13 Fearnach Bay

[NM 838 130]–[NM 832 141]

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Published in: The Dalradian rocks of the south-west Grampian Highlands of Scotland. PGA 124 (1–2) 2013 https://doi.org/10.1016/j.pgeola.2012.07.008. Also on NORA

13.1 Introduction

Fearnach Bay is located at the head of Loch Melfort, some 11 km east-north-east of the *Black Mill Bay* GCR site on the Isle of Luing. The GCR site consists of a narrow strip of coastal exposures, divided into two parts by the estuary of the River Oude (Figure 2.29). The rocks belong to the Craignish Phyllite Formation (Easdale Subgroup), and consist mainly of grey-green, generally calcareous, phyllitic metamudstones and metasiltstones, with thin quartzite and metacarbonate beds. The strata are largely right-way up, dip at a moderate angle to the east, and were strongly folded on all scales, from microscopic to mesoscopic, during the main phase of deformation (D1). The effects of later deformation on these structures are minimal.

The section provides a well-exposed sequence of rock types that characterize the Craignish Phyllite, and displays in splendid detail the 3-dimensional geometry of the first generation of minor folds and cleavages. Minor fold vergence, cleavage-bedding relationships, and way-up structures all indicate that the strata lie on the north-western limb of the Loch Awe Syncline. This GCR site also presents a good example of cylindroidal fold geometry on a mesoscopic scale ((Figure 2.29), inset), together with excellent examples of structural features such as cleavage refraction and cleavage fans, and sedimentary structures such as pseudo-ripple marks and ripple-drift lamination.

There is very little published work on the geology of this GCR site, apart from a comment in the original Geological Survey memoir (Peach *et al*., 1909); strain measurements made on a deformed basic sill (Borradaile, 1972b); and a brief mention in a field guide (Borradaile, 1977). The rock types closely resemble those at the *Port Cill Maluaig* and *Strone Point* GCR sites, but the structural styles at the three localities are completely different.

13.2 Description

The Craignish Phyllite Formation at Fearnach Bay consists largely of finely banded grey-green phyllitic metamudstone, with units of more-siliceous phyllitic metasiltstone up to 20 cm thick. The metamudstones and metasiltstones are commonly interbedded with thin beds of orange-brown-weathering metacarbonate rock, which vary from 2–6 cm in thickness, and have a characteristic etched appearance. In places, particularly in the north of the site around the pier, they are accompanied by beds of massive metacarbonate rock up to 20 cm thick, which show a gradational contact with the siliciclastic host rock. Beds of fine-grained, white quartzite from 15–50 cm thick occur throughout the sequence. South of locality A [NM 8350 1342] (Figure 2.29), the Craignish Phyllite becomes lithologically more monotonous; it is more siliceous and tougher, less well bedded, and with fewer metacarbonate and quartzite beds than farther north. Quartz-carbonate veins occur throughout the sequence.

Taken as a whole, the sequence becomes younger to the east. Ripple-drift cross-lamination is the main way-up indicator and occurs in units up to 3 cm thick at the base of thick, orange-brown metacarbonate beds (Figure 2.30)a, and also in alternating sequences of ripple-drift structures and 1–3 cm-thick metacarbonate beds, forming stacks up to 0.5 m thick.

The structure consists of a number of asymmetrical early (F1) folds, usually in pairs, which have N–S-trending axial traces. They are accompanied by a penetrative slaty cleavage (Figure 2.30)b that is associated with a poorly developed stretching lineation, plunging to the east-north-east at around 30°. The cleavage shows marked refraction across the more-competent layers in the slaty metamudstone, and slight normal fanning in fold closures. Metre-scale mesoscopic

folds are found throughout the section; in the north, in exposures around the pier, there is a set of at least five folds with overall vergence indicating a syncline to the east. Bedding in the middle limbs of these structures dips at 80°, and is overturned locally. The associated slaty cleavage dips at *c*. 31°, and the fold hinges plunge at *c*. 10° towards 002°. There is evidence for a preceding episode of layer-parallel extension, or boudinage.

Many of the beds east of the pier display patterns of lenticular, discontinuous, en-echelon, regularly spaced, pod-like structures on their top surfaces, which are 5–10 cm long and 4 cm deep. Bottom structures have been reported from this GCR site by Borradaile (1977), but those examples are pseudo- or tectonic ripples resulting from the development of small, doubly plunging, en-echelon, buckle folds on the surface of the bed.

