Diabaig

[NG 785 604]–[NG 798 600], [NG 820 622]–[NG 821 598]

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Introduction

The coastal section and inland outcrops around Diabaig, on the north side of Loch Torridon, constitute the type area for the Diabaig Formation, the lowest unit in the Torridon Group. The basal parts of the overlying Applecross Formation are also well exposed (Peach *et al.,* 1907). The beds mainly dip between 10° and 18° to the west and locally to the south-west and north-west. A geological map of the area is shown in (Figure 4.13). The Diabaig Formation was deposited in deep palaeovalleys eroded in the basement gneisses, reaching a maximum thickness at Diabaig of about 130 m. Breccias, which formed on the valley flanks, grade laterally into grey siltstones in the valley centres. Diabaig is renowned for the exceptional clarity with which this facies change can be demonstrated, and for its shore section, which displays a thick sequence of desiccated grey siltstones. Phosphate concretions in the siltstones contain well-preserved algal filaments and spheroidal microfossils (Downie, 1962; Peat and Diver, 1982). The earliest sedimentological study of the Diabaig Formation was the subject of a brief essay by Allen *et al.* (1960). Later work has concerned the boron content of illites in the siltstones (Stewart and Parker, 1979), the sedimentology and geochemistry (Rodd and Stewart, 1992), and the source of the sediments (Stewart, 1995b; Van de Kamp and Leake, 1997). Phosphorite samples from Diabaig have been dated by Rb-Sr methods to give an age of diagenesis for the Diabaig Formation of 994 ± 48 Ma (Turnbull *et al.,* 1996).

Description

The Diabaig GCR site area includes the well-exposed 1.5 km-long coastal section on the north shore of Loch Diabaig extending west from the jetty at Sgeir Ghlas [NG 7968 5982] and including its backing cliffs. The site extends north-east through Lower Diabaig to the rocky plateau above. It also includes a rocky inland area that stretches north from the eastern end of Loch Diabaigas Airde via Loch Roag to Loch na h-Uamhaig. The site adjoins the Alligin GCR site, which displays notable features in the Lewisian Gneiss Complex (see Chapter 3).

The Diabaig Formation was deposited on an irregular landscape cut into the Lewisian basement, with a relief of about 250 m at Diabaig. All the sediments of the formation accumulated in the lower parts of the palaeo-valleys, and laterally abut the basement gneisses that supplied the coarser detritus. The sediments nearest the gneiss, termed the 'breccia facies', are the coarsest at any given stratigraphical level of the Torridonian, consisting mostly of either massive breccias, or interbedded breccia and red sandstone. The clasts are mostly centimetre- or decimetre-size and only rarely exceed 1 m across. Reddened rims are common, and the clasts are more angular than those in the Stoer Group breccias. Away from the unconformity, clast-size diminishes and the proportion of sandstone increases. The breccias pass laterally into tabular sandstones, the transition being defined where the clast content falls below 50% (by volume). At Diabaig, this transition from breccias to tabular sandstones is always less than 400 m along a bedding plane from the unconformity.

The tabular sandstones owe their well-defined bedding to relatively fine-grained laminae, normally micaceous. They are ornamented by straight-crested, symmetrical ripples and small scours are common. Liquefaction of some of the tabular sandstone units immediately following deposition has produced large-scale mass-flow deposits at three localities in Upper Diabaig. The first locality lies 200–500 m north-east of Loch Roag [NG 823 613], while the second and third are about 1 km south-east of the loch at [NG 825 603] and [NG 825 600]. The mass-flow deposit nearest the loch is 20 m thick and its basal contact is sharp, with signs of injection and disruption. Wispy asymmetrical folds within the deposit indicate movement towards the south-west, down the local palaeoslope. At the third locality the base of the massive deposit cuts down through more than 5 m of the tabular sandstone facies. Undisturbed tabular sandstones cover all three flows. The mobilization of the sands may have been triggered by local seismicity.

