The Cletts, Exnaboe, Shetland

[HU 409 137]–[HU 406 122]

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Introduction

The sea cliffs between Vaakel Craigs and Millburn Geo, on the south-east coast of Shetland Mainland near Exnaboe provide excellent, continuous exposure through varied lacustrine, fluvial and aeolian strata of the Middle Devonian Brindister Flagstone Formation. The Cletts is a large and prominent bedding surface of pebbly sandstone within this section. The sequence lies to the east of the N–S-trending Nesting Fault, and so forms part of the easternmost of the three Devonian structural tracts of Shetland. The lithofacies present were produced during the cyclical deepening and shallowing of a large lake occupying part of the Orcadian Basin. Highstands of the lake are marked by two units of laminated mudstones, one including thin dolostone layers and lenses. The fossil fish fauna from this locality is of great importance, and is described in the GCR fossil fishes volume (Dineley and Metcalf; 1999). During lowstand periods of shallow-water, alluvial-fan gravels and deltaic sands prograded into the lake, and aeolian dunes prograded across the basin during periods of subaerial emergence.

The regional importance of The Cletts (Exnaboe) site lies in the well-preserved evidence for the cyclicity of depositional environments. This allows interpretation and characterization of otherwise little-known parts of the stratigraphy and tectonic framework of the Orcadian Basin. Overviews of the geology are provided by Mykura (1976, 1991) and Allen and Marshall (1981). A detailed sedimentological analysis for part of the site is given by Allen (1981b).

Description

The incised sea-cliffs forming the south-east coast of Shetland Mainland provide extensive exposure through a sequence of fluvial, lacustrine and aeolian Old Red Sandstone strata. The section spanning The Cletts (Figure 2.22), near the village of Exnaboe, lies within these cliffs, about 5 km north of Sumburgh Head. The strata are informally assigned to the Brindister Flagstone Formation and are of Givetian (Mid-Devonian) age. The beds dip consistently between 15° and 30° towards the south-east, resulting in several hundred metres of strata being exposed within the GCR site, although the continuity is locally disrupted by minor faulting, particularly at the northern end of the section. The section lies in the easternmost of three north-south, fault-bounded tracts of Devonian rocks in Shetland, and is characteristic of the strata in the tract.

The oldest strata present within the site crop out at its northern margin in the vicinity of Vaakel Craigs. There, coarse pebble and cobble conglomerate (Figure 2.23) is interbedded with thin, lenticular bodies of coarse-grained sandstone in a sequence at least 30 m thick. The conglomerate clasts range up to about 30 cm across, but most are 5–10 cm. The conglomerates occur in irregular bodies, either matrix- or clast-supported, in which clast imbrication is only weakly and locally developed. The clasts are predominantly of vein quartz and quartzite (both massive and laminated), but sporadic pebbles of granite (some of which are foliated) and gneiss are also present. Most clasts are subangular to well-rounded, but the degree of sphericity is variable. The interbedded sandstone lenses are commonly cross-bedded.

Southwards, and up the succession, the coarse conglomerate is succeeded conformably but quite abruptly by cross-bedded sandstone in thick sets up to about 2 m high. About 20 m of this cross-bedded sandstone form the cliffs around Sutherland and Steath Geo. The sandstone becomes more pebbly upwards, but the clasts are generally isolated and supported within the matrix. The clasts are generally less than 10 cm, with a few up to 25 cm, mostly rounded or well-rounded and have a high degree of sphericity. Most of them are of quartzite, commonly with a pinkish hue, but there are also some rare examples of granitic lithologies. Interbedded with the pebbly sandstone are thinly bedded units, up to about 50 cm thick, of red, laminated mudstone and siltstone.

South from Steath Geo, and up-sequence, the pebbles decrease in abundance and thick, cross-bedded sandstone bodies become dominant. These spectacular units are well exposed around Three Steps Geo (Figure 2.24), where individual sets range up to 2 m in thickness; sets up to 5 m thick (Mykura, 1976) and up to 3 m thick (Mykura, 1991) have been reported from elsewhere in this area. The sandstone is pale yellowish brown, variably quartzose or arkosic, and commonly with rounded grains. At least 50 m of the cross-bedded sandstone form the coastal cliffs between Steath Geo and Blo Geo, where they are abruptly overlain by about 4 m of very thinly bedded, laminated mudstone, siltstone and fine-grained, ripple-laminated sandstone, the last showing grading to siltstone over less than 5 mm. Preferential erosion of this unit created the deep inlet of Blo Geo.

Above the Blo Geo unit, there is an abrupt return to fairly massive pebbly sandstone. The concentration of pebbles increases irregularly upwards and most of them consist of quartz or quartzite; the pebbles range from lubangular to well-rounded, sphericity is highly variable, and most are matrix-supported. Crude, large-scale cross-stratification is present locally. This lithology forms the prominent headland at Point of Blo-geo, and The Cletts is an extensive bedding surface running south-west from that point. Shingly Geo lies immediately south of The Clefts and is another example of the preferential erosion of a fine-grained, thinly bedded unit (Figure 2.25), this one abruptly overlying The Cletts pebbly sandstone.

