QUARRY MOOR

OS Grid Reference: SE308691

Highlights

Quarry Moor, Ripon, uniquely exposes sea-marginal strata of the uppermost part of the late Permian Cadeby Formation, the Sprotbrough Member, and the transition to the overlying Edlington Formation. The rocks are mainly algal-laminated ooidal dolomites and limestone but higher beds in the section are contorted and include several clayey beds that may be evaporite-dissolution residues; all were formed at or very close to the Permian shoreline and tepee-like expansion structures, not reported elsewhere in British Permian marine strata, occur at some levels.

Introduction

The exposures of late Permian marine strata at Quarry Moor lie on the west side of the Harrogate–Ripon road just south of the City of Ripon. The quarry is now almost filled, but a section preserved along the western face reveals thin boulder clay overlying a gently northwards-dipping sequence of mainly algal-laminated ooidal carbonate rocks that span the transition between the Cadeby Formation (below) and the Edlington Formation. Together the Permian strata are about 9.5 m thick, but a further 3.7 m of underlying dolomite was visible in 1968, and parts of the quarry clearly cut into even lower strata. Neither shelly fossils nor signs of bioturbation have been found in any of the strata now exposed.

The quarry at Quarry Moor has existed for well over a century, and, judging from the distinctive lithology, provided much of the stone from which the earlier walls and buildings of Ripon were constructed. It was first mentioned in the literature bySedgwick (1829) and later by Tute (1868a), who included a sketch of slightly disturbed strata in one unspecified face; Fox-Strangways recorded several minor faults in sketches of Quarry Moor in his field notebooks (now lodged at the British Geological Survey, Keyworth) and subsequently mentioned it in the second edition of the Harrogate (Sheet 62) Memoir (Fox-Strangways, 1908, p. 13). More recently the section in the west face was described in detail by Smith (1974b, 1976) and was also discussed by Kaldi (1980, pp. 20, 154–155; 1986b) and Harwood (1981, pp. 32–33, 109–111). The lower part of the sequence is interpreted as having been formed under shallow water on a broad tropical marine shelf and the upper part is interpreted as the product of a peritidal to supratidal marine sabkha or coastal plain subject to periodic marine inundation; some of the clayey layers in this upper part are interpreted as the residues of dissolved primary and/or secondary evaporites with perhaps some siliciclastic terrigenous input. The widespread contortion, 'tepee'-like structures and partial brecciation here are regarded as the result of plastic flow, secondary volume changes and contemporaneous lithification.

The preservation of part of the western face at Quarry Moor followed representations to the local authority in 1968 by the Yorkshire Geological Society and the Yorkshire Naturalists' Trust (now the Yorkshire Wildlife Trust); tipping of domestic waste was suspended, landscaping ensued and the site was ultimately (1993) scheduled as an SSSI. An information board provides full geological information for visitors.

Description

The preserved rock face at Quarry Moor is about 110 m long and mainly 2–3.5 m high; it lies just within the western margin of the site, most of which was scheduled on botanical and entomological grounds. The position of the face and its geological sequence are shown in Figures 4.7 and 4.8 and the general disposition of strata is shown in Figure4.9. Lower parts of the sequence extend into private property to the south of the preserved face and should not be approached without prior authorization; higher parts of the section are repeated in a heavily overgrown 60 m exposure immediately to the north of the preserved section, where strata dip unevenly southwards.

