3 Hawks Ness

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3.1 Introduction

The sea cliffs and rocky foreshore around the promontory of Hawks Ness provide extensive exposure through a metasedimentary sequence extending from the top of the Whiteness Group through the lower part of the Clift Hills Group of the Shetland Dalradian. The lithologies present range from metacarbonate rocks of probable shallow-water origin, to metavolcanic rocks and deep-water turbidites. Sedimentary structures preserved in the turbiditic strata show locally opposed younging directions which, together with the exposure of fold closures, confirm the presence of isoclinal folds. Deformation has also produced a pervasive foliation, a linear fabric and a recrystallized, phyllitic mineral assemblage. Post-tectonic regional metamorphism led to the subsequent growth of staurolite and garnet porphyroblasts.

The regional importance of the Hawks Ness GCR site lies in the unusually wide range of sedimentary, tectonic and metamorphic features preserved in a succession that was deposited in an extensional basin setting. An understanding of the processes and sequence of events involved allows for a more-informed regional interpretation of an otherwise poorly known part of Scottish geology. A detailed account of the geology was given by Flinn (1967) whilst an overview of the regional geological setting was provided by Flinn and May (in Mykura, 1976); the GCR site area is included in the Geological Survey's one-inch Sheet 128 (Central Shetland, 1981).

3.2 Description

Around the promontory that culminates in Hawks Ness, steeply inclined strata strike north-north-east. The stratigraphical sequence commences with the Laxfirth Limestone (the top of the Whiteness Group) on the west side of the promontory, and proceeds upwards and eastwards through the Asta Spilitic Formation and Clift Hills Phyllitic Formation (the lower part of the Clift Hills Group) (Figure 7.6). The Asta Spilitic Formation has been correlated with the Easdale Subgroup in the Dalradian succession of the Scottish mainland (Flinn *et al.*, 1972) but more-recently a possible correlation with the Tayvallich volcanic rocks, at the top of the Argyll Group, has found more favour (Harris *et al.*, 1994; Flinn, 2007).

The Laxfirth Limestone crops out as a thin strip along the strike-parallel eastern coast of Lax Firth, although the full outcrop extends to the western side of the firth and the thickness probably exceeds 500 m. It is a crystalline, calcite metacarbonate rock containing scattered coarse grains of quartz, and with small quantities of epidote, zoisite, white mica and pyrite concentrated into fairly continuous laminae. On a larger scale, there is a faint, millimetre- to centimetre-scale colour banding through shades of pale grey and pale pink. Overall, the Laxfirth Limestone is relatively fine grained compared to some other Dalradian metalimestones. At its eastern boundary, it is intimately associated with conformable sheets of hornblende schist up to about a metre thick.

Conformably above the metalimestone is the Asta Spilitic Formation, which crops out along the north-west coast of Hawks Ness in a narrow zone no more than a few tens of metres wide. These largely pyroclastic rocks range from phyllitic fine-metatuffs to pyroclastic metabreccias and are generally thinly interbanded with feldspar-phyric hornblende schists and phyllitic pelites. Adjacent to the Laxfirth Limestone, and corresponding with the pyroclastic rocks, a narrow positive ground-magnetic anomaly of about 1000 nT can be traced continuously, southward to the sea at Scalloway and to the north-east almost as far as the Out Skerries. The pyroclastic rocks are succeeded by a zone, 10–20 m wide, in which beds of turbiditic gritty quartzite alternate with thin beds of laminated and graded, dark semipelite. Some hornblende schists commonly form boudinaged pods.

The north-east coast of Hawks Ness presents a continuous section through more than 300 m of the Clift Hills Phyllitic Formation. This unit contains phyllitic metagreywackes, thin beds of gritty quartzite, phyllitic gritty psammite, pelite, calcsilicate rock and sporadic lenses of hornblendic schist similar to those seen in the underlying Asta Spilitic Formation. The phyllitic rocks are laminated on a millimetre scale, the darker, more-micaceous laminae representing metamorphosed mudstone, while the paler laminae are probably derived from sandstones and siltstones. It is possible to detect small-scale cross-bedding in places, usually with the appearance of low-amplitude ripples (Figure 7.7). They have a strong foliation and are pervasively recrystallized to fine-grained quartz, feldspar and muscovite, together with biotite and/or chlorite; some are graphitic. Staurolite, biotite and chlorite porphyroblasts post-date the imposition of the tectonic foliation (Flinn, 1967). Inland, in the southern part of the Hawks Ness promontory, are large intrusions of hornblende metagabbro, containing ophitic blue-green hornblende and recrystallized primary albite. Smaller lenticular bodies of hornblende schist containing relict phenocrysts of plagioclase also attest to an igneous protolith.