The tabular sandstones farther away from the unconformity are interbedded with fine-grained micaceous sandstones and siltstones, in parts red but more generally grey. Those seen by the roadside near Upper Diabaig at [NG 8195 6016] have abundant W-migrating climbing ripples and are situated about 400 m down the palaeoslope from the gneisses. The thinnest and finest-grained sandstone beds have a persistency factor (lateral extent divided by maximum thickness) of 1000–10 000, while for beds with gneiss pebbles the factor is only 50–100. Farther still from the unconformity, the rocks are exclusively grey siltstones, and have been termed the 'grey 'shale' facies'.

The grey 'shale' facies is splendidly exposed along the shore north-west of Diabaig jetty (Figure 4.14). The jetty itself is built on gneiss, flanked to the north by some tabular beds of red sandstone containing angular gneiss clasts up to about 10 cm across. There is no contact with the siltstones at this point. The main siltstone section starts on the beach about 300 m to the north at [NG 797 601], where it is laterally equivalent to grey sandstone with gneiss fragments that can be seen by the roadside a few metres distant. The gneiss hill of An Torr towers above the road, and the horizontal distance from the shale facies to the Lewisian gneiss hillside is here only about 30 m. Some 520 m to the northeast, on the north side of An Ton, grey sandy siltstone is actually seen in contact with the gneiss [NG 8004 6057].

Three sub-facies can be distinguished in the grey 'shale' facies, which are exposed along the shore at Diabaig (Figure 4.14):

Silt–mud rhythmite, with laminae averaging 0.3 mm in thickness and only rarely reaching 2 mm. They have a persistency factor of about 3000. What appears to be a broad channel about 0.5 m deep cuts the siltstones 75 m above the base of the section. Calcareous sandstone makes up the lowest 10 cm of the channel infill and is overlain by bedded siltstones with an orientation slightly different to that beneath. Pale-blue-weathering phosphate concretions are common throughout the siltstones. They are black when freshly broken, oval, measuring up to 1 cm thick across the bedding and 5 cm along it. The shaly lamination wraps around the concretions, showing clearly that they formed prior to compaction. More-extensive phosphate laminae also occur. Organic-walled microfossils are common in the siltstones but are best preserved and quite undeformed in the phosphate concretions. They have never been described in detail.

Ripple-laminated sandstone beds of millimetre-to centimetre-thickness are interlayered with the siltstones. The ripple foresets have no consistent dip direction, and although the crests are fairly constant in orientation in any given stratigraphical interval, they gradually swing from east–west at the base of the section to north–south at the top. They do not indicate palaeocurrent directions and are interpreted as reflecting wave patterns related to the emergent gneiss topography. Desiccation cracks, which formed in the rhythmite, are filled by sand from the overlying ripple-laminated sandstone beds (Figure 4.15). The siltstones also show a reticulate pattern of small ridges on upward-facing bedding planes, described as rain prints by the Geological Survey (Peach *et al.,* 1907), and also by Allen *et at.* (1960). However, the structures closely resemble micro-load structures described by Dzulynski and Walton (1965).

Grey sandstone beds with sharp bases appear in the upper part of the grey 'shale' facies. The beds are up to 1 m thick and increase in frequency and thickness towards the top. The upper parts of the beds typically show ripple-drift lamination, especially clear where secondary calcification has occurred. They indicate a palaeocurrent direction from the west, as in the overlying Applecross Formation. The 'sandstone' is a fine- to medium-grained wacke, with about 20% matrix. Both the bases and the tops of some beds are channelled, so that the persistency factor ranges from 300 to 1000. The uppermost 25 m of the section contains abundant rippled sandstones (Figure 4.16), which are much coarser than those at lower levels, but the siltstones still show evidence of desiccation.

Small pyrite cubes have been noted near the base of the shore section but not at higher levels. There is no trace of either primary carbonate or evaporite minerals in the Diabaig Formation.

Facies inter-relationships in the Diabaig Formation are conveniently studied along the roadside north-east of Loch Diabaigas Airde. Exposures begin just above the bend in the road at [NG 8214 6008] where massive breccia is in contact with gneiss. Stratigraphically higher and progressively finer-grained beds crop out to the west, the last seen being red, micaceous, ripple-laminated beds at [NG 8187 6008]. The up-dip breccia equivalents of the micaceous beds can be seen to the NNE above the recent screes, with the Lewisian basement beyond.

