Cnoc nam Broc, Kishorn

[NG 838 420]–[NG 892 450]

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Introduction

The southern part of the Moine Thrust Belt is radically different in structure to that in the north in that the broad systems of imbricate thrusts that stack up the Cambrian stratigraphy in the Assynt and Eriboll districts are absent. On Skye and in Lochalsh the thrust belt is characterized by a major fold–thrust complex, termed the 'Kishorn Nappe'. The best place to study the relationships between the Kishorn Nappe and underlying structures is centred on Cnoc nam Broc on the eastern side of the Kishorn Valley, between the head of Loch Kishorn and Bealach a' Ghlas-chnoic (Figure 5.48).

Despite the importance of the area, there has been little published material on the geology in and around the Cnoc nam Broc GCR site since the Geological Survey's North-west Highlands memoir (Peach *et al.,* 1907) until Butler *et al.*(2007). The origin of the Kishorn Thrust Sheet is discussed by Butler *et al.* (2006). The area is frequently visited and studied by student groups, no doubt drawn by the generally excellent exposure of imbricate thrusts and the Kishorn Nappe. It offers excellent opportunities to examine many aspects of thrust tectonics: large nappes and major thrust surfaces; deformation fabrics associated with these sequence of thrust stack development. In features; lateral variations in nappe content and addition to these examples of contractional in branching imbricate thrusts; evidence for the structures associated with the Moine Thrust Belt, the GCR site also includes the Fasagh Fault (Peach *et al.,* 1907), one of the major Mesozoic faults associated with the Sea of the Hebrides sedimentary basin (Butler and Hutton, 1994). These 'morphotectonic' structures are commonly reflected in the topography (e.g. Watson, 1984) and apparently exerted considerable influence on Cainozoic landscape evolution.

Description

Cnoc nam Broc (348 m) is a small rocky protruberance that overlooks the Kishorn Valley. To the ENE the valley side rises up to the rocky ridge of Cadha nam Fiadh (*c.* 560 m), which in turn is overlooked by Sgurr a' Gharaidh (732 m). The Lewisian gneisses of the Kishorn Nappe form these higher summits and also underlie the extensive lochan-studded rocky plateau to the south at *c.* 550–700 m. The Kishorn Thrust is mapped in the lower part of the Alt Mòr at *c.* 70 m above OD. Its trace follows the course of the Allt Mor to the ENE and then forms a distinct feature by Cnoc nam Broc and is coincident with a distinct break in slope that tracks eastwards below the prominent steep crags of Sgurr a' Gharaidh, where it attains over 500 m in altitude.

The Cnoc nam Broc GCR site (Figure 5.48) contains the southernmost outcrops of the imbricate thrusts of Torridonian strata and Cambrian quartzites that dominate the geology of the area between Beinn Eighe and Achnashellach (see Butler *et al.,* 2007; and Meall a' Ghiubhais and Beinn Liath Mhor GCR site reports, this chapter). Moving south, within the Cnoc nam Broc site, the imbricate thrusts climb up the stratigraphical section into the An t-Sron Formation and Durness Group. Peach *et al.* (1907) mapped out over 20 repetitions of the Salterella Grit, which illustrates the potential for great structural complexity within thrust belts. This lateral transition occurs over only 1–2km. Structurally overlying the imbricated Cambrian rocks is the Kishorn Nappe, a far-travelled unit, which farther south contains a thick Torridonian succession but here is dominated by Lewisian basement.

The Kishorn Thrust and Nappe

The Kishorn Nappe is composed of Lewisian gneisses together with its cover of Torridonian Sleat Group grey sandstones and minor mudstones. On the south-west flank of Cearcall Dubh [NG 855 412], (Figure 5.48)a, the Torridonian sedimentary rocks lie unconformably upon Lewisian gneisses but the succession is strongly overturned. The outcrops lie on the eastern limb of the Lochalsh Syncline, a major W-facing fold that can be mapped through the

Lochalsh district and onto Skye (Johnson, 1960; Butler *et al.,* 2006).