About 4 m of laminated mudstone, siltstone and fine-grained sandstone with much small-scale cross-bedding and extensive rippled bedding planes are exposed at Shingly Geo. Within the top half of the unit are thin interbeds of dolomitic limestone that become more abundant and thicker upwards, to a maximum of about 5 cm. Fossil fish fragments have been recovered from this part of the sequence, the Exnaboe Fish Bed. Although not abundant, they include *Dipterus* sp., the commonest species, and *Stegotrachelus finlayi,* the second commonest. This is the only species of the genus and is found only in Shetland (Dineley, 1999a). The limestone layers are disrupted by soft-sediment structures, with evidence for both extensional and compressional deformation (Figure 2.26). There is also evidence for tectonic deformation, with an incipient cleavage cutting obliquely across the bedding and crenulating the more finely laminated lithologies. The exposure at Shingly Geo was modified by some limited, long-ceased quarrying, the limestone probably being burnt at the old kiln adjacent to the ruins of Clevigarth, about 500 m to the north.

The Shingly Geo unit is abruptly overlain by fine- to medium-grained, grey, micaceous, cross-laminated sandstone in beds generally 40–60 cm thick, with some up to about 1 m. This lithofacies continues to and beyond the southern margin of the GCR site.

Interpretation

The range of lithologies present within The Cletts GCR site represents deposition in the cyclically varying environments at the margin of a large lacustrine basin. The complexity of the fades relationships was stressed by Allen (1981b), who recognized the influence of both wave and current action in water depths of less than 5 m, and a deeper, offshore environment characterized by a lack of evidence for either wave- or current-action. The deep-water environment, during phases of maximum lake extent is represented by the thinly bedded units at Blo Geo, and, particularly, Shingly Geo. In both cases, mudstone/siltstone laminites were probably deposited from suspension of seasonal influx of clastic sediment, with the fine sandstone to siltstone gradations perhaps having a turbiditic origin. The carbonate laminae, lenses and thin beds may have formed during periodsof increased phytoplankton abundance, but some diagenetic re-distribution of carbonate seems likely. The primary bedding was further disrupted by soft-sediment deformation, facilitated by the earlier lithification of the dolostone, allowing it to behave in a brittle fashion while the enclosing clastic laminae were still ductile. The fish fossils at Shingly Geo are further evidence that this unit marks the maximum lake extent and probably the deepest water seen in the section. Water depths may have been up to 80 m (Hamilton and Trewin, 1988).

The pebbly sandstones that make up much of the lower part of the succession, and also separate the two thinly bedded lacustrine units, are probably braided stream and alluvial-fan deposits that prograded into the lake during periods of relatively low water-level. The matrix-supported nature of much of the pebbly sandstone suggests that slumping and mass-flow processes were also active. In their lower part, the pebbly sandstones are sporadically interbedded with thin red mudstone layers, representing overbank fades. The cross-bedded, fine-grained, micaceous sandstones at the top of