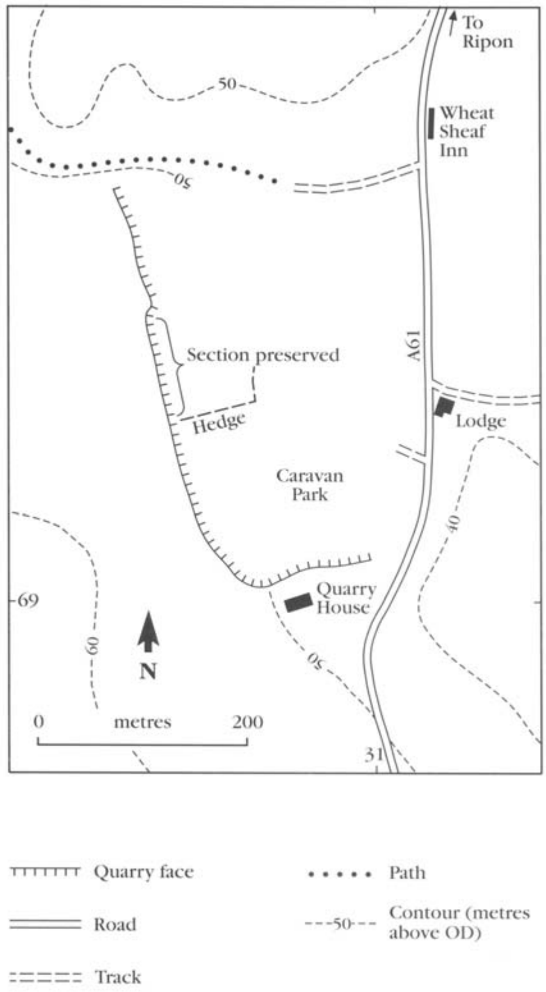

Figure 4.7: Quarry Moor, Ripon, showing the location of the preserved face.

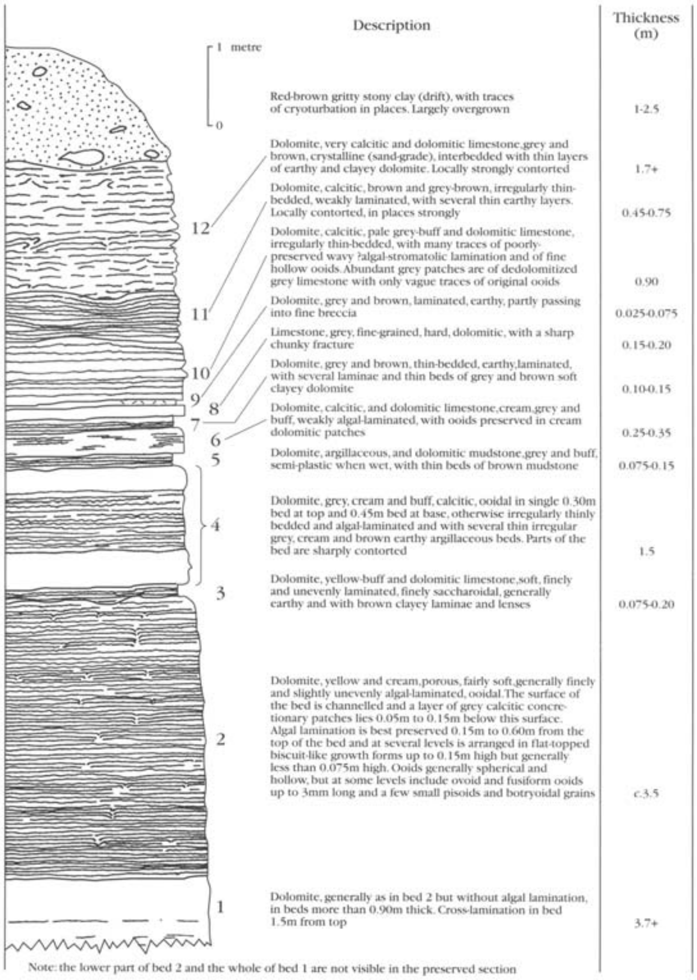

Figure 4.8: The sequence of late Permian strata at Quarry Moor. Most of the section lies in the uppermost part of the Sprotbrough Member of the Cadeby Formation, but some of the higher beds may be part of the overlying Edlington Formation.

