Gristhorpe Bay, Yons Nab and Red Cliff-Cunstone Nab, North Yorkshire

[TA 079 841]–[TA 093 835], [TA 085 842], [TA 076 840]–[TA 100 830]

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Introduction

The GCR sites on the North Yorkshire coast known as 'Gristhorpe Bay', 'Yons Nab' and 'Red Cliff-Cunstone Nab', which are assigned respectively to the Aalenian–Bajocian, Bathonian and Callovian GCR blocks, overlap in their geographical extent and stratigraphy, and are therefore considered together (Figure 5.7). The sites comprise cliff and foreshore exposures, now included in the Gristhorpe Bay and Red Cliff Site of Special Scientific Interest (SSSI), which have been known since the early days of geological investigation (Phillips, 1829; Leckenby, 1859; Wright, 1860; Hudleston, 1876; Fox-Strangways, 1892, 1904). Together they display the greater part of a classic Cleveland Basin Middle Jurassic succession comprising the Cloughton, Scarborough, Scalby, Cornbrash, Cayton Clay and Osgodby formations. Localities contained within these sites give their names to the Lebberston and Gristhorpe members of the Cloughton Formation, the Yons Nab Beds, which form the basal part of the latter member, the Cayton Clay Formation and the Redcliff Rock Member of the Osgodby Formation. The sites show a range of features of stratigraphical and sedimentological importance, and include the best Callovian–Oxfordian stage boundary sequence in the Cleveland Basin.

Description

The following notes are based mainly on Rawson and Wright (1992, 1995), Whyte and Romano (1994), Wright (1968, 1977) and Page (1988).

The oldest beds are exposed at, and immediately north of, Yons Nab where, at very low tides, sandstone of the lower part of the Cloughton Formation (Sycarham Member) can be seen at the seaward end of the rock platform beneath the massive rampart and natural breakwater formed by the Millepore Bed (Lebberston Member). The Millepore Bed and overlying Yons Nab Beds (Gristhorpe Member) run straight across the rock platform (Red Cliff Rocks and Horse Shoe Rocks) to meet the Red Cliff Fault as it runs out northwards into the sea (see Bate, 1959, pl. 3). In the cliff, this fault runs down a small gully at the eastern end of Red Cliff ((Figure 5.8) and (Figure 5.9)). The Millepore Bed consists of *c.* 7 m of cross-bedded calcareous sandstone (seen only at very low tides) overlain by *c.* 2 m of ooidal limestone with cross-bedding detectable beneath the barnacle-encrusted surface. Fragments of the bryozoan from which the bed takes its name are not common here (Figure 5.10). The Yons Nab Beds consist of *c.* 5 m of flaggy alternations of shale and siltstone–sandstone with numerous small, sideritic concretions and poorly preserved fossil bivalves; the lower parts are entirely shale with occasional ironstone bands and concretions. The ferrugi nous upper surface of the Yons Nab Beds shows internal moulds of bivalves including *Pholadomya, Pteroperna* and *Trigonia,* some in life position, together with some large vertical U-shaped burrows. Iron-rich concretions containing poorly preserved bivalves occur near the base of the overlying 4.5 m of tough sandstone; the middle part of this unit is strongly bioturbated and the upper part irregularly bioturbated. The succeeding Gristhorpe Plant Bed comprises thinly laminated, friable clays that have yielded a well-preserved fossil flora of stems and leaves of Bennetitales, Ginkgoales, conifers, ferns, Pteridophytes and Caytoniales (Figure 5.11). When first recorded by Wright (1860), the thickness of this bed was given as 2 ft (0.6 m); it probably ranges up to 1 m but Rawson and Wright's (1992, 1995) figure of 2.5 m seems excessive unless they were including in it some part of the overlying *c.* 5 m of largely rootletted beds that form the upper part of the Gristhorpe Member in the lower part of Low Red Cliff and the cliff at Yons Nab. These cliffs expose a strike section through the Gristhorpe Member that shows small channels and other lateral changes. Near the tip of Yons Nab, a NE–SW-trending channel cuts down from the Gristhorpe Member into the underlying Yons Nab Beds. The complex channel-fill sandstones are well displayed on the shore in front of Yons Nab. At the base of the cliff on the east side of Yons Nab, a sandstone with ironstone concretions and plant fragments contains occasional poorly preserved specimens of the freshwater bivalve *Unio.*

The overlying Scarborough Formation, which is seen in the cliff at Yons Nab, comprises 1.3 m of delicately laminated siltstone with well-displayed ripple-drift bedding and scour-and-fill structures of the Helwath Beck Member, overlain by *c.* 2 m of soft, argillaceous, Shelly limestone or shale with a layer of concretionary ironstone near the top, and crushed shells including the bivalves *Lopha, Meleagrinella* and *Trigonia,* gastropods and belemnites. These upper beds of the Scarborough Formation belong to the White Nab Ironstone Member.

Lenticular white sandstones and grey silt-stones at the base of the overlying Scalby Formation are exposed at the western end of Low Red Cliff. These may contain abundant, fine or coarse, coalified plant-debris. Pyritization and subsequent weathering of some of the plant material has given the cliff face a bright yellow sulphurous coating. In places, the basal beds of the Scalby Formation cut down into the Scarborough Formation, the top of which is disturbed. The east side of Yons Nab is well known for the large channel within the Scalby Formation that cuts down into the top of the Scarborough Formation; its base is marked by a conglomerate of pyrite nodules. This channel, first described in detail and illustrated by Black (1928), is itself cut through by a smaller channel, the base of which is marked by a bed of shale-conglomerate. The Scalby Formation can be followed into Gristhorpe Bay where it is nearly 40 m thick. The gentle landward dip of the strata is such that, in the cliffs at the centre of the bay, a succession from the Scalby Formation through the overlying Cornbrash, Cayton Clay and Osgodby formations, and into the Oxford Clay Formation can be seen (Figure 5.12). The Callovian formations and Oxford Clay Formation are also well exposed in Red Cliff at the southern end of Cayton Bay (Figure 5.13). Between there and Cunstone Nab, considerable lateral variation occurs within the Callovian formations, including the complete disappearance of some components. In consequence, no single location shows a complete succession. The following notes therefore provide a composite summary of the Callovian successions along this stretch of coast.

