TRIMDON GRANGE QUARRY

OS Grid Reference: NZ361353

Highlights

Trimdon Grange Quarry (not shown in Figure 3.2) is a secluded place where backreef to lagoonal limestone of the Ford Formation may be studied. Much of the rock has been severely altered by mineralogical changes linked to the dissolution or replacement of gypsum and/or anhydrite that were formerly abundant in it, but enough has escaped such alteration to show that the rock is mainly a cross-bedded, shallow-water ooid grainstone with traces of burrows and a sparse shelly fauna.

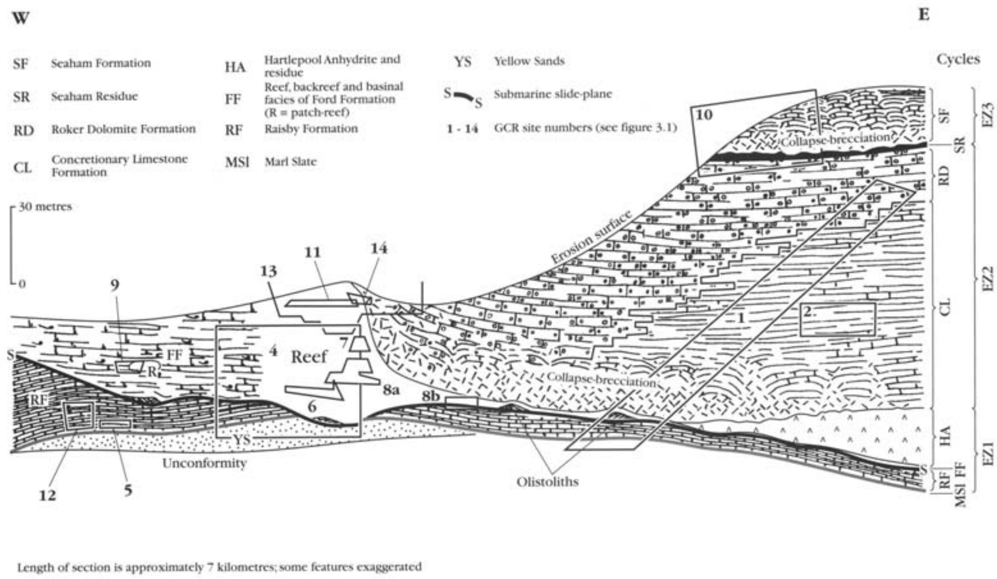

Figure 3.2: Approximate stratigraphical position of GCR marine Permian sites in the northern part of the Durham Province of north-east England (diagrammatic). Some sites in the southern part of the Durham Province cannot be accommodated on this line of section and have been omitted. The Hartlepool Anhydrite would not normally be present so close to the present coastline but is included for the sake of completeness. The biostrome is the Hesleden Dene Stromatolite Biostrome.

Introduction

This quarry, not to be confused with the Grange Quarry (NZ 362345) near Trimdon, lies about 1 m south-west of Trimdon Grange, County Durham; it is part of a nature reserve owned and managed by the Durham County Wildlife Trust, mainly for its botanical interest, but with considerable faunal interest also.

The quarry is about 70 m across and 5–9 m deep, and is cut entirely into gently-dipping, shallow-water, backreef or lagoonal carbonate rocks of the Ford Formation (formerly the Middle Magnesian Limestone). Most of these rocks probably were primary ooidal limestone, but they have undergone extensive mineralogical changes and are now a complex mixture of secondary limestone and subordinate dolomite; there is much evidence of replaced gypsum and/or anhydrite. The formation exposed here may also be seen in a number of other quarries in the area, although many nearby quarries have been filled in recent years and others are under threat; details of strata in all these exposures are available in the fieldnotes files of the British Geological Survey.

Trimdon Grange Quarry was first described by Smith and Francis (1967, p. 129) and further details were given by Smith (1981d). It is a peaceful place, almost cut off from the outside world, and its fascinating geology and botany are best enjoyed in the summer when its abundant wild strawberries are in season.

Description

The position and outlines of the designated area are shown in Figure3.60, together with the locations of the main features of geological interest. The main rock exposures are in the north-west and south-west faces, where exposures are up to 7 m high; smaller exposures are in the lower south face and behind undergrowth on both sides of the quarry entrance.