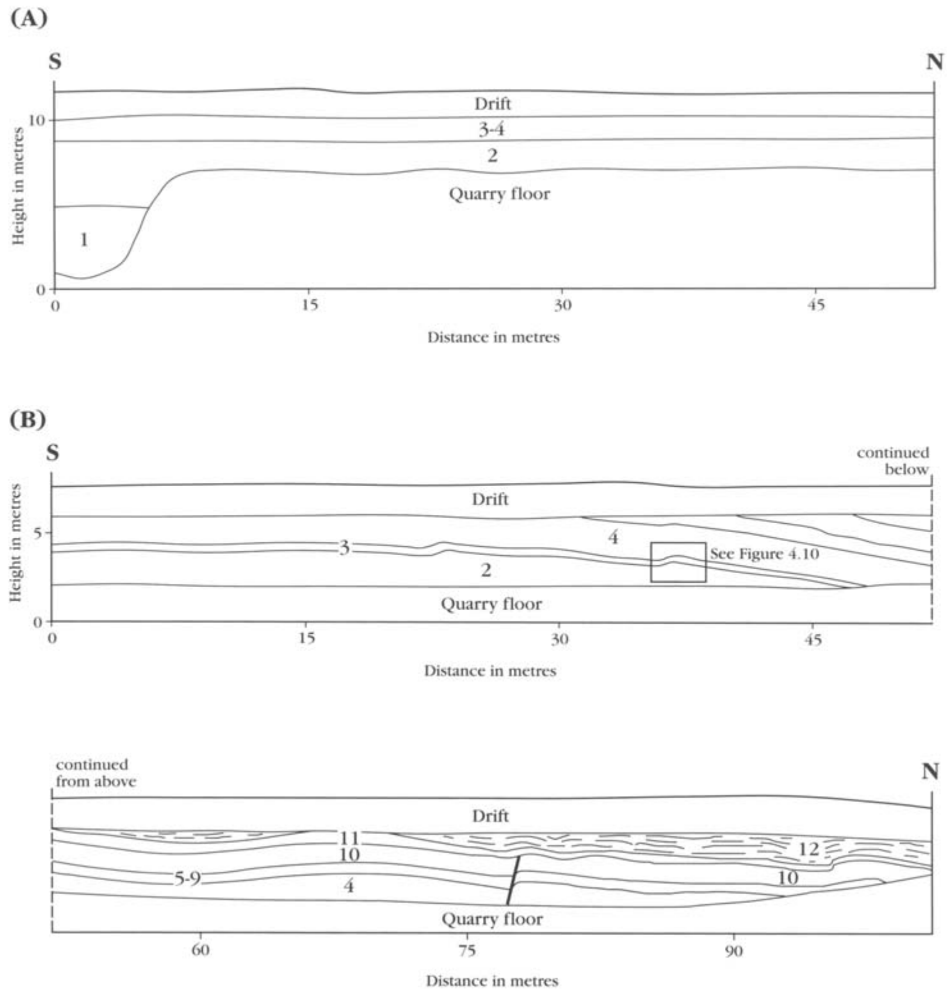

Figure 4.9: Sketches of late Permian strata at the west side of Quarry Moor. (A) In private property immediately south of the preserved face. (B) In the preserved face. Numbers refer to beds depicted in Figure 4.8.

All the strata in the preserved face at Quarry Moor are provisionally assigned to the Cadeby Formation, but strata above bed 2 were clearly influenced by an intermittent but generally progressive change in the depositional environment and it can be argued that some of the higher beds in the section, especially bed 12, should be assigned to the Edlington Formation. Petrographic details of the Quarry Moor rocks were given by Smith (1976) who showed that most (if not all) of the carbonate rocks there were originally ooidal but that many of the ooids had been diagenetically altered and are now obliterated or scarcely recognizable. Algal (stromatolitic or cyanophytic) lamination is a feature of most of the carbonate beds and thin dense cryptocrystalline layers (?crusts) occur at several levels in the upper part of the section; they also underlie erosion surfaces at the tops of beds 3 and 4. Some beds in the upper part of the sequence feature a dense network of narrow calcite veins. The petrographic evidence leaves little doubt that the limestone beds and patches at Quarry Moor are secondary and it seems likely that most of the calcitization was accomplished by reaction of dolomite with calcium-rich waters late during uplift and erosion. Beds 3, 4, 5, 7 and 12 contain laminae and thin layers rich in siliciclastic quartz and clay minerals but are composed mainly of very fine-grained calcite and dolomite; these are interpreted as normal low-energy coastal plain or lagoonal sediments. In contrast, thin earthy layers in beds 3, 4, 5, 7, 9, 11 and 12 are streaky or irregularly laminated and comprise rubbly aggregates of dolomite rhombs, small quartz crystals and fragments of dolomite rock; these layers are interpreted as evaporite dissolution residues, and a sample X-rayed from bed 12 was found to contain gypsum. Harwood (1981, p. 110) recorded discoidal gypsum in the laminites at Quarry Moor.

