Raisby Quarries

[NZ 34 35]

Highlights

In addition to being the type locality of the Raisby Formation, the whole of which is exposed in the north face, Raisby Quarries (not shown in (Figure 3.2)) are amongst the largest man-made excavations in northern England. The formation mainly comprises well-bedded sparingly fossiliferous dolomite rock, but here includes an atypically thick and somewhat more fossiliferous limestone in its lower part. The underlying Marl Slate and uppermost part of the Yellow Sands are exposed in the quarry floor, below the Raisby Formation, and the basal beds of the overlying Ford Formation are present at the top of the main face. A varied suite of secondary minerals has been reported from these quarries.

Introduction

The enormous eye-catching north face of Raisby Quarries (formerly known as Raisby Hill Quarry) lies a short distance east of Coxhoe and just north of the Butterknowle Fault. The quarries have been worked for most of this century; they are the type locality of the Raisby Formation (Smith *et al.,* 1986), here perhaps 58 m thick, which is underlain by Marl Slate (0.2–0.9 m) and overlain by basal beds of the Ford Formation (6 m+). Basal Permian (Yellow) Sands of ?early Permian age are present in part of the quarry and Westphalian B Coal Measures have been temporarily exposed and worked in the quarry floor.

Raisby Quarries are well known because the Raisby Formation here contains a thick mass of limestone in place of the more usual dolomite rock (Trechmann, 1914; Woolacott, 1919a, b; Smith and Francis, 1967; Lee and Harwood, 1989; Lee, 1990, 1993). These authors and Jones and Hirst (1972) noted the presence of diagenetic breccias in part of the sequence, and, together with Fowler (1943, 1957), Jones and Hirst (1972) and Hirst and Smith (1974) reported a substantial range of secondary minerals including small amounts of native copper. Rocks from the quarry figure largely in Lee and Harwood's (1989) detailed investigation of the isotopic composition, sedimentology and diagenetic history of the formation.

The quarries are fully operational and permission to enter must be obtained; stout footwear and hard hats are essential and the bases of the higher faces should be avoided.

Description

The position of the site is shown in (Figure 3.61), which also shows the location of the main points of geological interest. The principal face is more than 1.5 km long, though only part of this is to be preserved, and is worked in three main (1729 m) benches with a subordinate basal 4–6 m bench. Beds dip gently north-northeastwards.

The general sequence in Raisby Quarries is given below.

	Thickness (m)
Soil on thin Durham Lower Boulder Clay	0–4
———— unconformity ————	
Ford Formation, at top of highest part of face	0–6
Raisby Formation, forming most of the worked faces	?58
Marl Slate, exposed only in deepest part of quarry	0.2–0.9
Basal Permian (Yellow) Sands, in floor of quarry, forming a gentle WSW–ENE ridge	?0–6.0+
———— unconformity ————	

Coal Measures (Westphalian B), temporarily exposed and worked	8.0+

Basal Permian (Yellow) Sands

Unfossiliferous, almost uncemented, aeolian yellow sand, ranging from parallel-laminated to coarsely trough cross-stratified, forms the lowest unit semi-permanently exposed in the floor of the quarry. It is overlain by a thinner unit of carbonate-cemented, buff-brown, redistributed sandstone in which winnowed *Lingula* are locally present at the top. Both units are medium- to coarse-grained.

Marl Slate

This comprises a basal unit of dark grey, finely-laminated, argillaceous and carbonaceous dolomite mudstone which thins against eminences on the surface of the underlying Basal Permian (Yellow) Sands, and a more uniform upper unit of buff, finely-laminated dolomite mudstone. Both units contain scattered fish scales.

Raisby Formation

Summaries of the Raisby Formation in Raisby Quarries have been given by Woolacott (1919b, p. 167), Smith and Francis (1967, pp. 111–112), Lee and Harwood (1989) and Lee (1990, 1993); they differ in detail on matters of thickness and dolomite/calcite content, but all are agreed that a thick, limestone unit separates a thin, basal dolomite from a thick upper dolomite unit.