The critical area for understanding the relationships between tectonic units within the GCR site lies on the northern and western slopes of Sgurr a' Gharaidh [NG 884 444]. It is here (Figure 5.48)b, and around the Beallach a' Ghlas-chnoic, that the imbricate thrusts of the Achnashellach area converge with the Kishorn Thrust. The thrust crops out on a prominent bench below Creag na h-Iolaire (Figure 5.49), where it carries Lewisian basement onto Cambrian Pipe Rock. Deformation associated with the thrust may be studied north-east of Sgurr a' Gharaidh at [NG 890 447] where the hangingwall is marked by a few metres of Lewisian-derived mylonite with a moderately SE-dipping foliation, sub-parallel to the thrust surface. The foliation contains a prominent ESE-plunging stretching lineation (Figure 5.48)b and the main movement on the Kishorn Thrust may be inferred to be parallel to the lineation. In contrast, the footwall quartzites are not mylonitic, suggesting substantial displacements on the Kishorn Thrust.

To the west of Sgurr a' Gharaidh, at Creag Ghlas [NG 870 442]; (Figure 5.48)b, the contact between Lewisian and Torridonian units in the hangingwall to the Kishorn Thrust may be investigated. The Torridonian has an intense, E-to SE-dipping schistosity defined by flattened sedimentary grains and micas. Grain shapes also define an ESE-plunging stretching lineation. These fabrics have overprinted and modified any primary sedimentary structures so that, at this locality, it is difficult to demonstrate unequivocally the nature of the Lewisian–Torridonian contact. However, an inverted unconformity remains the most plausible explanation (Butler *et al.,* 2006). The same shape fabric is developed in adjacent Lewisian basement where it is defined by greenschist-facies minerals that overprint the original gneissose banding. However, pre-Caledonian agmatitic textures within the Lewisian basement may still be recognized in some exposures (e.g. [NG 870 441]). The greenschist-facies shape fabric developed in the Lewisian gneisses intensifies downwards towards the Kishorn Thrust and appears increasingly mylonitic. It is likely then that the development of the Lochalsh Syncline, to which the outcrops at Creag Ghlas belong, was associated with the formation of, and displacement on, the Kishorn Thrust (Johnson, 1960).

Beneath Cadha nam Fiadh [NG 877 445]; (Figure 5.48)b, the Kishorn Thrust carries a slice of Torridonian strata. The upper contact of the slice is marked by mylonitic Lewisian, and the mylonitic fabric is bulged around the slice, suggesting that the Torridonian slice is a distinct thrust-bound unit, rather than the unconformable cover to the Lewisian of the Kishorn Nappe. Additional support for this interpretation comes from the deformation style of the Torridonian, which is highly fractured and veined, but has no pronounced shape fabric. This is in contrast to the Torridonian sandstones at Creag Ghlas that are interpreted to be unconformable upon Lewisian gneiss within the Kishom Nappe. These issues are dealt with further in the Slumbay Island and Cam a' Bhealaich Mhoir GCR site reports (this chapter).

Imbricate zones of Cambrian sedimentary rocks

The footwall to the Kishom Thrust to the west of Sgurr a' Gharaidh lies in the Eilean Dubh Formation of the Durness Group. These carbonate rocks dominate the slopes that lead down to the Kishorn River and comprise a major part of the GCR site. The Geological Survey mapped out a series of folds and thrusts within the carbonate rocks, largely on the basis of the contact between the Eilean Dubh and Ghrudaidh formations (Figure 5.48)a. As these structures involve only carbonate rocks, it may be inferred that their floor thrust lies near the base of the Durness Group. Sheet 81E (Institute of Geological Sciences, 1975a) shows this floor thrust folded around imbricate slices of An t-Sron Formation rocks on the southern side of Bealach a' Ghlas-chnoic (Figure 5.48)a. The relationships between these two thrust systems (one in the Durness Group and one in the An t-Sron Formation) are exposed on the northern flanks of Cnoc na Creige [NG 885 452]. Here imbricate thrusts carrying Salterella Grit climb into the basal part of the Durness Group, presumably via lateral ramps. The same thrusts continue to the north where they repeat Salterella Grit and Fucoid Beds. Thus the floor thrust to the imbricate system in the carbonate rocks acts as a roof to the underlying imbricate slices of An t-Sron Formation (Butler *et al.,* 2007).