The Cornbrash Formation is divided into four units, the basal one of which (α_1) is present at all locations and rests, typically with burrowed contact, on mudstones of the Scalby Formation. It comprises 0.14–0.37 m of greenish-grey, red-weathering, berthierine and sideritic limestone, which becomes softer and more muddy towards Cunstone Nab. Its fauna is dominated by bivalves, including *Entolium* (particularly common), *Liostrea, Lopha marshii* (J. Sowerby) and *Pleuromya.* Rare ammonites include *Macrocephalites* ex gr. *terebratus* (Phillips). Unit α_2 is *c.* 0.15 m of pale-grey, shelly, variably ooidal limestone (micrite at Cunstone Nab). Its bivalve fauna is again dominated by *Entolium, Lopha marshii* and *Pleuromya* but also includes *Meleagrinella* and *Trigonia;* the gastropods '*Littorina*',*Pseudomelania* and '*Trothus*',and the ammonite *Macrocephalites terebratus* transient β (Callomon and Page in Callomon *et al.,* 1989) are also recorded. Unit α_3 is absent below Red Cliff but well developed in Gristhorpe Bay as a hard, sandy limestone up to 0.18 m thick and with an erosive base. It has yielded bivalves (including *Chlamys, Entolium, Liostrea* and *Trigonia*) and rare *Macrocephalites kamptus* transient αof Callomon and Page in Callomon *et al.,* 1989). The youngest unit of the Cornbrash Formation (α_4) is a thin silty or sandy shale that forms a lithological transition to the overlying Cayton Clay Formation. It has yielded the bivalves *Entolium* and *Meleagrinella* cf. *braamburiensis* (Phillips) and, locally in Gristhorpe Bay, the brachiopod *Microthyridina lagenalis* Douglas and Arkell *non* Schlotheim.

The base of the overlying Cayton Clay Formation is seen best in cliff exposures at Cunstone Nab. The formation comprises dark-grey shale or silty clay with one or more diffuse bands of small pale-greyish, phosphatic nodules. It yields a low-diversity fauna including *Meleagrinella* aff. *braamburiensis, Modiolus bipartitus* (J. Sowerby) and *Nuculana* sp.. This fauna is preserved uncrushed in the phosphatic nodules, which also commonly yield fragmentary small crustaceans. Occasional ammonites, crushed in the clay or with partly phosphatized body chambers, include *Macrocephalites polyptychus* (Spath). The shales typically become sandy in their uppermost part and grade into the basal Osgodby Formation (Redcliff Rock Member) above.

The Osgodby Formation comprises three members, all of which are well developed in Red Cliff and Gristhorpe Bay. The Redcliff Rock Member, at the base, is well developed in Red Cliff [TA 074 841]–[TA 078 841], which is its type section. The basal part (β_1 of Wright, 1968), passing up from the Cayton Clay Formation below, is pale-yellowish sandstone up to 6.85 m thick with hard calcareous concretions, up to 0.60 m across. The fauna is sparse, except in some concretions, and is dominated by small, often fragmentary, bivalves (including *Meleagrinella*)*. Kepplerites* (*Gowericeras*) has been recorded from the top of the unit. In contrast, Unit β_2 (up to 2.35 m thick) is dominated by rusty-weathering, orange to brownish, berthierine ooidal sandstone, the ooids often pale-green in colour. The fauna of β_2 is much richer and more varied than β_1 with many bivalves (including *Entolium, Liostrea* and *Modiolus*) and ammonites including *Cadoceras cf.*

tolype Spath, *Kepplerites* (*Gowericeras*) *indigestus* (S.S. Buckman), *Proplanulites ferruginosus* S.S. Buckman, and rarer *Chamoussetia boreale* (S.S. Buckman). The overlying β_3 (up to 1.98 m thick) is a fossiliferous non-ooidal or very sparsely ooidal sandstone with a similar fauna to the lower units but with a more varied bivalve fauna (including *Chlamys, Oxytonza* and *Trautscholdia*), ammonites (*Kepplerites* (*Gowericeras*) and *Proplanulites*) and occasional ?cylindroteuthid belemnites.

A younger unit (β_4), comprising pale-weathering berthierine ooidal sandstone up to 0.55 m thick, is impersistently developed in Red Cliff; it includes shelly concretions full of small bivalves (such as '*Astarte*'and *Entolium*) and rare ammonites (*?Proplanulites*). The youngest unit (β_5) recognized elsewhere may also be present as a soft sandstone, up to 0.65 m thick. Eastwards into Gristhorpe Bay, units β_2–β_5 are rapidly cut out by erosion at the base of the Langdale Member and, before Cunstone Nab is reached, the Redcliff Rock Member is completely removed and the Langdale Member rests directly on an erosively thinned Cayton Clay Formation (Figure 5.14). At Cunstone Nab, the Langdale Member comprises 2.35 m of fine to medium sandstone (γ_1 of Wright, 1968) with clay wisp bedding and small-scale ripple-lamination and scattered belemnites. At *c.* 0.65 m above the base, the ammonites *Erymnoceras* (*Erymnoceratites*) cf. *argoviense* Jeannet and *Kosmoceras* (*Zugokosmokeras*) *grossouvrei Douvillé* are common but poorly preserved. Westwards, the member thins rapidly and is absent at Red Cliff.

The overlying Hackness Rock Member is most thickly developed at Red Cliff where it is dominated by hard, greenish-grey, flaggy, berthierine oolite, which is often heavily oxidized. Bivalves (including *Gryphaea* and *Oxytoma*) are present but age-diagnostic ammonites (*Kosmoceras* and *Quenstedtoceras*) occur relatively rarely; the ammonite *Reineckeia* (*Collotia*) sp. has also been recorded (Rawson and Wright, 1992). Eastwards into Gristhorpe Bay, a tough berthierine ooidal limestone with *Quenstedtoceras* is developed; *Longaeviceras* may also be present (Callomon and Wright, 1989). However, at Cunstone Nab, parts of this succession have been cut out; 0.15 m of calcareous, slightly ooidal sandy siltstone (Bed 4 of Wright, 1968) with *Quenstedtoceras* ex gr. *lamberti* (J. Sowerby), *Peltoceras* (*Peltomorphites*) *subtense* (Bean), *Euaspidoceras hirsutum* (Bayle), *Poculisphinctes poculum* (Leckenby), *Alligaticeras alhgatum* (Leckenby) and *Kosmoceras* (*K.*) sp. is overlain by 0.15 m of grey sandy clay (Bed 5 of Wright, 1968) with scattered berth-ierine ooids. The latter unit is best included in the basal Oxford Clay Formation. It yields a crushed, less diverse fauna than the beds below but includes abundant *Quenstedtoceras paucicostatum* (Lange) with *Peltoceras* (*Peltomorphites*) sp.. The overlying 0.15 m of silty clay with berthierine oolite nodules yields *Cardioceras* ex gr. *scarburgense* (Young and Bird) and *Peltoceras* (*Peltomorphites*). At both Red Cliff and Gristhorpe Bay, the Oxford Clay Formation extends for many metres high up in the cliffs.

