SOUTH ELMSALL QUARRY

OS Grid Reference: SE483116

Highlights

South Elmsall Quarry (box 5 in Figure 4.2) is of national importance because it provides an unusually complete and readily accessible section through a typical patch-reef in the Wetherby Member of the Cycle EZ1 Cadeby Formation. The reef has a core of massive bryozoan dolomite and a broader spectacularly domed algal mantle; it passes laterally into well-exposed shallow-water ooidal and pisoidal dolomite of types that typify a wide north to south belt that extends along much of the outcrop in Yorkshire.

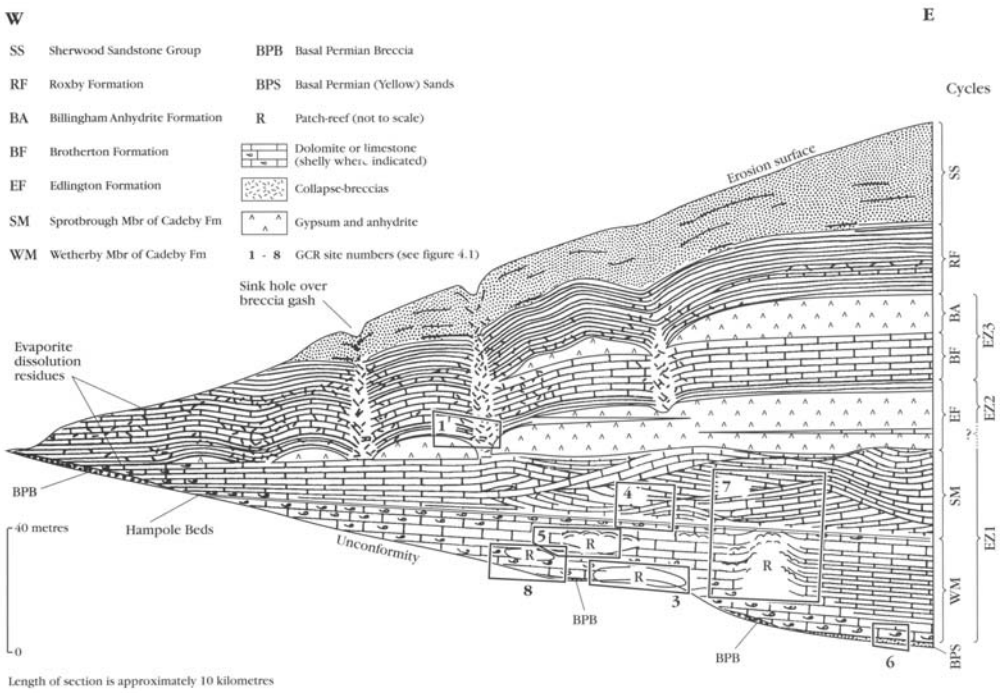

Figure 4.2: Approximate stratigraphical position of marine Permian GCR sites in the Yorkshire Province of north-east England (diagrammatic). Some sites cannot be shown on this line of section and have been omitted.

Introduction

The quarry lies on the south side of Field Lane, a few hundred metres east of South Elmsall village and was cut into about 15 m of dolomitized peloid grainstones of the Wetherby Member of the Cadeby Formation; the basal unconformity was probably a few metres below the quarry floor. Most of the quarry is now filled, but the main feature of interest, a bryozoan–algal patch-reef in the upper part of the sequence in the north-east corner, has been preserved in a 9 m high vertical face. The reef has the shape of a broad inverted cone surmounted by a complex gentle dome, and is at least 8 m thick; it was described and illustrated bySmith (1981b).

The reef was discovered and brought to the Nature Conservancy Council's attention in 1966, and its conservation involved ownership disputes, complete filling and re-excavation; resolution of these problems was followed by landscaping and enclosure of the site as one of the last acts of the West Yorkshire Metropolitan County Council before it was abolished in 1986. The official opening of the site, now known as the South Elmsall Interpretative and Study Centre, was on 14 February, 1986. An information board provides a geological interpretation for visitors.

