Whitby to Saltwick, North Yorkshire

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Introduction

The town of Whitby is one of the best-known Lower Jurassic sites in Britain, and the Whitby to Saltwick coast section is of international importance for its classic Lower Toarcian exposures, unconformably overlain by the Middle Jurassic Dogger Formation. The location gives its name to the Whitby Mudstone Formation, with part of its type section, and the type section of the Alum Shale Member, falling within the boundaries of this site (Powell, 1984). The term 'Whitbian' was also coined by Buckman (1910) for the lower part of the Toarcian Stage. It was re-defined by Dean *et al.* (1961) as the Whitbian Substage, encompassing only the Lower Toarcian Tenuicostatum to Bifrons zones. Although the term is seldom now used, the section is the type locality for this substage. In addition, there are superb, and readily accessible, exposures of the Alum Shale Member and underlying Mulgrave Shale Member, which have yielded a rich fauna of vertebrates and invertebrates, including the type fossils of many species. On the basis of its ammonite faunas the site includes stratotypes, or at least parastratotypes for several zones and subzones.

The coastal exposures of the Whitby Mudstone Formation (Toarcian) here have featured extensively in geological descriptions of the Yorkshire coast, including Young and Bird (1822, 1828), Phillips (1829, 1835, 1875), Simpson (1868, 1884), Tate and Blake (1876), Fox-Strangways (1892) and Herries (1906a,b), and Howarth (1962a). This last provides the best description of the succession at this site. The vertebrate palaeontology of the Whitby to Saltwick GCR site is included in the *Fossil Reptiles of Great Britain* (Benton and Spencer, 1995) and *Fossil Fishes of Great Britain* (Dineley and Metcalf, 1999) GCR volumes. Excursion details for the site are included in Rawson and Wright (1992) and Scrutton (1996). The Toarcian of the Whitby district has long been an important source of fossils, including many type specimens. However, published accounts and museum labels are often vague about the original source locality. In many instances 'Whitby' is just as likely to include specimens from Ravenscar or Port Mulgrave as from close to the town itself; and only taxa confined to strata above the Alum Shale Member or below the Mulgrave Shale Member can definitely be eliminated from any list of 'Whitby' fossils. Skeletons of large marine reptiles were among the first fossils to be described from here and, in contrast to so many other fossils, were sometimes associated with quite precise location details (Chapman, 1758; Wooller, 1758; Benton and Spencer, 1995). The ammonite faunas are particularly well-known, although old descriptions and material are often poorly localized. Many species were figured and described by Simpson (1855, 1884), Buckman (1909–1930) and Howarth (1962b, 1992). The belemnite faunas are similarly well-documented, with descriptions in Young and Bird (1822, 1828), Phillips (1835, 1875, 18651909), Simpson (1855, 1866, 1884), Tate and Blake (1876) and Doyle (1985, 1990–1992). The vertebrate fauna is also well-documented as a result of three reviews (Benton and Taylor, 1984; Benton and Spencer, 1995; Dineley and Metcaff, 1999). However, other than some of the 19th century texts there has been little systematic recording of other elements of the fauna at this site. Simms (1989) cited some poorly localized crinoid remains from the Whitby district while Watson (1982) collected almost 300 specimens *of Dacromya ovum* with a few adherent specimens of the brachiopod *Discinisca reflexa.*

Some of the fossils for which Whitby is so well known have formed the basis for folklore. The best known of these is the legend of the Whitby snakestones. When St Hilda (614–680), founder of one of the first churches in England, arrived in Whitby she found the area infested with snakes. To eradicate this supposed evil she cut off the serpents' heads and cast them into the sea, the legend thereby conveniently explaining why ammonites are common on the beaches of the district (Scrutton, 1996). This event is commemorated by the three coiled 'snakes' (ammonites) on the town's coat of arms and it spawned a souvenir trade in the mid- to late-19th century, with snakes' heads being carved on fossil ammonites (usually *Dactylioceras*). Legend meets science in the lectotype of *Dactylioceras commune,* which bears just such a carved snake's head at the end of its last whorl (Dean *et al.,* 1961). St Hilda's association with the town is further celebrated in the ammonite genus *Hildoceras,* the type species of which, *H. bifrons,* came from the area. Jet was another geological product that was sold extensively, mostly as jewellery or small carvings, in Whitby during the 19th century, although most

material was obtained from sites elsewhere on the coast since the main jet-bearing beds are exposed here only in small patches at low tide.

