British Middle Jurassic Stratigraphy

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Chapter 2

The Middle Jurassic stratigraphy of Wessex

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INTRODUCTION

B.M. Cox

The region covered in this chapter extends from the Dorset coast northwards as far as Bath, the southern limit of the Cotswold Hills (Figure 2.1). The Middle Jurassic strata are the sediments that accumulated in the Mid Jurassic depositional area known as the 'Wessex Basin', but also, north of the Mendips, within the southernmost part of the 'Worcester Basin' (see Figure 1.6d, Chapter 1). Deposition was largely fault-controlled with evidence of syndepositional normal-faulting in the Aalenian, Bajocian and Bathonian successions (Holloway in Whittaker, 1985; Callomon and Cope, 1995). The rocks of the Aalenian–Bajocian stages are together typically less than 10 m thick, though they may range up to about 40 m. The thinner successions, often of highly fossiliferous, 'iron-shot' limestones, are developed on the crests of tilted blocks on the upthrown sides of major E–W-trending fault-systems (Holloway in Whittaker, 1985; Hawkes *et al.*, 1998). The strata make strong features in the landscape, forming scarps and the caps of small hills. The characteristic features of the Aalenian–Bajocian succession in this region are (1) the general thinness of individual beds, which are often sharply delimited by partings or erosion-planes that may be bored and covered in large stromatolitic crusts or other epibiota, and may cut through fossils such as ammonites in the underlying bed; (2) the intensive bioturbation of the beds, often with large in-situ burrows; and (3) the rich fossil, particularly ammonite, content (Callomon and Cope, 1995). In the neighbourhood of the Palaeozoic rocks of the Mendip Hills, the Aalenian and Lower Bajocian parts of the succession were removed by erosion beneath the transgressive Upper Bajocian Substage, which crosses, almost unchanged, the easternmost outcrop of Lower Carboniferous limestones (Callomon and Cope, 1995); in this context, the **Vallis Vale** GCR site is of outstanding geological interest.

During Bathonian and Early Callovian times, considerable differential subsidence, associated with growth-faults, took place (Holloway in Whittaker, 1985). Unlike the Bathonian succession in other areas of Britain (see Chapters 3–6) it here consists largely of marine mudstones with some thin, micritic and, less commonly, shell-detrital limestones. In the northern part of the region, about 8 km south of Bath, the lithologies change, within a short distance, to ooidal and shell-detrital limestones indicative of a shallow-marine, high-energy carbonate

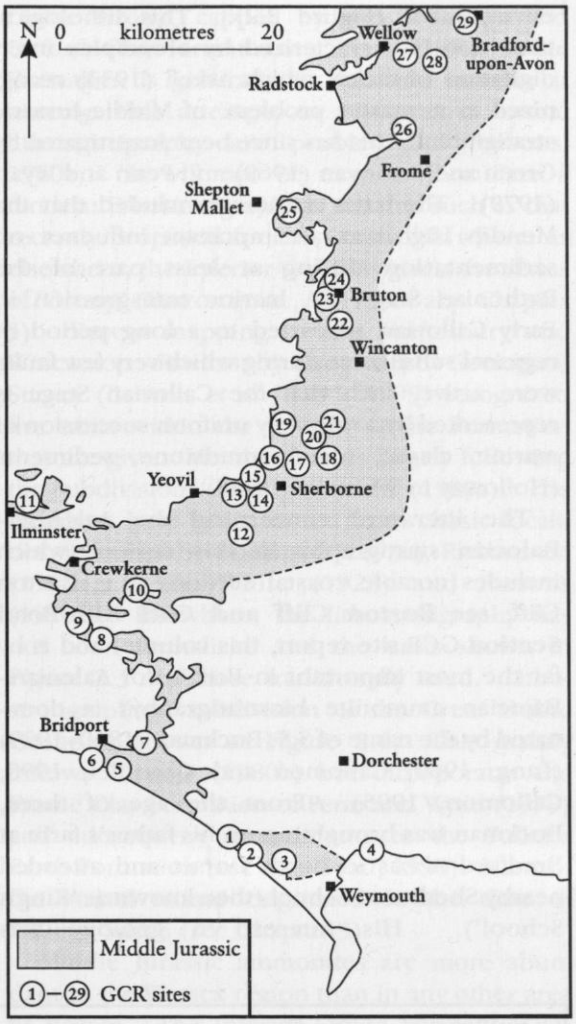

Figure 2.1 Geological sketch map showing the location of the GCR sites described in Chapter 2. (1) Shipmoor Point–Butterstreet Cove; (2) Tidmoor Point–East Fleet Coast; (3) Crookhill Brickpit; (4) Ham Cliff, Redcliff Point; (5) Burton Cliff and Cliff Hill Road Section; (6) Watton Cliff; (7) Peashill Quarry; (8) Horn Park Quarry; (9) Conegar Hill; (10) Ryewater, Corscombe; (11) Seavington St Mary Quarry; (12) Troll Quarry; (13) Bradford Abbas Railway Cutting; (14) Louse Hill Quarry; (15) Halfway House Cutting and Quarry; (16) Sandford Lane Quarry; (17) Frogden Quarry; (18) Goathill; (19) Holway Hill Quarry; (20) Milborne Wick Section; (21) Laycock Railway Cutting; (22) Shepton Montague; (23) Godminster Lane Quarry and Railway Cutting; (24) Bruton Railway Cutting; (25) Doulting Railway Cutting; (26) Vallis Vale; (27) Hinton Hill, Wellow; (28) Hinton Charterhouse; (29) Gripwood Quarry.

environment (Figure 2.2). This lithological transition is characterized by a complex interdigitation of facies, which Arkell (1933) recognized as a 'master problem' of Middle Jurassic stratigraphy. This has since been investigated by Green and Donovan (1969) and Penn and Wyatt (1979). The latter authors concluded that the Mendip High was an important influence on sedimentation during at least part of the Bathonian Stage. A marine transgression in Early Callovian times led to a long period of regional subsidence during which very few faults were active, such that the Callovian Stage is represented by a relatively uniform succession of marine, clastic, mainly mudstone, sediments (Holloway in Whittaker, 1985).

The literature concerning the Aalenian–Bajocian stratigraphy in this region (which includes notable coastal sections (e.g. Burton Cliff; see **Burton Cliff and Cliff Hill Road Section** GCR site report, this volume) and is by far the most important in Britain for Aalenian–Bajocian ammonite biostratigraphy) is dominated by the name of S.S. Buckman (1860–1929) (Lang, 1960; Callomon and Chandler, 1990; Callomon, 1995). From the age of three, Buckman was brought up on his father's farm at Bradford Abbas in north Dorset and attended nearby Sherborne School (then known as 'King's School'). His interest in geology was undoubtedly nurtured by his father, James, who had previously been Professor of Geology and Botany at the Royal Agricultural College in Cirencester, and who himself published a number of papers on the Middle Jurassic deposits of Wessex (Buckman, J., 1866, 1877, 1879, 1881). As a boy, the young S.S. Buckman would have had plenty of opportunity to collect fossils, which were extracted in abundance from the numerous quarries working at that time in the Sherborne area. Indeed, according to Callomon and Chandler (1990), the area in which Buckman spent his boyhood includes one of the most richly fossiliferous developments of Jurassic rocks in the world. After studying in Germany, Buckman returned to this country where, after a few years, he moved to Gloucestershire to set up a farm in Hampen, near Andoversford. He later moved to Stonehouse, near Stroud and then to Charlton Kings, near Cheltenham, by which time he was apparently able to devote almost all his time and energy to palaeontology and stratigraphy. Finally, in 1904 and in poor health, he moved to near Thame in Oxfordshire where he remained until his death. Although he had left the Middle Jurassic rocks of Dorset nearly 50 years previously, he always lived on or near a Middle Jurassic outcrop. Aalenian–Bajocian ammonites from Dorset and Somerset continued to be sent

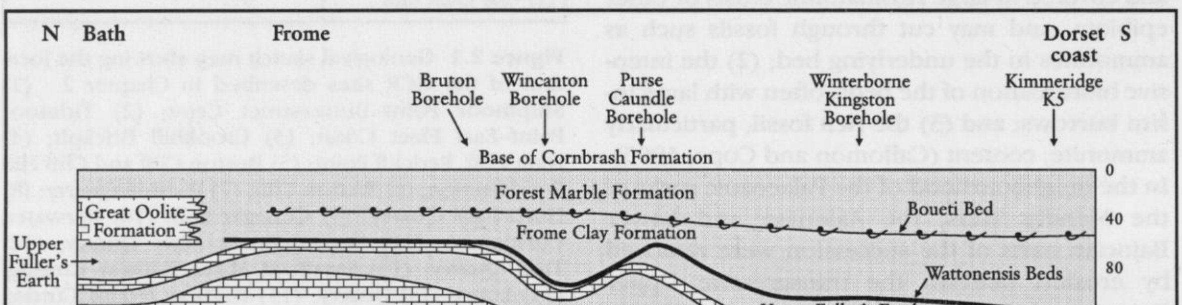

Figure 2.2 Simplified diagrammatic cross-section through the Bathonian strata of Wessex. (After Bristow *et al.*, 1995, fig. 23.)

to him for determination, notably by L.F. Richardson, who, in numerous papers, added much local detail to what was previously known of the Wessex Middle Jurassic succession (Richardson, 1907a, 1908, 1909a–c, 1913, 1914, 1915, 1916a,b, 1919, 1928, 1929a, 1930, 1932; Richardson and Walker, 1907; Richardson and Paris, 1908, 1912; Richardson *et al.*, 1911; Richardson and Butt, 1912; Richardson and Thacker, 1920). Buckman's own papers on Wessex were published over some 50 years (1878, 1881, 1883a,b, 1886, 1887–1907, 1889a,b, 1891, 1893a,b, 1910a,b, 1922a) and ammonites from there were described in his privately published *Type Ammonites* (Buckman, 1909–1930), which, despite some curious idiosyncrasies, continues to be the most comprehensive description of the British Jurassic ammonite fauna (Callomon, 1995; see also Chapter 1). Buckman's association with Wessex continued even in death for, at his request, his ashes were scattered by his sons at Golden Cap on the Dorset coast (Lang, 1960).

Subsequent work on the Wessex Middle Jurassic succession includes faunal monographs by Muir-Wood (1936) and Arkell (1951–1958), [British] Geological Survey memoirs by Arkell (1947a) and Wilson *et al.* (1958), and local section and palaeontological details by Arkell (1957), Fowler (1957), and Sylvester-Bradley and Hodson (1957). Other notes appeared in the 'Geology Reports' of the *Proceedings of the Dorset Natural History and Archaeological Society*. In the 1960s and 1970s, H.S. Torrens, himself a Sherborne alumnus, and C.F. Parsons revisited all of the classic localities described by Buckman and Richardson. Between them, they produced a number of papers, as well as their individual unpublished theses, elucidating the stratigraphy and recording further section details (Parsons, 1974a, 1975a,b, 1976a, 1977a, 1980a,b; Torrens, 1964, 1966, 1969a,b, 1974, 1980b). More recently, these localities, new temporary sections, and the ammonite biostratigraphy, have been investigated by J.H. Callomon, R.B. Chandler and their associates (Chandler, 1982; Callomon and Chandler, 1990, 1994; Morton and Chandler, 1994; Callomon and Cope, 1995; Callomon, 1995; Chandler, 1996; Dietze and Chandler, 1997).

The current lithostratigraphical scheme for the Middle Jurassic rocks of the Wessex (Dorset–Somerset) region divides the succession into the Inferior Oolite Formation and the Great Oolite Group, capped by the Kellaways and Oxford Clay formations. The Inferior Oolite Formation is generally so thin and variable at outcrop that attempts to construct a formal lithostratigraphy are problematic (Parsons, 1980a). It will not be easy to formulate a modern lithostratigraphical scheme such as that recently proposed for the Cotswolds where, as elsewhere, the Inferior Oolite is given the status of 'Group' (Barron *et al.*, 1997; see also Chapter 3). Recent mapping in the Shaftesbury and Wincanton districts by the British Geological Survey (Bristow *et al.*, 1995, 1999) recognized five units within the Inferior Oolite Formation that are given 'Member' status largely following the subdivisions used by Parsons (1980a). The members have been named from classic localities described by Buckman (1893a), Richardson (1916a, 1932), White (1923) and Parsons (1976a). Elsewhere, the lithostratigraphy has not been formalized and the units shown in Figure 2.3 are those traditionally used. Lithostratigraphical subdivision of the Great Oolite Group is shown in Figure 2.4. This mainly follows Torrens (1980b) but incorporates the Frome Clay Formation of Penn and Wyatt (1979) and consequent amendments to the Fuller's Earth Formation (see also Wyatt, 1998). Many of the stratal names originated in the time of William Smith (see Chapter 3).

Middle Jurassic ammonites are more abundant in the Wessex region than in any other area of Britain. The Inferior Oolite Formation has a rich ammonite fauna with each bed typically having its own assemblage (Callomon and Chandler, 1990; Callomon, 1995; Callomon and Cope, 1995). These have been used to construct the scheme of ammonite biohorizons within the established zonation as detailed in Chapter 1 and shown in Figures 1.3 and 1.4 (Chapter 1). The Great Oolite Group in this region is also more ammonitiferous than elsewhere and has yielded the majority of known British Bathonian ammonites and from the greatest number of stratigraphical horizons. These occurrences, and the zonation that they underpin, have been reviewed by Page (1996a) who demonstrated the feasibility of applying a single ammonite-based zonation to the Bathonian succession of the whole of Europe (see Chapter 1).

Further details of the main lithologies, thicknesses and depositional environments are included in the site descriptions that follow. In the following list of sites (arranged generally

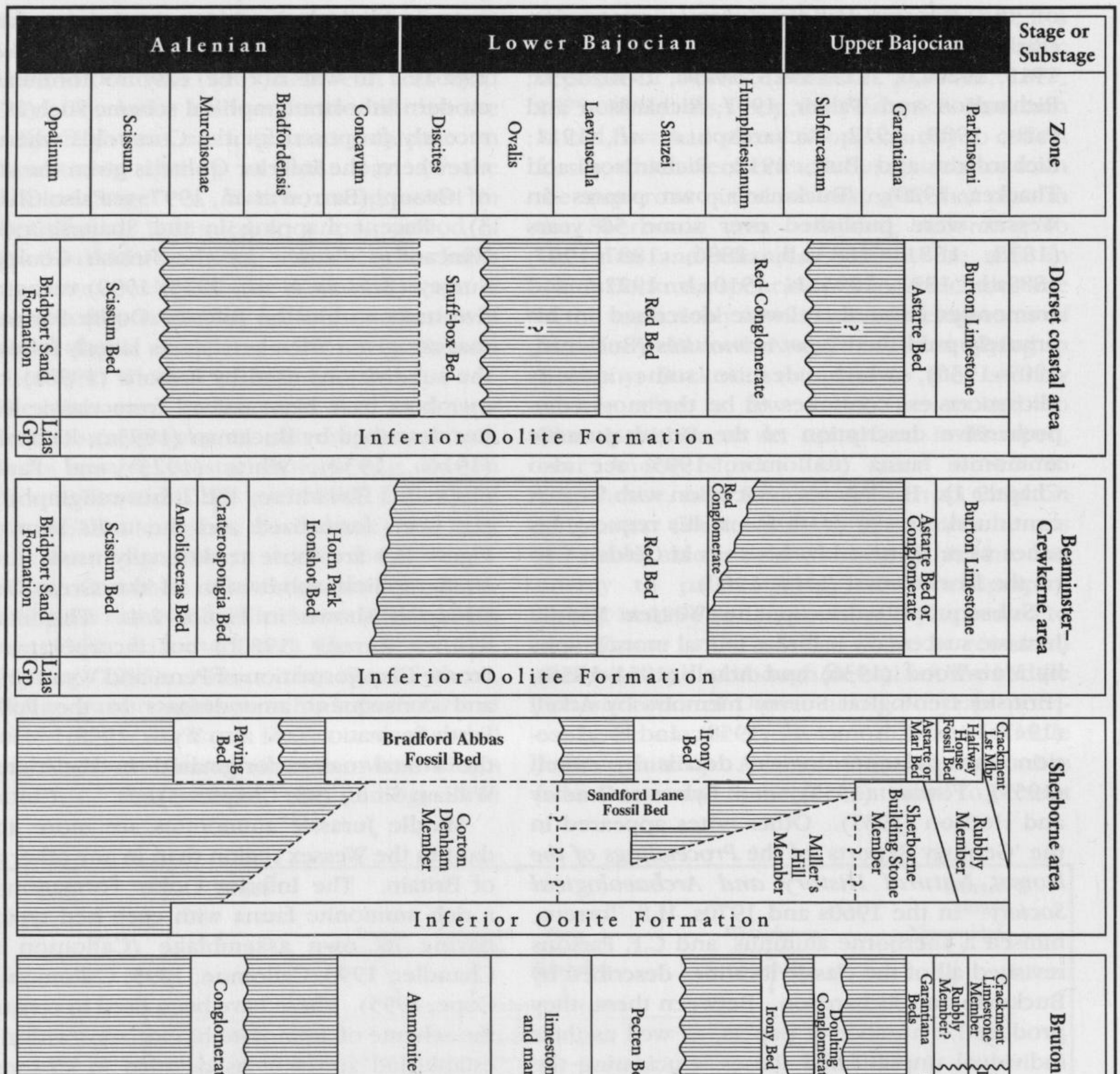

Figure 2.3 Simplified stratal subdivision of the Aalenian-Bajocian succession of the Wessex region. Vertical ruled lines indicate major non-sequences. Not to scale. (Based on data in Bristow *et al.*, 1995, 1999; Callomon and Cope, 1995; and Parsons, 1980a.)

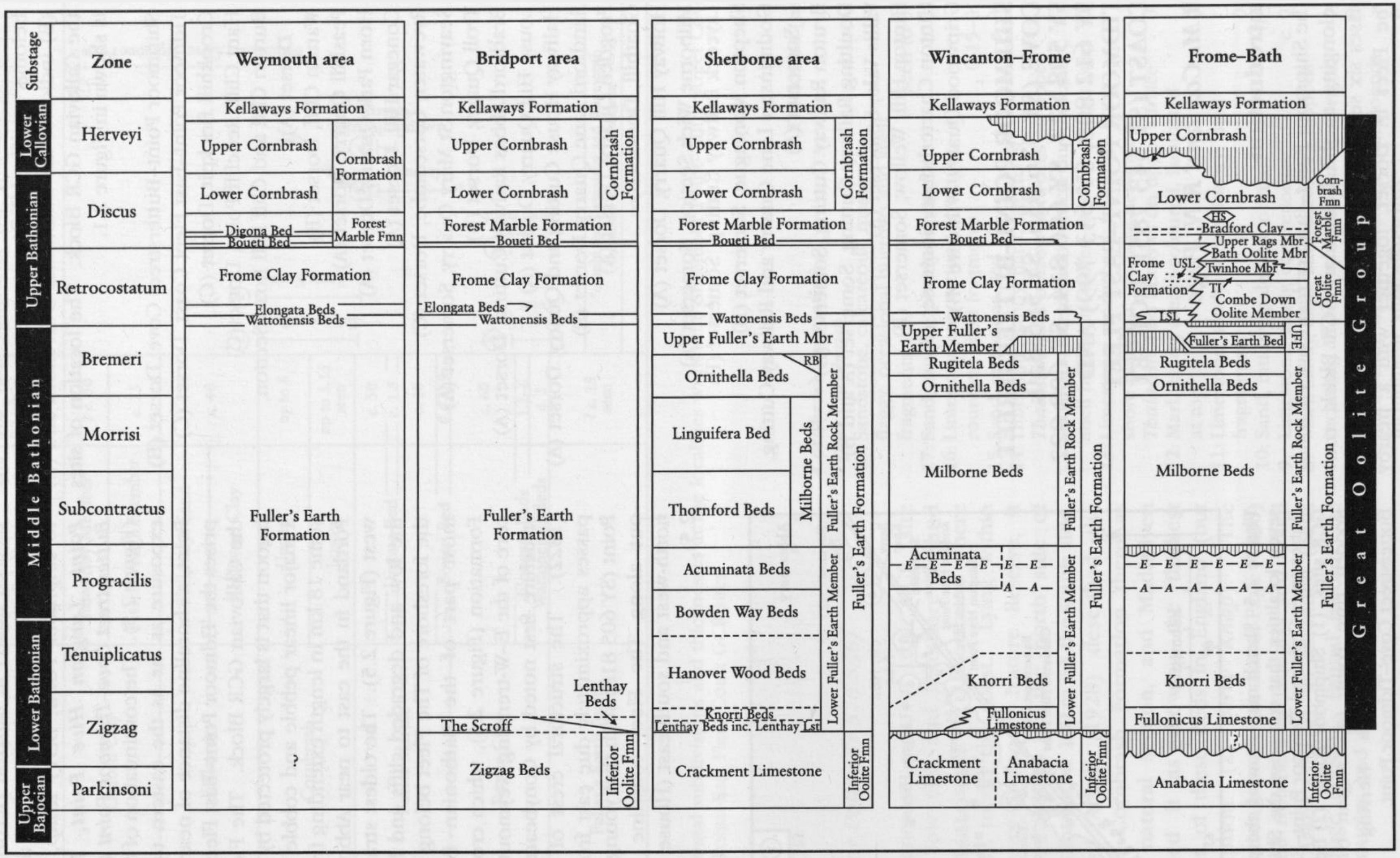

Figure 2.4 Lithostratigraphical classification of the Great Oolite Group in the Wessex region. Vertical ruled lines indicate non-sequence. (Based on data in Penn and Wyatt, 1979; Torrens, 1980b; Page, 1989, 1996a; Bristow *et al.*, 1995, 1999; and Wyatt, 1998.) (-E-E-E-E- = Echinata Bed; -A-A-A-A- = Acuminata Bed of Penn and Wyatt (1979); HS = Hinton Sand Member; LSL = Lower Smithi Limestone; RB = Rugitela Beds; TI = Twinhoe Ironshot; UFE = Upper Fuller's Earth Member; USL = Upper Smithi Limestone.)

south to north), (A) indicates that the site belongs to the Aalenian–Bajocian GCR Block, (B) indicates the Bathonian GCR Block and (C) the Callovian GCR Block. The location of sites is shown in Figure 2.1.

Shipmoor Point–Butterstreet Cove, Dorset (B)
Tidmoor Point–East Fleet Coast, Dorset (C)
Crookhill Brickpit, Dorset (C)
Ham Cliff, Redcliff Point, Dorset(C)
Burton Cliff and Cliff Hill Road Section, Dorset (A)
Watton Cliff, Dorset (B)
Peashill Quarry, Dorset (A)
Horn Park Quarry, Dorset (A)
Conegar Hill, Dorset (A)
Ryewater, Corscombe, Dorset (C)
Seavington St Mary Quarry, Somerset (A)
Troll Quarry, Dorset (B)
Bradford Abbas Railway Cutting, Dorset (A)
Louse Hill Quarry, Dorset (A)
Halfway House Cutting and Quarry, Dorset (A)
Sandford Lane Quarry, Dorset (A)
Frogden Quarry, Dorset (A)
Goathill, Dorset (B)
Holway Hill Quarry, Dorset (A)
Milborne Wick Section, Somerset (A)
Laycock Railway Cutting, Somerset (B)
Shepton Montague, Somerset (B)
Godminster Lane Quarry and Railway Cutting, Somerset (A)
Bruton Railway Cutting, Somerset (B)
Doulting Railway Cutting, Somerset (A and B)
Vallis Vale, Somerset (A)
Hinton Hill, Wellow, Somerset (B)
Hinton Charterhouse, Somerset (B)
Gripwood Quarry, Wiltshire (B)

SHIPMOOR POINT–BUTTERSTREET COVE (SY 576 836, SY 585 830, SY 598 822, SY 606 814, SY 608 822, SY 612 808, SY 633 799) AND TIDMOOR POINT–EAST FLEET COAST (SY 643 785), DORSET

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Introduction

The Shipmoor Point–Butterstreet Cove GCR site, belonging to the Bathonian GCR Block, comprises six separate exposures along the coast of The Fleet in Dorset, together with a nearby disused quarry at Langton Herring. From west to east, the coastal exposures are at and adjacent to *Shipmoor Point*, *Berry Knap*, *Rodden Hive Point*, *Langton Hive Point*, *Herbury* and *Butterstreet Cove–Tidmoor Point* (western side) (Figure 2.5). The continuation of the last named exposure as far as the eastern tip of Tidmoor Point, a shoreline distance of nearly 3 km, comprises the Tidmoor Point–East Fleet Coast site of the Callovian GCR Block. The Fleet is a saline lagoon that is largely protected by Chesil Beach, a major linear pebble and cobble storm feature some 18 km in length extending from the Isle of Portland in the east to near Abbotsbury in the west (Figure 2.5). The oldest strata exposed in the low and degraded cliffs and banks and on the foreshore of The Fleet belong to the uppermost part of the Bathonian Fuller's Earth Formation (Figure 2.6), which crops out in the core of the E–W-trending Weymouth Anticline, a structure first noted by Conybeare and Phillips (1822). The structural crest of the anticline passes approximately due east from Clay Hard Point (SY 605 818) such that younger strata crop out along The Fleet coastline both to the north-west and south-east (House, 1961; Figure 2.5).

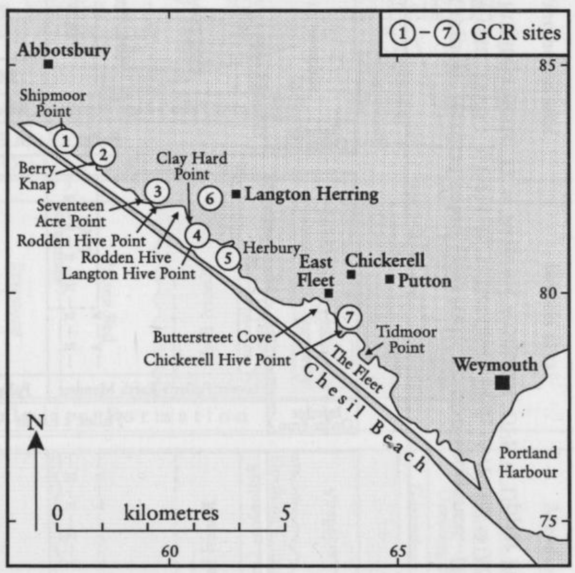

Figure 2.5 Sketch map showing the position of the seven localities that comprise the Shipmoor Point–Butterstreet Cove and Tidmoor Point–East Fleet Coast GCR sites. (1) Shipmoor Point; (2) Berry Knap; (3) Rodden Hive Point; (4) Langton Hive Point; (5) Herbury; (6) Langton Herring Quarry; (7) Butterstreet Cove–Tidmoor Point.

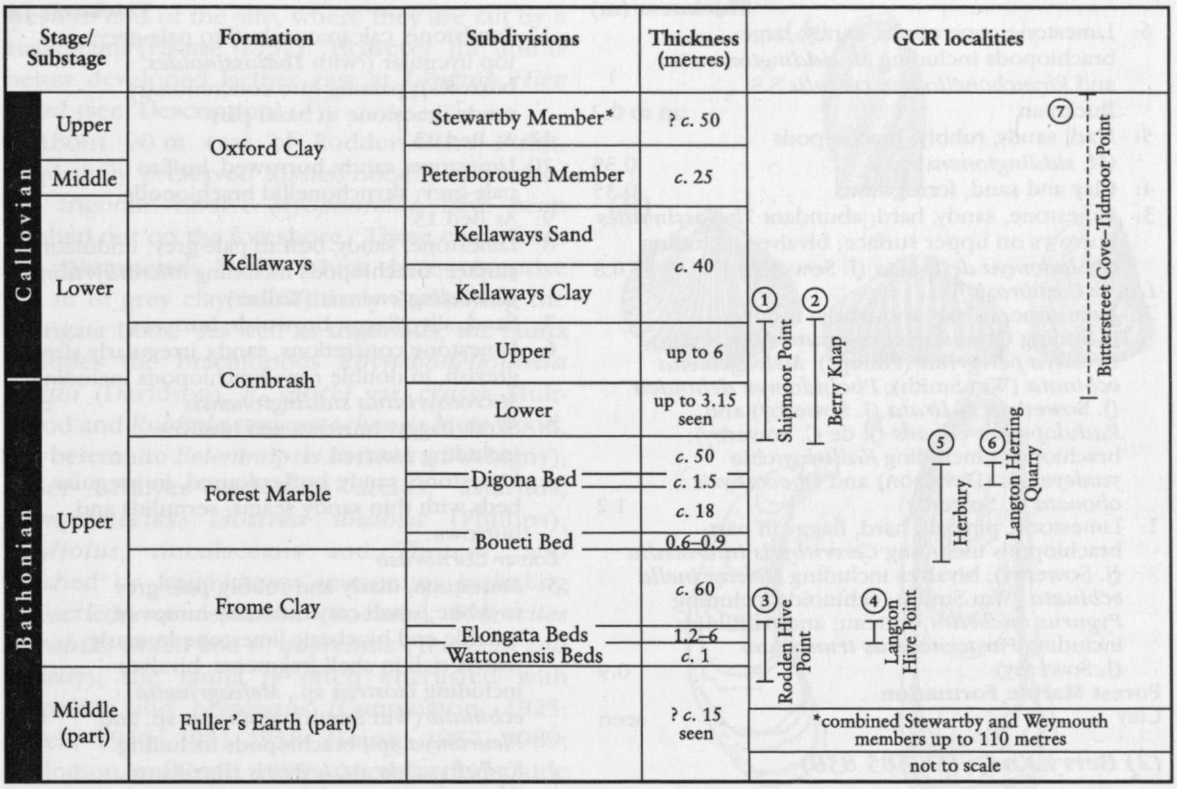

Figure 2.6 Stratal subdivisions and thicknesses at the localities within the Shipmoor Point–Butterstreet Cove and Tidmoor Point–East Fleet Coast GCR sites.

Description

(1) *Shipmoor Point (SY 576 836)*

This westernmost part of the GCR site covers the low cliff and foreshore around Shipmoor Point, south of Abbotsbury, where Chester's Hill meets the coast. Lying within the Abbotsbury Swannery Nature Reserve, it extends for *c.* 180 m on the north side of Shipmoor point and *c.* 100 m on the south side. Douglas and Arkell (1928) described the exposure of Cornbrash Formation there as a splendid natural section, and Madfadyen (1970) noted it as showing the thickest development of these beds in England (but see 'Description' (2) *Berry Knap*). The following section is based on that of Page (1988) using the bed numbers of Douglas and Arkell (1928) and Arkell (1947a), as extended (beds 15–18) by Page (1988). Faunal records are based on Douglas and Arkell (1928) and Page (1988).

	Thickness (m)
Cornbrash Formation	
Upper Cornbrash	
18: Sandstone, calcareous, massive to flaggy; occasional burrows and shell fragments	seen to 0.4
17: Sand, muddy; poorly exposed	*c.* 0.4
16: Limestone concretions, irregular, rounded; shell fragments	0.15–0.2
15: Sand, muddy, as Bed 17	*c.* 0.3
14: Limestone, sandy, hard, laminated; *Thalassinoides* burrow-networks on upper surface; scattered sub-vertical burrows and shell fragments; softer, sandy parting at base	0.4
13: Limestone, sandy, hard; forming a 'long-shore platform'; massive network of *Thalassinoides* burrows on upper surface	0.3
12: Marl, sandy, cream-coloured, laminated at top	0.4
11: Limestone, sandy, concretionary; shell fragments	0.3
10: Sand, muddy, pale-buff, or marl	0.35
9: Limestone, sandy, concretionary	*c.* 0.2
8: Marl, sandy, hard, laminated; brachiopods including *Microthyridina siddingtonensis* (Walker); serpulids; fish teeth	0.3
7: Marl, sandy; oysters common; brachiopods including *M. siddingtonensis*	0.6

	Thickness (m)
6: Limestone concretions, sandy, large; brachiopods including *M. siddingtonensis* and *Rhynchonelloidea cerealis* S.S. Buckman	up to 0.2
5: Marl, sandy, rubbly; brachiopods (*M. siddingtonensis*)	0.35
4: Clay and sand, ferruginous	0.35
3: Limestone, sandy, hard; abundant *Thalassinoides* burrows on upper surface; bivalves including *Pholadomya deltoidea* (J. Sowerby)	0.8
Lower Cornbrash	
2: Limestone, rubbly and marly; bivalves including *Ctenostreon rugosum* (Wm Smith), *Gresslya peregrina* (Phillips), *Meleagrinella echinata* (Wm Smith), *Pholadomya deltoidea* (J. Sowerby), *P. lirata* (J. Sowerby) and *Radulopecten vagans* (J. de C. Sowerby); brachiopods including *Kallirhynchia yaxleyensis* (Davidson) and *Obovothyris obovata* (J. Sowerby)	1.2
1: Limestone, pinkish, hard, flaggy in part; brachiopods including *Cererithyris intermedia* (J. Sowerby); bivalves including *Meleagrinella echinata* (Wm Smith); echinoids including *Pygurus michelini* Cotteau; and nautiloids including *Paracenoceras truncatum* (J. Sowerby)	0.9
Forest Marble Formation	
Clay	seen

(2) Berry Knap (SY 585 830)

This part of the site comprises *c.* 170 m of low cliff and foreshore centred on the stunted headland at the western end of Berry Knap. The whole of the Cornbrash Formation is exposed dipping 15° to the north (House, 1989). In recent years, exposure has been better than at *Shipmoor Point*, despite the latter's reputation (see 'Description' (1)), such that Page (1988) described it as the best and most complete exposure of the Cornbrash Formation known. Douglas and Arkell (1928) and Arkell (1947a) mentioned the section but gave no details other than a brief comparison with that at *Shipmoor Point* and a record of some additional fossils. Like *Shipmoor Point*, it also lies within the Abbotsbury Swannery Nature Reserve. The following section is based on that of Page (1989).