Description

The position and shape of the GCR site at South Elmsall Quarry are depicted in Figure4.18,

which also shows the location of the main features of geological interest. The preserved faces are about 170 m long and up to 9 m high.

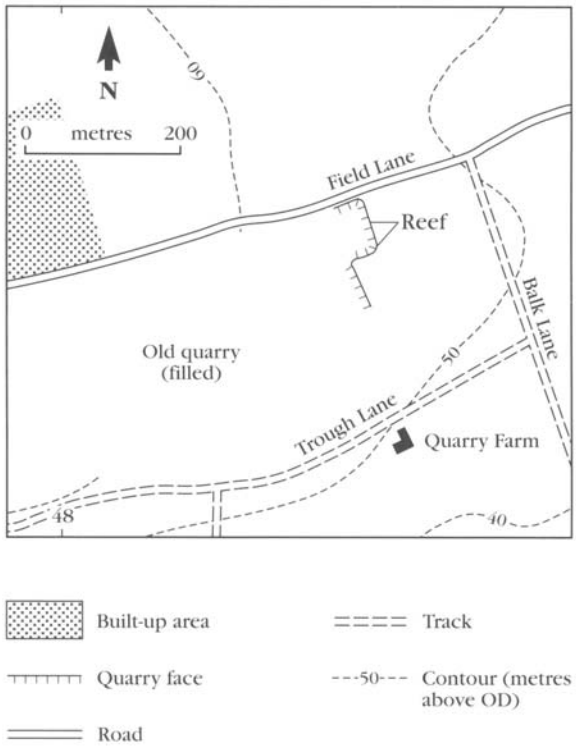

Figure 4.18: South Elmsall Quarry, showing the position of the GCR site.

The entire quarry was cut into the lower half of the Wetherby Member of the Cadeby Formation (formerly the lower division of the Lower Magnesian Limestone), here composed mainly of a varied mixture of dolomitized, partly skeletal, peloid grainstones. Although well within the belt of abundant patch-reefs (Smith, 1981b, 1989), the only reef exposed when working was ceased is in the north-east corner of the quarry; it is about 105 m across and at least 8 m high (the top is not exposed). This reef and its relationship to enclosing grainstones is shown in Figure 4.19.

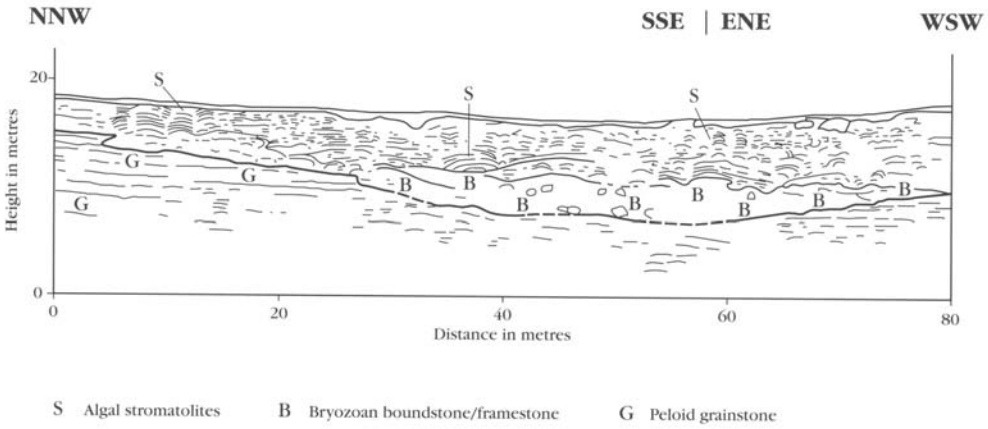

Figure 4.19: Cross-section of an algal-stromatolite reef in peloid grainstones of the Wetherby Member of the Cadeby Formation, South Elmsall Quarry. The core of the reef is of massive bryozoan boundstone and is overlain by more extensive stromatolites that pass laterally NNW into sparingly skeletal peloid grainstone. The stromatolites extend at least 30 m to the right of the area depicted. Note: lowest strata depicted are now covered. Slightly modified from Smith (1981b, fig. 12).

