16 Strone Point

[NN 113 088]–[NN 121 089]

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16.1 Introduction

One of the more-important major structures in the South-west Grampian Highlands is the Ardrishaig Anticline, an early fold whose axial trace passes just to the north of Inverary and continues to the south-west, parallel to the west coast of Loch Fyne. The significance of the Ardrishaig Anticline lies in the fact that it is folded south-eastwards over the Cowal Antiform to correlate with the Tay Nappe (Aberfoyle Anticline) in the Highland Border region. The actual closure of the Ardrishaig Anticline is not well exposed but its geometry is almost certainly mirrored by that of one of its satellite folds, the Strone Point Anticline, which is seen at Strone Point, 2 km east of Inverary (Figure 2.36). The hinge-zone and north-west limb of the Strone Point Anticline may be examined readily at this GCR site.

This GCR site is also valuable for providing an accessible section in which to examine the range in rock types, and structures, seen in the Ardrishaig Phyllite Formation south-east of the Loch Awe Syncline, as compared to those found in the equivalent Craignish Phyllite Formation on the north-west limb of the syncline, for example, at the *Fearnach Bay* GCR site.

The Strone Point section was first described for the Geological Survey by Hill (1905), who considered that the rocks there are representative of the facies shown by the Ardrishaig Phyllite ‘Group’ in the surrounding part of Cowal. Apart from reporting the presence of ‘isoclinal folding’, Hill (1905) gave no specific details of the structure. The only published account of the structural geometry is by Borradaile (1972b), who analysed in detail the mode of formation of the highly curvilinear minor folds that occur there. This GCR site provides an ideal opportunity to examine the geometry of these minor folds and their relationship to the regional stretching lineation.

16.2 Description

The Ardrishaig Phyllites are admirably exposed in the almost continuous rock exposure found on the narrow rock platform, backed by low cliffs a few metres high. The phyllitic metamudstones and metasiltstones that characterize the formation, are grey-green in colour, with a silvery or silky sheen, and contain beds of quartzite and metacarbonate rock. The quartzite beds are prominent, but few in number, and consist of fine-grained quartzite in uniform, non-graded units up to 2 m thick. The phyllitic rocks contain orange-weathering bands of metacarbonate rock, probably dolomitic, that are 20–50 cm thick, and are particularly common in the hinge-zone of the major anticline. There is also one small body of metadolerite, of the type commonly found in the Ardrishaig Phyllites elsewhere in the area.

The coastline east-north-east from Strone Point provides an excellent, slightly oblique, section through the north-west limb of the Strone Point Anticline (which includes a mesoscopic fold pair related to the major structure), and the hinge-zone, but the south-east limb lies beneath the loch. The closure of this fold, identified and named by Borradaile (1972b), is well exposed at [NN 1180 0880], where it is marked by symmetrical folds of metre-scale wavelength, which affect interbanded phyllitic rocks and orange-coloured metacarbonate rock. Although no way-up evidence has been recorded from these rocks, the Strone Point fold is an upward-facing anticline based upon evidence of inverted graded in the adjoining Ben Lui Schists (Borradaile, 1972b).

An intensely developed, penetrative cleavage, seen as a spaced cleavage in the metacarbonate rocks, and a slaty cleavage in the metamudstones, is axial planar to the major fold. In the hinge-zone, it is associated with a zig-zag

interdigitation of the two lithologies, resulting in a blurring of the original boundaries between the layers (Figure 2.37). The cleavage is very consistent in orientation (Figure 2.36), inset; (Figure 2.38) c, and on the north-west limb of the fold it dips consistently more steeply to the north-west than the bedding. This is in agreement with the presence of the anticlinal hinge to the south-east, but appears at first sight to be in conflict with the observation that both S- and Z-shaped, congruous, tight to isoclinal minor folds occur on the same fold limb. However, these folds give a consistent sense of vergence to the south, when viewed in the vertical plane, with minor axial planes consistently dipping at a steeper angle to the north-west, than bedding. The change in the down-plunge minor fold pattern, is due to a randomly distributed variation about the horizontal in the plunge direction of the minor folds from north-east to south-west. Indeed, individual minor folds are strongly curvilinear, and change their plunge direction in a single exposure (Borradaile, 1972b, plate 2). This is particularly well seen in the quartzite beds, as illustrated by Voll (1960, figures 19 a and b) from just outwith the GCR site (Figure 2.38) a and b. Quartzite beds are thickened into bulbous shapes where they pass around minor fold closures, but are considerably thinned on the fold limbs.