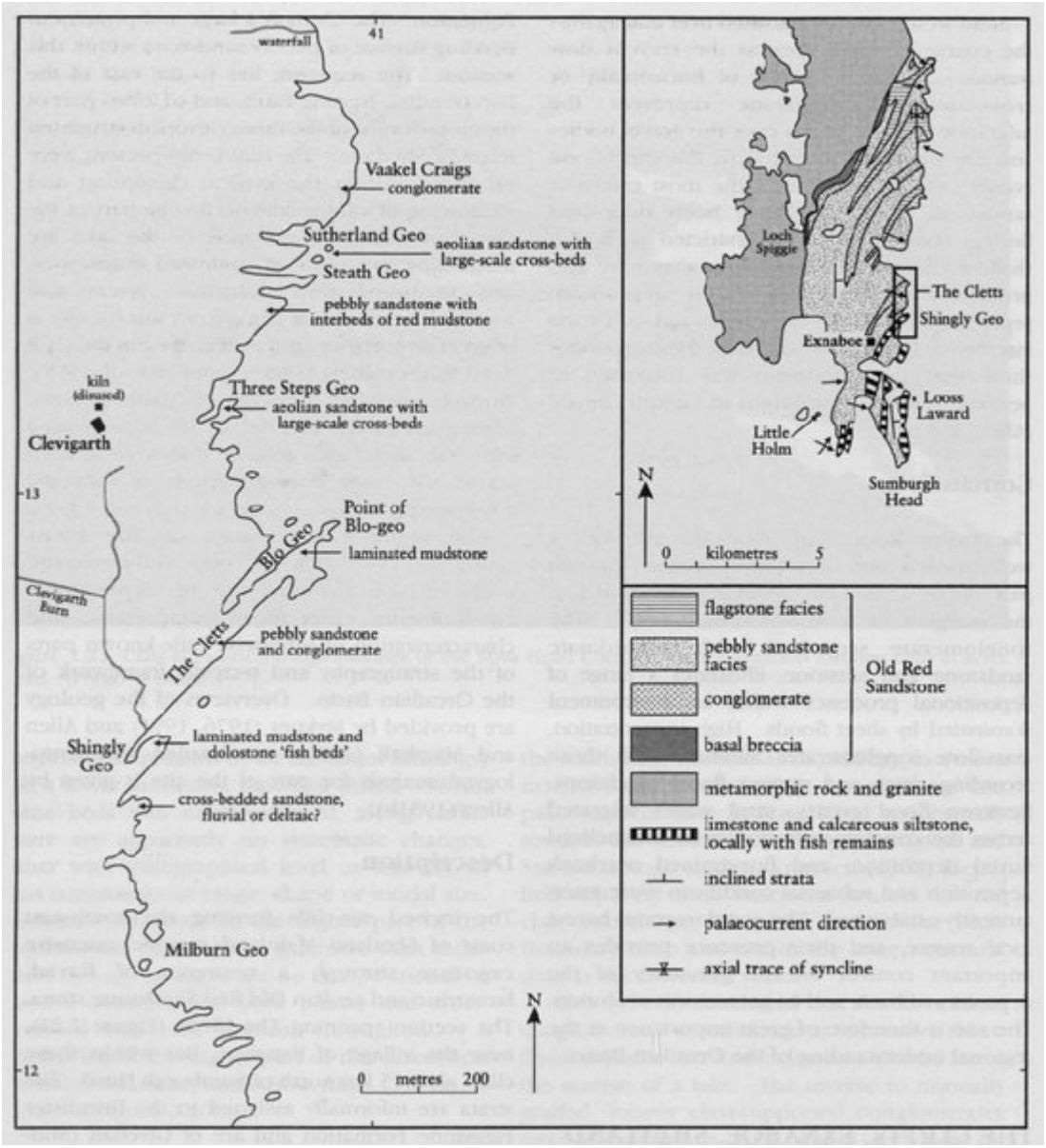
the succession within the GCR site were probably deposited in prograding deltas during a relative fall in the lake water-level. The regional current flow pattern indicates dispersal of sediment in a general south-easterly direction (Mykura, 1991). The preponderance of quartz and quartzite clasts in the pebbly sandstones and conglomerates suggests that those lithologies were dominant in the sediment provenance area, although the high percentage of well-rounded quartzite pebbles may be due to recycling of older conglomerates. The granite and gneiss clasts are more positively ascribed to basement rocks that were probably exposed in a north-south mountain range that formed the western margin of a large lacustrine basin.

The lowest water-levels within the lake allowed aeolian sand dunes to advance across areas that had once been underwater. The large-scale, cross-bedded sandstones around Sutherland, Steath and Three Steps geos are good examples of such dune sandstones (Mykura, 1976, 1991). They contain rounded grains of quartz and feldspar, occur in sets up to 5 m thick, and appear to have been driven by winds from the south and south-west (Allen and Marshall, 1981).

Conclusions

The Cletts, Exnaboe GCR site provides a well-exposed section representative of the Devonian strata in the easternmost of the Shetland structural tracts. It demonstrates the interplay of depositional environments at the margin of a large lake within the Orcadian Basin. Fluctuation in lake water-level produced a vertical succession of stacked cycles, in which lacustrine, locally fish-bearing, fine-grained laminites alternate with braided stream, alluvial-fan and ?deltaic sandstones. Low lake water-levels allowed the encroachment of aeolian dunes. The succession exposed in this section provides important insights into the evolution of an otherwise little-known part of the Orcadian Basin. The importance of this site is further enhanced by the presence of the Exnaboe Fish Bed, which contains *Stegotrachelus finlayi,* the only species of this genus, which is unique to Shetland. The fish bed is younger than others in Shetland, and may be the only late Givetian site this far north.

References



(Figure 2.22) Geological map of the Old Red Sandstone of south-east Shetland Mainland and detailed map of the Clefts GCR site. After Mykura (1976).

(Figure 2.23) Conglomerates at Vaakel Craigs. (Photo: P. Stone.)

(Figure 2.24) Planar cross-bedded, probably aeolian, sandstones, Three Steps Geo. (Photo: P. Stone.)

(Figure 2.25) The Cletts (bedding plane of pebbly sandstone, left), and gully eroded through the fish bed. (Photo: P. Stone.)

(Figure 2.26) Disrupted dolomitic layers in lacustrine laminites. Exnaboe Fish Bed at The Cletts. (Photo: P. Stone.)