Description

Only the middle part of the Whitby Mudstone Formation, comprising some 55 m of strata, is exposed in the cliffs and foreshore between Whitby East Pier and Saltwick Nab (Figure 6.21). The strata are folded into a broad, asymmetric syncline, so that from Whitby to Saltwick the gentle dip swings from south, to south-east and then south-west. The lowest strata seen are at about the level of the Whalestones (Bed 35 of Howarth, 1962a), towards the middle of the Jet Rock. They are exposed only around low-water mark along the seaward edge of the shore north-east of Saltwick Nab. Higher parts of the Mulgrave Shale Member and the full thickness of the Alum Shale Member are exposed on the fore shore to the north-east of Whitby East Pier as far as Long Bight, where the core of the syncline brings the base of the Dogger Formation down to beach level. Between there and towards Whitby East Pier the foreshore exposures pass down through the sequence to the base of the Alum Shale Member.

Howarth's (1962a) description of the Bituminous Shales was based on the exposures around Saltwick Nab. This is the only location where the complete Bituminous Shales succession can be examined on the foreshore: it effectively forms the type locality for this bed. Lamination is less well-developed, and the organic content lower, in the Bituminous Shales than in the Jet Rock below. The Alum Shale Member section was recorded between Saltwick Nab and Whitby by Howarth (1962a) and this forms its type section. The Main Alum Shale Beds have a calcium carbonate content sufficiently low that formerly they were used in the manufacture of Alum. The vast scars of this former industry litter the coast from Whitby to Boulby. The removal of many thousands of tonnes of shale led to the reduction of formerly grand headlands and cliffs to little more than stumps, such as at Saltwick Nab (Figure 6.22) and Kettleness. The Hard Shale Beds and Cement Shale Beds have slightly higher carbonate contents: concretions in the latter were once worked for cement manufacture. Thicknesses and lithological description of the Jet Rock are based on the section near Port Mulgrave, as recorded by Howarth (1962a). With minor revisions (Howarth, 1992), these form the basis of the following section.

	Thickness (m)
AALENIAN STAGE	
Dogger Formation	
Sandstone, grey, at base, lying unconformably on Whitby Mudstone Formation.	
LOWER TOARCIAN SUBSTAGE	
Whitby Mudstone Formation	
Alum Shale Member	
Cement Shale Beds	
Bifrons Zone, Crassum Subxone	
72 (part): Shale, grey, with calcareous nodules. *Catacoeloceras crassum, Hildoceras semipolitum, H.* ex grp *bifrons.* Belemnites include *Acrocoelites levidensis, A. tricissus, A. subtricissus, Simpsonibelus expansus, S. dorsalis, S. lentus* and *Dactyloteuthis crossotela.* This horizon corresponds to the *crassum–bifrons* and *crassum–semipolitum* biohorizons, while the base of the unit at Whitby is a parastratotype for defining the Crassum Subzone of Howarth (1992).	2.5
Fibulatum Subzone	