The contact between the grey 'shale' facies of the Diabaig Formation and the overlying Applecross Formation is defined at the western end of the shore section by the abrupt appearance of trough-cross-bedded red sandstone. The lowest 20 m of the Applecross Formation form a mappable member, exposed in the burn section of the Allt na Bèiste where it dashes down through the wooded scarp to the sea [NG 7929 6028]. This is the type section of the Allt na Bèiste Member. The Geological Survey described the unit as 'massive bright-red sandstones with shale partings' (Peach *et al.,* 1907) and included it in the Diabaig Formation, doubtless because it lacked large durable pebbles. However, the sandstones of the Allt na Bèiste Member, though finer grained than much of the Applecross Formation, have trough cross-bedding, contorted in places, which is similar to that seen elsewhere in the formation. The modal mineralogy is also very similar to that of the Applecross Formation, but is unlike that of the sandstones in the Diabaig Formation (see below). The Allt na Bèiste Member also contains 'porphyry' and black chert pebbles, typical of the Applecross Formation. These are most easily found on the low cliffs about 500 m west of the type section at [NG 7877 6029], where the exposures are fresher than in Allt na Bèiste.

The sandstone of the Allt na Bèiste Member weathers to a pale reddish-brown, but when fresh is pale red to greyish red. These colours largely reflect the K-feldspar content, which forms about 25% of the rock. This contrasts with the tabular sandstones of the Diabaig Formation, which contain about 40% detrital feldspar, mostly plagioclase derived from the local basement gneisses. The siltstones in the Allt na Bèiste Member are generally grey, becoming red toward the top of the succession. Palaeocurrents flowed eastwards, as in the underlying rocks of the Diabaig Formation and the higher parts of the Applecross Formation.

The top of the Allt na Bèiste Member in the type section is marked by the highest red siltstone, above which the sandstone is noticeably different to that below. The colour of this sandstone is reddish purple and the grain size is coarse to very coarse. About 50% of the beds are contorted as compared to only about 5% in the Allt na Bèiste Member. Half-centimetre-sized durable pebbles appear about 2 m above the top of the Allt na Bèiste Member, and pebbles over 1 cm across become common about 10 m higher.

Magnificent exposures of these coarse-grained beds of the Applecross Formation can be studied about 200 m west of the Diabaig township wall, at [NG 786 603], *c.* 45 m above sea level. More than half the beds show soft-sediment deformation features like those described by Owen (1995) from the Torridon area, including isolated structures, discrete units, chaotic units and multi-layer complexes (Figure 4.17), although the reported contorted heavy-mineral laminae are not present at Diabaig.

Interpretation

The palaeovalleys in the gneisses beneath the Torridon Group were initially half-filled by the breccias, sandstones and siltstones of the Diabaig Formation (Stewart, 1972). The clasts in the breccias accurately reflect the composition of the adjacent gneiss and represent fan-head deposits, grading laterally into the tabular sandstones, which were formed in the more-distal parts of the alluvial fans. The grey 'shale' facies, which occupies the centres of the palaeovalleys, represents lake deposits. The boron content of illite in the shale facies is low and does not suggest permanent marine conditions (Stewart and Parker, 1979). The breccia clasts and the sands were derived from the local gneiss palaeo-hills, but the geochemistry of the siltstones shows that about a quarter of the finest sediment was extraneous biotite. This biotite was probably supplied by the rivers that later deposited the Applecross Formation (Rodd and Stewart, 1992).

