Dun Chia Hill (Loch Duntelchaig), Invernessshire

[NH 600 285]–[NH 600 291]

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Introduction

At the south-west limit of the Orcadian Basin, the outcrop of Middle Old Red Sandstone (MOBS) rocks extends down the south-east side of the Great Glen as far as Foyers (Stephenson, 1972, 1977; Mykura, 1982). Within this outcrop 'extension', the basal beds are characterized by coarse breccias, breccio-conglomerates and conglomerates that rest on a highly irregular palaeo-landsurface of Grampian Group (Dalradian) metasedimentary rocks and late Caledonian granitic rocks. The unconformity is well exposed in several places, the most dramatic and instructive being on the southeast side of Dun Chia hill, between Loch Ruthven and Loch Duntelchaig. There, the unconformable junction is exposed continuously for a distance of some 1300 m and the overlying breccio-conglomerates form cliffs from Tom Mor [NH 591 280] in the southwest, through Craig no h-Iolaire [NH 597 282], to the spectacular, 50 m-high Creag nan Clag (Crag of the Bells; [NH 601 289]) in the northeast (Figure 2.65). The effects of pre-MOBS weathering and erosion on the underlying Grampian Group rocks are well seen and the breccio-conglomerates yield much information about sedimentary processes and palaeogeography of the region in Mid-Devonian time. Similar basal beds are also well exposed in cliffs between Creag Dhearg [NH 618 294] and Carn Mor [NH 627 303], 2–3 km to the ENE of Creag nan Clag, but the unconformity is less well-exposed.

The Old Red Sandstone rocks of the area were first described by Wallace (1880), who described the unconformity and the overlying beds at Dun Chia and Creag Dhearg in some detail. Further descriptions and interpretations of these localities were given by Mould (1946) in her account of the nearby Foyers granitic pluton. The most detailed investigation was that of Mykura (1982), which was used in the compilation of the 1:50 000 geological map, Sheet 73E (Foyers) (British Geological Survey, 1996) and is the basis for much of the following account.

Description

Between Loch Duntelchaig and Loch Ness in the Great Glen, there is a cross-strike outcrop width of about 5 km of Middle Old Red Sandstone strata. This represents a succession over 2 km thick that includes coarse and fine breccias, conglomerates, gritty, pebbly feldspathic and fine-grained sandstones, with subordinate mudstones, siltstones and calcareous beds. In general, the lower parts of the succession (up to 900 m) are of breccio-conglomerate and coarse bimodal conglomerate overlain by planar-bedded, medium- to fine-grained sandstones. The succession interdigitates along strike to the north-east with that of the Inverness and Nairnside districts, where fragmentary fish remains and plant spores of Mid-Devonian age have been found (Horne and Hinxman, 1914; Horne, 1923; Fletcher *et al.,* 1996). There is a regional dip of between 10° and 50° to the north-west.

Throughout the area in general, the pre-MORS topography was undulating, with some steep slopes locally that probably reflected active fault scarps (Stephenson, 1972; Mykura, 1982). Within the GCR site, between Tom Mor [NH 591 279] and Creag nan Clag [NH 600 287], the basal unconformity is exposed almost continuously for 1300 m at the foot of steep cliffs (Figure 2.66). It is undulating, but generally inclined in a NNW to westerly direction at angles ranging from 20° to 65°, with an average of 45°. Locally [NH 5985 2835], it is almost vertical on Craig na h-Iolaire.

The underlying rocks are platy psammites, gneissose in parts, of the Dairadian Grampian Group, which are generally vertical or steeply inclined, but exhibit some quite large-scale folding. Directly beneath the unconformity at the southern end of Creag nan Clag [NH 5988 2857]–[NH 6000 2870], a monocline, overturned towards the west, has a near-horizontal upper limb. Locally this limb is broken into small blocks, some rotated, but others still in their original position and enclosed by sandstone. Sandstone veins also penetrate downwards through the horizontal limb and axial plane of the monocline into the vertical limb beneath. A small Miler of psammite on the north-west slope of Dun Chia,

some 40 m below the summit (Figure 2.65), probably represents the peak of a buried hillock or ridge crest. Here, just below the unconformity, is another monocline overturned to the southwest.