72 (part): Shale, grey, with calcareous nodules. *Porpoceras* cf *vortex, P. verticosum, Hildoceras* ex grp. *bifrons, Acrocoelites levidensis, A. tricissus, A. subtricissus, Simpsonibelus expansus, S. dorsalis, S. lentus* and *Dactyloteuthis crossotela.* This corresponds to the *vortex* Biohorizon.	1.5
65–71: Shale with several rows *of* calcareous concretions. *Hildoceras* ex grp. *bifrons,* occasional *Phylloceras heterophyllum* and rare *Lytoceras cornucopia* at base. *Acrocoelites levidensis, A. subtricissus, A. inequistriatus, Simpsonibelus expansus, S. dorsalis* and *S. lentus* present.	1.85 (6 ft)
Main Alum Shale Beds	
63 (part)–64: Shale with bands of calcareous nodules. *Peronoceras fibulatum, P. turriculatum, Zugodactylites braunianus, Pseudolioceras lythense, Hildoceras* ex grp. *bifrons, Phylloceras heterophyllum* and *Lytoceras cornucopia* with *Acrocoelites vulgaris, Simpsonibelus expansus* and *S. dorsalis.* Corresponds to the *braunianus* Biohorizon.	1.9
60–63 (part): Shale with bands of calcareous nodules. The fauna is reported to be in the lower approximately 1 m and includes *Peronoceras fibulatum, P. turriculatum, P. perarmatum, P. subarmatum, Pseudolioceras lythense, Hildoceras* ex grp. *bifrons* and *Phylloceras.* Belemnites include *Acrocodites vulgaris, A. tricissus, A. inequistriatus, Simpsonibelus expansus, S. dorsalis and S. lentus.* These beds correspond to the *turriculatum* Biohorizon, while the base of Bed 60 at Whitby corresponds to the base of the Fibulatum Subzone as defined by Howarth (1992).	1.33
Commune Subzone	
55–59: Shale with bands of calcareous nodules. *Dactylioceras athleticum* and *D.* spp., *Hildoceras* ex grp. *lusitanicum, Pseudolioceras lythense, Phylloceras heterophyllum* and *Lytoceras cornucopia.* Also *Acrocoelites oxyconus, A. subtenuis, A. subgracilis, A. pyramidalis, A. vulgaris, A. tricissus, A. subtricissus, A. inequistriatus, Simpsonibelus expansus, S. dorsalis* and *S. lentus.* Corresponds to the *athleticum* Biohorizon.	2.8 (9 ft 2 in)
51–54: Shale with bands of calcareous nodules. *D. commune* and *D.* spp., *Hildoceras* ex grp. *lusitanicum, Phylloceras heterophyllum* and rare *Frechiella subcarinata.* Belemnites include *Acrocoelites oxyconus, A. subtenuis, A. longiconus, A. subgracilis, A. pyramidalis, A. vulgaris, A. tricissus, A. subtricissus, A. inequistriatus, Simpsonibelus expansus* and *S. dorsalis.* Corresponds to part of the *commune* Biohorizon.	9.5 (31 ft)
Hard Shale Beds	