	Thickness (m)
Cornbrash Formation	
Upper Cornbrash	
14: Limestone concretions, sandy, rounded but irregularly sized; often with fossiliferous cores of brachiopods including *Microthyridina* cf. *lagenalis* (Schlotheim); bivalves including abundant *Entolium* sp.; rare ammonites including *Macrocephalites* aff. *terebratus* (Phillips)	*c.* 0.1
13: Sand, silty, brownish	*c.* 0.3
12: Sandstone, calcareous, buff to pale-grey; top irregular (?with *Thalassinoides* burrows); passing into concretionary, sandy limestone in basal part	0.4
11: As Bed 13	0.8
10: Limestone, sandy, burrowed, buff to pale-grey; rhynchonellid brachiopods	0.2
9: As Bed 13	0.4
8: Limestone, sandy, buff to pale-grey; undulating surface; brachiopods including *Microthyridina* cf. *siddingtonensis* (Walker)	0.3
7: Sand, silty, flaggy, brownish; burrows	0.8
6: Limestone concretions, sandy, irregularly sized, greyish, in double row; brachiopods including *Microthyridina siddingtonensis*	*c.* 0.4
5: Sand, flaggy; burrows and bivalves including *Liostrea*	1.6
4: Limestone, sandy, buff-coloured, in irregular beds with thin sandy seams; serpulids and burrows	0.7
Lower Cornbrash	
3: Limestone, marly and rubbly, pale-grey to white; small concretionary lumps of micritic and bioclastic limestone in marly matrix rich in shell fragments; bivalves including *Liostrea* sp., *Meleagrinella echinata* (Wm Smith), *Modiolus* sp. and *Pleuromya* sp.; brachiopods including *Kallirhynchia yaxleyensis* (Davidson), *Obovothyris grandobovata* (S.S. Buckman), *O. obovata* (J. Sowerby) and *Ornithella classis* Douglas and Arkell; ammonites including *Clydoniceras* ex gr. *discus* (J. Sowerby) and *Homoeoplanulites* sp.	1.45
2: *Intermedia Bed*: Limestone, bioclastic and micritic, flaggy, in up to four courses separated by marl with shell-grit; pale-buff to yellowish or pale-greyish; *Meleagrinella echinata* (Wm Smith) abundant at top; other bivalves, including *Liostrea* and *Pleuromya*, throughout	1.25
1: Limestone, rubbly and marly; similar to Bed 3 but sandy in part and with brachiopods including common *Cererithyris intermedia* (J. Sowerby) and *Kallirhynchia yaxleyensis* (Davidson); bivalves including *Radulopecten* sp., *Liostrea* sp. and *Pleuromya* cf. *uniformis* (J. Sowerby); serpulids	seen to 0.45
Gap in exposure	
Forest Marble Formation	
Clay	seen

(3) Rodden Hive Point (SY 598 822)

This part of the GCR site, spanning *c.* 1 km of coastline, is centred around Rodden Hive Point (Figure 2.5). Between there and Rodden Hive, lumachelles of the oyster *Praeexogyra hebridica* (Forbes) var. *elongata* (Dutertre) totalling *c.* 1.2 m in thickness (the Elongata Beds of the basal Frome Clay Formation) are exposed. They also crop out at Seventeen Acre Point, at the western end of the site, where they are cut by a strike fault (House, 1957). However, the unit is better developed farther east at *Langton Hive Point* (see 'Description' (4)).

About 90 m east of Rodden Hive Point, exquisitely preserved fossils, notably species of the trigoniid bivalve *Myophorella*, have been washed out on the foreshore. These come from the Wattonensis Beds, which here comprise *c*. 1 m of grey clay immediately underlying the Elongata Beds. As well as trigoniids, the fauna includes the brachiopods *Rhynchonelloidella smithi* (Davidson), *R. smithi* var. *crassa* Muir-Wood and *Rugitela powerstockensis* Muir-Wood, the belemnite *Belemnopsis bessina* (d'Orbigny), other bivalves including arcids, astartids, *Camptonectes*, *Liostrea undosa* (Phillips), *Modiolus*, nuculaceans and *Thracia*, and crushed or fragmentary ammonites including *Eohecticoceras costatum* (Roemer), *Procerites mirabilis* Arkell and *P. quercinus* (Terquem and Jourdy); the fauna is often encrusted with serpulids and bryozoans (Cunnington, 1925; Arkell, 1940, 1951–1958; House, 1957, 1989; Callomon and Cope, 1995). Microfossils include ostracods, foraminifera and numerous fish otoliths (Stinton and Torrens, 1968; Torrens, 1969b). Beneath the Wattonensis Beds, there are an estimated *c*. 15 m of poorly exposed grey clays (Fuller's Earth Formation), with white unfossiliferous mudstone nodules in the upper part (House, 1957); these are the oldest strata exposed along the coast of The Fleet.

(4) Langton Hive Point (SY 606 814)

The exposure in the low cliff below the coastguard station at Langton Hive Point shows one of the thickest (5–6 m) and best developments of the oyster lumachelles that characterize the basal beds of the Frome Clay Formation (see also 'Description' (3) *Rodden Hive Point*). First cited by Damon (1860), the locality has since been noted by Arkell (1933, 1947a), House (1957, 1961, 1989), Torrens (1969b) and Callomon and Cope (1995). The lumachelles, which dip gently to the south, comprise a mass of *Praeexogyra hebridica* (Forbes), particularly the elongate form known as var. *elongata* (Dutertre) (Arkell, 1934; Hudson and Palmer, 1976; Figure 2.7), with a little clay matrix. They have been called the 'Elongata Beds' following Arkell (1933). The fossil oyster-shells are often encrusted with foraminifera including

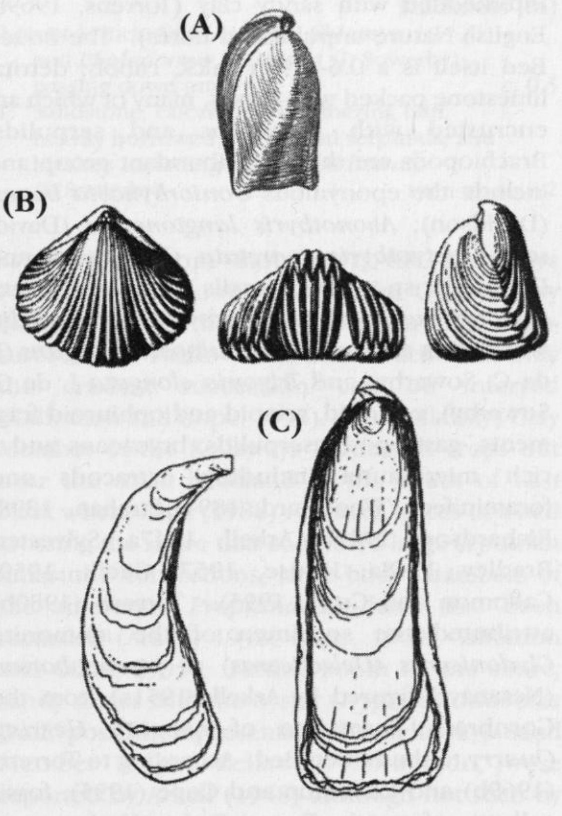

Figure 2.7 (A) *Digonella digona* (J. Sowerby); (B) *Goniorhynchia boueti* (Davidson); (C) *Praeexogyra hebridica* (Forbes) var. *elongata* (Dutertre). (Reproduced from Damon, 1860, fig. 4; and Arkell, 1947a, fig. 3.) All specimens are natural size.

Nubeculinella. Pectinid bivalves (*Camptonectes* and *Radulopecten*), often fragmentary, are also present, together with crushed rhynchonellid brachiopods.

(5) Herbury (SY 612 808)

Exposures on the shore of The Fleet at the Herbury peninsula show the uppermost part of the Frome Clay Formation overlain by the Forest Marble Formation. The locality is most famous for two brachiopod-rich marker beds in the Forest Marble Formation; the Boueti Bed at its base, and the Digona Bed, estimated by House (1961) to be about 18 m higher.

The Boueti Bed is exposed on the shore at the north-west corner of the peninsula where it overlies *c*. 7 m of Frome Clay Formation. The latter comprises up to *c*. 5 m of grey shale overlain by three courses of micritic limestone, with laminae of very fine bioclastic sand and silt, interbedded with sandy clay (Torrens, 1969b; English Nature unpublished notes). The Boueti Bed itself is a 0.6–0.9 m thick, rubbly, detrital limestone packed with fossils, many of which are encrusted with bryozoans and serpulids. Brachiopods are the most abundant group and include the eponymous *Goniorhynchia boueti* (Davidson), *Avonothyris langtonensis* (Davidson), *Dictyothyris coarctata* (Parkinson) and *Digonella* sp. Other fossils include bivalves (*Arcomytilus asper* (J. Sowerby), *Liostrea anclif-fensis* (Cox and Arkell), *Radulopecten vagans* (J. de C. Sowerby) and *Trigonia elongata* J. de C. Sowerby), echinoid, crinoid and ophiuroid fragments, gastropods, serpulids, bryozoans and a rich microfauna including ostracods and foraminifera (Woodward, 1894; Strahan, 1898; Richardson, 1909b; Arkell, 1947a; Sylvester-Bradley, 1948a; House, 1957; Cifelli, 1959; Callomon and Cope, 1995). Torrens (1980b) attributed the specimen of the ammonite *Clydoniceras* (*Delecticeras*) cf. *ptychophorum* (Neumayr) figured by Arkell (1951a) from the Cornbrash Formation of *Langton Herring Quarry* to the Boueti Bed. According to Torrens (1969b) and Callomon and Cope (1995), fossil collecting from the Boueti Bed at Herbury can be spectacular, particularly after storms, but House (1989) described the bed as almost collected out. The overlying beds comprise greenish and brown clay with harder mudstone laminae, and hard, flaggy, ooidal and shelly limestone (Macfadyen, 1970).

The Digona Bed is exposed on the south-eastern corner of the peninsula (Sylvester-Bradley, 1957; House, 1961; Holloway, 1981; Torrens, 1969b; Callomon and Cope, 1995). It comprises *c.* 1.5 m of pale-grey and cream-coloured limestone and marl, rich in fossils, particularly brachiopods including the eponymous *Digonella digona* (J. Sowerby), *Avonothyris bradfordensis* (Davidson), *Dictyothyris coarctata* (Parkinson) and *Rhynchonelloidella curvivarians* (S.S. Buckman). Other fossils include ossicles of the crinoid *Apiocrinites* and well-preserved bivalves including *Dacryomya lacrymya* (J. de C. Sowerby), *Oxytoma* cf. *costata* (Townsend), *Palaeonucula waltoni* (Morris and Lycett), *Plagiostoma subcardiiformis* Greppin, *Plicatula fistulosa* Morris and Lycett, *Praeexogyra hebridica* (Forbes), *Radulopecten hemicostata* (Morris and Lycett) and *R.* cf. *vagans* (J. de C. Sowerby), as well as micromorphic gastropods, serpulids, bryozoans and sponges (House, 1961, 1989; Torrens, 1969b; Holloway, 1981). At the base of the Digona Bed, Holloway (1981) reported a hardground encrusted with corals (*Isastraea* and *Thamnasteria*), which were themselves encrusted by *Praeexogyra hebridica* and bored by gastrochaenid or lithophagid bivalves. A loose specimen of the ammonite *Clydoniceras hollandi* (S.S. Buckman) from beneath the outcrop of the Digona Bed at Herbury has been reported by Torrens (1980b). The Digona Bed resting on a hardground has also been reported at *Langton Herring Quarry* (see 'Description' (6)).

(6) Langton Herring Quarry (SY 608 822)

A former exposure of Forest Marble Formation in a small quarry on the escarpment north of the coastguard station near Langton Herring was cited by Torrens (1968a) based on records made by F.H.A. Engleheart in an unfinished thesis for Oxford University in the 1920s. The quarry, which Torrens (1968a) described as 'now overgrown', exposed the Digona Bed, comprising up to 0.9 m of pale, cream-coloured, detrital limestone full of shell fragments, overlying 2.1 m of massive, somewhat ooidal, fine-grained limestone. A section at the quarry was subsequently recorded by Holloway (1981). As at *Herbury* (see 'Description' (5)), the Digona Bed rests on a surface bored by lithophagid bivalves and encrusted with oysters including *Liostrea wiltonensis* (Lycett), *Nanogyra crassa* (Wm Smith), *N. nana* (J. Sowerby) and *Praeexogyra hebridica* (Forbes). Beneath this hardground, the limestone, cross-bedded in its upper part, has two generations of cement: an early, radial sparry fringe around ooids and bioclasts, and a secondary, ferroan, void-filler. Torrens (1968a) and Holloway (1981) recorded an extensive faunal list very similar to that for *Herbury* (see 'Description' (5)); the latter author noted that the quarry was the only exposure of the Digona Bed where the eponymous brachiopod *D. digona* was common.

(7) Butterstreet Cove–Tidmoor Point (SY 633 799 and SY 643 785)

The easternmost part of the Bathonian GCR site lies in Butterstreet Cove (SY 633 799) and is continued south-eastward by the Callovian GCR site as far as the eastern tip of Tidmoor Point; the boundary between the two sites is taken where the stream, that passes through East Fleet village crosses the shore (Figure 2.5). Within this *c.* 2.8 km stretch of coast, the Cornbrash, Kellaways and Oxford Clay formations are intermittently exposed on the shore or in banks or low cliffs (Blake, 1905; Arkell, 1947a, 1948; Cope, 1969; Macfadyen, 1970; Page, 1988; Chapman, 1997). Parts of the succession may be repeated by small faults.

Three small exposures of the Cornbrash Formation on the eastward-facing flank of Butterstreet Cove were described by Page (1988), who recorded up to 1.7 m of thinly bedded or massive, silty or calcareous sandstones and sandy limestones. The beds are burrowed but generally poorly fossiliferous with only shell fragments and serpulids, although one exposure yielded the ammonite *Macrocephalites*. Calcareous concretions, up to 0.5 m in diameter, are also present.

Passing eastwards on to the south-facing flank of Butterstreet Cove, Page (1988) recorded a small exposure of Kellaways Formation comprising *c.* 0.05 m of thinly bedded, grey, muddy sandstone with abundant bivalves, including *Goniomya literata* (J. Sowerby), *Nanogyra*, *Pholadomya* and *Pleuromya uniformis* (J. Sowerby), the ammonite *Cadoceras* and a nautiloid, passing down into *c.* 0.25 m of bluish-grey sandy clay with some shell fragments.

Between there and the shore at East Fleet, Page (1988) recorded two further exposures of the Cornbrash Formation. The following section is based on that recorded just west of the East Fleet stream.

	Thickness (m)
Cornbrash Formation	
Upper Cornbrash	
4: Sandstone, calcareous, pale brownish-grey, weathering buff; irregular upper surface; shelly concretions with bivalves including *Pholadomya deltoidea* (J. Sowerby); silty and sandy seam at base	0.2–0.3
3: Sandstone as Bed 4; massive in upper part; thin, irregular bedding in lower part; varied assemblage of trace fossils including *Rhizocorallium*; clusters of shells, often fragmentary, in upper part; 'myid' bivalves (*Pholadomya* and *Pleuromya*) in growth position; ammonites including *Paracadoceras breve* (Blake) on irregular upper surface and *Macrocephalites* cf. *terebratus* (Phillips) near middle	0.45–0.5
2: Limestone, sandy, rubbly/brashy, weathering brown, in sandy matrix with wisps of grey mud; calcareous concretions with shelly cores abundant in lower part; bivalves	
2 (cont.): including *'Astarte'*, *Chlamys* and *Pholadomya deltoidea* (J. Sowerby); passing down into	*c.* 0.5
1: Sandstone, calcareous, weathering buff, heavily burrowed; occasional serpulids; and bivalves including *Goniomya literata* (J. Sowerby)	seen up to 0.2

Southwards from East Fleet, the Kellaways Formation and lower part of the Oxford Clay Formation have been reported but the exposures are so shallow and intermittent that only the crudest succession can be inferred (Callomon and Cope, 1995). The Kellaways Clay Member of the Kellaways Formation crops out near the small headland to the south of East Fleet where Page (1988) reported traces of a bed crossing the shore that contained large septarian limestone concretions; large body chambers of the ammonite *Proplanulites* have also been recorded (Arkell, 1948; Cope, 1969; Callomon and Cope, 1995). Farther south on the shore, sandy shales with the oyster *Gryphaea dilobotes* Duff, possibly representing the Kellaways Sand Member of the Kellaways Formation, were reported by Arkell (1948) although not seen by Page (1988). Between there and Chickerell Hive Point (see Figure 2.5), the latter author reported an exposure of *c.* 1 m of grey clay with large septarian concretions occasionally containing the ammonite *Kosmoceras jason* (Reinecke); these Oxford Clay Formation beds had previously been seen by Arkell (1948) and noted by subsequent authors (e.g. Cope, 1969).

Higher levels of the Oxford Clay Formation are exposed along the shore on the north-east side of Chickerell Hive Point, where bituminous shales with some layers of large septarian concretions up to 0.6 m in diameter have been reported together with the ammonites *Kosmoceras castor* (Reinecke) and *Kosmoceras grossouvrei* Douvillé, and in the bay on the west side of Tidmoor Point where shales with *Kosmoceras transitionis* Nikitin have been recorded (Arkell, 1948; Cope, 1969; Callomon and Cope, 1995).

The banks of Tidmoor Point itself expose slipped grey clays with occasional pale phosphatic and calcareous nodules, typically comprising ammonite body chambers. Clays on the flat foreshore have yielded countless small pyritic and limonitic ammonites of the genera *Alligaticeras*, *Distichoceras*, *Euaspidoceras*, *Grossouvria*, *Hecticoceras*, *Kosmoceras*, *Pachyceras*, *Paralcidia*, *Peltoceras* and

Quenstedtoceras, but these are not now found in such abundance, even after winter storms, and no succession can be made out easily (Chapman, 1997). Belemnites, including common *Hibolithes hastatus* de Montfort and ?*Lagonibelus*, nautiloids (*Paracenoceras*), pyritized bivalves (*Grammatodon* and *Nuculana*) and gastropods (*Procerithium*), and pentacrinoid stem fragments are also common.

East of Tidmoor Point, and beyond the eastern boundary of the GCR site, younger (Oxfordian) beds of the Oxford Clay Formation crop out but are commonly heavily obscured by seaweed (Callomon and Cope, 1995; Chapman, 1997, 1999).

Interpretation

The small and discontinuous nature of the exposures along The Fleet coastline and general lack of useful borehole data in the Weymouth Anticline as a whole has meant that previously published formational thicknesses for the Middle Jurassic succession have largely been crude estimates. The values shown in Figure 2.6 are based on those given on the latest edition of the 1:50 000 geological map (British Geological Survey, 2000), which are based on deep borehole data (C.R. Bristow, pers. comm.) and the BGS Seabarn Farm Borehole (SY 6263 8054) (Whittaker *et al.*, 1985; Hamblin *et al.*, 1992). Some of the thicknesses, notably those of the Frome Clay and Forest Marble formations, are substantially greater than previous estimates.

Frome Clay Formation

Up until the 1980s, the beds now classified as the Frome Clay Formation were referred to as 'Upper Fuller's Earth Clay' (e.g. Torrens, 1969b, 1980b; Holloway, 1981, 1983) but since then, the consensus view has increasingly favoured use of the former term following Penn and Wyatt (1979) (see **Watton Cliff** GCR site report, this volume, for discussion). At Watton Cliff, the basal stratum of the Frome Clay Formation is the Wattonensis Beds (Kellaway and Wilson, 1941), which there comprise *c.* 8 m of alternating clays and thin limestones with a rich and varied fauna dominated by brachiopods including the eponymous *Rhynchonelloidella wattonensis* Muir-Wood and *Wattonithyris wattonensis* Muir-Wood. Within the Shipmoor Point–Butterstreet Cove GCR site area, almost all authors have recognized the Wattonensis Beds as the *c.* 1 m of clay yielding exquisitely preserved fossils that underlies the Elongata Beds at *Rodden Hive Point* (see 'Description' (3)). However, House (1989) preferred only to infer possible equivalence to the Wattonensis Beds, noting the absence at *Rodden Hive Point* of the brachiopod *Wattonithyris*. Some earlier authors had thought the clay belonged to the Kellaways Formation (e.g. Arkell, 1932) or the Oxford Clay Formation (e.g. Cunnington, 1925), but Arkell (1940) corrected these interpretations after seeing in-situ material in excavations made beneath the Elongata Beds. The ammonites recorded from the Wattonensis Beds at *Rodden Hive Point* (e.g. Callomon and Cope, 1995) indicate the Upper Bathonian Retrocostatum Zone, Quercinus Subzone (Page, 1996a).

When first noted and figured by Damon (1860) and later cited by other authors (e.g. Woodward, 1894; Buckman, 1922a), the characteristic elongate oyster (*Praeexogyra hebridica* var. *elongata*) of the Elongata Beds, which are seen at both *Rodden Hive Point* and *Langton Hive Point* (see 'descriptions' (3) and (4)), was identified incorrectly as *Ostrea acuminata* J. Sowerby. The latter species occurs in the underlying Fuller's Earth Formation where, farther north, it gives its name to a marker bed(s) (see Figure 3.4, Chapter 3). The oyster lumachelles that constitute the Elongata Beds, although quite widely distributed, show considerable variation in thickness (see, for example, 'descriptions' (3) *Rodden Hive Point* and (4) *Langton Hive Point*) and, in places within the area of the Weymouth Anticline, may thin out altogether (House, 1957). Some authors have not adopted Arkell's (1933) name, as endorsed by Torrens (1980b), for this stratum, but instead have used the term 'Hebridica Beds' (e.g. House, 1989) or 'Oyster Beds' (e.g. Callomon and Cope, 1995).

Forest Marble Formation

The richly fossiliferous Boueti Bed provides a widespread marker bed at the base of the Forest Marble Formation from the Weymouth Anticline to nearly as far north as the Mendip Hills (see also **Watton Cliff** GCR site report, this volume). Brachiopods, in particular the eponymous *Goniorhynchia boueti* (Davidson), are more abundant at *Herbury* (the type locality of the latter species) than at Watton Cliff. Arkell (1933) noted that the Boueti Bed at *Herbury* had supplied nearly enough rhynchonellids and terebratulids to pave the beach. The morphological variation of a random *G. boueti* population from there was assessed by Aitken and McKerrow (1948) and Blundell (1948) whose statistical studies of external morphology indicated that all of the morphological variants, however extreme, belonged to a single homogenetic community. De la Beche (1846) regarded the fauna as suggestive of the Bradford Clay of Wiltshire, and Woodward (1894) and later authors (e.g. Richardson, 1909b; Arkell, 1947a) endorsed this correlation. However, Sylvester-Bradley (1957) thought instead that the Bradford Clay might correlate with his newly named 'Digona Bed', the higher brachiopod marker bed in the Forest Marble Formation at *Herbury* but which cannot be recognized at **Watton Cliff** (see GCR site report, this volume). Torrens (1969b) subsequently correlated the Boueti Bed with the Twinhoe Ironshot of the Great Oolite Formation, which underlies the Forest Marble Formation in the Bath area (see Figure 2.4 and **Hinton Hill** GCR site report, this volume). However, the discovery that, in the latter area, faunas of Bradford Clay aspect occur at a number of horizons, especially at the base of and directly above the Upper Rags Member of the Forest Marble Formation (Green and Donovan, 1969; Cave, 1977; Penn and Wyatt, 1979) has led to the current view that the Boueti Bed correlates with the basal shell-bed of the Upper Rags Member, and that the Digona Bed correlates with the Bradford Clay of Bradford-on-Avon (see **Gripwood Quarry** GCR site report, this volume; Penn, 1982; see also Figure 2.4). The ammonite *Clydoniceras hollandi* (S.S. Buckman) reported loose from below the outcrop of the Digona Bed at *Herbury* (Torrens, 1980b) indicates the Upper Bathonian Discus Zone, Hollandi Subzone (Page, 1996a). The poorly preserved *Clydoniceras* (*Delecticeras*) cf. *ptychophorum* (Neumayr) alleged to come from the Boueti Bed (see 'Description' (5) *Herbury*) may indicate the underlying Retrocostatum Zone and Subzone but this is not certain (Torrens, 1980b; Page, 1996a).

Cornbrash Formation

The relatively thick development of the Cornbrash Formation seen on The Fleet coast compared with other localities in Britain led Page (1989), in his stratigraphical revision of the English Lower Callovian strata, to propose addition of the geographical epithet Abbotsbury to the formational name. He also formally divided the formation into two members – the Berry Member and the Fleet Member – to replace respectively the Lower and Upper Cornbrash of Douglas and Arkell (1928) and later authors. The section at *Berry Knap* (see 'Description' (2)), the most complete natural exposure of the formation, provided the type locality for both members. However, many authors feel that the two members cannot be distinguished on lithological criteria alone and have preferred to continue using the traditional terms Lower and Upper Cornbrash, of respectively Bathonian and Callovian age, within an unqualified Cornbrash Formation. The mollusc and brachiopod fauna of Bed 3 at *Berry Knap* is characteristic of the terminal Bathonian times (*Clydoniceras hochstetteri* Biohorizon, Discus Zone and Subzone; Page, 1996a). Stratigraphically important taxa include the ammonites *Clydoniceras* ex gr. *discus* (J. Sowerby) and *Homoeoplanulites* sp., and the brachiopod *Obovothyris obovata* (J. Sowerby).

The brachiopod *Microthyridina siddingtonensis* (Walker) in beds 5–8 at *Shipmoor Point* and in beds 6 and 8 at *Berry Knap* indicates the *siddingtonensis* Biozone of Douglas and Arkell (1928) and therefore the Lower Callovian Herveyi Zone, Keppleri Subzone (Page, 1989). Confirmatory in-situ ammonite evidence is not yet available in the area but specimens of *Macrocephalites* cf. *jacquoti* Douvillé and *M.* cf. *verus* S.S. Buckman found loose near East Fleet (Page, 1988) also indicate the Keppleri Subzone. *Microthyridina* cf. *lagenalis* (Schlotheim) and *Macrocephalites* aff. *terebratus* (Phillips) from near the top of the section at *Berry Knap* suggest the next youngest Terebratus Subzone (Page, 1988, 1989). Similar levels near East Fleet have yielded the ammonite *Paracadoceras breve* (Blake), including its holotype (Blake, 1905); this is the only confirmed occurrence of this Arctic genus in Britain (Callomon, 1985b; Page, 1988, 1989).

Kellaways Formation

Following the loss of the former exposure at Putton Lane Brickpit (Arkell, 1947a, 1948; Macfadyen, 1970), only traces of the overlying Kellaways Formation remain visible in The Fleet area. The large *Proplanulites* body chambers recorded from the Kellaways Clay Member in Butterstreet Cove have been identified as *Proplanulites* cf. *majesticus* S.S. Buckman, suggesting the Gowerianus Subzone of the Koenigi Zone (Arkell, 1948; Page, 1988). Similar *Proplanulites*, with keppleritid ammonites including *Kepplerites* (*Gowericeras*) *metorchus* S.S. Buckman and septaria, from the former Putton Lane Brickpit provide supporting evidence for the lower part of the Koenigi Zone. There are no specific records of younger levels of the Kellaways Clay Member on the shores of The Fleet but the next youngest Curtilobus Subzone of the Koenigi Zone is indicated locally by calcareous nodules simply labelled 'Weymouth', which have yielded the holotype of *Kepplerites* (*Gowericeras*) *dorsetensis* Tintant, and the Calloviense Zone and Subzone were formerly seen at Putton Lane Brickpit (Arkell, 1933, 1947a, 1948). The diagnostic ammonite fauna of the latter, as re-determined by Page (1988), includes *Sigaloceras* (*S.*) *calloviense* (J. Sowerby), *Proplanulites* ex gr. *crassicostatus*/*petrosus* S.S. Buckman, *Cadoceras sublaeve* (J. Sowerby), *Macrocephalites* sp. and *Reineckeia* cf. *britannica* Zeiss; *Oxytoma*-rich nodules are also present. *Macrocephalites* and *Reineckeia* are genera having southern affinities and are generally very rare or absent at equivalent levels elsewhere in Britain. Indeed, examination of old museum collections suggests that the Kellaways Formation in The Fleet area may contain faunas unknown elsewhere in Britain. The overlying Kellaways Sand Member appears to be very thin in The Fleet area. In fact, as the Kellaways Clay Member itself normally includes some sandy and silty lithologies in which the 'muddy sandstone' at Putton Lane Brickpit (Arkell, 1947a, 1948; Page, 1988) and 'sandy shale' on The Fleet shore could be accommodated, it may be that the whole of the Kellaways Formation here can be assigned to that member (e.g. British Geological Survey, 2000). The ammonite fauna includes taxa with southern affinities that are generally very rare or absent at equivalent levels in Britain; for example, *Macrocephalites* and *Reineckeia* in the Calloviense Zone.

Oxford Clay Formation

The Oxford Clay Formation straddles the Callovian and Oxfordian stages but the Callovian part is nowhere continuously exposed in the Weymouth area. The lowest beds (Calloviense to Jason zones), including a basal layer of large septarian concretions, were formerly exposed at the Putton Lane Brickpit (Arkell, 1947a). On the shores of The Fleet, a dark grey, pyritic septarian concretion yielding *Sigaloceras* (*Catasigaloceras*) cf. *anterior* (Brinkmann), *Cadoceras* sp. and *Macrocephalites* ex gr. *tumidus* (Reinecke) found loose in Butterstreet Cove near East Fleet (Page, 1988) may come from this level; the ammonite assemblage indicates the Calloviense Zone, Enodatum Subzone. The patchy exposures reported above on the north-east side of Chickerell Hive Point and in the bay on the west side of Tidmoor Point show slightly higher levels of the Oxford Clay Formation Peterborough Member (Jason to Athleta zones); these are or have been better exposed in the nearby **Crookhill Brickpit**, (see GCR site report, this volume). The clays exposed on the western banks of Tidmoor Point belong to the overlying Stewartby Member, which, in this area, cannot be distinguished on lithological grounds alone from the overlying Weymouth Member. The latter, of Oxfordian age, can be seen to the east of Tidmoor Point and at **Ham Cliff** (see GCR site report, this volume) (Chapman, 1999). The prolific pyritic ammonite fauna that the clays at Tidmoor Point have yielded led Arkell (1947a) to describe it as one of the most celebrated fossil localities in England. Although many type specimens almost certainly come from here, it is possible that some specimens came instead from some now obliterated brickpit, from Radipole Backwater or from Weymouth Pottery, as the preservation of many old museum specimens is not absolutely typical of material from Tidmoor Point. Ammonite specimens from the latter are mainly nuclei or inner whorls. Identified taxa have been listed by Spath (1933) and Arkell (1947a); according to Page (herein), these include *Quenstedtoceras* ex gr. *lamberti* (J. Sowerby) (possibly including the type specimen of the species), *Q. leachii* (J. Sowerby) (including the neotype figured by Arkell 1947a, pl. 2, fig. 6), *Q.* cf. *brasili* Douvillé, *Kosmoceras* (*K.*) ex gr. *spinosum* (J. de C. Sowerby) (including possible topotypes and maybe the holotype of *K. tidmoorense* Arkell), *Hecticoceras* (*Putealiceras*) ex gr. *puteale* (Leckenby), *H.* (*Lunuloceras*) sp., *Paralcidia* sp., *Euaspidoceras hirsutum* Bayle, *Alligaticeras* (*A.*) aff. *alligatum* (Leckenby), *Grossouvria* (*Poculisphinctes*) aff. *poculum*

(Leckenby), *G.* (*?G.*) *trina* (S.S. Buckman), *Peltoceras* (*Peltomorphites*) spp. including *P. subtense* (Leckenby), *Distichoceras bicostatum* (Stahl) and *Pachyceras lalandeanum* (d'Orbigny). The bulk of this fauna belongs to the Upper Callovian Lamberti Zone with evidence of both the Henrici and Lamberti subzones, but late Athleta Zone (Spinosum Subzone) faunas could also be represented. Thus, although Tidmoor Point remains a classic locality of historical interest, Arkell's (1947a) remark that 'for the classification of the Oxford Clay in north-west Europe the importance of this locality could hardly be over-estimated' is now an over-statement because the fauna is stratigraphically mixed, *ex situ*, and no succession can be deduced. Other localities in Yorkshire (see Chapter 5), central England (see Chapter 4), Dorset (see **Ham Cliff** GCR site report, this volume) and elsewhere in Europe have since provided measurable sections and in-situ stratigraphical and palaeontological information at this level.

Conclusions

The exposures along the coast of The Fleet provide a cross-section through the E–W-trending geological structure known as the 'Weymouth Anticline', and have had a long history of investigation. Although much of the coastline is developed as scenically unattractive low clay banks and cliffs, and exposed sections are often short and scruffy, a discontinuous sequence through the upper part of the Bathonian Stage (uppermost Fuller's Earth Formation to Cornbrash Formation) and the entire Callovian Stage (Cornbrash, Kellaways and Oxford Clay formations) is recognized here. The site includes an important Bathonian–Callovian stage boundary section within the Cornbrash Formation, as well as the proposed type locality of the latter. Many beds are highly, sometimes uniquely, fossiliferous and they have yielded a number of type specimens including ammonites of international importance. The site thus has stratigraphical and palaeontological significance at a regional, national and international level.

CROOKHILL BRICKPIT, DORSET (SY 644 798)

K.N. Page

Introduction

Close to the shores of the Fleet on the Dorset coast (see **Shipmoor Point–Butterstreet Cove and Tidmoor Point–East Fleet Coast** GCR site report, this volume), the disused brickpit (Figure 2.8) at Crookhill, Chickerell, exposes a degraded section in the Oxford Clay Formation

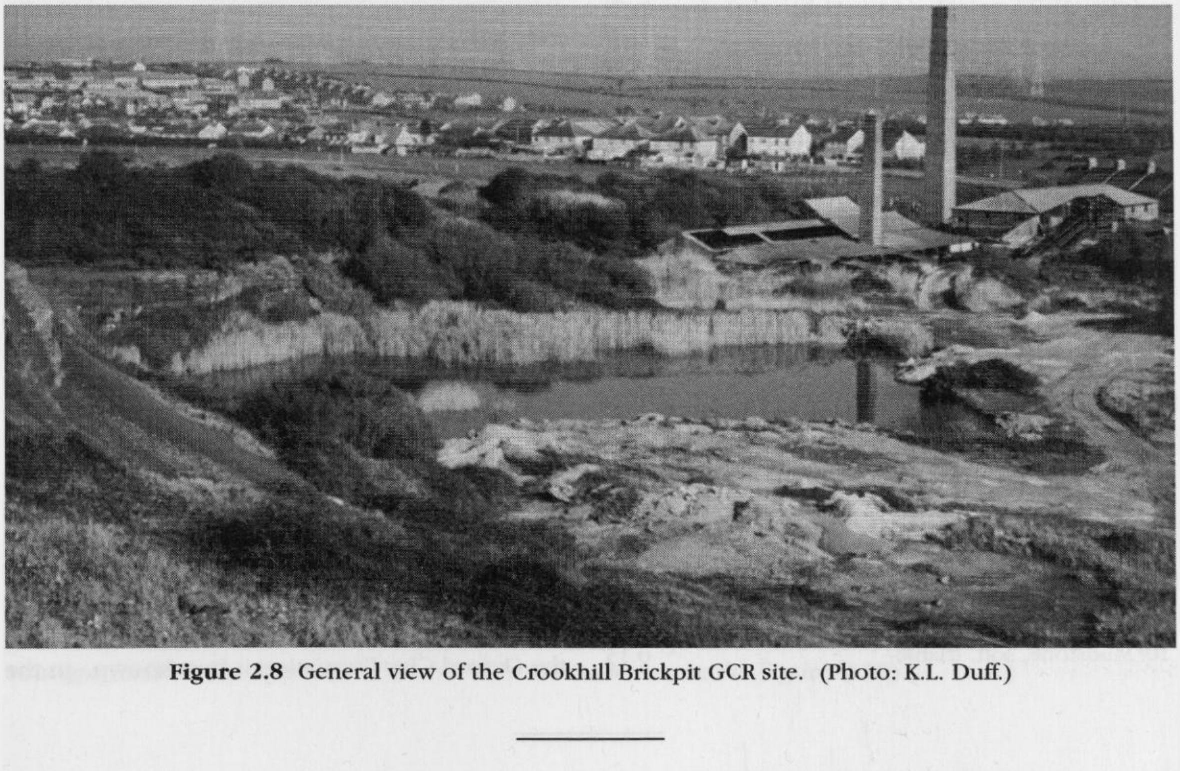

Figure 2.8 General view of the Crookhill Brickpit GCR site. (Photo: K.L. Duff.)

spanning the Middle–Upper Callovian substage boundary. The succession, in predominantly mudrock facies, has yielded a rich fauna of ammonites, belemnites and bivalves, particularly from the Upper Callovian Athleta Zone.

