Milton Ness, Aberdeenshire

[NO 766 650]–[NO 771 648]

Potential GCR site

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Introduction

The coast section at Milton Ness near Montrose (Figure 3.18) provides the best example of mature Old Red Sandstone carbonate soil (calcrete) development in Scotland. The calcrete occurs in the Upper Devonian–Lower Carboniferous (Upper Old Red Sandstone) Kinnesswood Formation (of the Inverclyde Group), in a down-faulted block of predominantly fluvial sedimentary rocks. The near-horizontal rocks crop out in a wave-cut cliff up to 10 m high and about 500 m long, providing excellent lateral exposure. This has allowed a detailed examination of the morphology and development of a mature calcrete at the top of the section by Satin (2000). Palaeokarst cavities, reworked hardpan calcrete and rhizoliths were recognized by Balin for the first time in the Old Red Sandstone at this locality. In addition to the features commonly seen in Quaternary calcretes, the Milton Ness horizon preserves some features that are unusual in calcretes of any age. The rhizoliths are some of the finest examples seen in Palaeozoic rocks. Mature calcrete development is largely restricted to the Kinnesswood Formation in Scotland, with minor amounts in the Lower Old Red Sandstone of the Orcadian Basin and almost none in the Middle Old Red Sandstone.

Description

The geology of Milton Ness [NO 766 650]–[NO 771 648] was described in a field guide by Trewin (1987c). The Upper Old Red Sandstone is down-faulted against Lower Old Red Sandstone lavas and conglomerates by a NE-trending fault at Rock Hall (Figure 3.18). The cliffs from here south-eastwards to Milton Ness expose an interesting succession of mudstones, sandstones, conglomerates and calcretes (Figure 3.19). Trewin (1987c) recognized three fining-upward cycles in the 10 m section. Intraformational conglomerate lenses form the base of the cycles, resting on the underlying scoured surface, locally filling the bases of channels and containing calcrete lasts. Cross-bedded and parallel-bedded sandstones overlying the conglomerates contain sporadic *Beaconites* burrows and calcified root tubules (rhizoliths). The tops of the cycles comprise red siltstones/mudstones with an abundance of carbonate nodules ('cornstone' of the older literature) interpreted as immature calcrete horizons. The nodules at the top of the uppermost cycle (Cycle 3, (Figure 3.19)) increase in abundance and size upwards and are capped by the laminated, brecciated and karstified calcrete described by Balin (2000).

Balin (2000) noted significant lateral variation in the amount and type of pedogenic alteration throughout the calcrete horizon, but locally, development of the profile shows an idealized vertical zonation comprising: upper compact crust or hardpan (70 cm); platy, sheet-like carbonate (70 cm); dusters of carbonate nodules (120 cm); uniformly distributed chalky carbonate (55 cm); unaltered host mudstone. At the eastern end of the outcrop, karst cavities and reworked, intraformational calcrete-clast conglomerate represent additional stages, with a subsequent period of calcretization completing the development of the profile.

The hardpan layer is up to 1.5 m thick at the eastern end of the section, where it crops out as a resistant ledge extending for 150 m and forms the topmost part of a 4 m-thick calcrete profile. It is a brecciated limestone with irregular, sub-horizontal carbonate layers, horizontal, wavy to irregular chert layers and relicts of the original sandstone. Much of the limestone is an irregularly mottled dark and pale grey micrite, the latter grading to microspar, in a 'clotted' fabric typical of calcrete. Calcite spar fenestrae vein the micrite and sand and silt grains 'float' in the dotted fabric, surrounded by microspar fringes. The chert layers are of buff yellow and pink, brecciated and laminated silica, locally with pisolites 0.1–2.5 mm in diameter and containing vugs filled with chalcedony, quartz and calcite.