The size of the Diabaig lake is indicated by the dimensions of the grey 'shale' facies, which extends southwards from Diabaig for at least 70 km, and attains some 400 m in thickness on Rum (Figure 4.4). The lack of evaporites and primary carbonates suggests that the lake had an outlet and that solute concentrations were consequently low (Rodd and Stewart, 1992). Diabaig was near the lake margin, and episodic variations in lake level may have caused temporary emergence and desiccation of the lake sediment. Assuming a typical sedimentation rate of around 500 m/Ma (Baltzer, 1991) and one desiccated surface every 6 cm (see above), there must have been an average of one desiccation event each century. This could easily have been caused by changes either in climate or in the height of the outlet. Such changes produce variations of a few metres in the water level of African rift lakes in a century (Beadle, 1981) and suggest that the lake at Diabaig was only a few metres deep.

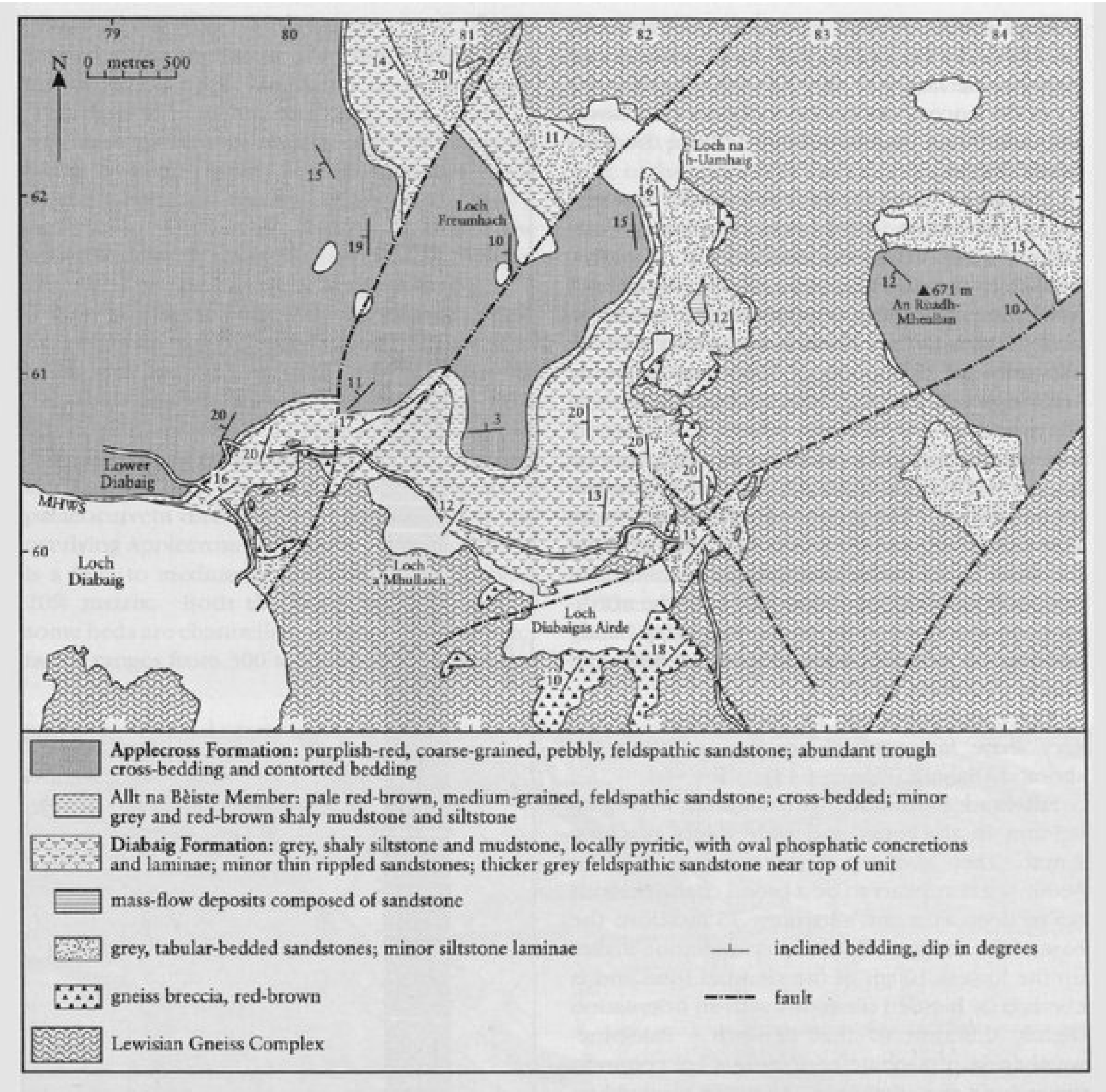
The grey sandstone sub-facies are interpreted as turbid underflows, fed by the Applecross' rivers advancing from the highlands to the west (Stewart, 1988b). These too seem to have formed in shallow water, as shown by the presence of desiccation cracks in the intervening siltstones and the evidence of scouring of the tops of some beds. The sandstones of the Allt na Bèiste Member represent the first true alluvial sediments, deposited in shallow channels by braided streams.