South of the River Oude, the coastal section as far as locality A, runs parallel to the strike of both bedding and cleavage, but several natural cross-sections are seen. In two of these sections a deformed basic intrusion is seen to be concordant with bedding in the metasedimentary rocks, and shows some internal compositional layering. A 15 cm-thick bed of quartzite, with what appears to be a muddy top, occurs between it and the more-typical phyllitic country-rock. The sill can be traced around several fold closures at this locality, and contains a penetrative fabric, defined by flattened amygdales. This fabric is continuous with the slightly fanned, slaty cleavage in the adjoining rocks. Measurement of the strain, represented by deformed amygdales, carried out at two localities by Borradaile (1972b, locations 13 and 14), gave X/Y ratios of 2.87–2.91. Buckle folds, affecting beds that vary considerably in thickness and competence, give rise to a plethora of minor folds whose wavelengths show a marked positive correlation with the bed thickness.

The geometry of the tectonic structures at this GCR site is summarized by the stereographic projections in (Figure 2.29). Because the cleavage in the northern section has a more-shallow dip than in the southern section, there is quite a large spread in the orientation of poles to the S1 slaty cleavage. The computed π-axis derived from a plot of poles to bedding for the whole site is [plunge 05°NE; trend, 020°; N (number of readings)=20]. This is almost coincident with the mean orientation for the calculated best-fit line of intersection of the slaty cleavage planes [plunge 04°NE; trend, 024°; N=10] and the mean orientation of bedding-cleavage intersections and minor fold hinges [plunge 06°NE; trend, 021°; N=9], and shows that on a major scale, the structures are almost perfectly cylindroidal. It also demonstrates the inherent symmetry of structures in rock.

A second tectonic fabric (S2) is present locally as a millimetre-spaced crenulation cleavage in slaty metamudstone layers, and generally dips at less than five degrees. It is associated with rare, centimetre-scale, late folds, which refold tight to isoclinal F1 folds and plunge at a low-angle to the north-north-east.

13.3 Interpretation

The Craignish Phyllite was laid down in a shallow-water environment, as witnessed at this GCR site by the preservation of abundant ripple-drift bedding at different levels in the sequence. The depositional environment was probably similar to the near-shore to intertidal settings in which gypsum-bearing sediments, preserved at the *Craignish Point* GCR site, were being deposited at the same time (Anderton, 1976). However, in the area of Fearnach Bay, the Craignish Phyllite originally consisted of somewhat calcareous muds and silts (now metamorphosed to chlorite-white mica-carbonate-bearing phyllitic metamudstones and metasiltstones) and this contrasts with its lateral equivalent at Craignish Point, 15 km to the south-west, where the formation was formed from interbedded sands and silts with subordinate muddy layers.

The Craignish Phyllite is correlated across the Loch Awe Syncline with the Ardrishaig Phyllite. Indeed, the Craignish Phyllite at Fearnach Bay has much more in common with the Ardrishaig Phyllite, as seen at the *Strone Point* and *Port Cill Maluaig* GCR sites, than with rocks of the same formation farther west (i.e. at the *Craignish Point* GCR site). This is because the rocks at the three easterly sites are at a higher metamorphic grade, and have been more pervasively deformed, than the same lithostratigraphical sequence farther west.

The fold structures at Fearnach Bay are of primary, D1, age and appear to be virtually unaffected by any later deformation. They may be correlated with D1 structures at the *Black Mill Bay* GCR site, with which they share a common geometry (compare the inset on (Figure 2.29) of this report with the inset on (Figure 2.25) of the *Black Mill Bay* GCR site

report).

