# Farr Bay (Bettyhill)

[NC 711 632]–[NC 719 624], [NC 701 620]–[NC 724 615]

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## Introduction

The Farr Lewisianoid Inlier and adjacent migmatitic Moine metasedimentary rocks are well exposed in clean exposures along the high-water mark at the north-east end of Farr Bay. These rocks strike south-east through sand dunes and are next seen in inland cliffs adjacent to the lower part of the Clachan Burn, immediately south of the A896 road (Figure 6.27). Locally, excellent examples of fold interference structures in gneisses of the Bettyhill Banded Formation (Moine) are seen. There are also roadside exposures immediately south of Clerkhill, for example at [NC 7160 6280], which show augen hornblende-granite gneisses, ultramafic (hornblende-pyroxene) rocks, and amphibolites belonging to the Clerkhill Intrusion, previously referred to as the 'Clerkhill Appinite Suite' (Moorhouse *et al.,* 1988).

B.N. Peach first mapped the Bettyhill–Farr area for the Geological Survey in 1891–1892. Cheng (1942, 1943) subsequently studied the complex metamorphic and structural relationships between the hornblendic gneisses, the amphibolites and the Moine metasedimentary rocks. Cheng (1943) termed the Farr Lewisianoid gneisses 'Durcha Moines' (see 'Introduction' and Allt Doir' a' Chatha GCR site report, this chapter), but distinguished them from the Clerkhill and other mafic rocks of the Bettyhill area. V.E. Moorhouse remapped the area in the 1970s (Moorhouse, 1979; Moorhouse *et al.,* 1988). More recently I.M. Burns studied the tectonothermal evolution and petrogenesis of the Naver and Swordly nappes (Burns, 1994).

## Description

Farr Bay is a NW-facing sandy bay that lies about 1 km north-east of Bettyhill. Rocky cliffs bound its outer parts and the bay is backed by extensive sand dunes. Although the degree of exposure in the bay varies yearly, dependent on the amount and distribution of blown sand, the exposures provide instructive sections across lithological strike and exhibit remarkable structural detail.

The site also includes a well-exposed section in the lower rocky gorge of the Clachan Burn, and in the cliffs of Creag Clachain [NC 714 621] and Creag a' Bhodaich [NC 7230 6215], both of which lie immediately south of the main A836 road.

The dominant lithologies around the bay and in Creag Clachain and Creag a' Bhodaich are migmatitic, layered, gneissose Moine psammite and semipelite of the Bettyhill Banded Formation. On the east side of the bay are thinly layered hornblendic felsic and mafic gneisses of the Farr Lewisianoid sheet. This sheet is some 80–100 m wide adjacent to the sandy bay, but lenses out to the north-west (Figure 6.27). The sheet can be traced to the south-east for 3 km to just west of Loch Strathy [NC 777 471].

The primary compositional layering in the Moine metasedimentary rocks reflects the original bedding, but any evidence of sedimentary structures has been destroyed by the polyphase amphibolite-facies metamorphic events and related migmatization. These have resulted in a recrystallized, and in part segregated, foliation, with new mineral assemblages and textures. Pegmatite granite, quartz and quartz-feldspar veins, pods and stringers of various widths are abundant in these migmatitic rocks. The migmatitic layering and veining commonly show small- and medium-scale folding that varies in style from tight early folds to more-open later folds. A typical example is seen at [NC 7177 6212] where Z-profile, close to tight folds show NNE- to SE-plunging axes. A prominent axial rodding and mullioning is seen, particularly in the quartz and quartz-feldspar segregation veins. The fold axial planes lie sub-parallel to the regional foliation and dip steeply to the ENE.

Evidence for the several deformation phases that have affected the Moine rocks is well seen in Farr Bay. Clean and etched exposures reveal tight F2 folds and more-open, upright F3 folds, which in places combine to form fold interference structures. At [NC 7159 6272], situated at the top of a sandy scree slope, is a classic example of a type-3 fold interference structure (Ramsay and Huber, 1987) (Figure 6.28). Tight F2 structures with SE-plunging axes fold the fine-scale migmatitic layering and are refolded by close to tight F3 folds. The later F3 folds are almost coaxial with the earlier F2 structures but have ENE-dipping axial surfaces.