Description

The site was referred to by Spath (1933) and described more fully by Arkell (1947a) as later reviewed by Macfadyen (1970). Smith (in Torrens, 1969c) re-described the section, as summarized by Callomon and Cope (1995), and the following details are based on their combined records; the lower beds, as described below, are no longer visible.

	Thickness (m)
Oxford Clay Formation	
?***Stewartby Member***	
21: Clay, weathered brown, with large septarian concretions; well-preserved ammonites (mainly body chambers) including *Peltoceras trifidum* (Quenstedt) (= *P. athleta* auctt *non* Phillips), *P.* (*Rursiceras*) *baylei* Prieser, *Kosmoceras* ex gr. *proniae* (Teisseyre) (including *K. bigoti* Douvillé); abundant *Gryphaea lituola* Lamarck	5.0
20: Clay, blue-grey; small septarian concretions; fauna as in Bed 21 but sparser with ammonites including *Hecticoceras*, *Kosmoceras*, *Pseudopeltoceras chauvinianum* (d'Orbigny) and *Reineckeia* (*Collotia*?)	3.0
Peterborough Member	
19: Mudstone, hard; ammonites including *Brightia* and *Lunuloceras*	0.2
18: Mudstone, soft; *Lunuloceras*	0.2
17: Mudstone, tough, bituminous; ammonites including *Brightia*, *Kosmoceras* and *Peltoceras* (*Rursiceras*)	0.25
16: Mudstone, soft; abundant bivalves including astartids and nuculaceans	0.95
15: Mudstone, hard; ammonites including *Brightia*, *Lunuloceras* and *Kosmoceras phaeinum* (S.S. Buckman)	0.20
14: Clay and soft, friable mudstone	0.25
13: Mudstone, hard, brown, bituminous; many oppeliid ammonites including *Brightia* and *Lunuloceras*; *Kosmoceras aculeatum* (Eichwald) and *K. phaeinum*	0.80
12: Mudstone and soft clay; many nuculacean bivalves and crushed *Gryphaea*	0.35
11: Mudstone, hard, bituminous; ammonites including *Kosmoceras aculeatum* with *Reineckeia* (*Reineckeites*) and other perisphinctids	1.70
10: Mudstone, soft, friable	0.15
9: Mudstone, hard, brown, bituminous; ammonites including *Hecticoceras*, *Kosmoceras aculeatum*, *K. ornatum* (Schlotheim) and *K. phaeinum*	0.25
8: Clay, soft, blue	0.10
7: Clay, tough, brown, bituminous; ammonites including *Binatisphinctes comptoni* (Pratt) (macroconch and microconch) and other perisphinctids, *Kosmoceras acutistriatum* (S.S. Buckman), *K. ornatum* and *K. phaeinum*	0.35
6: Clay, soft; ammonites including *K. ornatum*	0.40
5: Mudstone, tough, calcareous; abundant kosmoceratid and perisphinctid ammonites including *K. aculeatum*, *K. acutistriatum*, *K. gemmatum* (Phillips), *K. phaeinum* and *Binatisphinctes comptoni* (macroconch and microconch)	1.5
4: Mudstone, tough, brown, bituminous; abundant ammonites including macroconch and microconch *Binatisphinctes comptoni*, *Hecticoceras*, *Kosmoceras castor* (Reinecke), *K. gulielmi posterior* Brinkmann, *K. grossouvrei* Douvillé and *K. pollucinum* (Teisseyre); bivalves, including *Bositra buchii* (Roemer); cerithiid gastropods and crustaceans	1.2
3: Mudstone, hard, bituminous, alternating with soft clay with septarian cementstone doggers; abundant crushed and finely pyritized ammonites including *Erymnoceras coronatum* (Bruguière), *Kosmoceras castor*, *K. grossouvrei* and *K. pollux* (Reinecke)	6.15
2: Mudstone, bituminous, greenish-grey with bands of clay; crushed ammonites including *Erymnoceras coronatum*, *Kosmoceras castor*, *K. gulielmi* and *K. obductum* (S.S. Buckman); fairly common belemnites (*Cylindroteuthis pusoziana* (d'Orbigny)); abundant nuculacean bivalves with *Gryphaea* and cerithiid gastropods	3.8
1: Clay, tough, blue and grey, bituminous; crushed ammonites including *Kosmoceras gulielmi* and *K. jason* (Reinecke); many oysters and nuculacean bivalves; palynomorphs reported by Sarjeant (1960)	seen

Beds 4 and 5 form a more resistant, prominent band in the western face of the pit.

Interpretation

The succession exposed at Crookhill Brickpit shows the boundary between the Peterborough and Stewartby members (the Lower and Middle Oxford Clay of traditional usage) although the two are not so clearly differentiated as in the South and East Midlands (see Chapter 4), where the Oxford Clay Formation is best known. In the

Midlands, the Peterborough Member mainly comprises predominantly brownish-grey, fissile, 'bituminous' (i.e. organic-rich) mudstone with a fauna dominated by crushed aragonitic ammonites and bivalves, the latter including nuculacean and *Meleagrinella* shell beds. The Stewartby Member is predominantly pale- to medium-grey, commonly smooth-textured, variably silty, calcareous, generally rather poorly fossiliferous, blocky mudstone with ammonites and other macrofauna usually preserved as pyritic internal moulds (Cox *et al.*, 1992). At Crookhill Brickpit, beds up to and including Bed 19 are clearly Peterborough Member and the top of that bed has generally been accepted as the boundary between the two members.

The ammonite faunas enable recognition of the Middle Callovian Jason Zone (and Subzone) (Bed 1) and Coronatum Zone (beds 3–4), and the Upper Callovian Athleta Zone (beds 5–21). Both subzones of the Coronatum Zone are present, the Obductum Subzone in Bed 2 and the Grossouvrei Subzone in beds 3–4. Specimens of the ammonites *Erymnoceras coronatum* and *Kosmoceras grossouvrei* from here were figured by Page (1991). The presence in Bed 4 of the ammonite *Binatisphinctes comptoni* indicates its nominal biohorizon, which terminates the latter subzone, and correlation with the marker bed known in the Midlands as the Comptoni Bed. The Grossouvrei Subzone here has also yielded an interesting teuthid (i.e. non-belemnite coleoid) fauna (Carreck, 1960; Page and Doyle, 1991), and teleostean fish (Carreck, 1960).

Ammonites in the lower part of the succeeding Bed 5 indicate the *K. acutistriatum* Biohorizon at the base of the Athleta Zone. This bed is partly equivalent to the well-defined marker horizon called the 'Acutistriatum Band' in the Midlands succession (see **Peterborough Brickpits** GCR site report, this volume). The Phaeinum Subzone, the oldest of the Athleta Zone, is recognized up to and including Bed 19. Above this bed, the ammonite fauna in beds 20 and 21 is characteristic of the Proniae Subzone, an interval that is not now as fully exposed and with such a varied fauna anywhere else in Britain. The presence of several Tethyan Reineckeiidae at this level is potentially significant for detailed correlations with more southerly areas of Europe where the genus *Reineckeia* is common and used as a stratigraphical index fossil.

Conclusions

The brickpit at Crookhill, Chickerell, Dorset, which ceased to be worked in 1969, has been known in the literature for over 60 years. Correlatives of the Comptoni Bed and Acutistriatum Band, well-known widespread marker beds in the Oxford Clay Formation of central and eastern England, can be recognized here, and the ammonite faunas endorse the Middle–Upper Callovian substage boundary at this level. The ammonites of the Athleta Zone are of particular interest as they include Tethyan elements, not well represented elsewhere in Britain; these offer the potential of detailed correlations with Callovian successions elsewhere in Europe.

HAM CLIFF, REDCLIFF POINT, DORSET (SY 713 817)

K.N. Page

Introduction

The coastal exposure of the Oxford Clay Formation at Ham Cliff, at the east end of Weymouth Bay in Dorset, spans the Callovian–Oxfordian stage boundary (Figure 2.9). Other exposures of the Upper Callovian and Lower Oxfordian substages on the Dorset coast tend to be masked by slumping or superficial deposits, or are on a flat foreshore where no proper succession can be deduced (see **Shipmoor Point–Butterstreet Cove and Tidmoor Point–East Fleet Coast** GCR site report, this volume). At Ham Cliff, a good section can generally be exposed with minimal digging and, as a natural coastal exposure, it may be considered to be essentially permanent. The site has been known for a long time but it was not until coastal erosion in the 1990s improved the exposure that the relatively expanded and ammonitiferous stage boundary beds were fully appreciated (Chapman, 1999).

Description

The site has been noted by Arkell (1947a) and Cope (1969) but the most recent and fullest account is that of Callomon and Cope (1995) on which the following details, including bed numbers, are based. The measured section is in the cliff but Bed 1, at the base, extends downwards for up to a metre into the beach below high-water mark (Figure 2.10).

Figure 2.9 General view of Ham Cliff from Redcliff Point. The Callovian–Oxfordian stage boundary lies in the grey clays of the Oxford Clay Formation on the right of the picture. The steep cliff is in the lower part of the Corallian Group. (Photo: K.N. Page.)

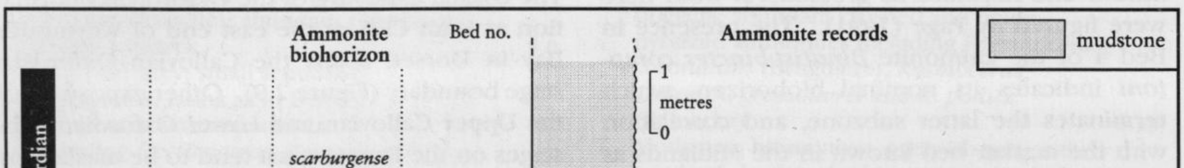

Figure 2.10 Graphic section of the Callovian–Oxfordian stage boundary beds at Ham Cliff. (After Callomon and Cope, 1995, fig. 21.) For lithologies, see text.

	Thickness (m)
Oxford Clay Formation	
5: Clay, dark, slightly fissile, richly fossiliferous with abundant ammonites, including macroconch and microconch *Quenstedtoceras* cf. *woodhamense* Arkell at base, *Q. mariae* (d'Orbigny) and *Q. woodhamense* at 0.7 m above base, and typical *Cardioceras scarburgense* (Young and Bird) with common *Gryphaea dilatata* J. Sowerby at 1.5 m above base; ammonites crushed but with body chambers preserved in yellowish-brown slightly phosphatized marlstone	up to 11.5
4: Clay, dark, slightly fissile, very sparsely fossiliferous with scattered ammonites (*Quenstedtoceras* cf. *paucicostatum* (Lange)); fairly persistent bands of brown, ferruginous mudstone at 1.8 and 2.2 m above base; in upper part of bed, ammonites crushed and with phosphatized body chambers; tenacious in upper 0.3 m	4.5
3: Pyritic shell-detrital bed forming persistent, but not always prominent, marker; locally with lenticular, brown ironstone	0.10
2: Clay, slightly pyritic, weathering more flaky; sparsely fossiliferous with *Quenstedtoceras lamberti* (J. Sowerby) often with uncrushed pyritic inner whorls; thin ironstone in lenses near sharp base	0.75
1: Clay, pale-grey, fairly tough, non-laminated, calcareous; occasional thin (0.01–0.03 m), lenticular layers of brown ferruginous mudstone or ironstone at or near top; shell-plaster of crushed white ammonites at top forming slight ledge and marker; common *Quenstedtoceras praelamberti* Douvillé at 0.75 m below cliff base with *Q.* (*Eboraciceras*) sp. and *Euaspidoceras* sp. up to 0.50 m below cliff base; scattered *Q. praelamberti* above but becoming abundant in top 0.3 m with profuse *Q. lamberti sensu stricto* and *Q. flexicostatum* (Phillips), fairly common *Kosmoceras* sp., occasional *Hecticoceras* sp., *Alligaticeras* sp. and *Peltoceras* sp.	seen to *c.* 3.0

Interpretation

The ammonite faunas of beds 1–4 indicate the Upper Callovian Lamberti Zone and Subzone (including the *praelamberti*, *lamberti* and *paucicostatum* biohorizons). The older Henrici Subzone of the Lamberti Zone is not reached. The ammonites of Bed 5 indicate the Lower Oxfordian Mariae Zone. The boundary between these two zones is usually indicated by the transition from ammonites of the group of *Q. lamberti* to those of the *Q. mariae* group. Callomon and Cope (1995) described this as a 'matter of some delicacy and possibly to some degree arbitrary' when the faunal successions are seemingly continuous as at Ham Cliff. In the Midlands, the zone and stage boundary coincides with the top of the Lamberti Limestone, a condensed 'event horizon' that also marks the boundary between the Stewartby and Weymouth members of the Oxford Clay Formation (the Middle and Upper Oxford Clay of traditional usage). The Stewartby Member is a predominantly pale- to medium-grey, commonly smooth-textured, variably silty, calcareous, generally rather poorly fossiliferous, blocky mudstone with ammonites and other macrofauna usually preserved as pyritic internal moulds (see **Crookhill Brickpit** GCR site report, this volume). The Weymouth Member is a predominantly pale-grey, blocky, smooth-textured, calcareous mudstone, generally only slightly silty but with thin dark-grey, carbonaceous beds with striking interburrowing at some levels as well as thin calcareous siltstones; although generally poorly fossiliferous, large *Gryphaea* are characteristic and the ammonite fauna is usually pyritized and occasionally associated with sideritic mudstone nodules (Cox *et al.*, 1992). At Ham Cliff, where the succession is relatively expanded, the two members cannot be differentiated on the basis of lithology alone and there appears to be no detectable lithological change or marker bed comparable with the Lamberti Limestone such as is developed elsewhere.

The *praelamberti*, *lamberti* and *paucicostatum* biohorizons are now widely recognized in Europe (Thiérry *et al.*, 1997). The *paucicostatum* Biohorizon is of particular importance in the definition of the Callovian–Oxfordian stage boundary. It was first recognized as a separate faunal biohorizon by Marchand (1979) who referred the species to the genus *Cardioceras* but Callomon and Cope (1995) considered that the morphological affinities seemed closer to *Q. lamberti*. Whatever the generic assignment, the *paucicostatum* Biohorizon is now taken as the youngest and final part of the Callovian Stage throughout much of north-west Europe (Fortwengler and Marchand, 1994). On the Yorkshire coast, which had previously been considered as the best area for a British reference section for the Callovian–Oxfordian stage boundary (see **Osgodby Point** GCR report, this volume), the boundary succession is much thinner than at Ham Cliff; for example, the *paucicostatum* Biohorizon is only 0.15 m thick compared with *c.* 4.2 m at Ham Cliff.

Conclusions

The succession at Ham Cliff is in ammonitiferous clay facies without major non-sequence and may justifiably be considered as potentially the most important, and certainly the most complete, Callovian–Oxfordian stage boundary section in Britain. The facies is more favourable than that at comparable sections elsewhere in Europe for the recovery of microfossils as well as for chemostratigraphy and magnetostratigraphy. The section is thus a most important one for international correlation of the base of the Oxfordian Stage.

BURTON CLIFF AND CLIFF HILL ROAD SECTION, DORSET (SY 478 895–SY 492 887, SY 487 892)

B.M. Cox

Introduction

The major part of the Burton Cliff and Cliff Hill Road Section GCR site comprises the coastal section at Burton Cliff, near Burton Bradstock in Dorset, which extends for *c.* 1.5 km from near Burton Freshwater (the mouth of the River Bride) in the west to the National Trust car park opposite the Bay View Hotel in the east (Figure 2.11). The Aalenian–basal Bathonian Inferior Oolite Formation, overlying Toarcian–Aalenian Bridport Sand Formation and underlying Bathonian Fuller's Earth Formation, crops out high up in the cliff face and is inaccessible, but its constituent beds, many of which are highly fossiliferous, can be examined in fallen blocks on the beach (particularly at the western end) and these provide an excellent substitute for study. In addition, the GCR site includes a separate section in the deep cutting on Cliff Road (SY 487 892), sometimes referred to as the 'Cliff Hill Section' (Richardson, 1928; Wilson *et al.*, 1958), which lies *c.* 150 m north of Burton Cliff. The cutting, from which collecting is not possible, extends towards Burton Bradstock for *c.* 130 m and, when clear of vegetation, exposes a similar, but more accessible, Inferior Oolite Formation succession to that of the cliffs together with the underlying Bridport Sand Formation (Figure 2.12). The semi-permanent exposure at the nearby Freshwater Caravan Park (SY 479 897) which in recent years has enabled additional fossil collecting and provided further sedimentological detail (Callomon and Chandler, 1994; Callomon and Cope, 1995) is not included within the GCR site.

Figure 2.11 East end of Burton Cliff showing the Bridport Sand Formation capped by the Inferior Oolite Formation. (Photo: A5849, British Geological Survey, 1932.)

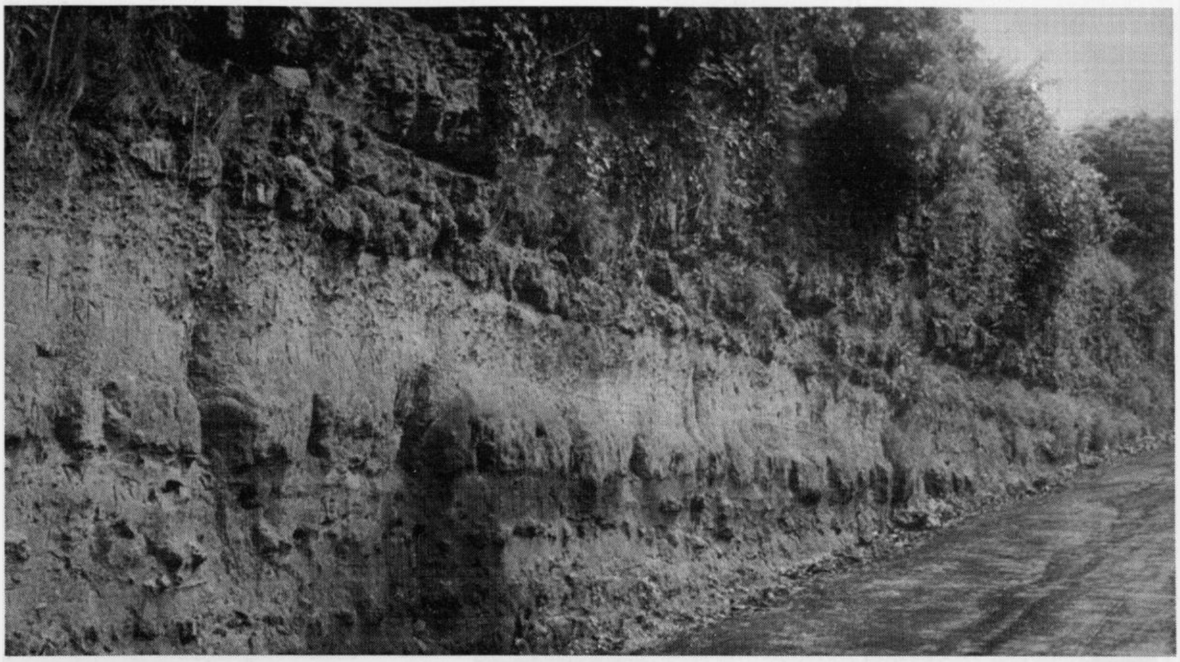

Figure 2.12 Section of Inferior Oolite Formation capping Bridport Sand Formation in the cutting on Cliff Road, Burton Bradstock. (Photo: A5851, British Geological Survey, 1932.)

Description

The following record of the Burton Cliff section (also Figure 2.13) is largely based on that of Callomon (in Callomon and Cope, 1995). His bed numbers originated with Torrens (1969b), who provided the first modern revision of the section based on Buckman (1910a) and Richardson (1928), and are essentially those of the latter author but in reverse order. Other earlier reports of the section include those of Wright (1856, 1860), Day (1863), Hudleston (1887), Woodward (1894), Arkell (1933) and Wilson *et al.* (1958). Following Callomon (in Callomon and Cope, 1995), the fauna recorded below, which is biased towards the ammonites, has been enhanced on the basis of material from the more readily collectable exposure at the nearby Freshwater Caravan Park.

	Thickness (m)
Great Oolite Group	
Fuller's Earth Formation	
19: Clay, grey, somewhat calcareous and silty; poorly fossiliferous; bivalves (*Bositra buchii* (Roemer))	seen to 5.0
Inferior Oolite Formation	
18: *The Scroff*: Marl, rusty, iron-stained, impersistent; belemnites; brachiopods (*Aulacothyris*); poorly preserved ammonites, often encrusted with serpulids	0.05–0.15
17: *Zigzag Bed*: Limestone, nodular, hard, blue-hearted, locally limonitic or pyritic; ammonites including *Ebrayiceras*, *Morphoceras*, *Oecotraustes*, *Oxycerites*, *Parkinsonia*, *Procerites*, *Procerozigzag* and *Zigzagiceras* welded to underlying bed	*c.* 0.15
Burton Limestone	
16: Limestone, pale, more-or-less hard and massive, bioclastic, bioturbated, poorly fossiliferous; parting into three courses	0.65
15: *Sponge Bed*: Limestone, marly, variable; well bedded in several courses, separated by thin, marly partings; thicker limonitic marl at top; coarsely bioclastic with clasts largely of sponge fragments; occasional poorly preserved ammonites (*Parkinsonia*); profuse calcareous sponges; bivalves; brachiopods; bryozoans; crinoids; echinoids (*Cidaris*, *Clypeus*, *Collyrites*); marl parting at base	0.35
14: Limestone, harder than above, coarsely biodetrital and somewhat rubbly packstone; clasts largely of echinoids; divided into two courses (a,b) by undulating parting; sparsely fossiliferous with fauna as above but better preserved; ammonites (*Parkinsonia* (*P.*) *bomfordi* Arkell); large nautiloids; bivalves; brachiopods including *Sphenorhynchia plicatella* (J. de C. Sowerby); echinoids; sponges; undulating parting at base	0.40
13: Limestone, in three main courses (a–c), variably hard; brachiopods (*Sphaeroidothyris sphaeroidalis* (J. de C. Sowerby)) abundant throughout	

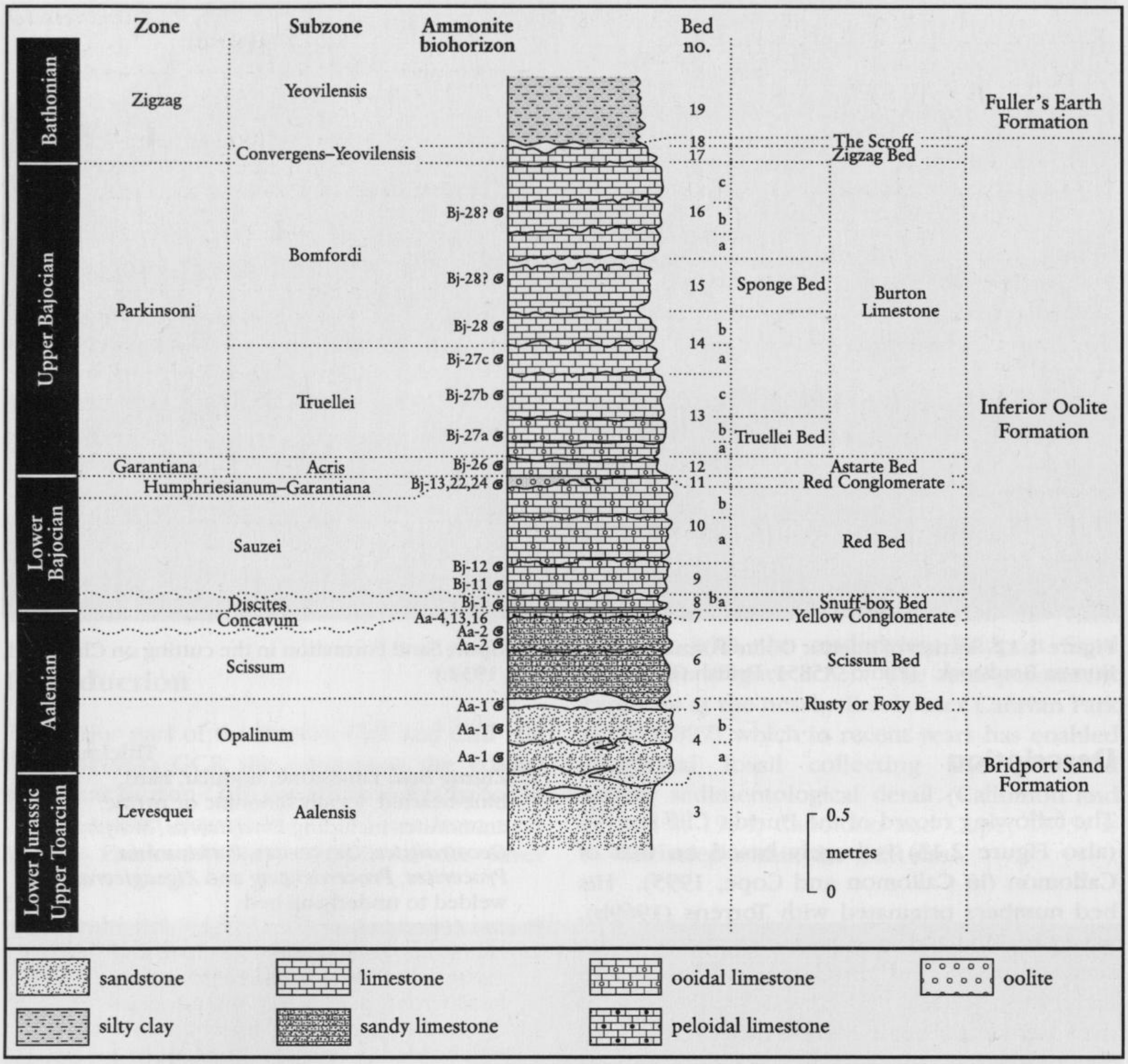

Figure 2.13 Graphic section of the Inferior Oolite Formation at Burton Cliff, Burton Bradstock. (After Callomon and Cope, 1995, fig. 9.) For lithologies, see text.

		Thickness (m)
13c:	Packstone, fine grained, biomicritic, marly, somewhat ferruginous with weathered pockets of limonite; ammonites, as wholly decalcified internal casts including *Lobosphinctes intersertus* S.S. Buckman, *Oxycerites aspidoides* (Oppel), and macroconch and microconch *Parkinsonia pseudoferruginea* Nicolesco; nautiloids	0.30
13b:	*Truellei Bed*: Biosparite, hard, somewhat peloidal with scattered large, cream-coloured ooids and characteristic small black grains or specks; many well-preserved but difficult to extract fossils including macroconch and microconch *Bigotites petri* Nicolesco, *Cadomites daubenyi* (Gemmellaro), *Dimorphinites defrancii* (d'Orbigny), *Lissoceras* spp., *Parkinsonia (Durotrigensia) dorsetensis* (Wright), *Parkinsonia (P.) parkinsoni* (J. Sowerby) β, *Polyplectites*, *Strigoceras truellei* (d'Orbigny); large thick-shelled bivalves including *Ctenostreon*, *Neocrassina*, *Trigonia*; echinoids (*Holectypus*, *Stomechinus*); gastropods; nautiloids; parting at base	0.15–0.20
13a:	Limestone, marly, biomicritic packstone or wackestone; sparsely (upper part) to fairly densely (lower part) ooidal with large, weathering cream-coloured, ooids; less fossiliferous than 13b with ammonites including *Bigotites* sp., *Parkinsonia (Durotrigensia)* aff. *dorsetensis* (Wright) and *P. (P.) parkinsoni* (J. Sowerby) α; belemnites	0.10

Thickness (m)

12: *Astarte Bed*: Limestone, softer than bed above, marly, densely 'iron-shot' ooidal, variable; richly fossiliferous with diverse fauna ranging from bored, thick-shelled bivalves encrusted with epifauna and limonite to perfect 'fresh' ammonites with lappets preserved; *Diplesioceras* spp., *Garantiana* including *G. garantiana* (d'Orbigny), *G. longidens* (Quenstedt) and *G.* (*Pseudogarantiana*) *minima* Wetzel, *Leptosphinctes* (*Cleistosphinctes*) *subdivisus* (S.S. Buckman), abundant *L.* (*Vermisphinctes*) *meseres* (S.S. Buckman), *Lissoceras*, *Oppelia*, *Parkinsonia rarecostata* (S.S. Buckman), *Plagiamites costatus* (Morris), *Sphaeroceras*, *Spiroceras waltoni* (Morris), *Strigoceras septicarinatus* S.S. Buckman; bivalves including, most commonly, *Neocrassina modiolaris* (Lamarck); gastropods including *Pseudomelania procera* (Deslongchamps); small, solitary corals including *Discocyathus* and *Trochocyathus*; spectacular limonitic, algal crust at base 0.10

11: *Red Conglomerate*: Oolite, 'iron-shot' with berthierine, highly variable, preserved in patches and pockets let down into karstic undulating surface of bed below; often conglomeratic with limonite-encrusted worn pebbles including belemnites and ammonite nuclei; locally re-cemented in crimson limonite, sometimes with stromatolitic lamination; in places, thickening into lenticular 'iron-shot' oolite with 'fresh' fossils, particularly ammonites; undulating, sharp base 0–0.15

Divisible into three generations of sediment:

11c. Limestone, white, preserved in blocks as fissure-infills; ammonites including *Cadomoceras* and *Garantiana*; large nautiloids; brachiopods; echinoids

11b. Limestone, white, soft, in small pockets; ammonites including *Leptosphinctes*, *Spiroceras* and *Strenoceras*

11a. Oolite, 'iron-shot', bioturbated but well bedded; well-preserved ammonites including *Dorsetensia* cf. *regrediens* (Haug), *Sonninia* cf. *hebridica* (Morton), rare *Sphaeroceras brongniarti* (J. Sowerby), *Stephanoceras kreter* (S.S. Buckman), *S. mutabile* (Quenstedt), *S. umbilicum* (Quenstedt), *S.* (*Normannites*) *braikenridgii* (J. Sowerby), *S.* (*N.*) *latum* Westermann and *S.* (*Phaulostephanus*) aff. *diniense* Pavia

Red Bed

10: Limestone, massive, hard, in two courses; somewhat ooidal, coarse bioclastic packstone rich in crinoid and echinoid plates; weathering white or pale-pink; totally bioturbated with overprint of large, irregular, vertical burrows often marked by red limonite; sparsely fossiliferous; belemnites; undulating surface largely covered in stromatolitic crusts up to 0.05 m thick at base 0.30–0.50

Thickness (m)

9: Limestone, biodetrital packstone as bed above but somewhat finer; moderately to densely ooidal; weathering olive-grey; ammonites including *Emileia*, *Labyrinthoceras*, *Otoites*, *Nannina evoluta* S.S. Buckman, *Sonninia celans* S.S. Buckman, *S. felix* S.S. Buckman, *S. propinquans* (Bayle) and *Stephanoceras rhytum* (S.S. Buckman); large bivalves; and gastropods (*Bathrotomaria*); sharp base 0.20–0.25

8: *Snuff-box Bed*: Limestone, marly, blue-grey; sparsely to densely ooidal; ooids large and limonitic, concentrated in pockets; scattered large echinoid spines and plates; numerous ellipsoidal, limonitic, strongly laminated oncoids ('snuff-boxes') concentrated locally and embedded at all angles; sharp base 0–0.10

7: *Yellow Conglomerate*: Limestone, marly, weathering yellow with masses of pebbles including rolled, worn ammonites and many belemnites; 'fresh' ammonites including *Graphoceras limitatum* S.S. Buckman; sharp but undulating erosive base 0.05

6: *Scissum Bed*: Limestone, sandy, hard, massive when unweathered; ammonites including, most commonly, *Leioceras* (*L.*) *undulatum* S.S. Buckman (microconch)/*L.* (*Cypholioceras*) *lineatum* S.S. Buckman (macroconch) and rarer *Cylicoceras* (*C.*) *uncinatum* S.S Buckman (macroconch)/*C. subcostatum* S.S. Buckman – *C. paucicostatum* Rieber (microconchs) as well as *Bredyia subinsignis* (Oppel), *Csernyeiceras verpillierense* (Roman and Boyer), *Erycites* aff. *barodiscus* Gemmellaro, *E.* cf. *fallifax* Arkell, *Hammatoceras lorteti* Dumortier, *Planammatoceras planinsigne* (Vacek), *Tmetoceras scissum* (Benecke); *Leioceras* cf. *opalinum* (Reinecke) in lower part; large bivalves including *Ctenostreon* and *Plagiostoma inoceramoides* (Windborne); fossil wood 0.45–0.50

Lias Group

Bridport Sand Formation

5: *Rusty* or *Foxy Bed*: Marl, sandy, brown, somewhat laminated, moderately fossiliferous with ammonites, including *Alocolytoceras taeniatum* (Pompeckj), *Bredyia subinsignis* (Oppel) and *Leioceras opalinum* (Reinecke) (microconch)/ *L. opaliniforme* S.S. Buckman (macroconch); brachiopods; passing down into *c.* 0.05

4b: Sandstone, fine grained, highly calcareous, hard, burrowed and piped; few fossils except local accumulations of *Leioceras opalinum* (Reinecke) near top, *Pachylytoceras torulosum* (Zieten) and rare *Tmetoceras scissum* (Benecke); indistinct parting at base 0.25

4a: Sandstone, fine grained, weakly calcareous, somewhat concretionary; undulating base *c.* 0.20

1–3: Sand, slightly micaceous, yellow, with layers of calcareous, burrowed concretionary sandstone; ammonites including *Pleydellia aalensis* (Zieten) 1.50

Sand with occasional concretionary sandstones seen to 30–40

Interpretation

The ammonite fauna enables recognition of the Aalenian Opalinum, Scissum, Concavum and Discites zones, the Lower Bajocian Sauzei and Humphriesianum zones, and the Upper Bajocian Subfurcatum, Garantiana and Parkinsoni zones (Figure 2.13). In the Aalenian Stage, a non-sequence at the base of Bed 7 cuts out the Murchisonae and Bradfordensis zones, although ammonites indicative of those zones occur as a reworked element in the fauna of Bed 7 (the Yellow Conglomerate of Buckman, 1910a). In the Lower Bajocian Substage, a non-sequence at the base of Bed 9 cuts out the Ovalis and Laeviuscula zones.

The Toarcian–Aalenian stage boundary is taken at the base of Bed 4 in which the ammonite fauna is indicative of the Opalinum Zone and the oldest known Aalenian ammonite biohorizon (Aa-1 *Leioceras opalinum*) (Callomon and Chandler, 1990; Callomon and Cope, 1995). The ammonite *Pleydellia aalensis* (Zieten) in the underlying Bed 3 gives its name to the Aalensis Subzone, the youngest subzone of the Levesquei Zone and Toarcian Stage. At Burton Bradstock and elsewhere in this area, many authors (e.g. Wilson *et al*., 1958; Torrens, 1969b; Parsons, 1980a; Callomon and Cope, 1995 (text only); Hesselbo and Jenkyns, 1995) have taken the top of the Opalinum Zone at the top of the Rusty or Foxy Bed – alternative stratal names, used since Buckman (1910a) – for a thin, brown, sandy marl (Bed 5 above) or iron-stained clay seam. At some localities including the Cliff Hill Road Section, this bed overlies an irregular hardground (Hesselbo and Jenkyns, 1995). The top of the Rusty or Foxy Bed has also been taken by some authors (e.g. Torrens, 1969b; Parsons, 1980a; Hesselbo and Jenkyns, 1995; Cox *et al*., 1999; and herein) as the Bridport Sand–Inferior Oolite formational boundary (see **Conegar Hill** GCR site report, this volume). Although Callomon (in Callomon and Cope, 1995) took this boundary somewhat lower (at the base of Bed 4), he acknowledged that Bed 4a was probably already the topmost cemented member of the Bridport Sand Formation. Buckman (1910a), Arkell (1933) and Wilson *et al*. (1958) had earlier taken the boundary somewhat higher, at the top of Bed 6 (the Scissum Bed). The latter term, which takes its name from the hildoceratid ammonite *Tmetoceras scissum* (Benecke), was first introduced from the Cotswolds (see Chapter 3) to the Dorset succession by Richardson (1928–1930). According to Hesselbo and Jenkyns (1995), the Scissum Bed, which they described as a highly calcareous sandstone rather than a sandy limestone, is similar in aspect to the cemented bands in the Bridport Sand Formation but with much better sorting.

