
15 Port Cill Maluaig

[NR 722 700]–[NR 714 690]

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15.1 Introduction

This relatively small GCR site is located along the seaward edge of the raised beach to the south-west of Port Cill Maluaig, on the east coast of Loch Caolisport in Knapdale (Figure 2.34). Minor geological structures are the main focus of attention, as the rocks all belong to the Ardrishaig Phyllite Formation and show very little overall variation in lithology. The 'Ardrishaig Phyllites', as previously known, are the uppermost formation of the Easdale Subgroup. They have been intruded by basaltic sills, and all of the rocks have undergone greenschist-facies regional metamorphism within the biotite zone.

The GCR site lies on the south-east limb of the F1 Ardrishaig Anticline (Figure 2.34), which is correlated with the Aberfoyle Anticline on the south-east side of the F4 Cowal Antiform to form part of an overall F1 structure that is generally referred to as the Tay Nappe. The site is located within the Knapdale Steep Belt (Roberts, 1974) and, in contrast to the other GCR sites in Knapdale, the rocks have been affected by *both* the D1 and D2 phases of the Grampian Event. These two phases of early deformation are closely related to one another: D1 resulted in the development of the slaty cleavage (S1), which was overprinted and virtually destroyed by the development of the later, closely spaced S2 fabric. Bedding in these rocks is inverted and, together with S1, dips steeply towards the north-west; it is cut by a penetrative S2 fabric which dips at a lower angle in the same direction (inset on (Figure 2.34)).

This site provides exceptional examples of minor F2 folds with strongly curvilinear fold hinges, which form miniature elongated basins and domes locally, where they affect thin beds of fine-grained quartzite. It also provides a lithological and structural contrast with the Ardrishaig Phyllites within the *Kilmory Bay* GCR site, which lie on the opposing, north-west limb of the Ardrishaig Anticline, and are dominated by early (D1) minor structures.

There is no published map that gives details of the geology of the area around, and including, the GCR site and the only description is in a field guide by Roberts (1977c). However, a 13.4 m-thick basic meta-igneous sill, exposed at the north end of the section, figured prominently in a study of variations in fluid flow during regional metamorphism across Knapdale (Skelton *et al.*, 1995).

15.2 Description

The Ardrishaig Phyllites at this site consist of grey-green phyllitic metamudstone and metasiltstone, interbedded with fine-grained quartzite and uncommon metalimestone. The quartzite beds vary in thickness along their length and some are seen to die out within a few metres. A number of the thicker quartzite beds contain discontinuous, calcite-rich, layers or lenses.

Minor F2 folds are common. They are identified from the fact that they fold the following: (a) pre-existing slaty cleavage in metamudstone, or finely-spaced cleavage in metasandstone; (b) a penetrative fabric in the basic meta-igneous bodies; (c) a pre-existing striation lineation; and (d) in a few instances, early isoclinal folds. The minor F2 folds verge overall towards the north-west, and are associated, in the phyllitic rocks, with a penetrative, finely-spaced crenulation cleavage developed parallel to their axial surfaces. This cleavage forms the dominant fabric in the rock, dipping north-west at a moderately steep angle (30–60°), consistently shallower than the bedding (60–80°). A fibrous mineral lineation, plunging at 25–45° to the west-north-west, defines the D2 stretching direction.

The mesoscopic and minor F2 folds occur as Class 1C folds (Ramsay, 1967) where they affect the more-competent layers of fine-grained quartzite, rather than Class 3 folds, which are developed in the less-competent layers formed by the phyllitic rocks. Thus, the more-competent layers tend to maintain the same thickness, as they are traced around the fold hinges, while the less-competent layers thicken into the fold hinges, so that overall the folding is similar in style.

The F2 fold hinges mostly plunge north-east at a moderately steep angle. However, some minor F2 folds have hinges that are strongly curved within their axial planes, so that their plunge passes from north-east through the horizontal to south-west within a short distance. Where two adjacent curvilinear minor folds run parallel to one another, the two fold trains are commonly 'out of phase', with plunge culminations in one, being adjacent to plunge depressions in the other, and nearest neighbours in the two fold trains plunging in opposing directions. Alternatively, adjacent minor folds affecting the same bed may plunge, sometimes steeply, in opposite directions (Figure 2.35). Excellent examples of curvilinear F2 fold-hinges are seen to the south-west of a thin Palaeogene basalt dyke at [NR 717 697], giving rise to hump-backed exposures of fine-grained quartzite, all closely packed together.