There are two small exposures of layered felsic and mafic gneiss of the Farr Lewisianoid Inlier at the high-water mark in the bay [NC 7146 6266]. More-extensive exposures are seen south of the A836 road in the lower Clachan Burn and here clinopyroxene-bearing mafic gneiss is recorded (Moorhouse, 1979). The Moine–Lewisianoid boundary is exposed at [NC 7180 6210] and farther south-east in the Clachan Burn sections, but no obvious dislocation is observed. The Lewisianoid rocks are massive, cream, pink and dark green-black, thinly striped, hornblende-bearing acid and mafic gneisses with amphibolite pods and lenses. They show no sign of a strong superposed fabric near the margin of the inlier. The Farr Lewisianoid sheet is the only significant 'basement' body within the Naver Nappe (British Geological Survey, 1996), although smaller lenses of Lewisianoid gneiss occur farther to the SSE. Small inliers are also found in the footwall of the Swordly Thrust to the east.

Metamorphosed ultramafic (hornblende-pyroxene) rocks, amphibolites and dioritic gneisses with abundant pink K-feldspar augen, which together constitute the western part of the Clerkhill Intrusion, can be examined in roadside exposures near [NC 7160 6280] (see Glaisgeo–Farr Point GCR site report, this chapter). The Clerkhill Intrusion is separated from the eastern boundary of the Farr Lewisian body by a thin zone of migmatitic psammitic gneiss (Figure 6.27).

## Interpretation

The Farr Lewisianoid sheet occurs in a relatively low-strain zone (evidenced by the local occurrence of fold interference patterns) and is structurally symmetrical with similar Moine metasedimentary rocks on both sides. Hence, Moorhouse *et al.* (1988) inferred that it occupies a complex fold core, similar to other Lewisianoid inliers in Sutherland (Strachan and Holdsworth, 1988). The lithologies exposed and geochemical evidence provided by Moorhouse (1979) suggest that the gneisses have affinities with the Scourian gneisses of the foreland Lewisian. However, recent isotopic data on the Farr Lewisianoid Inlier suggests that the gneisses cannot be correlated simply with the foreland

Lewisian. Friend *et al.* (2008) obtained concordant zircon U-Pb SHRIMP ages of 2905 ± 24 Ma for the protolith of the Farr Lewisianoid gneisses. There was no evidence of the 2490 Ma granulite-facies Badcallian reworking event, but a discordant array suggested significant isotopic disturbance involving Pb loss as early as *c.* 1600 Ma.