The limonitic oncoids known locally by the quarryman's term 'snuff-boxes', which give their name to Bed 8, are a well-known sedimentological feature in the European Bajocian Stage and they have been investigated in some detail (e.g. Sellwood *et al*., 1970; Gatrall *et al*., 1972; Palmer and Wilson, 1990; Hesselbo and Jenkyns, 1995; Figure 2.14). The bed is assigned to the Discites Zone on the basis of ammonites, including *Hyperlioceras*, recorded by Parsons (1972) from an inland trench section *c*. 2 km to the north-east. The internal structure of the snuff-boxes, which are roughly discoidal with diameters between 30 mm and 0.3 m and thicknesses up to 80 mm, comprises discontinuous limonite lamellae with encrusting calcareous organisms (principally serpulids and bryozoans, but also foraminifera, sponges, bivalves and brachiopods) and diagenetic fibrous calcite at interlamellar boundaries. Accretion took place around a large shell-fragment or lithoclast but, apparently, on only one side at a time; individual snuff-boxes were probably overturned several times during their development (Palmer and Wilson, 1990; Hesselbo and Jenkyns, 1995). According to Palmer and Wilson (1990), the form of the outermost lamellae and nature of the intergrown encrusting fauna (gloomy-cavity and gloomy-crevice dwellers) suggests that the lamellae accreted only on the underside of each snuff-box, and that the micro-organisms involved in their genesis were non-photosynthetic, iron-oxidizing bacteria. Subsequently, Hesselbo and Jenkyns (1995) queried whether the lack of light indicated by the encrusting fauna might be related to water depth rather than to shadow. The present orientation of the snuff-boxes, which are in contact with one another in three dimensions, usually with their long-axes parallel to bedding but sometimes tilted, and with some sets of steeply dipping imbricated individuals, suggested to Palmer and Wilson (1990) that they grew and accumulated as cobble-sized concretions lying free on an agitated sea-bottom with episodes of movement and stacking by strong currents. Hesselbo and

Figure 2.14 Fallen block of the Snuff-box Bed showing cross-sections of the characteristic limonitic oncoids known as 'snuff-boxes'. (Photo: A5845, British Geological Survey, 1932.)

Jenkyns (1995) raised the possibility that disturbance by large scavengers might also be an influence on the present orientation. Gatrall *et al.* (1972) had earlier suggested a depositional environment of turbulent water some tens of metres deep on a submarine swell or slightly undulating shelf, and Jenkyns and Senior (1991) postulated highly turbulent water on a particularly shallow, fault-controlled sector of the sea floor.

As originally used by Buckman (1910a), the term Red Bed referred to all of the strata between the Yellow Conglomerate and the Astarte Bed, and thus included the Snuff-box Bed (Bed 8) and the Red Conglomerate (Bed 11). Subsequently, most authors grouped beds 8, 9 and 10 together as the 'Red Bed' (e.g. Richardson, 1928–1930; Wilson *et al.*, 1958) or 'Red Beds' (e.g. Parsons, 1980a) but latterly, the term Red Bed has been applied to beds 9 and 10 only (e.g. House, 1989; Callomon and Cope, 1995). At Burton Cliff, Bed 9 forms hard massive blocks on the beach that are difficult to break up. However, at the nearby Freshwater Caravan Park, where Bed 9 divides into three courses, weathered exposures led Callomon and Cope (1995) to describe it as one of the most interesting beds in the Inferior Oolite Formation, displaying extensive marly partings, marking stromatolitic crusts, and numerous flat oncoids; the latter are less prominent but often much larger than the snuff-boxes of Bed 8, and their nuclei are 'fresh' or corroded ammonites. According to Callomon and Cope (1995), ammonites occur throughout Bed 9 and include almost the entire fauna of the Lower Bajocian Sauzei Zone. At Burton Cliff, the sparsely fossiliferous Bed 10 comprises two courses, and its characteristic overprint of large, irregular vertical burrows often marked by red limonite gives it a distinctive appearance that enables it to be traced over much of southern Dorset (Callomon and Cope, 1995). The top of the Red Bed is an important erosion surface and is a good example of a hardground (Sellwood *et al.*, 1970).

The oldest element (11a above) of the overlying and discontinuous Red Conglomerate belongs to the basal Humphriesianum Zone, probably near to the Sauzei–Humphriesianum zonal boundary. Ammonites in the next youngest element (11b above) indicate the Polygyralis Subzone of the Upper Bajocian Subfurcatum Zone, and the youngest element (11c above), which Buckman (1910a, 1922a) called the 'White Bed' or '*Nautilus* Bed', belongs to the Upper Bajocian Garantiana Zone (Callomon and Cope, 1995). Further lithological details of the last-named sediment were given by Jenkyns and Senior (1991). The fissures that it infills were created by movements of the synsedimentary Bride Fault that truncates Burton Cliff at its eastern end and brings the Bridport Sand Formation of Toarcian–Aalenian age and Fuller's Earth Formation of Bathonian age into juxtaposition (Hesselbo and Jenkyns, 1995). The interpretation of these fissure-infills has not always been understood and they perplexed the early workers such as Buckman (1910a, 1922a), Richardson and Butt (1912) and Richardson (1915, 1928–1930). According to Hesselbo and Jenkyns (1995), a trace of a fault, identified as the 'Bride Fault' by Jenkyns and Senior (1991), is sometimes visible on the upper beach where a sliver of Inferior Oolite Formation is caught up in the fault zone. With bored limestone boulders and laminated ferruginous concretions set in a highly fossiliferous ferruginous limestone matrix, the latter authors described it as an 'anomalous facies' containing ammonites indicative of the Subfurcatum Zone (Baculata Subzone) (i.e. an age intermediate between that of 11b and 11c). Hesselbo and Jenkyns (1995) thought that the beach fault was more likely to be the onshore extension of a substantial fault, albeit joined to the Bride Fault, mapped offshore by Darton *et al.* (1981).

The algal crust that separates the Red Conglomerate (Bed 11), or in its absence the Red Bed (Bed 10), from the overlying Astarte Bed (Bed 12) has been investigated by Radley (1986). It lies below an erosion surface marking the base of the latter bed and is composed of stromatolites, ranging up to *c.* 0.5 m in diameter, which are often limonitic on their upper surfaces. The stromatolites are colonized by serpulids that, together with the absence of features such as desiccation cracks and evaporite traces, led Radley (1986) to conclude that they were almost certainly of normal marine subtidal origin and that the substrate on which they accumulated was probably a rocky platform (top of Red Bed) with topographical lows in which the Red Conglomerate accumulated. The erosional 'event' at this level is the Bajocian Denudation of Buckman (1895), the Bajocian Oscillation of Sollas (1926) and the Vesulian Oscillation or Transgression of Arkell (1933). Callomon and Cope (1995) and Hesselbo and Jenkyns (1995) referred to this level as the 'Vesulian Unconformity'. 'Vesulian' is an otherwise obsolete term, dating from Marcou (1848), which was once used as a stage name for the Upper Bajocian. The Astarte Bed itself is widespread in Dorset and is present at several other GCR sites (see **Horn Park Quarry**, **Seavington St Mary Quarry**, **Louse Hill Quarry** and **Halfway House Cutting and Quarry** GCR site reports, this volume). The term was used by Hudleston (1887) and Buckman (1910a) but Richardson (1915, 1932) and some subsequent authors later called it the '*Astarte obliqua* Bed'. The common astartid bivalve that characterizes the bed is now identified as *Neocrassina modiolaris* (Lamarck) (e.g. Callomon and Cope, 1995).

The term 'Burton Limestone' (beds 13–16) was introduced by Parsons (1975b) for the beds previously and variously known as the 'Microzoa Beds', 'Massive Beds', 'Sponge Beds' and 'Top Limestones' (Richardson, 1928–1930). Parsons (1975b) considered that these earlier terms either referred to facies of limited geographical and stratigraphical range or had been used in a wider sense thereby including several distinct lithostratigraphical units. He therefore proposed the Burton Limestone, with Burton Cliff as its type locality, as a single lithostratigraphical unit covering all of the bioclastic limestones and subsidiary marl partings between the Astarte Bed (Bed 12) and the Zigzag Bed (Bed 17). Bed 13, beds 14–15 and Bed 16 are respectively the Third, Second and First beds of Buckman (1910a), and beds 14–15 are the Sponge Beds of Richardson (1928–1930). Bed 15 is particularly rich in calcareous sponges and Callomon and Cope (1995) referred to it as the Sponge Bed. Bed 14 is the type horizon of the ammonite *Parkinsonia* (*P.*) *bomfordi* Arkell, which gives its name to the youngest Bajocian subzone and is the index taxon of the youngest Bajocian ammonite biohorizon (Bj-28) (Callomon and Cope, 1995). The lower part of Bed 13 includes the Truellei Bed (Richardson, 1915) (13b above), which takes its name from the strigoceratid ammonite *Strigoceras truellei* (d'Orbigny). Its well-preserved fauna is the same as that of the Halfway House Fossil Bed (see **Halfway House Cutting and Quarry** GCR site report, this volume), which is the type horizon of the Truellei Subzone of the Upper Bajocian Parkinsoni Zone (Buckman, 1891; Arkell, 1951a). Some authors (e.g. Rioult *et al.*, 1991) have followed Richardson (1928–1930) by calling the whole of Bed 13 the Truellei Bed.

The Zigzag Bed (Bed 17) and The Scroff (Bed 18), the youngest beds of the Inferior Oolite Formation at this site, belong to the Lower Bathonian Zigzag Zone. The Scroff – the name given to a thin irony layer by the quarrymen who worked the Inferior Oolite Formation in quarries around the village of Burton Bradstock (Buckman, 1910a) – forms the reworked top of the Zigzag Bed, which, like the zone, takes its name from the perisphinctid ammonite *Zigzagiceras zigzag* (d'Orbigny). This taxon is itself named after its distinctive style of ribbing. As at **Horn Park Quarry** (see GCR site report, this volume), the Zigzag Bed includes all of the characteristic ammonites of the Zigzag Zone (Arkell, 1951a, 1958a; Torrens, 1974). All three of the latter's subzones (Convergens, Macrescens and Yeovilensis) are condensed into the two beds, although the youngest (Yeovilensis) is also represented in the overlying Fuller's Earth Formation (Torrens, 1980b; Callomon and Cope, 1995).

The succession at Burton Cliff featured in the sequence stratigraphical analysis of Rioult *et al.* (1991), which was based primarily on detailed bed-by-bed outcrop observation and sedimentological and biostratigraphical analysis, as well as comparison with similar data from the Normandy coast of France. They recognized sequence boundaries at the top of the Scissum Bed (base of Bed 7), at the top of the Red Bed (base of Bed 11) and at the base of the Bomfordi Subzone (base of Bed 14b); maximum flooding surfaces between the Snuff-box Bed and the Red Bed (base of Bed 9), possibly between the Astarte Bed and the Truellei Bed (*sensu* Richardson, 1928–1930; base of Bed 13) and between The Scroff and the Zigzag Bed (base of Bed 18); the Red Bed (beds 9 and 10) and possibly the upper part of the Truellei Bed (*sensu* Richardson, 1928–1930; upper part of Bed 13) as highstand systems tracts; the conglomeratic accumulation of rolled, worn ammonites in the Yellow Conglomerate (Bed 7) as a transgressive lag; and a transgressive surface between the Red Conglomerate and the Astarte Bed (base of Bed 12).

The probable palaeogeographical setting for the Inferior Oolite Formation of the Wessex Basin is an intrabasinal structural high distal to carbonate ramp facies developed around the London Platform and the Worcester Basin to the north (Hesselbo and Jenkyns, 1995). Some of the characteristic sedimentological features of the formation in Dorset and Somerset and their significance are discussed in the **Seavington St Mary Quarry** GCR site report (this volume).

Conclusions

The coastal sections of Dorset are among the most famous Jurassic sections in the world. Burton Cliff is the best locality for studying the Inferior Oolite Formation, together with the underlying Bridport Sand Formation and is one of the most visited and studied Aalenian–Bajocian sites in Britain; it features extensively in the geological literature for over 100 years. Fallen blocks from high up in the cliff face enable the thin, highly fossiliferous and sedimentologically fascinating Aalenian–Bajocian succession to be examined on the beach. The rich ammonite faunas establish the zonal/subzonal succession and, together with palaeontological and sedimentological data from other sites in the region, enable the complexities of the depositional history of the Aalenian–Bajocian stages in Wessex to be unravelled. The nearby Cliff Hill Road Cutting repeats the succession, which can be seen, when clear of vegetation, *in situ* at eye-level. This composite site is thus of regional, national and international importance in several fields of geological research.

WATTON CLIFF, DORSET (SY 454 907)

B.M. Cox

Introduction

The GCR site at Watton (or West) Cliff covers about 750 m of cliff and foreshore between Eype Mouth and the River Brit. It represents the best single exposure of Bathonian sediments in Dorset (Figure 2.15) although the state of the exposure depends on the extent of landslips. The Bathonian section, comprising Forest Marble Formation overlying Frome Clay Formation, is faulted against older Jurassic (Lias Group) beds at both its eastern and western ends. A tiny patch of Cornbrash Formation was formerly present on the summit of Watton Cliff, but has since been eroded away, suggesting that the Forest Marble Formation is largely complete (Arkell, 1933). The section is famous for two

Figure 2.15 Watton Cliff. The Boueti Bed at the base of the Forest Marble Formation cuts the cliff near the sharp bend in the cliff profile on the left (arrowed). Below lies the Frome Clay Formation. (Photo: A5838, British Geological Survey, 1932.)

brachiopod marker horizons: the Wattonensis Beds (named after the two most common species, *Rhynchonelloidella wattonensis* Muir-Wood and *Wattonithyris wattonensis* Muir-Wood; Kellaway and Wilson, 1941) at the base of the Frome Clay Formation; and the Boueti Bed (named after *Goniorhynchia boueti* (Davidson)) at the base of the Forest Marble Formation. Although, as their name implies, the section is the type locality for the Wattonensis Beds, they are visible only in three places: indifferent exposure above the landslip beside the Eype Mouth Fault in Fault Corner; intermittent exposure beneath the beach shingle on the foreshore at the seaward end of the Eype Mouth Fault; and in a disturbed state in the *c*. 9 m-wide shatter-belt of the so-called 'West Cliff Fault' (Figure 2.16). The rest of the succession is well exposed in the cliff, though not easily accessible, and is becoming degraded. The section was cited by Buckland and De la Beche (1836) and later described by Woodward (1894), Buckman (1922a), Arkell (1933), Wilson *et al*. (1958), Torrens (1969b), Hallam (1970), Macfadyen (1970), Holloway (1981, 1983) and Callomon and Cope (1995).

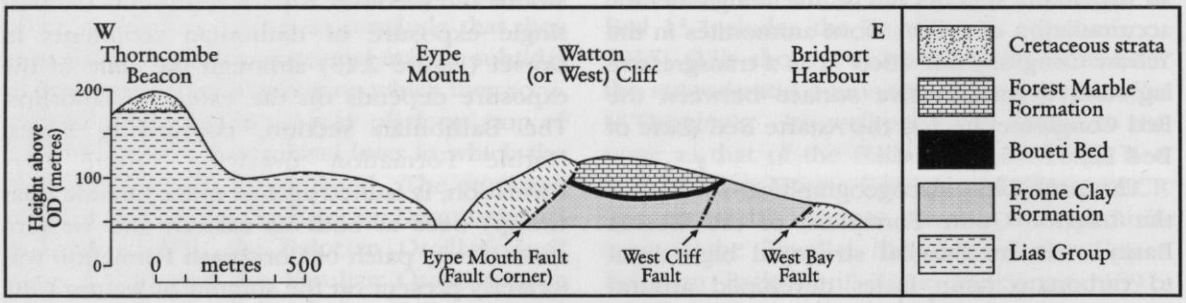

Figure 2.16 Diagrammatic cross-section of the cliffs between Eype Mouth and the River Brit (Bridport Harbour), including the Watton Cliff GCR site. (After Macfadyen, 1970, fig. 18.)

Description

The following description is modified from Callomon and Cope (1995), whose description was itself based on Wilson *et al*. (1958) and Torrens (1969b). Additional data has been inserted from Hallam (1970) and Holloway (1981, 1983). Bed numbers follow Torrens (1969b).

	Thickness (m)
Forest Marble Formation	
7: Clay with laminated lenses of sandstone forming 'tiles' with spectacular trace fossils including *Gyrochorte comosa* Heer (common), *Imbrichnus wattonensis* Hallam, *Monocraterion*, *Neonereites*, *Pelecypodichnus*, *Planolites*, *Rhizocorallium*, *Teichichnus*, *Thalassinoides* and *Tibikoia*	2.5
6: Clay and shale with lenses of shelly limestone and laminated, ripple-marked sandstone	6.0
5: Limestone, calcirudite, massive, ooidal, flat- and cross-bedded; bored pebbles (up to 0.15 m diameter) of grey micrite and sparsely ooidal micrite; shelly with abundant broken or complete but disarticulated pectinid bivalves and oysters, common crinoid columnals, shark teeth, fossil wood (logs up to 1 m long) and occasional disarticulated brachiopods	2.0
4: Clay, blue, with silt streaks	0.5
3: Limestone, argillaceous, fine grained, weathering cream-coloured, hard, forming prominent bed	0.3
2: Shale, calcarenitic, laminated and with silt streaks	1.8
1: Shale, blue-grey; lenses of brownish-grey, fissile calcirudite and calcarenite including, 6.6 m above the base, a 200 m-long, wedge-shaped unit thinning and fining from a coarse 0.35 m-thick calcirudite to a 0.10 m-thick calcarenite	12.0
Boueti Bed (unnumbered)	
Marl, calcareous (argillaceous micrite), whitish, very shelly; fossils include bivalves (*Arcomytilus asper* (J. Sowerby), *Camptonectes laminatus* (J. Sowerby), *Catinula ancliffensis* (Cox and Arkell), *Chlamys* (*Radulopecten*) *vagans* (J. de C. Sowerby), *Gervillella acuta* (J. de C. Sowerby), *Nicaniella* (*Trautscholdia*) *cordata* (Trautschold), *Pholadomya* sp., *Placunopsis socialis* Morris and Lycett, *Praeexogyra hebridica* (Forbes), *Trigonia costata* J. Sowerby and *Vaugonia impressa* (Broderip)); gastropods (*Pleurotomaria burtonensis* Lycett and *Turbo burtonensis* Lycett); brachiopods (*Goniorhynchia boueti* and terebratulids); echinoderms (*Apiocrinus elegans* (Defrance) and '*Cidaris*' sp.); serpulids; bryozoans; occasional corals (*Montlivaltia*); large *Thalassinoides* burrow-networks at base	0.35
Frome Clay Formation	
8: Marl, shaly, blue	1.5
7: Limestone, argillaceous, fine grained, laminated, white	1.5
6: Marl, blue-grey	16.4
5: Alternating pale, argillaceous, fine-grained limestone and marl	0.45
4: Clay, marly to beach level	6.0
3: Gap	?
2: Oyster bed; clay with abundant small or broken *Praeexogyra hebridica*	0.75
1: *Wattonensis Beds*: Alternating clays and thin limestones; richly fossiliferous with varied fauna dominated by brachiopods including *Acanthothiris powerstockensis*, *Rhynchonelloidella* spp., *Rugitela* spp., *Tubithyris* spp. and *Wattonithyris* spp.; bivalves including *Catinula knorri* (Voltz), *Modiolus anatinus* Wm Smith, *Parallelodon* sp. and *Trigonia elongata* J. de C. Sowerby; occasional ammonites including holotype of *Procerites wattonensis* Arkell	seen to *c*. 8

The gap in the section of the Frome Clay Formation, recorded above as Bed 3, was estimated by Buckman (1922a) to represent 12 m of strata but Torrens (1969b) and Callomon and Cope (1995) considered this was probably an underestimate.

Callomon and Cope (1995) replaced the descriptors 'sandy calcareous', 'sandy' and 'calcareous sandstone' of Wilson *et al*. (1958) and Torrens (1969b) with the terms 'calcarenite' and 'calcarenitic' implying that there was no silt- or sand-grade quartz material present in the Forest Marble Formation. However, the detailed investigation of these beds by Holloway (1981, 1983) indicates that such material is indeed present as streaks and lenses, particularly in the upper beds.

The brachiopod fauna of the Wattonensis Beds (Buckman's 'Brachiopod Beds') was described by Buckman (1922a) and Muir-Wood (1936). Other faunal records from the locality include foraminifera (Cifelli, 1959), holothurians (Hampton, 1957), mammalian teeth (Freeman, 1976) and other vertebrate (including fish and reptile) remains (Dineley and Metcalf, 1999).

Interpretation

Up until the 1980s, the beds now classified as Frome Clay Formation were referred to as 'Upper Fuller's Earth Clay' (e.g. Torrens, 1980b; Holloway, 1981, 1983). Since then, however, Penn and Wyatt's (1979) claim that the latter member lay *below* the Wattonensis Beds rather than above has been more widely accepted, and their term 'Frome Clay Formation' is therefore now used for the higher beds (e.g. Callomon and Cope, 1995). The revised classification is based on Penn and Wyatt's (1979) correlation of the Wattonensis Beds with the Lower Smithi

Limestone of the Bath–Frome area rather than the Rugitela Beds at the top of the Fuller's Earth Rock Member (see Figure 2.4). The latter marks the base of the Upper Fuller's Earth Clay in the type area of the Fuller's Earth Formation at Bath.

According to Callomon (in Callomon and Cope, 1995), the holotype of Arkell's (1958b) ammonite *Procerites wattonensis* from the Wattonensis Beds on the foreshore at the Eype Mouth Fault can be re-identified as *P.* cf. or aff. *quercinus* (Terquem and Jourdy). This taxon is indicative of the Quercinus Subzone to which Callomon therefore assigned the whole of the Frome Clay Formation at Watton Cliff. Recognition of this subzone is particularly significant because it allows the Wessex Middle–Upper Bathonian succession to be integrated with that of other European areas by the application at this level of their better substantiated ammonite-based Bremeri and Retrocostatum zones. The base of the Retrocostatum Zone is marked by the base of the Quercinus Subzone. Recognition of subzones in common with continental Europe means that the previously used Hodsoni and Orbis zones can be superseded (Page, 1996a).

At the base of the Forest Marble Formation, the Boueti Bed is easily recognizable although it is less accessible and its fauna is rather less diverse here than farther east at Herbury (see **Shipmoor Point–Butterstreet Cove and Tidmoor Point–East Fleet Coast** GCR site report, this volume). The bed forms a remarkably constant and persistent marker nearly as far north as the southern edge of the Mendips but the only ammonites known from it are small microconch *Clydoniceras* (known as *Delecticeras*) that are diagnostic only of the Upper Bathonian Substage in general. Elsewhere, the overlying lower part of the Forest Marble Formation has yielded *Clydoniceras hollandi* (S.S. Buckman), which is indicative of the Hollandi Subzone of the Discus Zone. Deposition of the Boueti Bed is considered to have been slow because many of its shells are encrusted with bryozoans and serpulids (e.g. Arkell, 1933; Wilson *et al.*, 1958). The Digona Bed, which forms another brachiopod marker bed higher up in the Forest Marble Formation at Herbury (see **Shipmoor Point–Butterstreet Cove and Tidmoor Point–East Fleet Coast** GCR site report, this volume), cannot be recognized at Watton Cliff. The impersistent occurrence of this bed led Holloway (1981, 1983) to doubt its correlative value.

The single sheets of calcirudite/calcarenite that occur within the Forest Marble Formation, for example in Bed 1, were probably derived from an accumulation of allochthonous shell-debris that was re-distributed into a thin layer (Holloway, 1983). These lithologies also occur as compound sequences of sheet and lensoid shell-bodies such as in Bed 5. The tops of the shell bodies are usually cross-bedded, suggesting that they were reworked by currents. This facies may represent shallow-marine shoals built by episodic high-energy events, such as storms, of sufficient strength to rework the tops of the shoals and erode small channels within them (Holloway, 1983). Bed 5 may represent a laterally extensive, correlatable horizon in the Wessex region. Elsewhere in Dorset, the massive limestones of this unit were formerly worked for local building stone and for road-metalling. Mammalian teeth from Watton Cliff recorded by Freeman (1976) probably came from this bed.

The trace fossils notable in Bed 7 of the Forest Marble Formation have been described by Hallam (1970) and Holloway (1981). The most common form is *Gyrochorte*. At the time of Hallam's work, the interpretation of this ichnogenus, which appears as low, winding ridges with a plaited structure on bedding surfaces, was the subject of debate and no definite conclusion could be drawn regarding the nature of the *Gyrochorte* organism or the precise mechanism of formation of the structures. Heinberg (1973) thought they were produced by a polychaete-like worm moving obliquely through the sediment, and Häntzschel (1975) concluded that they were doubtless made by an organism (possibly a worm or a crustacean) tunnelling through the sediment. However, Holloway (1981) thought they might be formed by the movement of infaunal bivalves through soft sediment because they are intimately associated with the bivalve resting-trace *Pelecypodichnus*; this seems dubious as abundant *Pelecypodichnus* are known in beds with no *Gyrochorte* at all (J.D. Hudson, pers. comm.). Hallam (1970) did, however, interpret the depositional environment of the deposits containing *Gyrochorte*, which he envisaged as shallow marginal marine, probably a coastal lagoon with slightly lowered salinity owing to the influx of freshwater from a nearby river or system of rivers. He considered the other trace fossils to be consistent with this interpretation. These include *Imbrichnus wattonensis*, the type specimen of which, as its name implies, comes from this locality.

Conclusions

Watton Cliff, although unscalable from above and below without specialist equipment, is the single most important exposure of Bathonian rocks in Dorset. The succession here, comprising the Frome Clay Formation overlain by the Forest Marble Formation, is predominantly of clay and shale, with some limestone beds. The exposure of the Frome Clay Formation, which occurs only in the Wessex region, is particularly important because, in its type area, it is known mainly from cored boreholes. There are two important faunal marker horizons: the Boueti Bed at the base of the Forest Marble Formation, and the Wattonensis Beds at the base of the Frome Clay Formation. Named after particular species of brachiopods, these marker horizons are widespread and persistent and important for regional correlation. The Wattonensis Beds have also yielded sparse ammonites that enable recognition of the Upper Bathonian Quercinus Subzone and partial chronostratigraphical classification of the section. The upper part of the Forest Marble Formation here shows a varied suite of trace fossils.

PEASHILL QUARRY, DORSET (SY 495 916)

B.M. Cox

Introduction

The Peashill Quarry GCR site is a small disused quarry now occupied by two residential properties at the corner of Shipton Road and Burbitt Lane in the village of Shipton Gorge, Dorset (Wilson *et al.*, 1958). In the older literature, the locality is referred to as the quarry near or opposite the New Inn, Shipton Gorge (e.g. Walford, 1889; Woodward, 1894). Since the 1880s, the locality has been famous for the fauna of small fossils, notably bryozoa, and sponges that the Upper Bajocian part of the Inferior Oolite Formation has yielded. Indeed, the residential property that has the main exposure of the former quarry as the northern boundary of its garden is called 'Polyzoa', the name previously given to bryozoa. In addition to the palaeontological interest, the quarry section also originally showed a major non-sequence, with youngest Bajocian strata (Parkinsoni Zone) resting directly on oldest Aalenian strata (Opalinum Zone).

Description

The following description of the section, including the bed notation, is based on that of Richardson (1928–1930). A slightly modified version of the latter was given by Macfadyen (1970). The lower part of this section has not been visible for some years. The lithostratigraphical classification has been updated, where appropriate, following Parsons (1980a).

	Thickness (m)
Soil, brown	0.35
Inferior Oolite Formation	
Burton Limestone	
A: Limestone, bluish-grey, rubbly; ammonites including *Oecotraustes*; nautiloids; belemnites; rhynchonellid and terebratulid brachiopods; echinoids; bivalves including 'myids', pectinids and *Protocardia*	0.5
B: Marl, grey and brown, rich in sponges and microfauna (including bryozoans, foraminifera, ostracods, micro-brachiopods and crustaceans); ammonites (*Oecotraustes*); bivalves; terebratulid brachiopods; gastropods	0.1
C: Limestone, greyish-white, rubbly; echinoids including cidarids and *Clypeus*	0.15
D: Marl, as B above; ammonites (*Oecotraustes*)	0.35
Limestone, white with 'yellow ochreous matter'; fossils including ammonites (*Parkinsonia*); bivalves including astartids, *Ctenostreon*, pectinids and *Trigonia*; rhynchonellid and terebratulid brachiopods	1.2
Bridport Sand Formation	
Limestone, rubbly, 'impure', very hard, full of ammonites; belemnites; rhynchonellid brachiopods	seen

Interpretation

In Richardson's (1928–1930) original description of the section, he assigned beds A–D to the 'Microzoa Beds', and the underlying limestone to the 'Massive Beds'. He had introduced these terms earlier in his 1928 paper for the two-fold subdivision of the upper part of the Inferior Oolite Formation between Burton Bradstock and Beaminster. Within the Microzoa Beds, he separated beds B–D at Peashill Quarry as the 'Sponge Beds', a term that he also used at Burton Bradstock (see **Burton Cliff and Cliff Hill Road Section** GCR site report, this volume). However, Parsons (1975b) considered that these three stratal terms, as well as Richardson's (1928–1930) 'Top Limestones', either referred to facies of limited geographical and stratigraphical range or had been used in a wider sense, thereby including several distinct lithostratigraphical units. He therefore proposed that Richardson's terminology should be replaced by a single lithostratigraphical term – the Burton Limestone.

The microscopic bryozoan fauna (Figure 2.17), for which the locality is perhaps most famous, was first reported by Walford (1889, 1894) who believed that he had recovered about 50 different forms representing 12 or more genera from the marl beds of the Burton Limestone (beds B and D above). Apart from at Peashill Quarry and Burton Bradstock (see **Burton Cliff and Cliff Hill Road Section** GCR site report, this volume), these marls are invariably absent (Parsons, 1975b). The bryozoan fauna from Peashill Quarry was revised by Walter (1967) based on a study of the Walford collection held at the University Museum Oxford. He rejected Walford's (1894) new genus *Pergensia*, but confirmed the latter author's assessment of

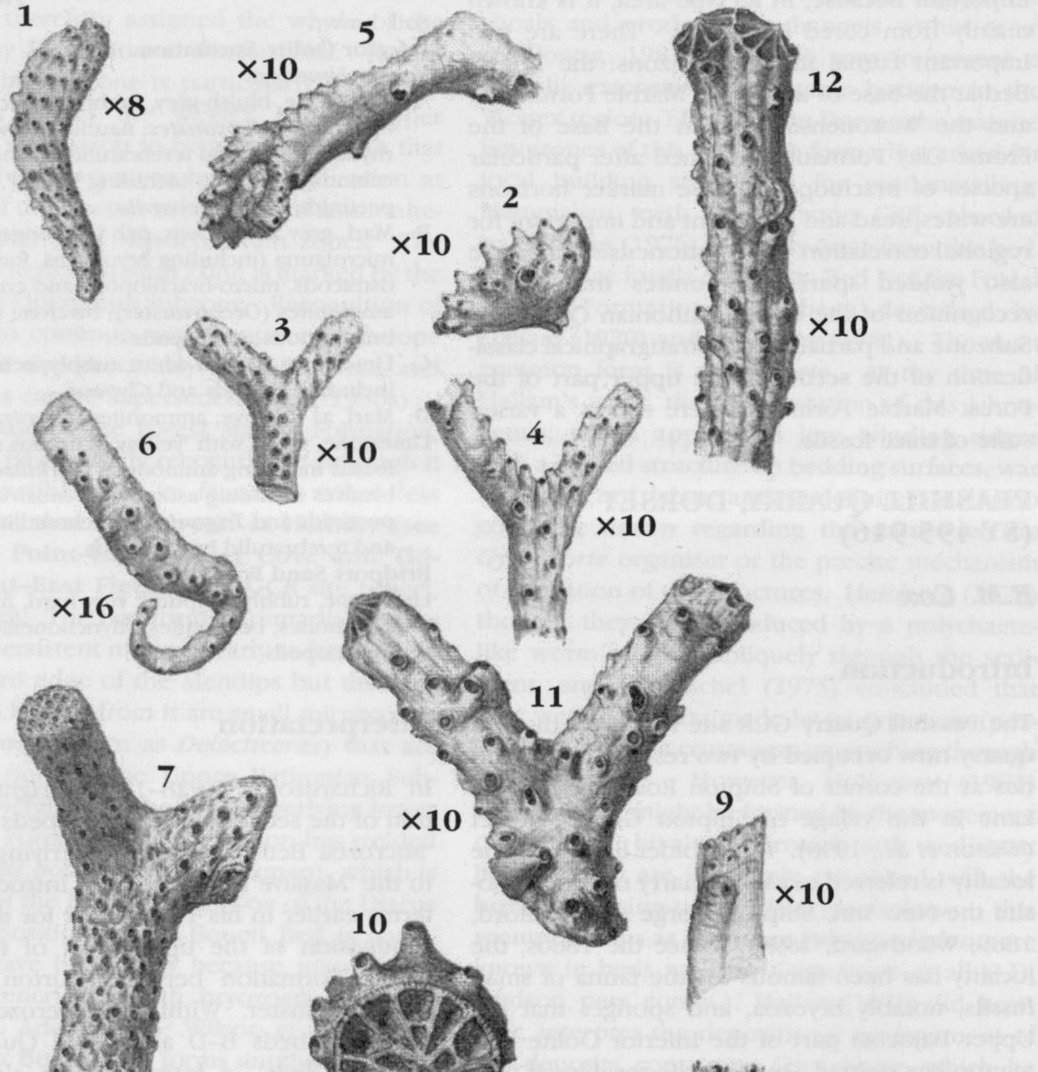

Figure 2.17 Bryozoa from Peashill Quarry as illustrated by Walford (1889, pl. XIX). According to Walter (1967), figures 1–9 are *Idmonea triquetra* Lamouroux, figure 10 is *Stomatopora spatiosa* (Walford) and figures 11–12 are *Mecynoecia bajociana* (d'Orbigny). Magnifications, ranging from ×8 to ×20, are shown beside each figure.

the diversity of the fauna, recognizing 13, mainly monospecific, genera (*Acanthopora*, *Apsendesia*, *Collapora*, *Entalophora*, *Idmonea*, *Mesenteripora*, *Mecynoecia*, *Multisparsa*, *Neuropora*, *Plagioecia* (two species), *Proboscina*, *Stomatopora* (three species) and *Theonoa*). He concluded that, in life, the bryozoa had been attached to seaweed or hard objects such as shells, rather than to the sea bottom itself, which would have been too soft. Like Walford, he also thought that the high proportion of slender forms suggested minimal current activity.

