Gruinard Bay, Ross and Cromarty

[NG 897 943]–[NG 902 921]

Introduction

The foreshore on the south side of Gruinard Bay provides excellent exposures of rocks of the Stornoway Formation, which rests unconformably on the Torridonian Sandstone at the western end of the section. The Stornoway Formation here consists of conglomerates, sandstones, and siltstones, commonly arranged in fining-upwards fluvial sequences. Calcretes, representing the carbonate-rich remnants of ancient soils, are well developed in many parts of the succession. These palaeosols contain the clay mineral palygorskite, normally found in weathering soil profiles, and offer evidence for repeated cycles of tropical rainfall and evaporation.

The succession at Gruinard Bay has been described in detail by Steel (1974b) and *en passant* by Craig (1965), Steel *et al.* (1975), Storetvedt and Steel (1977), Stewart (1978), and Hudson (1983).

Description

The sea cliffs and rocky foreshore on the south side of Gruinard Bay expose approximately 300 m of sediments (Steel *et al.,* 1975) assigned to the Stornoway Formation, which have been downfaulted against older strata (Craig, 1965). The sedimentary sequence at Gruinard Bay consists of the Torridonian Sandstone Formation (late Precambrian), overlain unconformably by a thick, almost continuous succession of Stornoway Formation conglomerates, sandstones and siltstones (Figure 3.10), with localized developments of calcrete throughout the sequence. The contact between the Triassic sediments and Jurassic rocks to the east is obscured by a break in exposure (Steel, 1974b). The mineral palygorskite is commonly found on the Torridonian Sandstone–Stornoway Formation unconformity surface.

The rudaceous and arenaceous sediments at Gruinard Bay are arranged in a series of approximately 30 fining-upwards sequences (Figure 3.11) in a succession some 155 m thick. The boundaries between the cycles are generally erosion surfaces. The calcretes are more common in the fine-grained sections of the sequences (Steel, 1974b).

The calcretes at Gruinard Bay take many forms that reflect the maturity of the palaeosol profiles. They often reach a maximum thickness of 1 m, and are dominated by irregular nodules, sometimes elongate, vertically orientated, and of rhizocretion form, which range from 10 to 150 mm in diameter (Figure 3.12). In many cases there is a gradual increase in nodule size upwards through the calcrete units. Of lesser importance are vertical pipes and sheets, which form up to 50% of the sediment. The final calcrete form is characterized by a predominance of calcium carbonate, with only small, localized patches of host sediment. Generally, any sedimentary structures within the host sediment, such as mudstone laminae interbedded with micro-breccias, are preserved in the calcrete. Clasts within the breccia are locally derived carbonate material, although chert is also present. The pore spaces may be infilled with quartz, spherulitic chalcedony, sandy sediment or pisolites (Steel, 1974b).

No fossils have been reported from the Stornoway Formation at Gruinard Bay. Age evidence has been obtained from palaeomagnetic studies, which confirm an assignment to the Permo-Triassic (Storetvedt and Steel, 1977), but nothing more precise.

Interpretation

The Stornoway Formation at Gruinard Bay was deposited under predominantly terrestrial conditions. The fining-upwards sequences are interpreted as fluvial deposits that record repeated changes in the environment of deposition, from high-energy processes characteristic of alluvial fans, responsible for the coarse-grained conglomeratic facies, through a gradual decline in energy and sediment grain size, indicating river sand and floodplain facies.

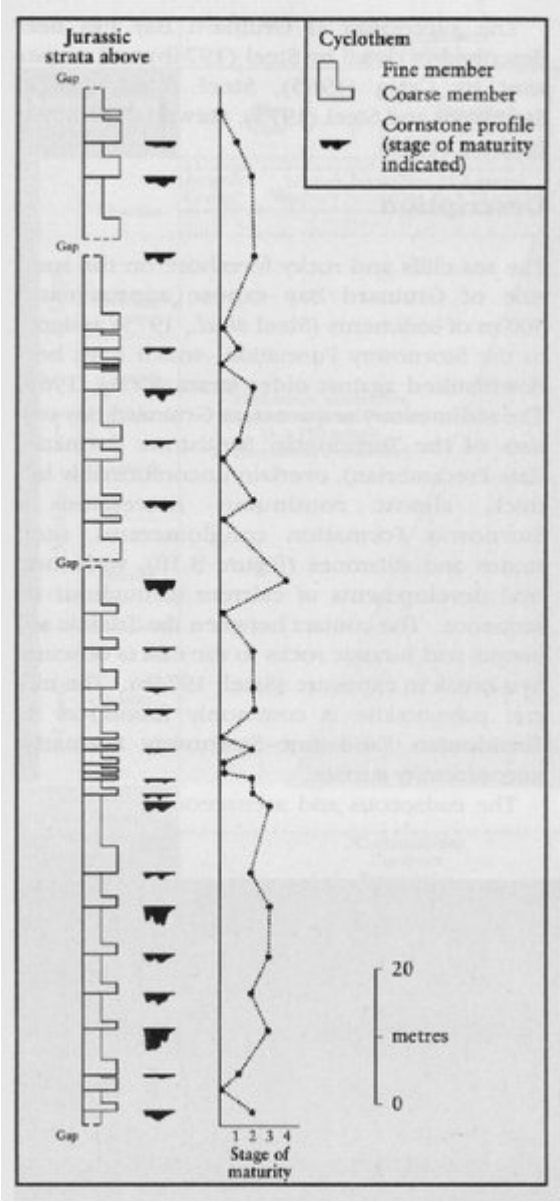
The well-developed calcrete horizons indicate a semi-arid climate (Hudson, 1983). The mineral palygorskite at the boundary between the Torridonian Sandstone Formation and the Stornoway Formation suggests that pedogenic processes were a common phenomenon. The physical and textural characteristics of the calcrete horizons, for example the presence of laminae, micro-breccias, pisolitic clasts, and the association of calcite with silica, indicate pedogenic and diagenetic processes that operate above the water table. The unusually thick calcrete horizons at Gruinard Bay are probably the result of many phases of palaeosol development in a subsiding basin, as it is unlikely that one calcrete horizon would result from a single rainfall, percolation and desiccation cycle alone (Steel, 1974b). The relative thickness of the Gruinard sequence of cornstone (calcrete) cycles in comparison with similar successions indicate that the Gruinard area was subsiding more frequently and more rapidly than that, for example, on the Isle of Rum.