49–50: Shale with concretions and pyritic masses, capped by a 0.13 m-thick red sideritic mudstone band. *Dactylioceras commune, D. temperatum* in upper part, also *Hildoceras* cx grp. *lusitanicum, Parapassaloteuthis polita, Acrocoelites subtenuis* and *Simpsonibelus dorsalis.* This corresponds to the lower part of the *commune* Biohorizon, while the base of Bed 49 here marks the base of the Commune Subzone as defined by Howarth (1992).	6.4 (20 ft 9 in.)
Mulgrave Shale Member	
Bituminous Shales	
48: Ovatum Bed: Double row of large sideritic concretions in grey shale, with irregular masses of pyrite and occasional 'belemnite battlefields' with abundant *Acrocoelites subtenuis* and *A. vulgaris. Ovaticeras ovatum* formerly common, probably including the holotype, with *Dactylioceras* cf. *consimile* and occasional *Phylloceras heterophyllum.* Corresponds to part of the *ovatum* Biohorizon.	0.25 (10 in.)
47 (part): Shale, grey bituminous with occasional *Ovaticeras ovatum,* also *Parapassaloteuthis polita, Acrocoelites subtenuis, A. vulgaris* and *Simpsonibelus dorsalis.* Corresponds to part of the *ovatum* Biohorizon.	0.75
Serpentinum Zone, Falciferum Subzone	
46–47 (part): Shale, grey, bituminous, with a 0.13 m-thick sideritic mudstone at base. *Dactylioceras* sp., *Parapassaloteuthis polita, Acrocoelites subtenuis, A. vulgaris* and *Simpsonibelus dorsalis.*	4.98
44–45: Shale, grey, bituminous, with a row of scattered concretions at base. *Harpoceras* ex grp *falciferum* (J. Sowerby), *D.* cf. *consimile* and *P. heterophyllum,* also *Parapassaloteuthis polita, Acrocoelites* (*A.*) *subtenuis, A.* (*O.*) *subtricissus* and *Simpsonibelus dorsalis.* The *falciferum* Biohorizon lies within these two beds.	3.5 (11 ft 6 in.)
41–43: Shale, grey, bituminous, with a row of scattered, pyrite-skinned concretions, containing abundant *Pseudomytiloides,* near the middle. *Harpoceras* ex grp. *falciferum,* including *Harpoceras mulgravium, Dactylioccras* spp. and *Nodicoeloceras incrassatum, Parapassaloteuthis robusta, P. polita, Acrocoelites subtricissus, A. inequistriatus, Simpsonibelus dorsalis, Youngibelus tubularis* and Y. *simpsoni;* the last two species are restricted to Bed 43 of Howarth (1962a), which was termed the '*tubularis* Bed' in unpublished notes by Phillips (Doyle, 1985). These beds probably include the *mulgravium* Biohorizon. The base of Bed 41 at Saltwick is effectively a parastratotype for the base of the Falciferum Subzone (Howarth, 1992).	13.8 (44 ft 10 in.)
Jet Rock	
Exaratum Subzone	

40: **Millstones**: Giant, flattened lenticular calcareous concretions, reaching more than 4.5 m in diameter, in grey bituminous shale. They are exposed near low-water mark to the north of Saltwick Nab, extending south-eastwards in the direction of Whitestone Point. Corresponds to part of the *elegans* Biohorizon.	0.3 (1 ft)
39: **Top Jet Dogger**: Continuous band of argillaceous limestone. *Acrocoelites trisulcolosus.* Corresponds to part of the *elegans* Biohorizon.	0.23 (9 in)
38: Shale, grey, bituminous, with occasional calcareous concretions. *Acrocoelites trisulcolosus* and *A. ilminsterensis* present.	1.5 (5 ft)
37: **Curling Stones**: Calcareous concretions up to 0.45 m in diameter, with pyritic skins and almost perfect spheroidal shape, set in grey bituminous shale. *Acrocoelites trisulcolosus* and *A. ilminsterensis* present. Corresponds to part of the *elegans* Biohorizon.	0.3 (1 ft)
36: Shale, grey, bituminous. *Acrocoelites trisulcolosus* and *A. ilminsterensis.*	1.08 (3 ft 6 in)
35: **Whalestones**: Large ovoid calcareous concretions up to 3 m long and 1 m thick, with many smaller concretions, in grey bituminous shale. They form a conspicuous feature at low tide, beyond the outcrop of the Millstones, capping pillars of the underlying shale (Bed 34). Between Black Nab and Whitestone Point their position is often marked by a line of breaking waves. *Cleviceras exaratum,* with less frequent *Harpoceras serpentinum, Lytoceras crenatum* and probably also *Dactylioceras* sp.. This may be the type locality and horizon for *Hildaites forte* and *H. murleyi* (Howarth, 1992). *Acrocoelites trisulcolosus* and *A. ilminsterensis.* Corresponds to part of the *exaratum* Biohorizon.	0.92 (3 ft)