An important feature of these rocks is the development of a down-dip stretching lineation on the slaty cleavage planes (Borradaile, 1972b), which is marked by a fine, silky striation lineation, first described by Clough (in Gunn *et al*., 1897) from the Cowal peninsula. When plotted on the same stereographic projection as the poles to cleavage, the D1 fold hinges and bedding/cleavage intersection lineation lie on a great circle that is only at an angle of 04° to the mean orientation of the penetrative cleavage, and contains the stretching lineation (Figure 2.38)c. From a thin-section study of 40 deformed quartz grains in slaty metamudstone, Borradaile (1972b) confirmed that the lineation is parallel to the long axes of the grains, and hence represents the X direction. Pyrite crystals that grew in the mudstone before deformation are commonly streaked-out parallel to the stretching lineation, a feature accentuated by their subsequent oxidation to form rusty-looking, commonly elliptical streaks on the cleavage plane. It is of historical interest that the Duke of Argyll published a paper in 1889 interpreting these artefacts as fossil annelid worm tubes.

16.3 Interpretation

The Ardrishaig Phyllites have been affected by a single ductile deformation phase (D1) that resulted in the formation of the Strone Point Anticline and its associated minor folds, spaced and slaty cleavages, and stretching lineation. The only evidence of later ductile deformation is given by open warps that locally affect the early cleavage in the hinge-zone of the major structure, and centimetre-spaced kink bands, which are common from Strone Point northwards along the west side of the headland.

The Strone Point Anticline is an upward-facing F1 structure, whose axial surface is inferred to dip north-west at 29°, parallel to the mean orientation of the associated penetrative cleavage. In the absence of bedding readings from the south-east limb, and with minor folds and bedding cleavage intersection lineations having orientations that vary in trend by 180° or more (Figure 2.38)c, there is a problem with determining its axis orientation. Within the hinge-zone of the major fold, a strong ?axial lineation plunges at 10–26° to the north, which would make the fold a sideways-closing structure. However, if the major fold mimics the behaviour of its minor satellites, and is strongly curvilinear, the orientation seen in one slice through the structure at Strone Point, is but a single snapshot of a structure that has an overall near-horizontal axis that trends north-east–south-west, and hence faces up to the south-east.

The Strone Point Anticline lies to the south-east of a major F1 fold of the same age, the Ardrishaig Anticline, which is considered to represent the Tay Nappe to the north of the later Cowal Antiform (Bailey, 1938; Roberts, 1966a). The presence of other major folds of the same age as the Ardrishaig Anticline in the Ardrishaig Phyllites is consistent with the recent interpretation of the Tay Nappe as a plexus of large fold closures, rather than a single major fold (Krabbendam *et al*., 1997).

An S1 slaty, to spaced cleavage, is dominant at this locality and is related to the formation of the Strone Point Anticline. Although Borradaile (1972b) stated confidently that the main cleavage was the first to form in these rocks, and is of D1 age, he also recorded the presence of a coplanar crenulation cleavage in a few instances. Further fabric analysis is needed to clarify this situation.

The significance of the curvilinear minor folds, and their relationship to the stretching lineation, is discussed in the *Glen Orchy* GCR site report in Treagus et al. (2013). The wide range in minor fold axis orientations at the Strone Point GCR site has resulted from the rotation of the originally horizontal, or slightly sinusoidal minor fold hinges, towards the orientation of the NNW-trending stretching lineation (the X direction of the strain ellipsoid), with increasing, but locally variable, amounts of strain. Only a single section through the major fold is available for study, so it is not known whether the major fold in this case is also curvilinear.

