Dundonnell

[NH 114 880]–[NH 137 880]

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Introduction

The Dundonnell GCR site (Figure 5.37), at the head of Little Loch Broom *c. 2–4*km east of Dundonnell, demonstrates that the Moine Thrust is tightly folded, yet the intensity of folding decreases downwards in the underlying thrust sheets and may be absent altogether from lower structural levels. The structure, now interpreted as an antiformal-stack duplex, has been crucial in arguments concerning the sequence of thrust development in the Moine Thrust Belt.

During the original mapping by the Geological Survey (Peach *et al.,* 1907), considerable debate built up between different surveyors as to the relative timing of movements on the Moine Thrust and the underlying structures of the thrust belt. For the principal authors of the 1907 memoir, the field relationships in southern Assynt were critical and led them to finally deduce an overall sequence whereby the Moine Thrust was the last to develop (see Knockan Crag GCR site report, this chapter). However, Cadell (in Peach *et al.,* 1907, pp. 471–2) dissented from this model, partly based on experimental modelling (Cadell, 1888), suggesting instead that the thrusts developed with the highest (i.e. the Moine Thrust) being the earliest and the deeper ones being younger. The structural relationships at Dundonnell, illustrated in figure 45 of Peach *et al.* (1907), were cited to support his notion. Field mapping at Dundonnell (by W. Gunn) showed that the Moine Thrust is tightly folded whilst structurally lower thrusts are unfolded or only gently folded; in essence a microcosm of the Assynt Culmination. These field relationships were largely ignored until reexamined by Elliott and Johnson (1980). They restored the stack of thrust slices within the Dundonnell culmination to their original disposition and related folds farther to the east, within the Moine outcrop, to the underlying thrust process. Matthews (1984) remapped the area as part of a reappraisal of the thrust sheet geometry, but the Dundonnell locality is rarely visited despite its importance.

Description

The Dundonnell GCR site extends east for some 2 km from the top of the forestry in Srath Beag and includes the 150–200 m-high W-facing scarp and the oblong protruding Creag Chorcurach (374 m). Unfortunately, the site is not well exposed, with the flat wet peaty plateau of Fèithe Bhaite occupying its eastern part. There are a few critical exposures of the thrust sheets developed in the footwall to the Moine Thrust and there are reasonable exposures of Moine mylonites, together with less strongly deformed Moine metasedimentary rocks, around the flanks of the culmination (Figure 5.37). The crucial part of the Dundonnell GCR site lies on a broad plateau and is represented by a nearly complete window through the Moine mylonites within which lie intermediate thrust slices. It is an antiformal feature, about 1 km across, with a hinge line trending WSW–ESE.

The structure of the western part of the site is best appreciated from three stream sections (Figure 5.37). In the southern one (Allt na Creag Chorcurach), the Moine Thrust lies on a footwall of Pipe Rock quartzites. The thrust climbs up-section to the north to lie within the Salterella Grit. These An t-Sron Formation rocks, and locally the lowest beds of the Durness Group, are weakly imbricated so that the outcrop of Fucoid Beds is repeated tectonically when seen in the stream section of Allt a' Char in the northern part of the site. These imbricate slices form the lowest structures in this part of the Moine Thrust Belt, presumably flooring along the Sole Thrust, which runs at the base of the Fucoid Beds. The Sole and Moine thrusts join to the south.

In the Allt a' Char section, the imbricate slices of An t-Sron Formation are overlain tectonically by Torridonian sandstones of Elliott and Johnson's (1980) 'Sheet II'. This thrust sheet continues to the south, capping the imbricate slices of An t-Sron Formation, and eventually lensing out against the overlying Moine Thrust before reaching the Allt na Creag Chorcurach section (Figure 5.37). Shattered and generally steeply dipping Torridonian sandstones dominate the few exposures in the boggy ground that drains into the Allt a' Bhodaich. This area also contains rare exposures of Lewisian

gneisses (e.g. at [NH 120 888]), presumably basement to the Torridonian and indicative of internal thrust repetition within this thrust sheet.