The invertebrate macrofossil fauna of the Whitby Mudstone Formation at this site is dominated by cephalopods, mostly dactylioceratid and hildoceratid ammonites and belemnites, but including the nautiloid *Cenoceras astacoides* from the Alum Shale Member (Howarth, 1962b). Belemnites are especially abundant and the Whitby district has yielded many type specimens; those definitely known to be from this site include *Acrocoelites inequistriatus, A. trisulculosus, Simpsonibelus dorsalis, Youngibelus tubularis* and *Y. simpsoni.* The type specimens of several other species are said to be from Whitby (Doyle, 1990–1992) but, as with many other old records, such labels may encompass several other sites along the coast. Specimens of *Youngibelus tubularis* and *Y. simpsoni* from Bed 43 at Saltwick Nab were used by Doyle (1985) to argue that these two nominal species were sexual dimorphs of a single species. Lenticular concentrations of belemnites at the level of the Ovatum Bed were termed 'belemnite battlefields' by Doyle and McDonald (1993). The remainder of the invertebrate fauna is of low diversity, as is typical of the Mulgrave Shale and Alum Shale members at other sites. In the Mulgrave Shale Member *Pseudomytiloides dubius* is one of the few common non-cephalopod macrofossils, while in the succeeding Alum Shale Member *Dacromya ovum* may be abundant at certain levels, sometimes associated with commensalistic examples of the brachiopod *Discinisca reflexa* (Watson, 1982). Morris (1979) provides a more complete list of bivalve taxa found in the two members. Rare examples of the crinoids *Pentacrinites dichotomus* and *Seirocrinus subangularis* have been recorded from the Bituminous Shales (Simms, 1989), with at least some probably recovered from this site. Small pyritic burrows occur at some levels in the Alum Shale Member.

The vertebrate fauna of this site is well documented through the work of Benton and Taylor (1984), Benton and Spencer (1995) and Dineley and Metcalf (1999). Among the reptile fauna plesiosaurs, ichthyosaurs, crocodiles and possibly a dinosaur are represented and include many nominal type species (Benton and Taylor, 1984). However, although detailed

locality data is available for some specimens, even from more than two centuries ago (e.g. Chapman, 1758; Wooller, 1758), for many others a Whitby label is not necessarily proof that the specimen was obtained from this site. It is clear from Benton and Taylor's (1984) study that Saltwick was an exceptionally rich source of fossil marine reptiles with most of the better-recorded specimens obtained from the Main Alum Shale Beds (Benton and Spencer, 1995), the only level which was extensively quarried in the region, with a few from the Bituminous Shales. Fish remains have an almost equally long history of study, with eight type species described from here in papers by Agassiz (1833–1845), Egerton (1852), Simpson (1855) and especially by Woodward (1896, 1897, 1898, 1899). However, some taxa listed as from here have since been deemed indeterminate or are thought to have originated from localities outside of Yorkshire (Dineley and Metcalf, 1999). Many of the earlier collections were made from the Bituminous Shales but in later times material was also obtained from industrial workings of the Alum Shale Member. Many of the fish described from this site, particularly those within carbonate nodules, are beautifully preserved in a high degree of articulation although others typically occur as disarticulated remains. Among these are remains of the giant chondrostean *Gyrosteus mirabilis,* thought to reach lengths of 5–6 m. The fish fauna as a whole is dominated by osteichthyans, such as *Gyrosteus, Lepidotes, Pachycormus, Pholidophorus* and *Leptolepis.* Chondrichthyans appear to be absent, or at least have not been recorded from here.

Interpretation

The ammonite faunas of the Bituminous Shales and the Alum Shale Member at Whitby have formed the basis of many stratigraphical reviews and include the stratotypes, or parastratotypes, of the Commune, Fibulatum and Crassum subzones of the Bifrons Zone (Howarth, 1992). Cox (1990) suggested that the area could provide reference sections for the Serpentinum (= Falciferum) and Bifrons zones. The Whitby area is the type locality for many ammonite species (Howarth, 1962b, 1992) some of which may not have come from the near the town. For example, the types of *Elegantuliceras elegantulum* and *Dactylioceras semicelatum* are both from levels stratigraphically lower than any beds currently exposed between Whitby and Saltwick (Howarth, 1973, 1992). They could have come from Hawsker Bottoms to the south or beyond Sandsend to the north. Type specimens of some species, used as zonal indices, are more likely to have come from the Whitby to Saltwick area.

