Melby: Matta Taing to Lang Rigg, Shetland

[HU 165 560]–[HU 177 575]

Potential ORS GCR site

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Introduction

Fluvial and lacustrine strata of the Middle Devonian Melby Formation are spectacularly exposed within the sea cliffs and rocky foreshore between Matta Taing and Lang Rigg, on the north-west extremity of the Walls Peninsula, Shetland Mainland. The section is about 2–3 km west of Melby village, and to the north and west of Huxter. It lies to the west of the Melby Fault, in the westernmost of the tracts of Devonian strata of Shetland.

The lithofacies demonstrate the cyclical transgressions and regressions of a large lake within the Orcadian Basin. Highstands of the lake are marked by two units of laminated lacustrine mudstone with carbonate nodules. The nodules contain a regionally important fish fauna, which is described in the GCR fossil fishes volume (Dineley and Metcalf; 1999). During periods of lowstand, fluvial systems of braided channels prograded into the lake and deposited thick bodies of cross-stratified sands. Sandstone composition and palaeocurrent direction change through the succession, reflecting changes in the local palaeogeography.

The regional importance of the Melby site lies in the well-exposed evidence for the cyclicity of depositional environments in the northern extremity of the Orcadian Basin, and the insights provided into local palaeogeographical changes. The fish beds are also of great importance, being the northernmost correlatives of the Achannaras horizon of Caithness. All these factors allow better interpretation and characterization of the regional tectonic framework and development of the Orcadian Basin. Overviews of the geology are provided by Mykura (1976, 1991) and a detailed account of the section is given by Mykura and Phemister (1976). Details of the fish beds are given by Hall and Donovan (1978) and Dineley (1999a).

Description

West and south-west from Melby and Huxter, high sea-cliffs and rocky foreshore areas provide excellent, continuous exposure through a sequence of fluvial and lacustrine Old Red Sandstone strata, the Melby Formation. The beds strike approximately north-east and dip consistently towards the south-east between 25° and 45°, so that a vertical succession of about 250 m is represented, with faulting causing some local repetition. The western section from Matta Taing [HU 166 560] to Quilva Taing [HU 171 572] has high, rugged sea-cliffs cutting across the strike, and the north-western coastline, from Quilva Taing to Lang Rigg [HU 177 577], is approximately a strike section (Figure 2.8). The fossil fish faunas recovered from two horizons and spore analysis establish a late Eifelian–early Givetian (Mid-Devonian) age.

The oldest strata are seen along the northwestern coast between Lang Rigg and Ayre of Huxter [HU 173 574]. There, over 50 m of reddish brown, feldspathic sandstones pass upwards into grey-brown, calcareous sandstones. Mykura and Phemister (1976) described the rocks as poorly graded arkoses, comprising up to 80% quartz, up to 40% feldspar and a small proportion of lithic grains. Conversely, sandstones described by Knudsen (2000) are quartz arenites with a modal content of over 90% quartz, less than 5% feldspar and less than 5% lithic fragments. There is very little detrital matrix, and carbonate occurs as a secondary cement in the higher part of the sequence. Large-scale cross-bedding is ubiquitous. The cross-bedded sets range up to 3 m in thickness and are tabular (Figure 2.9)a or show complex convolutions in their upper parts (Figure 2.9)b. The convolute folds are overturned locally, invariably towards the east (Mykura and Phemister, 1976), in keeping with a dominant palaeocurrent flow from the west, as indicated by the dip of the foresets. Sporadic interbeds of siltstone reach about 50 cm in thickness, with the thickest example having an eroded top overlain by intraformational conglomerate. Locally, some of the thinner horizons of siltstone and shale contain

sandstone-filled shrinkage cracks.