Conclusions

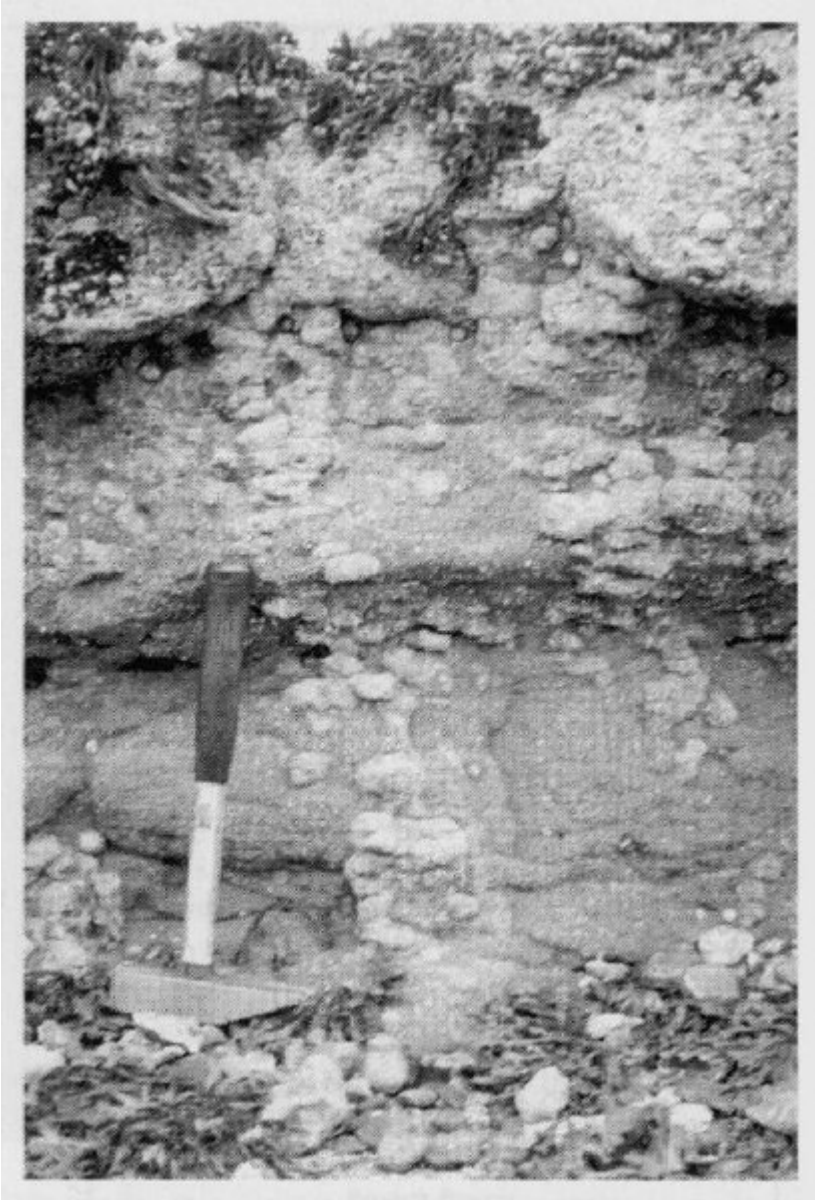
The coastal sequence at Gruinard Bay exposes an excellent accessible section through the Stornoway Formation. The sediments unconformably overlie the Precambrian Torridonian Sandstone Formation. The Stornoway Formation consists of fining-upwards sequences of conglomerates, sandstones, and siltstones. Calcretes are common in parts of the sequence, and indicate tropical climatic conditions. These sediments were deposited under predominantly terrestrial conditions by rivers, with soils forming on the river floodplain.

References

(Figure 3.10) Stornoway Formation sediments at Gruinard Bay, with geological hammer for scale (arrowed). (Photo: C. MacFadyen.)



(Figure 3.11) The calcrete ('cornstone') facies at Gruinard Bay. Stages 1 to 4 represent informal measures of palaeosol maturity based on depth of palaeosol and intensity of palaeosol formation. (After Steel, 1974b.)



(Figure 3.12) Close-up of a vertical nodular structure interpreted as a large rhizocretion, within a palaeosol at Gruinard Bay. (Photo: P Turner.)