The D2 deformation strongly affects, and overprints, the earlier S1 cleavage, which lies close to the bedding and is difficult to distinguish from the microcrenulation form of S2 in the field. Minor F1 folds are rarely seen in these rocks, probably due to the intensity of the D2 deformation. However, an area of reddened rocks, exposed on the raised beach 50 m to the north-east of the small beach at Port Mhoirich [NR 716 696], displays a series of minor, possibly F1 folds, affected by the F2 folding.

A gently dipping to horizontal crenulation cleavage locally affects the D2 structures and represents the late-stage deformation that is seen generally throughout Knapdale.

15.3 Interpretation

The Ardrishaig Anticline is a major fold structure in the South-west Grampian Highlands that can only be recognized on stratigraphical grounds, from the correlation of the Ardrishaig Phyllite Formation and Erins Quartzite Formation, within the Cowal Antiform to the south-east, with the equivalent Ardrishaig Phyllite Formation and Crinan Grit Formation to the north-west (Figure 2.34). The relative structural age of the Ardrishaig Anticline is a matter of inference, since the nature of the early (D1) structures within the Cowal Antiform, has been obscured by the intensity of the D2 deformation. Recognition of the age of the Ardrishaig Anticline, as an F1 fold, relies upon evidence from the equivalent Aberfoyle Anticline in the Highland Border region (see the *Ardscalpsie Point* and *Cove Bay to Kilcreggan* GCR site reports in Tanner et al., 2013b). Having concluded that the Ardrishaig Anticline is a D1 structure, it is then clear, that the north-westerly vergence displayed by the F2 folds on the lower limb of this fold at Port Cill Maluaig, corresponds to the same vergence shown by F2 folds on the lower limb of the Tay Nappe in the Aberfoyle Anticline on the south-east limb of the Cowal Antiform (for example at the *Cove Bay to Kilcreggan* GCR site).

The curved nature of the F2 fold hinges at Port Cill Maluaig reflects the non-cylindroidal character of the initial F2 fold-buckles, which can be interpreted as having been accentuated by the intensity of the D2 deformation (Roberts and Sanderson, 1974). Individual fold hinges change their direction of plunge in a regular manner, forming sinuous lines that lie in a plane. The well-developed stretching lineation lies in the same plane, bisecting the angle between opposing plunge directions (the 'apical angle'). This provides the clue as to how the originally horizontal bedding surfaces have been distorted to form basins and domes on a metre scale, by folding followed by progressive rotation of individual fold hinges towards the stretching direction. The reasons for this are discussed in the *Glen Orchy* GCR site report in Treagus et al. (2013), and examined in full in the *Strone Point* GCR site report in this paper.