The psammites are intruded by dykes, up to 10 m thick, of microgranitic rock ('felsite') and microdiorite. Many of the felsites are intensely shattered at the unconformity and are overlain by a deposit composed almost entirely of felsite clasts.

The MORS rocks of the Moray Firth area are formally assigned to the Inverness Sandstone Group, and the basal beds at the GCR site are all part of the Bochruben Formation (Mykura, 1982). These are mainly breccio-conglomerates and conglomerates in which almost all of the clasts are locally derived from the Grampian Group or the nearby Foyers Pluton. Horizontal and vertical variations in the basal beds of the formation are well displayed in the cliffs on the east side of Dun Chia.

At the south end of Creag nan Clag, the lowest 5–10 m are composed entirely of angular, locally derived clasts, with plates of psammite and felsite in roughly equal proportions; felsite clasts predominate in the vicinity of felsite dykes. Elsewhere, for example at the eastern end of the inlier on the north-west flank of Dun Chia, felsite clasts commonly constitute 40%, and in some restricted areas up to 90%, of the basal deposits.

The basal breccias of almost in-situ angular material are overlain by massive, very crudely bedded breccio-conglomerates composed of ungraded, subangular clasts up to 60 cm in diameter. The larger clasts are not in contact and are supported in a sparse red gritty matrix. Their long axes are randomly orientated, some being almost perpendicular to the bedding. Most are psammite and quartzite of local origin, with subordinate granite-gneiss and gneissose semipelite, but angular felsite clasts constitute up to 30% in places. Rounded boulders of biotite granite also occur sporadically. The breccio-conglomerates vary in thickness, being thickest in the cliffs of Creag nan Clag and thinning to the north-east and south-west, although they still form the greater part of all of the cliff sections.

The north-west flanks of Dun Chia and parts of the summit ridge are composed of bimodal conglomerates with a high proportion of leucogranite clasts. On Craig na h-Iolaire, coarse conglomerates with rounded granite boulders up to 60 *cm* in diameter overlie Dalradian 'basement' almost directly in places, although residual patches of local breccia only a few metres thick, and some breccio-conglomerates are also present. Sandstone lenses are intercalated locally with the conglomerates, such as those dipping at 15° to the WNW, between 6 m and 10 m above the unconformity at the southwest end of Creag nan Clag.

Interpretation

The prominent monocline in the Dalradian 'basement' at Creag nan Clag has an axial plane almost parallel to the unconformity and was interpreted by Mykura (1982) as flexuring due to hill creep prior to deposition of the MORS sediments. However, this coherent fold is on a remarkably large scale to have been formed in such a manner and subsequent visitors to the site have rejected the interpretation, observing that the geometry of the fold is of a tectonic style and conforms with others in the surrounding psammites. At one locality a dyke, truncated by the unconformity, is intruded along the vertical limb of the monocline but is not bent as it enters the horizontal limb. Mykura explained this by suggesting that the dyke was intruded after the hill creep but before MORS sedimentation. This somewhat implausible scenario does fit a further suggestion by Mykura (1982), concerning the origin of local concentrations of felsite in the basal MORS. Observing that, in several places on Dun Chia and Creag Dearg, the percentage of felsite clasts (40–90%) is much higher than the percentage of felsite dykes seen in the Dalradian beneath, Mykura suggested that the dykes may have been feeders to small extrusive domes on the pre-MORS land surface. Such domes are usually unstable and would have crumbled to breccia shortly after extrusion; hence no definite domes have been identified. However, in the absence of any other evidence for volcanism in the Grampian Highlands in Mid-Devonian time, this scenario is also regarded as highly tenuous.

The local origin of most of the clasts in the basal MORS and the low degree of sorting indicate that many of the deposits were formed quite near to the source of their constituents. Much of the angular material in the basal breccias is virtually in-situ and is in effect a regolith, or, if on a steep original slope, a 'fossil scree'. The lack of movement is particularly

noticeable above some felsite dykes where it is difficult to separate the in-situ felsite from 'felsite scree'. This effect is even more characteristic of basal MORS deposits to the south-west of the GCR site, where 'granitic screes' are indistinguishable in places from underlying in-situ granitic rocks (Stephenson, 1972; Mykura, 1982). The freshness of many of the clasts indicates rapid accumulation in a climate in which chemical weathering was minimal. However, oxidation is commonly intense, imparting a red or purple hue to the matrix of the rocks, so climatic conditions during deposition were probably arid or semi-arid.

