
4 Lochan Uaine

[NH 611 224]–[NH 613 228]

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4.1 Introduction

Locating and understanding the nature of the contact between the rocks of the Northern Highlands and Grampian terranes has long been a major challenge of Highland geology (Harris *et al.*, 1994; Strachan *et al.*, 2002). In particular the junction and relationship between the Moine and Dalradian supergroups and the correlation of their tectonothermal histories, has provided a focus of study for many eminent geologists for over a century. Despite this attention, the junction remains elusive and interpretations are based on educated guesswork or model-driven hypotheses.

The Lochan Uaine GCR site is situated south of Dunmaglass Mains farm in the headwaters of the River Farigaig in Strath Errick (Figure 5.11). Its importance stems from the original belief that it represents a candidate for the missing junction between the Moine and Dalradian successions. The site contains excellent examples of highly contrasting rock types and clear, easily accessible exposures of their contacts. Migmatitized and gneissose semipelites are juxtaposed across a zone of relatively high strain against variably gneissose psammite and quartzite containing abundant sedimentary structures. The sedimentary structures confirm that the psammites and quartzites are everywhere structurally and stratigraphically below the semipelite. The contact zone is a zone of high strain but is distinctly different from the Grampian Shear-zone as described at *The Slochd* and *An Suidhe* GCR sites in that it lies along the common limb linking two major fold structures and it does not contain deformed pegmatitic granite veins, quartz veining, pods of garnet amphibolite or books of muscovite.

The nature of the contact between these two contrasting rock types was first described in the Strath Errick area in an abstract by Harris *et al.* (1981), who noted the presence of a zone of strong deformation marked by platy quartzite. They considered the contact to be a modified unconformity between the 'Newer Moine' rocks, which pass upwards into the Dalradian, and an 'Old Moine' basement. Highton (1986) provided a more-detailed description and re-interpreted the contact zone as a ductile thrust carrying the 'older' migmatites over younger Dalradian metasedimentary rocks. The primary survey of the area was completed in 1989 by P Haselock under contract to BGS (1:10 000 Sheet NH62SW), and this was included in the BGS 1:50 000 Sheet 73E (Foyers, 1996).

4.2 Description

Within the Lochan Uaine area, the contrasting lithologies can be studied in the craggy outcrops around the summit and eastern flanks of Beinn Mheadhoin [NH 6045 2175] and on Garbhal Mor [NH 6260 2344]. Their contact relations are best observed in the prominent meltwater channel and jokallhaup basin, which includes Lochan Uaine, between [NH 6122 2276] and [NH 6124 2257]. The rocks, all at amphibolite-facies metamorphic grade, dip steeply eastwards and are overturned locally. A series of map-scale reclined folds (F2) trend north-west–south-east and are refolded about N-S-trending axes of later upright folds (F3).

Two lithostratigraphical units have been defined. The stratigraphically and structurally lowest strata are represented by the variably gneissose Gairbeinn Pebbly Psammite Member of the Garva Bridge Psammite Formation in the Glenshirra Subgroup (Smith *et al.*, 1999). These are the lowest strata recognized in the Grampian Group and form a geochemically distinct metasedimentary unit across the Northern Grampian Highlands (Haselock, 1994; Banks and Winchester, 2004). The uppermost and younger lithological unit, the Ruthven Semipelite Formation, comprises intensely migmatized semipelite with thin units of psammite and calcsilicate rock. This unit was considered to be older by early workers, and

was correlated with the Moine rocks of the Northern Highlands Terrane, mainly on textural grounds and the presence of additional deformation phases. However, it is now correlated with the Coire nan Laogh and Kincaig formations which together form the basal units of the Corrieyairack Subgroup (Smith *et al.*, 1999).

The Gairbeinn Pebbly Psammite Member comprises medium-grained, typically grey- to pink-weathering psammite and micaceous psammite, with subordinate quartzite and distinctive thin pebbly units. It is comparable to the strata described at the *River E* GCR site. In thin section the psammites are dominated by plagioclase, K-feldspar, quartz and mica. Highton (1986) separated the pebbly and magnetite-bearing rocks of Beinn Mheadhoin from the variably gneissose psammites on Garbhal Mor (his Can Ban Psammite), largely on the basis of degree of metamorphic recrystallization. However, subsequent recognition of pebbly bands and sedimentary structures on Garbhal Mor and on the nearby hills of Carn Poullachie and Carn Ban, has confirmed a correlation with the Beinn Mheadhoin outcrop and this suggests that the development of gneissose textures was controlled by intra-formational variations in bulk chemistry.

