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A review of the Torridonian rocks of the Assynt area

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A review of the Torridonian rocks of the Assynt area

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Cleaved basal Torridonian
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Foreword

This report is the published product of a study by the British Geological Survey (BGS) Moine Thrust Project, as part of the revision of the Assynt Special Sheet.

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Summary

This report describes the geology of the Torridonian rocks on the Assynt Special Sheet. A review of previous literature is followed by a summary of preliminary field observations during 2001 and recommendations for further work.

1 Introduction and review of literature

The Torridonian sequence of NW Scotland is a several kilometre thick, unmetamorphosed, Precambrian sedimentary succession dominated by red arkosic sandstones. A comprehensive review is given in Stewart (1991) and recent work is summarised by Young (1999). The Torridonian sequence crops out on the Caledonian foreland and within the Moine Thrust Zone, unconformably overlying an irregular surface cut into the Lewisian gneisses. It is divided into three groups: the Stoer Group, exposed in the foreland between Stoer and Gairloch; the Sleat Group, exposed in the Kishorn Thrust sheet on the Sleat peninsula of Skye and in Lochalsh; and the voluminous Torridon Group which can be seen in various areas in the foreland and within the Moine Thrust Zone between Skye and Cape Wrath. There is a strong angular unconformity between the Stoer Group and the overlying Torridon Group, whereas in the Kishorn nappe the Sleat Group passes conformably up into the Torridon Group. The Stoer Group has been dated at *c.* 1200 Ma (Turnbull *et al.*, 1996), whereas the Sleat and Torridon Groups are considerably younger (*c.* 1000 Ma; Turnbull *et al.*, 1996; Rainbird *et al.*, 2001).

The Torridonian of the Assynt District has been little studied since the original primary survey towards the end of the 19th century. Torridonian exposures on the Assynt Special Sheet (1965) are found in two distinct areas: in the foreland, where they form the spectacular mountains of Quinag, Beinn Garbh, Canisp, Suilven and Cul Mór; and in the Moine Thrust Zone, where they can be seen within the Ben More Thrust sheet. The Torridonian sandstones of the foreland in Assynt chiefly belong to the Applecross Formation of the Torridon Group, and were described as ‘massive false-bedded purple grits and sandstones’ by Peach *et al.* (1907). They observed the striking relief of the sub-Torridonian unconformity, drawing attention to the northwesterly trend of the ridges and structural features in the underlying Lewisian gneiss, and noted the presence of conglomerate and breccia (the Diabaig Formation of the Torridon Group) outcropping immediately above this unconformity at various localities. The presence of Torridonian sandstone above the Ben More Thrust plane on Conival and Sgonnan Mór, and in the klippen north and south of the Allt nan Uamh, was also noted. On the Assynt Special Sheet, the Torridonian rocks which outcrop in the Ben More Thrust sheet to the south of Conival are shown as “Diabeg Group” (equivalent to the present day Stoer Group & Diabaig Formation of the Torridon Group) but this is not mentioned in the Northwest Highlands memoir (Peach *et al.*, 1907).

Williams (1966) carried out a detailed sedimentological study of the Applecross Formation northwards from Quinag and showed that the palaeocurrents in this area generally flowed from a northwesterly direction. However, he also identified a radiating pattern to the palaeocurrents, and suggested that the Applecross Formation was deposited as large-scale alluvial fans, sourced from an uplifted area approximately in the present-day location of the Outer Hebrides. This theory was supported by Stewart (1982) who suggested that the whole Torridonian sequence was deposited in an active rift environment, with the rift (both in Stoer Group and Torridon Group times) lying roughly between the present-day Outer Hebrides and Moine Thrust zones.

Elliott & Johnson (1980) looked at the distribution of Torridonian rocks in Assynt and proposed that they were deposited in two basins: a large, regionally extensive ‘Foreland basin’ and a smaller ‘Assynt basin’ to the east, separated by an anticlinal structure. The idea of Precambrian folding leading to the formation of outliers of Torridonian sandstone dates back to Peach *et al.* (1907), and had been re-emphasised by Soper & Barber (1979), who suggested that the Torridonian outliers were preserved in synclines while the crests of the anticlines were eroded beneath the sub-Cambrian unconformity. Butler (1997) presented structural field data from the Ben More Assynt area to show that the preservation of Torridonian sediments was controlled by

Precambrian normal faults rather than by folding. He noted that, around Conival, the basal Torridonian sediments consist of a 10m conglomerate unit overlain by arkosic grits and gravels, and have been deformed. Similar basal conglomerates were noted further to the south near Sgonnan Mór, but Butler did not look at the supposed “Diabeg Group” rocks on the east side of Glen Oykel.

