# Gilleylaw Plantation Quarry

[NZ 375 537]

## Highlights

Though small, the old quarry (box 9 in (Figure 3.2)) in Gilleylaw Plantation, Silksworth, is the best remaining exposure of a late Permian marine patch-reef in the Durham Province of north-east England. The reef forms part of the Ford Formation and rests discordantly on bedded dolomite also probably of the Ford Formation; the quarry is cut into the northern end of the patch-reef and is the source (or one of the sources) of more than 20 type, figured or cited genera of marine invertebrates and of several growth-forms of supposed marine algae.

## Introduction

Gilleylaw Plantation Quarry lies amongst trees at the northern end of a long low north-south hill at Silksworth in the south-western outer suburbs of Sunderland. The hill is probably roughly co-extensive with the patch-reef exposed in the quarry and has also been quarried along much of the northern part of its western side. Quarrying ceased long ago.

A quarry at Silksworth was mentioned by both Howse (1848, 1858) and King (1848, 1850), but no details were given and its exact site is unknown; it seems likely, however, that this quarry is that in Gilleylaw Plantation because both authors quote substantial fossil lists and Gilleylaw Plantation Quarry is much more fossiliferous than the others. Silksworth was also the source of many fossil specimens in the Kirkby collection, housed at the Hancock Museum, Newcastle upon Tyne. The quarry was not mentioned again in the literature until Smith (1958, 1981a) briefly described the section and illustrated oncoids and several other algal growth-forms from there, and Logan (1967) illustrated lectotypes of several species of late Permian bivalves from Gilleylaw. Most recently, a detailed faunal and ecological analysis was given by Hollingworth (1987).

Strata exposed in Gilleylaw Plantation Quarry comprise a lower unit of unevenly-bedded soft saccharoidal dolomite, a median unit of varied reef dolomite (a mixture of algal-bryozoan boundstone and Shelly rubble) and a thin upper unit of thin-bedded pisoidal (oncoidal) dolomite. Early authors (e.g. Howse, 1848; King, 1850) apparently believed the reef-rock to be an outlying erosional relic of the main 'Shell-Limestone' reef, then thought to be 1.3–5 km wide; the present view that it is more likely to be a patch-reef in the lagoon landward of a much narrower main reef was proposed by Smith (1981a) and supported on palaeontological grounds by Hollingworth (1987).

After lying unused for over a century, the quarry was filled with builders' rubble during the early 1980s; it was subsequently re-excavated following representations by staff of the Planning Department of the Sunderland Borough (now City) Council acting in consultation with staff of the Nature Conservancy Council and Sunderland Museum and Art Gallery. The floor of the quarry is now occupied by a house and garden, but the face remains available for study by prior permission of the occupants.

## Description

The position and shape of Gilleylaw Plantation Quarry are shown in (Figure 3.36), which also shows the location of the main features of geological interest. The faces of the quarry total about 60 m in length and the main face is up to 11 m high; parts of the face are obscured by vegetation and soil.

The general geological sequence in the quarry is shown below.

| | Thickness (m) |
|---|---|
| Ford Formation, oncoid facies | up to 1.3 |
| Ford Formation, probable patch-reef | up to 5.5 |

?Erosion surface
?Ford Formation, backreef (lagoonal) facies up to 5.2

The disposition of the lithological units exposed in the south and east faces of the quarry is shown in (Figure 3.37).

### ?Ford Formation, backreef (lagoonal) facies

Strata beneath the ?erosion surface at Gilleylaw Plantation Quarry comprise unevenly thick-bedded cream and buff porous saccharoidal dolomite that contains sparingly scattered molluscan bioclasts and many empty or thinly calcite-lined cavities up to 10 cm across after secondary anhydrite; the rock is probably an altered ooid grainstone. These strata may be divided into two main units, the lower (*c.* 2.8 m+) of which comprises rock that is variably bedded and rather vuggy, and the upper (3–3.5 m) comprises clearly bedded rock with continuous beds 0.1–0.4 m thick and only local wedging-out. Beds just above the base of the upper unit feature two mound-like structures (Figure 3.37); the larger of these is about 3 m across and 0.7 m high and has a confused (possibly brecciated) mainly dolomite core, and the other (Figure 3.38) is about 1 m across and 0.4 m high and has a core of dense grey limestone (?dedolomite). The mounds contain no obvious organic framework, but are clearly contemporaneous and they may be small algal patch-reefs.