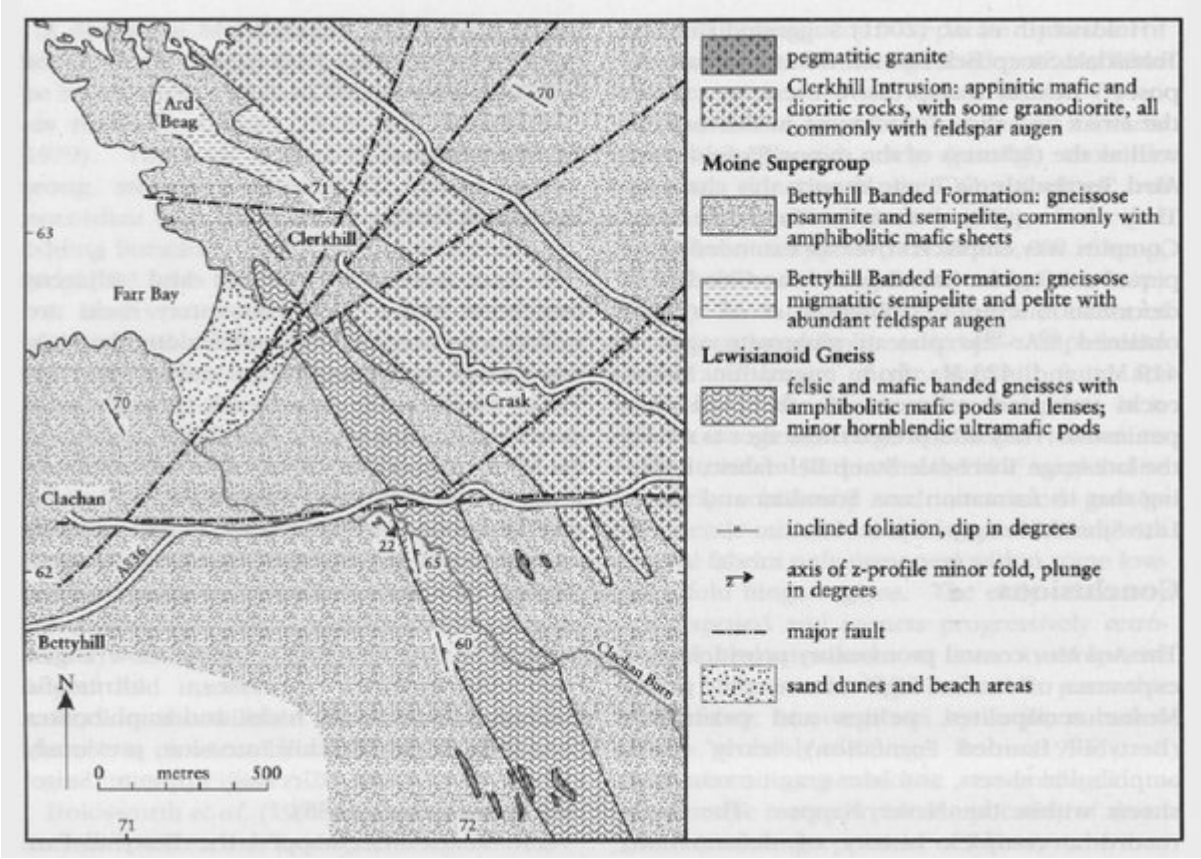
The Farr Lewisianoid sheet is believed to be the structurally highest, unequivocal Lewisianoid inlier of any significant size in the Moine succession of Sutherland. Farther east small lenticular Lewisianoid gneiss bodies lie in the footwall to the Swordly Thrust and can be traced south to Ben Klibreck. The Strathy Complex (Moorhouse and Moorhouse, 1983) that structurally overlies the Swordly Nappe farther east has petrological and geochemical characteristics suggesting a lower crustal origin. However, it is petrologically and geochemically unlike the Lewisianoid inliers elsewhere in the Moine succession and its affinity is presently unclear (Moorhouse and Moorhouse, 1983; Moorhouse *et al.,* 1988; Burns *et al.,* 2004).

The type-3 fold interference structures here described above probably lie within a narrow zone of relatively low strain, possibly close to a major F3 hinge. These F2 + F3 coaxial folds (Moorhouse, 1979) demonstrate the polyphase nature of tectonometamorphic events within the Naver Nappe. It is tempting to correlate the D2 and D3 phases with the Early Ordovician Grampian and Late Silurian Scandian orogenic events respectively (Dallmeyer *et al.,* 2001). However, it is unclear as to whether the D2 phase is Ordovician, as there is considerable evidence farther south that D2 structures are Neoproterozoic in age (see 'Introduction', Chapter 8), and there is evidence for Knoydartian metamorphism farther west. It is dear that the area has been reactivated during several orogenic events but the exact age of the particular structures and their composite nature is difficult to determine. The area appears to be less affected by the Torrisdale Steep Belt, with F2 and F3 fold axes plunging to the south-east, rather than the SSE.