The Applecross Formation was deposited on the Diabaig Formation, and the remaining basement hilltops by braided rivers flowing from a mountainous source some distance to the west (Nicholson, 1993; Van de Kamp and Leake, 1997; Rainbird *et al.,* 2001; Stewart, 2002).

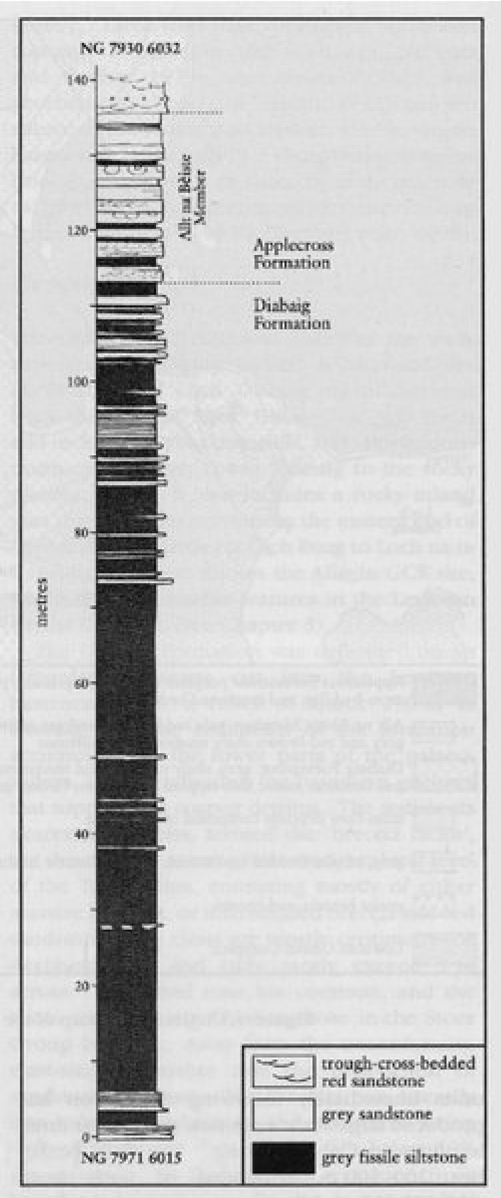
Conclusions

The Diabaig area provides the type locality for the basal units of the Diabaig Formation, the oldest formation of the Torridon Group. It is an exceptional site for demonstrating the progressive burial of Precambrian topography by lake silts and river sands accumulating in a rift-valley environment. The microfossils, excellently preserved in phosphate concretions in the grey lacustrine siltstones, have yet to be described in detail. Their stratigraphical value and relationship to the contemporaneous sedimentary environment are promising subjects for future research. The sedimentary rocks are so little altered that they appear to be quite recent, whereas in fact they date from about 1000 million years ago. The site demonstrates the facies variations that prevailed at the base of the Torridon Group and is of national, possibly international, significance.

