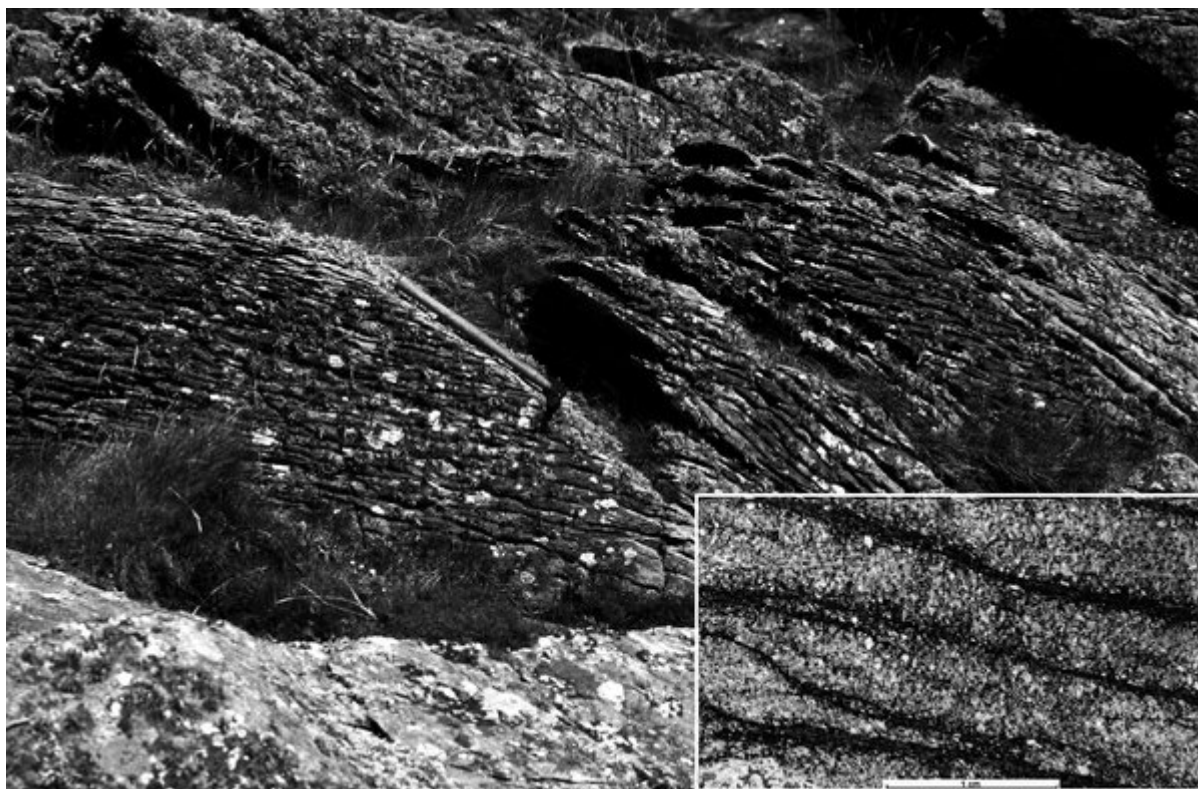
At this site, the Dalradian rocks belong to the St Ninian Formation, a thick unit of pebbly metagreywackes and thin beds of slaty metamudstone, which was deposited from turbidity flows in a submarine fan environment. It is amongst the youngest of the Dalradian formations, and occupies a position close to the top of the Southern Highland Group. Sedimentary structures, especially graded bedding, and bedding-cleavage relationships can be very clearly seen in these rocks on the 400 m-long coastal section adjacent to *Ardscalpsie Point*. The combination of undoubted, and plentiful, way-up evidence, with structural data, provides a very clear demonstration that the St Ninian Formation lies on the upper limb of a major F1 fold, the 'Tay Nappe', that closes *downwards* and yet has the older rocks in its core. It is a downward-facing, or synformal, anticline, as envisaged by Shackleton (1958), from preliminary observations at *Ardscalpsie*. This fold, originally flat-lying, was rotated into its present position by folding on the Highland Border Downbend (see the *Portincaple* GCR site report).