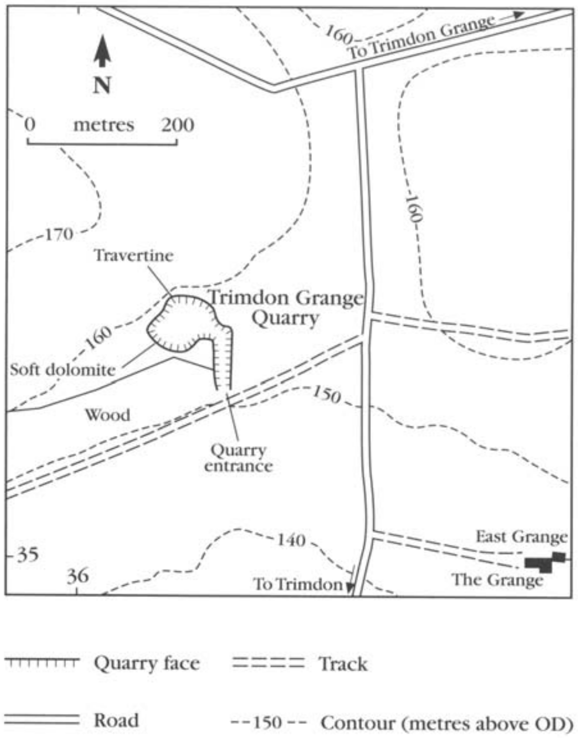

Figure 3.60: Trimdon Grange Quarry and its immediate surroundings, showing the main features of geological interest.

The rocks in the faces of Trimdon Grange Quarry are extremely varied, both vertically and laterally, and almost all display evidence of a complex diagenetic history; they dip gently eastwards, roughly parallel with the quarry floor, and about 9 m of strata are exposed. Strata in the north-west face and in some northern and upper parts of the south-west face are mainly of hard, off-white to pale buff-grey, finely saccharoidal secondary limestone, and most of the rock in the south face is of hard, coarsely saccharoidal, brown and grey-brown secondary limestone; rocks in the lower and southern parts of the south-west face are mainly of fairly soft, cream, finely crystalline dolomite which in places is soft and powdery. Traces of hollow ooids and of pisoids up to 4 mm across suggest that much of the rock was formerly an ooidal and pisoidal grainstone, though thin packstones and wackestones were probably also present. Much of the bedding has been blurred or obliterated by diagenetic changes, but enough has survived to suggest a mixture of beds, wedges and gentle lenses generally less than 1 m thick; abundant traces of low-angle, herringbone tabular cross-stratification (in sets up to 0.3 m thick) and hints of minor channels are present locally. Sub-vertical and U-shaped burrows up to 8 mm across are common in some beds and these have preferentially calcitized walls, but possible invertebrate remains are restricted to scattered bivalve-shaped casts.

Secondary features in the rocks of this quarry take the form of scattered, ovoid to irregular calcite-lined cavities up to 0.1 m across, of widespread, 'felted', platy calcite crystals after anhydrite or gypsum and of extremely numerous rectilinear and stellate intercrystalline dissolution voids; judging from the distribution and abundance of these features, the proportion of sulphate may once have ranged from 10 to as much as 90% of the rock. The 'felted' fabric is particularly eye-catching and is commonly associated with a boxwork of thin calcite veins; it was prevalent in cross-stratified ooidal dolomite exposed in a railway cutting (now filled) immediately east of the quarry. Other secondary features include widespread, patchy brick-red staining and a thick, sub-horizontal lens of coarsely-crystalline white calcite (recrystallized travertine?) in the north-east corner of the quarry.

Interpretation

Trimdon Grange Quarry provides a readily accessible and representative section in the backreef lagoonal strata of the Ford Formation, and, where least altered, is typical of lagoonal ooid grainstones of all ages. Where highly altered, as in much of the quarry, it affords an unrivalled opportunity to study the diagenetic influence of former pervasive secondary calcium sulphate minerals.

