Foreland succession of the Loch Assynt roadside, North-west Highlands - an excursion

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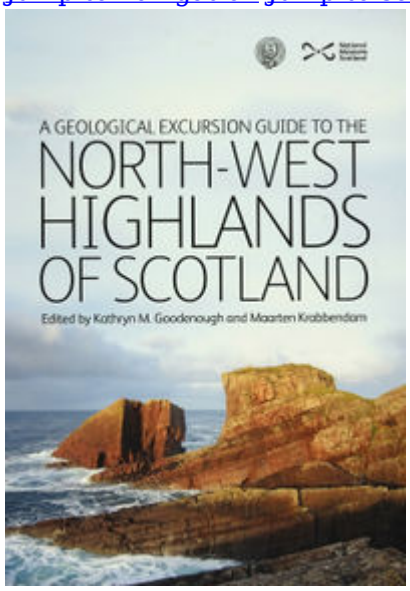

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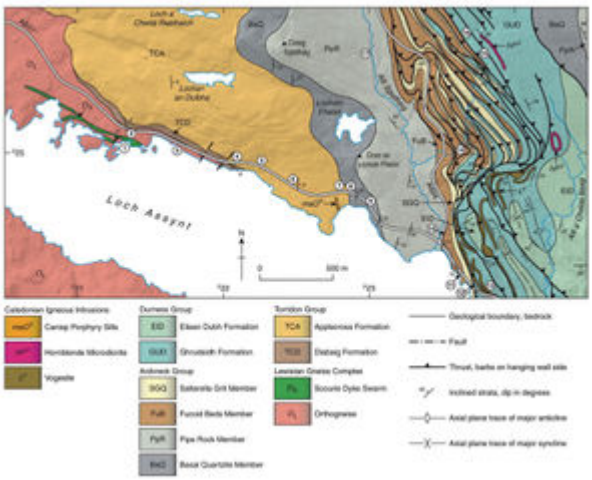

Geological map of the Loch Assynt area, after British Geological Survey (2007), showing the localities described in Excursion 1.

Outcrops of Lewisian gneiss on the shore of Loch Assynt at Locality 1.1. (BGS photograph P531871, © NERC)


Massive, trough cross-bedded sandstones of the Applecross Formation overlying flaggy Diabaig Formation strata at Locality 1.4. (BGS photograph P506431, © NERC)

File:EGS NWH FIG 014.jpg

Trough cross-bedded arkosic sandstones and granulestones of the Apple-cross Formation at [NC 2164 2539]. One metre rule for scale; note the convolute lamination

in the lowest bed. (Photograph: © M. P. Smith)

Distinctive surfaces of Pipe Rock Member at Skiag Bridge, Locality 1.10. (BGS photograph P531881, © NERC).

Close-up of Fucoid Beds Member at Skiag Bridge, Locality 1.11. (BGS photograph P531882, © NERC).

File:EGS NWH FIG 017.jpg

White quartz arenites of the Salterella Grit Member overlain by grey dolostones of the Ghrudaidh Formation at Locality 1.12. This boundary is also the Ardvreck–Durness group boundary. (Photograph: © M. P. Smith)

Excursion 1A from: Goodenough, Kathryn M. and Krabbendam, Maartin (Editors) A geological excursion guide to the North-west Highlands of Scotland. Edinburgh : Edinburgh Geological Society in association with NMS Enterprises Limited, 2011.

