

Fig. 11.7 Simplified geological map (a) and cross-section (b) of the Arnaboll hill area. Modified after Coward, 1984

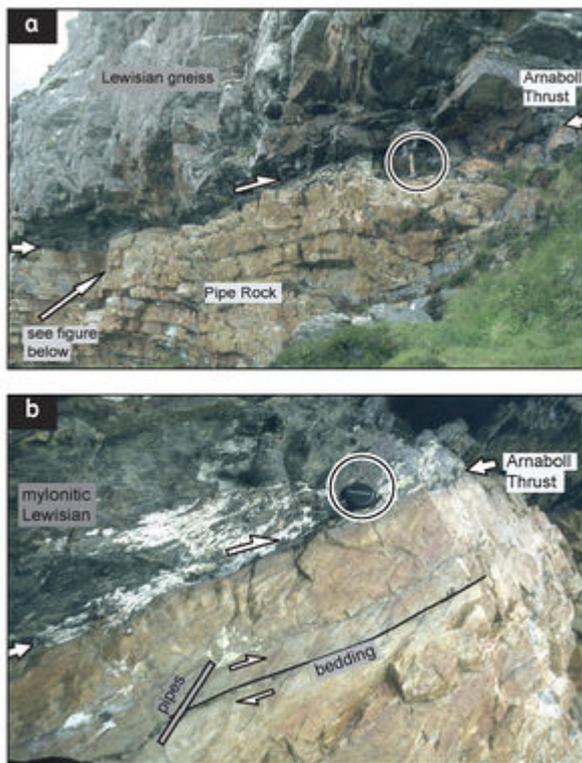


Fig. 11.8 The classic location (2C) of the Arnaboll Thrust and of Lapworth's (1883) mylonites

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Contents

- [1 Excursion 11 The Moine Thrust Belt at Loch Eriboll is composed of the following articles:](#)
- [2 Excursion 11 The Moine Thrust Belt at Loch Eriboll. Transect 2: Arnaboll](#)
- [3 Transect 2: Arnaboll](#)
- [4 References](#)

Excursion 11 The Moine Thrust Belt at Loch Eriboll is composed of the following articles:

- [Excursion 11 The Moine Thrust Belt at Loch Eriboll - introduction](#)
- [Transect 1: South Eriboll.](#)
- Transect 2: Arnaboll.
- [Transect 3: Kempie.](#)
- [Transect 4: Creagan Road.](#)

Excursion 11 The Moine Thrust Belt at Loch Eriboll. Transect 2: Arnaboll

Transect 2: Arnaboll

Along with Glencoul in northern Assynt, Ben Arnaboll is one of the most important geological sites in NW Scotland. It was here that Lapworth (1883) first demonstrated that the rock sequence was repeated by what were to become known as thrusts (Callaway did the same at Glencoul). Exposures of the Arnaboll Thrust in its type area, placing Lewisian gneisses onto Cambrian Pipe Rock, are justly famous and have inspired generations of both student and professional geologists for well over a century. Indeed Geikie (1884) first coined the term 'thrust' to describe these relationships. They are also Lapworth's (1885) type-locality for mylonites. The site was important in the 1980s for determinations of thrust sequences and for deducing the geometric evolution of rather complex thrust structures, especially by Coward (1980; 1984, 1988). It has continued to influence discussions of how basement comes to be incorporated into thrust belts (e.g. Rathbone *et al.*, 1983; Ramsay, 1997; Butler *et al.*, 2006). These inspirational outcrops form the cornerstone of this transect. The adjacent geology ([Fig.11.7](#)), chiefly concerned with imbricated Cambrian strata, is described to provide context.

The Arnaboll outcrops can readily be accessed over a period of a couple of hours, although diversions over Heilam can occupy a full day. In contrast with the southern end of the Loch, the weather in northern Eriboll is positively arid. However, the terrain is still rough and includes steep hillsides and cliffs. As ever, these outcrops should be treated with great respect and should not be hammered.