The breccio-conglomerates that dominate the GCR site merge with the basal breccias and have no marked basal erosion surfaces. They are unstratified and poorly sorted, with mainly subangular clasts of local material 'floating' in a matrix, usually of mud or silt grade. These are the characteristics of debris flows that moved as dense, viscous masses in which waterlogged matrix was able to support and transport clasts up to boulder size. Such deposits form typically in areas of high relief and rapid erosion, in which deposition on steeply sloping alluvial-fans results from occasional sheet floods during sudden violent rainstorms in an otherwise dry area. The thickest development of breccio-conglomerate, in the 50 m-high cliffs of Creag nan Clag, has no horizontal breaks and it is possible that the entire section represents a single debris flow, possibly filling a palaeovalley. Lenses of conglomerate and sandstone within the sequence probably originated as channel-fill deposits within the alluvial fans and some of these have cut down to rest directly on basement in places.

Higher in the sequence, reworking by water becomes apparent as the breccias become slightly better sorted, some bedding is evident and clasts become more rounded. Debris of a less local nature appears, including leucogranite clasts that must have been transported for some distance. Bimodal clast-supported conglomerates, which occur locally as channel-fills within the breccio-conglomerates, become dominant higher in the succession, from the summit of Dun Chia north-westwards. These higher conglomerates are of fluvial origin and probably originated as braided river deposits on the distal parts of fans and on the piedmont plain. Beyond the GCR site, still higher parts of the succession record the eventual burial of the fans by finer-grained sediments that accumulated on a broad floodplain (Mykura, 1982).

By the time of deposition of the MORS sediments, the Grampian Highlands had already experienced considerable rapid uplift at the end of the Caledonian Orogeny. An estimate of the scale of uplift in the northern Grampians can be obtained from petrological evidence in the aureole of the Foyers Pluton, which Marston (1971) suggested had a possible cover of 7 km at its time of emplacement in Early Devonian times. The cover was removed in a maximum of about 20 Ma to expose the pluton in Mid-Devonian time. This represents an erosion rate of at least 3.5 cm per 100 years, comparable with rates in present-day newly formed mountain areas.