Interpretation

According to Livera and Leeder (1981), the sandstones of the Sycarham Member seen at Yons Nab represent a large fluvial, channel-sand body that cross-cuts earlier overbank deposits containing thick roots. In the overlying Millepore Bed, cross-stratification has well-preserved bi-polar palaeocurrent directions but the palaeo-currents show no relationship to those demonstrated by wave-ripple sets that are often preserved with ironstone drapes. In the eastern part of the exposure at Yons Nab, there is a strong erosion surface suggesting shallow channel formation. This shallow marine coastal unit is now the sole representative of the Lebberston Member because, following a suggestion of R.W.O'B Knox (in Rawson and Wright, 1995), the Yons Nab Beds, which were previously included therein but which in places are scarcely marine, are now considered to be the basal unit of the overlying Gristhorpe Member. According to Livera and Leeder (1981), the Yons Nab Beds were probably deposited in deeper, quieter water conditions than the Millepore Bed, with little carbonate input, coarsening-upwards on shallowing, allowing complete reworking of the sediment by highly active infauna. Precise environmental analysis is difficult owing to the destruction of all primary sedimentary structures but the latter authors suggested that the sequence probably represents delta-front sedimentation with bioturbated shoreface sandstones. Above the Yons Nab Beds, the remaining Gristhorpe Member records a gradual return to freshwater facies. No body fossils are found in these beds possibly owing to the very early solution of calcareous material, which is commonly associated with brackish-water environments (Livera and Leeder, 1981). Near the base, an upper deltaic plain channel sandstone body, with well-developed lateral accretion sets, cuts down into the Yons Nab Beds. The dark shales, which are rich in organic matter, make up the Gristhorpe Plant Bed formed after channel abandonment. The Gristhorpe Plant Bed is probably the most famous of all of the plant beds that occur in the Middle

Jurassic succession of the Cleveland Basin; its fossil flora shows exceptional diversity and preservation (Williamson, 1841; Leckenby, 1864; Black, 1929; Harris, 1942–1953, 1953, 1961–1979). Although the bed includes some water-worn material, there are also larger delicate leaves that cannot have been carried far from their place of growth. The frequent occurrence of leaves with their reproductive organs also suggests that the plant material has been fossilized, probably in sluggish or stagnant river-channels of a fluvio-deltaic environment, close to where the plants grew. Cayton Bay gives its name to the '*Caytonia* plant', which consists of the leaf *Sagenopteris* (Figure 5.11), the mega-sporophyll (seed) *Caytonia,* the microsphero-phyll *Caytonanthus* and the stem. It is remarkable for its state of preservation and the amount of detail in which it is known. The Caytoniales do not compare closely with any living primitive flowering plants (angiosperms) although they must be very close to this group. Another famous plant reconstruction is the *Wilssonia* plant' comprising the leaves *Nilssonia,* the female cone *Beania,* the male cone *Androstrobus* and the scale leaf *Deltolepis* (Figure 5.11). The plant has been reconstructed, with a hypothetical stem, as a small tree with spreading branches and leaves borne in clusters at the end of short shoots; it probably grew very near the edge of the delta or alluvial plain. The succession above the Plant Bed includes a number of sheet sandstones formed by crevasse splays in an overbank environment (Livera and Leeder, 1981). The sandstones show loaded bases, internal convolute-lamination and were colonized by plants leaving thick root-systems.

The basal unit of the Scarborough Formation is thought to have been deposited in shallow subtidal conditions (Livera and Leeder, 1981); it shows wedge, trough and hummocky cross-stratification without bioturbation. The formation is very attenuated compared with its development in the centre of Cayton Bay where most of the seven members of the type section (see Iron Scar–Hundale and Hundale Point–Scalby Ness GCR site report, this volume) can be identified. This is due to the fact that Yons Nab and Gristhorpe Bay were sited on the eastern flank of the Peak Trough (Milsom and Rawson, 1989), east of the Red Cliff Fault, where subsidence was much less and where less sediment therefore accumulated. The Scalby Formation, Cornbrash Formation and Hackness Rock Member also show this trend (Rawson and Wright, 1992).

There has been considerable speculation about the depositional environment (coastal alluvial-plain or delta) of the Scalby Formation, which probably represents a long period of very interrupted sedimentation spanning much of the Late Bajocian and Bathonian ages (e.g. Leeder and Nami, 1979; Hancock and Fisher, 1981; Fisher and Hancock, 1985; Alexander, 1989 and references therein). The basal Moor Grit Member, deemed by Livera and Leeder (1981) to be absent at Yons Nab but recognized there by Rawson and Wright (1992, 1995), is thought to have been deposited as an alluvial channel-system over a newly emergent subaerial surface of the Scarborough Formation; the overlying beds of the Scalby Formation are interpreted as predominantly floodplain deposits of the lower coastal plain.

The lowest unit (α_1) of the overlying Cornbrash Formation is widespread, and represents the deposits of a major marine transgression that established quiet marine conditions in the centre and east of the Cleveland Basin. The sediments accumulated in a shallow iron-rich environment with berthierine oolite shoals in the east separated from turbulent areas with bioclastic sediment in the west (Wright, 1977). The quiet conditions of α_1 favoured a predominantly burrowing fauna including the bivalves '*Astarte*', *Goniomya, Pleuromya, Pseudolimea* and *Trigonia.* Epifaunal, byssally attached forms are virtually absent and infaunal bysally attached forms are rare. Surface faunas were dominated by oysters such as *Liostrea* and *Lopha* although the pectinid *Entolium* is abundant and presumably lived attached to some of the surface dwellers. A short phase of erosion was succeeded by quiet conditions during which α_2 was locally deposited and a rich benthic fauna developed. The lack of terrigenous sediment allowed more surface faunas to exist than before, including gastropods; the bivalve fauna includes *Lopha* and *Nanogyra* as well as infaunal trigoniids and *Pleuromya.* A further shorter erosive phase was followed by the establishment of more turbulent open-water conditions in which the dominantly bioclastic limestone of α_3 was deposited (Wright, 1977). Surface and semi-infaunal faunas now proliferated; *Liostrea, Lopha* and serpulids are very abundant and byssally attached forms (*Chlamys, Gervillella, Modiolus, Oxytoma*) are quite common although vagile gastropods are rare. As a response to the more unstable conditions, burrowing forms are usually dominated by thick-shelled *Trigonia* and '*Astarte*' (Wright 1977). α_4 represents a sandy, clayey depositional episode transitional to the Cayton Clay Formation, the base of which is marked by an influx of clay that completely changed the environment. The faunas became dominated by forms adapted to living attached to marine algae or other objects in order to avoid the less favourable seabed conditions. The formation appears to represent a period of relative quiescence over much of England with dark-shale deposition and some phosphate nodule formation.