Karstic dissolution and reworking of the hardpan horizon produced cavities and an intraformational calcrete clast bed respectively. At least ten karst cavities penetrate the hardpan at the easternmost end of Milton Ness, the largest measuring 1.2 m in depth and 1.2 m at its top. They formed in slight depressions in the hardpan, where water collected on the impermeable surface. The conglomerate forms a laterally persistent bed, draping the tops of the karstic cavities. It consists of clasts of relict host sandstone, as well as chert and carbonate clasts. Abrasion of the small chert pebbles indicates some transport and not in-situ modification of the underlying calcrete. Balin (2000) referred to the bed as a 'boulder calcrete', to denote clasts derived from the break-up of a hardpan calcrete during weathering, although later calcretization of the bed precludes determination of the original clast size.

Interpretation

The succession at Milton Ness is interpreted as a series of channel deposits built by laterally migrating river systems on an alluvial plain (Trewin, 1987c). Much of the Upper Old Red Sandstone in this part of the Midland Valley represents the distal part of an east-flowing axial drainage system. However, palaeocurrents at Milton Ness and nearby Boddin Point are south-directed, suggesting a tributary system in which the relatively small catchment area would have contributed to the low sedimentation rates necessary for calcrete formation (Balin, 2000).

The presence of calcrete in the finer-grained floodplain deposits points to a hot, semi-arid, seasonally wet climate. The laminated hardpan top to the calcrete at the top of the section represents a maturity (Stage N of Machette, 1985) very rarely seen in Old Red Sandstone calcretes. Balin (2000) discussed the probable timescale of the horizon's formation, noting that Leeder (1975) proposed a minimum of 10 000 years for calcrete of similar maturity, but that a considerably longer period seems probable. Recent studies (e.g. Marriott and Wright, 2004) suggest that hundreds of thousands to millions of years may have been required for the formation of mature Old Red Sandstone calcretes. To this must be added the karstification, reworking and subsequent calcretization seen at Milton Ness. Given the semi-arid climate and presumed low discharge rates, Balin noted that carbonate dissolution rates would have been low, and that the karst cavities up to 1.2 m deep would have taken a minimum of several thousand years to form. The subsequent reworking of the karst surface and re-calcification of the resultant deposit extended the total period of stabilization and calcrete formation at this horizon, to perhaps hundreds of thousands of years.