About 2 m of ripple cross-laminated sandstone mark the top of the sandstone-dominated sequence. These are overlain by approximately 12 m of thinly bedded, fine-grained lithologies that together form the lower of the two Melby fish beds ((Figure 2.10), section a). There is considerable lateral variation within the Lower Melby Fish Bed, but it can be broadly subdivided into three units (Mykura and Phemister, 1976). The lowest unit, about 3 m thick, consists of pale grey, laminated siltstone and mudstone with desiccation cracks and sporadic plant remains. The middle unit, also 3 m thick, comprises grey to black, locally bituminous, laminated mudstone with irregular carbonate-rich ribs and nodules. A few thin interbeds of siltstone to fine sandstone have rippled upper surfaces. Plant remains areabundant and fossil fish fragments have been recovered from the calcareous ribs and nodules, which are mostly up to about 25 mm by 75 mm. Disarticulated fragments of *Coccosteus* are the commonest fish fossil; Dineley (1999a) provides a full list of species recovered, including the index species *Pterichthyodes milleri.* The top 4.5 m unit consists of laminated siltstone and mudstone with sporadic lenses of fine-grained sandstone. Finely disseminated plant debris occurs on some bedding surfaces, the larger fragments having an ESE–WNW alignment.

The Lower Melby Fish Bed is overlain by about 100 m of predominantly fine- to medium-grained sandstones. Individual sandstone beds range up to about 1 m in thickness and are variably pale yellowish brown to red in colour. They are interbedded with reddish, lenticular siltstone layers up to about 1 m thick, which give a marked banded appearance to parts of the succession (Figure 2.11)a. Many of the sandstone beds have large-scale, planar cross-bedding (Figure 2.11)b in which the foresets dip mainly towards the east. Trough cross-bedding is present locally on a small-scale (Figure 2.11)c. Ripple cross-lamination is common, especially towards the top of the unit, and is locally convoluted, with pseudonodule structures. Compositionally, the sandstones are arkoses with approximately equal proportions of quartz and feldspar (Mykura and Phemister, 1976). Grains are angular to subrounded and there is virtually no detrital matrix. Small worm tubes occur in the highest of the sandstone beds, immediately below the abrupt junction with the Upper Melby Fish Bed.

The Upper Melby Fish Bed comprises about 4 m of thinly bedded, pale grey siltstone and darker, laminated shale with lenticular carbonate layers (Figure 2.12)b and nodular concretions of carbonate and sulphide; some calcareous layers are nearly black and slightly bituminous. The best-developed lamination is caused by alternating silt, carbonate and organic carbon laminae forming triplets 0.3 mm to 2 mm thick. The thin siltstone beds and rare fine-grained sandstone layers, the latter generally lenticular, are pervasively convoluted (Figure 2.12)b with rippled upper bedding surfaces (Figure 2.12)c and contain sporadic plant material. The carbonate layers and nodules contain a well-preserved but fragmentary fossil fish fauna listed by Dineley (1999a) that includes *Coccosteus cuspidatus, Homosteus milleri* and *Mesacanthus* sp.. The sulphide nodules in the upper part of the fish bed are complex, varved and tectonically deformed. They contain varying proportions of pyrite, chalcopyrite, covellite, bornite, sphalerite, galena and tennantite and have a complex, multi-phase origin (Hall and Donovan, 1978). The fish bed is overlain by brown, fine- to medium-grained, feldspathic sandstone with some large-scale cross-stratification. The sandstone has a quartz/feldspar ratio of 65:35, with a significant quantity of felsite grains (up to 10%), and relatively abundant, large grains of garnet (Mykura and Phemister, 1976).