Bedding is generally 5–20 cm but locally up to 50 cm thick and is defined by variations in grain size, the proportion of mica and by magnetite-rich laminae. Semipelite is rare but bands up to 0.4 m thick were noted by Highton (1986). Evidence for stratigraphical younging is common and includes graded bedding, cross-bedding, small-scale ripple drift and flaser lamination, ripple lamination, convolute lamination and slump folds (Figure 5.12). Younging is everywhere towards the contacts with the structurally overlying semipelite. Laterally impersistent pebble beds, up to 30 cm thick, are seen immediately south of Lochan Uaine at [NH 6117 2241] and on Garbhal Beag [NH 6224 2418]. The clasts, up to 10 cm in diameter and composed of microcline and quartz-feldspar aggregates, are dispersed within the matrix of the rock but are sufficiently abundant locally for the rock to be clast supported. The pebble beds and heavy-mineral seams contain magnetite, titanite and epidote. These impart a detectable magnetic signature to the formation and have been used to map out its outcrop throughout the district (e.g. Haselock and Leslie, 1991) (Figure 5.11). Farther to the north-east, on Garbhal Mor at [NH 621 238] and on the hill of Carn Ban, the formation is variably gneissose with units containing abundant granitic segregations rimmed by biotite-rich selvages.

Highton (1986), Haselock and Gibbons (1990) and the summary of geology accompanying the BGS 1:50 000 Sheet 73E (Foyers, 1996) have all described a transitional junction between the two formations south of Garbhal Mor at [NH 6225 2274] (Figure 5.11). The transition is marked by the incoming of bands of siliceous psammite, passing upwards into interbanded impure quartzite and psammite; the proportion of semipelite decreases but thin seams of semipelite are still present up to 200 m from the contact. Individual units of quartzite reach 50 m in thickness locally. Elsewhere in the area, the contact relations are less clear due to the focussing and overprint of ductile shear along the contact zone. However, despite the high strain and resultant attenuation, the transitional nature of the junction has now been well established by several authors and major excision of strata along the line of the shear-zone is unlikely.

The Ruthven Semipelite Formation is characterized by medium- to coarse-grained gneissose and migmatitic semipelite and pelite. Rare thin units of psammite, layers of calcsilicate rock and variations in the frequency of quartzofeldspathic segregations define original lithological variation. In thin section the semipelite contains the assemblage biotite, muscovite, quartz, garnet and plagioclase. Pelites containing kyanite, fibrolite and K-feldspar are recorded elsewhere in the district. At Lochan Uaine, the formation is spectacularly exposed in large boulders at the southern end of the loch and in the crags to the east (e.g. at [NH 6128 2275]). The migmatites are stromatic (lit-par-lit) and comprise quartzofeldspathic leucosomes, up to 10 cm thick, surrounded by screens of biotite and muscovite. Layering, commonly accentuated by effects of later deformation, becomes more schistose locally. No sedimentary structures have been observed.

The metasedimentary rocks at Lochan Uaine are affected by three phases of deformation and associated amphibolite-grade metamorphism. An early tectonic event produced a near-bedding-parallel foliation in the psammites, which is transitional into the coarser grained migmatitic fabrics in the micaceous psammite and the semipelite. Earlier workers separated these two fabrics into two distinct events, with the gneissosity predating the foliation (Harris *et al.*, 1981; Highton, 1986). In the Gairbeinn Pebbly Psammite Member this early fabric, probably a composite of S₀ and S₁, is defined by aligned micas. The main D₂ deformation produced a series of NW-trending steep to reclined folds with steep NE-dipping axial planes, a strong axial planar crenulation cleavage in the hinge-zones and transposition of the earlier gneissosity. An antiform-synform pair controls the disposition of lithologies and the early fabrics at the GCR site and the

common limb, which runs close to Lochan Uaine, is strongly attenuated and faulted. Garnets within the semipelite show two-stage growth, typically with inclusion-free rims around a core rich in quartz and magnetite. The final and weakest phase of deformation (D3) produced regional upright tight N-S-trending folds with an axial planar crenulation overprint; these features are not well developed at the GCR site.