### The ?erosion surface

The inferred patch-reef is separated from the underlying bedded dolomite by a sharp break interpreted as an erosion surface (Figure 3.37). This has a relief in the quarry of more than 2 m, and sharply truncates beds beneath it on the east face where it dips north-eastwards at about 20°; its precise position and relief on the remaining (mainly inaccessible) faces is less clear. Hollingworth (1987) noted no evidence of contemporaneous cementation beneath the ?erosion surface.

### Ford Formation, probable patch-reef

The inferred patch-reef at Gilleylaw Plantation Quarry occupies most of the upper part of the main face and comprises a varied mixture of massive dolomitized algal-bryozoan boundstone and subordinate dolomitized shelly rubble (Figure 3.37). The boundstone is a dense hard rock (bafflestone/framestone) in which scattered pinnate and straggling bryozoans are partly to thickly encrusted by fine concentric ?algal coating; in a massive 1.5 m bed in the south face such encrustations exceed 90% of the bulk of the rock. Only a restricted range of invertebrates is found in the boundstone masses but the shelly talus, exposed mainly in the east face of the quarry, contains a varied and abundant invertebrate fauna. The biota includes some genera that are absent or very uncommon in the main shelf-edge reef and lacks some common reef forms such as *Horridonia* and *Cyathocrinites* (Hollingworth, 1987); a full list by Hollingworth shows the striking difference between the faunal assemblages of the two rock types in the Gilleylaw reef and also between the overall biota of the inferred patch-reef and that of the main shelf-edge reef.

The association of massive bryozoan–algal boundstone and shelly rubble in the Gilleylaw reef is not unlike that in parts of the main shelf-edge reef, at the Humbledon Hill site for example, and it must be assumed that most of the type, figured and cited genera listed in the early works were specimens collected from the shelly rubble.

### Ford Formation, oncoid facies

Up to 1.3 m of irregularly thin-bedded grey and buff oncoidal dolomite was formerly exposed at the top of the slope above the south face of the quarry where it rested with pronounced onlap on the uneven surface of the underlying patch-reef (Figure 3.37). These beds are now mainly covered, but many small exposures and loose blocks may still be found; they appear to contain no invertebrate remains.

Most of the beds and lenses of oncoidal dolomite are composed of poorly-sorted aggregates of rolled compound and subordinate simple oncoids (ie. concentrically-layered algal balls more than 2 mm in diameter) up to 5 cm across (Smith, 1958, plate VIA) in a matrix of abraded oncoid debris and algal chips; they include many grains that bear clear evidence of one or more episodes of fracturing and re-coating (Smith, 1981a, fig. 17). The concentric laminae of the oncoids

comprise couplets of alternately turbid and relatively clear dolomite microspar, commonly exceeding 100 in number. F.W. Anderson (in Smith, 1958, plate Vlll, fig. 3) doubtfully identified the algal (cyanophyte) growthforms *Aphralysia* and *Bevocastria* in oncoids from these beds. The uppermost bed and several other thin beds and lenses of the former exposure comprised unevenly finely sinuously laminated stromatolitic dolomite bindstone composed partly of laterally-linked hemispheres and partly of tightlyfitted oncoids similar to those figured by Smith (1981a, fig. 12c) from the nearby High Newport railway cutting [NZ 388 538]. These *in situ* stromatolitic beds and lenses yielded the mammillar algal growth-form, cf. *Bevocastria conglobata* Garwood (F.W. Anderson in Smith, 1958, plate VII, figs. l, 2). The visible relief of the base of the oncoidal dolomite was about 0.6 m.