A natural section through the imbricated Cambrian sedimentary rocks beneath the Kishorn Thrust is provided by hillsides running ESE from the north-east flank of Cnoc na Creige and forming the southern side of the Bealach a' Ghlas-chnoic (Butler *et al.,* 2007). In this area the Kishorn Thrust is separated from the Durness Group by a thrust-bounded slice of Pipe Rock, one of the upper parts of the imbricate thrust system of the Achnashellach area (Figure 5.48)a. The slice tapers out against the Kishorn Thrust near Cadha nam Fiadh (Figure 5.48)b. In the eastern part of the Bealach a'

Ghlas-chnoic section the Pipe Rock is thrust over imbricated An t-Sron Formation rocks. This thrust is folded with its footwall and breached by the imbricate thrusts so that Salterella Grit and, locally, Fucoid Beds now lie upon the Pipe Rock. This style of folding and thrusting continues to the west where the imbricate thrusts and folds cored by An t-Sron Formation rocks incorporate slices of the overlying Durness carbonate rocks. Imbricate thrusts within the carbonate rocks are folded and truncated by the structurally lower thrusts.

Late faults

The east side of the Kishorn Valley contains a segment of the Caledonian deformation front on the Scottish mainland. In contrast, the western side consists of undeformed red-brown Applecross Formation (Torridon Group) sandstones, pebbly beds and local conglomerates, capped on Beinn Damh (NG 893 502; (Figure 5.48)a by Cambrian quartzites. This abrupt change is due to a major fault that throws down the thrust belt to the south-east. This structure, the Fasagh Fault (Peach *et al.,* 1907), forms part of an array of extensional structures, which affect the neighbouring Applecross peninsula and the islands of Raasay and Scalpay. Although there are no sedimentary rocks younger than the Durness Group preserved in the Kishorn area, by analogy with the adjacent regional geology, the Fasagh Fault is probably of Mesozoic age (Butler and Hutton, 1994; Roberts and Holdsworth, 1999). It is well displayed in the lower part of the Allt na Criche [NG 857 447]; G.E. Lloyd, pers. comm., 1997), where there are at least two major slip surfaces.

Interpretation

The Kishorn Nappe is a far-travelled unit of Torridonian and Lewisian rocks. Near the thrust plane both units are deformed by an intense greenschist-facies schistosity, which is mylonitic within a few metres of the thrust. The internal structure of the thrust sheet includes a NW-facing syncline with a preserved overturned limb of Torridonian strata. This is the northern preservation limit of the Lochalsh Syncline and marks the transition into the major recumbent fold system on Skye (Johnson, 1960). Butler *et al.* (2006) suggested that the folding initiated at Precambrian normal faults, as proposed for the structures along the Ben More Thrust in Assynt (Butler, 1997; see Ben More Assynt–Conival–Na Tuadhan GCR report, this chapter).

The movement direction on the Kishorn Thrust may be inferred to have been top-to-the-WNW It is folded around underlying thrust slices and thus apparently moved at an early stage in the development of the thrust belt. On a regional scale (e.g. (Figure 5.48)a, the Kishorn Thrust appears to be bulged up by the large-scale imbrication of Torridonian and Cambrian units that crop out in the Achnashellach area (Butler *et al.,* 2007; see Beinn Liath Mhor GCR site report, this chapter). However, the sequence of thrust development in the units in the immediate footwall to the Kishorn Thrust is less clear.

The relative timing of thrust development in the Durness Group and An t-Sron Formation, together with other structures, may be inferred from the section beneath Sgurr a' Gharaidh (Figure 5.49). There, emplacement of the thrust slice of Pipe Rock that lies immediately beneath the Kishorn Thrust and at least partial imbrication of the Durness Group apparently occurred prior to thrusting in the underlying units. However, the relative timing of the Kishorn Thrust itself in this area is less easy to determine. It is not folded by underlying structures and is generally sub-planar, except where folded by the attached slice of fractured Torridonian rocks. These observations might suggest that the Kishorn Thrust, with its minor slice attached, moved later to truncate the folds in the Pipe Rock and Durness Group in its footwall. However, the field relationships are ambiguous: the footwall folds have axes that run sub-parallel to the outcrop trace of the thrust; and there is no indication from hangingwall structures that the Kishorn Thrust is late in that the mylonitic fabric is sub-parallel to the thrust.