Interpretation

The range of lithologies and sedimentary features seen in the Melby section between Matta Taing and Lang Rigg reflect the varying environment close to the margin of a large lake within the Orcadian Basin. Lake transgression and regression were the principal controlling influences. The fish beds, particularly the central part of the upper one, were deposited in reducing conditions during the acme of the transgression and maximum water depths, perhaps up to 50 m (Mykura and Phemister, 1976). Hall and Donovan (1978) described the laminated fish bed lithofacies as non-glacial varves deposited in a stratified tropical lake. Seasonal algal bloom resulted in increased photosynthesis and carbonate precipitation, the dead algae accumulating on the lake floor and being preserved as organic carbon. The clastic laminae formed either by continuous settlement from suspension or by small turbidity flow influx, perhaps with a seasonal or annual periodicity. Hall and Donovan (1978) emphasize one important difference between the Melby laminites and similar lithofacies elsewhere in the Orcadian Basin. At Melby, apparently uniquely, the dastic laminae consist largely of green clay, rather

than mainly silt. The clay is a mixture of illite and chlorite and may have been derived by the weathering of a nearby volcanic massif. Hall and Donovan attributed the sulphide nodules in the Upper Melby Fish Bed to groundwater enriched by nearby volcanic activity.

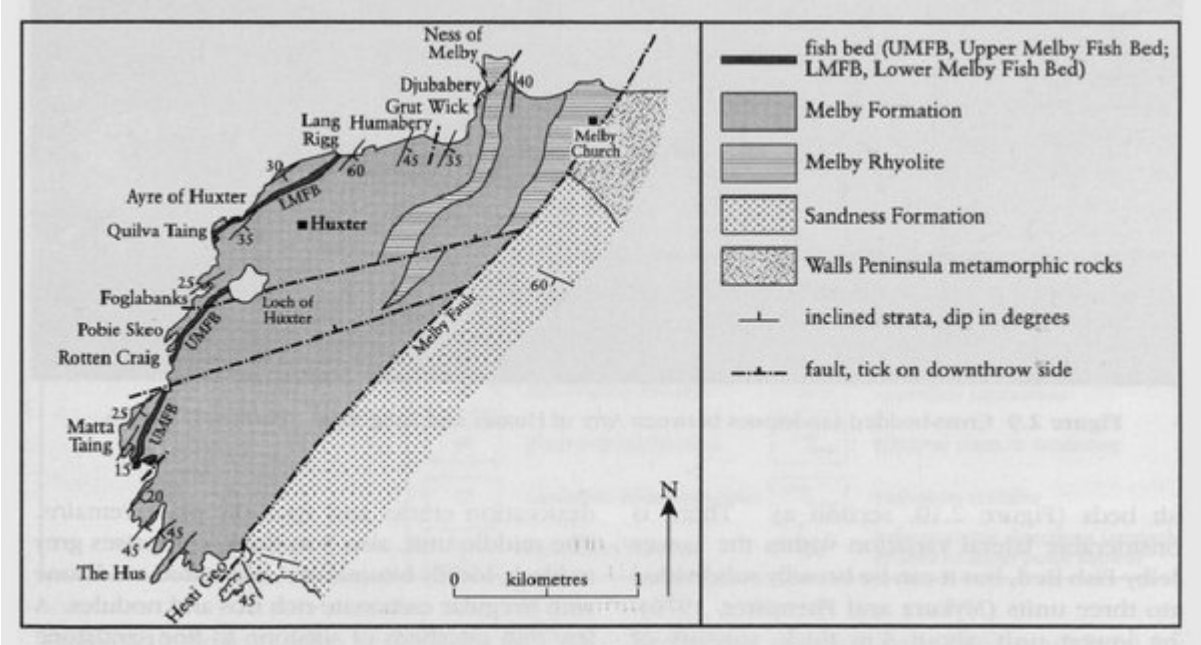
The Lower Melby Fish Bed, and the top and bottom parts of the Upper Melby Fish Bed, are variable and record the irregular progress of lake transgressions and regressions. In these sections lacustrine sediments alternate with low-energy, fluvial sediments of channel, crevasse and overbank origin. Full lake regression allowed relatively high-energy fluvial systems to prograde into the shallow lake margins, depositing thick, cross-stratified sands. Convoluted tops to many of the cross-bedding sets suggest rapid de-watering of the sediment. Below the Upper Melby Fish Bed, the foresets of most planar cross-bedded sandstones dip eastwards, suggesting a current flow predominantly from the west. This broad uniformity suggests deposition in braided channels, with the sporadic finer-grained beds representing the remains of overbank sediment accumulations. Thinly bedded, ripple cross-laminated sandstones below and between the two fish beds were probably laid down by relatively sluggish currents, probably in crevassed channels or as overbank deposits on an alluvial plain (Mykura and Phemister, 1976).