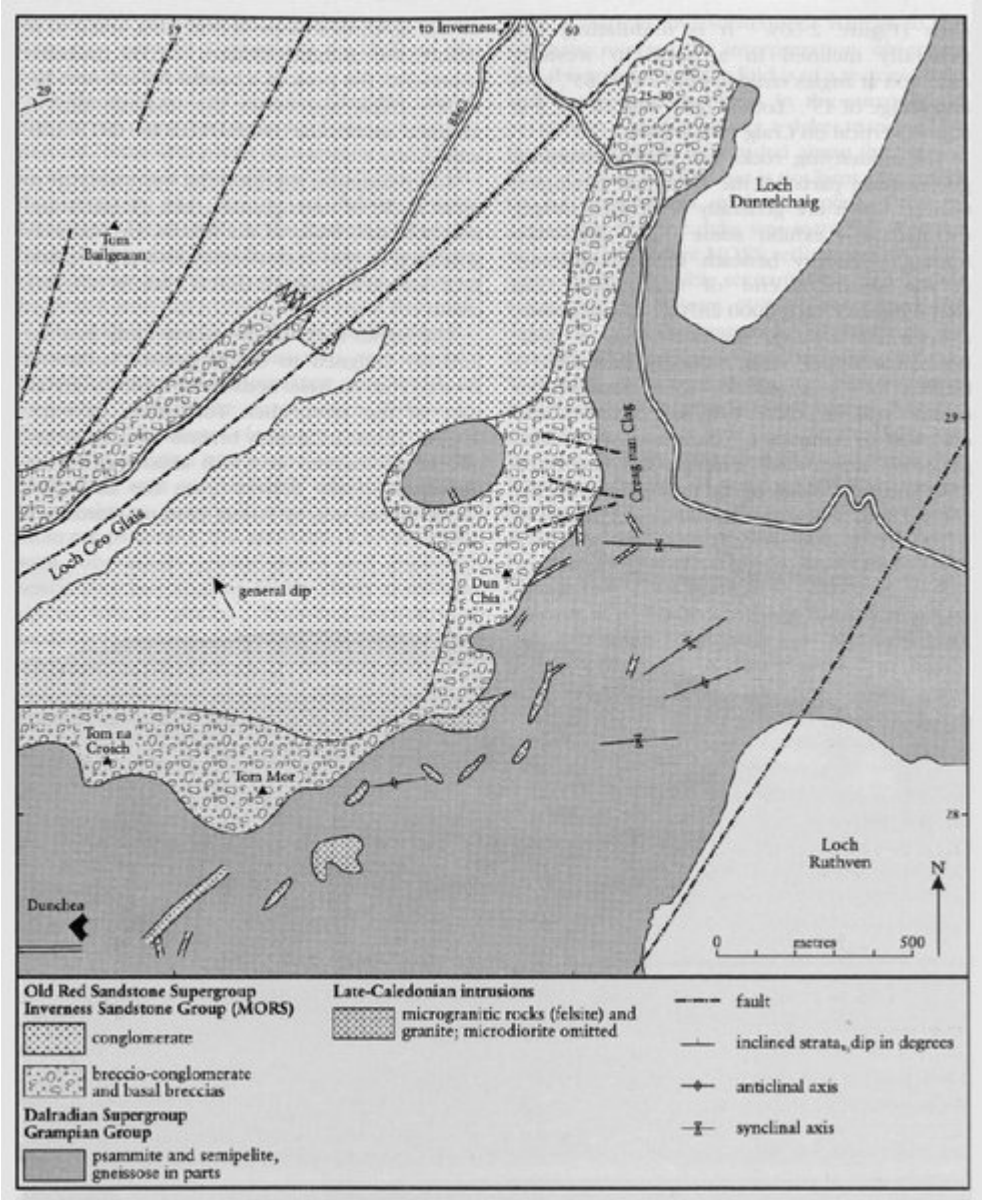
The Great Glen Fault was already in existence in Mid-Devonian times and may have been the locus of a major valley that drained north-east and was bounded to the south-east by high mountains (Stephenson, 1972, 1977). The MORS basal sediments were deposited predominantly in coalescing alluvial-fans along the foot of these mountains and in the valley bottom, which widened out north-eastwards into a piedmont plain on the edge of the main Orcadian Basin. The plain probably extended across the Great Glen Fault into the area now occupied by the Black Isle and Tarbat Ness (Mykura, 1982, fig. 11). Close to the Great Glen Fault, in the Foyers–Inverfarigaig area, the highlands to the south-east were probably bounded by major active NE–SW fault scarps, related to the Great Glen Fault and with a component of downthrow to the northwest. However, around Loch Duntelchaig, the edge of the hills probably swung to the ENE; here major fault scarps were probably absent and the boundary zone between plain and mountain may have been a belt of foothills with several small active local fault scarps.