Excursion 1 overview

Excursion 1B: The stratigraphy and structure of the Achmore Duplex and adjacent foreland

□

Contents

Locality 1.1 Lewisian outcrops, Loch Assynt. [NC 2125 2507]

Park in the lay-by [NC 212 251] alongside the A837 to Lochinver from Skiag Bridge (second lay-by on the left). From the lay-by, walk down to a small east-facing bay on the shore of Loch Assynt (See image), adjacent to an island with two large Scots Pines and many dead trees. The bay [NC 2125 2507] contains a 9m-wide, ESE-trending ultramafic Scourie Dyke, intruded into Lewisian orthogneisses with a westward dipping foliation P531871. The core of the dyke is a fairly fresh, olivine-rich metaclinopyroxene-norite (Tarney, 1973). The host rocks are chiefly pyroxene-bearing felsic gneisses, consisting of quartz, feldspar and hypersthene, with hornblende and biotite also present. Lenses, pods and bands of both mafic and ultramafic rock are common and are generally unfoliated.

Locality 1.2 Basal unconformity of the Torridon Group. [NC 2134 2516]

Return to the lay-by and examine the roadside cutting opposite the eastern entrance to the lay-by. Conglomerates and pebbly sandstones of the Diabaig Formation (Torridon Group) unconformably overlie highly weathered, pale green to cream Lewisian gneisses with some red staining. Two litho-facies are present in the Diabaig Formation; the first is a poorly lithified and poorly sorted, tabular-bedded, very coarse sandstone with a muddy matrix and matrix-supported pebbles composed principally of gneisses and vein quartz. The pebbles are rounded to sub-rounded and frequently preserve a desert varnish; wind-etched dreikanter pebbles are not uncommon.

The second lithofacies is better sorted and comprises very coarse sand to granule grade sediment with matrix-supported pebbles. Some beds have erosive bases and there is poorly developed inverse

grading with concentra-tions of pebbles at bed tops. Parallel lamination is also evident at the top of some beds.

In both lithofacies the matrix is arkosic. Further evidence of terrestrial erosion comes from the presence of highly rounded, almost millet seed, sand grains within the matrix. Both facies are the product of alluvial fans inter-acting with lacustrine environments, and palaeocurrent data suggests that the fans may have been confined within valleys (Stewart, 2002).

The unconformity at this locality represents an enormous amount of 'missing' time. The Lewisian gneisses here have protolith ages of about 3000 Ma (Kinny and Friend, 1997), and the Scourie Dykes were intruded around 2400–2000 Ma (Heaman and Tarney, 1989). In contrast, the sand-stones of the Diabaig Formation were deposited at about 1000 Ma (Turnbull *et al*., 1996). Thus, over 20% of Earth history is missing at the unconfor-mity surface.

Locality 1.3 Relief on the basal Torridon Group unconformity. [NC 2175 2503]

Walk eastwards to the 'falling rocks' road sign. Beds of Diabaig Formation are truncated against a topographic high on the Lewisian gneiss erosion surface. There has been some minor faulting on the flanks of the high during compaction, but the relationship is to a large degree the original strati-graphical one. To the east, the Diabaig Formation is visible in the top of the road cut for around 100m until it is thrown down on a normal fault [NC 2183 2499]. The Lewisian gneiss is highly weathered to at least 10m beneath the unconformity. Beyond the small fault, the Diabaig Formation reaches its greatest thickness in this section and is at least 25m thick – the variable thickness reflects the local derivation of sediment and the infilling of topographic hollows on the unconformity surface. Looking southwards across Loch Assynt, considerable topography can be seen on top of the Lewisian Gneiss Complex. Around Quinag, to the north of Loch Assynt, there is up to 400m of relief on the unconformity (Stewart, 2002).

Locality 1.4 Base of the Applecross Formation. [NC 2194 2497]

Thirty metres before the end of the roadside safety barrier, the character of the road-cut changes and thick, trough cross-bedded sandstones of the Applecross Formation (Torridon Group) can be seen to conformably overlie the thinly bedded, poorly sorted, laminated granulestones of the Diabaig Formation (P506431). The lithology of the Applecross Formation will be examined at Locality

Locality 1.5 Glacial striae. [NC 2225 2489]

A small cutting by the road preserves well-developed glacial striae on the surface of ice-sculpted Applecross Formation sandstone (best seen on the southern side of the east end of the cutting). Striae are rarely seen on Torridon Group sediments, but here they have been protected from erosion by peat cover.