On the south-east side of the Hawks Ness promontory, the top part of the Clift Hills Phyllitic Formation is the Dales Voe Grit Member, which comprises 1.5 km of turbiditic gritty quartzites. Excellent exposures are provided by the rocky headlands of Brim Ness and Fora Ness. In this well-layered sequence, units of impure quartzite, with bed thickness ranging from several centimetres up to several metres, alternate with subordinate units of thinly bedded laminated and graded semipelite. At Brim Ness there is a thin, conformable interbed of granular calcsilicate rock, whilst thin metalimestones and lenses of Asta Spilite-like rock occur sporadically. Within the quartzite units, many individual beds show normal, upwards grading from coarse, locally pebbly bases, through coarse-grained, gritty quartzite to finely laminated semipelite. Cross-bedding is seen in the upper parts of many beds, whilst evidence of channelling and current scour is preserved on basal bedding planes. This abundance of sedimentary younging evidence demonstrates local reversals that can be attributed to tight folding; many hinges are spectacularly preserved (Figure 7.8)a. These are dominantly single-bed intrafolial isoclinal folds most of which face eastwards and upwards, but a minority face westwards and downwards.

On the eastern side of the Dales Voe Grit, on the opposite side of Dales Voe, there is an upward transition from the gritty metasandstone back into chloritic phyllites. These then continue eastwards, and stratigraphically upwards until, farther south, they are seen to underlie the pelitic Dunrossness Phyllitic Formation, which in turn underlies the volcanic Dunrossness Spilitic Formation, part of which crops out in the *Cunningsburgh* GCR site.

Post-tectonic lamprophyre dykes, one of which can be seen to the south of Brim Ness, are probably of Early- to Mid-Devonian age.

3.3 Interpretation

At the base of the succession within the GCR site, the thick metacarbonate unit of the Laxfirth Limestone suggests sedimentation in relatively shallow water. The subsequent volcanicity recorded in the Asta Spilitic Formation, and the closely associated turbiditic metasedimentary rocks of the Clift Hills Phyllitic Formation, then suggest a phase of rapid subsidence and the establishment of a deep-water depositional environment. The following Dales Voe Grit beds have all the characteristics of deep-water turbidites. The individual beds are graded in their lower parts, passing up into a laminated and sporadically cross-bedded upper sector that is either abruptly overlain by the coarse base of the succeeding bed or passes up into a unit of thinly bedded, graded siltstones. The thicker, sandstone beds were deposited from large-volume and high-density turbidity flows, whereas the sequences of more thinly bedded, graded siltstones derive from a series of smaller, low-density flows. The bases of the thicker beds commonly carry flute and groove casts from which Flinn (1967) was able to calculate an original current flow from the north.

The array of sedimentary features that are preserved also allows the local sedimentary younging direction to be established. Throughout the GCR site area, the beds strike 030° and, in general, theydip steeply to the north-west in the west and to the south-east in the east. The overall stratigraphical trend is for successively younger units to crop out sequentially towards the south-east. This situation is confirmed by some of the localized sedimentary younging evidence but is contradicted in places by unequivocal examples of younging towards the north-west (Figure 7.7). Flinn (1967) recognized this phenomenon and related it to short wave-length isoclinal folding, which is shown by individual beds

(Figure 7.8)a. This was linked to the main tectonic deformation, which produced a steep schistosity and a lineation plunging at *c*. 20° to the south (Figure 7.8)b; a similar fabric and orientation to that in the rocks of the *Scalloway* GCR site to the south-west. However, while the fabric lineation plunges at 20° or so to the south, the axes of the folded turbidite beds plunge at 20–30° to the north (Figure 7.6), inset.