At Lochan Uaine, the boundary between the Gairbeinn Pebbly Psammite Member and Ruthven Semipelite Formation lies on the right way-up limb of the F2 fold-pair and is marked by a zone of deformation previously termed the Lochan Uaine or Gairbeinn slide (Highton, 1986; Haselock and Gibbons, 1990). Haselock and Gibbons (1990) correlated this structure with a slide-zone that marks the upper boundary of the Glenshirra Subgroup with younger rocks throughout the western part of the Northern Grampian Highlands. The zone of deformation is well exposed in the crags at the northern and southern ends of Lochan Uaine, where the transition from feldspathic pebbly psammite to pelite occurs over a distance of c. 2 m. It is marked by platy psammite and quartzite and by schistose semipelite in which the original bedding and coarse gneissose fabrics have been obliterated and transposed into the main shear fabric. Highton (1986) described the progressive deformation of pebbles and sedimentary structures that define a strain gradient consistent with simple-shear and minimal horizontal extension. Above the contact, the rapid fall off in strain and the presence of ribboned quartz grains in thin section led Highton (1986) to interpret these rocks as the products of a ductile thrust or zone of decollement, synchronous with D2 in the gneissose semipelites and with his first deformation in the psammites. A shape fabric in the pebbly bands, together with mineral fabrics, defines a lineation that plunges gently to the north. This is progressively re-orientated into steep plunges in the shear-zone. Shear-sense indicators have not been recorded, although Highton (1986) noted an anticlockwise sense of rotation from augen of restite grains and muscovite in the semipelite. The BGS 1:10 000 Sheet indicates a top-to-the-west sense of shear, though the basis for this interpretation is not clear.

4.3 Interpretation

The startling contrast between the Gairbeinn Pebbly Psammite Member and Ruthven Semipelite Formation, as highlighted by a variety of features including sedimentary environment, metamorphic fabric and structural history, has led previous workers to consider the Lochan Uaine GCR site as a candidate for the elusive Moine–Dalradian contact, a zone of major ductile thrusting or a local zone of attenuation on the common limb between two major folds.

In sedimentary terms, the presence of superb sedimentary structures and grain-size variation with local development of pebble bands indicates high-velocity, rapid rates of sedimentation for the Gairbeinn Pebbly Psammite Member. The psammites are texturally and mineralogically immature and this, combined with the nature of the sedimentary structures, indicates deposition within an alluvial to shallow marine environment (Banks and Winchester, 2004). The pebbly beds might indicate shallow marine fan-type deposits whilst the presence of slump folds suggests liquifaction and rapid sedimentation. Regionally, the Gairbeinn Pebbly Psammite is interpreted as having been deposited within a SE-thining fan-delta clastic wedge (Banks and Winchester, 2004). The presence of clasts and pebbles suggest proximity to an uplifted block of granitoid basement (Smith *et al.*, 1999).

In contrast, the Ruthven Semipelite Formation formed in a wholly marine environment and passes stratigraphically upwards into a thick sequence of rift-related turbiditic metasedimentary rocks. The base of the formation, like the Coire nan Laogh Semipelite Formation elsewhere (see the *Garva Bridge* GCR report), represents an important sequence boundary and defines the base of the Corrieyairack Subgroup (Banks and Winchester, 2004; Banks, 2005). This base is marked by the transitional unit of interbedded quartzite and semipelite seen on Garbhal Mor and at Lochan Uaine.

Superficially the two formations appear to record distinct metamorphic histories, with a major gneiss-forming event preserved in the semipelites but not in the psammites in which bedding is commonly well preserved. This has now been re-interpreted as a response to differences in primary composition. During deformation, the plagioclase-bearing psammites on Beinn Mheadhoin were essentially unreactive and thus preserve their original primary structures, whereas the stratigraphically equivalent K-feldspar-bearing micaceous psammites and semipelites on Garbhal Mor developed gneissose and migmatitic fabrics. Similarly the mica-rich pelites of the Ruthven Semipelite Formation were readily migmatized during deformation and metamorphism. On this basis the strata on either side of the postulated shear-zone share a common tectonothermal history and hence there is no evidence for an orogenic unconformity as was proposed

by Harris *et al.* (1981).