Above the Upper Melby Fish Bed, palaeocurrent flow direction shows a reversal, with consistent foreset dips to the west, indicating current flow from the east (Mykura and Phemister, 1976). This change coincides with the appearance in the sandstones of significant quantities of mainly felsitic volcanic detritus, but also including some basalt. The volcanic rocks being eroded may have been the precursors to the Esha Ness and Papa Stour volcanic complexes, which are believed to overlie the Melby Formation. The identification by Hall and Donovan (1978) of volcaniclastic clay in the Upper Melby Fish Bed is further evidence for the active erosion of volcanic rocks during the deposition of the Melby Formation.

Conclusions

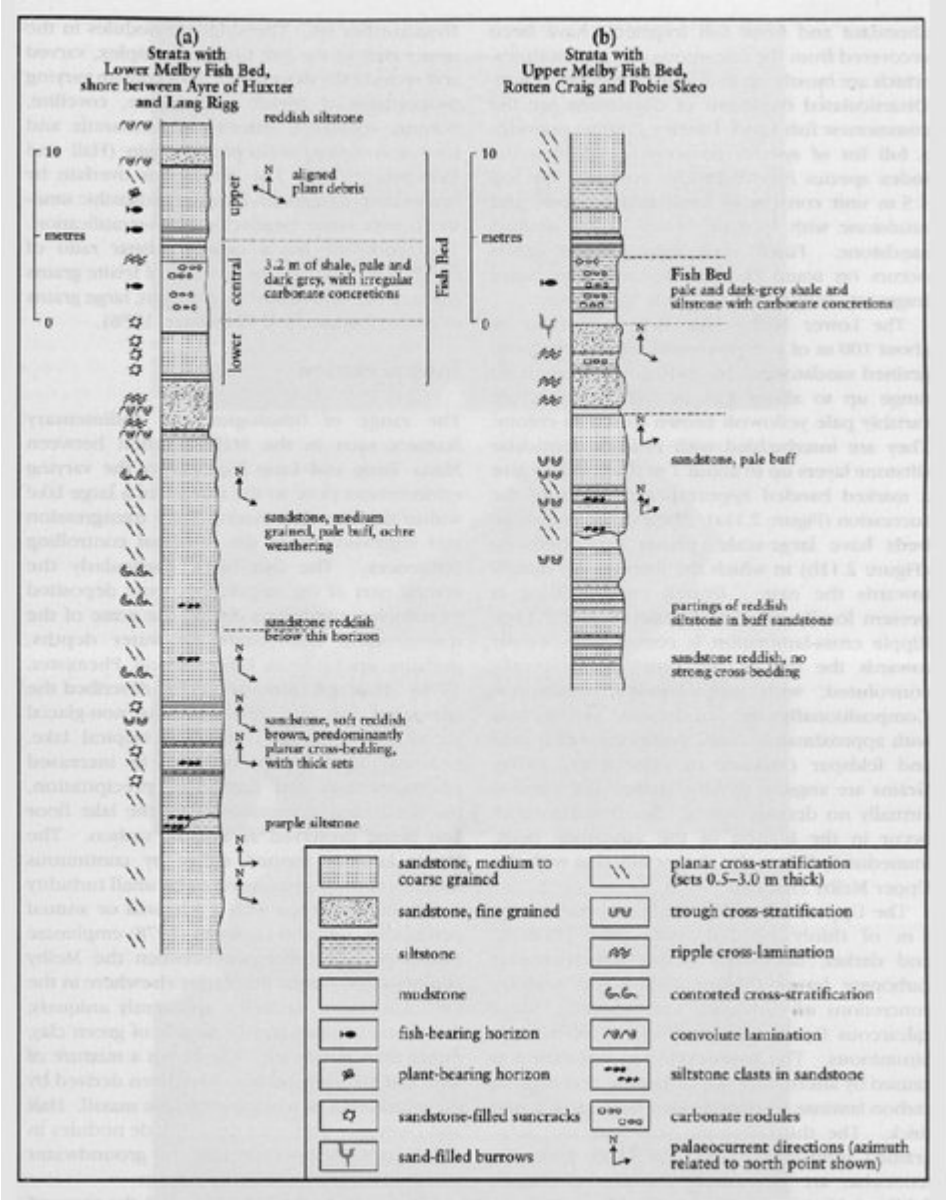
The cliffs and shoreline containing the Melby GCR site provide a well-exposed, representative section of the Middle Devonian (upper Eifelian–lower Givetian) strata in the westernmost of the Shetland structural tracts. The section demonstrates the varying depositional environments during lake transgression and regression, with lacustrine sediments interbedded within a dominantly fluvial sequence. The lacustrine strata are fine-grained, thinly bedded or laminated lithologies with carbonate (and locally sulphide) nodules. The carbonate nodules contain an important fossil fish fauna, allowing regional correlation with the Achanarras horizon of Caithness. Fluvial strata are mainly thick, cross-stratified, arkosic sandstones. Palaeoflow in the braided channel systems shows a marked change of direction within the succession exposed in the GCR site. The change coincides with a new volcanic source of detritus and is of regional palaeogeographical significance. Overall, the site provides important insights into lake evolution in the northernmost part of the Orcadian Basin and its fish fauna allows regional correlation with the Middle Devonian strata of mainland Scotland.