## Interpretation

Gilleylaw Plantation Quarry is of major importance as (a) the most accessible and complete exposure of a late Permian inferred marine patch-reef in the Durham Province and (b) the prime source of more than 20 type, figured and cited specimens of late Permian marine invertebrate specimens and algal growth-forms. It is also the first locality in Britain from which late Permian marine oncoids were illustrated, though some of the beds from which these were obtained are no longer fully exposed.

### The erosion surface and underlying strata

These are closely comparable with the erosion surface and underlying strata exposed in Humbledon Hill Quarry in the main reef 1.7 km NNE of Gilleylaw Plantation Quarry and comments made in the Humbledon Hill account apply equally here. Judging from the record of strata proved in Silksworth Colliery South Shaft [NZ 3766 5404] located some 350 m NNE of the quarry, the base of the inferred patch-reef lies at least 115 m above the base of the Raisby Formation, which is unlikely to be more than 50 m thick in the Silksworth area; it follows, therefore, that the Gilleylaw reef is probably at least 50 m above the base of the Ford Formation and that the beds below it in the quarry are of backreef (lagoonal) facies of the Ford Formation. This important conclusion can only be reconciled with Hollingworth's (1987, p. 367) view that the patch-reefs were formed at much the same time as the basal coquina and lower core of the main shelf-edge reef if it is accepted that the latter may be widely underlain by a considerable thickness of bedded dolomite of Ford Formation age.

The ?erosion surface and up to 4.5 m of underlying bedded ?ooidal grainstones are (or have been) exposed discontinuously for more than 150 m in the old quarries almost immediately south of the site. Here the relief of the ?erosion surface is generally low, but the underlying beds are indistinguishable from their counterparts in Gilleylaw Plantation Quarry.

### Ford Formation, probable patch-reef

Gilleylaw Plantation Quarry and adjacent sections provide the most readily accessible exposures of a late Permian inferred patch-reef in the Durham Province of north-east England; such bodies are concentrated in the Silksworth area and are not known farther south. The only other permanently exposed large inferred patch-reef is in an abandoned railway cutting [NZ 387 538] at High Newport, about 1.2 km farther east; it differs from the Gilleylaw reef in a number of respects and is, on balance, less varied. Both bodies are only a few metres thick. Other, smaller, reef bodies have been noted in temporary excavations around Silksworth by Smith (1971, 1981a, 1994) and Hollingworth (1987) and it is probable that they number some scores or perhaps hundreds in total; some are wholly embedded in shelly lagoonal ooid grainstones.

The doubts about whether the reef-rocks around Silksworth are truly patch-reefs stem from the generally poor quality of most of the exposures and from the lack of exposure between Silksworth and the main shelf-edge reef complex. The early view that the reef-rock at Silksworth is part of the main reef was presumably based on lithological and fauna! similarities, and in the absence of firm evidence to the contrary, cannot yet wholly be refuted; however, the discovery by Smith (1981a) that the main reef is generally much narrower than previously thought made this view difficult to sustain and the visible bilateral symmetry and fringing talus of some of the temporarily exposed, small reef bodies made

interpretation as patch-reefs seem almost unavoidable.

This interpretation is strongly supported by the faunal evidence advanced by Hollingworth (1987), especially his discovery that infaunal bivalves and the bryozoan *Kingopora* are relatively much more abundant in the rubble of the inferred patch-reefs than in the main reef, and that crinoids are absent.

The Gilleylaw patch-reef is also exposed for more than 150 m in a series of old quarry faces stretching southwards from the private grounds of Woodchester (Figure 3.36) into the upper car park of 'The Cavalier' public house where the reef-rock is readily accessible. Here the reef is a coarsely and very unevenly bedded body dominated by hard buff dolomite boundstone composed of complex algal laminites, encrustations and ovoid masses and, in places, including tilted blocks up to 0.5 m across of algal laminite and bryozoan–algal boundstone; contemporaneous lithification and considerable energy levels are indicated. Most of the bryozoans and shelly fossils are tightly cemented into the rock, which lacks talus sheets, but scattered pockets and lenses contain many small gastropods and bivalves. The overall appearance and composition of the reef-rock in the 'Cavalier' car park is much like that of the reef-flat sub-facies of the main shelf-edge reef at Townfield Quarry ([NZ 434 438], Easington Colliery) and at the Hawthorn Quarry site, and similar shallow-water deposition seems likely.