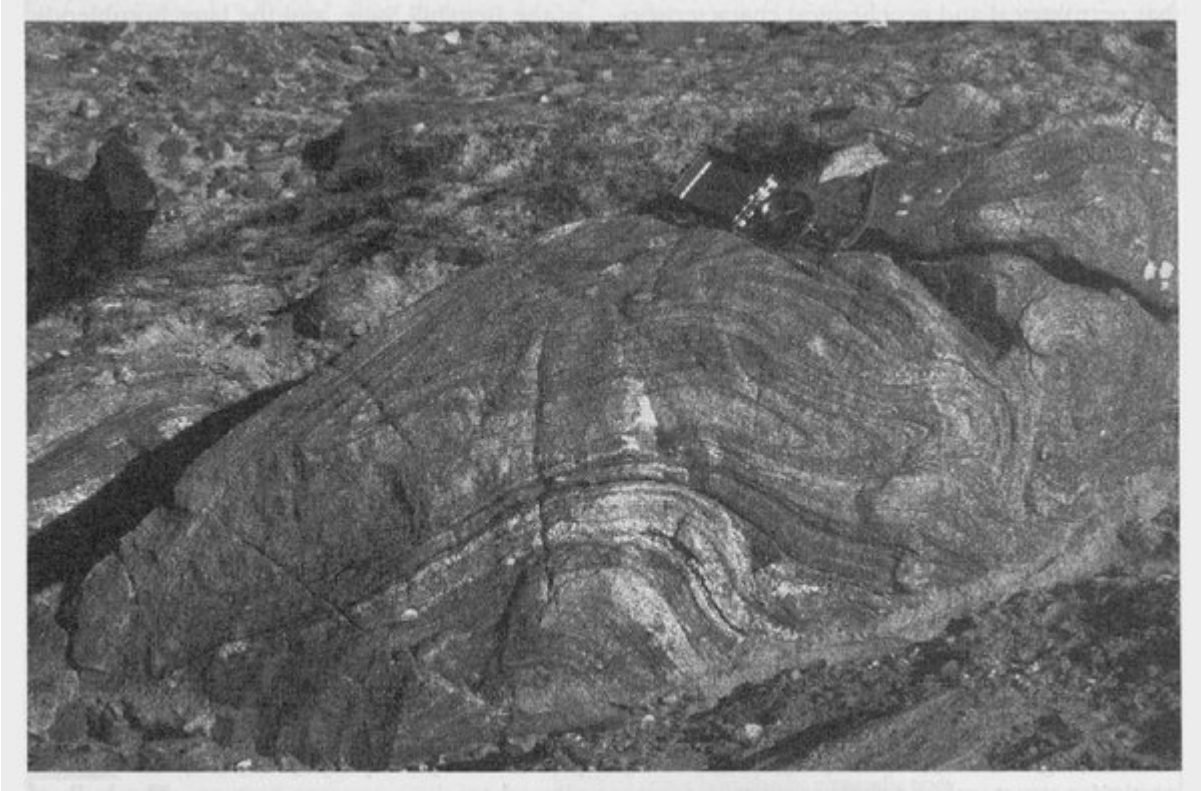
## Conclusions

The Farr Bay site provides clean exposures where the nature of the Moine and Lewisianoid rocks of the Naver Nappe can be easily studied. These pertain to basement-cover relationships, early igneous activity and the number and nature of the various orogenic events that have affected this part of the Moine succession. The basement comprises the Farr Lewisianoid body, the main Lewisianoid inlier within the migmatitic Moine rocks of north-east Sutherland that lie east of the Naver Thrust Zone. The Moine rocks are migmatitic psammitic and semipelitic gneisses of the Bettyhill Banded Formation. Superb refolded folds and minor folds in Moine psammites can be readily examined in several sand-blasted and etched rock pavements. The site is one of the few places where the three main groups of hornblendic rocks found in Sutherland are juxtaposed and thereby readily compared. These are the hornblendic mafic gneisses of the Lewisianoid inlier, the 'early Moine' amphibolites of the Bettyhill Suite, and the later hornblendic mafic and dioritic members of the Clerkhill Intrusion. The site is of national importance and is likely to remain an important locality for further study and for teaching purposes.

**References**




*(Figure 6.27) Map of the Farr Bay GCR site. Based on Cheng (1943) and British Geological Survey 1:50 000 Sheet 115W, Strathy Point (1996).*



*(Figure 6.28) Tight F2 folds refolded by more-open F3 folds giving a type-3 interference structure. Top of sandy scree slope, Farr Bay, at [NC 7159 6272]. The compass is 18 cm long. (Photo: V.E. Moorhouse, BGS No. P580518, reproduced with the permission of the Director, British Geological Survey, © NERC.)*