Conclusions

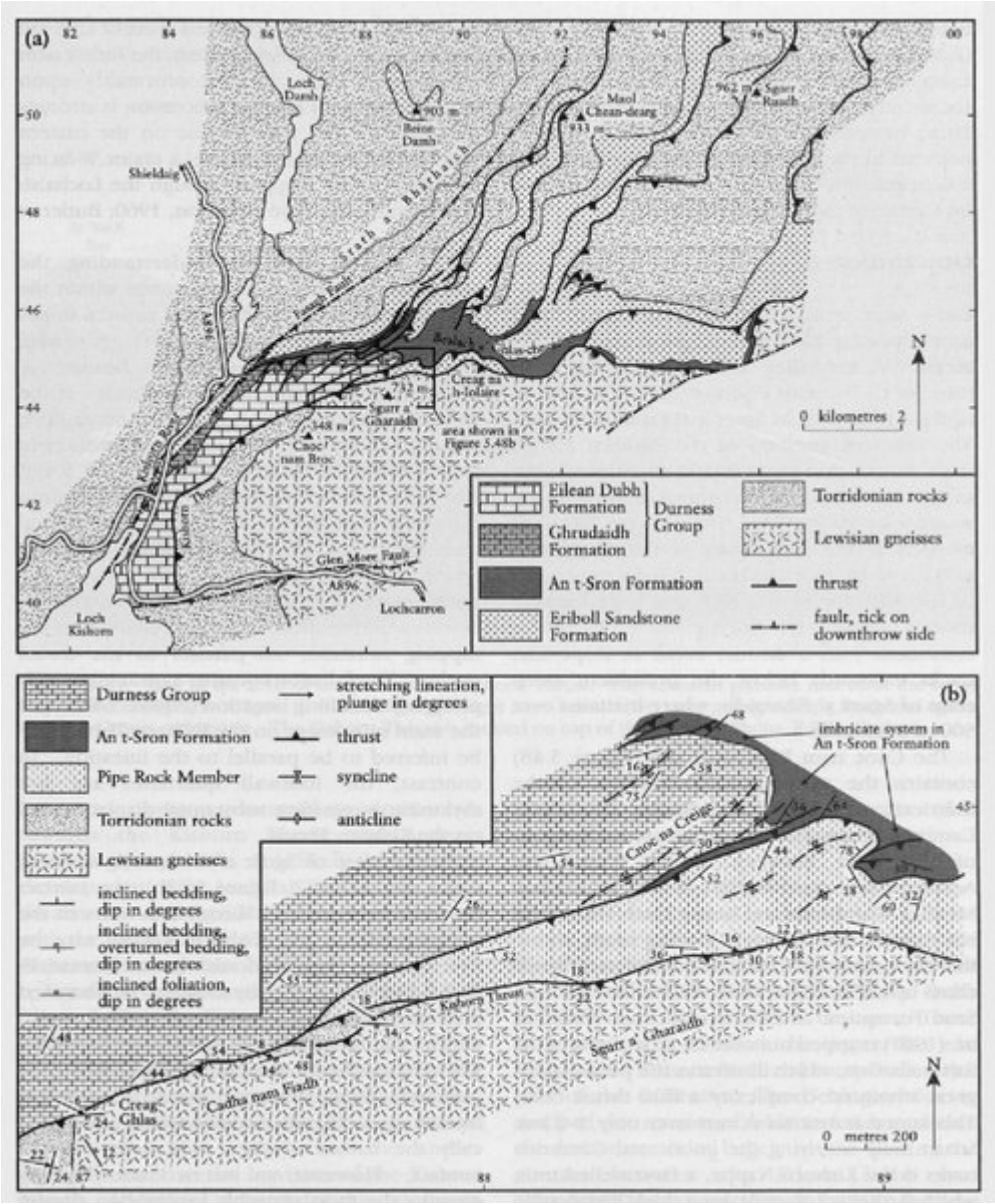
The Cnoc nam Broc GCR site offers excellent opportunities for examining the Kishorn Nappe, one of the major structures of the southern Moine Thrust Belt, together within its relationship to surrounding thrust structures (Butler *et al.,* 2006). Inverted Torridonian sedimentary rocks within the thrust sheet are recognizably unconformable upon their overlying Lewisian basement, but Torridonian rocks also occur as small, highly fractured, thrust-bounded slices. The rocks show a

variety of deformation states and are highly sheared locally.