These include *Cleviceras exaratum, Dactylioceras commune, Hildoceras bifrons* and *Peronoceras fibulatum.* Unusual elements in the ammonite faunas include the Tethyan giant *Phylloceras heterophyllum,* which occurs sporadically throughout the succession here, and the rarer *Lytoceras* ex grp. *cornucopia.* Both appear to have greatly expanded their range northwards at this time, perhaps due to more open seaways associated with the mid-Toarcian eustatic highstand (Hesselbo and Jenkyns, 1998). This may also account for the presence of the Mediterranean Bouleiceratine *Frechiella subcarinata,* of which the holotype is probably from Whitby, which reached the area in small numbers during the Commune Subzone (Donovan, 1967).

Throughout the Whitby Mudstone Formation succession exposed here the fauna is dominated by nektonic, planktonic and pseudoplanktonic taxa, with few unequivocally benthic forms. Morris (1979) used these and other observations to interpret the Mulgrave Shale Member as a 'bituminous-shale facies' and the succeeding Alum Shale Member as a 'restricted-shale facies'. The presence of finely preserved, commonly articulated vertebrates indicates that scavenging benthos was largely absent from the Mulgrave Shale and Alum Shale members. O'Brien (1990) noted that the organic content and the development of lamination was weaker in the Bituminous Shales than in the Jet Rock. He interpreted these as indicators of increasing water depth. They might also indicate a decline in biological productivity in near-surface waters, perhaps reflecting changes in marine circulation or climatic conditions (Hesselbo and Jenkyns, 1995).

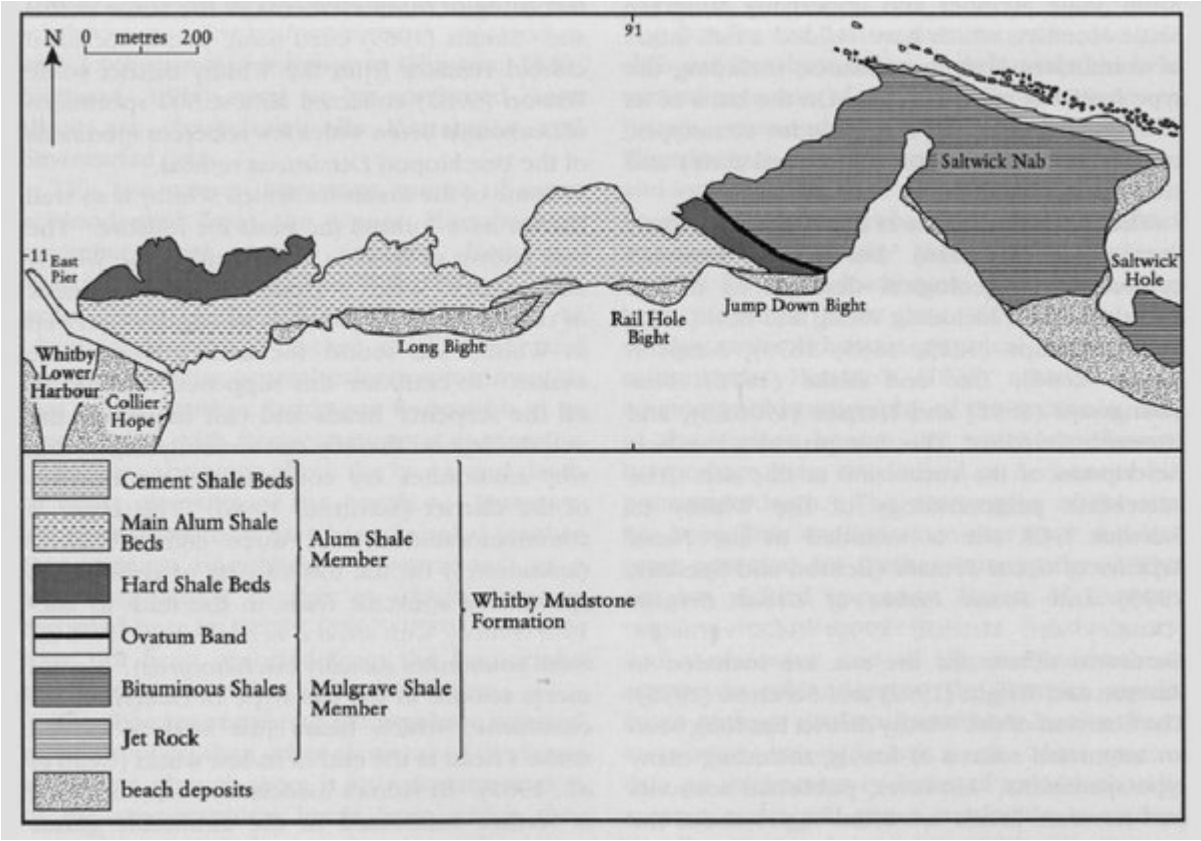
The absence of chondrichthyan fish at this site, a common element of many other early Jurassic fish faunas (Dineley and Metcalt 1999) seems significant. However, this observation appears to hold largely true also for the German correlative of these strata, the Posidonienschiefer. Only *Hybodus hauffianus* occurs in equivalent strata in Posidonienschiefer, where it has been reported from the Serpentinum Zone, but even there it occurs only rarely among a fish fauna comprising many thousands of specimens. Perhaps the rarity of chondrichthyans in these anoxic mudstone facies reflects an at least intermittently benthic habit for these fish which lack a swim bladder, and hence must swim actively to remain at the bottom.