A major influx of coarse clastic material marks the beginning of Osgodby Formation sedimentation. Wright (1978) interpretated the facies belts and faunal changes he observed regionally in the Redcliff Rock Member as representing a transition from mudflats (possibly brackish-water) and very shallow water (?intertidal sand flats) to more turbulent conditions with sand bars. A reduction in sediment supply and the probable establishment of coastal lagoons in the area led to the development of berthierine ooids (the iron coming from 'tropical' rivers of the northwest and north-east). The benthic fauna of the berthierine ooid-rich sandstones and siltstones is often limited to surface-living oysters, and burrowers are more common where the iron content is less (suggesting to Wright (1968) an ecological effect); younger berthierine-free sands contain richer faunas of surface and burrowing forms thereby supporting this idea.

After a period of uplift, flexuring and erosion later in Early Callovian and early Mid Callovian times (Calloviense and Jason zones), a sheet of Langdale Member sand and silt (γ_1) spread across much of the area, unconformably overlying the Redcliff Rock Member succession and locally over-stepping its component units (as seen particularly well between Red Cliff and Cunstone Nab) (Figure 5.14). Wright (1978) interpreted the sands of γ_1 as beach sands, and the establishment of shallow open-water encouraged the settling of *Gryphaea* larvae. A further phase of uplift and erosion reinstated Redcliff Rock Member β_2-like conditions, favouring berthierine oolite formation and deposition. As in the earlier deposits, the benthic fauna of the Hackness Rock is generally impoverished although *Gryphaea* is often present. Ammonites, however, are locally relatively common, suggesting the likelihood of drifting from more open water and settling under the relatively quiet seabed conditions. The shortage of sediment in eastern areas consequently led to the formation of thin beds of berthierine oolite, locally rich in pelagic fossils. A major transgressive episode at the beginning of the Oxfordian Stage brought considerable amounts of mud (Oxford Clay Formation) into the region and berthierine oolite sedimentation of the Osgodby Formation was brought to an end.

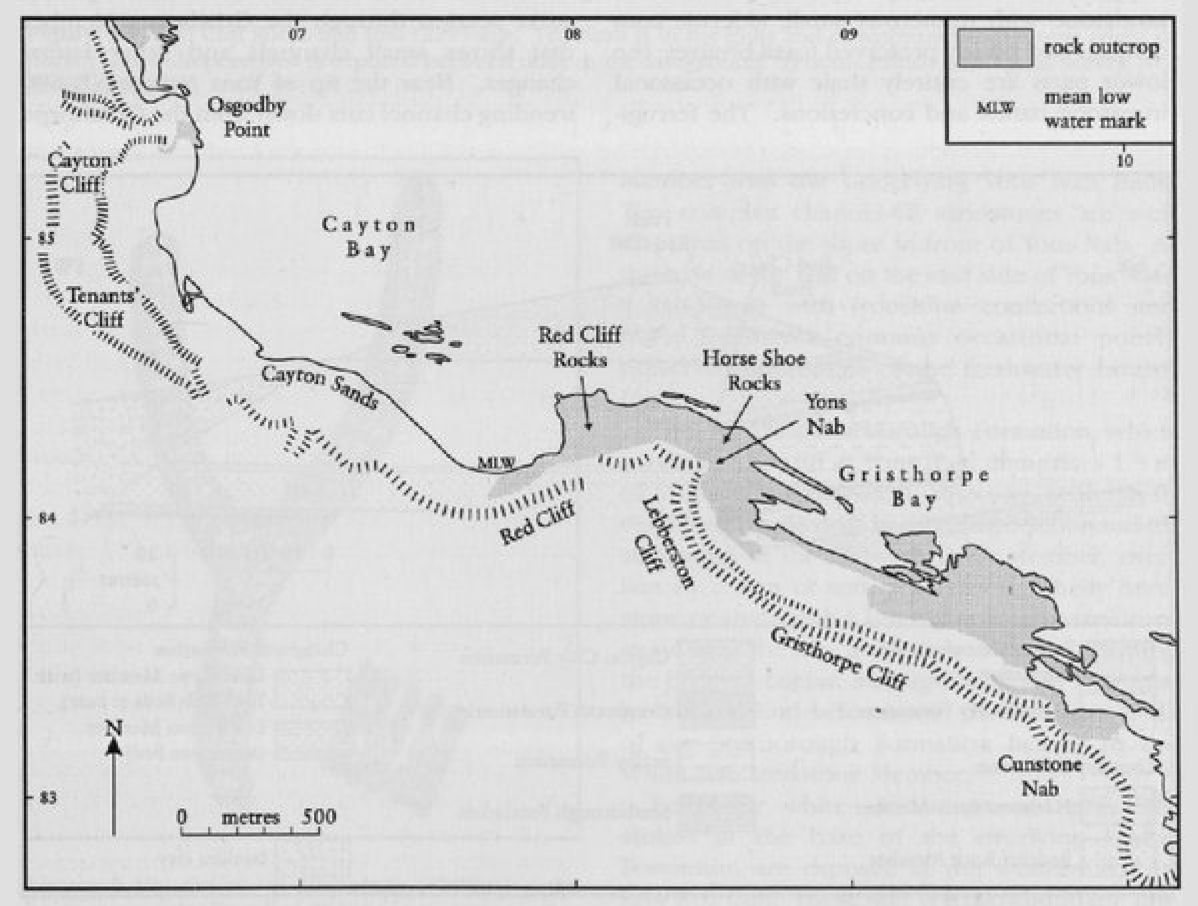
Much of the dating of the succession remains imprecise, but specimens of the ammonite *Teloceras* in the Scarborough Formation at Gristhorpe Bay and Low Red Cliff, including those recorded by Farrow (1966), indicate the (Lower Bajocian) Humphriesianum Zone and Subzone (Parsons, 1977b). Apart from this, only the ammonitiferous Callovian strata can be satisfactorily assigned to chronostratigraphical units. Large, early forms of *Macrocephalites* ex gr. *terebratus* in α_1 of the Cornbrash Formation are suggestive of the *terebratus* α Biohorizon of Callomon and Page in Callomon *et al.* (1989), which was taken by Page (1989) to define the base of the Terebratus Subzone (Lower Callovian, Herveyi Zone). Historically, the overlying α_2 yielded the richest faunas of the Yorkshire Cornbrash Formation, apparently mainly from reefs in Cayton Bay below Red Cliff. The *Macrocephalites terebratus* transient β in that unit indicates the *terebratus* β Biohorizon (Terebratus Subzone), and the *Macrocephalites* in α_3 indicate the *kamptus* αBiohorizon of the early Kamptus Subzone (Herveyi Zone). Callomon *et al.* (1989) defined the base of the latter subzone at this level but Page (1989) subsequently considered that the section at Thrapston (see GCR site report, this volume) to be more appropriate. The brachiopod *Microthyridina lagenalis,* which occurs in abundance in α_4 at Gristhorpe Bay is a stratigraphically important form also indicative of the *kamptus* α Biohorizon. *Macrocephalites polyptychus,* which occurs in the Cayton Clay Formation, is the index species of the *polyptychus* Biohorizon in the upper part of the Kamptus Subzone. The ammonite faunas of these levels are dominated by Tethyan Macrocephalitinae but at higher levels the ammonite fauna is entirely Boreal with Arctic Province cardioceratids (*Cadoceras* and *Chamoussetia*) together with *Kepplerites* and the Subboreal Province indicator *Proplanulites. Kepplerites* (*Gowericeras*) from the upper part of β_1 of the Redcliff Rock Member indicates the Koenigi Zone but the lower 6 m+ of that unit has yielded no age-diagnostic fauna Q.K. Wright, pers. comm., 1996). The ammonite assemblage of β_2 is an internationally important fauna defining the *indigestus* Biohorizon of the Curtilobus Subzone (Lower Callovian, Koenigi Zone). This fauna is better preserved at Red Cliff than elsewhere in the region and the site is the likely type locality of most of the 'Kelloway Rock' ammonite species described from North Yorkshire. The fauna can also be recognized in southern England (Wiltshire) but as no sections now remain in that area, the national and international correlative importance of the Cayton Bay section is increased. Another important correlative ammonite fauna may be present in the Redcliff Rock Member since specimens of the microconch form *Kepplerites distans* Tintant have been recovered, sometimes associated with *Chamoussetia boreale.* The former species has not been found with *K. indigestus* in the main fossiliferous levels in Red Cliff studied by Page (1988), and the preservation of the two forms are commonly distinct. However, the precise biostratigraphy of all but the main fossiliferous horizon of β_2 remains unclear and the possibility that a new correlatively important biohorizon could be established in the Redcliff Rock Member remains open.