Conclusions

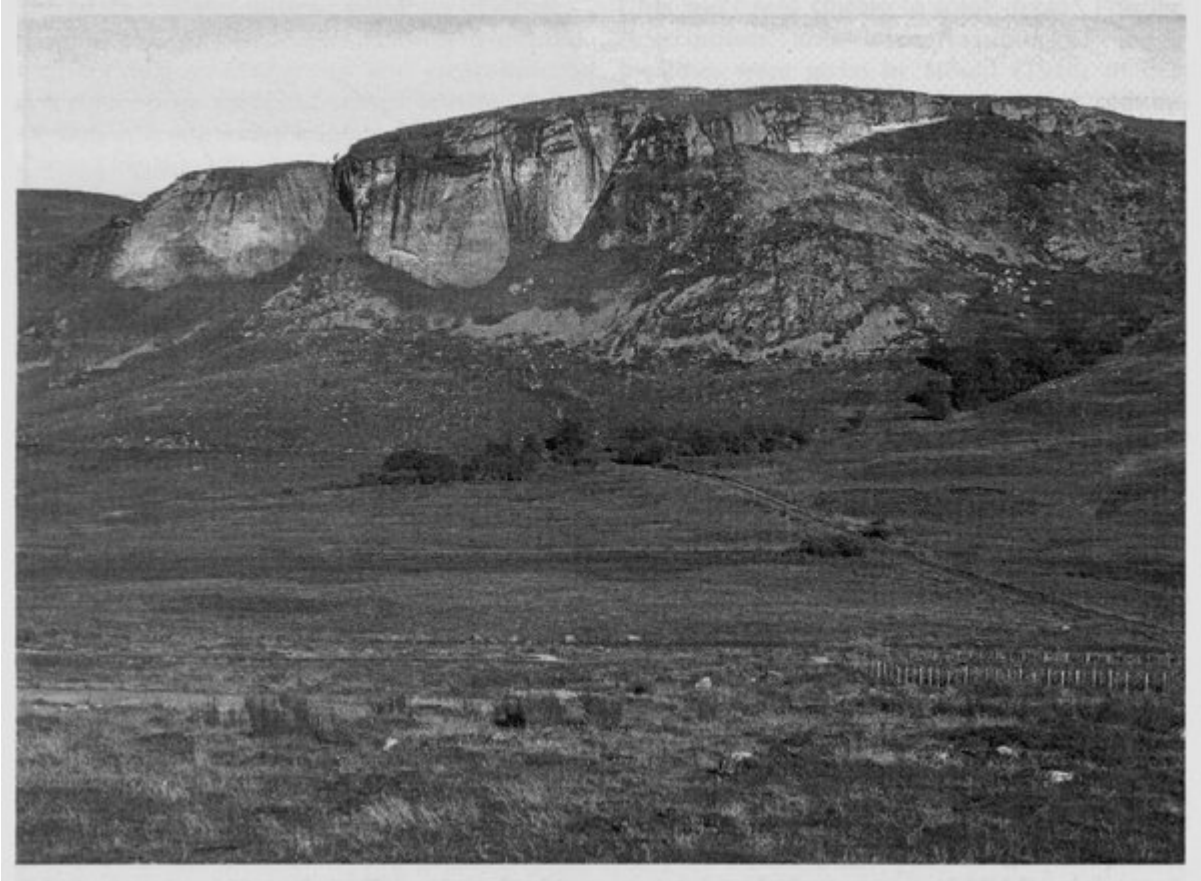
The spectacular cliffs on the south-east flank of Dun Chia hill, at the south-west end of Loch Duntelchaig, provide a representative section of the basal beds of the Middle Old Red Sandstone at the southern limit of the Orcadian Basin. The unconformable junction beneath these beds is very well-exposed almost continuously over a distance of 1300 m and is probably one of the best preserved 'buried landscape' unconformities in Great Britain. It is certainly of national importance and visitors cannot fail to be impressed by the scale of the exposure and by the many exceptional features that are exhibited. Beneath the unconformity, folded Neoproterozoic flaggy metasandstones, cut by felsitic dykes, are

disaggregated and shattered close to an undulating former land surface. The overlying angular debris can be matched precisely to the immediately underlying rock in many places and probably accumulated as scree. Poorly sorted mixtures of angular fragments and rounded boulders (breccio-conglomerates) comprise the majority of the section and probably originated as debris flows or sheet floods associated with alluvial fans that debouched from mountainous terrane to the south-east and spread out over a broad piedmont plain to the north on the edge of the alluvial plain of the main Orcadian Basin.

References



(Figure 2.65) Map of the area around Dun Chia hill, at the south-west end of Loch Duntelchaig. After British Geological Survey 1:50 000 Sheet 73W (Scotland), Foyers (1996).



(Figure 2.66) The cliffs of Creag nan Clag, on the eastern flank of Dun Chia hill. The undulating unconformity between Middle Old Red Sandstone massive breccio-conglomerates and underlying flaggy psammites of the Grampian Group (Dalradian) can be traced for 1300 m along the base of the steep upper cliffs. (Photo: BGS No. D1813, reproduced with the permission of the Director, British Geological Survey, NERC.)