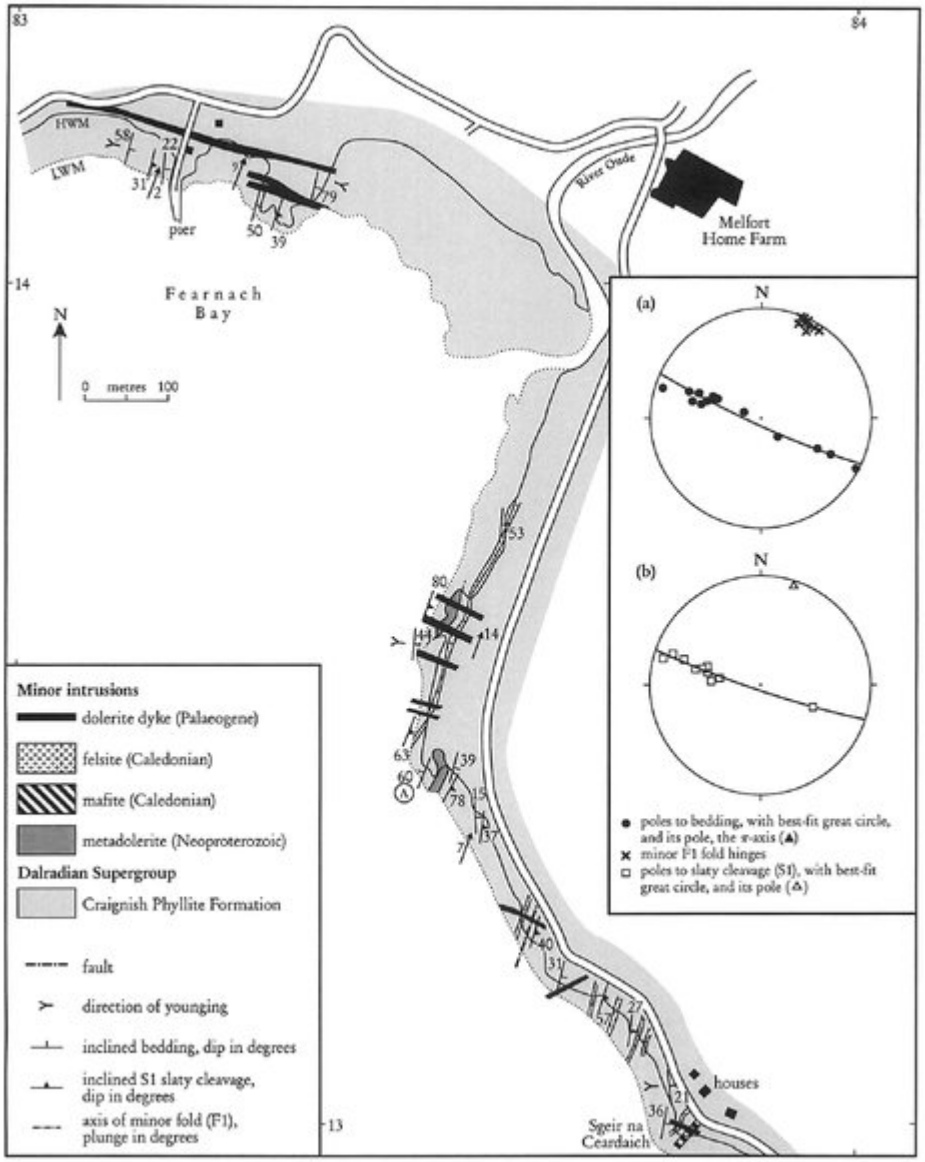
13.4 Conclusions

The Fearnach Bay GCR site occupies a crucial position on the north-western limb of one of the most fundamental structures of the South-west Grampian Highlands, the near-upright F1 Loch Awe Syncline. A train of metre-scale folds, accompanied by a penetrative cleavage, is virtually unaffected by later deformation making this a site of major national importance. The geometry of the minor structures, which include folds, cleavage, and lineations, is that of a perfectly cylindroidal structure plunging at *c*. 5° to the north-north-east. Cleavage dips more steeply than bedding on the long limbs of these folds, consistent with their position on the north-western limb of the regional-scale fold. The inspiration to be gained from seeing such beautifully preserved folds and related cleavages in three dimensions, in all of their intricate detail, enhances the value of the site considerably.