In summary, the evidence suggests that whilst construction of the main shelf-edge reef was actively proceeding a short distance to the east, the shallow ooid-dominated floor of the backreef lagoon was, in the Silksworth area, dotted with bun-shaped patch-reefs ranging from less than 1 m to (exceptionally) several scores or hundreds of metres across. In time, perhaps through building up to sea level, slight sea-level fall and/or a salinity increase, the tops of the larger patch-reefs evolved to become inhospitable (?hypersaline) algal flats.

Although patch-reefs in the Durham Province are restricted to the Ford Formation in and around Silksworth, hundreds of patch-reefs occur in dolo-mitized open shelf ooid grainstones of the Wetherby Member of the Cadeby Formation in the Yorkshire Province (Smith, 1974a, b, 1981b, 1989); striking examples of the Yorkshire patch-reefs are exposed in the GCR sites at Cadeby Quarry [SE 52 00], Newsome Bridge Quarry [SE 379 514], South Elmsall Quarry [SE 483 116], Ashfield Brick-clay Pit [SK 515 981] and Wood Lee Common [SK 53 91] and the mutual relationships of reefs and enclosing grainstones are particularly well seen in the picturesque lanes of Hooton Pagnell [SE 48 08]. The patch-reefs in Yorkshire differ from those in the Durham Province in having cores composed of sack-like masses ('saccoliths') of straggling bryozoans almost without laminar encrustations, and, in the larger examples, having an upper unit of coarsely domed algal stromatolites.

### Ford Formation, oncoid facies

The importance of this thin unit rests partly on its role as the prime source of most of the small number of figured late Permian marine oncoids and partly on the light it throws on contemporary depositional conditions. The oncoidal bed is also poorly exposed at the top of a disused quarry [NZ 3759 5354] some 160 m farther south, where it is closely comparable with that in the GCR site. Elsewhere in the Permian marine sequence of north-east England, lithologically similar rocks have been recorded only in the reef-flat sub-facies of the main shelf-edge reef in Stony Cut (Cold Hesledon) Cutting [NZ 418 473] (Smith and Francis, 1967, p. 133) and in exposures of reef-flat rocks at Yoden [NZ 4315 4176] (Smith and Francis, 1967, p. 139 and plate )03); superficially similar pisoids at the top of the Boulder Conglomerate of the Hesleden Dene Stromatolite Biostrome at the Hawthorn Quarry and Blackhalls Rocks sites may have a different origin from those at Gilleylaw, Cold Hesledon and Yoden.

Modern oncoids comparable with those at Gilleylaw are formed in a range of peritidal and shallow-water environments near the hypersaline margins of tropical seas such as the Persian Gulf and the Red Sea. The reworked Gilleylaw oncoids presumably accumulated as lenses and sheets of fine gravel on a shallow or peritidal reef-flat in comparable latitudes; the abundant evidence of fracturing, abrasion and re-cementation points to some contemporaneous lithification and to at least moderate energy levels at times, and the apparent absence of a shelly fauna is consistent with an atypical (either high or low) salinity. These inferences on the palaeo-environments of the oncoids suggest a sharp and considerable change of conditions from those under which the underlying patch-reef was formed, although a shallowing water level and partial exposure may have sufficed.

Despite the presence of algal influences on the formation of the oncoids, the lamination of many of them lacks undoubted organic growth-forms and at least partial inorganic precipitation (as in some modern pisoids formed in unusual environments, such as splash-cups and surge pools) cannot be wholly excluded.

### Future research

There are uncertainties and substantial gaps in our knowledge and understanding of most aspects of the Gilleylaw patch-reef and the light it throws on the late Permian sedimentary and stratigraphical evolution of the area. Aspects in particular need of detailed research are listed below.