There is little published work on the sedimentology of the Torridonian rocks in the Assynt area and, significantly, no-one seems to have attempted to compare the lithologies or provenance of the Torridonian in the Ben More thrust sheet with that in the foreland. Hypotheses of a separate ‘Assynt basin’ have not been further investigated by sedimentological studies. As noted by Butler (1997) the deformation of the Torridonian rocks in the Ben More Thrust sheet makes this type of study somewhat difficult. To the south, in the Kishorn thrust sheet, the rocks of the Sleat Group are distinctly different from sequences on the foreland, and have been interpreted as having been deposited in a separate fault-bounded basin (Stewart, 1991). Study of the Torridonian rocks within the Ben More thrust sheet may indicate a similar situation for the ‘Assynt basin’.

The most important recent contribution to Torridonian sedimentology has been that of Nicholson (1993), who carried out a regional-scale study of the Applecross Formation in the foreland, including analysis of palaeocurrent data. Palaeocurrents from a number of localities, including Quinag, were shown to be flowing towards the ESE, with no evidence for radiating patterns as suggested by Williams (1966). Nicholson (1993) also demonstrated the large scale of cross-stratification in the Applecross Formation, showing that major rivers were present within the Torridon Group fluvial system. These rivers may have had drainage basin sizes of over 100,000 km², indicating that the Applecross Formation was deposited on a major alluvial braidplain rather than in an alluvial fan. Nicholson (1993) concluded that the rocks of the Torridon Group were deposited in a large braided river system flowing into a post-rifting thermal relaxation basin, with the rocks of the Sleat Group possibly representing the initial rifting phase of basin development. The concept of a large Torridon Group depositional basin is supported by recent provenance studies which indicate a distal source on the Laurentian shield for the Applecross and overlying Aultbea formations (Van de Kamp & Leake, 1997; Young, 1999; Rainbird *et al.*, 2001). However, most recently, Williams (2001) has re-emphasised the sedimentological evidence for an alluvial fan environment for the Applecross Formation.