The sponge fauna from Peashill Quarry, which Walford (1889) had also noted, features in Hinde's (1893) monograph of British fossil sponges, and Richardson and Thacker's (1920) review of sponge occurrences in the Inferior Oolite Formation. A revised summary of the recorded sponges, including both calcareous and siliceous forms, is given in Macfadyen (1970). Other microscopic fossils from the marl beds include foraminifera, ostracods, microbrachiopods, fish teeth and crustacean claws. An extensive list of taxa is given in Richardson (1928–1930).

Amongst the larger fossils in the Burton Limestone, the ammonites *Oecotraustes costiger* S.S. Buckman and *Parkinsonia* sp., recorded by Richardson (1928–1930), indicate the Upper Bajocian Parkinsoni Zone. These contrast with the ammonite fauna recorded from the lowest bed ('*Alocolytoceras tæniatum* (Pompeckj)' and '?*Canavarella* sp.'), which indicates the much older Opalinum Zone of the basal Aalenian Stage. There is thus a major non-sequence here that cuts out the Aalenian Scissum, Murchisonae, Bradfordensis and Concavum zones, the entire Lower Bajocian Substage, and the Upper Bajocian Subfurcatum and Garantiana zones. Richardson (1928–1930) considered that the presence of *Alocolytoceras tæniatum* suggested that the Rusty Bed, which, in this area, is generally taken as both the top bed of the Bridport Sand Formation and of the Opalinum Zone (see **Burton Cliff and Cliff Hill Road Section** and **Conegar Hill** GCR site reports, this volume) was once present here. He surmised that while the ammonite became affixed to the surface of the limestone, the soft material of the Rusty Bed was washed away. Richardson (1928–1930) noted that the level surface of this lowest bed in the quarry was visible in the road opposite and that, in the lane below, there were underlying massive sandstones and then yellow sands with lenses of calcareous sandstone typical of the Bridport Sand Formation (see also **Conegar Hill** GCR site report, this volume).

Conclusions

Peashill Quarry is the only Aalenian–Bajocian GCR site in Wessex whose palaeontological interest does not pertain primarily to ammonites. The Inferior Oolite Formation here has yielded a rich fauna of sponges and microscopic bryozoans, as well as other microfossils, and it is the type locality for a number of sponge and bryozoan taxa. The original quarry section also showed that a major part of the Aalenian and Bajocian stages, more than at any other GCR site in Wessex, is missing, with youngest Bajocian strata resting on oldest Aalenian strata. The site thus provides an excellent example of the intra-formational breaks in deposition that affect the Inferior Oolite Formation in this region. Combined with its palaeontological credentials, this makes the site one of local, regional, national and international importance.

HORN PARK QUARRY, DORSET (ST 457 021)

B.M. Cox

Introduction

Horn Park Quarry, *c.* 1.5 km north-west of Beaminster in Dorset, is one of the most famous Aalenian–Bajocian localities in Britain. The highly fossiliferous Inferior Oolite Formation there has been quarried intermittently over many years, and has yielded many thousands of ammonites. Sections were recorded by Richardson (1928–1930), Bomford (1948), Torrens (1969b) and Senior *et al.* (1970), and the succession was summarized by Parsons (1980a). Since then the locality has featured prominently in the reassessment of the Aalenian–Bajocian ammonite faunas and stratigraphy of this region (Chandler, 1982, 1996; Callomon and Chandler, 1990; Morton and Chandler, 1994; Sandoval and Chandler, 2000). It is particularly important for the Aalenian Stage as nearly all of that stage's currently recognized ammonite biohorizons are present. According to Callomon and Cope (1995), the profusion of ammonites has also given the opportunity to record the rarer elements of the fauna.

Description

The following record of the section (also Figure 2.18) is largely based on that of Callomon (in Callomon and Cope, 1995); his bed numbers are modified from Senior *et al.* (1970). The faunal determinations are biased towards the ammonites, which occur in particular abundance.

Thickness (m)

Great Oolite Group

Fuller's Earth Formation

Clay, grey — seen to 1–2

Inferior Oolite Formation

Zigzag Bed

11: Limestone, marly, rubbly, lenticular; indistinctly divisible into four courses (11a–11d) with limonite-encrusted parting between 11b and 11c; many ammonites including profuse *Parkinsonia convergens* (S.S. Buckman) (both macroconchs and microconchs) in layer at top of 11a and abundant *Oxycerites yeovilensis* Rollier (both macroconchs and microconchs) in 11d; undulating base — 0.35

Burton Limestone

10: Limestone, variably hard and marly, nodular, patchily ferruginous, bioturbated; *Parkinsonia*; serpulid-encrusted sponges; many echinoids — 0.70

9: Limestone, pale-grey, crinoidal, locally ooidal to pisoidal and with marly patches; ammonites including *Cadomites*, *Parkinsonia parkinsoni* (J. Sowerby) and common *Polyplectites*; common belemnites; large bivalves; brachiopods including *Sphaeroidithyris*, echinoids; gastropods — 0.50

Astarte Bed

8: Limestone, ferruginous, 'iron-shot' ooidal in part; sparse but including typical bivalve and brachiopod fauna and the ammonite *Sphaeroceras tutthum* S.S. Buckman; conglomeratic pebbles at erosional base — 0–0.10

Red Bed

7a: Limestone, hard, shell-detrital packstone, crinoidal, sparsely ooidal, pale-grey, weathering pink with ferruginous patches and vertical burrows filled with reddish marly material; planed upper surface; very sparsely fossiliferous; *Stephanoceras* cf. *rhytum* (S.S. Buckman); thickening eastwards; erosional base — 0.05–0.40

7b: Limestone, as 7a but finer grained, more evenly bedded; planed upper surface; very hard, white with limonitic marly wisps and pockets of sparse ooids; sparsely fossiliferous with ammonites including *Skirroceras leptogyrale* S.S. Buckman and *Sonninia* or *Papilliceras* sp.; thickening westwards; erosional base — 0.15–0.45

Thickness (m)

6: Clay, brown, greasy — 0–0.03

Horn Park Ironshot Bed

5: Oolite, brown, 'iron-shot' with grey marly limestone matrix; weathering into several indistinct and irregular courses; strongly bioturbated; planed upper surface cutting through ammonites, sometimes infilled with crystalline calcite; fossils, including abundant ammonites, clearly stratified (5a–5e)

5e: Hard, sparsely fossiliferous, thinning eastwards; ammonites including *Euhoploceras acanthodes* (S.S. Buckman), *Fontannesia grammoceroides* (Haug), *Graphoceras formosum* (S.S. Buckman) and *Hyperlioceras* — 0.10–0.20

5d: Slightly softer and more densely 'iron-shot' than 5e; ammonites including *Bradfordia costata* S.S. Buckman, *Eudmetoceras eudmetum* S.S. Buckman, *Graphoceras concavum* (J. Sowerby), *Haplopleuroceras subspinatum* (S.S. Buckman), *Pseudaptetoceras amplectens* (S.S. Buckman) and *Stephanoceras* aff. *perfectum* (S.S. Buckman); indistinct parting at base — 0.10

5c: As above; *Graphoceras cavatum* (S.S. Buckman) in upper part, *Brasilia decipiens* (S.S. Buckman), *B. maggsi* (S.S. Buckman) in lower part; other ammonites including *Abbasites abbas* S.S. Buckman, *Eudmetoceras sieboldi* (Oppel), *Megalytoceras confusum* (S.S. Buckman), *Stephanoceras* aff. *perfectum* (S.S. Buckman) and *Tmetoceras* cf. *scissum* (Benecke); prominent layer of large bivalves (*Ctenostreon pectiniforme* (Schlotheim)) at base — 0.15

5a,b: Oolite, fine, dense, as above, completely bioturbated, profusely fossiliferous notably with gigantic (up to 0.5 m diameter) graphoceratid ammonites and many large bivalves; ammonites including *Abbasites abbas* S.S. Buckman, *Brasilia gigantea* (S.S. Buckman), *B. platychora* (S.S. Buckman), *Megalytoceras confusum* (S.S. Buckman), *Parammatoceras grande* Elmi, *Praestrigites praenuntius* S.S. Buckman, *Stephanoceras* aff. *perfectum* (S.S Buckman) and *Tmetoceras* sp.; bivalves including *Coelastarte*, *Ctenostreon*, *Plagiostoma*, *Pleuromya* and *Trigonopsis*; gastropods including *Bathrotomaria*; indistinct and undulating base — 0.25

4: Limestone, hard, shell-detrital and shelly, densely ooidal; ooids fine and non-limonitic (buff 'iron-shot'); weathering cream; ammonites including *Abbasites*, *Brasilia baylii* (S.S. Buckman), *B. bradfordensis* (S.S. Buckman), *B. similis* (S.S. Buckman), *Erycites partschi* Prinz, *Megalytoceras*, *Pachylytoceras*, *Planammatoceras* cf. *planiforme* S.S. Buckman, *Pseudaptetoceras klimakomphalum* (Vacek) and *Tmetoceras*; well-preserved bivalves; sponges in lower part; undulating parting at base — 0.55

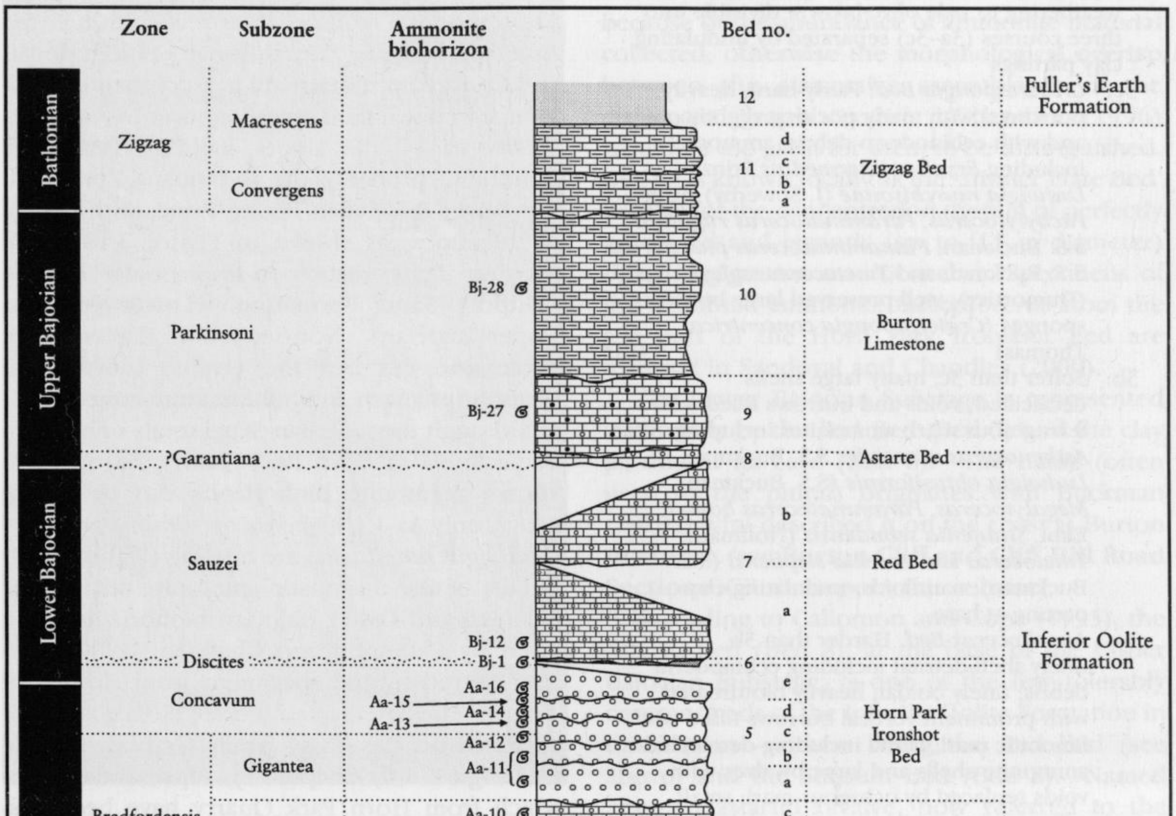

Figure 2.18 Graphic section of the Inferior Oolite Formation at Horn Park Quarry. (After Callomon and Cope, 1995, fig. 10.) For lithologies, see text.

	Thickness (m)
3: Limestone, sandy, marly, variably ferruginous, weathering to pale olive-brown; divisible into three courses (3a–3c) separated by undulating clay partings	
3c: *Craterospongia Bed*: Fairly hard, heavily burrowed with marly pockets, slightly ooidal and with echinoderm debris; ammonites including *Erycites intermedius* Prinz, *Ludwigia murchisonae* (J. Sowerby), large *Pachylytoceras*, *Parammatoceras rugatum* S.S. Buckman, *Planammatoceras planiforme* S.S. Buckman and *Tmetoceras regleyi* (Dumortier); well-preserved large bivalves; sponges (*Craterospongia concentrica* Thomas)	0.15
3b: Softer than 3c; many large shells decalcified; voids and burrows filled with ferruginous marl; ammonites including *Asthenoceras nannodes* S.S. Buckman, *Ludwigia obtusiformis* (S.S. Buckman), *Megalytoceras*, *Parammatoceras boyeri* Elmi, *Staufenia sehndensis* (Hoffman), *Tmetoceras* and *Vacekia stephensi* (S.S. Buckman); nautiloids; undulating clay parting at base	0.30
3a: *Ancolioceras Bed*: Harder than 3b, finely shell-detrital including echinoderm debris; finely ooidal; heavily bioturbated with prominent vertical burrows filled with limonitic marl; fauna including decalcified ammonite shells and large bivalves with voids replaced by ochreous marl; small solitary corals and occasional sponges (*Craterospongia*); ammonites including *Ancolioceras opalinoides* (Mayer), *A. substriatum* S.S. Buckman, *Ludwigia crassa* (Horn), *Megalytoceras*, *Pachylytoceras* aff. *torulosum* (Zieten) and *Staufenia sinon* (Bayle); erosional base	0.25
Scissum Bed	
2: Limestone, fine grained, white, hard, massive with planed upper surface; forming floor of quarry	
2b: Bioturbated with ochreous burrows and pockets; highly fossiliferous with ammonites (*Leioceras bifidatum* (S.S. Buckman) and *L. capillare* (S.S. Buckman)); large bivalves including *Ceratomya* and *Plagiostoma*; small solitary corals (*Montlivaltia delabechei* Tomes)	0.15
2a: Massive, becoming sandy downwards; fewer fossils than 2b; ammonites including *Leioceras comptum* (Reinecke) and *L. lineatum* S.S. Buckman	0.40
Bridport Sand Formation	
1: Sand, fine grained, yellow, locally cemented into sandstone lenses (seen in access road cuttings)	

Additional records of the non-ammonite fauna can be found in Richardson (1928–1930) and, particularly, in Bomford (1948).

Interpretation

The ammonite fauna enables recognition of the Aalenian Scissum, Murchisonae, Bradfordensis and Concavum zones, with most of their component subzones, the Lower Bajocian Discites and Sauzei zones, the Upper Bajocian Parkinsoni Zone and, probably, the Garantiana Zone, and the Lower Bathonian Zigzag Zone, with two of its subzones, as shown in Figure 2.18. The Scissum Zone rests non-sequentially on the Bridport Sand Formation (?Lower Jurassic, Upper Toarcian). Non-sequences higher in the succession cut out the Ovalis, Laeviuscula, Humphriesianum and Subfurcatum zones.

Although the Aalenian Stage totals only 2.4 m in thickness at Horn Park Quarry, 14 of its 16 known ammonite biohorizons can be recognized; only Aa-1 (*Leioceras opalinum*) and Aa-6 (*Ludwigia patellaria*) are missing (Figure 2.18). Details of the diagnostic ammonite taxa of the Aalenian and Lower Bajocian biohorizons were given by Callomon and Chandler (1990) who also figured several specimens from Horn Park Quarry. The Aalenian ammonite biohorizons are all based on the single family Graphoceratidae (see Figure 1.4, Chapter 1), representatives of which from Horn Park Quarry have been discussed and figured by Chandler (1996). The oldest Aalenian stratum is the Scissum Bed, a name first introduced to the Dorset succession by Richardson (1928–1930) (see also **Burton Cliff and Cliff Hill Road Section** GCR site report, this volume). Richardson (1928–1930) was also responsible for naming the Ancolioceras Bed (Bed 3a) after a graphoceratid ammonite genus that was considered to be a junior synonym of *Leioceras* by Donovan *et al.* (1981) and taken as one of that genus' macroconch subgenera by Chandler (1996). Bed 3b provided the first British record of the graphoceratid genus *Staufenia*, allowing a useful correlation with sequences in continental Europe (Chandler, 1982). The Craterospongia Bed (Bed 3c) was first named by Parsons (1980a) after a sponge genus for which Horn Park Quarry is the type locality (Dighton Thomas, 1948).

The richly fossiliferous Horn Park Ironshot Bed (Bed 5) (Figure 2.19) is the lateral equivalent of the Bradford Abbas Fossil Bed (see **Bradford Abbas Railway Cutting** GCR site report, this volume) but the Gigantea Subzone of the Aalenian Bradfordensis Zone (represented by the lower part of the Horn Park

Figure 2.19 Surface of the Horn Park Ironshot Bed (Bed 5a) with the graphoceratid ammonite *Brasilia*. The ruler at the bottom right is 15 cm long. (Photo: R.B. Chandler.)

Ironshot Bed) is missing at Bradford Abbas Railway Cutting, and the younger part of the Bajocian Discites Zone (represented by the upper part of the Bradford Abbas Fossil Bed) is missing at Horn Park Quarry (Callomon and Cope, 1995); indeed, the latter zone is present only at the western end of the quarry where Bed 5e is thickest. Nevertheless, Callomon and Chandler (1990) considered that the section at Horn Park Quarry would do well as an English reference section for the Aalenian–Bajocian stage boundary (see also **Seavington St Mary Quarry** GCR site report, this volume). This local 'coming and going' of individual beds, which is characteristic of the Aalenian–Bajocian succession in this region, as well as the other sedimentological features (see **Seavington St Mary Quarry** GCR site report, this volume), are almost certainly the result of tectonic activity. According to Callomon and Cope (1995), the seven successive ammonite faunas (biohorizons Aa-11–Aa-16 and Bj-1) recognized within the Horn Park Ironshot Bed have been resolved only because of the abundance of ammonite material collected; otherwise the morphological overlap between the successive assemblages of the dominant graphoceratids (Chandler, 1996) would be too great for them to be distinguished. Bed 5a is known locally as the 'Dinner Plate Bed' because of the concentration therein of perfectly preserved and gigantic (up to 0.5 m diameter) *Brasilia gigantea* macroconchs. Specimens of the sonniniid ammonite *Euhoploceras* from the top part of the Horn Park Ironshot Bed are featured in Sandoval and Chandler (2000).

The Lower Bajocian Substage is represented exclusively by the Red Bed (Bed 7) and the clay parting at its base (Bed 6). The name (often used in the plural) originates with Buckman (1910a) who described it on the coast at Burton Bradstock (see **Burton Cliff and Cliff Hill Road Section** GCR site report, this volume).

According to Callomon and Cope (1995), the Astarte Bed (Bed 8), at the base of the Upper Bajocian Substage, is one of the few tolerably constant beds of the Inferior Oolite Formation in this region – others being the Red Bed (see above) and the Scissum Bed (Bed 2). Named after an astartid bivalve, now referred to the genus *Neocrassina*, it has elsewhere locally yielded ammonites diagnostic of the Garantiana Zone (see **Seavington St Mary Quarry**, **Bradford Abbas Railway Cutting**, **Louse Hill Quarry** and **Halfway House Cutting and Quarry** GCR site reports, this volume). Its characteristic fauna includes belemnites, bivalves, brachiopods, echinoids and gastropods (e.g. Wilson *et al.*, 1958; Senior *et al.*, 1970).

The ammonite fauna of the overlying 'Burton Limestone', so named by Parsons (1975b) (see **Burton Cliff and Cliff Hill Road Section** GCR site report, this volume), is indicative of the terminal Bajocian Parkinsoni Zone. Although Callomon and Cope's (1995) illustration (fig. 10) indicated the presence of two ammonite biohorizons within the Burton Limestone at Horn Park Quarry, as shown in Figure 2.18, full specifications for these and others in the Upper Bajocian succession have not been published and are not yet fully resolved (cf. Callomon and Cope, 1995, fig. 7; and Callomon, 1995, fig. 3). Indeed, Callomon (1995) commented that the faunal succession of the Garantiana and Parkinsoni zones in general had so far received little more than cursory attention.

The Zigzag Bed, the youngest bed of the Inferior Oolite Formation at Horn Park Quarry, belongs to the Lower Bathonian Zigzag Zone (see also **Burton Cliff and Cliff Hill Road Section** GCR site report, this volume). The many ammonites in Bed 11 include almost the entire known fauna of the Zigzag Zone (Arkell, 1951a, 1958a; Torrens, 1974) and enable recognition of the Convergens Subzone in beds 11a and 11b, and the Macrescens Subzone in beds 11c and 11d (Callomon and Cope, 1995).

Conclusions

The succession at Horn Park Quarry possibly represents the most complete record of the Aalenian and lowest Lower Bajocian successions in southern England. The richness of the ammonite fauna, much of which is perfectly preserved, has made it a world famous and key locality for Middle Jurassic stratigraphy. It has played a major role in the elucidation of the regional stratigraphy, particularly of the Aalenian Stage, and has enabled the type material of many of the ammonite species first described by S.S. Buckman to be accurately pinpointed. It includes the richest development of the upper Aalenian Stage in Dorset. Horn Park Quarry is thus a locality of both national and international importance for Aalenian–Bajocian stratigraphy as well as being a prime palaeontological site.

CONEGAR HILL, DORSET (ST 439 028)

B.M. Cox

Introduction

The GCR site known as 'Conegar Hill' comprises both sides of a deep cutting on the B3164 road immediately north of Broadwindsor, Dorset. The northward ascent out of Broadwindsor, along which the cutting extends, is known as 'Hollis Hill', which, a little farther north, runs into Conegar Hill itself; the latter is formed of Cretaceous Upper Greensand capped by cherty gravels (Wilson *et al.*, 1958). The site extends for about 200 m and exposes, when clear of vegetation, Inferior Oolite Formation resting on Bridport Sand Formation. Compared with the succession at **Horn Park Quarry** (see GCR site report, this volume), which lies *c.* 2.5 km to the south-east, Conegar Hill shows that a considerable part of the Inferior Oolite Formation, including all of the Lower Bajocian succession, is missing. However, the boundary with the underlying Bridport Sand Formation has been well exposed, and the latter formation has yielded ammonites indicative of the basal Aalenian Opalinum Zone, which has not been proved at Horn Park Quarry.

Description

The cutting was cited by Woodward (1894) and Wilson *et al.* (1958) but the only published description of the section remains that of Richardson (1928–1930) on which the following is based. The graphic section in Richardson (1930) was repeated from Richardson (1919). The lithostratigraphical classification has been updated, where appropriate, following Parsons (1980a).

	Thickness (m)
Inferior Oolite Formation	
Burton Limestone	
Limestone, yellowish; belemnites; brachiopods (*Sphaeroidothyris*); perisphinctid ammonites; basal erosion surface	seen to 0.9
Murchisonae Bed	
Limestone, hard, yellowish as above but iron-stained; planed upper surface; terebratulid brachiopods quite common in upper part; ammonites including *Ludwigia*; bivalves including pectinids, 'myids' and trigoniids; irregular base	0.3
Ancolioceras Bed	
Limestone, similar to bed above; corals (*Montlivaltia*) at top; bivalves including astartids, *Ctenostreon*, *Gryphaea* and 'myids'; ammonites	0.3
Limestone, paler than above; bivalves including pectinids; ammonites; irregular base	0.3
Scissum Bed	
Sandstone, hard, calcareous, rubbly with interstitial sand; bivalves including arcids, 'myids', mytilids, pectinids and *Plagiostoma inoceramoides* (Whidborne); irregular base	0.4
Sandstone in irregular layers with partings of sand; belemnites; gastropods; nautiloids; serpulids; bivalves including 'myids', pectinids, *Gryphaea* and trigoniids	*c.* 1.0
Sandstone, very soft in top 0.1 m, harder in middle part; passing down into	0.6
Sandstone, hard; terebratulid brachiopods	0.3
Bridport Sand Formation	
Rusty Bed: Marl, brown and sandy at top, dull-grey and marly at base; ammonites including *Leioceras*; belemnites; terebratulid brachiopods	0.15
Sandstone, very fossiliferous; abundant ammonites; bivalves including arcids and pectinids; rhynchonellid brachiopods; serpulids	0.45
Sandstone, passing down into	0.4

	Thickness (m)
Sand, yellow; occasional lenses of calcareous sandstone; rhynchonellid brachiopod near top	c. 4.6
Sandstone	0.2
Sand, soft, yellow	1.5
Sand, yellow, and lenses of calcareous sandstone in about eight layers; serpulids	c. 6.7
Sand, soft, yellow	c. 2.1
Sandstone	0.3
Sand	seen to 0.3

Interpretation

Unlike **Horn Park Quarry** and many of the other Inferior Oolite Formation sections in this chapter, Conegar Hill has not been the subject of recent reassessment and new collecting, and the published ammonite records remain as given by Richardson (1928–1930). However, comparison with the succession at **Horn Park Quarry** and that on the coast at Burton Bradstock (see **Burton Cliff and Cliff Hill Road Section** GCR site report, this volume) together with others in Parsons (1980a) enables the zonal succession to be deduced (Figure 2.20).

There is no reason to suppose that the ammonite genera (*Canavarella*, *Lioceras* (=*Leioceras*) and *Pleydellia*) recorded by Richardson (1928–1930) from the Rusty Bed, at the top of the Bridport Sand Formation, and the underlying very fossiliferous sandstone indicate anything other than the Aalenian Opalinum Zone as at other localities in south Dorset (Parsons, 1980a; Callomon and Cope, 1995). Indeed, the Rusty Bed – a name used by Buckman (1910a) for a distinctive thin band of sandy marl – is now generally taken as both the top bed of the Opalinum Zone and of the Bridport Sand Formation in the whole of the area from Burton Bradstock to Broadwindsor (e.g. Torrens, 1969b; Hesselbo and Jenkyns, 1995). However, at Burton Bradstock, Callomon and Cope (1995) took the formation boundary a little lower and Buckman (1910a) and Arkell (1933) took it somewhat higher, at the top of the Scissum Bed (see **Burton Cliff and Cliff Hill Road Section** GCR site report, this volume). The lowest 15 m or so of Bridport Sand Formation at Conegar Hill, from which no ammonite has been reported, probably belong to the Lower Jurassic Upper Toarcian Substage; the Toarcian–Aalenian stage boundary is thus present here.

The overlying basal bed of the Inferior Oolite Formation is the Scissum Bed, which, as elsewhere, is assigned to the Scissum Zone although no ammonite has been recorded. The overlying

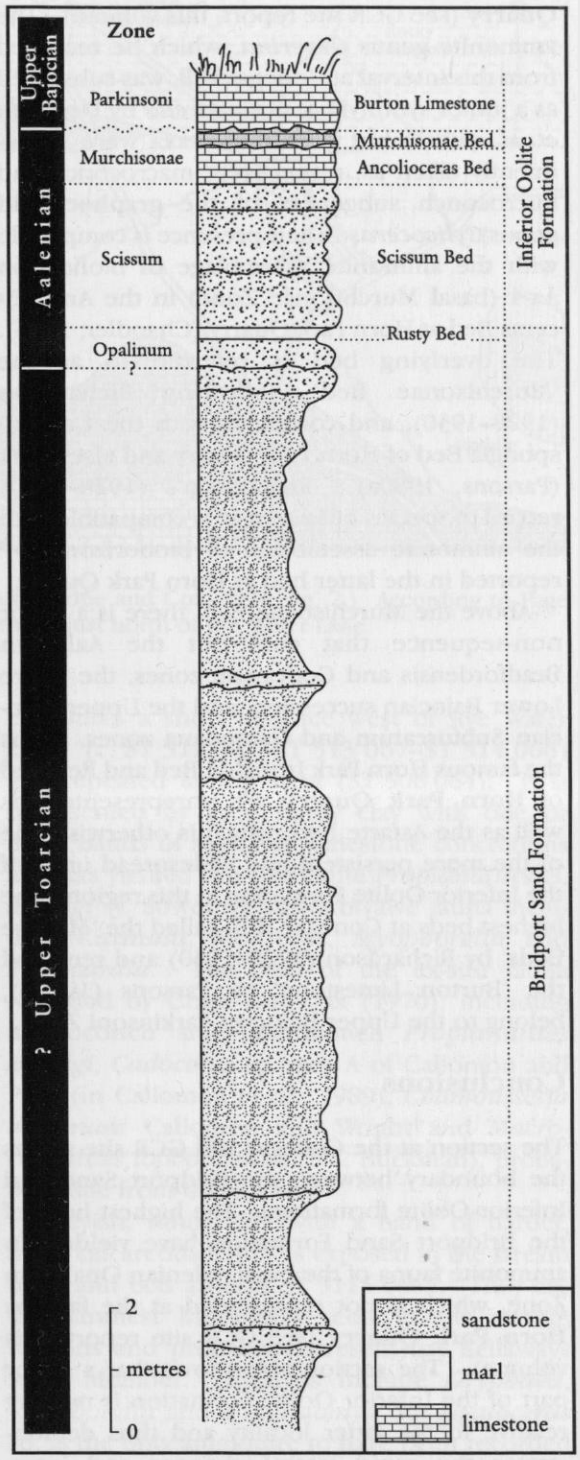

Figure 2.20 Graphic section of the succession at the Conegar Hill GCR site. (After Richardson, 1928–30, fig. 7.) For lithologies, see text.

limestones were classified as the Ancolioceras Bed by Richardson (1928–1930) as at **Horn Park Quarry** (see GCR site report, this volume). The ammonite genus *Geyerina*, which he recorded from this interval at Conegar Hill, was subsumed as a junior synonym of *Canavarella* by Donovan *et al.* (1981) but both these taxa were subsequently taken as, respectively, macroconch and microconch subgenera of the graphoceratid genus *Cylicoceras*. Their presence is compatible with the ammonite assemblage of biohorizon Aa-4 (basal Murchisonae Zone) in the Ancolioceras Bed at Horn Park Quarry (Chandler, 1996). The overlying bed is referred to as the 'Murchisonae Bed', following Richardson (1928–1930), and correlated with the Craterospongia Bed of Horn Park Quarry and elsewhere (Parsons, 1980a). Richardson's (1928–1930) record of species of *Ludwigia* is compatible with the ammonite assemblage of biohorizon Aa-7 reported in the latter bed at Horn Park Quarry.

Above the Murchisonae Bed, there is a major non-sequence that cuts out the Aalenian Bradfordensis and Concavum zones, the entire Lower Bajocian succession, and the Upper Bajocian Subfurcatum and Garantiana zones. Thus the famous Horn Park Ironshot Bed and Red Bed of **Horn Park Quarry** are unrepresented, as well as the Astarte Bed, which is otherwise one of the more persistent and widespread units of the Inferior Oolite Formation in this region. The highest beds at Conegar Hill, called the 'Massive Beds' by Richardson (1928–1930) and renamed the 'Burton Limestone' by Parsons (1975b), belong to the Upper Bajocian Parkinsoni Zone.

Conclusions

The section at the Conegar Hill GCR site shows the boundary between the Bridport Sand and Inferior Oolite formations. The highest beds of the Bridport Sand Formation have yielded an ammonite fauna of the basal Aalenian Opalinum Zone, which is not represented at the famous **Horn Park Quarry** (see GCR site report, this volume). The section also shows that a major part of the Inferior Oolite Formation is missing relative to the latter locality and thus demonstrates the rapid lateral changes and intraformational breaks in deposition that occur within the local Aalenian–Bajocian succession. The site thus contributes to an understanding of the complexities of Aalenian–Bajocian sedimentation and depositional history in Wessex.

RYEWATER, CORSCOMBE, DORSET (ST 513 062–ST 514 067–ST 506 064)

K.N. Page

Introduction

The GCR site known as 'Ryewater', near Corscombe, comprises intermittent stream-bed and bank exposures in two streams near Rye Water Farm, *c.* 1 km north-west of the village of Corscombe in Dorset. The western 'limb' of the site is the stream section from near Redland Coppice to just north of the bridge over Rye Water Lane, and the eastern 'limb' is the stream section from near Lovelands to the confluence with the western stream, just south of the Rye Water Lane bridge (Figure 2.21). In addition, a small section of the stream that runs parallel with, and to the north-east of, Rye Water Lane is also included. These exposures of mainly the Kellaways and Oxford Clay formations were probably amongst those referred to by Wilson *et al.* (1958) as 'an occasional stream section' in an area of otherwise poor exposure but they were not specifically noted until exceptionally heavy rainstorms at the end of June 1968 flushed out the streams to leave areas of clear exposure and well-preserved fossils in the stream-bed shingle (Cope and Cox, 1970). The site includes a more-or-less permanent exposure of the Kellaways Clay Member of the Kellaways Formation and has yielded important ammonite faunas of the Lower Callovian Koenigi Zone and Subzone. Fossiliferous exposures of the underlying Upper Cornbrash are also present as well as the overlying Kellaways Sand Member and probably the lowest part of the Oxford Clay Formation.

Description

The succession at Ryewater occupies the core of a narrow syncline as a result of which exposures of the Upper Cornbrash and Kellaways Formation repeat themselves.