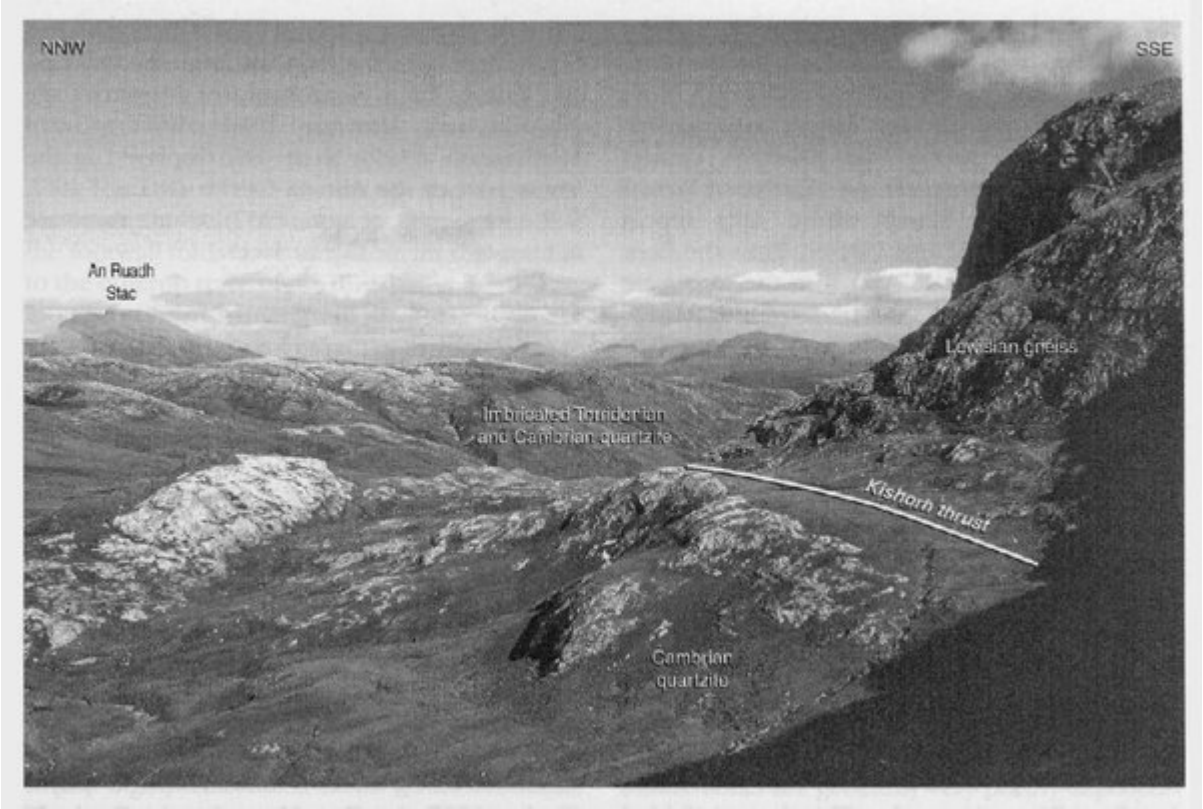
The footwall to the Kishorn Nappe consists of folded and thrust Cambrian strata that show remarkable variations in structure along strike. Detachment horizons within the stratigraphical pile, notably at the base of the Fucoid Beds Member and just within the Durness Group, have allowed the development of two imbricate thrust systems. The structurally lower of these systems imbricated the An t-Sron Formation. It was the last to form and thereby folded and breached the structurally higher imbricate system within the Durness Group together with an overlying far-travelled thrust sheet of Pipe Rock (Butler *et al.,* 2007).

The site is therefore an excellent place to study not only lateral variations in thrust geometry, but also the evidence necessary to deduce the relative timing of thrust structures. It has the additional advantage of exposing an example of the post-Caledonian faults that formed during Mesozoic crustal extension, and control many topographical features in north-west Scotland. The Cnoc nam Broc GCR site is undoubtedly of national importance and the area remains suitable for further studies.

References



(Figure 5.48) (a) Map of the area around the Cnoc nam Broc–Kishorn Valley area, mainly based upon Institute of Geological Sciences (1975a) and Geological Survey of Scotland (1913b). (b) Detail of the northern slopes of Sgurr a' Gharaidh, illustrating the relationships between folds and thrusts in the footwall to the Kishorn Thrust. After Butler et al. (2007).



(Figure 5.49) View to the ENE of the trace of the Kishorn Thrust. The Lewisian gneisses that form the steep slopes and north face of Sgurr a' Gharaidh to the right have been thrust over pale-grey Pipe Rock and white Durness Group carbonates. The Kishorn Thrust is located on top of the bench. (Photo: R.W.H. Butler.)