The lithostratigraphy of the Mulgrave Shale and Alum Shale members at this site is similar to that at others north-west of the Peak Fault. Many of the marker bands can be recognized along this whole stretch of coast. The succession differs markedly from the correlative succession south-east of the Peak Fault. There is little difference in the thickness of the Mulgrave Shale Member on either side of the fault (Howarth, 1962a), but the nodule horizons in the Jet Rock at Whitby are largely absent south of the fault. In the Bituminous Shales and Alum Shale Member there are again significant differences between the succession recorded here and that at Blea Wyke. Lithostratigraphical correlation between the two sites of Whitby–Saltwick and Blea Wyke is difficult, with only the Ovatum Bed at the top of the Bituminous Shales common to both sections. The ammonite faunas allowed Howarth (1962a) to make tentative correlation of various horizons and to establish that the unconformity at the base of the Dogger Formation cuts out approximately the top 2 m of the Alum Shale Member at Whitby. The most significant difference between the two sections is the expansion of the succession at Blea Wyke compared to that at Whitby, with most of this occurring in the Cement Shale Beds. There is no evidence of a non-sequence at this level in the Whitby section so presumably this represents a brief increase in subsidence rate within the Peak Trough.

Conclusions

The cliffs and foreshore between Whitby and Saltwick expose a classic Toarcian section which has been a rich source of type and figured fossils, particularly ammonites and vertebrates. The section exposes the higher part of the Mulgrave Shale Member and an almost complete Alum Shale Member succession: it is the only site where the Alum Shale Member is extensively exposed and accessible on the foreshore. At other sites this part of the succession is exposed only in relatively inaccessible cliff sections or in old quarry workings now degraded by weathering. The section includes stratotypes, or at least parastratotypes for several lithostratigraphical and chronostratigraphical units, and it is the type locality for the Toarcian Whitbian Substage. The ammonites have inspired legends of serpents and are commemorated on the Whitby coat of arms.

References



(Figure 6.21) Outcrop map of the Whitby Mudstone Formation on the foreshore between Whitby and Saltwick. After Howarth (1962a).

(Figure 6.22) The Whitby Mudstone Formation in the cliffs at its type location. (Photo: K.N. Page.)