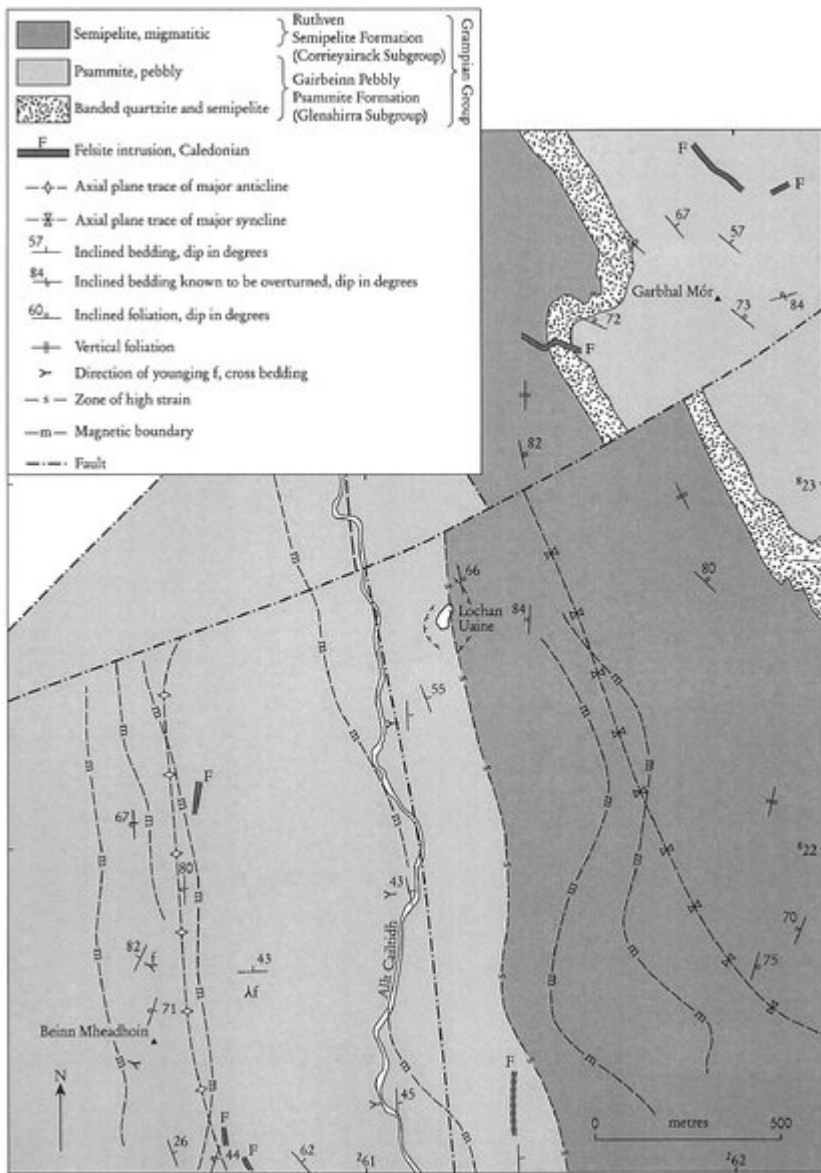
The nature of the contact and the amount of translation across the shear-zone remain debateable. If the correlation of the psammities on Beinn Mheadhoin and Garbhal Mor is accepted then there is little requirement for a significant break, and the deformation zone can be explained in terms of attenuation along major rheological contrasts on the long limb of a fold during the D2 event. Shear-zones propagating on minor F2 fold limbs were noted by Highton (1986) in Strathnairn and are common throughout the Northern Grampian Highlands. Alternatively, if stratigraphical excision is envisaged then the shear-zone, with a presumed top-to-the-west sense of movement, contravenes the first rule of thrusting as it brings younger rocks over older.

4.4 Conclusions

Interest in the Lochan Uaine GCR site was first aroused because the exposed contact between two distinctly different metasedimentary units, one gneissose and the other non-gneissose with good sedimentary structures, was thought to be a possible junction between the Moine and Dalradian successions. Subsequent contrasting interpretations of the contact have varied from an unconformity overprinted by a shear-zone, to a thrust and, more recently, to a zone of attenuation along the long limb of an F2 fold. Such variance highlights the need for care in the interpretation of stratigraphical contacts and metamorphic fabrics in such lithologies. This historical site now provides an exceptional example of how contrasts in physical properties and differences in bulk-rock chemistry can produce markedly different looking rocks.

Superbly exposed psammities and quartzites with abundant sedimentary structures (the Gairbeinn Pebbly Psammite) young upwards towards a transitional contact with strongly migmatitic semipelite (the Ruthven Semipelite). The two units share a common tectonothermal history and both are now assigned to the Grampian Group of the Dalradian. During the main phase of deformation (D2), rheological contrasts across the contact zone have provided the focus for ductile strain to produce platy, mylonitic fabrics along the long limbs of major fold structures.

[References](#)



(Figure 5.11) Map of the Lochan Uaine area, Strath Errick (after BGS 1:10 000 Sheet NH62SW).



(Figure 5.12) Convolute lamination and cross-lamination in the Gairbeinn Pebbly Psammite Formation, east flank of Beinn Mheadhoin [NH 607 217], near the Lochan Uaine GCR site. Lens cap is 7 cm in diameter. (Photo: BGS No. P 518573, reproduced with the permission of the Director, British Geological Survey, © NERC.)