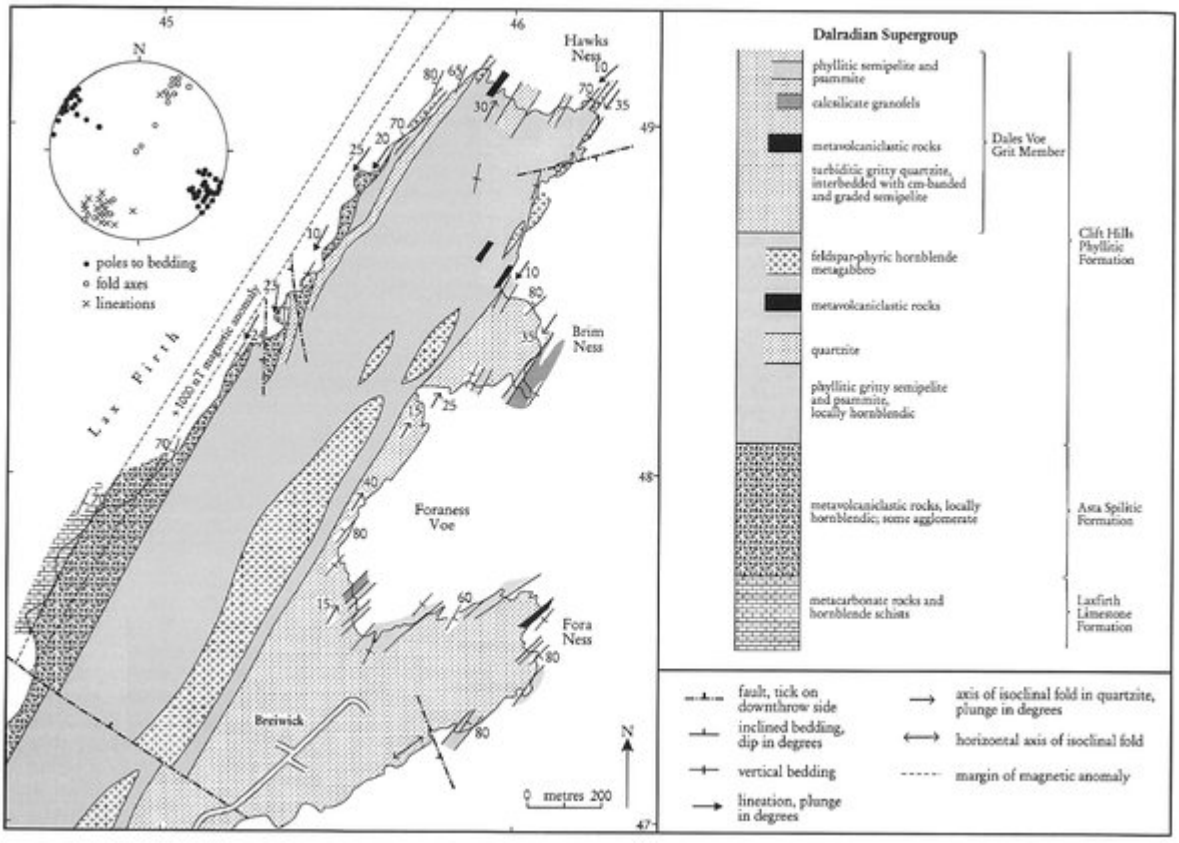
The local syn-tectonic metamorphic mineral assemblage is dominated by muscovite, biotite, chlorite, quartz and plagioclase. Post-tectonic regional metamorphism has led to the porphyroblastic growth of staurolite, garnet, biotite and chlorite.

3.4 Conclusions

The Hawks Ness GCR site provides a well-exposed and instructive representative section through a metasedimentary sequence extending from the top of the Whiteness Group (the Laxfirth Limestone) through the lower part of the Clift Hills Group (the Asta Spilitic Formation and the Clift Hills Phyllitic Formation) in the Dalradian succession of Shetland. These units are currently thought to be broadly equivalent to the Tayvallich Subgroup of the Scottish mainland succession. The sequence demonstrates deposition in a progressively deepening marine environment with sub-marine volcanism marking the onset of rapid subsidence.

Structural and metamorphic features within the GCR site make a significant contribution to interpretation of the deformational and metamorphic history of the Shetland Dalradian. Deep-water turbiditic strata (in the Dales Voe Grit) preserve sedimentary structures from which opposing stratigraphical younging can be deduced, confirming that the sequence has been affected by short-wavelength, isoclinal folding, which is commonly shown by individual beds. A phyllitic mineral assemblage (muscovite-biotite-chlorite-quartz-plagioclase) formed during deformation-related metamorphism and staurolite, garnet, biotite and chlorite were produced during post-tectonic, regional metamorphism.

References



(Figure 7.6) Map of the area around the Hawks Ness GCR site. Inset is an equal-area stereographic projection showing the relationship between poles to bedding, axes of prominent isoclinal folds in individual quartzite beds and fabric lineations.

(Figure 7.7) Ripple cross-lamination preserved within the Dales Voe Grit Member of the Clift Hills Phyllitic Formation. Brim Ness [HU 4606 4825]. Hammer head is 16.5 cm long. (Photo: F. May, BGS No. P 726605.)

(Figure 7.8) Structures in the Clift Hills Phyllitic Formation (see stereoplot inset in (Figure 7.6)). (a) Isoclinal synform in beds of turbiditic psammite of the Dales Voe Grit Member. Houbie [HU 4572 4807]. (b) South-west-plunging lineation caused by tectonic elongation of clastic grains in a bed of coarse, schistose psammite. North-west tip of Hawks Ness [HU 4583 4909]. Coin is 30 mm diameter. (Photos: F. May, BGS Nos. P 726606 and P 726607.)