As is common at this level in the Wetherby Member, the patch-reef in South Elmsall Quarry is in two main parts (Figure 4.19). The lower part, about 55 m across and up to 3.5 m thick, comprises buff, massive bryozoan boundstone (framestone/bafflestone) formed of a sparse framework of slender arborescent *Acanthocladia* colonies, and a predominant matrix of slightly turbid dolomite microspar and micrite, and, although complex diagenesis has obliterated much of the primary reef fabric, a few bivalve casts (mostly of *Bakevellia binneyi*) may still be found. The upper part of the reef (0–5 m) is composed of complexly domed, buff, laminated saccharoidal dolomites (Figure 4.20), interpreted on their morphology (Smith, 1981b, fig.13) as algal stromatolitic (cyanophytic) bindstones; here, too, most of the delicate structures have been almost obscured by diagenetic changes and no undoubted algal remains have been detected. The base of the massive part of the reef is sharp and apparently slightly discordant, but the base of the stromatolitic mantle, where it oversteps the massive core, is less sharp, and at the northern margin the stromatolites grade almost imperceptibly into the surrounding grainstones.

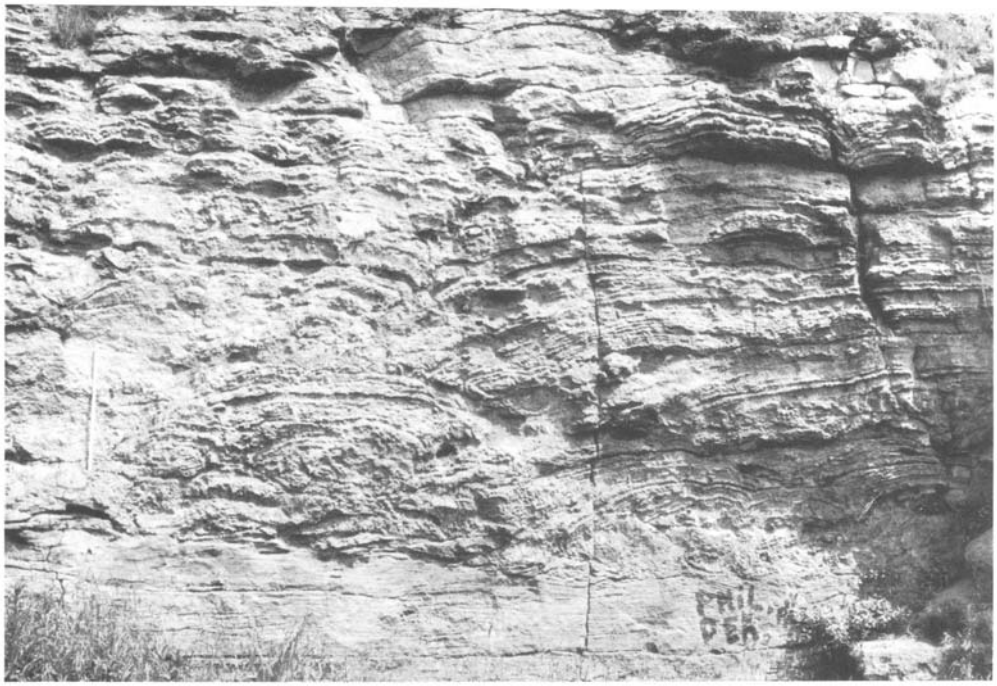

Figure 4.20: Complexly domed dolomitized algal-stromatolites discordantly overlying thin-bedded dolomite peloid grainstones. Central part of east face of South Elmsall Quarry. Bar: 1 m. (Photo: D.B. Smith.)