Locality 1.6 Typical outcrops of Applecross Formation. [NC 2248 2479]

Continuing eastwards, just beyond an old road sign and set back 20m from the road next to a small holly is an easily accessible outcrop of typical Applecross Formation. The grain size varies from very

coarse sand to granule and the clasts are angular to sub-angular; there is very little silt or clay, in common with most of the Applecross Formation. Compositionally, the sediment contains a high proportion of terracotta-coloured feldspar and lithic clasts in addition to vein and polycrystalline quartz. Trough cross-bedding is common throughout, with sets varying from 10–20cm (See image). On the upper surface of the outcrop, sets can be seen clearly in 3D with current directions towards 100˚. The sediments were deposited by deep, perennial braided rivers that formed a very large-scale braidplain, with a mean current direction of 123˚ (Stewart, 2002).

Locality 1.7 The basal Cambrian unconformity. [NC 2273 2470]

The last outcrops of Applecross Formation by the road provide a good viewpoint north-westwards towards the summit of Spidean Coinich (764m), one of the summits of Quinag. White, well-bedded quartz arenites of the Eriboll Formation dip east at 12–15˚ and overlie the sub-horizontal Applecross Formation with angular unconformity, the boundary descen-ding to the road just beyond a small stream.

The slabs of Applecross Formation by the road again preserve friction cracks and good striae at 113˚, indicating westward transport of ice along the valley axis.

Locality 1.8 The base of the Eriboll Formation. [NC 2291 2472]

The Applecross–Eriboll formation boundary is not exposed (though there are excellent exposures of this unconformity about 1.5km from the road at [NC 220 257]). The first roadside outcrop of the lower member of the Eriboll Formation, the Basal Quartzite Member, is just past the stream culvert. These are very light grey-weathering, very coarse sandstones–granulestones, which have a high content of terracotta-coloured feldspars, enough to be classified as sub-arkoses despite the name of the member. Small-scale cross-bedding is evident.

Locality 1.9 Typical outcrops of the Basal Quartzite Member. [NC 2308 2453]

A large cutting within the Eriboll Formation lies 200m farther eastwards. Much of the sedimentary detail is obscured by mineral-coated joint faces, including slickensides, but good exposures lie around 20m before the end of the safety barrier, within the upper part of the Basal Quartzite Member. The sediment is generally finer than at the base, but there is still granule-grade material on the bounding surfaces. The proportion of feldspar has also decreased and the sediments here are true quartz arenites. Well-developed planar tabular cross-bedding forms 5–20cm sets. Bipolar current directions are evident (towards 290˚ and 055–110˚) and, in places, well-developed herringbone cross-bedding is present. A small-scale duplex structure that shows floor and roof thrusts and several imbricate slices can also be seen within this outcrop.

The youngest beds in the cutting [NC 2313 2451] contain very faint, but clearly distinguishable, *Skolithos* ‘pipes’, indicating that the Basal Quartzite–Pipe Rock Member boundary lies a few metres from the top of the exposed succession. In beds where *Skolithos* is ambiguously developed in vertical profile, this can often be verified by looking for the tell-tale dimples and corresponding warts on the bedding surfaces where the burrows pass through.

Locality 1.10 Classic outcrops of the Pipe Rock Member. [NC 2349 2440]

Twenty metres up the Kylesku road from Skiag Bridge lie some of the most photographed trace fossils in the United Kingdom. The matrix of the Pipe Rock Member is here stained red by diagenetic iron oxide, but the *Skolithos* burrows remain white as a result of differential early diagenesis. Somewhat masked by the red staining and the abundant *Skolithos* burrows, the Pipe Rock Member contains abundant large-scale planar tabular cross-bedding in sets of 0.5–1.5m; each set is divided by green mudstone seams from which sphaeromorph acritarch floras have been recovered. The *Skolithos* burrows are *c*.1cm wide with lengths of many tens of centimetres: precise maximum lengths are difficult to estimate since outcrop faces are not coincident with the burrow axes.