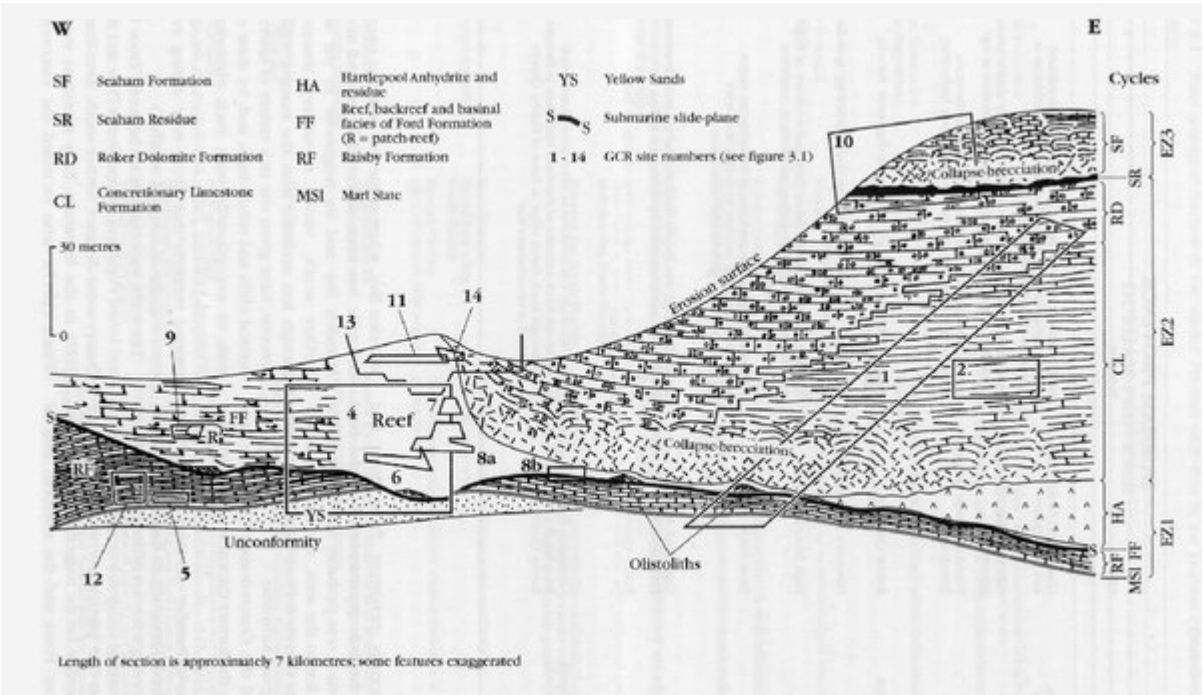
1. The lithology and diagenetic history of the three main rock units exposed in Gilleylaw Plantation Quarry and also in the car park of 'The Cavalier' public house.
2. The stratigraphical position of the Gilleylaw reef and its relationship (if any) to the main shelf edge reef and the significance of the presumed erosion surface. If it can be proved that the reef is both well above the base of the Ford Formation and roughly synchronous with the basal coquina and lower core of the main shelf-edge reef, present interpretations of the local late Permian stratigraphy will need to be reconsidered.
3. The nature and origin of the apparently contemporaneous minor mounds in beds underlying the reef.

## Conclusions

The massive and rubbly dolomite of this small historic quarry contains an abundant and varied marine fauna, and much evidence of the former presence of marine algae. The massive rock is interpreted as a patch-reef and the rubbly dolomite is thought to be talus at the margin of the reef. The reef overlies a minor erosion surface of unknown significance and is surrounded by shallow-water lagoonal oolites which contain many other small patch-reefs in the Silksworth area. The upper surface of the reef is also an erosion surface, and is overlain by a thin deposit of marine pisoliths.