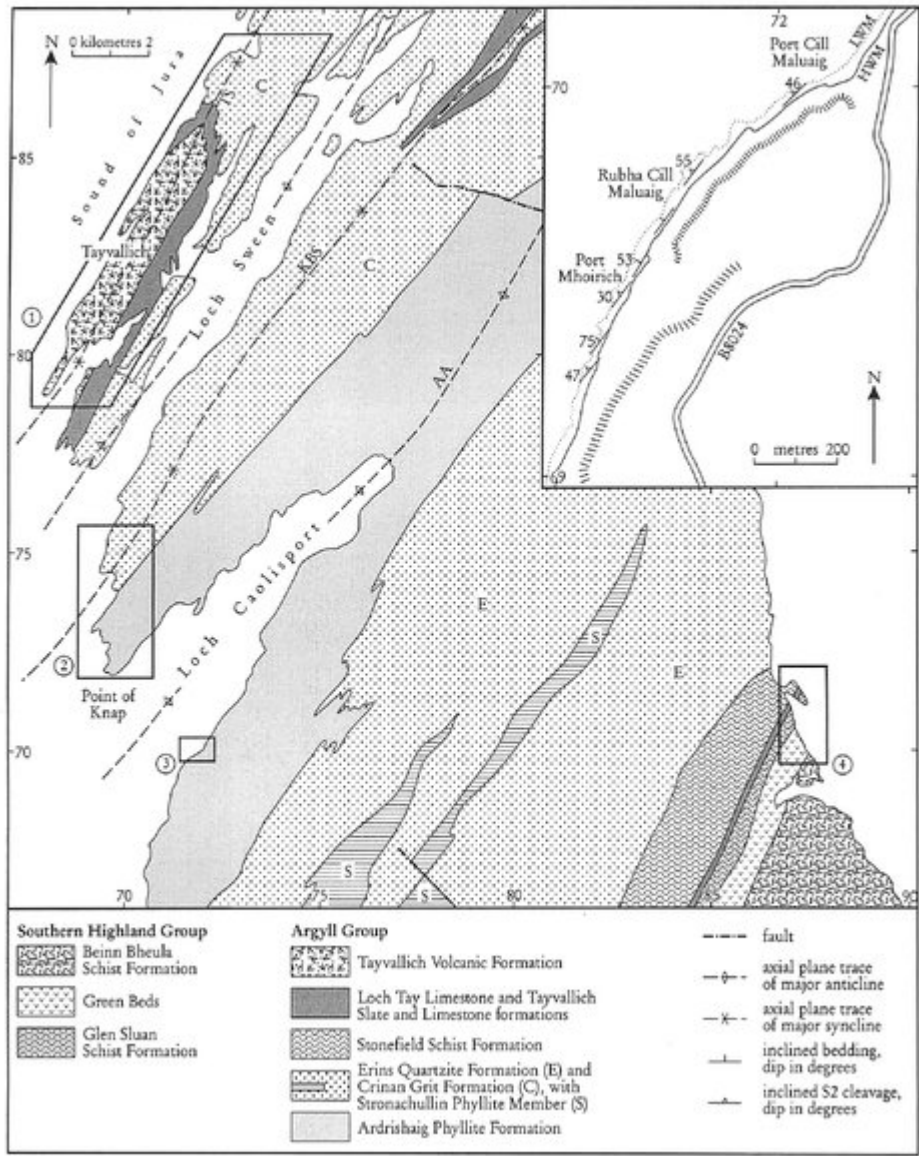
15.4 Conclusions

The coastline south of Port Cill Maluaig exposes a representative cross-section through the Ardrishaig Phyllites on the south-east limb of the Ardrishaig Anticline, one of the major early (F1) folds in the South-west Grampian Highlands. The rocks consist of grey-green phyllitic metasilstones and metamudstones, with beds of fine-grained quartzite and two thick sills of dark green, amphibolitic meta-igneous rock. The rocks are affected by two phases of regional deformation: the D1

phase produced an early cleavage lying very close to the bedding, presumably on the limbs of tight to isoclinal F1 folds, whilst the D2 phase resulted in development of a penetrative fabric, which virtually obliterated the evidence for the sedimentary and early structural history of these rocks.

The GCR site displays superb examples of minor F2 folds with strongly curved fold hinges. They are displayed at Port Cill Maluaig in three-dimensions with a perfection that is difficult to match from elsewhere in the Dalradian outcrop.

References



(Figure 2.34) Map of Knapdale and north Kintyre (based on Roberts, 1977c), showing outcrops of the main Dalradian units and locations of GCR sites: 1 West Tayvallich Peninsula, 2 Kilmory Bay, 3 Port Cill Maluaig, 4 South Bay, Barmore Island. AA Ardrishaig Anticline, KBS Kilmory Bay Syncline, TS Tayvallich Syncline. Inset shows the geology of the Port Cill Maluaig GCR site (3).



(Figure 2.35) (a) Minor F2 folds showing strongly curved fold-hinges, which plunge in opposing directions, Port Cill Maluaig. Hammer shaft is 47 cm long. (b) Mesoscopic and minor F2 folds from Port Mhoirich (Port Cill Maluaig GCR site), viewed to the north-east. Note the control of bed thickness on the wavelength of the folds. Hammer shaft is 47 cm long. (Photos: P.W.G. Tanner.)