The Langdale Member was proposed by Wright (1968) for pale non-ooidal sandstones and silts of Mid Callovian age overlying the Redcliff Rock Member. Its type locality is inland in Langdale but Cunstone Nab provides one of the best available fossiliferous sections. Ammonites there indicate the Grossouvrei Subzone of the Middle Callovian Coronatum Zone. The type locality of the Hackness Rock Member is also inland (see Hackness Quarry GCR site report, this volume) but the coastal sections between Castle Hill, Scarborough and Cunstone Nab have yielded most of the well-known fauna of that horizon, including the type specimens of many species. At Red Cliff the presence of *Quenstedtoceras* indicates the Upper Callovian Lamberti Zone (probably Lamberti Subzone), and *Kosmoceras* (*Lobokosmokeras*) cf. *proniae* Teisseyre indicates the Upper Callovian Athleta Zone (possibly Proniae Subzone). At Gristhorpe Bay, the Lamberti Zone and Subzone are also indicated by the presence of *Quenstedtoceras* and some evidence that the Athleta Zone is present is provided by records of *Kosmoceras* (*Lobokosmokeras*)*compressum* (Quenstedt) from hereabouts (Wright, 1968). Gristhorpe Bay was an important source of Lamberti Zone fossils to early collectors and the type specimens of *Poculisphinctes poculum* and various species of *Quenstedoceras* probably synonymous with *Q.* ex gr. *lamberti,* including *Q. ordinarium* (Bean) and *Q. vertumnus* (Leckenby), probably came from here. At Cunstone Nab, the Athleta Zone is entirely cut out but the succession is otherwise rich in age-diagnostic ammonites and represents the most complete Callovian–Oxfordian stage boundary sequence in the Cleveland Basin. The Lamberti Zone (Lamberti Subzone) is represented by only 0.15 m of strata (Bed 4 of Wright, 1968). The abundant *Quenstedtoceras paucicostatum* with *Peltoceras* (*Peltomorphites*) in the overlying bed (Bed 5 of Wright, 1968) indicate the terminal Callovian *paucicostatum* Biohorizon (Callomon, 1990). This biohorizon was previously considered to represent the basal Oxfordian Stage (e.g. by Marchand, 1979; Wright, 1983) but that horizon is, in fact, indicated by *Cardioceras* ex gr. *scarburgense* in the overlying Bed 6 of Wright (1968). As the best boundary section in the Scarborough district, Cunstone Nab has added international significance because the district is the historical type locality for the basal Oxfordian Scarburgense Subzone of Buckman (1913). The presence of the *paucicostatum* Biohorizon indicates that the boundary section at Cunstone Nab is more complete than that at nearby Osgodby Point (see GCR site report, this volume), which was proposed by Callomon (1990) as a candidate Global Stratotype Section and Point (GSSP) for the base of the Oxfordian Stage.