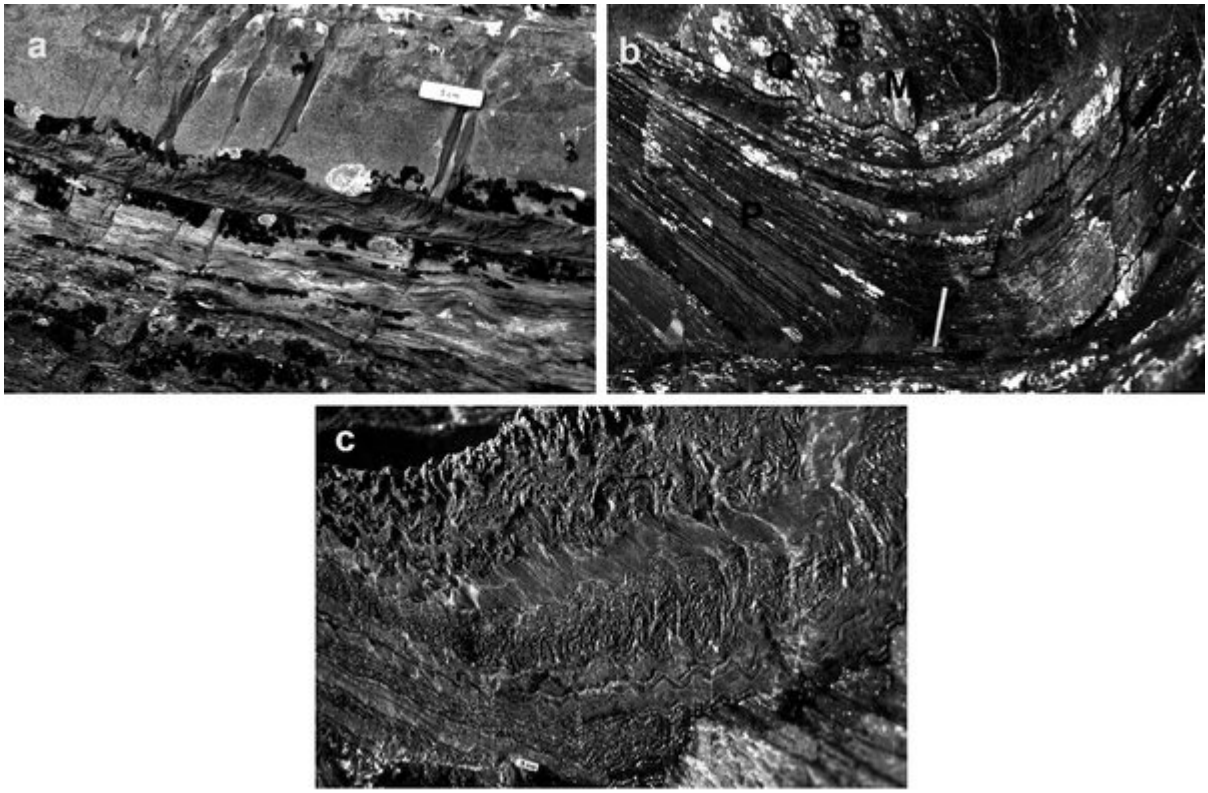
The Dalradian rocks at this GCR site were formed from muddy and calcareous sediments, laid down in a shallow-water environment, and represent a more highly metamorphosed and deformed part of the Craignish Phyllite than is seen at the *Craignish Point* GCR site. Hence, this site provides a lithostratigraphical link, between the Craignish Phyllite and its generally higher grade equivalent on the other limb of the Loch Awe Syncline, the Ardrishaig Phyllite.

Regional metamorphism (to lower greenschist facies) altered the mud-rich sedimentary rocks to chlorite-white mica-rich phyllitic rocks, and caused recrystallization of the less reactive rocks such as limestone and quartzite. After lithification, the sedimentary rocks were intruded by basic magma that crystallized to form several thin sheets, concordant with the bedding.