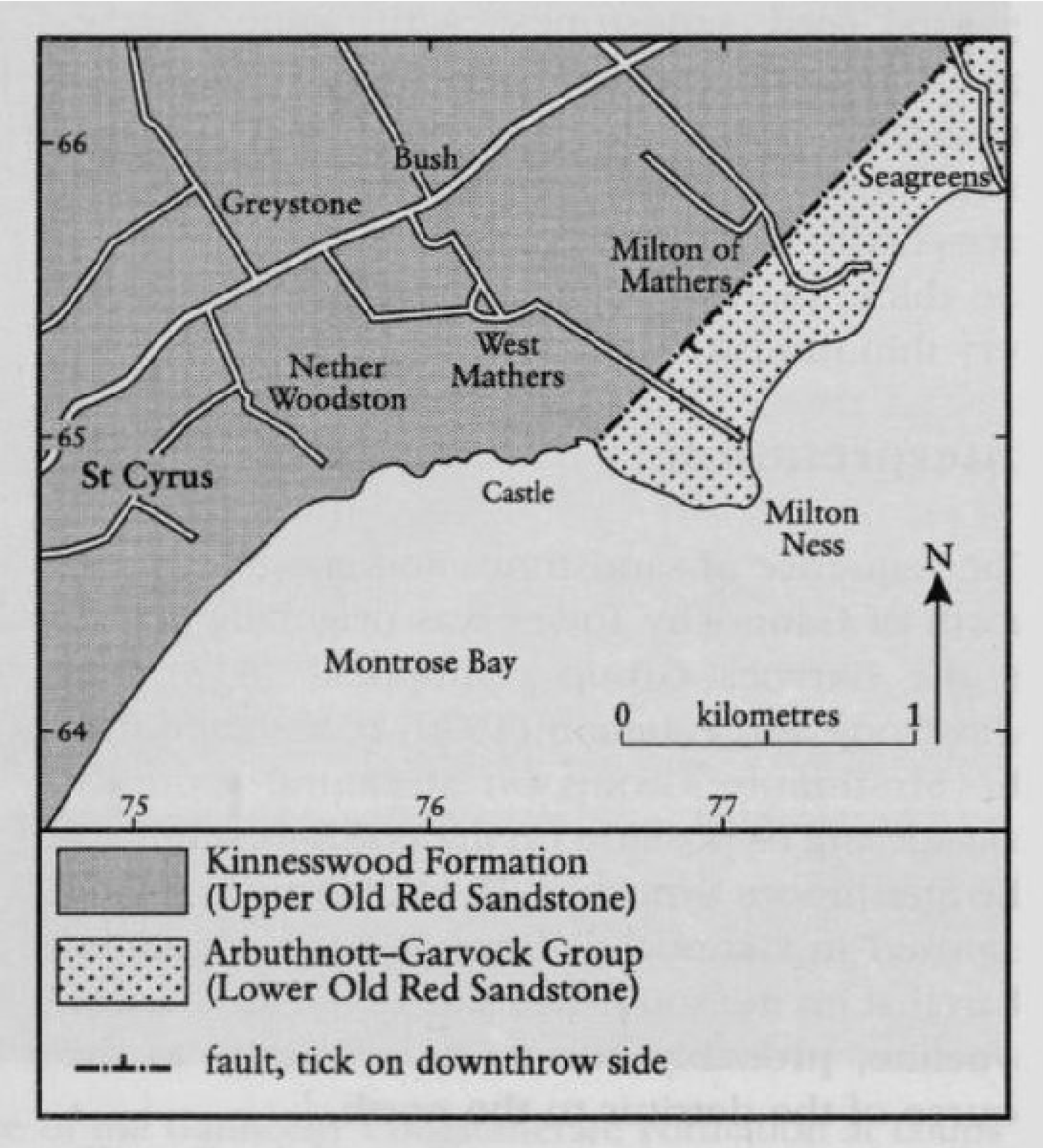
Karst formation is generally ascribed to a wetter, more humid climate, in contrast to the semi-arid conditions required for calcrete formation. However, Balin (2000) interprets the Milton Ness example as the result of water collecting in hollows on the impervious hardpan surface under constant semi-arid conditions, possibly with tree-like roots initiating and contributing to the dissolution process.

The presence of rhizoliths in the sandy parts of the alluvial cycles suggests that the environment on the floodplain some distance from the rivers was less hospitable to plant growth because of a low water-table, or that the floodplain mudrocks were impermeable (Balin, 2000). The presence of horizontal, ramifying networks of rhizoliths rather than vertical tap roots points to plant colonization of sandy point bars. The large size of some of the tubules at Milton Ness (over 3 cm) points to relatively large, shrub- or tree-like plants, confirming that plant development was well advanced by Late Devonian times (Balin, 2000). The *Beaconites* trace-fossil burrows were probably made by arthropods that burrowed into the channel sands to escape the arid, dry season conditions (Trewin, 1987c).