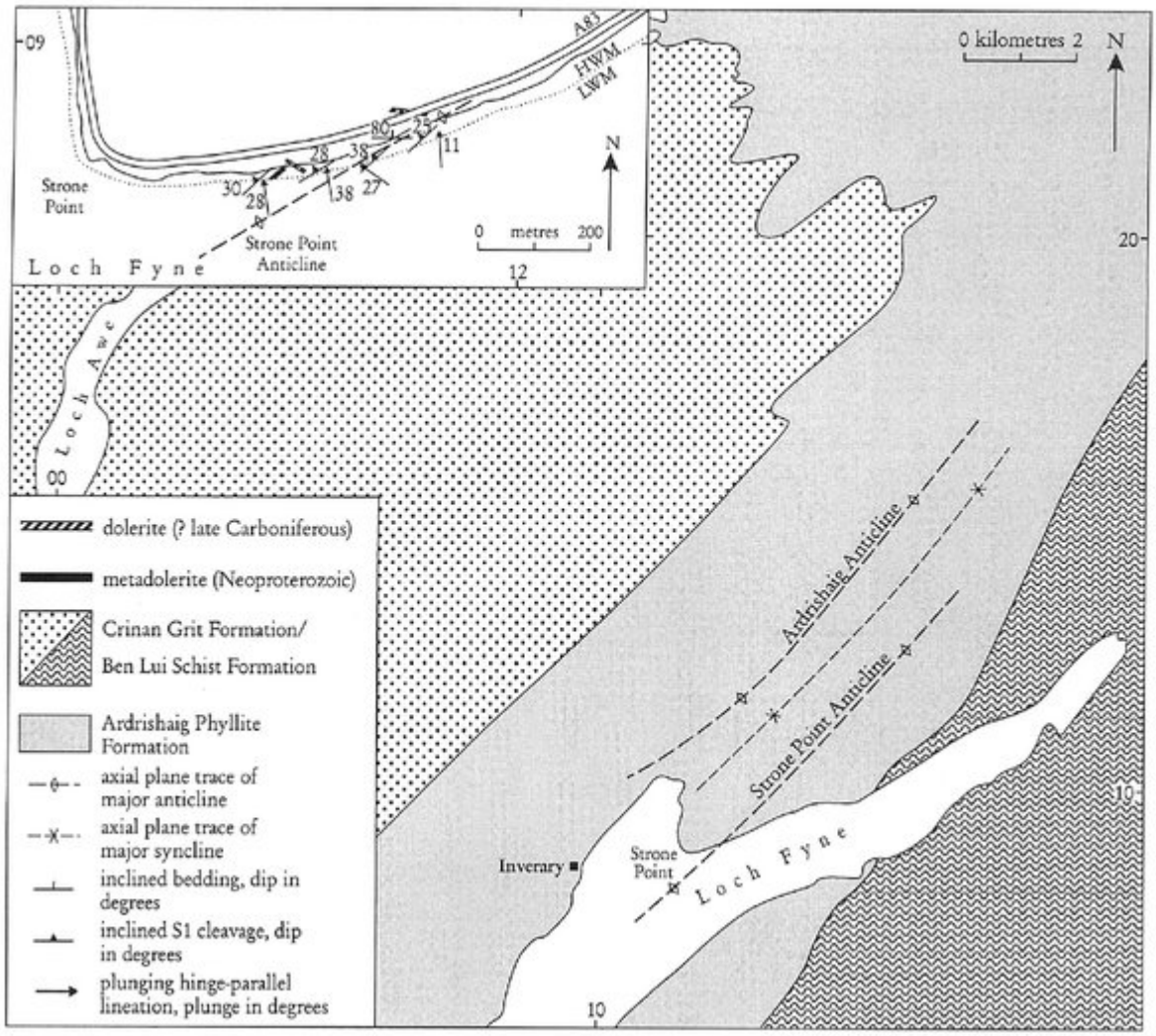
16.4 Conclusions

Strone Point is an excellent GCR site for demonstrating the techniques used for unravelling the geometry and evolution of a large fold structure, in this instance the Strone Point Anticline. It also provides a well-exposed and readily accessible representative section of the Ardrishaig Phyllite Formation to the south-east of the Loch Awe Syncline, which is stratigraphically equivalent to the Craignish Phyllite Formation to the north-west (see the *Fearnach Bay* and *Craignish Point* GCR site reports).