Hard, shelly limestone, with bivalves including *Meleagrinella echinata* (J. Sowerby), belonging to the Lower Cornbrash, is exposed upstream of the ford at Lovelands (*c.* ST 5135 0625), and the lower part of the overlying Upper Cornbrash, which is at least 5 m

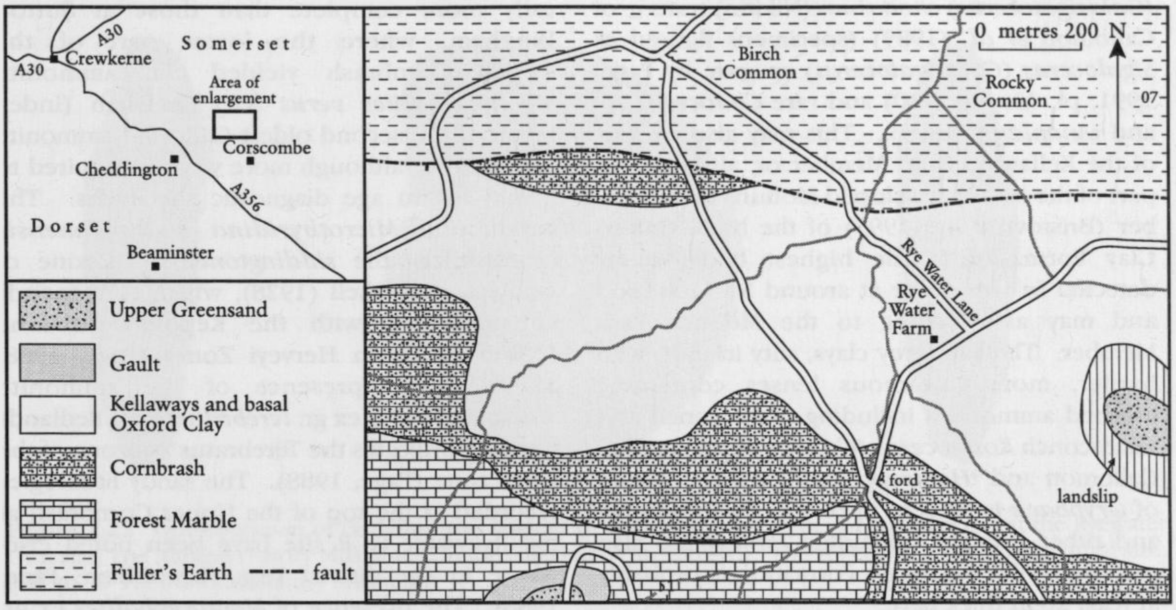

Figure 2.21 Sketch map of the Ryewater GCR site. (After Cope and Cox, 1970, fig. 2.) According to Page (1988), the Cornbrash Formation also crops out in the stream just north of Rye Water Lane.

in total thickness, has been reported nearby (Page, 1988). The latter comprises sandy, nodular and bedded limestones with locally abundant specimens of the terebratulid brachiopod *Microthyridina siddingtonensis* (Walker). Traces of similar *M. siddingtonensis*-rich sandy concretions have been recorded west of Redland Coppice (*c.* ST 5045 0650). Higher levels of the Upper Cornbrash include massive beds of sandy limestone interbedded with sandstones, sometimes with limestone concretions. These can be seen in the stream bed immediately downstream of Lovelands Ford, and again immediately east of the Rye Water Lane bridge (ST 5140 0675), in Redlands Coppice (ST 5062 0643) and possibly in a faulted outcrop at ST 5167 0676. A fragment of the ammonite *Macrocephalites* ex gr. *terebratus* (Phillips) collected near Redlands Coppice appears to be from these levels. The highest beds of the Upper Cornbrash crop out close to the eastern side of Rye Water Lane bridge and include grey sandy clay overlain by 0.4 m of muddy sand with an abundant bivalve fauna including *Goniomya*, *Modiolus*, *Pholadomya* and *Pleuromya*, and the ammonite *Macrocephalites* ex gr. *kamptus* (S.S. Buckman).

The overlying Kellaways Clay Member of the Kellaways Formation is seen in several small exposures a short distance west of Rye Water Lane (*c.* ST 512 067–ST 513 067–ST 514 066) and repeated farther west (ST 506 064). It is represented by grey, sandy clay with one or more bands of septarian limestone concretions and has yielded the ammonite *Proplanulites* cf. *koenigi* (J. Sowerby) and a bivalve fauna including *Catinula*, *Modiolus*, *Myophorella* and *Protocardia*. The bulk of the ex-situ fauna recorded by Cope and Cox (1970), including macroconch and microconch *Proplanulites koenigi*, *Cadoceras* sp. nov. A of Callomon and Page (in Callomon *et al.*, 1989), *Chamoussetia buckmani* Callomon and Wright and *Macrocephalites lophopleurus* (S.S. Buckman), probably came from these levels.

Greyish, sandy clay with a band of harder, more calcareous lenses is exposed in the stream bank and bed around ST 5115 0665. They are the sandiest lithologies seen in the stream sections and probably represent the Kellaways Sand Member. Bivalves include *Gryphaea*, *Myophorella* and ?*Pholadomya* but *Sigaloceras* sp. is the only ammonite to have been recorded *in situ* (Page, 1988). Around ST 5108 0660, *c.* 0.6 m of blue-grey sandy clay has yielded abundant aragonitic fossils including the bivalves *Gryphaea*, *Oxytoma*, *Thracia* and *Trautscholdia*, and ammonites including macroconch and microconch *Sigaloceras*

(*Catasigaloceras*) *enodatum* (Nikitin) trans α of Callomon *et al.* (1989) (specimens figured as *Sigaloceras* (*Catasigaloceras*) sp. nov. by Page, 1991, pl. 13, figs 9,10) and rare *Cadoceras* sp. and ?*Anaplanulites* sp.. This may also be part of the Kellaways Sand Member or, alternatively, part of the locally developed Mohuns Park Member (Bristow *et al.*, 1995) of the basal Oxford Clay Formation. The highest beds so far detected *in situ* occur at around ST 5100 0655 and may also belong to the Mohuns Park Member. They are grey clays, silty in part, with harder, more calcareous lenses containing crushed ammonites including macroconch and microconch *Kosmoceras* (*Gulielmiceras*) *medea* Callomon and ?*Homoeoplanulites* sp.. A band of *Gryphaea* is present in one of the exposures and other bivalves (including *Pinna*) are also recorded. The Kellaways Formation is probably at least 20 m thick here.

Interpretation

By comparison with former sections recorded near Corscombe, the Lower Cornbrash at Ryewater is assumed to be of latest Bathonian age (Discus Zone and Subzone; Douglas and Arkell, 1928; Page, 1988, 1989).

The Upper Cornbrash exposures are virtually the only ones in the region. They are of particular significance as they are close to important localities in the Corscombe district referred to by Douglas and Arkell (1928), which yielded the ammonites *Macrocephalites* cf. *jacquoti* Douvillé and the very rare basal Callovian index taxon *Kepplerites* (*K.*) *keppleri* (Oppel). This fauna indicates the internationally important *Kepplerites keppleri* Biohorizon that is used to correlate the base of the Callovian Stage from the Caucasus through Europe to east Greenland, and which is also recognizable in southern Alaska, British Columbia and possibly Japan (Callomon, 1994). The records of this fauna in the Corscombe area suggest that the Ryewater GCR site may include one of the most complete Bathonian–Callovian stage boundary successions in Britain. The site is also only *c.* 6 km from the sections at Sutton Bingham described by Arkell (1954a) and used by Callomon (1964) to define the base of the Macrocephalus (now Herveyi) Zone and therefore the base of the Callovian Stage. The Corscombe sections are probably stratigraphically more complete than those at Sutton Bingham, where the lower part of the Upper Cornbrash yielded the ammonite *Macrocephalites verus* S.S. Buckman (index taxon of the second oldest Callovian ammonite biohorizon), although more work is required to obtain in-situ age diagnostic specimens. The brachiopod *Microthyridina siddingtonensis* characterizes the *siddingtonensis* Biozone of Douglas and Arkell (1928), which corresponds approximately with the Keppleri Subzone (Lower Callovian Herveyi Zone) (Page, 1988, 1989). The presence of the ammonite *Macrocephalites* ex gr. *terebratus* near Redlands Coppice indicates the Terebratus Subzone of the latter zone (Page, 1988). The sandy lithologies recorded at the top of the Upper Cornbrash at the Ryewater GCR site have been noted elsewhere in the district (e.g. Rampisham; Page, 1988). The presence of *Macrocephalites* ex gr. *kamptus* in these highest sandy beds suggests the Kamptus Subzone (youngest subzone of the Herveyi Zone).

The exposure of the overlying Kellaways Clay Member is particularly significant; nowhere else is a fossiliferous sequence now exposed more-or-less permanently; the type section of the member, designated by Page (1989), is a cored borehole near Kellaways in Wiltshire (see **Kellaways–West Tytherton** GCR site report, this volume). The recorded ammonite fauna is indicative of the Koenigi Zone, Gowerianus Subzone and certainly includes elements of the *Kepplerites metorchus* Biohorizon. This fauna is of particular biostratigraphical significance because it includes probable chorotypes (i.e. specimens from a neighbouring locality but at a similar stratigraphical level to the holotype) of the zonal index ammonite *Proplanulites koenigi* (J. Sowerby) (Figure 2.22). The type locality of the species is likely to have been the now obliterated brickpit near Rampisham, *c.* 6 km to the south-east (Page, 1988).

The sandiest bed in the stream sections is assigned to the Kellaways Sand Member. The single *Sigaloceras* fragment recorded from it suggests the Calloviense Zone and Subzone. This may be confirmed by a loose specimen of *Proplanulites* ex gr. *petrosus* (S.S. Buckman)–*crassicosta* (S.S. Buckman) in a sandy matrix (originally reported by Cope and Cox (1970) as *Reineckeia rehmanni* (Oppel)).

The ammonite fauna recorded from the

Figure 2.22 Type specimen of *Proplanulites koenigi* (J. Sowerby), chorotypes of which occur at the Ryewater GCR site; The Natural History Museum, London, specimen No. 43891C). The specimen is shown at natural size. (Photo: © The Natural History Museum.)

topmost part of the Kellaways Sand Member (beds that might belong instead to the Mohuns Park Member of the basal Oxford Clay Formation) indicates the *Sigaloceras enodatum* α Biohorizon of the Calloviense Zone, Enodatum Subzone. The highest beds exposed, with their fauna of *Kosmoceras medea* and ?*Homoeoplanulites*, belong to the Middle Callovian Jason Zone, Medea Subzone.

Conclusions

The outcrops in the stream beds and banks near Rye Water Lane, Corscombe which comprise the Ryewater GCR site, provide the best more-or-less permanent exposure of the Kellaways Clay Member of the Kellaways Formation in Britain. The member there yields the only in-situ ammonite fauna of the Lower Callovian Koenigi Zone, Gowerianus Subzone in England. Associated exposures of the Upper Cornbrash and ?basal Oxford Clay Formation also yield stratigraphically important faunas, and together these may comprise one of the most complete Bathonian–Callovian stage boundary successions in Britain. The ammonite faunas collected from the site can be related to those, including type material, from old, now obliterated exposures in the area that are recorded in the literature. These ammonite faunas are important for international correlations of the Lower Callovian Substage.

SEAVINGTON ST MARY QUARRY, SOMERSET (ST 400 144)

B.M. Cox

Introduction

The Seavington St Mary Quarry GCR site lies to the south of the village of Seavington St Mary, north-west of Crewkerne, in Somerset, and is located on a faulted outlier that comprises the most westerly outcrop of the Inferior Oolite Formation in England. The section was first noted by Wilson *et al.* (1958) who recorded *c.* 5 m of beds in a *c.* 90 m-long face. It exposes Aalenian and both Lower and Upper Bajocian strata although, as elsewhere in this region, major non-sequences interrupt the succession. The beds are richly fossiliferous, and the zonal/subzonal sequence is substantiated by ammonites that have contributed to the recognition and definition of Aalenian and Lower Bajocian ammonite biohorizons in southern England (Callomon and Chandler, 1990).

Description

The following description is based on that of Torrens and Parsons (in Torrens, 1969b). The graphic section shown in Figure 2.23 is based on Callomon and Chandler (1990, fig. 3) who used Torrens and Parsons' bed numbers but

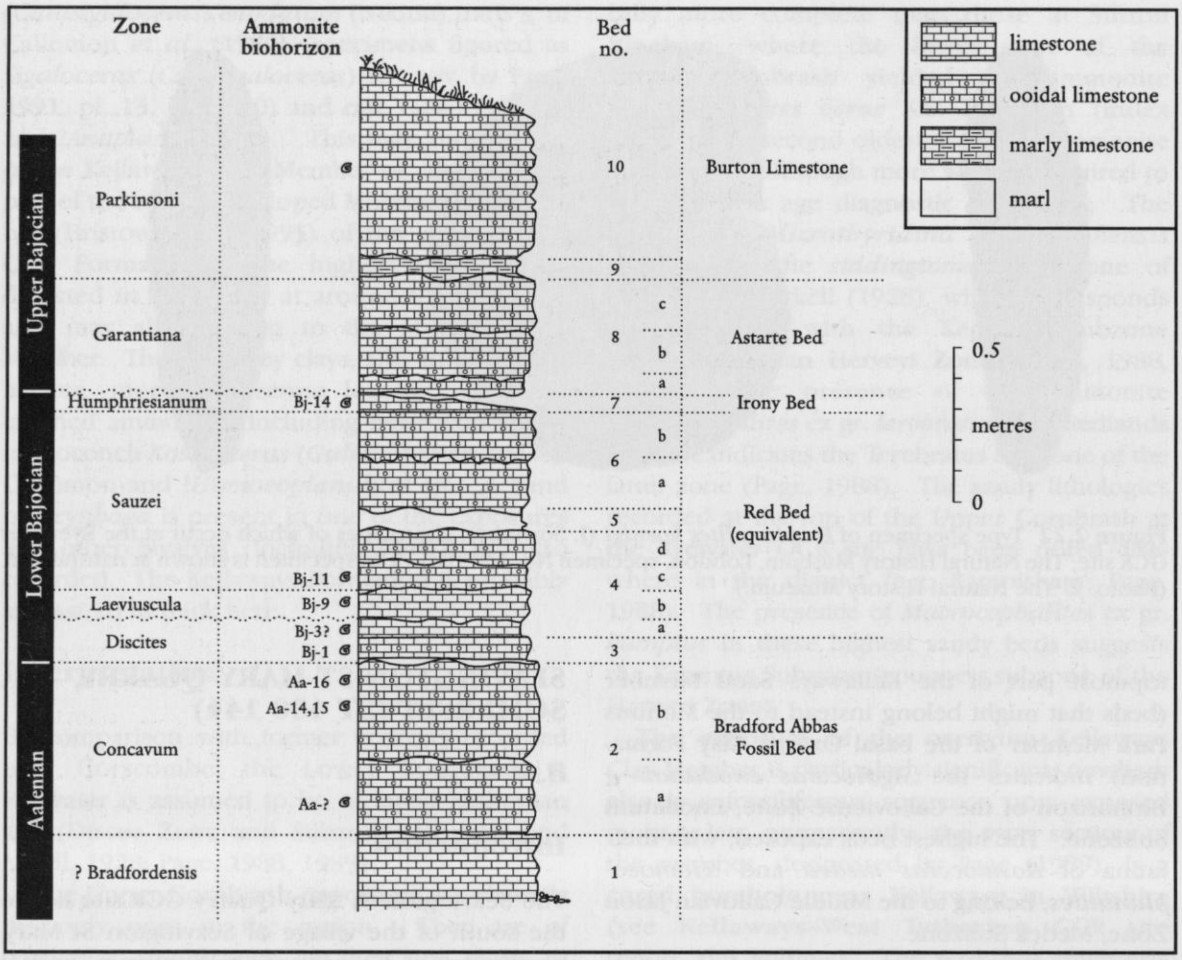

Figure 2.23 Graphic section of the Inferior Oolite Formation at the Seavington St Mary Quarry GCR site. (After Callomon and Chandler, 1990, fig. 3.) For lithologies, see text.

added further subdivisions. The informal lithostratigraphical terms follow Parsons (1980a) who based them largely on terms used by Buckman (1893a, 1910a) and Hudleston (1887).

	Thickness (m)
Inferior Oolite Formation	
Burton Limestone	
10: Limestone, rubbly, detrital, cream-coloured, bioturbated; sparse cream-coloured ooids; fossils, including ammonites (*Parkinsonia*, *Polyplectites*, *Strigoceras*) and echinoids (*Holectypus*, *Pygorhytis*), concentrated 0.45 m above base; *Parkinsonia* at base	seen to 0.75
9: Limestone, marly, very soft and rubbly; small sphaeroidal, laminated concretions of dark limonite; ammonites (*Parkinsonia*) and echinoids (*Collyrites*, *Holectypus*, *Pygorhytis*) common at top; undulating surface at base	0.10
Astarte Bed	
8: Limestone, 'iron-shot' with ferruginous ooids becoming less common towards top; weathering buff-brown, rubbly, with limonitic crusts and concretions; shelly and detrital with abundant belemnites, ammonites (*Garantiana* and *Sphaeroceras*) and echinoids (*Collyrites*); basal 0.13 m locally conglomeratic with ammonite fragments from Bed 7 and pebbles; planed surface at base	0.2–0.4
Irony Bed	
7: Algal limestone, very hard, crinoidal, dark-red; nests of large ooids; limonitic crusts, pebbles and small 'snuff-boxes'; abundant belemnites and crinoid stems, oppeliid ammonites, rhynchonellid brachiopods and casts of pleurotomariid gastropods; prominent flat, bored hardground forming good marker horizon at base	0–0.13
Red Bed (equivalent)	
6: Limestone, very hard, crinoidal; cream-coloured ooids and rare fossils including ammonites (*Oppelia* and *Sphaeroceras*) at top	0.45
5: Marl, silty, finely laminated and cross-bedded; irregular, undulating base, heavily stained with limonite; 'snuff-boxes'	0.13

		Thickness (m)
4c–d:	Limestone, soft, poorly bedded, pale-coloured, crinoidal; sparse, large ooids falling out to leave cavities; ammonites (*Emileia*, *Papilliceras*, *Stephanoceras*); planed surface with pebbles and planed ammonites at base	0.20–0.23
4a–b:	Limestone, soft, poorly bedded, pale-coloured, cross-bedded; fossils, including ammonites (*Docidoceras*, *Hammatoceras*, *Witchellia*), more common towards brown marl at sharp, flat base	0.28–0.30
Bradford Abbas Fossil Bed		
3:	Limestone, soft, weathering brown and decalcified; where fresh, blue and marly with large ooids; many fossils including ammonites (*Graphoceras* (very common), *Sonninia* (*Euhaploceras*), *Trilobiticeras*), small belemnites and *Plagiostoma*; marl parting at undulating base	0.05–0.08
2:	Limestone, massive, finely ooidal, dividing into two, approximately equal, tiers; ammonites (including very common *Graphoceras*) preserved at all angles to bedding; rhynchonellid brachiopods; sharp base	0.85
1:	Limestone, massive, hard, grey, crinoidal, non-ooidal	seen to 0.15

Other fossils, including bivalves, gastropods and nautiloids, were recorded by Wilson *et al.* (1958) but these cannot be assigned to a specific bed in the section detailed above.

Interpretation

The ammonite faunas enable recognition of the Aalenian Concavum Zone in Bed 2, with the Bradfordensis Zone possibly represented by Bed 1 (Parsons, 1980a). All of the Lower Bajocian zones, except the Ovalis Zone, are represented albeit incompletely, but much of the Upper Bajocian succession is missing (Figure 2.23); only the youngest part of the Garantiana Zone and the Parkinsoni Zone are represented (Bed 8 and beds 9/10 respectively). The Lower–Upper Bajocian boundary is thus marked by a significant non-sequence spanning much of the Humphriesianum Zone, the Subfurcatum Zone and much of the Garantiana Zone (Parsons, 1980a). According to Callomon and Chandler (1990), the youngest Lower Bajocian ammonite biohorizon recorded here is their Bj-14 (*Poecilomorphus cycloides*) although this has subsequently been replaced by biohorizons Bj-14a (*Chondroceras delphinum*) and Bj-14b (*Chondroceras wrighti*) (Callomon and Cope, 1995). Other Bajocian biohorizons recognized are shown in Figure 2.23 (see also Figure 1.4, Chapter 1), and details of their diagnostic ammonite taxa were given by Callomon and Chandler (1990). These authors recognized only biohorizons Aa-14/15 (*Graphoceras concavum*/*Graphoceras formosum*) in the Aalenian strata here but they considered that the ammonite data from the Aalenian–Bajocian boundary (base of Bed 3) interval was sufficient to merit the site as a possible candidate reference section for this stage boundary. Subsequently, Morton and Chandler (1994) recognized the *Euhoploceras acanthodes* Biohorizon (Horizon Aa-16 of Callomon and Chandler, 1990), with species of *Graphoceras*, *Euaptetoceras*, *Euhoploceras* and *Hyperlioceras* in Bed 2 here, and reaffirmed the *Hyperlioceras politum* Biohorizon (Horizon Bj-1 of Callomon and Cope (1995) emend.), with species of *Hyperlioceras*, *Eudmetoceras*, *Euhoploceras* and *Graphoceras* in Bed 3.

The succession at Seavington St Mary Quarry is typical of the Inferior Oolite Formation in Dorset and Somerset, with small stratal thicknesses but with individual beds that do not give the impression of being particularly condensed (Callomon and Chandler, 1990). According to these authors, ammonites preserved at all angles to the bedding (for example, in Bed 2 of the above section) indicate that the sediments remained unconsolidated for a relatively long time (although not necessarily more than a few years). Marked changes in the ammonite faunas between beds are not necessarily accompanied by a profound lithological change but, in other cases, non-sequences are revealed by spectacular erosion planes marked by stromatolitic crusts and other epifauna and flora, borings, and planing off of large body fossils such as ammonites (for example, in Bed 4c). Lateral persistence of thin beds, their facies and faunas, point to tranquil bottom conditions during depositional periods and there are no indications of the proximity of shorelines. The causes of the complex pattern of deposition, non-deposition and erosion are almost certainly predominantly tectonic (Callomon and Cope, 1995).

Conclusions

The section at Seavington St Mary Quarry complements other local sections that together enable the complex geological history of the Aalenian and Bajocian stages in this region to be unravelled. Ammonite faunas enable recognition of distinctive faunal horizons and help to substantiate breaks in the succession. The ammonites are sufficient to justify the site as a possible candidate reference section for the Aalenian–Bajocian stage boundary in England. It is thus of both national and international importance for Aalenian–Bajocian stratigraphy as well as the depositional history and palaeogeography of the Wessex region.

TROLL QUARRY, DORSET (ST 594 127)

B.M. Cox

Introduction

Troll (sometimes known as 'Trill') Quarry, Thornford, near Sherborne, Dorset, is a famous Middle Jurassic locality where the Fuller's Earth Rock Member was once worked (Woodward, 1894; Richardson *et al.*, 1911; Buckman, 1921). First described in some detail by Buckman (1927a), the quarry yielded a distinctive ammonite fauna, almost exclusively of the cadicone genus *Tulites*. Such ammonites are a characteristic element of the Fuller's Earth Rock Member fauna in southern England, and Woodward (1894) termed this interval the 'zone of *Amm. subcontractus*' after one of the most common species (Figure 2.24). The Fuller's Earth Rock Member in the Sherborne area is one of the most ammonitiferous developments of rocks of this age known in Europe (Torrens, 1974), and Troll Quarry is now well established as the type locality of the Middle Bathonian Subcontractus Zone as used throughout Europe today (Torrens, 1980b). The quarry was visited by L. Richardson and W.J. Arkell in 1931. The manuscript containing their measured section is held in the Arkell archives at the University Museum Oxford and was reproduced by Torrens (1966). When the quarry ceased working, it became overgrown and degraded but, in 1964, a magnificent new section (Figure 2.25) became available when the old quarry was re-excavated during construction of a new sewage works immediately to its east, and many more ammonites were collected (Torrens in House, 1965). This section revealed a greater thickness of strata than had ever been recorded in the old quarry workings (Torrens in House, 1965; Torrens, 1969a, 1974).

Description

The following section is based on Torrens (1966, 1974) and relates to the most westerly face of the extended exposure seen during construction of the sewage works in 1964. The section became degraded and overgrown; in 1992, English Nature (unpublished records) reported no exposure within the site.

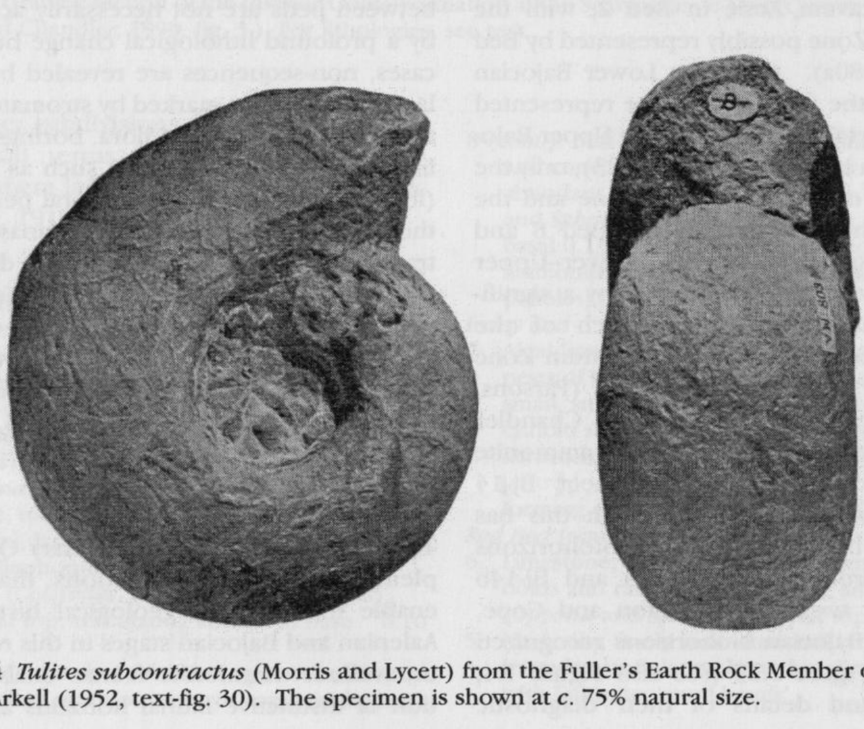

Figure 2.24 ***Tulites subcontractus*** (Morris and Lycett) from the Fuller's Earth Rock Member of Troll Quarry as figured by Arkell (1952, text-fig. 30). The specimen is shown at *c.* 75% natural size.

Figure 2.25 The main face at Troll Quarry, as exposed in 1964. (Photo: H.S. Torrens.)

	Thickness (m)
22: Soil	0.23
Fuller's Earth Formation	
Fuller's Earth Rock Member	
Thornford Beds	
21: Marl; *Pholadomya lirata* (J. Sowerby)	0.15
20: Limestone, impersistent; *Tulites*; *Pholadomya lirata*	0.075
19: Marl; *Tulites*	0.15–0.23
18: Limestone, variable; *Tulites* (macroconch and microconch); nautiloid; *Pholadomya lirata*	0.075–0.15
17: Clay, marly with thin limestone towards base; *Tulites*; *Pholadomya lirata*	0.38–0.46
16: Limestone, variable; clusters of *Rhynchonelloidella*; *Pholadomya lirata*	up to 0.15
15: Marl; *Tulites*; *Pholadomya lirata*	0.15
14: Limestone; *Tulites*; marl parting at base	0.075–0.13
13: Limestone; *Tulites*; clusters of *Rhynchonelloidella*; belemnite fragments; very irregular base	up to 0.10
12: Marl; divided about the middle by impersistent, rubbly limestone; *Catinula*, *Pholadomya lirata*, *Pleuromya* cf. *alduini* (Brongniart); belemnite fragments; *Pleurotomaria* cf. *cotswoldensis* Cox and Arkell (some bored); *Rhynchonelloidella*	0.38
11: Limestone	0.075
10: Limestone	0.23
9: Marl; *Pholadomya lirata*	0.23–0.25
8: Limestone; marl parting at base	0.10
7: Limestone, prominent	0.36
6: Limestone	0.15
5: Limestone, soft and marly	0.075
4: Limestone	0.30
3: Limestone, soft and marly	0.075
2: Limestone, blue-hearted, hard	0.30
Lower Fuller's Earth Member	
1: Clay, compact, dark-blue where unweathered; belemnite fragment	0.30

According to Torrens (1966), individual beds of the Fuller's Earth Rock Member here, which totalled about 3.8 m, could only be clearly differentiated where weathered. In particular, beds 9–12 were barely separable where fresh. In addition to the fauna given above, Torrens (1966) also reported ex-situ occurrences of the oppeliid ammonite *Oecotraustes* and the bivalves *Camptonectes* cf. *laminatus* (J. Sowerby), *Entolium corneolum* (Young and Bird) and *Trigonia elongata* (J. de C. Sowerby); the ammonites were occasionally seen encrusted with serpulids and oysters. Other references to this site (Arkell, 1939a; Kellaway and Wilson, 1941; Wilson *et al.*, 1958; Torrens in House, 1965; Torrens, 1969a) add no further lithological or faunal detail except to record the bivalve *Meleagrinella*. According to Muir-Wood (1936), brachiopods are rare at Troll Quarry and differ from those of any other Fuller's Earth Rock Member locality in being dwarf or immature forms (but see also **Goathill** GCR site report, this volume). Most of the specimens, amongst which she identified *Rugitela cadomensis* (Eudes-Deslongchamps) and the new species *Ornithella haydonensis*, *Rhynchonelloidella wattonensis* and *Kallirhynchia platiloba*, are poorly preserved. Her record of *Rugitela* was challenged by Torrens (1966).

Interpretation

In Dorset and Somerset, Buckman (1918, 1921) recognized an upper division of the Fuller's Earth Rock Member, which he termed the 'Milborne Beds', and a lower division that he termed the 'Thornford Beds'. The latter was based on the beds exposed in Troll Quarry. The Milborne Beds were described as brown ('iron-shot') limestones, and the Thornford Beds as whitish, chalky limestones. Although Arkell (in Donovan and Hemingway, 1963; Arkell, 1933) considered these subdivisions to be unnecessary and not well founded, accusing Buckman of not 'describing a single section in support of his conclusion', the terms are still used today. In fact, the Milborne Beds are the more widespread facies; the major part of the Fuller's Earth Rock Member throughout the main escarpment of Somerset is classified as such (Arkell, 1933) (see Figure 2.4). Torrens (1966) clarified their definition according to which they comprise the thick limestone beds that lie between the Acuminata Beds (Lower Fuller's Earth Member) below and the Ornithella Beds above, north of Milborne Port. Their upper and greater part typically consists of thick courses of brown, often very shelly, limestones, and the lower part consists of marls with occasional beds of soft limestone. Large bivalve casts are common, and simple corals are common towards the base of the upper part. The Thornford Beds are more restricted; indeed, the only locality where Buckman recognized them was Troll Quarry and, according to Arkell (1933), it was the only exposure of the Fuller's Earth Rock Member that Buckman ever described from first-hand experience (in 1921, with additions in 1927a). Arkell (1933) recognized that the Fuller's Earth Rock Member here was 'certainly peculiar' and concluded that Troll Quarry apparently afforded a glimpse of beds that are not developed in fossiliferous facies anywhere along the Somerset outcrop. He agreed with Buckman that the Thornford Beds, of which Troll Quarry is the type locality, appeared to be on a somewhat lower horizon than most of the ordinary Fuller's Earth Rock Member or Milborne Beds. In fact, they are largely contemporaneous but the upper part of the Milborne Beds is younger than any part of the Thornford Beds (Torrens, 1966).

The definition of the Thornford Beds was clarified by Torrens (1966). Typically, they comprise whitish, chalky limestones separated by beds of grey-white marl. The limestones may be massive and occur in thick, compact courses. Softer marly beds are developed in the lower part. Apart from the ammonite fauna discussed below, the most common fossil is the bivalve *Pholadomya lirata*; the brachiopod fauna is mainly dwarfed. Where complete, the Thornford Beds are overlain by the easily distinguished rubbly, brown-weathering, brachiopod-rich Linguifera Bed (see **Goathill** GCR site report, this volume). Buckman (1927a) recognized a specific 'Rhynchonella Bed' and 'Pholadomya Bed' within the Thornford Beds at Troll Quarry. These stratal terms were sanctioned by Arkell (in Donovan and Hemingway, 1963) but Torrens (1966) recommended that they should be abandoned because the fossils, after which they were named, were not restricted to any particular bed. The large 'myid' bivalves of the genus *Pholadomya* ranged from the base of Bed 9 up to Bed 21, and rhynchonellid brachiopods occurred in clusters in both beds 13 and 16, as well as individually in other beds.

Although, as a whole, the beds at Troll Quarry are monotonous and poorly fossiliferous, they have yielded an interesting ammonite fauna that Buckman (1927a) described as 'almost, if not quite, unique in England'. According to Torrens (1974), many English museums hold ammonites obtained from here between 1885 and 1945. Buckman (1923a, pls 338A, 367–371) figured several, amongst which he recognized a number of tulitid genera: *Pleurophorites*, *Rugiferites*, *Sphaeromorphites* and *Tulophorites*. By comparing the matrix of the specimens with his measured section, he ordered these, together with the genus *Madarites*, into a possible sequence. Buckman (1927a) conceded that this might well be an unreliable method of establishing the ammonite succession; Arkell (1933) confirmed this by reporting *Sphaeromorphites in situ* within the top metre of the section whereas Buckman had deduced this genus to belong to the lowest beds. Arkell (1933) concluded that the peculiar ammonites here probably lived contemporaneously and together formed a single 'faunizone'. Later, Arkell (1951–1958) figured other ammonite specimens from Troll Quarry that led Torrens (1974) to comment, when he proposed the site as type locality of the Subcontractus Zone, that it made an ideal type section because its fauna was so well documented. Almost all of the tulitid ammonites recorded from Troll Quarry are now assigned to the genus *Tulites*. Over a hundred specimens were collected when the section was re-excavated for the sewage works in the 1960s. The great majority of these are macroconchs, which outnumber microconchs by over 100 to 2; for the latter, Torrens (1970) proposed the name *Trolliceras*, after this locality. The lowest in-situ occurrence of *Tulites* is Bed 13 but Torrens (1974) considered that there was no doubt, from the matrix of loose specimens, that the genus ranged lower. He recommended that the base of the Subcontractus Zone should be drawn at the base of Bed 2; the top of the zone was not seen. According to Page (1996a), most of the nominal species described from Troll Quarry can probably be placed in synonymy. They include *Tulites calvus* (S.S. Buckman), *T. glabretus* (S.S. Buckman), *T. modiolaris* (Wm Smith), *T. praeclarus* (S.S. Buckman), *T. pravus* (S.S. Buckman), *T. pumilus* (Arkell), *T. reuteri* (Arkell), *T. sphaeroidalis* (S.S. Buckman), *T. subcontractus* (Morris and Lycett) and *T. tulotus* (S.S. Buckman). *Bullatimorphites rugifer* (S.S. Buckman), *B. polypleurus* (S.S. Buckman) and *?B. pleurophorus* (S.S. Buckman) are also present. Torrens' (1966) preferred name for the macroconchs was *T. modiolaris*. Page (1996a) considered it likely that more than one ammonite faunal horizon was present but this could not be demonstrated because none of the many type ammonites described from the quarry by Buckman (1909–1930) and Arkell (1951–1958) had any associated stratigraphical information.

The Fuller's Earth Rock Member can be traced continuously from north of Bath to just south-west of Yeovil where it dies out and is probably replaced laterally by clay. Troll Quarry is sited near this southern limit. The cadicone–sphaerocone tulitids also die out where the limestone facies passes into clay that led Torrens (1967, 1969b, 1974) to suggest that they may have been somewhat facies-dependent. However, later (Torrens, 1980b), he suggested that this problem had probably been overstated.

Conclusions

The Fuller's Earth Rock Member in Dorset and Somerset shows one of the best developments of Middle Bathonian rocks in Europe. The section at Troll Quarry provides the type locality for the Subcontractus Zone, which can be recognized throughout Europe, as well as the Thornford Beds, a local facies of the Fuller's Earth Rock Member. The zonally diagnostic tulitid ammonite fauna recovered from Troll Quarry in the past has been well described and illustrated in the published literature. The site is thus a most important one for regional, national and international correlation.

BRADFORD ABBAS RAILWAY CUTTING, DORSET (ST 592 145)

B.M. Cox

Introduction

Bradford Abbas, Dorset was the childhood home of S.S. Buckman; his father James, one time Professor of Geology at the Royal Agricultural College in Cirencester, is buried in the grounds of the parish church there (Chandler and Sole, 1996). Soon after moving to Bradford Abbas, Buckman senior became aware of the 'richness of the oolitic strata of the district in fossil remains' and both father and son investigated the quarries and railway cuttings in the neighbourhood (J. Buckman, 1877). The GCR site comprises the railway cutting on the eastern side of Bradford Abbas, on the line between Salisbury and Yeovil. Access is restricted because of high-speed trains. The cutting extends for *c.* 340 m eastwards from the Back Lane overbridge, and both the north and south sides, exposing beds of the Inferior Oolite Formation, are included (Figure 2.26). The most famous stratum hereabouts is the Bradford Abbas Fossil Bed, up to *c.* 1 m thick, which yields a rich fauna, including ammonites, gastropods, bivalves and brachiopods, of the Aalenian Concavum and Lower Bajocian Discites zones.