The Torridonian sandstones of the composite 'Sheet II' appear to wrap around a steeply dipping panel of Fucoid Beds and Salterella Grit. Despite the rather poor exposure, this area is critical for understanding the structure at Dundonnell. There are two small groups of exposures, both characterized by very steep bedding with an ENE strike. The eastern of these two groups at [NH 126 879] shows a repetition of An t-Sron Formation stratigraphy, whereas in the western one at [NH 123 877], internal repetition within the Fucoid Beds may be inferred. These two localities represent part of Elliott and Johnson's (1980) 'Sheet IV', which forms the core of the Dundonnell Antiform. It is likely that these imbricate slices are continuous with those that crop out below the Torridonian sheet to the west.

The Geological Survey recorded an intermediate slice of Pipe Rock which wraps the An t-Sron Formation, separating it from the overlying Torridonian sheet (Peach *et al.,* 1907). Elliott and Johnson (1980) followed this interpretation, naming it 'Sheet III'. However, the only recorded exposure of this thrust sheet now appears to be obscured by peat.

The antiformal structure at Dundonnell, if rather difficult to reconstruct from available exposures in its core, is well displayed by the trend of mylonitic foliation and lithological banding within the Moine Thrust Sheet. The northern limb of the antiform may be traced eastwards as a belt of near-vertical foliation and otherwise anomalous folds (Figure 5.37). These are well displayed on glaciated pavements on Cnoc an Droighinn [NH 145 887].

Interpretation

Elliott and Johnson (1980) interpreted the Dundonnell structure as a thrust culmination, formed by the 'superposition of the sheets directly above one another'. Since then this structure has acquired international fame and become accepted as a type example of an 'antiformal-stack duplex' — a pile of imbricate thrust slices where the lower ones bulge up the higher ones into an antiformal shape (e.g. Boyer and Elliott, 1982). This type of geometry is widely thought to be diagnostic of a sequence of thrusting where the structurally highest thrust sheet was the earliest to be emplaced, followed systematically in turn by those underneath — a sequence described as 'piggy-back' (e.g. Elliott and Johnson, 1980). The earliest and structurally highest thrust sheet is folded more intensely than the later, lower sheets. Indeed, the lowest sheet need not be folded at all, as appears to be the case in Dundonnell. Although Cadell (in Peach *et al.,* 1907) suggested that the antiformal pile of thrust slices at Dundonnell demanded a 'piggy-back' thrust sequence, Peach, Horne and others thought that thrust structures at Knockan (where the Moine Thrust truncates structures in its footwall and is reasonably planar) typified the general thrusting sequence. The relative timing of structures within the thrust belt remains a topic of active research (Butler, 2004a; Butler *et al.,* 2007).