Grainstones and subordinate packstones (11 m, including about 2 m now covered) exposed in the north-eastern corner of the site mainly comprise level-bedded, buff and cream-buff, peloidal dolomite. Ooidal rocks form most of the uppermost 6 m of the section and also occur in parts of the lowest 4 m, and some beds feature low-angle cross-stratification in sets up to 0.3 m thick; casts of bivalve and gastropod shells occur at several levels and are scattered abundantly, and most beds contain a few stromatolite flakes, pellets, compound coated grains and other pisoids. Pisoids up to 8 mm across are abundant, however, in a 0.9 m bed 6–7 m below the top of the section, and are accompanied by reworked flaky clasts of ooidal and pisoidal grainstone exceptionally up to 0.1 m across, but generally less than 0.3 m. Such clasts were first noted at this quarry by Mitchell *et al.* (1947, p. 122), who referred to them as 'pebbles'. The pisoids may be oncoidal (algal) in origin, but no algal filaments have been recognized. Leaching has removed the cores of many peloids and parts of the grainstone sequence also contain cavities up to 0.1 m across after leached secondary anhydrite. The biota of the grainstones in the Wetherby Member at South Elmsall Quarry has not been investigated in detail, but Mitchell *et al.* (1947, pp. 118 and 121) recorded *Bakevellia antiqua* (*binneyi*), *Liebea squamosa*, *Pleurophorus Permophorus costatus*, *Schizodus truncatus* (= *s. obscurus*) and several species of small gastropod from the north-west part of the quarry and other exposures nearby.

Interpretation

South Elmsall Quarry contains the most accessible and one of the best and most complete sections through a typical late Permian bryozoan–algal patch-reef in the Magnesian Limestone of the Yorkshire Province. Its complexly domed stromatolitic mantle is instantly impressive (Figure 4.20), and the relationships of the reef to enclosing peloidal grainstones, and the nature of the latter, is particularly clear.

Although the presence of unbedded masses of dolomite in the Cadeby Formation was mentioned by several authors, including Kirkby (1861) who recognized that they contained a sessile fauna that had probably grown *in situ*, these were first described as reefs by Mitchell (1932a). These reefs were subsequently documented briefly in a series of Geological Survey memoirs covering the Magnesian Limestone outcrop from Wetherby southwards (Edwards *et al*., 1940, 1950; Mitchell *et al*., 1947; Eden *et al*., 1957) and their structure, composition and biota were discussed in greater detail by Smith (1974a, b; 1981b).

Patch-reefs in the Wetherby Member are unevenly scattered throughout an 8–12 km wide belt that generally follows the present outcrop and extends from near Harrogate to Barlborough (SK 4777), south-east of Sheffield (Smith, 1989, fig. 6). Most of these appear to have projected no more than 2 m above the surrounding sea floor. The reefs lie at all levels in the Wetherby Member between the top of the widespread Bakevellia Bed (which may have provided a stable substrate) and the Hampole Discontinuity, and range from simple hemispherical bodies less than 1 m across and 0.4 m thick to complex bodies more than 100 m across and up to 30 m thick; most are 10 to 25 m across and 3 to 8 m thick, and many of the largest bodies were formed by the coalescence of a number of smaller reefs. In places such as Hooton Pagnell village (SE 4808), patch-reefs make up at least half of the Wetherby Member, and more than 20 reefs have been partly to wholly quarried away during the excavation of the 1 km² site at Cadeby Quarry; elsewhere, as at South Elmsall Quarry, reefs are relatively uncommon.