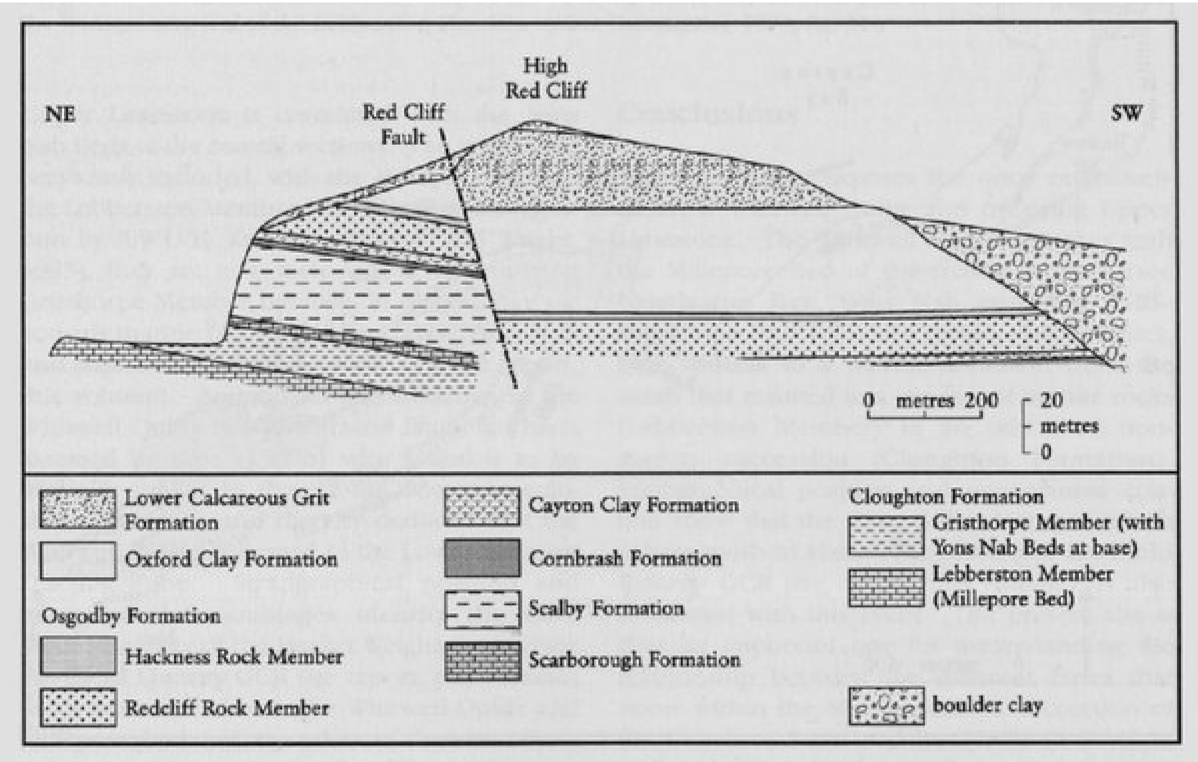
Conclusions

The cliff and foreshore exposures from the southern end of Cayton Bay (Red Cliff) to Cunstone Nab on the North Yorkshire coast display a substantial part of the Cleveland Basin Middle Jurassic succession. The non-marine (deltaic-alluvial) facies of the Ravenscar Group, and two intercalated marine units (Lebberston Member and Scarborough Formation), are exposed at Yons Nab and in the adjoining cliffs. These show a number of interesting sedimentological features including well-developed, complex, channel-fill sandstones, and the internationally famous fossil flora of the Gristhorpe Plant Bed. At Red Cliff and Gristhorpe Bay to Cunstone Nab, cliff and cliff-base exposures provide some of the most impressive and instructive Callovian sequences in Britain. The area includes type sections of the Cayton Clay Formation and the Redcliff Rock Member of the Osgodby Formation. Lower Callovian ammonite faunas of international importance for correlation and the definition of the Terebratus and Kamptus subzones of the Herveyi Zone and the *indigestus* Biohorizon of the Curtilobus Sub-zone (Koenigi Zone) are present. Type material of several fossil species comes from here. In addition, the site at Cunstone Nab includes the best-developed Callovian–Oxfordian boundary section in the Cleveland Basin. The remarkable lateral variation in terms of erosive loss of different parts of the Callovian succession, provides an important insight into the development of the Cleveland Basin as a whole in late Mid Jurassic times.