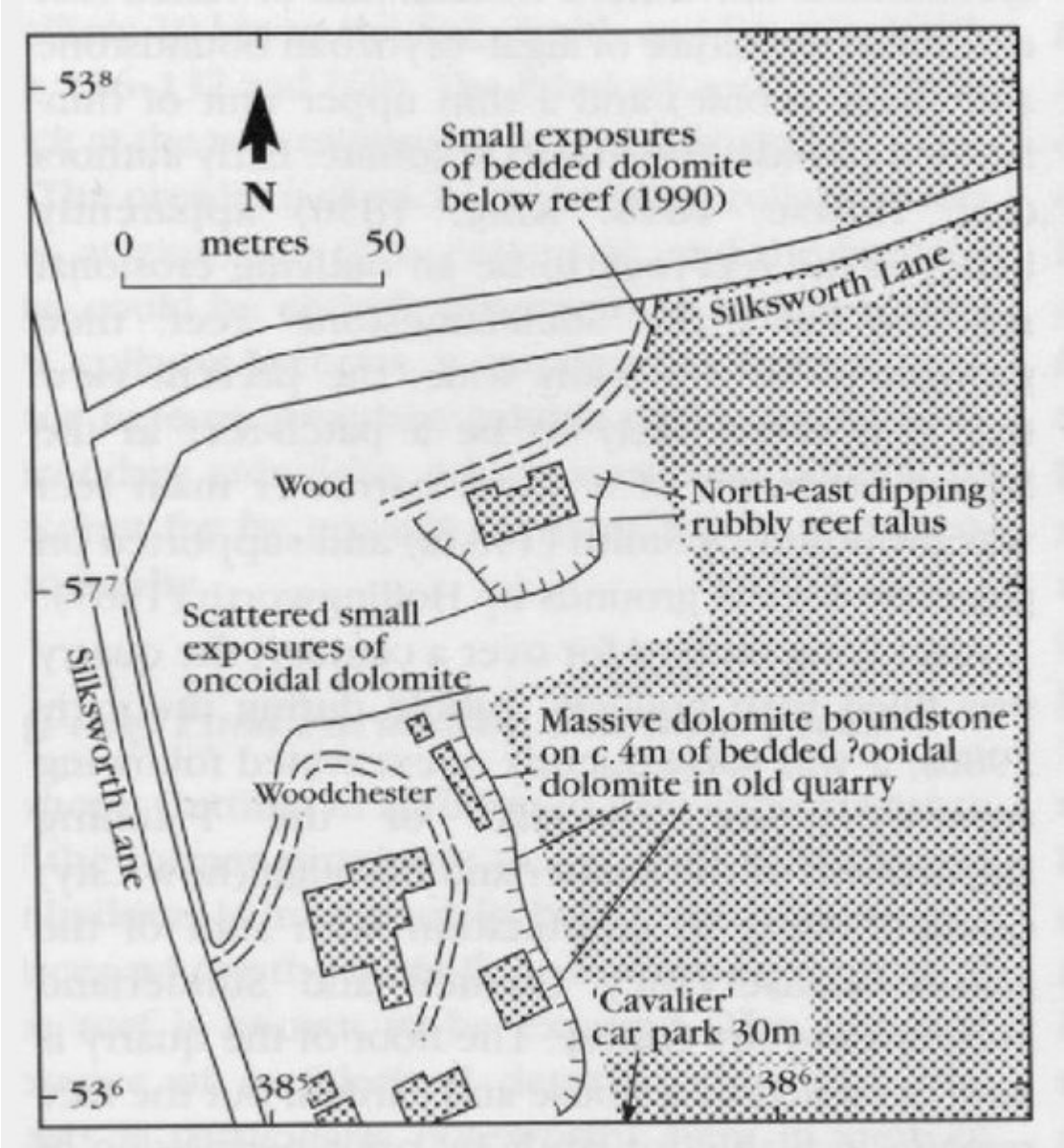
The detailed sedimentation and stratigraphical position of the patch-reefs are still relatively unknown, and further research is needed, as outlined above. The preservation of Gilleylaw Plantation Quarry is essential both to achieve this aim and to safeguard an example of a patch-reef formed in the late Permian backreef lagoon.