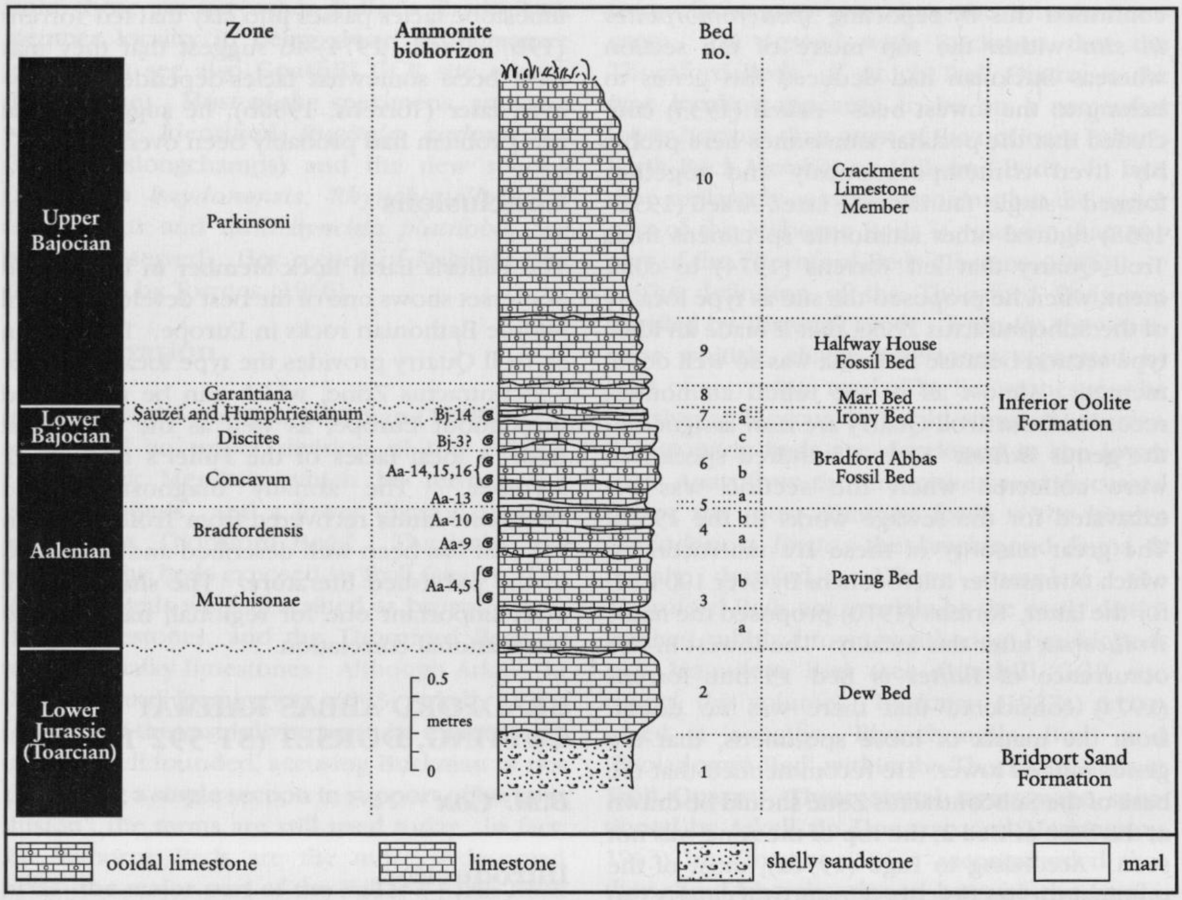

Figure 2.26 Graphic section of the Inferior Oolite Formation at Bradford Abbas Railway Cutting. (After Callomon and Chandler, 1990, fig. 3.) For lithologies, see text.

Description

The only published description of the section is that of Woodward (1894), as later mentioned by Richardson (1932). Composite faunal lists were given by Wilson *et al.* (1958), and Parsons (1974a) described the ammonite fauna of the Bradford Abbas Fossil Bed. Most other authors, including the Buckmans, concentrated on the section exposed at East Hill Quarry (Buckman, 1893a), sited *c.* 600 m NNW of the railway cutting, where the succession is closely similar. This quarry was situated in the corner of a field farmed by James Buckman, who had it worked from time to time in order to obtain fossils (Richardson, 1932); it has recently been re-investigated by Chandler and Sole (1996). The section in the railway cutting given below is based mainly on that in the unpublished thesis of Parsons (1980b), modified following Callomon and Chandler (1990) and Callomon and Cope (1995). Bed numbers follow Callomon and Chandler (1990); these agree with those of Parsons (1980b) except for the lowest beds. The informal lithostratigraphical terms mainly follow Parsons (1980a,b) who based them largely on terms used by Buckman (1893a). The ammonite names used by Parsons (1980b) have been rationalized following Callomon and Chandler (1990) and Chandler and Sole (1996).

	Thickness (m)
Inferior Oolite Formation	
Crackment Limestone Member	
10: Limestone, poorly bedded, rubbly, white, weakly oodial; deeply weathered and relatively unfossiliferous; *Parkinsonia* in basal 0.10 m	seen to 2.0
Halfway House Fossil Bed	
9: Limestone, soft, cream-coloured with yellow-brown limonite ooids; fossiliferous with shells, notably the bivalve *Neocrassina*, replaced by limonite; numerous small 'snuff-boxes'; *Parkinsonia*	0.35–0.65

	Thickness (m)
Marl Bed	
8: Limestone, limonite-rich, 'iron-shot'; planed top surface; in places reduced to limonitic clay parting; very fossiliferous with bivalves (*Neocrassina*) and terebratulid brachiopods (*Goniothyris*); numerous 'snuff-boxes'	0–0.20
Irony Bed	
7c: Marl, limonitic, patchy; occasional 'snuff-boxes'; capped by flat hardground; locally thickened and hardened into lenses of crimson ironstone, patchily ooidal; fills depressions in bed below; *Sphaeroceras* sp.	
7b: Limestone, hard, somewhat fissile, crystalline, white to pale-grey with ferruginous patches; scattered large, coarse limonitic ooids and echinoderm debris	
7a: Marl, ochreous or limonitic crust; 'snuff-box' oncoids	0–0.15
Bradford Abbas Fossil Bed	
6: Limestone, 'iron-shot', very fossiliferous; divided into two or three courses (6a–6c) by one or two discontinuous and irregular clay partings	
6c: Oobiomicrite, densely 'iron-shot'; fine, brown limonite ooids set in pale blue-grey matrix; joint faces and fossils stained black; ammonites including *Euhoploceras*, *Hyperlioceras* and *Trilobiticeras*; persistent marl parting at base	0.18–0.20
6b: Oobiomicrite, densely 'iron-shot'; ooids yellower and matrix browner than Bed 6c; ammonites including *Bradfordia*, *Eudmetoceras*, *Euhoploceras*, *Graphoceras*, *Haplopleuroceras*, *Trilobiticeras*; impersistent marl parting at base but where absent, Bed 6b not separable from 6a	0–0.25
6a: As Bed 6b; ammonites including *Graphoceras*	0.25–0.38
(Total thickness for Bed 6 is 0.50–0.70 m)	
5: Marl, brown, prominent	0–0.04
Paving Bed	
4a–b: Limestone, hard, rubbly, ooidal; small yellow ooids set in pale blue-grey fine spar matrix; joint faces and relatively rare fossils stained dark red-purple; *Ludwigia* 0.12 m below top; impersistent limonite-stained parting at base	0.25–0.38
3a–b: Limestone, hard, rubbly, ooidal; superficially similar to Bed 4 but, where fresh, matrix seen to be sandier and more yellow-grey; ammonites including *Brasilia* and *Ludwigia*	0.30–0.70
Dew Bed	
2: Biosparite, extremely hard, coarsely shelly, blue-hearted; prominent, bored, undulating upper surface in places thickly smeared with limonite; moderately shelly but fossils very difficult to extract; impersistent limonite layer at base, otherwise base transitional	0–0.28
Lias Group	
Bridport Sand Formation	
1: Sandstone, hard, nodular, very shelly, blue-hearted but weathering yellow	0.35–0.40
Sand, soft, yellow; occasional sandstone doggers	seen to 0.60

Woodward (1894) and Richardson (1932) reported two faults, the western one of which brought the Inferior Oolite and Bridport Sand formations against the Fuller's Earth Formation (Bathonian) (Figure 2.27).

Interpretation

According to Chandler and Sole (1996), identification and evaluation of the fossils from the Bradford Abbas area is ongoing and there continues to be associated, more-or-less provisional, changes to the ammonite taxonomy and recognition of Callomon and Chandler's (1990) Aalenian–Bajocian ammonite biohorizons.

In the lower part of the section, ammonite faunas enable recognition of the Aalenian Murchisonae, Bradfordensis and Concavum zones. Chandler and Sole (1996) recorded a typical *Ludwigia murchisonae* (J. de C. Sowerby), eponymous ammonite of the Murchisonae Zone, in the lower part of Bed 4. This occurrence may mean that the Murchisonae–Bradfordensis zonal boundary

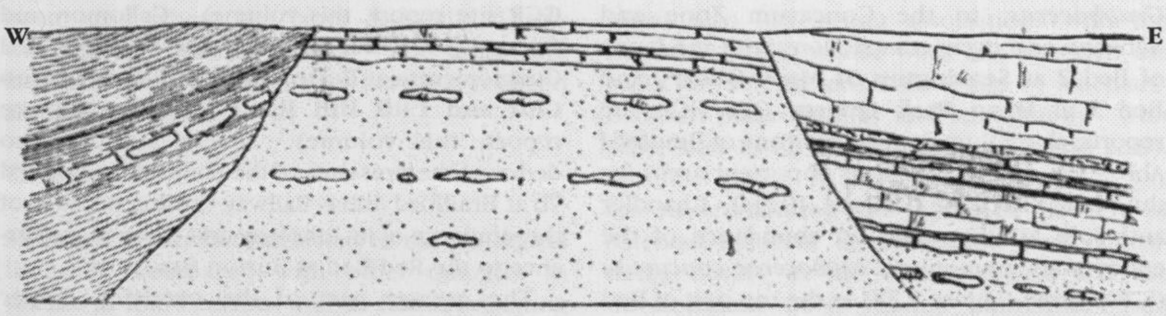

Figure 2.27 Geological sketch section of the Bradford Abbas Railway Cutting as illustrated by Woodward (1894) showing the Inferior Oolite Formation in the east faulted against the Bridport Sand Formation which, to the west, is faulted against the Fuller's Earth Formation.

should be taken somewhat higher than the position shown in Figure 2.26, which is at the base of Bed 4, between ammonite biohorizons Aa-5 (*Ludwigia obtusiformis*) and Aa-9 (*Brasilia bradfordensis* and *B. baylii*) of Callomon and Chandler (1990). The Murchisonae Zone rests unconformably on Lower Jurassic (Toarcian) strata (Figure 2.26).

There is some confusion in the literature regarding the limits of the so-called 'Paving Bed', which was first described as the 'Pavingstone' or '*Murchisonae*-bed proper' by Hudleston and Woodward (1886). They used the term for the *c*. 0.3 m-thick bed between the Dew Bed and the 'great shell bed' (= Bradford Abbas Fossil Bed) at East Hill Quarry, describing it as a 'slabby ironshot oolite' that was used for 'gutters etc'. There has been some subsequent confusion about whether the term should be applied to the combined beds 3 and 4 of the section recorded above or whether it should be restricted to Bed 4 alone, and there is disparity between Parsons (1980b) and Callomon and Chandler's (1990) bed numbers at this level. At East Hill Quarry, Buckman (1893a) certainly restricted the term to the equivalent of Bed 4 but Callomon and Cope (1995) implied that, at the railway cutting, the term covered Bed 3. For convenience, the term is applied herein to the combined beds 3 and 4.

The Aalenian–Bajocian stage boundary lies within the Bradford Abbas Fossil Bed, which Parsons (1980b) described as 'world famous' for its rich fossil content. Although Buckman (1893a) divided this bed into only two, which he assigned to his *concavum* and *discites* hemerae, Parsons (1974a) used two marl partings to establish a three-fold division from which he collected three successive ammonite faunas. He assigned the lowest part (Bed 6a), with an ammonite fauna dominated by species of *Graphoceras*, to the Concavum Zone and Subzone and drew comparisons with the fauna of Bed 2 at **Seavington St Mary Quarry** and Bed 5 at **Horn Park Quarry** (see GCR site reports, this volume). The environs of Bradford Abbas are one of the most important areas for the Concavum Zone (Parsons, 1974a). Chandler and Sole (1996) noted an abundance of the eponymous ammonite *Graphoceras concavum* (J. Sowerby) (Figure 2.28) in the top part of Bed 6a. The oldest ammonite biohorizon reported in Bed 6 by Callomon and Chandler (1990) was Aa-13 (*Graphoceras cavatum*) but if the Bradford Abbas Fossil Bed is taken to include also Bed 5 then, by comparison with the nearby East Hill Quarry, ammonite biohorizon Aa-10 (*Brasilia bradfordensis similis*) might also be represented at about this level (Chandler and Sole, 1996). This would require an upward adjustment to the Bradfordensis–Concavum zonal boundary as shown in Figure 2.26. At present, Aa-10 is at least questionably recognized in the top part of the underlying Paving Bed (Bed 4) at both localities. The middle part (Bed 6b) of the Bradford Abbas Fossil Bed, with a more varied ammonite fauna characterized by the genera *Bradfordia*, *Eudmetoceras*, *Euhoploceras* and *Haplopleuroceras* as well as *Graphoceras*, is assigned to younger levels of the Concavum Zone; Parsons (1974a) again compared this ammonite assemblage with that of Bed 5 at **Horn Park Quarry**. At the base of Bed 6c, which is assigned to the Lower Bajocian Discites Zone, there is almost certainly a non-sequence (Callomon and Chandler, 1990) that coincides with the Aalenian–Bajocian stage boundary. The oldest Bajocian ammonite biohorizon reported, albeit tentatively, by Callomon and Chandler (1990) was Bj-3 (*Hyperlioceras subsectum*); at East Hill Quarry, Chandler and Sole (1996) reported older biohorizons including Bj-1 (*Hyperlioceras politum*).

According to Callomon and Chandler (1990), there is a non-sequence at the base of Bed 7 that cuts out the Ovalis and Laeviuscula zones, although there is possibly some evidence of these at East Hill Quarry (Chandler and Sole, 1996). The Humphriesianum Zone is thinly represented by Bed 7c in which Callomon and Chandler (1990) reported their ammonite biohorizon Bj-14 (*Poecilomorphus cycloides*) (since replaced by Bj-14a and Bj-14b; Callomon and Cope, 1995; see **Seavington St Mary Quarry** GCR site report, this volume). Callomon and Cope (1995) likened this bed to the Red Conglomerate at Burton Bradstock (see **Burton Cliff and Cliff Hill Road Section** GCR site report, this volume). These authors also deduced the presence of the Sauzei Zone in Bed 7b at Bradford Abbas Railway Cutting because of the similarity of its lithology and general appearance to the Red Bed at Burton Bradstock.

The greater part of the overlying Upper Bajocian succession belongs to the Parkinsoni Zone although the Marl Bed (Bed 8), at the base,

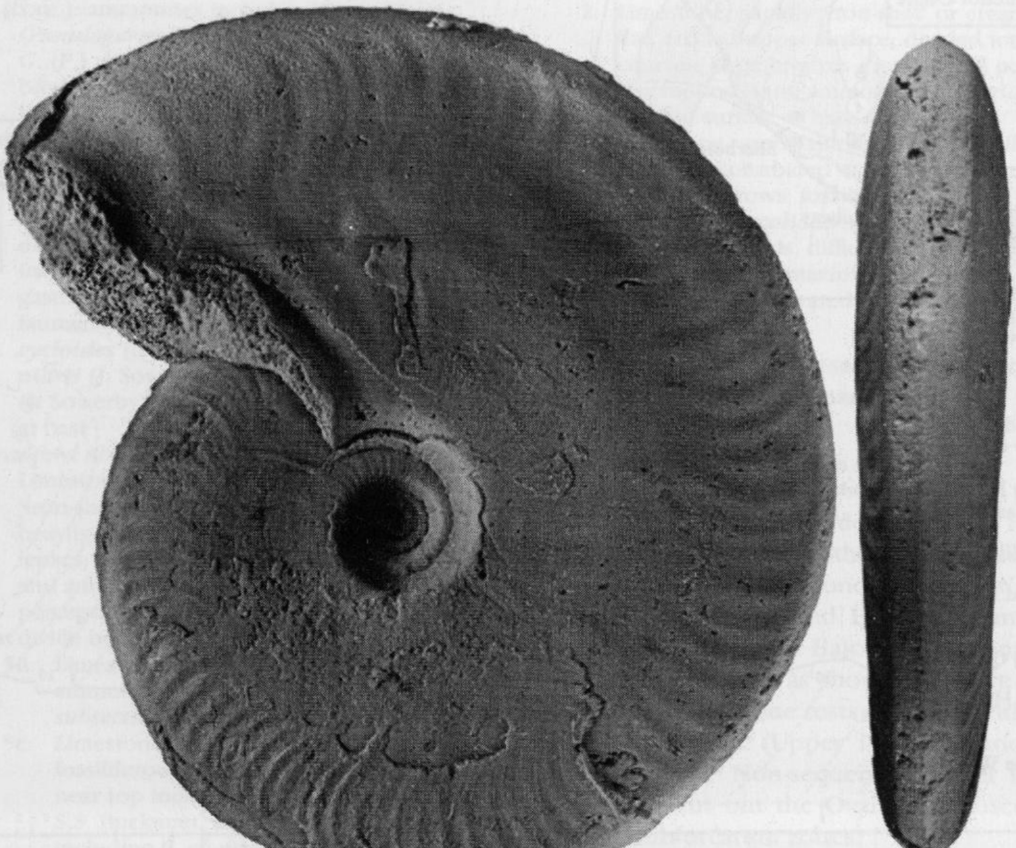

Figure 2.28 *Graphoceras concavum* (J. Sowerby) (Sedgwick Museum, Cambridge, X27846) – eponymous ammonite of the Aalenian Concavum Zone – from Bed 6a of the Bradford Abbas Railway Cutting GCR site as illustrated by Chandler and Sole (1996, pl. 2, figs 1a,b). The specimen is shown at natural size. (Photo: R.B. Chandler.)

was referred to the Garantiana Zone by Parsons (1980a). This bed is equivalent to the 'Astarte Bed' of other localities in the region (e.g. **Seavington St Mary Quarry**, see GCR site report, this volume) but the name 'Marl Bed' has been used where the latter is locally deeply weathered (Parsons, 1980a). The ammonite faunas of these youngest beds have not yet been studied in detail.

Conclusions

Although somewhat neglected in the geological literature compared with other quarries in the area, the Bradford Abbas Railway Cutting offers a permanent section through highly fossiliferous beds of the Inferior Oolite Formation. In particular, the Bradford Abbas Fossil Bed yields ammonite faunas from the Aalenian–Bajocian stage boundary interval (Concavum–Discites zones); the Concavum Zone faunas are especially renowned. Bradford Abbas also has strong associations with the Buckman family whose work has provided the basis for our present knowledge of Aalenian–Bajocian palaeontology and stratigraphy. With other sites in the Sherborne area (Figure 2.29), Bradford Abbas Railway Cutting is a key site for understanding the complex pattern of Aalenian–Bajocian sedimentation and depositional history in the Wessex region and the development of a refined ammonite-based chronology of national and international importance.

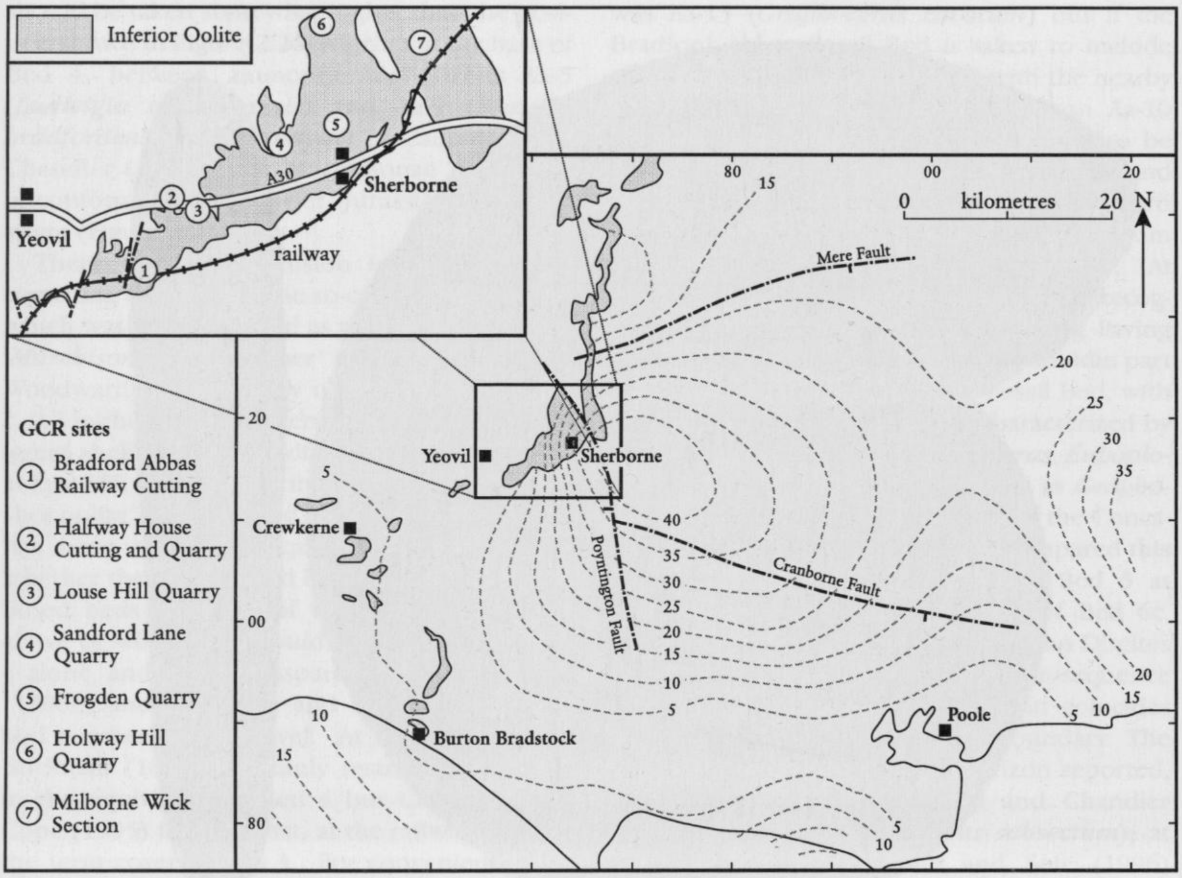

Figure 2.29 Sketch map showing isopachytes (in metres) for the Inferior Oolite Formation in the Wessex Basin and the GCR sites in the Sherborne area. (After Parsons, 1976a, fig. 1; and Barton *et al*., 1993, fig. 5.)

LOUSE HILL QUARRY, DORSET (ST 610 161)

B.M. Cox

Introduction

Apart from **Bradford Abbas Railway Cutting** (see GCR report, this volume), Louse Hill Quarry is the only historically famous Inferior Oolite Formation section in the Bradford Abbas area of Dorset that remains reasonably well exposed (Callomon and Cope, 1995). Sections hereabouts are well known in the literature through the work of S.S. Buckman and his father James who resided at Bradford Abbas (see **Bradford Abbas Railway Cutting** GCR site report, this volume). The Bradford Abbas Fossil Bed, yielding a rich fauna including ammonites, other molluscs and brachiopods of the Aalenian Concavum and Lower Bajocian Discites zones, and the overlying Irony Bed, with a notable brachiopod fauna, are well exposed in the quarry.

Description

The section has been recorded by Buckman (1893a), Richardson (1932) and Macfadyen (1970), but the following section (including bed numbers) is based mainly on that of Callomon and Cope (1995). The quarry is situated at the top of a steep bank and, as testified by the long face, has been quarried for many years (Richardson, 1932).

	Thickness (m)
Inferior Oolite Formation	
?Halfway House Fossil Bed	
8: Calcarenite, well bedded, yellow-weathering, forming thin capping	–
Astarte Bed	
7: Limestone, somewhat ferruginous, marly, lenticular; in lower part, locally developed pockets of 'snuff-box' oncoids, embedded at all angles, and other limonite-encrusted fossils;	

Thickness (m)

7 (cont.): ammonites including *Garantiana (Pseudogarantiana) platyrryma* (S.S. Buckman), *G. (P.) dichotoma* (Bentz) and *Spiroceras*; bivalves, including common astartids; brachiopods; basal erosion surface — 0.25

Irony Bed

6: Limestone, hard, crystalline, grey, pink or brown (ferruginous); flat, eroded upper surface; numerous pebbles, sometimes oncoidal, with dark-brown or black ferruginous crust, and including ammonites; many poorly preserved gastropods (*Bathrotomaria*); diverse brachiopod fauna; ammonites including *Poecilomorphus cycloides* (d'Orbigny), *Sphaeroceras* cf. *brongniarti* (J. Sowerby) and *Oppelia subradiata* (J. Sowerby); undulating parting with hollows at base — 0.03–0.07

Bradford Abbas Fossil Bed

5: Limestone, variably ferruginous, brown, 'iron-shot', ooidal, very irregularly bedded, heavily burrowed, separating into irregular lenses; fossils including belemnites, brachiopods and ammonites; where very weathered, barely perceptible and highly undulating partings divide bed into four parts:

5d: Limestone, hard, 'iron-shot', few fossils; ammonites including *Hyperlioceras* cf. *subsectum* S.S. Buckman — *c.* 0.10

5c: Limestone, slightly softer and more fossiliferous than above; layer of ammonites near top including *Hyperlioceras rudidiscites* S.S. Buckman, fairly common *Euhoploceras*, including *E.* cf. *dominans* (S.S. Buckman) and *E.* cf. *modestum* (S.S. Buckman), and *Docidoceras* sp.; large bivalves including *Ctenostreon proboscideum* (J. Sowerby) and *Plagiostoma rigida* J. Sowerby; indistinct parting, locally film of clay, at base — *c.* 0.15

5b: As above but slightly less 'iron-shot'; many ammonites including *Graphoceras formosum* (S.S. Buckman), *G. limitatum* (S.S. Buckman) and *Euhoploceras* cf. *marginatum* (S.S. Buckman) — *c.* 0.10

5a: As above but very hard, weathering into cavernous rubble; fossils rarer than above and often fragmentary; ammonites including *Graphoceras limitatum* and *G. v-scriptum* S.S. Buckman; fairly sharp, slightly undulating base with clay parting — *c.* 0.20

4: Limestone, fine grained, weakly ooidal; weathering pale-grey; richly fossiliferous, mainly ammonites with shells preserved including *Graphoceras concavum* (J. Sowerby), *Eudmetoceras* and *Haplopleuroceras*; also bivalves, brachiopods and gastropods; sharp, slightly undulating base — 0.20

3: Limestone, slightly ferruginous, weathering darker than bed above; divisible roughly into three parts (3a–c); ammonites including *Brasilia*, with *B. decipiens* (S.S. Buckman) fairly common at top (in 3c); brachiopods including *Homoeorhynchia ringens* (von Buch); belemnites common; sharp erosion surface at base — 0.55

Thickness (m)

2: Limestone, slightly 'iron-shot' or creamy ooidal; flat, eroded upper surface; divided into three courses; large bivalves ('myids' and pectinids); brachiopods; and ammonite *Ludwigia*; sharp erosion surface at base — 0.20–0.40

1: Limestone, sandy, thick, massive, shelly, strongly bioturbated with prominent vertical burrows; fossils, including ammonite *Ancolioceras* near top, bivalves and brachiopods, difficult to extract — 0.90

Bridport Sand Formation

Sand, yellow or indurated sandstone — seen

Bed 5a is slightly recessive in the quarry face and Bed 4 forms a clear marker bed.

Interpretation

The ammonites recorded at Louse Hill Quarry enable recognition of the Aalenian Murchisonae, Bradfordensis and Concavum zones, the Lower Bajocian Discites and Humphriesianum zones, and the Upper Bajocian Garantiana and Parkinsoni zones as shown in Figure 2.30. The Murchisonae Zone rests non-sequentially on the Lower Jurassic (Upper Toarcian) Bridport Sand Formation. Non-sequences higher in the succession cut out the Ovalis, Laeviuscula, Sauzei and Subfurcatum zones.

The rhynchonellid brachiopod fauna of Bed 3 is sufficiently characteristic for Richardson (1932) to have suggested the name '*Rhynchonella ringens* Beds' (Ringens Bed) for it (see also **Holway Hill Quarry** and **Halfway House Cutting and Quarry** GCR site reports, this volume). The fossils in the overlying Bradford Abbas Fossil Bed (beds 4–5), which totals *c.* 0.75 m in thickness, retain their stratification, and ammonite biohorizons Aa-14 (*Graphoceras concavum*), Aa-15 (*Graphoceras formosum*), Aa-16 (*Euhoploceras acanthodes*), Bj-2b (*Hyperlioceras rudidiscites*) and Bj-3 (*Hyperlioceras subsectum*) straddling the Aalenian–Bajocian stage boundary can be separately identified in their correct sequence (Figure 2.30; Morton and Chandler, 1994; Callomon and Cope, 1995).

The Irony Bed (Bed 6), although thin, is widely developed. At Louse Hill Quarry, its ammonites indicate the Romani Subzone of the Humphriesianum Zone but the bed appears to be diachronous. At East Hill Quarry (see **Bradford Abbas Railway Cutting** GCR site report, this volume), it has yielded ammonites indicative of the older Sauzei Zone. Buckman

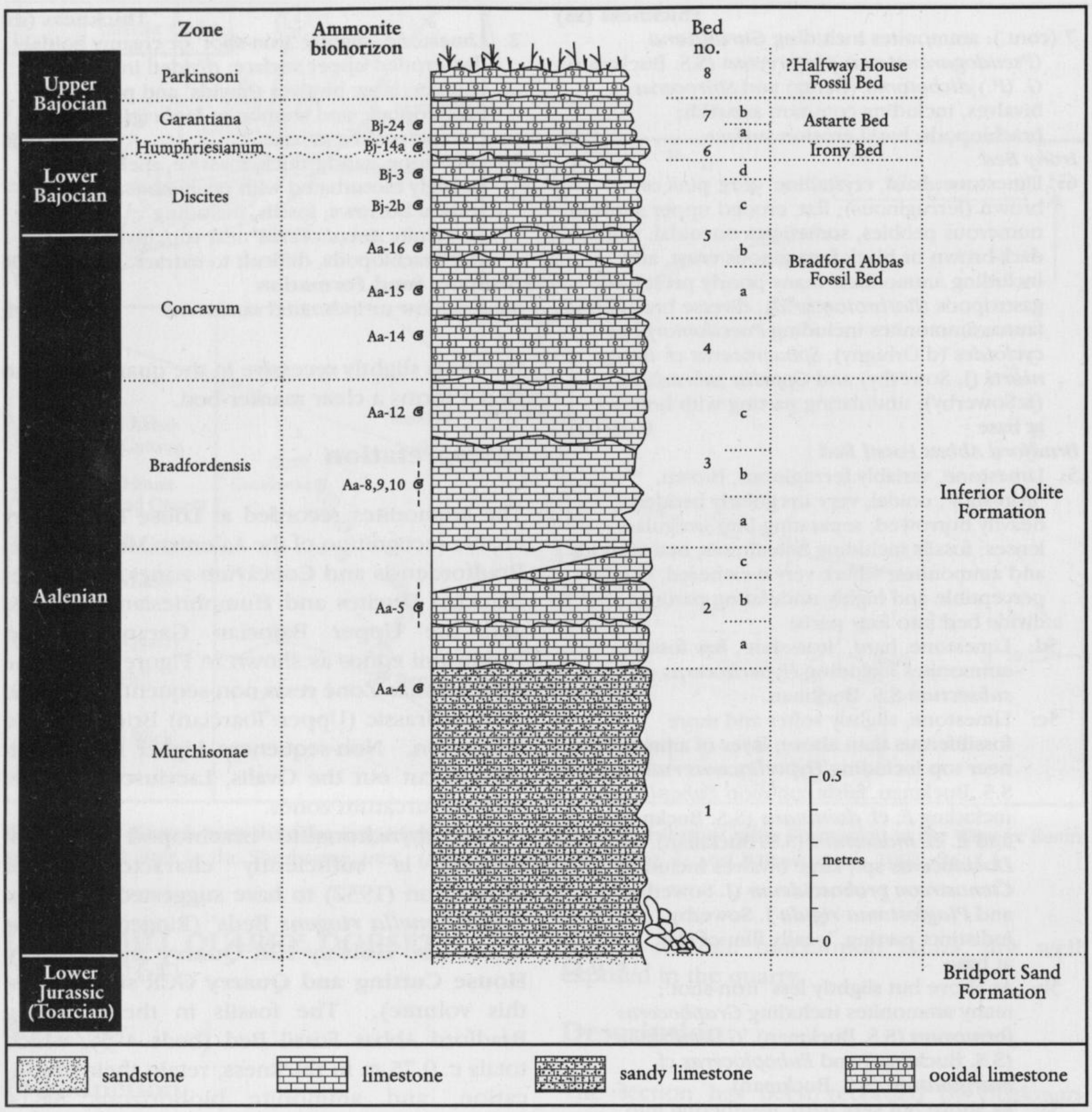

Figure 2.30 Graphic section of the Inferior Oolite Formation at Louse Hill Quarry. (After Callomon and Cope, 1995, fig. 11.) For lithologies, see text.

(1910a) reported that at Louse Hill Quarry, the Irony Bed was 'one of the most remarkable repositories of brachiopod species in this country', having many distinctive and peculiar forms of both rhynchonellids and terebratulids. Richardson (1932) listed 13 species and Macfadyen (1970) listed others; type specimens of several came from here.

The Astarte Bed (Bed 7) at Louse Hill Quarry is the only place so far known in England where the Dichotoma Subzone of the Upper Bajocian Garantiana Zone has been unambiguously recorded (Callomon and Cope, 1995). Also known as the 'Rotten Bed' (e.g. Macfadyen, 1970), the Astarte Bed is overlain non-sequentially by the Parkinsoni Zone. The missing younger subzones of the Garantiana Zone reach a thickness of at least 5 m in the town of Sherborne, only 4 km to the east. The bed is widespread in Dorset and occurs at a number of GCR sites (e.g. **Burton Cliff and Cliff Hill Road Section**).

The residual thin capping of calcarenite at the top of the section is tentatively identified as the Halfway House Fossil Bed, which takes its name from the quarries at Halfway House, to the north-west of Louse Hill Quarry (see **Halfway House Cutting and Quarry** GCR site report, this volume). Richardson (1932) recorded a greater thickness (0.6 m) than that given in the above section, and a fauna of belemnites and terebratulid brachiopods.