The character and shape of the reefs varies according to the stratigraphical level at which they occur within the member (Smith, 1974b, 1981b), and all the main types are represented in one or more of the reef GCR sites in the Yorkshire Province. Those formed near the base of the formation, as exemplified by the reefs of the Wood Lee Common site, Maltby, comprise an untidy aggregate of bryozoan saccoliths, and those near the top of the member, such as the youngest of those at Cadeby Quarry, are mainly of domed algal stromatolites. Those at stratigraphically intermediate levels, such as the reefs at the South Elmsall and Newsome Bridge sites, have a core of bryozoan saccoliths and a mantle of algal stromatolites. It is possible, of course, that some apparently wholly stromatolitic reefs near the top of the member may be founded on saccolithic cores outside the plane of section. Other stromatolite-mantled reefs were formerly exposed in a road cutting at Collingham (SE 398460), near Wetherby, and in Alverley Grange Quarry (SK 554992) near Doncaster, and are poorly exposed behind houses in the village of Bramham (SE 435428); those at Cadeby Quarry differ in some respects from the reef at South Elmsall and these differences are described in the relevant account.

The open-shelf patch-reefs in the Wetherby Member of the Cadeby Formation are all older than those in the lagoonal beds of the Ford Formation of the Durham Province and differ from them greatly in their structure and biota (see the account of Gilleylaw Plantation Quarry in Chapter 3); in particular, the reefs in the Wetherby Member (1) have a much less diverse range of frame-builders and other indigenous organisms than those in the Durham Province, (2) contain virtually none of the lamellar encrustations that characterize much of their Durham counterparts, (3) are not associated with contemporaneous talus and (4) many have evolved into stromatolite bodies that have no parallel in Durham. No patch-reefs like those in the Yorkshire Province have been reported from the contemporaneous Raisby Formation of the Durham Province, but the Durham rocks belong mainly to a deeper-water facies found east of the reef belt in Yorkshire, and reefs could have lain west of the present Durham outcrop, but since been removed by erosion.

The dolomitized grainstones surrounding the South Elmsall reef are typical of much of the outcropping Wetherby Member wherever patch-reefs are present and are also well-exposed in several neighbouring quarries. The generally good grading and the cross-lamination of the

ooidal rocks, and the comparative rarity of carbonate muds, point to accumulation and winnowing under at least moderately agitated conditions though large bedforms are uncommon, and the local abundance of compound grains and rip-up clasts suggest phases of sea-floor cementation and perhaps of relative quiescence punctuated by occasional storms. The general impression is of a tropical open-shelf sea no more than a few metres deep and widely dotted with generally small patch-reefs; there is no firm evidence of subaerial exposure either of the reefs or surrounding grainstones. The grainstone floor clearly supported an abundant, but low-diversity bivalve-gastropod biota, but the growth of small bush-like bryozoan colonies led to the creation of a more varied suite of reefy subenvironments in which a rather more diverse and different fauna flourished.

Future research

The main strength of the exposures of reef and surrounding strata at South Elmsall Quarry lies in their visual impact and their scale and mutual relationships; because of the profound alteration of much of the reef-rock, the exposure is probably better suited to a study of the advanced diagenesis rather than to research into reef fabric and ecology. The main face must remain, however, one best viewed from a distance and there is much to be said for a 'no hammering' policy and the preservation of the impressively photogenic faces unscarred by heavy sampling.

Conclusion

This GCR site is of national importance in that it contains one of the best sections through a patch-reef and its surrounding shallow-water carbonate rocks. The sequence is within the Wetherby Member which forms the lower part of the Cadeby Formation in Yorkshire. The morphology of the patch-reef is uniquely displayed as an inverted shallow cone with a gently dome-shaped top; the lower part contains a bryozoan framework and the dome-shaped top is composed of algal stromatolites. The surrounding oolites contain a restricted suite of fossils, chiefly bivalves and gastropods. The site illustrates the structure and spatial relationships of the reef to the surrounding sediments, and, for this reason, South Elmsall Quarry has been preserved for further study and research.

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