Locality 1.11 Outcrops of the Fucoid Beds Member. [NC 2359 2423]

Return to the junction and continue eastwards along the lochside road towards Inchnadamph. The Pipe Rock Member is conformably overlain by the orange-brown Fucoid Beds Member (An t-Sròn Formation) a short distance east along the roadcut, and typical lithofacies are exposed 10m east of the brown tourist sign. Two lithofacies are present, the dominant one being dolomitic wavy bedded silt-stones. *Skolithos* and *Palaeophycus* are common, but a diverse assemblage of other trace fossils is present, including *Planolites*, *Cruziana* and *Rusophycus*. Together these are characteristic of the *Cruziana* ichnofacies, which is indicative of a position above storm wave base but beneath fair weather wave base. It was the occurrence of abundant black burrows on bedding surfaces that early geologists mistook for fossil seaweeds, giving rise to the name of the member. The Fucoid Beds Member is the earliest unit in the Cambrian succession to contain abundant body fossils as well as trace fossils, and trilobites that have been found in this member indicate a position within the *Bonnia–Olenellus* Biozone (late Early Cambrian to earliest Middle Cambrian).

The less abundant lithofacies comprises distinctive 10–30cm beds of dolomitic grainstones in which the dominant allochems are echinoderm fragments. McKie and Donovan (1992) identified eocrinoid fragments amongst the debris. The grainstones are cross-bedded with E-to NE-directed palaeocurrents and are interpreted as storm event beds.

Locality 1.12 Outcrops of the Salterella Grit Member and Ghrudaidh Formation. [NC 2372 2408]

The Fucoid Beds Member is conformably overlain by the Salterella Grit Member, which forms the upper part of the An t-Sròn Formation and marks a return to cross-bedded quartz arenite deposition. The roadside outcrop contains prominent *Skolithos* and less conspicuous examples of the body fossil *Salterella*. The latter is an organism of unknown affinity, but may be a primitive mollusc that produced an agglutinated rather than microcrystalline shell. In hand specimen, it appears as a cone a few milli-metres long that produces dark, circular or v-shaped profiles depending on the section; very occasional 3D specimens are white or black, but the shell is frequently dissolved out leaving distinctive mouldic cavities. *Salterella* occurs from the upper part of the Pipe Rock Member through to the base of the Ghrudaidh Formation, but is particularly abundant in the epony-mous member. The genus is stratigraphically restricted to the *Bonnia– Olenellus* Biozone. Other shell material is present as small fragments.

The Salterella Grit Member is conformably overlain by lead grey dolostones of the Ghrudaidh

Formation (Durness Group), marking a major shift in depositional style on the Laurentian margin from clastic-to carbonate-dominated. In the roadside section the boundary is gradational over a metre or so, marked by a rubbly sandy dolostone. This is significantly different to the boundary exposed a few hundred metres away in the lowest horses of the Achmore Duplex (see Locality 1.14) where a low energy, dolomitic siltstone marks the boundary. The dolostones in the road cut are faintly mottled as a result of differential dolomitisation in burrow systems, and there are occasional quartz sands with intraclasts. Towards the top of the outcrop, irregular white vugs become common and represent pseudomorphed evaporite nodules, probably of anhydrite.

Locality 1.13 Vogesite sills and Sole Thrust. [NC 2382 2403]

Beyond the end of the lay-by, the top of a vogesite (hornblende lamprophyre) sill that intrudes the Ghrudaidh Formation is seen by a culvert. Ten metres farther east is a 5m-thick vogesite sill with a rubbly base, which has been interpreted as the floor thrust of the Achmore Duplex, and the lowest thrust (Sole Thrust) of the Moine Thrust Zone in this area.

References

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