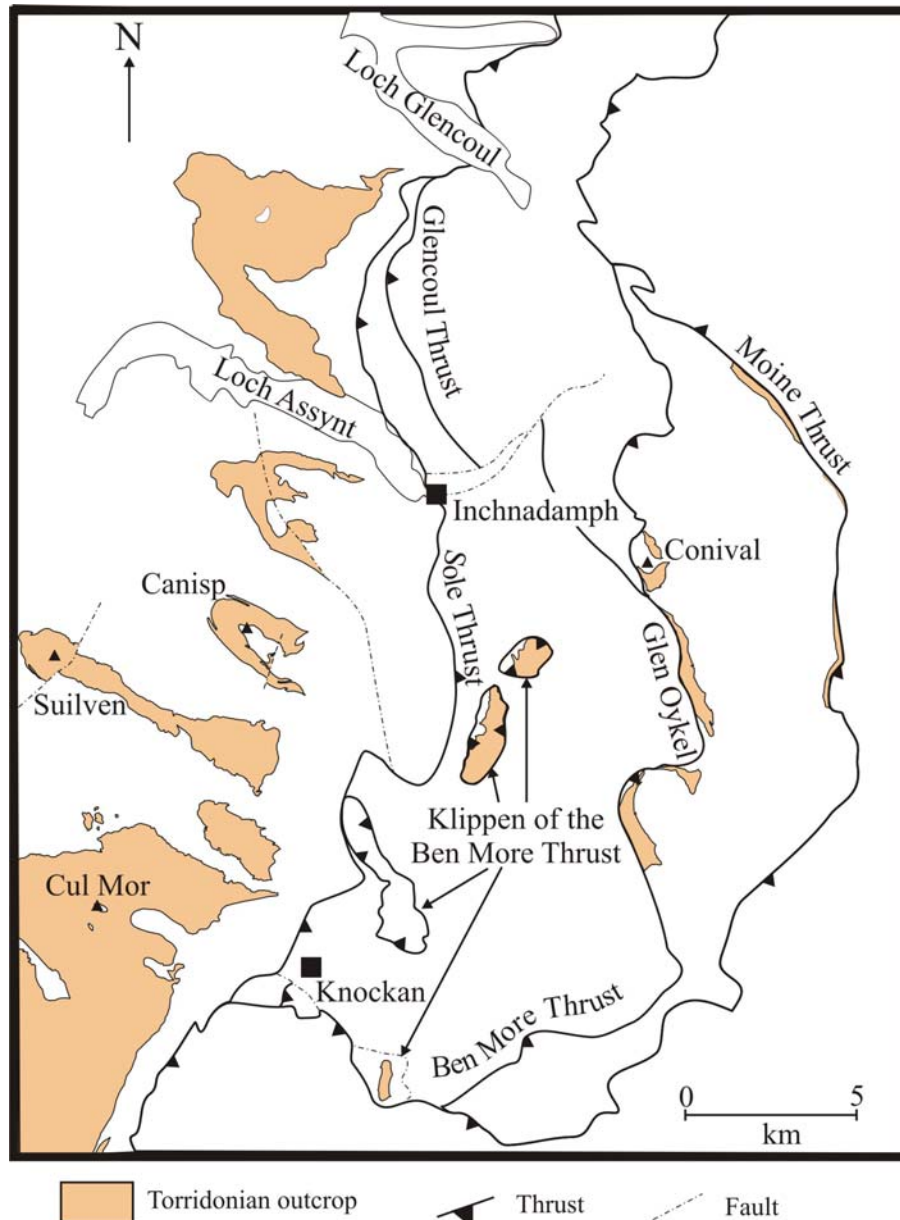


Figure 1: Sketch map showing the location of Torridonian outcrops (shaded) in the Assynt area, based on Peach *et al.* (1907). Major thrust positions from Peach *et al.* (1907) with modifications after Coward (1983).

2 Review of preliminary fieldwork, 2001

During a preliminary field visit in 2001, the lower parts of the Torridonian succession were studied both within the Caledonian foreland and within the Ben More Thrust sheet. Foreland exposures were seen in the road section along the north side of Loch Assynt, whilst those in the thrust sheet were seen in Coire a'Mhadaidh and in Glen Oykel.

FORELAND EXPOSURES.

The base of the Torridonian succession is exposed in road cuts for about a kilometre along the N shore of Loch Assynt. The most westerly exposure in the road section is at NC 2132 2516, where the Torridonian overlies weathered Lewisian gneiss. The Torridonian here consists of ~ 50 cm thick bands of red-grey gritty sandstone separated by softer shaly mudstone layers, with fairly sharp contacts between the layers. All the layers contain sub-rounded to angular pebbles, which

are up to 2cm long, and largely composed of gneiss and quartzite. Some dreikanter pebbles have been recognised at this locality. These exposures are considered to belong to the Diabaig Formation of the Torridon Group (Stewart, 1978).

From there eastwards to NC 2183 2501 are further exposures of the Lewisian / Torridonian unconformity, which is clearly irregular and is also displaced across several small faults.

At NC 2196 2494 there is a distinct change in the Torridonian lithology (Figure 2). The lower 5m of exposure is a continuation of the Diabaig Formation as described above. The upper 5-10m of exposure in this cutting consist of massive, trough cross-bedded, coarse red arkosic sandstones with rounded weathering surfaces. These appear to be typical sandstones of the Applecross Formation of the Torridon Group.

On the Assynt Special Sheet (1965), the Torridonian is largely undifferentiated, although basement conglomerates are marked. It would appear that we could improve the new map by mapping in the different formations of the Torridon Group, as has been done on sheet 101E (1998).



Figure 2: Exposures of Torridonian sandstone in the road cutting at NC 2196 2494, with flaggy Diabaig Formation rocks in the lower part of the outcrop overlain by more massive sandstones of the Applecross Formation.