The basal dolomite is about 5 m thick and is very finely crystalline; it comprises a brown-buff flaggy sequence overlain by a grey thin-bedded nodular sequence; the contact with the underlying Marl Slate is sharp and planar, without interdigitation.

The median limestone thins westwards (Francis, in Smith and Francis, 1967) and comprises uniformly bedded grey and blue-grey calcite microspar which, according to Lee (in Lee, 1993) is thinly layered in shades of grey in its lower two-thirds, and is of a more uniform dark blue-grey above; the base and top of the limestone is gradational, with limestone nodules in a dolomite matrix. Lee (1990, 1993) and Lee and Harwood (1989) recorded hemispherical concretionary masses averaging 0.1 m across of dolomite-replacive coarsely-crystalline calcite in upper parts of the limestone and Lee and Harwood (1989) investigated the isotopic composition of these masses. Patchy *in situ* brecciation in the transitional nodular beds between the limestone and the overlying dolomite has been recorded by several authors and was investigated in detail by Lee and Harwood (1989).

The thick uppermost unit of the Raisby Formation here is of relatively evenly-bedded cream and buff very finely crystalline dolomite with many calcite-lined irregular cavities (after secondary anhydrite); much of the unit appears to be unfossiliferous. Lee (1990) recorded patchy to pervasive calcite replacement of dolomite in this unit.

Fossils in the Raisby Formation at the type locality are concentrated in the lower beds of the limestone unit, in which a few beds are relatively rich in a varied assemblage of foraminifers, bryozoans, brachiopods, bivalves and ostracods (see list by Pattison in Smith and Francis, 1967, p. 111); amongst forms listed by Pattison and illustrated and further discussed by him in Smith and Francis (1967, plate VI and p. 181) is an unnamed and previously undescribed cryptostome bryozoan resembling *Penniretopora waltheri.* Some beds low in the sequence bear abundant invertebrate burrows and trails, and complex grazing patterns are present at some levels (Figure 3.62); Trechmann (1914) also recorded plants from these early Raisby Formation beds. The dolomite in the upper part of the sequence contains only a sparse fauna of poorly-preserved foraminifera and bivalves.

Ford Formation

Rocks of this formation lie at the top of the 26–29 m uppermost bench and are being progressively removed as the face recedes; they comprise up to 6 m of cream and pale-buff, cavernous, ooidal and pisoidal grainstones which, according to

Lee (1990), are of calcitized dolomite with leached grain centres. The rocks are evenly bedded with traces of cross-lamination, and the base, though not readily accessible, appears to be conformable.

Secondary minerals

The quarries have long been known for their suite of secondary minerals which occupy veins, geodes and replacive patches; authors reporting mineralization are listed in the introduction. Minerals recorded from here include azurite, baryte, calcite, chalcocite, fluorite, galena, malachite, selenite, pyrite and sphalerite. Of these, the copper minerals and much of the calcite and some dolomite occupy fractures, and the remainder (including much calcite) occur either in geodes or are replacive.

Interpretation

Raisby Quarries are unique in exposing the full thickness of the Raisby Formation, and the section also includes an unusually thick unit of primary limestone. Beds below and above the formation are typical of their respective stratigraphical units.

The thin Basal Permian (Yellow) Sands at Raisby Quarries lie at the north-eastern extremity of the Chilton sand ridge documented by Smith and Francis (1967, fig. 18) and the clear evidence of onlap of the lower part of the Marl Slate against the flanks of the ridge is typical of this formation. Similar relationships, in which the lower (dark grey) carbonaceous part of the Marl Slate is overlapped by the grey, less carbonaceous, upper part which then thins out over the highest ridges have also been seen at Houghton Quarry [NZ 340 506], Sherburn Hill Quarry [NZ 345 417] and Quarrington Quarry [NZ 327 380]. The Marl Slate is a principal feature of the fish- and plant-bearing GCR site at Middridge, some 15 km south-west of Raisby Quarries. Lower beds of the Raisby Formation are gently arched over the Yellow Sands ridge, without onlap, but the arch dies out upwards by slight differential thinning of the beds.