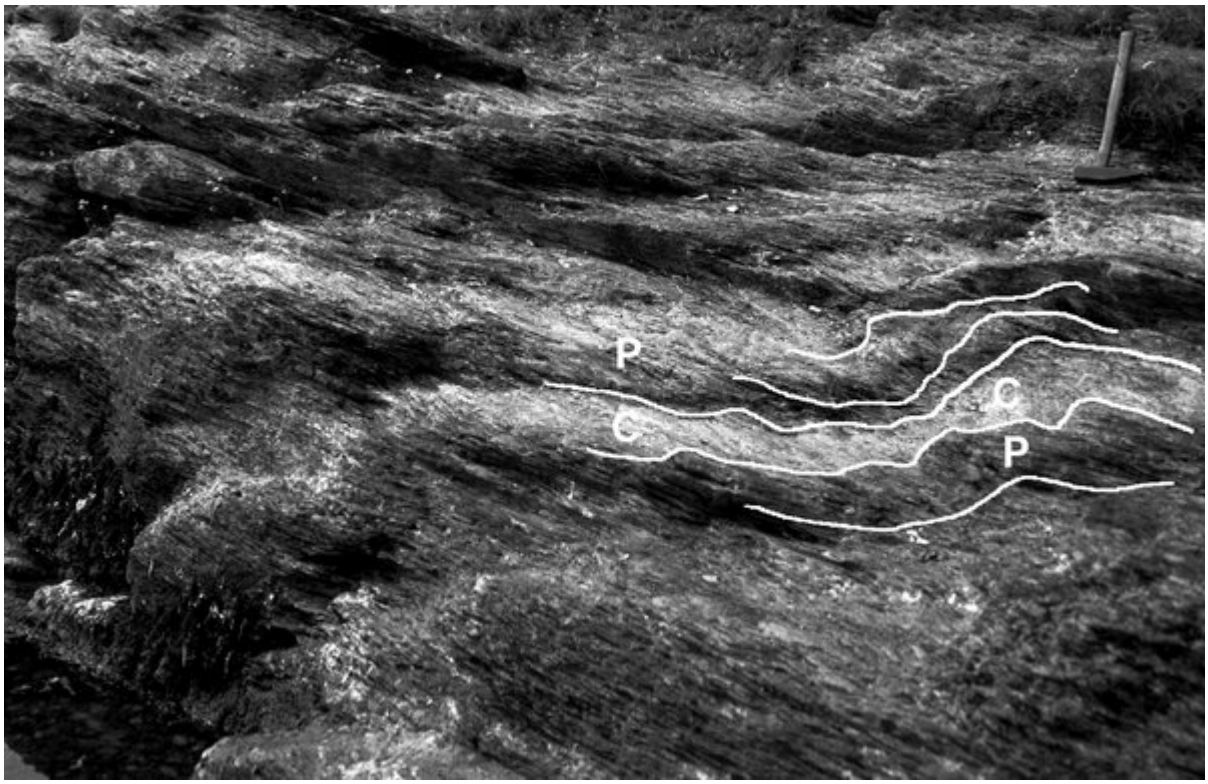
The main value of this locality lies in the fact that the Strone Point Anticline is of the same age as, and can act as a proxy for, the neighbouring but poorly exposed Ardrishaig Anticline. The axial trace of the latter major structure runs in a north-easterly direction a few kilometres to the north-west of Strone Point. This surrogate role is important, as the Ardrishaig Anticline is the north-western equivalent of the Tay Nappe, one of the largest fold structures in the South-west Grampian Highlands. Thus, the structures described from this GCR site may be compared in detail with the fabrics (such as cleavages) and minor fold structures found in the core of the Tay Nappe, for example at the *Cove Bay to Kilcreggan* GCR site, described in Tanner et al. (2013b).

This is also a valuable location for studying the mode of development of folds with highly curved hinges, and complements a similar study, in rocks of the Beinn Udlaidh Syncline at the *Glen Orchy* GCR site (Treagus et al., 2013), which were at the time much more deeply buried in the Earth's crust, and hence hotter.