Park in the large lay-by on the A838 [NC 4520 5992], or on a portion of the old road opposite. Before starting the transect it is worth examining the view across Loch Eriboll from the parking area. The hillside on the western shore of the loch displays prominent slabs of Cambrian quartzite that incline down to the sea. This is a dip-slope, inclined at 12° which, although tilted, is essentially undeformed. These distant rocks form part of the foreland. The dip-slope can be traced southwards to the head of the loch, running down from the summits of Beinn Spionnaidh (773m) and Cranstackie (801m). The Cranstackie dip slope runs along the ridge towards the hill of Conamheall (482m). At the saddle between the hills the simple dip of bedding in the quartzites becomes disrupted. The rocks here have been imbricated, stacked up on thrusts. The lower edge of the simple dip slope is the approximate position of the Sole Thrust - the outer edge of the Moine Thrust Belt. The rest of this area is described in transect 1 of the Eriboll excursion.

Although the chief objective of this transect is the Arnaboll Thrust, the approach route crosses an important tract of imbricated Cambrian strata (Coward, 1984; [Fig.11.07](#)). These are described on the approach. From the parking area take the old road for a few metres, then head SE across boggy ground to a grassy gully [NC 4568 5971] that leads up a short escarpment.

The southern (right) side of the gully includes a cliff of Fucoïd Beds. These are thrust onto Durness

carbonates seen to the north of the gully. At the top of the gully the terrain opens up, revealing low outcrops and some rather boggy ground. Ahead, to the southeast, the upper crags of Ben Arnaboll are visible. Between the gully and these crags lie imbricated Cambrian strata, chiefly Furoid Beds and Salterella Grit together with a few metres of the uppermost Pipe Rock. The imbricates have an across-strike width of several hundred metres. Exploring geometry of these structures can be instructive. Directly ahead of the gully, across some marshy ground, lies a small outcrop of Pipe Rock, about 1m high, sandwiched between Furoid Beds (Locality 11.2A, [NC 4574 5969]). The Pipe Rock slice can be traced to the north, on the western flank of a knoll. The thickness of the slice gradually increases to about 8m, implying that the imbricate thrust that carries it changes its stratigraphic position. Indeed all of the imbricate thrusts in this area display the same trend, carrying more Pipe Rock in the north than in the south.

After this diversion, scramble to the top of the knoll (Locality 11.2B, [NC 4581 5971]) for the view onto the western cliffs of Ben Arnaboll. This view is generally down the inferred direction of thrust transport so the variations in the structure seen in the cliff are lateral. The highest crags are Lewisian gneiss, with their characteristic massive appearance, that form the hanging-wall to the Arnaboll Thrust. They lie on a near-continuous cliff of bedded, cream-coloured rocks - the Pipe Rock. The bedding is not continuous, but terminates to form features that appear to be sedimentary channels. Closer inspection reveals that these are thrust structures, with the bedding terminations representing lateral ramps. The Arnaboll Thrust is clearly visible at the base of the Lewisian gneisses. It is folded by the underlying imbricates, a feature best appreciated at the small cave [NC 4596 5938]. In the foreground, forming the gentle ground beneath the cliffs, are imbricates of Furoid Beds and Pipe Rock, readily identified from the characteristic vegetation and outcrop of these units.

The excursion now visits the exposures of the Arnaboll Thrust. From the knoll, head down the heathery slope to the southeast and then ascend the steep slope between the crags to the Lewisian of the Arnaboll Thrust sheet. This ascent is aided by an indistinct track, but beware slippery rocks amongst the heather. A brief diversion can be taken to the north to find exposures of the Arnaboll Thrust plane ([NC 4617 5951]; see White 1998). However, great care should be taken here on this steep ground. Otherwise continue onto the plateau and walk northeast along the top of the cliffs.