References

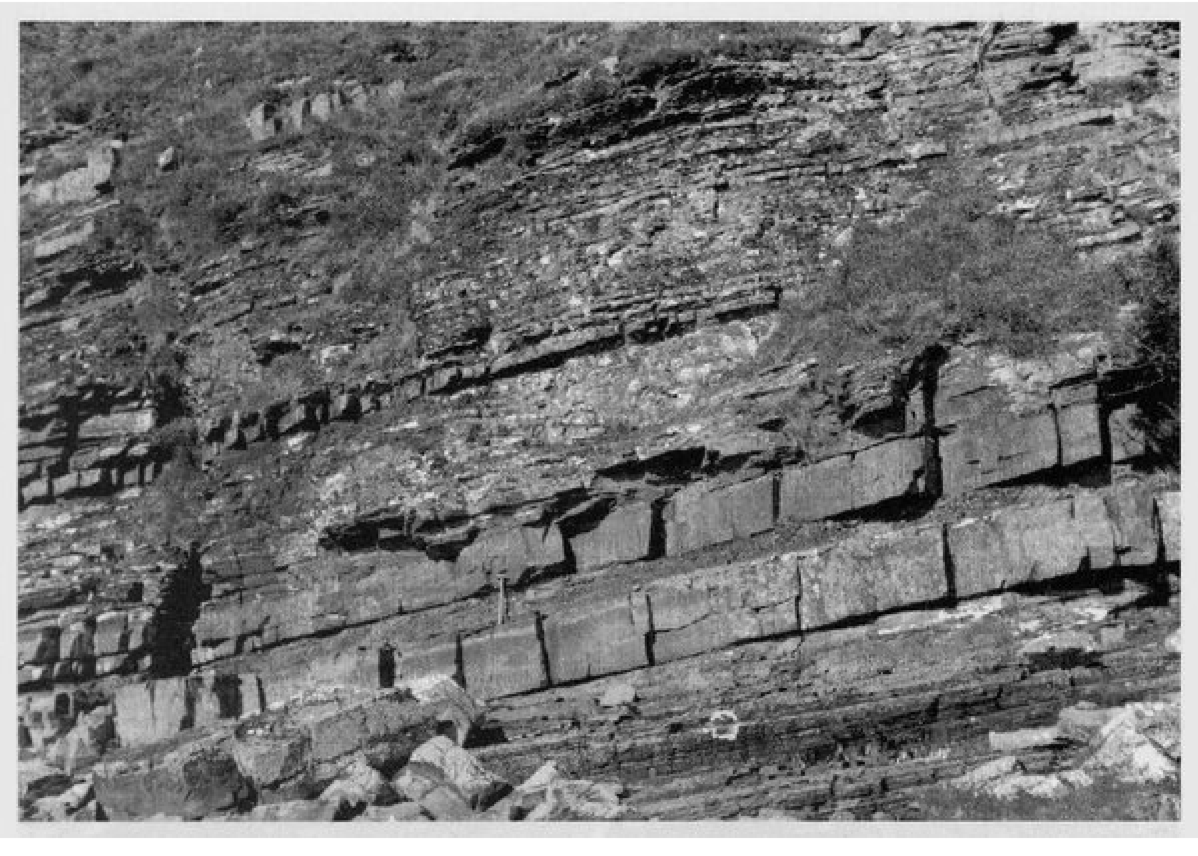


(Figure 4.13) Geological map of the Diabaig area. After Stewart (2002).