EXPOSURES IN THE BEN MORE THRUST SHEET

The basal Torridonian within the Ben More Thrust Sheet was briefly studied at two localities, in Coire a'Mhadaidh below Conival and in the stream draining Dubh Loch Beag in Glen Oykel. At both localities are exposures of basal conglomerates with large, rounded pebbles, chiefly of gneiss. The conglomerate contains a well-developed penetrative cleavage. In Coire a'Mhadaidh (NC 303 209), typical gritty sandstones are found above the conglomerates, and also interfingering with them. This locality has been described by Butler (1997) but would repay further study.

In the stream draining Dubh Loch Beag (NC 3188 1578), and on adjacent glacially scoured outcrops, are excellent examples of cleaved Torridonian conglomerates. The cleavage in these outcrops is near-vertical and axial planar to the major syncline, shown on the 1:63360 map and

mapped by Milne (1978). The overturned Torridonian/Lewisian unconformity on the upper (eastern) limb of the syncline can be seen in the stream at NC 3189 1585, striking at 175° and dipping at 58° to the east. It is marked by a few centimetres of highly sheared, chloritised rock.

This relatively small area of Torridonian in Glen Oykel has courted some controversy. It was originally mapped as ‘Diabeg Group’ – the only location in the Assynt Sheet at which the Torridonian was differentiated by Peach & Horne. Milne (1978) mapped this area and identified a thrust (the Glen Oykel Thrust) along the eastern margin of the Torridonian. He suggested that the Loch Ailsh syenites cut across this thrust, and therefore that thrusting must have started prior to intrusion of the Loch Ailsh syenites at 439 Ma. Butler (1997) suggested that the thrust at this locality was ‘more plausibly an overturned unconformity’ and concluded that the Loch Ailsh syenites predated thrusting. However, it is worth noting that Butler does not appear to have mapped the Glen Oykel area in detail, concentrating instead on the outcrops on Sgonnan Mor and Conival. The identification of a zone of shearing along the Torridonian/Lewisian unconformity during 2001 fieldwork suggests that there may be a thrust along this margin, although it may not extend as far as the Loch Ailsh syenites. The Torridonian within the Ben More Thrust in Glen Oykel thus appears to be a key location for more detailed study.

3 Recommendations for further work

TORRIDONIAN IN THE FORELAND

As discussed above, much of the Torridonian in the Assynt foreland is representative of the Applecross Formation which has been widely studied. The tectonic framework in which this formation was deposited is still subject to some debate, but recent evidence favours the concept of a large-scale depositional basin (Nicholson, 1993) over that of a more restricted rift valley (Stewart, 1982). Detailed sedimentological mapping and provenance studies in Assynt could help to resolve this debate, but it is unlikely that any major breakthrough will be developed by further work. The Assynt Special Sheet will be improved by distinguishing the Diabaig and Applecross Formations on the map, and thus a rapid survey of the basal part of the Torridonian in the foreland is recommended.

TORRIDONIAN IN THE BEN MORE THRUST SHEET

The Torridonian within the Ben More Thrust sheet has barely been described, and although it appears to be generally believed to belong to the Applecross Formation (Nicholson, 1993), Peach *et al.* (1907) were more inclined to attribute it to the Stoer Group/Diabaig Formation. The basal unconformity, with associated conglomerates, is exposed at various places, such as on the ridges below Conival and at Sgonnan Mór, suggesting that these rocks are more likely to correlate with the Diabaig Formation. The priority is to map these rocks in detail, in order to interpret them in relation to the known Torridonian stratigraphy (if possible) and to study their petrography and clast populations. Careful identification of pre- and post-Cambrian structures will also be required (*cf.* Butler, 1997).

Sedimentological, geochemical and provenance (detrital mineral) studies of the Torridonian within the Ben More Thrust sheet, as well as comparison with other Torridonian sequences within the Moine Thrust Zone (including the Sleat Group and the Tarskavaig Moines) should allow us to build up a far better picture of the Torridonian environment (perhaps a series of small rift basins, eventually eclipsed by the development of a much larger thermal relaxation basin?) and should assist in the investigation of the possible correlation between the Moine and the Torridonian. This should also allow us to recognise any pre-existing structural architecture, which may have influenced the development of the Moine Thrust Zone.

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