The outcrops hereabouts are Lewisian gneisses that show little sign of Caledonian deformation. Structures, including the gneissic banding, developed under and preserve amphibolite facies metamorphic assemblages. They are cross-cut by, presumably, late Laxfordian (Palaeoproterozoic) granitic pegmatites. At the northern end of the plateau [NC 4611 5951] there is a spectacular viewpoint north up the coast towards Whitten Head and, in the immediate ground, onto Ben Heilam ([Fig.11.1](#)). The general 'grain' of the geology, picking out the trend of the imbricate thrusts of Pipe Rock and Furoid Beds discussed above, can be traced across Heilam. To the NE lies typical Moine outcrop.

From the plateau drop carefully down to the west for a few metres. Here are the outcrops of the Arnaboll Thrust (Locality 11.2C, [NC 4615 5958]; ([Fig.11.8](#))). This internationally-important site should be treated with the utmost respect. According to Teall (see White, 1998), the site was important for Lapworth's (1885) first descriptions of mylonites. Lewisian gneisses rest tectonically upon a footwall formed of Pipe Rock. Bedding is clearly visible within these quartzites, parallel to the thrust contact. *Monocraterion* burrows show the Pipe Rock to be the correct way up, demonstrating that the presence of Lewisian gneisses above requires the contact to be tectonic, rather than, say, an upside-down unconformity. Despite the recognition of sedimentary structures, the Pipe Rock has been sheared with the prominent *Skolithos* burrows inclined with respect to bedding. Given the assumption that these burrows formed perpendicular to bedding, they constitute excellent markers by which the deformation can be quantified (see Fischer & Coward, 1982). This deformation

penetrates for at least 2m below the thrust. The sense of deflection clearly indicates a top-to-the-WNW shearing which presumably reflects the tectonic transport direction of the Arnaboll Thrust sheet.

The Arnaboll Thrust plane itself is a discrete, knife-sharp surface, although it is locally warped by minor thrust structures within the Pipe Rock below. Its hanging-wall is marked by a narrow zone of dark, chlorite-rich mylonite about 50cm wide. More than about 3m above the thrust plane the Lewisian shows few effects of Caledonian deformation (as seen on the plateau). So the thrust zone shows a dramatic gradient, not only in deformation but also in the intensity of the greenschist overprint (Wibberley, 2005). The deformation can be tracked using the pegmatites embedded within the gneisses that are progressively more streaked out and deflected towards the thrust.

If time and the inclination permit, it is instructive to walk out the Arnaboll Thrust across the slopes to the SE of Locality 11.2C as far as Locality 11.2D [NC 4626 5933]. The thrust is cut repeatedly by thrusts that climb out of the underlying Pipe Rock and up into the overlying Lewisian (([Fig.11.7](#))b). This type of geometry is described as 'breaching' (Butler, 1987) and gives a clear indication of the relative sequence of thrust development: the Arnaboll Thrust sheet was emplaced onto the Pipe Rock before the imbricates within it developed. One of the clearest examples of this geometry is to be found in the small natural amphitheatre [NC 4622 5953]. Further along the outcrop trace, the Arnaboll Thrust can be inferred to have been folded ([Fig.11.7](#)) so that it maps out as a vertical contact. At the end of the short walk (Locality 11.2D) outcrops of the Pipe Rock, from the footwall to the Arnaboll Thrust, can be found with similarly sub-vertical dips. Careful searching reveals Monocraterion burrows that, as at Locality 11.2C, young towards the Lewisian rocks of the Arnaboll Thrust sheet.

From this outcrop area head back across the plateau of gneiss, carefully locating the way through the crags on the steep escarpment that was used for the ascent, and hence return to the vehicles. An alternative route back is to walk north, joining the A838 and following this for a couple of kilometres back to the parking area.

References

At all times follow: [The Scottish Access Code](#) and [Code of conduct for geological field work](#)

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- [2. Northern Highlands](#)

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- Not logged in
- [Talk](#)
- [Contributions](#)
- [Log in](#)

- [Request account](#)

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- [Page](#)
- [Discussion](#)

Variants

Views

- [Read](#)
- [Edit](#)
- [View history](#)
- [PDF Export](#)

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- [Main page](#)
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- [Random page](#)
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- [What links here](#)
- [Related changes](#)
- [Special pages](#)
- [Permanent link](#)
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