References

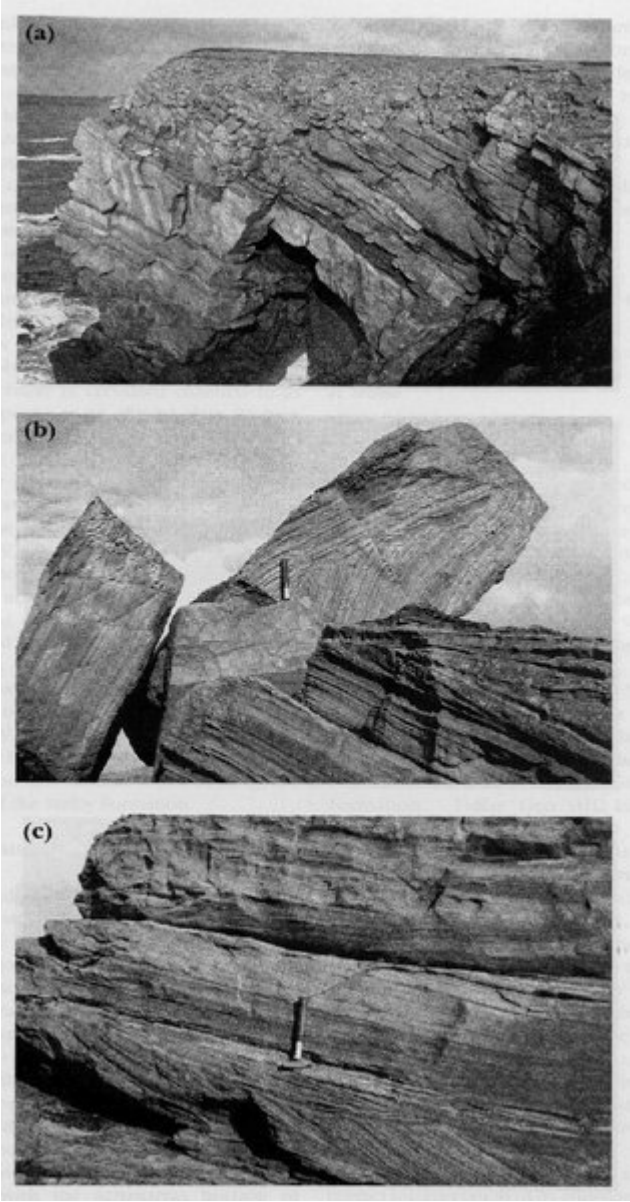


(Figure 2.8) Geological sketch map of the Melby Formation on Shetland Mainland. After Mykura and Phemister (1976).

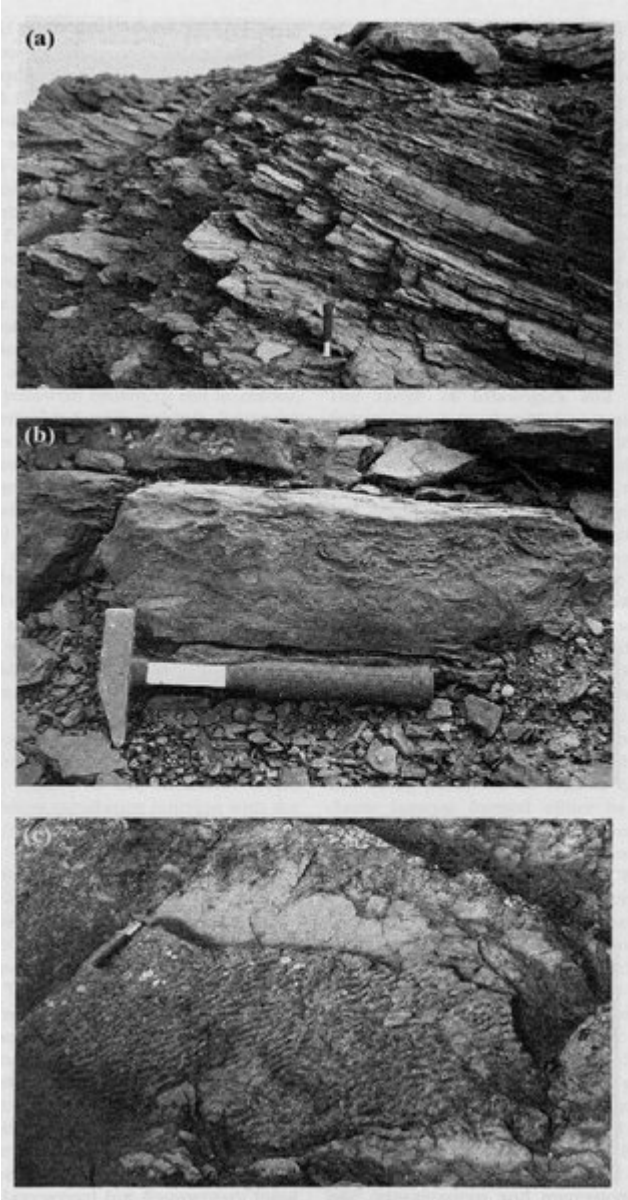
(Figure 2.9) Cross-bedded sandstones between Ayre of Huxter and Lang Rigg. (Photos: P. Stone.)



(Figure 2.10) Stratal settings of the Melby fish beds. After Mykura and Phemister (1976), reproduced from Dineley (1999a).



(Figure 2.11) Sandstones between the two Melby fish beds. (a) Pobie Skeo; (b) large-scale planar cross-bedding; (c) small-scale trough cross-bedding. (Photos: P. Stone.)



(Figure 2.12) The Upper Melby Fish Bed, Rotten Craig. (a) Laminated mudstones with dolomitic layers; (b) convolute lamination in thin sandstone bed; (c) rippled siltstone bedding surface. (Photos: P. Stone.)