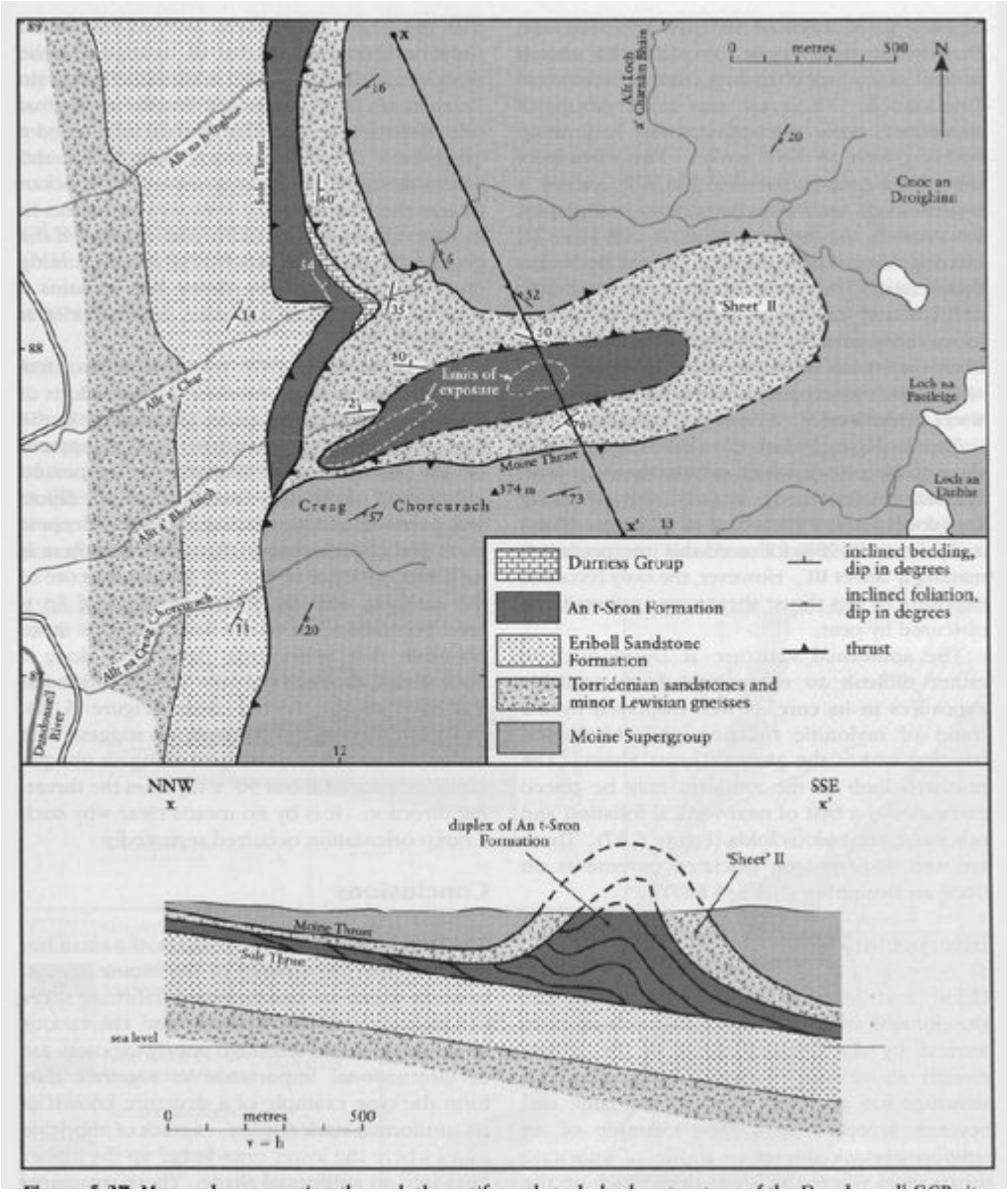
The Dundonnell GCR site does offer a few conundrums, notwithstanding the limitations of exposure in the critical parts, for example in the core of the antiform. In essence, the development of the thrust stack involves the repeated imbrication of the An t-Sron Formation. Elliott and Johnson (1980) showed that the deepest parts of the stack contain Pipe Rock but there is no direct evidence of this. By linking the core of the antiform with the imbricate slices of An t-Sron Formation just to the west, it seems more plausible that imbrication developed along a floor thrust, the regional Sole Thrust, located at the base of the Fucoid Beds (Figure 5.37). However, the trend of the antiform suggests that the imbricate zones developed along an oblique ramp, orientated about 30° away from the thrusting direction. It is by no means clear why such a ramp orientation occurred repeatedly.

Conclusions

The Dundonnell GCR site consists of a small but highly significant upwarp of the Moine Thrust, beneath which are tightly folded imbricate slices of Cambrian and Torridonian rocks. The various structural features, although poorly exposed, are of international importance as together they form the type example of a structure known as an 'antiformal-stack duplex' — a stack of imbricate slices where the lower ones bulge up the higher ones into an antiformal shape. These structures are important in explaining large-scale folds within thrust belts and orogens and also give clear evidence for the sequence of thrust development, from hinterland to foreland. This site provides a fine example of how such conclusions may be drawn

from limited field data. In this respect, the Dundonnell GCR site has historical significance: the principal original surveyors were of the opinion that movement on the Moine Thrust was the latest event, but evidence from the site suggested to other members of the team that the Moine Thrust Belt, at least locally at Dundonnell, operated as a 'piggy-back' system, with the Moine Thrust as the earliest structure.

References



(Figure 5.37) Map and cross-section through the antiformal-stack duplex structure of the Dundonnell GCR site. Based on Matthews (1984) and modified after Elliott and Johnson (1980). Note that the section line is highly oblique to the direction of movement.