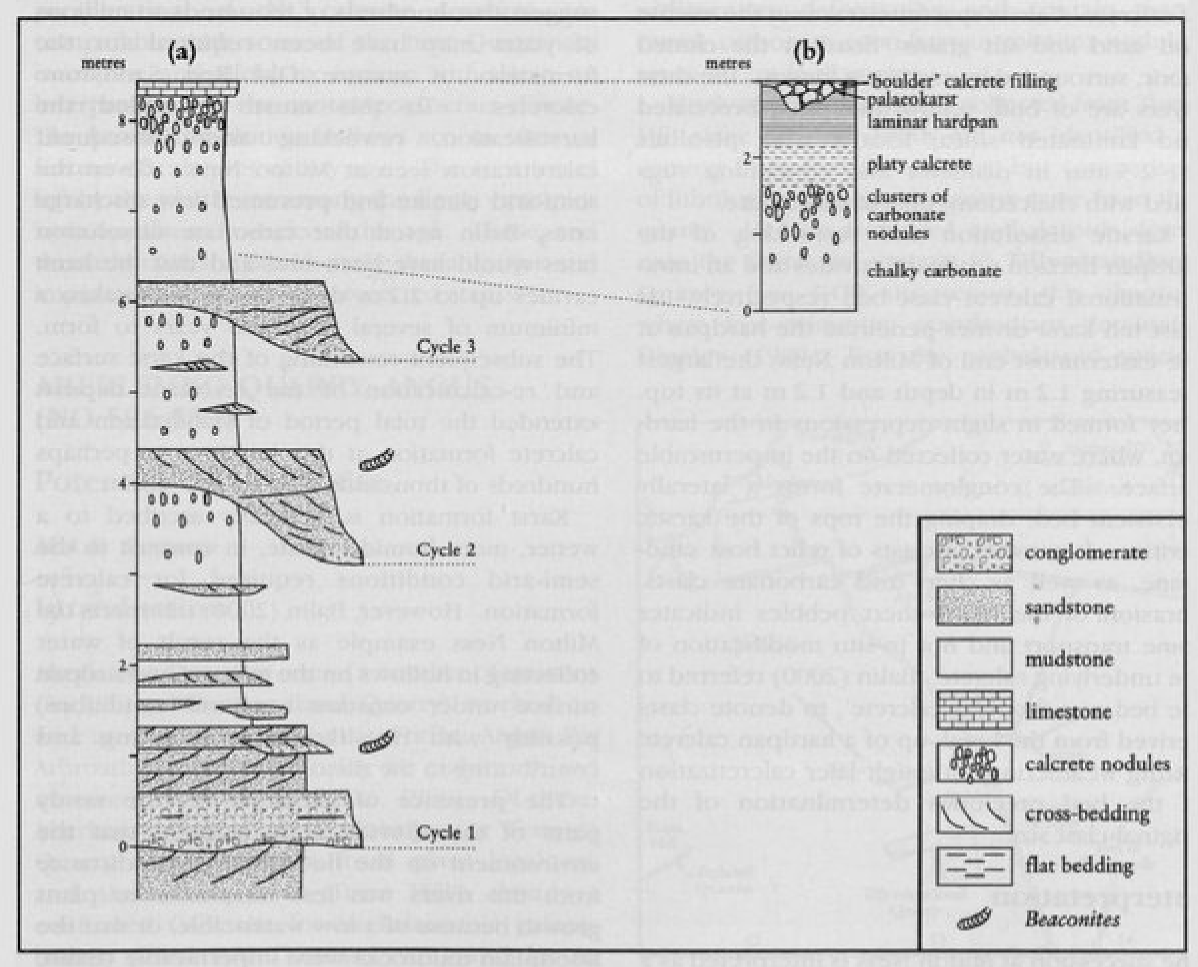
Conclusions

The coast section at Milton Ness provides superb lateral exposure for about 500 m of a mature fossil carbonate soil (calcrete) in the Upper Old Red Sandstone. This is one of the best sections of Old Red Sandstone calcrete in Scotland, and one of very few in the Old Red Sandstone of Great Britain where soil development to a stage of laminated hardpan is recorded. The excellent preservation of the calcrete textures are comparable with some of the best Quaternary examples, and allow, by analogy with these, an interpretation of the contemporaneous climate. The karstic dissolution hollows are an unusual feature of calcretes of any age. The root traces left by the plants are among the finest examples seen anywhere in rocks of this age. These, and the carbonate soil fabrics make this a unique and important site worthy of protected status.

[References](#)



(Figure 3.18) Location and geological map of the Milton Ness area. After Trewin (1987c).



(Figure 3.19) Log of the section at Milton Ness. (a) After Trewin (1987c); (b), idealized calcrete profile after Balin (2000).