**References**

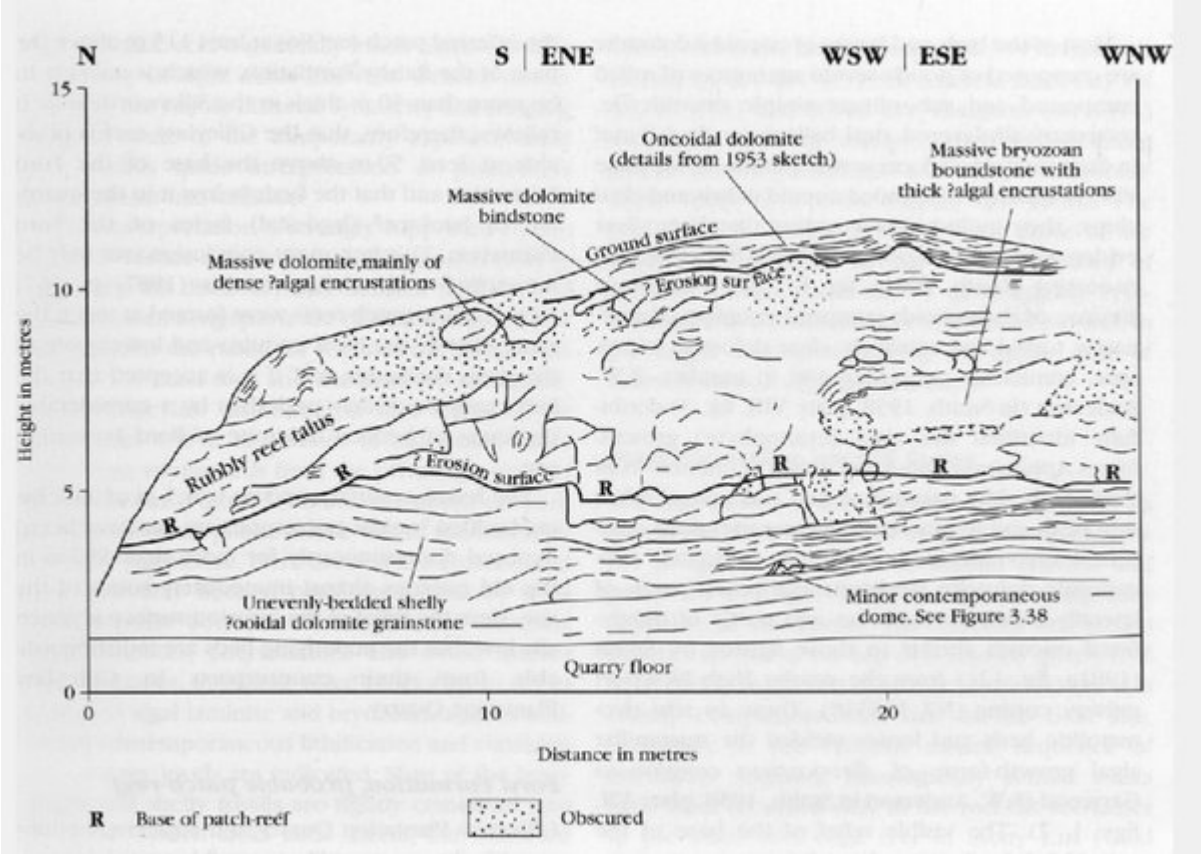



*(Figure 3.2) Approximate stratigraphical position of GCR marine Permian sites in the northern part of the Durham Province of north-east England (diagrammatic). Some sites in the southern part of the Durham Province cannot be*

*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 3.36) Gilleylaw Plantation Quarry and its immediate surroundings, showing the position of the main features of geological interest.*




*(Figure 3.37) Sketch of patch-reef in the east and south faces of Gilleylaw Plantation Quarry, incorporating some details of strata formerly exposed, but not now visible.*

*(Figure 3.38) Contemporaneous minor mound-like structure in backreef dolomite of the Ford Formation in the south face of Gilleylaw Plantation Quarry. Bar: 0.32 m. (Photo: D.B. Smith.)*