
4 Portincaple

[NS 227 928]–[NS 232 937]

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4.1 Introduction

This GCR site is situated on the eastern shore of Loch Long at the small hamlet of Portincaple (Figure 4.11)a. It consists of a rock platform fringing the coastline in the south, and low cliffs in the north that together expose an excellent section through the southern part of the hinge-zone of the Highland Border Downbend. This structure was responsible for rotating the Tay Nappe from an originally gently dipping orientation now represented by the Flat Belt, to its steeply dipping orientation in the Highland Border Steep Belt (as represented by the *Cove Bay to Kilcreggan* GCR site).

Here, the broad, open form of the F4 hinge-zone and the concordant geometry of the related minor structures are clearly shown. The geometry and vergence of D3 structures may also be readily examined, and there is clear evidence of their refolding by the major F4 downbend. The value of this site is also enhanced by the fact that it is the first significant accessible coastal section on the lower limb of the Tay Nappe north of Coulport, 5 km to the south. All of the intervening ground has been acquired by the Ministry of Defence and closed to public access.

The rocks consist of metagreywackes belonging to the Beinn Bheula Schist Formation. Bedding was thoroughly reworked during the formation of two pressure-solution cleavages (S1 and S2) and has been largely destroyed or rendered obscure during the process. However, a wealth of folded and overprinted cleavages, intersection and stretching lineations, and minor folds belonging to the three latest generations of structures, are very well preserved in clean rock exposures above mean tide level.

The Portincaple GCR site lies on the eastern margin of BGS 1:50 000 Sheet 37E (Loch Goilhead, 1990), but neither the map nor the original sheet memoir (Peach *et al.*, 1905) provide any geological information specific to this site. The Tay Nappe and the manner in which it is bent down by the Highland Border Downbend were first recognised by Shackleton (1958), from mapping in adjoining areas and the hinge structure at Portincaple was first mapped by Stringer (1957). The area then received no further attention until Roberts (1977b) gave a brief description of the minor structures seen at Portincaple. This was followed by a more-detailed field guide to the locality by Tanner (1992).

4.2 Description

The Beinn Bheula Schist Formation belongs to the upper part of the Southern Highland Group and consists of fine- to coarse-grained metagreywacke and metasiltstone interbedded with lesser amounts of grey-green phyllitic rock. Bedding in these rocks has been largely destroyed, except in a few gritty, non-graded metagreywackes and one prominent, non-graded, pebbly metaconglomerate, less than 1 m thick, which appears to be little deformed.

The Beinn Bheula Schists are highly contorted due to the cumulative effects of four separate deformation events. The main planar element is the spaced S2 fabric, generally seen as anastomosing microlithons a few millimetres to over 1 cm thick, within which traces of the S1 spaced fabric can be seen in places. This fabric is identical to that which dominates the northern part of the *Cove Bay to Kilcreggan* GCR site but here it has been deformed by two further deformations, D3 and D4.

A SSE-plunging stretching lineation is seen as silky striations that make a high angle with the L2 on S2 cleavage surfaces. It is also present as quartz-fibre lineations in many of the quartz-carbonate veins.

The D3 deformation is represented by fairly common sideways-closing folds which invariably have the same vergence and Z-shaped down-plunge profile throughout the area. The axial-planar dip of these folds varies in a progressive but non-systematic manner from 50° N at the southern end of the section, to around 20° N in mid-section, to about 5° N at the northern end. The minor folds are on a decimetre scale and are curvilinear, plunging at a low angle to both east-north-east and west-south-west. In these rocks they fold the S2 spaced cleavage, the L2 intersection lineation seen on the S1 cleavage, and the stretching lineation (?L2). A weak S3 crenulation cleavage is largely restricted to the hinge-zones of these folds, where it cuts across and dissects the folded S2 cleavage.

Step-like, metre-scale, F4 minor folds are found throughout the coastal section (Figure 4.11)b. These folds are open to close, upright structures that have nearly horizontal, slightly curvilinear fold hinges. Their steep limbs are parallel to the mean orientation of the foliation in the Steep Belt, and the near-horizontal middle limb is parallel to the general orientation of the same foliation in the Flat Belt (Figure 4.11)b. The associated crenulation cleavage is near vertical and has a fairly constant strike (070–080°) but can be seen in the field to vary in dip about the vertical as a result of cleavage refraction through rock packages of differing competence. It is characteristically widely spaced (1–2 mm) (Figure 4.12)c. Flat-lying kink bands that rework the S4 cleavage are seen locally. An equal-area stereographic plot of poles to S2 and S4 shows that the major fold plunges at 10° to 079° (Figure 4.11)c.

A number of faults are seen in the southern part of the GCR site. They are either vertical or dip steeply to the south and have a mean spacing of about 4 m (Figure 4.11)b.