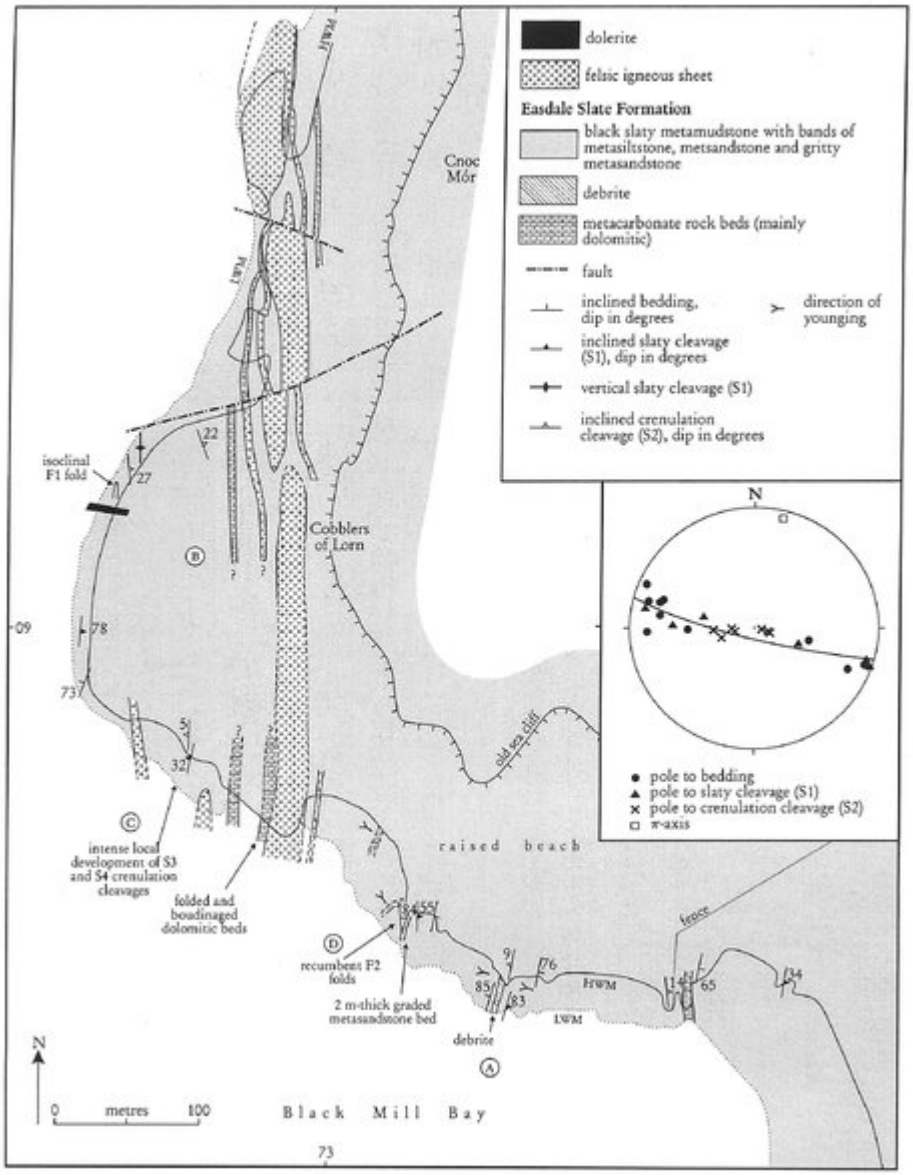
References



(Figure 2.29) Map of the area around the Fearnach Bay GCR site, Loch Melfort. A, locality mentioned in the text. Inset: Equal-area stereographic projections of poles to bedding, together with minor D1 fold hinges, and slaty cleavage (S1) (see text for explanation).



(Figure 2.30) (a) Cross-lamination at the base of a massive bed of metacarbonate rock in the Craignish Phyllite Formation, [NM 8336 1406], Fearnach Bay, Loch Melfort. Scale is 5 cm long. (b) The contact between a basic sill (B) and phyllitic semipelite (P) folded by an upright F1 syncline at locality A [NM 8350 1342], Fearnach Bay, Loch Melfort (Figure 2.29). The fanned cleavage in the phyllite contrasts with the axial planar cleavage in the metadolerite sill (M). A thin band of quartzite (Q) occurs at the contact. Hammer shaft is 60 cm long. (c) Intense folding of sandy metacarbonate layers, and cleavage refraction in the intervening metapelite, within the Craignish Phyllite Formation, a short distance north of locality A [NM 8350 1342], Fearnach Bay, Loch Melfort (Figure 2.29). The bar scale is 5cm long. (Photos: P.W.G. Tanner.)



(Figure 2.25) Map of the area around the Black Mill Bay GCR site. A–D, localities mentioned in the text. Inset: An equal-area stereographic projection of poles to bedding, slaty cleavage (S1), and crenulation cleavage (S2), together with the best-fit line (π-girdle) containing the poles to bedding and cleavage. The nearly horizontal π-axis, gives the mean orientation of the related major fold axis.