The Raisby Formation is the carbonate member of the first sub-cycle of English Zechstein Cycle 1, and was formally defined by Smith *et al.* (1986, pp. 13–14). It is thickest in a roughly north-south belt in eastern County Durham (Smith and Francis, 1967, fig.19) and is thought to have been formed on the outer part of the Zechstein marginal shelf and adjoining slope (Smith, 1989, fig. 6). Evidence of mass downslope sediment movement such as is seen at High Moorsley Quarry and several other localities (Smith, 1970c) has not been recognized at Raisby. Other GCR sites at which the Raisby Formation is present are Claxheugh Rock [NZ 362 574] at Sunderland, Trow Point [NZ 34 67] and Frenchman's Bay [NZ 389 662] at South Shields, and Dawson's Plantation Quarry [NZ 326 548] at Penshaw.

Primary Limestone in the Raisby Formation is relatively uncommon and is concentrated in (though not confined to) the lower half of the formation. In addition to Raisby Quarries, it was reported by Woolacott (1919a, b) in the Cotefold ('Cotefield') Close Borehole [NZ 4319 3276] where it was about 30 m thick, and in the Sheraton Borehole [NZ 4338 3466] where it was about 36 m thick; farther south, Trechmann (1914) recorded a 3 m lens of shelly limestone low in the formation at Thickley Quarry [NZ 240 257] and Mills and Hull (1976) record patchy limestone at several places in the Middridge area. To the north, Lee (1990, 1993) reported limestone in Penshaw Quarry [NZ 334 544], in the nearby Dawson's Plantation Quarry, at Houghton Quarry [NZ 341 506] and at High Moorsley Quarry [NZ 334 455]. In surface exposures the limestone may generally be distinguished by its pale grey colour, but in boreholes it is commonly buff or brown. A primary origin for the limestone at Thickley and Raisby was suspected by Trechmann (1914, p. 259) who remarked that the rocks seemed to have escaped the otherwise ubiquitous dolomitization of the formation, and a similar conclusion was reached by Lee (1990, 1993) who speculated that early cementation of the limestone may have made it less susceptible to penetration by dolomitizing fluids. If this speculation is correct, the spectacularly complex patchiness and near-vertical margins of several of the limestone bodies in the Raisby Formation in the quarries near Middridge, point to equally complex patchiness of the cements and the involvement of yet other factors.

The patchy brecciation of the transitional top of the limestone was ascribed by Woolacott (1919b, p. 166) to post-depositional internal volume changes and by Jones and Hirst (1972) to collapse following the dissolution of interbedded sulphates. Lee and Harwood (1989) deduced that the brecciated rock had undergone a complex diagenetic history and that the brecciation occurred at about the time when abundant replacive anhydrite in the rock was being dissolved; they speculated that this dissolution might have been effected by fluids introduced during Tertiary re-activation of the nearby Butterknowle Fault. Farther east, away from known faults, apparently secondarily brecciated dolomite was reported by Magraw *et al.* (1963) at a comparable stratigraphic level in Elwick No. 1 Borehole [NZ 4531 3117] and Dalton Nook Plantation Borehole [NZ 4811 3144].

The mineralization of the rocks at Raisby Quarries has been considered by a number of authors (see Introduction). There is reasonable agreement that the copper mineralization is related to the proximity of the Butterknowle Fault, but somewhat more diverse views on the mode of emplacement of the remaining minerals. It is generally agreed, however, that secondary anhydrite was once widespread and abundant in these rocks and, on dissolution, was the source of marine sulphate ions involved in the formation of baryte. Jones and Hirst (1972) speculated that the anhydrite, perhaps with a bacterial and organic carbon involvement, was the source of sulphide ions incorporated into galena and sphalerite. Lee and Harwood (1989) envisage a complex sequence of events leading to the precipitation of late-stage anhydrite, baryte and fluorite following the dissolution of early diagenetic anhydrite by meteoric-derived fluids during the Tertiary to present cycle of uplift.