4.3 Interpretation

This GCR site is situated at the northern extremity of the Highland Border Steep Belt where it turns into the antiformal closure of the Highland Border Downbend, which is in effect a monoform. The northern limb of the downbend (the Flat Belt) is best seen 3 km farther north near Glenmallan [NS 249 965], where the exposures are on two natural rock platforms formerly accessed by fixed steel ladders from road level. There, the composite S1/S2 fabric is generally flat-lying but is affected by strongly developed upright F4 folds associated with a steep to vertical crenulation cleavage.

In the southern part of the Portincaple GCR site, F4 minor folds with wavelengths of over 2 m are clearly congruous to a major antiformal structure to the north and adopt a neutral vergence in northern part of the section as the major fold hinge-zone is entered. The axial trace of the major antiform/monoform trends parallel to the strike of the measured crenulation cleavage and this fold correlates with that identified on Loch Lomondside by Stringer (1957) and Shackleton (1958).

No major F3 folds have been recognized in this area and this phase of folding appears to have only local significance, for D3 structures are absent to the north-east along strike from Aberfoyle (Tanner and Leslie, 1994) (see the *Craig a' Barns* GCR site report). Ever since it was first discovered by Clough (in Gunn *et al.*, 1897), there has been disagreement over the relative age of the downbend, but from the data presented here it is clear that it is a D4 structure.

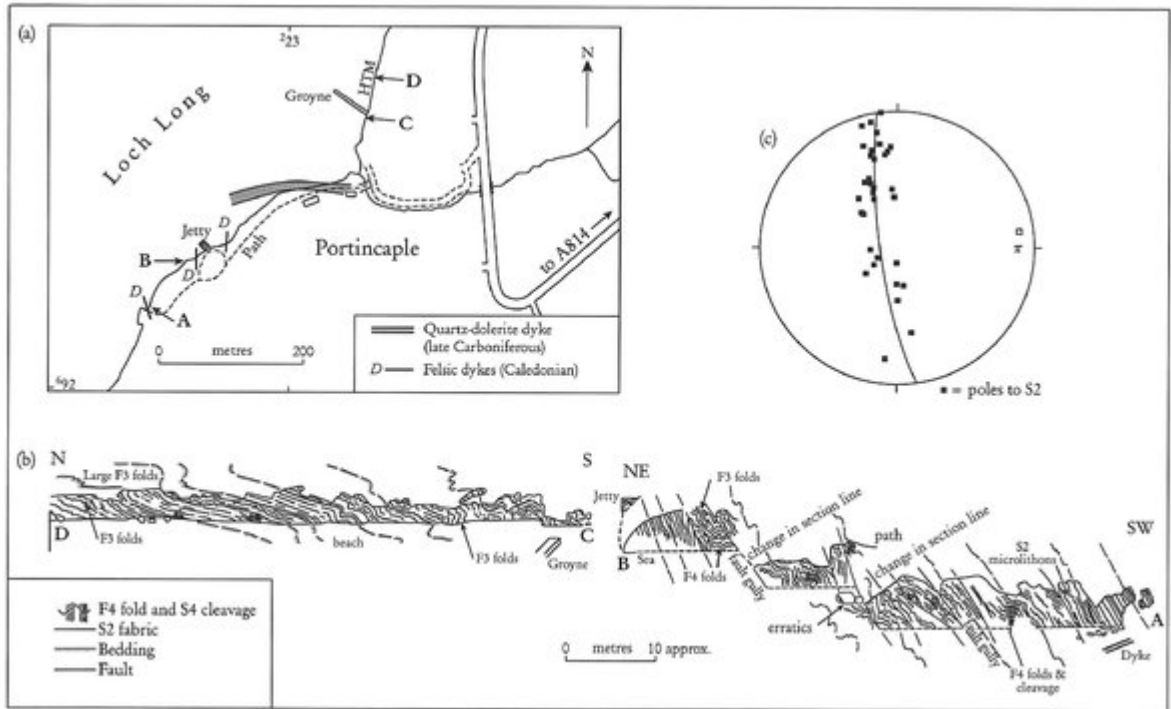
4.4 Conclusions

The *Portincaple* GCR site provides the best accessible coastal section through part of the hinge-zone or closure of the Highland Border Downbend to be found in the south-western Grampian Highlands. This major D4 structure is responsible for folding the Tay Nappe into a downward-facing structure along the entire Highland Border zone from Loch Lomond to Stonehaven.