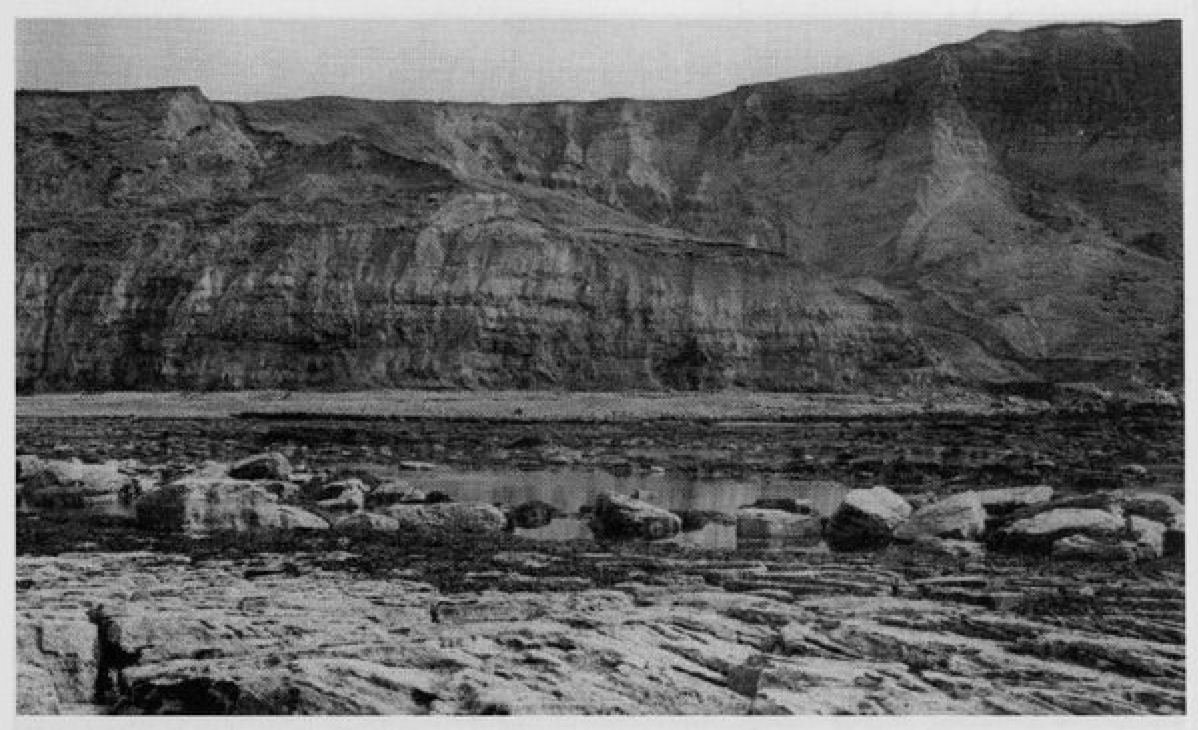
References



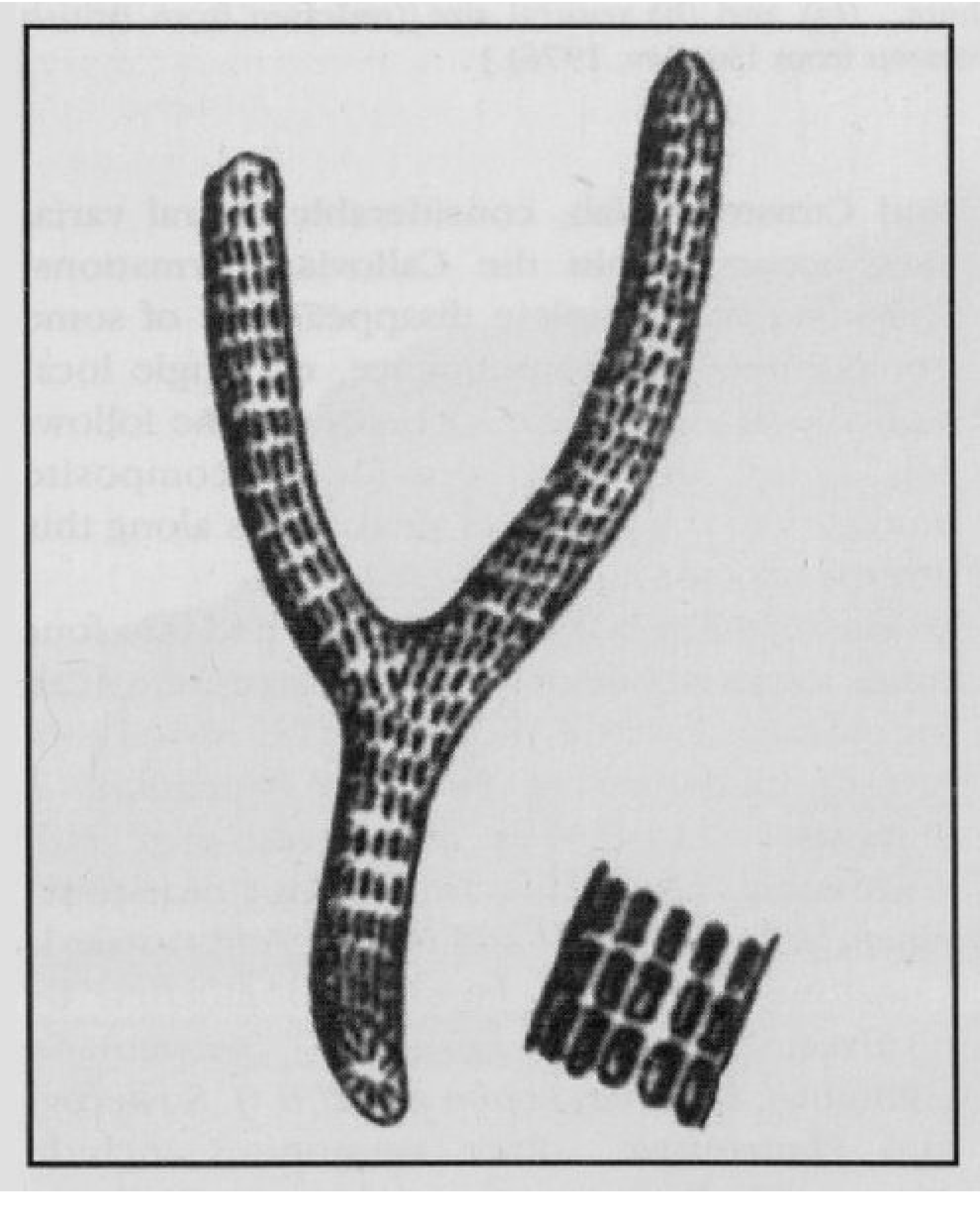
(Figure 5.7) Locality map for Gristhorpe Bay, Yons Nab and Red Cliff–Cunstone Nab.)



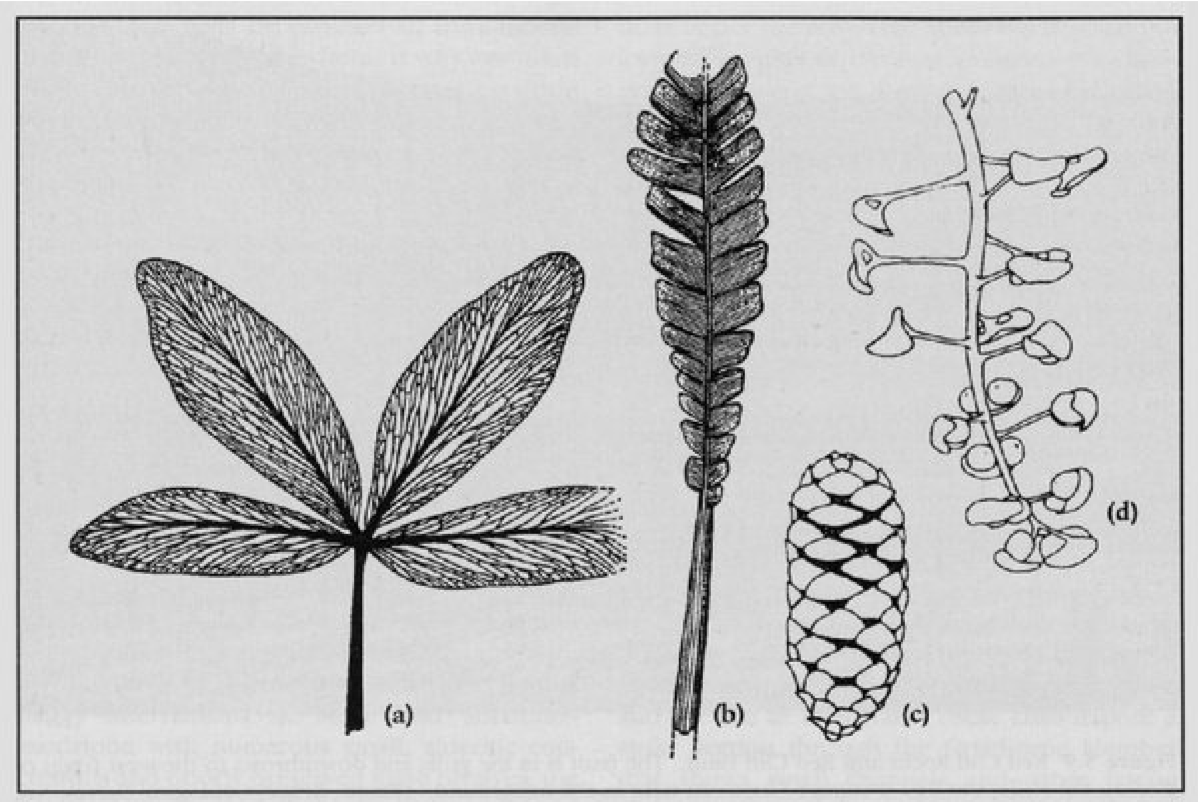
(Figure 5.8) Diagrammatic cross-section of the cliffs at the south-eastern end of Cayton Bay. (After Rawson and Wright, 1992, fig. 24.))