Ford Formation strata landward of the shelf-edge reef occupy most of the outcrop of the Magnesian Limestone in County Durham, forming a triangular belt that exceeds 8 km in width in the Trimdon area; they are more than 100 m thick where adjoining the reef, but thin westwards (partly through erosion) and are probably mainly 30–60 m thick around Trimdon. Exposures are uncommon and mainly small in the narrow north of the outcrop, where they are near the reef and generally of shelly ooidal dolomite with scattered patch-reefs (as at Silksworth; see the account of Gilleylaw Plantation Quarry). In the wide outcrop to the south, by contrast, there are many quarries and natural exposures of only sparingly shelly ooidal strata lying several kilometres west of the reef (Smith and Francis, 1967, pp. 123–131) and it is these rocks that are epitomized by the beds exposed at Trimdon Grange Quarry. Ubiquitous low-angle cross-stratification, shallow channels and lenticular bedding all point to free grain movement under agitated (perhaps occasionally intertidal) shallow water, and the scarcity and low diversity of the shelly fauna may indicate slightly enhanced salinity. Lateral salinity gradients are common in many modern tropical lagoons and shallow marine shelves and may account for the westwards-diminishing faunal abundance and diversity in the Ford Formation. The general impression is of a broad, shallow marine shelf that evolved into a lagoon when the shelf-edge reef built up to sea level; near normal salinity probably characterized eastern parts, near the reef, but salinity increased gradually westwards (landwards) where the shelf/lagoon probably shelved imperceptibly into a marginal sabkha plain in which secondary evaporites may have been formed penecontemporaneously.

The predominantly dolomitic character of the rocks in the west face of Trimdon Grange Quarry is typical of the backreef/lagoonal peloid grainstones of the Ford Formation in a broad belt extending westwards to Bishop Middleham (NZ 3331) and northwards to South Hetton (NZ 3845), but most large exposures display some or all of the diagenetic changes noted in the rocks in the remainder of the quarry. In particular the 'felted' fabric is extremely common and dominates some exposures; it results from the volume-for-volume replacement by calcite of sheaths and aggregates of intersecting secondary calcium sulphate crystals (Jones, 1969). In addition, irregular layers and patches of secondary limestone (dedolomite) occur in many exposures, and fractured strata alongside faults are almost invariably of dense crystalline secondary limestone. As an exception, almost the whole of the formation exposed in Witch Hill Quarry (NZ 34439), Old Cassop, has been converted into massive and complex dedolomite. Field and petrographic evidence suggest that the proportion of former secondary sulphate and subsequent dedolomite in the rocks increases westward, perhaps in sympathy with the inferred westward salinity increase in the lagoon; it must be emphasized, though, that there is no evidence of the precipitation of primary evaporites on the lagoon floor.

The dolomitization of the backreef/lagoonal strata of the Ford Formation has been ascribed to refluxing dense brines relatively enriched in magnesium by the precipitation of thick calcium sulphate rocks in the succeeding Edlington Formation (Smith, 1981a, p. 179). Such brines might also have been generated in sabkhas marginal to the Ford Formation lagoon, which have now been eroded off. Harwood (1986) postulated a similar mechanism to account for the equally pervasive dolomitization of equivalent strata in the Yorkshire Province, and Lee and Harwood (1989) invoke a reflux mechanism for the dolomitization of the underlying Raisby Formation in Durham. The calcium sulphate ions that subsequently replaced much of the dolomite presumably were introduced in the brines that effected dolomitization, and much of the dedolomitization was probably accomplished when the anhydrite was hydrated and dissolved during the current cycle of uplift (?Tertiary to present).

Future research

There has been relatively little research into the diagenetic and depositional history of the backreef/lagoonal beds of the Ford Formation and both these aspects deserve attention; Trimdon Grange Quarry would form an excellent starting point.

Conclusion

Trimdon Grange is the only GCR site in which can be observed an accessible section of typical backreef or lagoonal carbonate sediments formed some kilometres west of the shelf-edge reef, the dominant feature of late Permian sedimentation in County Durham. Where unaltered, the oolitic limestones display bedding and channelling characteristic of lagoonal environments. However, in much of the exposure they are highly altered, the original limestone having been replaced by dolomite and this by calcium sulphate. The latter, in turn, was then either dissolved and its place taken by calcite, or replaced by calcite (together with some dolomite), producing a fascinating variety of rock fabrics and textures. The preservation of this site is important to safeguard the section of 'normal' lagoonal sediments, and the profound effects of later diagenetic processes.

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