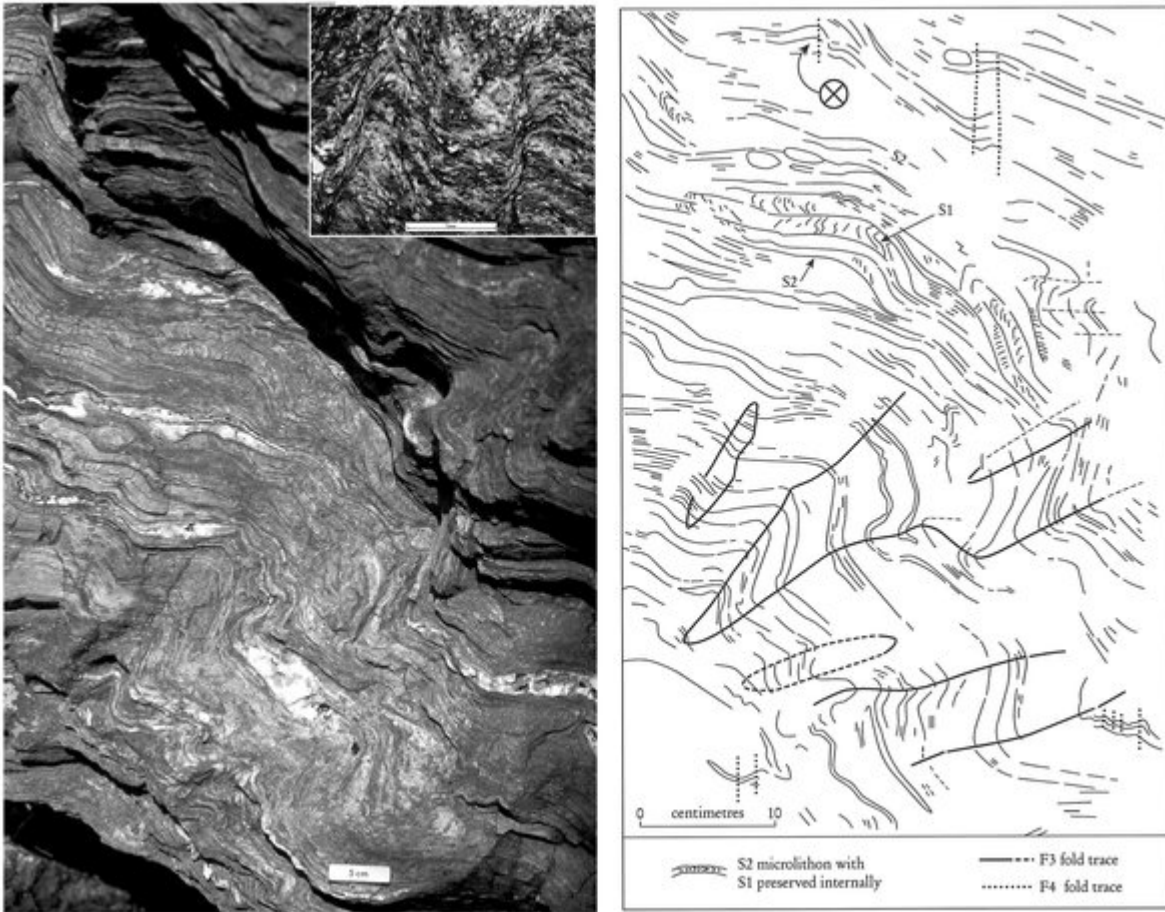
At this GCR site, minor structures formed in all four of the main deformation episodes to affect the Dalradian succession can be identified, and it is an excellent section for demonstrating the effects of three-dimensional polyphase deformation. Geometrical integrity of individual phases can be demonstrated, despite the seemingly chaotic assemblage of ductile structures and the complexity of their interference patterns. The clean rock exposures provide a wealth of information on the minor folds, cleavages, lineations, veins and fracture geometry found in this complex zone.

This site could be considered as the type section for studying the D3 deformation and for separating it clearly from the effects of D2 and of D4. It therefore contrasts with and complements the section farther north-east in the Birnam area at the *Craig a' Barns* GCR site, where D3 is not developed.

References



(Figure 4.11) (a) Location map of the Portincaple GCR site. Bedrock is the Beinn Bheula Schist Formation, cut by the few dykes shown. A–B, C–D, lines of cross-section for (b). (b) True-scale field sketch of a vertical cross-section, viewed approximately down-plunge for F4, across the southern part of the hinge-zone of the Highland Border Downbend (F4). The main fabric in these rocks is a centimetre-spaced pressure-solution (or dissolution) cleavage (S2). (c) Equal-area stereographic projection showing poles to the S2 fabric that defines a best-fit great circle whose π axis plunges at 10° to 079° , parallel to the major F4 fold axis of the Highland Border Downbend.



(Figure 4.12) (a) A vertical rock face in the Bheinn Bheula Schist Formation at Portincaple [NS 2297 9327], viewed to the north-east (054°), showing asymmetrical, Z-shaped F3 folds on the southern limb of the Highland Border Downbend. The D3 structures deform the main S2 spaced fabric; the poorly developed minor upright F4 folds are accompanied by a near-vertical, crenulation cleavage that, although restricted to the pelitic seams, is clearly imprinted on and hence post-dates all of the other structures. Note the local preservation of the S1 fabric within the S2 microlithons. (Photo: P.W.G. Tanner.) (b) An explanatory outline drawing of (a). (c) Photomicrograph of the S4 crenulation cleavage at X on (b). (Photo: P.W.G. Tanner.)