In addition, this GCR site is also excellent for studying the development of spaced cleavage in quartz-rich metasedimentary rocks, and is one of the few places where a branch of the Highland Boundary Fault, the major fault bounding the Dalradian outcrop on its south-east side, is fully exposed. In this part of Bute, the Highland Boundary Fault brings Dalradian rocks against Lower Carboniferous rocks: a related fault-zone is fully exposed 600 m north-west of *Ardscalpsie Point* and is marked by a zone of brecciated Dalradian rock up to 14 m wide, and by major rectilinear fractures, which bring the Dalradian and Carboniferous rocks into direct, knife-sharp contact. Evidence from this locality that the Carboniferous rocks once lay unconformably on the Dalradian rocks immediately north of the Highland Boundary Fault suggests that the post Early Carboniferous displacement on the fault branch at *Ardscalpsie* might have been relatively small.

[References](#)

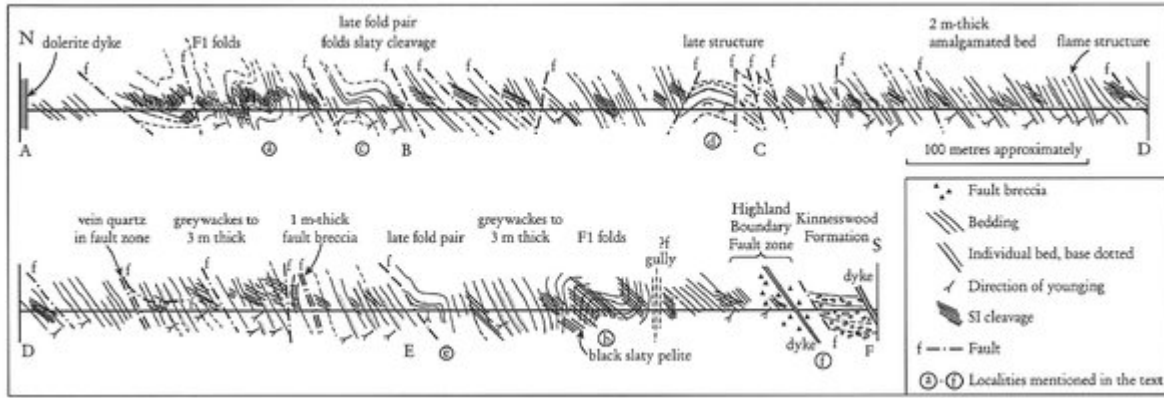


(Figure 4.6) Map showing the bedding-cleavage relationships in the Dalradian rocks immediately north-west of a splay of the Highland Boundary Fault, north of Ardsalpsie Point, Isle of Bute. A–F, reference points on the line of cross-section shown in (Figure 4.8).



(Figure 4.7) (a) An inland exposure at Ardsalpsie Point [NS 0440 5766], showing the bedding-cleavage relationship found typically on the upper limb of the Tay Nappe at this GCR site. Bedding, which is parallel to the hammer shaft, is cut by the spaced S1 cleavage (seen as etched lines on the surface) that dips at a more-gentle angle to the south-east (right on photo). Hammer shaft is 60 cm long. (Photo: P.W.G. Tanner.) (b) Photomicrograph showing the relatively undeformed

nature of the D1 metasandstone microlithons which, together with the intervening thin dark cleavage domains, constitute the S1 cleavage in (a). (Photos: P.W.G. Tanner.)



(Figure 4.8) A true-scale, NNW–SSE-trending cross-section, prepared from field sketches, of the structures along the line A–F in (Figure 4.6), Ardscaipsie Point GCR site.