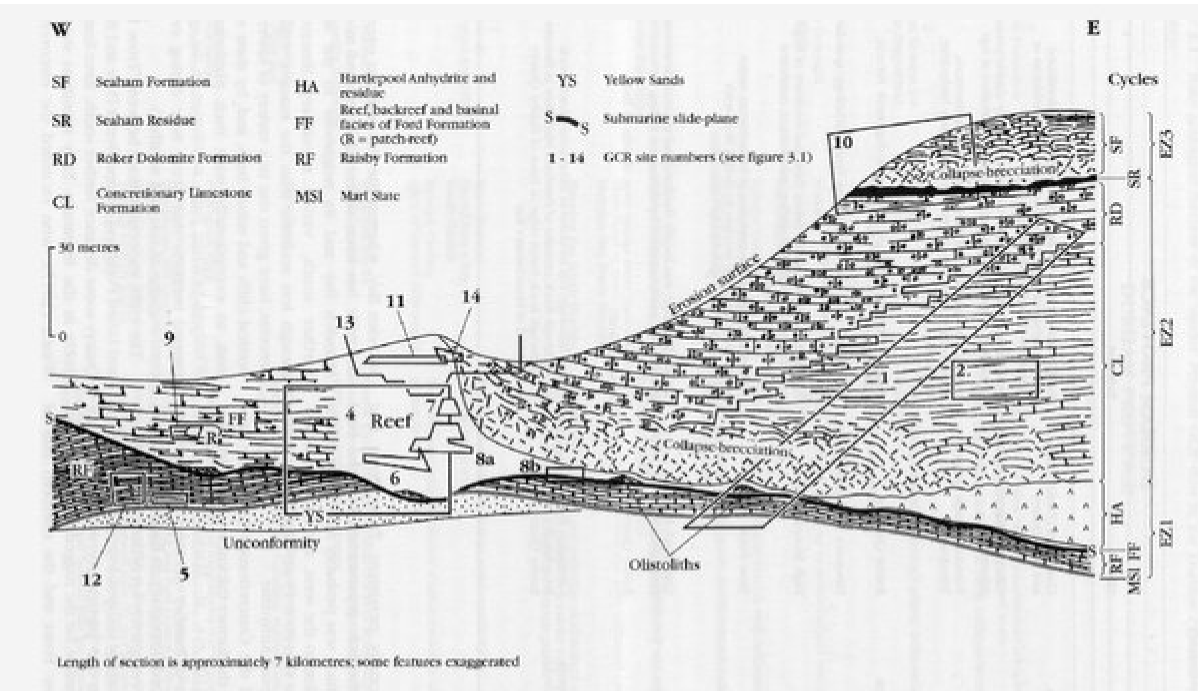
Future research

The geology of this quarry is reasonably well known and understood and there is relatively little immediate scope for further research; its main use is as a superb reference section.