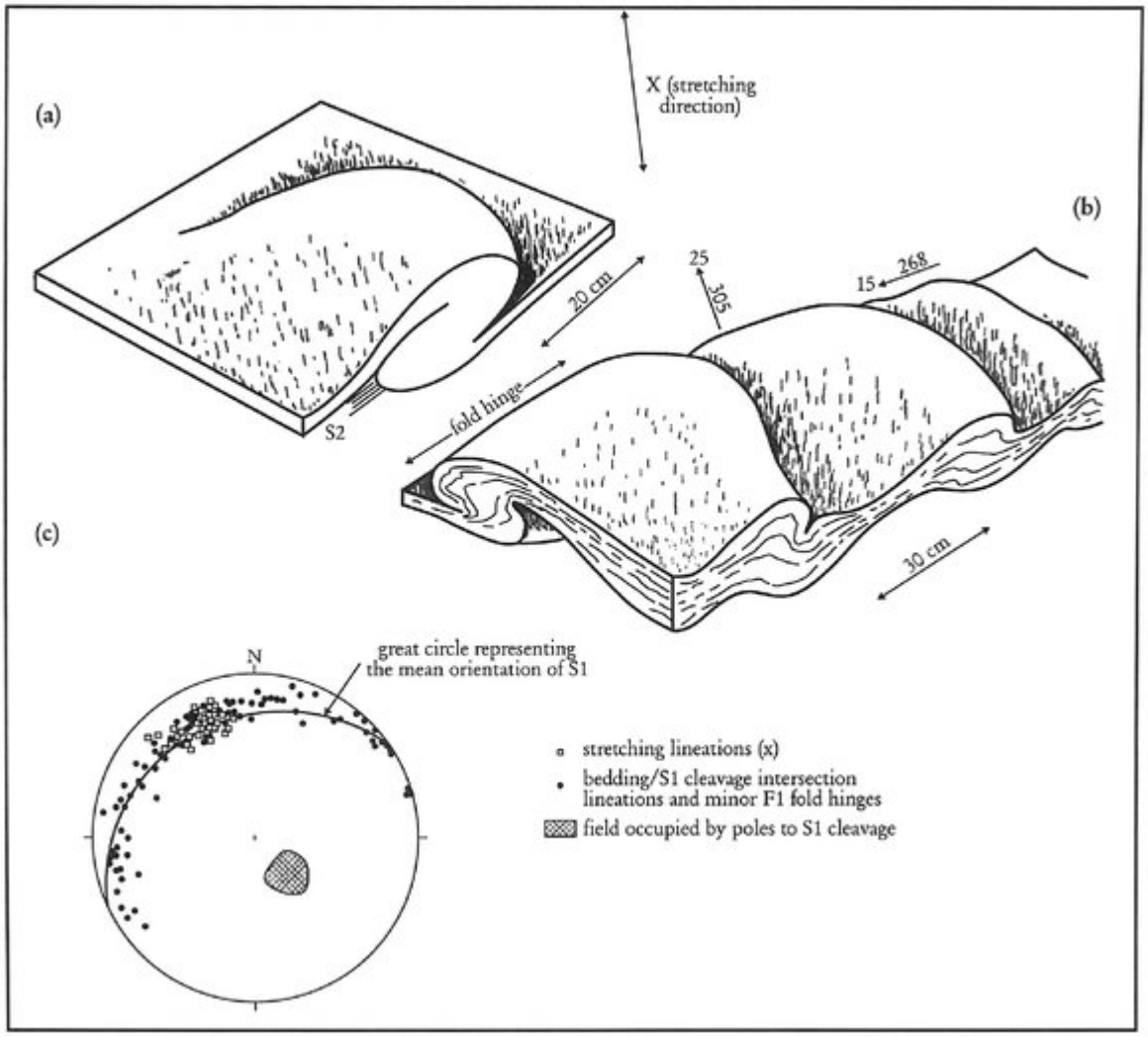
References



(Figure 2.36) Map of the area around the Strone Point GCR site, showing the position of the Ardrishaig and Strone Point anticlines, linked by an inferred syncline (modified from Borradaile, 1970). The inset map shows the detailed geology of the Strone Point GCR site.



(Figure 2.37) Strongly folded and cleaved layers of orange-brown metacarbonate rock (C) and grey-green phyllitic metamudstones (P) define rather open S-folds on the lower part of the hinge-zone of the Strone Point Anticline at Strone Point [NN 1183 0884]. The penetrative S1 cleavage dips at a shallow angle to the north-west, the direction of view being to the south-west. Solid lines highlight the trace of the bedding. Hammer shaft is 47 cm long. (Photo: P.W.G. Tanner.)



(Figure 2.38) Sketch of typical curvilinear folds at Strone Point, based on part of figure 19 of Voll (1960). The geometry of the folds is illustrated by the equal-area stereographic projection, reproduced from figure 2a of Borradaile (1970), augmented by data collected by P.W.G. Tanner.