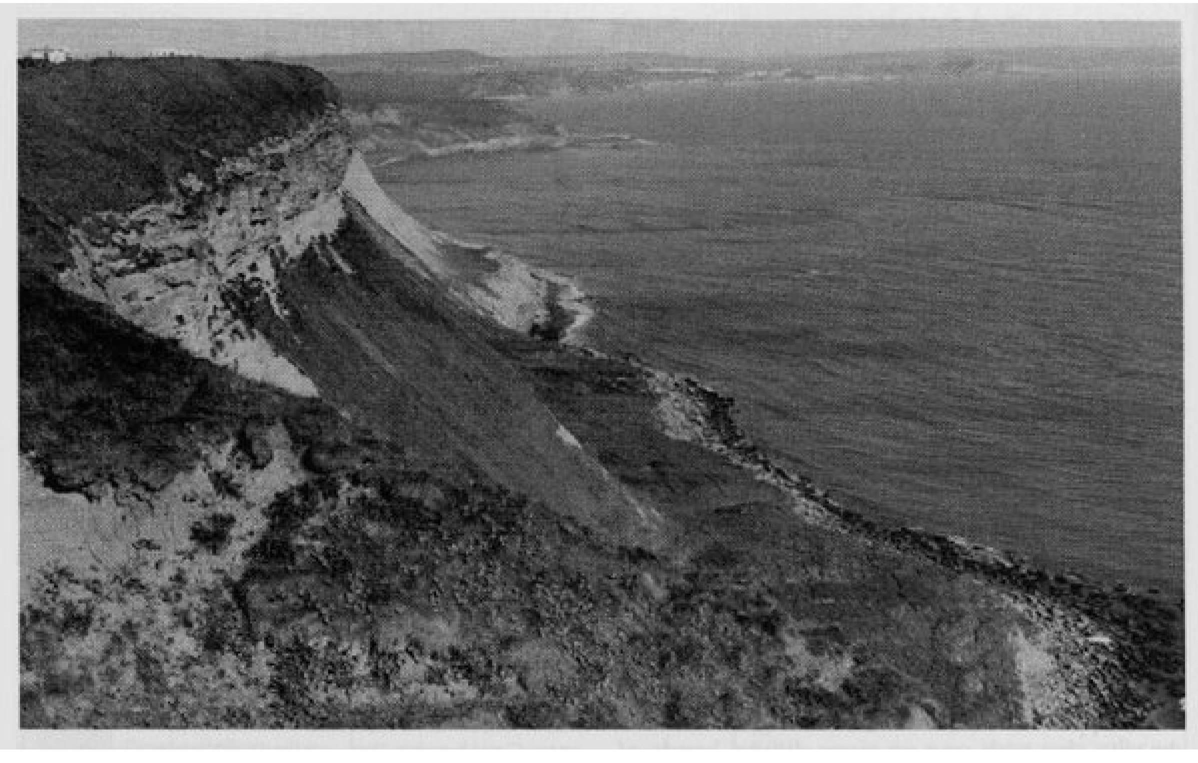
(Figure 5.9) Red Cliff Rocks and Red Cliff Fault. The fault is in the gully and downthrows to the west (right of photo); the Millepore Bed is exposed between tides in the foreground. (Photo: British Geological Survey, No. A5487, 1931.))



(Figure 5.10) Collapora straminea (Phillips) — the bryozoan, originally called Millepora straminea, that gives its name to the Millepore Bed. (Reproduced (x4) from Phillips, 1835, pl. 9, fig. 1.))

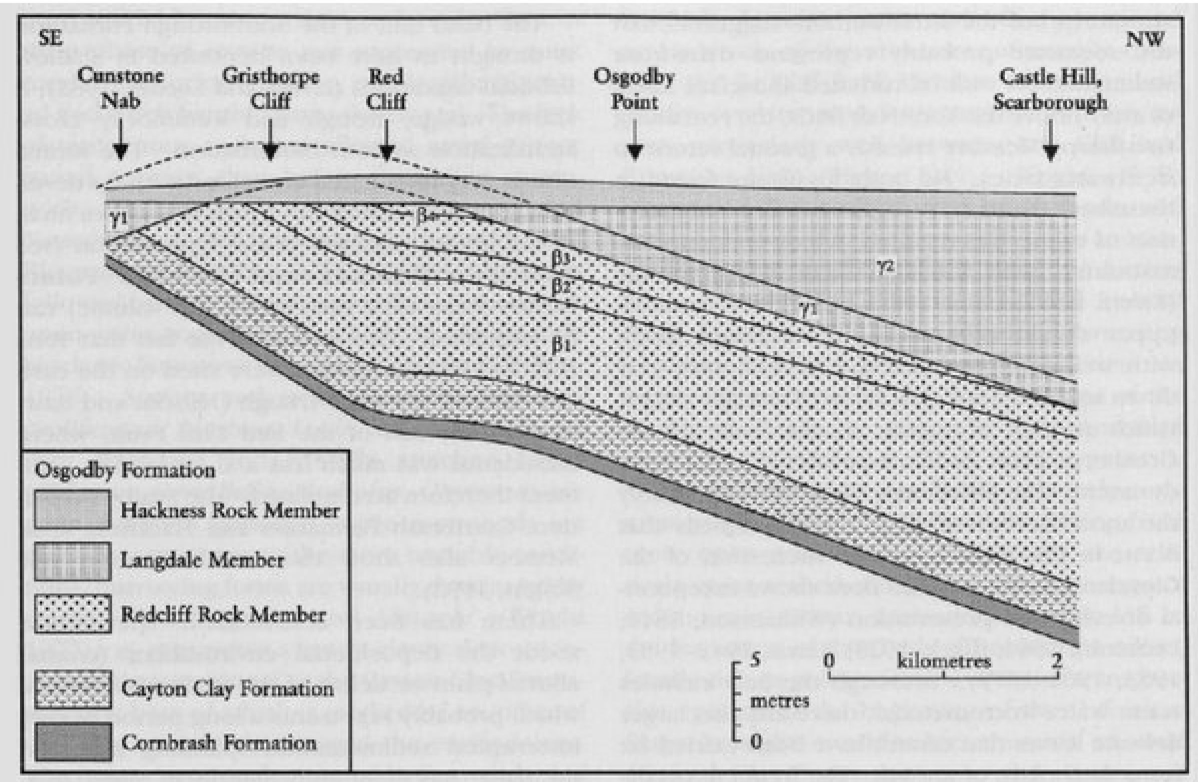


(Figure 5.11) Examples of fossil plants from the Gristhorpe Plant Bed. (a) Leaf Sagenopteris phillipsi (Brongniart); (b) leaf Nilssonia compta (Phillips); (c) restoration of male cone Androstrobus manis Harris; (d) restoration of female cone Beania gracilis Carruthers. ((a) and (b) natural size (redrawn from British Museum (Natural History), 1975), (c) and (d) x 0.5 (redrawn from Hughes, 1976).))



(Figure 5.12) Gristhorpe Bay. In the middle distance is the headland Yons Nab and in the far distance Scarborough. (Photo: British Geological Survey, No. L1342; reproduced with the permission of the Director; British Geological Survey, © NERC, 1974.))

(Figure 5.13) High Red Cliff, Cayton Bay. (Photo: British Geological Survey, No. A5488, 1931.))



(Figure 5.14) Diagrammatic cross-section of the Callovian succession on the coast south of Scarborough. (After Wright, 1968, fig. 3.))