Conclusions

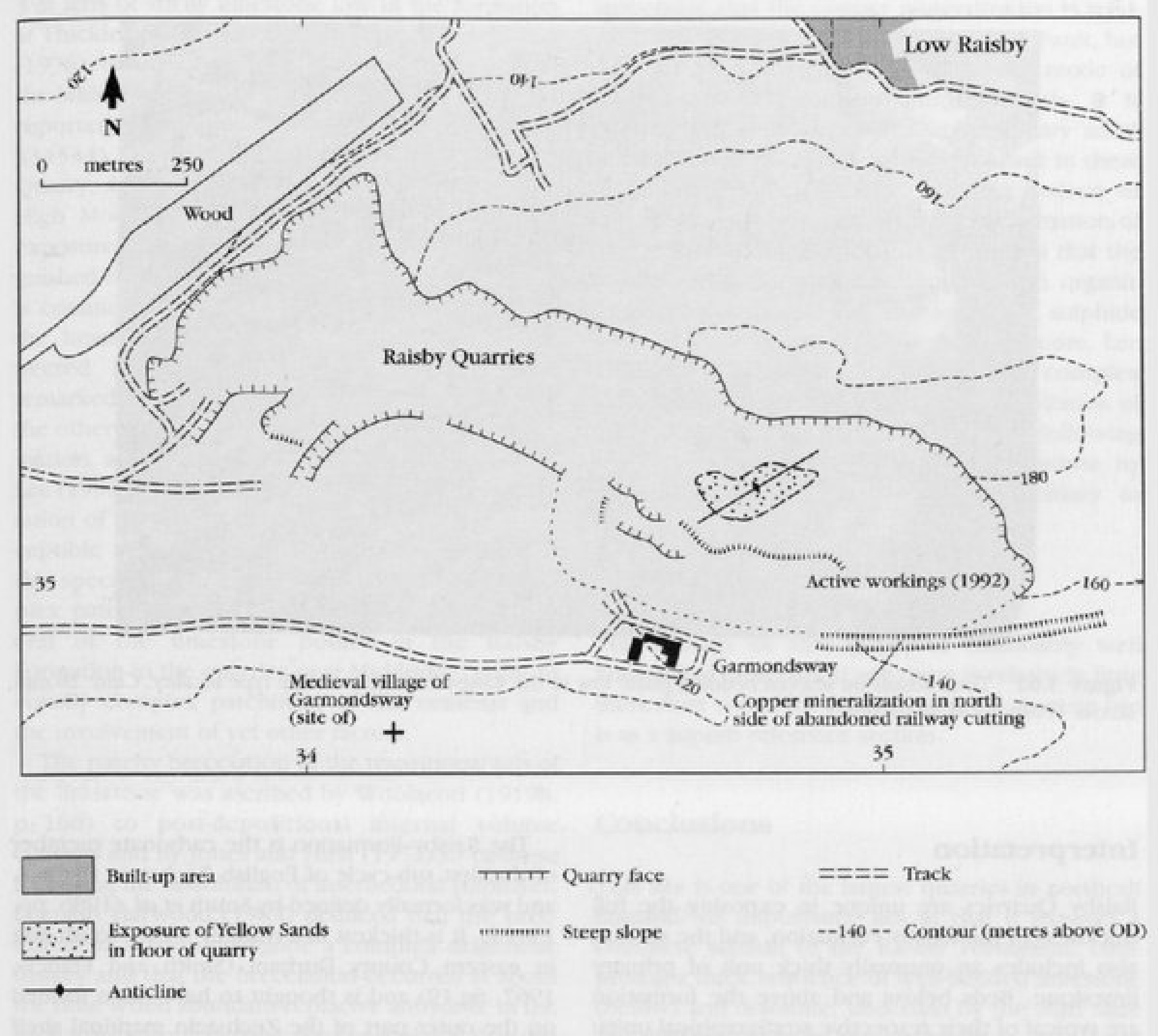
This site is one of the largest quarries in northern England. Its importance lies in that it exposes a complete section of the Raisby Formation, comprising a thick sequence of well-bedded limestone (below) and dolomite, underlain by the Marl Slate and Yellow Sands in the quarry floor. The basal few metres of the overlying Ford Formation are present at the top of the main face. Much of the limestone of the Raisby Formation is original, particularly in the lower part of the formation, but higher beds are mainly of dolomite. This limestone and dolomite contains a well-documented suite of secondary minerals. Fossils are concentrated. in the primary limestones in the lower part of the formation. The principal significance of Raisby Quarries is that they provide an excellent type section of the Raisby Formation.

References



(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.



(Figure 3.61) Raisby Quarries: the north face in the cast is the type locality of the Raisby Formation (Smith et al., 1986).

(Figure 3.62) Trace fossils on uneven bedding plane low in the Raisby Formation at the type locality. Coin: 26 mm across. (Photo: T.H. Pettigrew.)