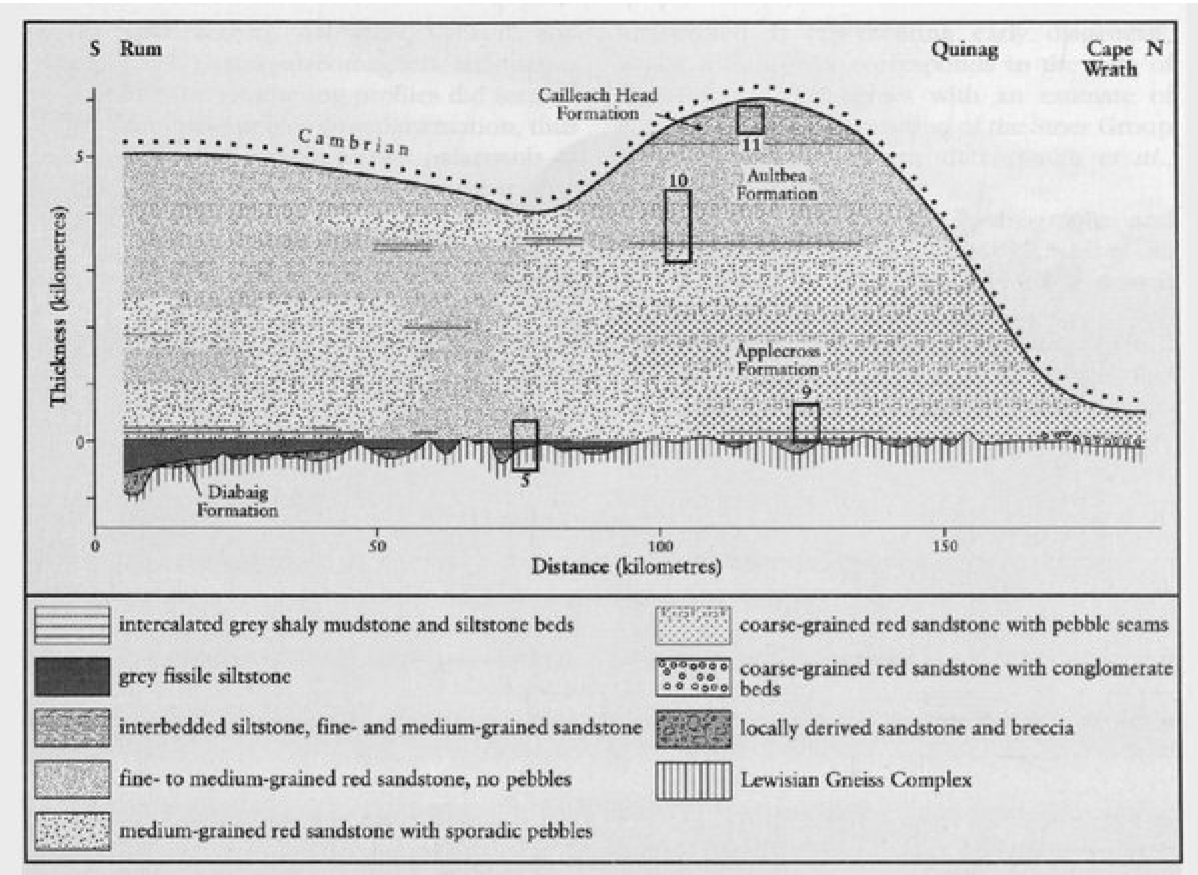
(Figure 4.14) Graphic log of the grey 'shale' facies (Diabaig Formation) and Allt na Beiste Member (Applecross Formation), exposed along the coast west of Diabaig jetty

(Figure 4.15) Desiccation cracks in the grey 'shale' fades of the Diabaig Formation at Diabaig. The exposure is on the shore about 400 m north-west of Diabaig jetty [NG 7964 6017]. The hammer shaft is 50 cm long. (Photo: A.D. Stewart.)



(Figure 4.16) Grey sandstone beds in the upper part of the grey 'shale' fades at Diabaig. The two prominent beds touching the hammer are at 96–97 m on the section in Figure 4.14. The location is just above high-water mark at the mouth of Allt na Beiste [NG 7927 6027]. The hammer shaft is 50 cm long. (Photo: A.D. Stewart.)

(Figure 4.17) Contorted bedding in the Applecross Formation at Diabaig. Note the truncation plane at the level of the hammer head. Water-escape structures like this affect over half the Applecross Formation and the whole of the Aultbea Formation. The exposure is about 170 m west of Diabaig township [NG 7867 6037]. The hammer shaft is 50 cm long. (Photo: A.D. Stewart.)



(Figure 4.4) Stratigraphical section through the Torridon Group perpendicular to the dominant palaeocurrent direction of the Applecross Formation (A = 123°). The Applecross and Aultbea formations are not separable over the southern half of the section. The stratigraphical positions of GCR sites are shown as boxes, numbered as in Figure 4.1.