Gentle to strong contortion and fractures are widespread in higher parts of the Quarry Moor sequence and are thought to be related to plastic flow, volume changes resulting from the formation, dehydration, hydration and dissolution of evaporites (mainly sulphates but possibly including halite) and, in some examples, to early lithification and expansion (Smith, 1976). The tepee-like structures (Figure 4.10) comprise asymmetrical domes or anticlines about 1–1.5 m across and 0.5 m high in which competent (i.e. already lithified) carbonate beds have been fractured and thrust by lateral expansion; interbedded softer strata have been folded and squeezed-out by this process which, judging from onlap of overlying beds against the sides of the structures, and erosion at the top, must have been contemporaneous.

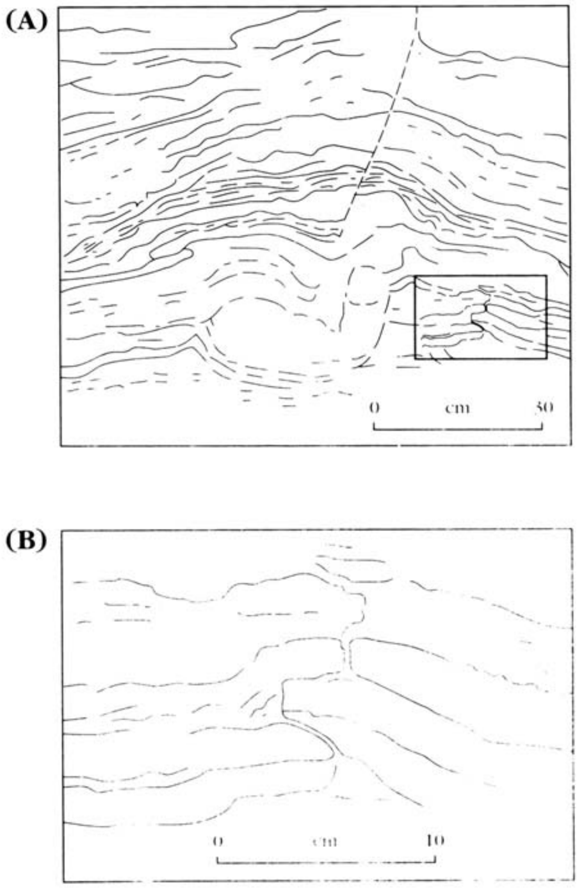

Figure 4.10: (A) Non-tectonic tepee-like anticline in beds 6, 7, 8 and 9 of the sequence at Quarry Moor, with a 0.3 m shortening shown by overthrust near the base and a minor fault near the top. Note the almost level bedding and apparent onlap in the uppermost strata, implying contemporaneous formation and burial. For position see Figure 4.9(B). (B) Detail of ?contemporaneous overthrust at bottom right of (A).

Interpretation

Quarry Moor is the only site where sea-marginal carbonate rocks at the top of the Sprotbrough Member of the Cadeby Formation may be studied in a large surface exposure and is also the only place where such rocks feature evaporite-related contortion and tepee-like expansion structures. The exposed rocks are interpreted (Smith, 1974a, 1976; Kaldi, 1980; Harwood, 1981) as a shallowing-upward regressive sequence, evolving from high subtidal ooid grainstone sheets and shoals (bed 1) to extensive high subtidal algal (stromatolitic) flats (beds 2–4) and finally to a coastal plain (sabkha) environment subject to sporadic flooding and to the formation of primary and secondary evaporites. With a tidal range probably of less than 1 metre, slopes on the coastal plain must have been negligible.

Elsewhere, algal lamination at the top of the Sprotbrough Member has been noted in surface exposures at Wallingwells (SK 570843) (Kaldi, 1980, p. 202; Harwood, 1981, p. 32) and at Darrington (SE 494202 but now almost filled); few details of the Wallingwells exposure are available but Kaldi (1980, fig. 2.2e) illustrates columnar algal stromatolites about 0.10 m in diameter and height, that he describes as capping an ooid barrier shoal. Algal lamination has also been noted at the top of the Sprotbrough Member in a number of cored boreholes, including one a few kilometres north of Ripon where evaporite-bearing basal beds of the Edlington Formation overlie 1.25 m of algal-laminated ooidal dolomite (Smith, 1976); farther away, a similar sequence in the Bank End Bore (SK 706997) contains 2.5 m of algal-laminated sabkha dolomite at this stratigraphical level (Fuzezi, 1970, 1980; Smith, 1976; Kaldi, 1980, fig 2.6c; Harwood, 1981), and algal lamination has also been recorded at this level in the Camblesforth (SE 649358) (Fuzezy 1970), Milford Hagg (SE 533323) (Harwood, 1981), and Wistow Wood (SE 567358) (Harwood, 1981) bores, and in a number of boreholes seen by the writer in the Doncaster and Whitwell areas. The list is almost certainly not exhaustive and it is probable that other comparable sequences in boreholes have not been recorded adequately. The data do not allow full assessment of the overall distribution of Quarry Moor-type sequences but it seems likely that they cap the Sprotbrough Member over perhaps one-tenth to one-fifth of the crop and near-crop area and overlie, in different places, rocks of restricted shelf or lagoon facies and offshore shoal facies. Elsewhere marine oolites of the Sprotbrough Member are directly and sharply overlain by evaporites or siliciclastic beds of the Edlington Formation.

Whilst the common occurrence of algal lamination is consistent with a prograding coastline, it is not clear from the evidence at Quarry Moor and elsewhere whether the progradation resulted from normal sedimentary accretion or from a slight relative fall in sea level; the latter is favoured by the report of karstic features at the top of the formation at Langwith, Derbyshire, (Smith, 1974b) and elsewhere, though Harwood (1981, 1986) argues against marked drawdown and extensive exposure of the Cycle EZ1 carbonate shelf. The relatively even character of the algal lamination at Quarry Moor and the absence of fenestral fabric and rip-up clasts point to accumulation on a low-energy shallow marine shelf and the lack of evidence of bioturbation and the preservation of the lamination is consistent with abnormal salinity and/or an anoxic substrate; all these features are typical of carbonate/evaporite associations at the margins of shallow tropical seas.

Dolomitized bedded algal laminites (bindstones) also occur in the English Zechstein sequence at the top of the Wetherby Member (Cycle EZ1 Ca (a)) and the Seaham (Brotherton) Formations (Cycle EZ3 Ca) but have not been reported at the top of Cycle EZ2 carbonate rocks. Those at the top of the Wetherby Member mainly comprise the lower dolomite of the Hampole Beds (Smith, 1968) and are up to 4 m thick but generally 0.2–0.8 m; they differ from those at Quarry Moor in being widely fenestral, in their common content of small clasts derived from the fracturing of thin contemporaneous crusts, and, at Bramham (SE 4242) and Wetherby (SE 4049), by the presence of small volcano-like structures (see account of Micklefield Quarry). The algal laminites at the top of the Cycle EZ3 carbonate rocks are generally less than 1 m thick and are dolomite mudstones; in County Cleveland and eastern parts of North Yorkshire they are interbedded with nodular anhydrite at the transition to the overlying Billingham Anhydrite (Smith, 1974a).

Future research

Whilst there is general agreement on the overall environmental and diagenetic interpretation of the section at Quarry Moor and in the boreholes cited, much of the petrographic and geochemical detail is virtually unknown. Future research should aim to address these aspects, with the aim of further elucidating the environmental and diagenetic history of the rocks, and, in particular, of determining the role played by probable former evaporites and early lithification. Extra information on the distribution of Quarry Moor-type strata at the top of the Sprotbrough Member must await a thorough search of confidential records and the drilling and careful logging of additional cored boreholes.

Conclusion

The site is unique in that it exposes the transitional relationship of the Sprotbrough Member of the Cadeby Formation and the overlying Edlington Formation. The lower part of the sequence comprises algal-laminated oolitic carbonates and thin clay laminae, which were formed on a shallow marine shelf at a time of increasing salinity. The shelf later shallowed further and environments evolved to intertidal and then coastal plain. In the upper part of the sequence, some clay layers are probably the residues of former evaporites, and widespread contortion, expansion structures and partial brecciation are probably the result of flowage under pressure and secondary volume changes. The site is important because of the unique features displayed, and for the exposure of a rarely seen part of the late Permian sequence in Yorkshire.

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