Conclusions

The section at Louse Hill Quarry complements that in **Bradford Abbas Railway Cutting** (see GCR site report, this volume), access to which is restricted because of high-speed trains. The Bradford Abbas Fossil Bed yields ammonite faunas from the Aalenian–Bajocian stage boundary interval (Concavum–Discites zones), and the overlying Irony Bed (Humphriesianum Zone) yields a notably rich and diverse brachiopod fauna. As is typical of the Inferior Oolite Formation in the Wessex region, the total Aalenian–Bajocian succession at Louse Hill Quarry is only a few metres thick and is interrupted by some significant non-sequences. Together with others in the Sherborne area, it contributes to an understanding of the complex pattern of Aalenian–Bajocian sedimentation and depositional history in the Wessex region which has international palaeontological and stratigraphical interest.

HALFWAY HOUSE CUTTING AND QUARRY, DORSET (ST 601 164)

B.M. Cox

Introduction

The Halfway House Cutting and Quarry GCR site comprises a cutting on the northern side of the A30 road, about midway between Sherborne and Yeovil, and two adjacent old quarries – those known in the literature as 'Rock Cottage Quarry' and 'Chapel Quarry'. The site comprises localities 2, 3 and 4 of Torrens (1969a, fig. 1). Exposure in the quarries, first noted by Wright (1856), is generally now rather poor and recent accounts of the succession have concentrated on the road cutting that was excavated during the latter part of the summer of 1963 (Torrens, 1969a; Whicher, 1969). The locality is particularly famous for the so-called 'Halfway House Fossil Bed' (Buckman, 1893a), the ammonite assemblage of which is taken as typical of the Truellei Subzone (Upper Bajocian Parkinsoni Zone).

Description

The Halfway House Cutting and Quarry GCR site has been well established in the literature since J. Buckman (1877), although it does not feature prominently in the recent published reviews of the Inferior Oolite Formation in this area (e.g. Callomon and Chandler, 1990). Sections at both the Rock Cottage and Chapel quarries were reported by Buckman (1893a) (his sections IV and V respectively) and Richardson (1932) (his sections 17 and 17a respectively). A composite section, based on Richardson (1932), through the whole of the Inferior Oolite Formation and the Bajocian Stage here was reported by Macfadyen (1970). Other records include those of Woodward (1894), Wilson *et al.* (1958) and Callomon and Cope (1995). Part of the section at Chapel Quarry was illustrated by Richardson *et al.* (1911, pl. XXXIX, fig. 1).

The section given below is based on that recorded by Torrens (1969b), Whicher (1969) and Callomon and Cope (1995) in the road cutting on the A30.

	Thickness (m)
Inferior Oolite Formation	
Crackment Limestone Member	
10: Limestone, white, chalky with marl partings	seen
9: Limestone, grey-brown, sandy, marly; poorly fossiliferous and much stained with limonite; becoming more massive towards base; ammonites (*Parkinsonia*); brachiopods (*Acanthothiris*); echinoids (*Collyrites*, *Pygomalus* and *Pygorhytis*)	seen to 4.0
8: *Halfway House Fossil Bed*: Limestone, ooidal, very fossiliferous with ammonites (including *Cadomites*, *Leptosphinctes*, *Parkinsonia* and *Strigoceras*); nautiloids; echinoids; bivalves	0.25
7: *Astarte Bed*: Limestone, ooidal, brown, limonite-stained with limonitic concretions; many fossils coated in limonite and encrusted with serpulids; *Neocrassina* very common together with other bivalves, gastropods and ammonites	0.10–0.30
Irony Bed	
6: Limestone, crystalline, iron-stained, ooidal in places, lensoid; thick layer of limonite at top; conglomeratic at base; ammonites (*Caumontisphinctes*); gastropods; abundant brachiopods	0–0.25

	Thickness (m)
5: Limestone, pale-brown to blue-hearted, ooidal; ammonites, including *Graphoceras*; belemnites; bivalves; *Homoeorhynchia ringens* (von Buch) in basal 0.10 m	1.20–1.30
Dew Bed	
4: Limestone, very hard, grey, crystalline with shell debris; top surface encrusted by oysters and extensively bored by *Lithophaga* and thin, vertical annelid borings	0.30
3: Fissure-filling from Bed 5 above; ooidal matrix with some limonite concretions and pebbles	0–0.15
2: As Bed 4 above	0.50
Lias Group	
Bridport Sand Formation	
1: Sand, soft, friable, micaceous	seen to 2.0

Interpretation

Wright (1860) first used the name Dew Bed (beds 2–4 above) for the hard, crystalline limestone at the base of the Inferior Oolite Formation hereabouts. It is also present in the **Bradford Abbas Railway Cutting** (see GCR site report, this volume) where it is assigned to the Lower Jurassic Toarcian Stage. Torrens (1969b) tentatively assigned the Dew Bed at the Halfway House Cutting and Quarry GCR site to the Levesquei Zone, Moorei Subzone of the latter stage and it therefore seems appropriate to assign the sands of the underlying Bed 1 there to the Bridport Sand Formation of the Lias Group; Wilson *et al.* (1958) and Macfadyen (1970) included the Dew Bed itself in that group.

According to Richardson *et al.* (1911), the quarrymen called Bed 5 'the Blue Beds'. The presence of the brachiopod *Homoeorhynchia ringens* in its basal part is indicative of the Ringens Bed (see **Holway Hill Quarry** and **Louse Hill Quarry** GCR site reports, this volume). Davidson (1878) described the species as being abundant and two of his three figured specimens came from here (see Figure 2.38, **Holway Hill Quarry** GCR site report, this volume). Ammonites, notably the genus *Brasilia*, from the latter localities and elsewhere locally indicate that the Ringens Bed belongs to the Aalenian Bradfordensis Zone. *Graphoceras*, which has been recorded from Bed 5 at the Halfway House Cutting and Quarry GCR site, may indicate the next youngest Concavum Zone (Callomon and Chandler, 1990).

The Irony Bed (Bed 6) is well developed in this area (see **Seavington St Mary Quarry**, **Bradford Abbas Railway Cutting** and **Louse Hill Quarry** GCR site reports, this volume). It appears to be locally diachronous within the Lower Bajoican Sauzei and Humphriesianum zones (Parsons, 1980a; see **Louse Hill Quarry** GCR site report, this volume), although the record of *Caumontisphinctes* at the Halfway House Cutting and Quarry GCR site, if correct, would also imply the Upper Bajocian Subfurcatum Zone. There is a substantial non-sequence at the base of the bed where at least the Discites, Ovalis and Laeviuscula zones are missing.

The Astarte Bed (Bed 7) is generally recognized as the oldest Upper Bajocian stratum present in this area, where it is known at several localities (e.g. **Louse Hill Quarry**, see GCR site report, this volume). Its ammonites indicate the Garantiana Zone although, within that zone, it appears to be diachronous. Ammonites at **Louse Hill Quarry** indicate the Dichotoma Subzone (Callomon and Cope, 1995) but at **Seavington St Mary Quarry**, it has been assigned to the Acris Subzone (Parsons, 1980a). The bivalve that gives its name to the bed is now referred to the genus *Neocrassina* (see **Burton Cliff and Cliff Hill Road Section** GCR site report, this volume).

The highest beds (8–10) of the section, with the ammonite *Parkinsonia*, are assigned to the Upper Bajocian Parkinsoni Zone. Bed 8 (the Halfway House Fossil Bed – a term first used by Buckman, 1893a) is the type horizon for the Truellei Subzone (Buckman, 1891; Arkell, 1951a). The fauna of this very fossiliferous bed is the same as that of the Truellei Bed at Burton Bradstock (see **Burton Cliff and Cliff Hill Road Section** GCR site report, this volume). It includes large specimens of the ammonites *Leptosphinctes meseres* (S.S. Buckman) and *Parkinsonia dorsetensis* (Wright) (Figure 2.31). These species used to be particularly common at Halfway House Cutting and Quarry, and specimens, when sliced in half and polished, formed the basis of a small local ornament industry (Woodward, 1894; Torrens, 1969a; Arkell, 1956b; Callomon and Cope, 1995). In addition to the fauna given in the description above, Macfadyen (1970) cited belemnites (*Belemnopsis*) and gastropods (*Natica* and *Pleurotomaria*) based on Richardson's (1932) earlier records. The Halfway House Fossil Bed is also recognized at **Bradford Abbas Railway Cutting** (and see also **Louse Hill Quarry** GCR site report, this volume).

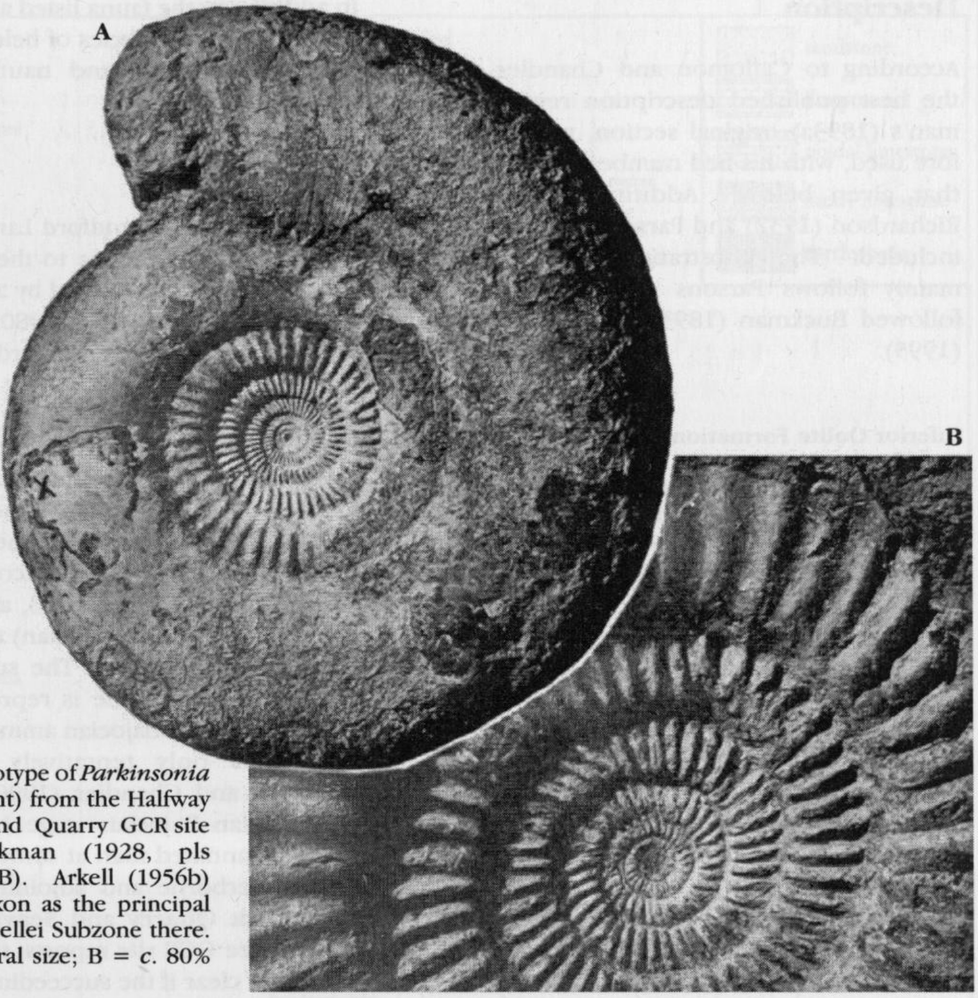

Figure 2.31 Lectotype of *Parkinsonia dorsetensis* (Wright) from the Halfway House Cutting and Quarry GCR site based on Buckman (1928, pls DCCLXVIIA and B). Arkell (1956b) described this taxon as the principal species of the Truellei Subzone there. (A = *c.* 20% natural size; B = *c.* 80% natural size.)

Conclusions

The Halfway House Cutting and Quarry GCR site displays nearly the whole of the local Aalenian–Bajocian succession, albeit very attenuated, with its characteristic 'hardgrounds', conglomerates and thin, lenticular 'iron-shot' limestones. It includes a number of significant non-sequences and the zonal succession is even less complete than at the nearby **Bradford Abbas Railway Cutting** and **Louse Hill Quarry** GCR sites with which it otherwise has features in common. The Halfway House Fossil Bed is particularly famous and provides the type horizon for the Truellei Subzone of the Upper Bajocian Parkinsoni Zone. Sited in an area of complex Aalenian–Bajocian stratigraphy, the Halfway House Cutting and Quarry locality is thus an important one for the interpretation of the local and regional succession as well as for correlations farther afield.

SANDFORD LANE QUARRY, DORSET (ST 628 178)

B.M. Cox

Introduction

The now disused Sandford Lane Quarry, near Sherborne, Dorset, was first described by Buckman (1893a) who established it as an important locality for Aalenian and Bajocian stratigraphy. The rich and well-preserved ammonite faunas, particularly those of the famous 'Fossil Bed', have provided type material for many species and genera from the Lower Bajocian Laeviuscula and Sauzei zones. The site is also important as a reference section for the Upper Bajocian Garantiana Zone, all of the component subzones of which can be recognized (Parsons, 1980a).

Description

According to Callomon and Chandler (1990), the best published description remains Buckman's (1893a) original section, which is therefore used, with his bed numbers, as the basis of that given below. Additional details from Richardson (1932) and Parsons (1974a) are also included. The lithostratigraphical subdivision mainly follows Parsons (1980a), who largely followed Buckman (1893a), and Bristow *et al.* (1995).

	Thickness (m)
Inferior Oolite Formation	
Rubbly Member	
1: Limestone in 'irregular masses with earthy marl intermixed'; terebratulid brachiopods in clusters at 2.3 m above base; ammonites (including *Garantiana*) 1.3 m above base	3.7
2: Limestone in 'fairly large blocks'	1.5
3: Limestone, sandy and marl; *Parkinsonia*	0.4
Sherborne Building Stone Member	
4: Limestone, grey, in five courses separated by sandy partings; clusters of brachiopods (*?Sphaeroidothyris*) in middle course	1.5
5: Limestone, sandy, dark-brown; poorly fossiliferous	0.7
Miller's Hill Member	
6: *Sandford Lane Fossil Bed*: Limestone, hard, ooidal, fossiliferous with abundant ammonites; upper surface smooth, planed off and level;	
6a: deep-blue and 'iron-shot', weathering dark-brown, with conglomerate of soft, pale-grey limestone clasts at base; ammonites including *Emileia* (*E.*), *E.* (*Otoites*), *Kumatostephanus*, *Labyrinthoceras*, *Sphaeroceras*, *Stephanoceras* (*Normannites*), *S.* (*Skirroceras*), *Sonninia*, *Sonninites* and *Witchellia*	
6b: pale-yellow and greenish-grey, marly, with yellow ooids and green glauconite grains; hardground at top with eroded ammonites, limonite encrustations and serpulid masses; ammonites including *Bradfordia*, *Emileia* (*E.*), *E.* (*Otoites*), *Euhoploceras*, *Mollistephanus*, *Shirbuirnia* and *Witchellia*	0.5–0.7
?Corton Denham Member	
7: Sand	0.03
8: Limestone, sandy, greyish-green; poorly preserved sonniniid ammonites including large macroconch; astartid bivalves	0.15
9: Limestone, sandy, brown; fossiliferous with abundant terebratulid brachiopods; bivalves including *Gervillella*, *Gryphaea*, *Pseudolimea* and trigoniids; ammonites including *Hyperlioceras*	0.2
10: Limestone, sandy, grey; *Hyperlioceras* and terebratulid brachiopods	0.1
11: Limestone, sandy, grey; ammonites including *Graphoceras*	0.3
12: Earthy parting	0.08
13: Sandstone, grey; ammonites including *Euhoploceras* and *Graphoceras*	0.6

In addition to the fauna listed above, Richardson (1932) recorded species of belemnites, bivalves, corals, gastropods and nautiloids from the Rubbly Member.

Interpretation

The succession at Sandford Land Quarry ranges from the Aalenian Stage to the Upper Bajocian Substage but is interrupted by at least one major non-sequence (Parsons, 1980a; Figure 2.32). The oldest beds (11–13) recorded belong to the Aalenian Concavum Zone but Parsons (1980a) noted beds of similar lithology in a nearby temporary exposure that yielded ammonites of the older Murchisonae Zone and Subzone. Exposures of the intervening Bradfordensis Zone have not been reported from hereabouts. Callomon and Chandler (1990) recognized their biohorizons Aa-15/16 in Bed 13, and Aa-16 (representing the youngest Aalenian) tentatively also in Bed 11 (Figure 2.32). The succeeding Lower Bajocian Discites Zone is represented by beds 8–10. The oldest Bajocian ammonite biohorizon (Bj-1) was only tentatively recognized by Callomon and Chandler (1990) and therefore the Aalenian–Bajocian stage boundary is less well substantiated than at some other GCR sites in the Sherborne and adjoining area (notably **Horn Park Quarry** and **Seavington St Mary Quarry**, see GCR site reports, this volume).

It is not clear if the succeeding Ovalis Zone of the Lower Bajocian Substage is represented in Bed 7 and/or Bed 8 or whether there is a non-sequence at this level (Parsons, 1974a, 1980a; Callomon and Chandler, 1990) but the overlying Laeviuscula and Sauzei zones are well represented in Bed 6 (see below). There is no evidence of the Humphriesianum or Subfurcatum zones, and thus a non-sequence is assumed to be present beneath the Upper Bajocian Garantiana Zone at the base of Bed 5 (Figure 2.32). Extensive ammonite faunas of the latter occur in the Rubbly Member where the Tetragona and Acris subzones have been recognized (Parsons, 1980a). The Dichotoma Subzone, constituting the oldest part of the Garantiana Zone, is thought to be represented in the Sherborne Building Stone Member from which rare specimens of the eponymous ammonite *Garantiana dichotoma* (Bentz) have been recorded (Parsons, 1980a). The older (Truellei) subzone of the Parkinsoni Zone was reported by Parsons (1980a) in the top part of the Rubbly Member.

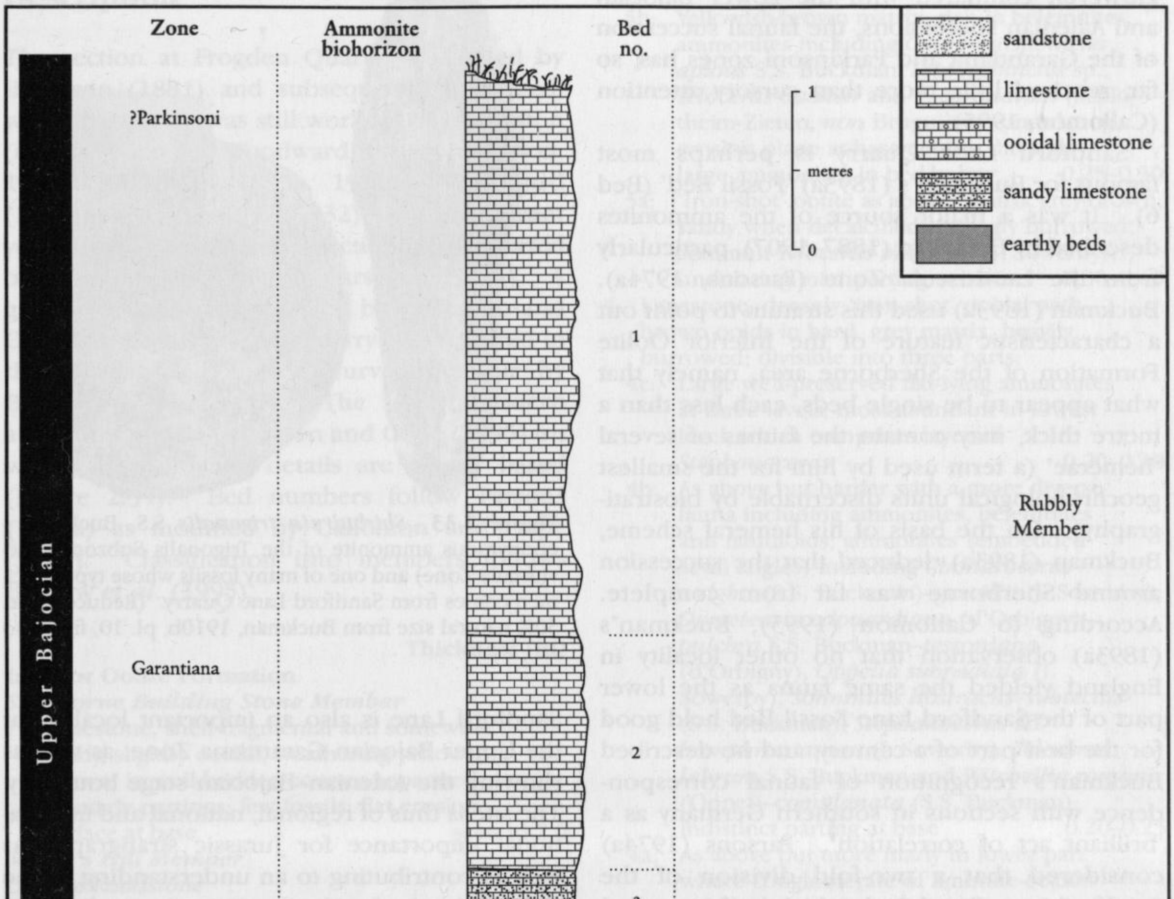

Figure 2.32 Graphic section of the Inferior Oolite Formation at the Sandford Lane Quarry GCR site. (After Callomon and Chandler, 1990, fig. 4.) For lithologies, see text.

However, compared with the Lower Bajocian and Aalenian successions, the faunal succession of the Garantiana and Parkinsoni zones has, so far, received little more than cursory attention (Callomon, 1995).

Sandford Lane Quarry is perhaps most famous for Buckman's (1893a) 'Fossil Bed' (Bed 6). It was a major source of the ammonites described by Buckman (1887–1907), particularly from the Laeviuscula Zone (Parsons, 1974a). Buckman (1893a) used this stratum to point out a characteristic feature of the Inferior Oolite Formation of the Sherborne area, namely that what appear to be single beds, each less than a metre thick, may contain the faunas of several 'hemerae' (a term used by him for the smallest geochronological units discernable by biostratigraphy). On the basis of his hemeral scheme, Buckman (1893a) deduced that the succession around Sherborne was far from complete. According to Callomon (1995), Buckman's (1893a) observation that no other locality in England yielded the same fauna as the lower part of the Sandford Lane Fossil Bed held good for the best part of a century, and he described Buckman's recognition of faunal correspondence with sections in southern Germany as a 'brilliant act of correlation'. Parsons (1974a) considered that a two-fold division of the Sandford Lane Fossil Bed (which he later called the 'Sandford Bed' (Parsons, 1980a)) was most appropriate; a lower part (Bed 6b) with an ammonite fauna of the Laeviuscula Zone, and an upper part (Bed 6a) with an ammonite fauna of the Sauzei Zone. The two are separated by an irregular parting that Parsons (1974a) believed marked the position of an extensive hardground. Callomon and Chandler's (1990) more recent work indicated that, within these zones, at least five of their ammonite biohorizons may be distinguishable (Figure 2.32).

Conclusions

Sandford Lane Quarry is one of several sites in the Sherborne area made famous through the work of S.S. Buckman in the 1890s. The richly fossiliferous Sandford Lane Fossil Bed here has yielded ammonite faunas of the Lower Bajocian Laeviuscula and Sauzei zones. The site is particularly important for the faunas of the former zone, which are not well represented elsewhere in England but which can be correlated with those in continental Europe (Figure 2.33).

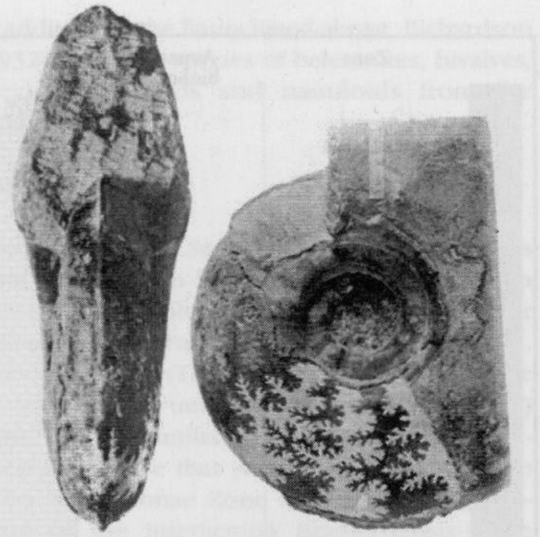

Figure 2.33 *Shirbuirnia trigonalis* S.S. Buckman – eponymous ammonite of the Trigonalis Subzone (Laeviuscula Zone) and one of many fossils whose type specimen comes from Sandford Lane Quarry. (Reduced to *c.* 50% natural size from Buckman, 1910b, pl. 10, figs 2,3.)

Sandford Lane is also an important locality for the Upper Bajocian Garantiana Zone, as well as showing the Aalenian–Bajocian stage boundary. The site is thus of regional, national and international importance for Jurassic stratigraphy as well as contributing to an understanding of the complexities of Aalenian–Bajocian sedimentation and depositional history in the Wessex region.

FROGDEN QUARRY, DORSET (ST 649 183)

B.M. Cox

Introduction

Frogden Quarry, near Oborne, Dorset, has been well known in the geological literature for over 100 years. The section is notable for the relatively complete zonal succession across the Lower–Upper Bajocian substage boundary (Humphriesianum–Subfurcatum zones). At other localities in the Sherborne area (see Figure 2.29), this interval is usually much condensed or absent (e.g., **Bradford Abbas Railway Cutting**, **Louse Hill Quarry**, **Sandford Lane Quarry**, see GCR site reports, this volume). The site has yielded abundant fossils including the type material of many ammonite species (Parsons, 1976a) and other molluscs.

Description

The section at Frogden Quarry was noted by Buckman (1881) and subsequently described, when the quarry was still worked, by Hudleston (in Hudleston and Woodward, 1886; Hudleston, 1887), Buckman (1893a, 1910b), Woodward (1894) and Richardson (1932). In more recent years, the disused quarry section was reported by Macfadyen (1970) and Parsons (1976a). A graphic section was included by Callomon and Chandler (1990) and the quarry also featured in the [British] Geological Survey memoir by Bristow *et al*. (1995). The fullest modern account is that of Callomon and Cope (1995) on which the following details are largely based (Figure 2.34). Bed numbers follow Parsons (1976a) as modified by Callomon and Cope (1995). Classification into members follows Bristow *et al*. (1995).

Thickness (m)

Inferior Oolite Formation

Sherborne Building Stone Member

7: Limestone, shell-fragmental and somewhat sandy, slightly ooidal, weathering yellow-brown; in well-bedded courses separated by marly partings; few fossils; flat erosion surface at base — seen to 2.0

Miller's Hill Member

Oborne Roadstone

6: Limestone, marly, ferruginous, ooidal, variably indurated, strongly bioturbated, indistinctly divisible into four courses:

6d: *Cadomense Bed*: Hard, somewhat concretionary; many fossils including ammonites (*Garantiana baculata* (Quenstedt), *Leptosphinctes davidsoni* (S.S. Buckman) and *Strenoceras subfurcatum* (Zieten)), and gastropods — 0.15–0.20

6c: As 6d but softer, sandy and with fewer fossils; ammonites including *Caumontisphinctes polygyralis-phaulus* S.S. Buckman — 0.35–0.40

6b: *Sphaeroidothyris Bed*: As 6c but more strongly cemented and with nests of terebratulid brachiopods; ammonites including *Cadomites deslongchampsi* (d'Orbigny), *C. homalogaster* S.S. Buckman, *Caumontisphinctes phaulus* (S.S. Buckman), *Orthogarantiana haugi* Pavia and *Torrensia gibba* (Parona); highly undulating parting at base — 0.10–0.20

6a: As 6b but softer with large ammonites including *Teloceras banksii* (J. Sowerby) resting on planed erosion surface at base — 0.05–0.15

5: Limestone, more massive than above, densely 'iron-shot' ooidal; in two courses:

Thickness (m)

5b: Yellowish-brown matrix, rich in belemnites; ammonites including *Caumontisphinctes aplous* S.S. Buckman, *Leptosphinctes* sp., *Teloceras banksii* and *T. coronatum* (Schlotheim-Zieten, *non* Bruguière); undulating erosion plane at base cutting through large ammonites in bed below — 0.25–0.30

5a: 'Iron-shot' oolite as above; matrix grey-brown, sandy when decalcified, strongly burrowed; common *Teloceras blagdeni* (J. Sowerby); undulating marl parting at base — 0.30–0.40

4: Limestone, densely 'iron-shot' ooidal with brown ooids in hard, grey matrix, heavily burrowed; divisible into three parts:

4c: Large well-preserved flat-lying ammonites at three levels, most abundant in lowest level, which comprises layer of *Stephanoceras* — 0.20–0.30

4b: As above but harder with a more diverse fauna including ammonites, belemnites and nautiloids; ammonites (embedded at all angles) including *Chondroceras wrighti* (S.S. Buckman)–*gervillii* (J. Sowerby), *Dorsetensia edouardiana* (d'Orbigny)–*pulchra* S.S. Buckman–*tessoniana* (d'Orbigny), *Oppelia subradiata* (J. Sowerby), *Sonninites liostracus–subtectus* (S.S. Buckman), *Stephanoceras* aff. *humphriesianum* (J. Sowerby), *Teloceras labrum* S.S. Buckman and *Witchellia romani* (Oppel)–*complanata* (S.S. Buckman); indistinct parting at base — 0.20–0.25

4a: As above but more marly in lower part where conglomerate of limonite-coated pebbles, corroded ammonites, occasional 'snuff-box' oncoids, and much shell debris; sharp lithological change at base — 0.15–0.20

Corton Denham Member

3: *Spissa Bed*: Marl, soft, non-ooidal, greenish-white, glauconitic; richly fossiliferous with ammonites, including *Bradfordia* (*Amblyoxyites*) *amblys* S.S. Buckman, *Emileia brocchi* (J. Sowerby), *Frogdenites spiniger* S.S. Buckman, *Mollistephanus*, *Otoites contractus* (J. de C. Sowerby), *Papilliceras arenatus* (Quenstedt), *Shirbuirnia superba* (S.S. Buckman), *Skirroceras* and common *Witchellia laeviuscula* (J. Sowerby) and variants, retaining purplish-grey calcitic shells; common pleurotomariid gastropods; passing down into — 0.05–0.10

2: *Blue Bed*: Limestone, somewhat glauconitic, very hard, blue-hearted, extensively burrowed with narrow marl-filled vertical burrows from bed above; sparsely shelly with ammonites including *Emileia catamorpha* S.S. Buckman, '*E*.' *crater* S.S. Buckman and *Witchellia rubra* S.S. Buckman — 0.40

1: Sand, calcareous and marl, sandy, somewhat glauconitic, indurated at several levels into hard stony bands; sparsely shelly with ammonites including *Emileia contrahens* S.S. Buckman, *Fissilobiceras* cf. *ovalis* (Quenstedt) and *Witchellia connata* (S.S. Buckman); poorly exposed — *c*. 4.0

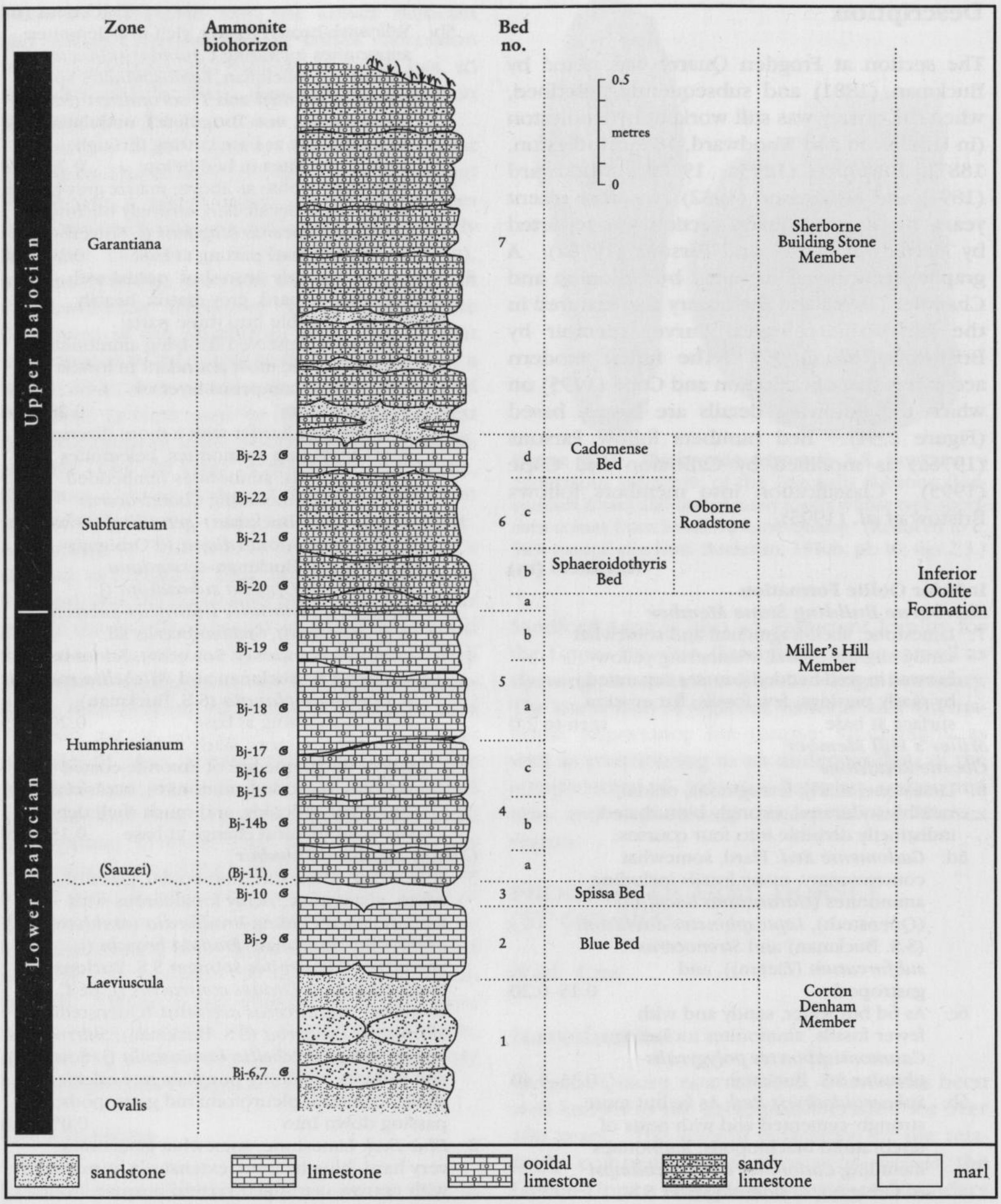

Figure 2.34 Graphic section of the Inferior Oolite Formation at Frogden Quarry. (After Callomon and Cope, 1995, fig. 12.) For lithologies, see text.

According to Callomon and Cope (1995), a borehole sited 800 m to the south-east (Wilson *et al.*, 1958) proved a further 3 m of Sherborne Building Stone Member overlain by *c.* 13 m of Rubbly Member and *c.* 12 m of Crackment Limestone Member with Lower Fuller's Earth Member above and, at the base of the succession, a further 5 m of Inferior Oolite Formation with the Bridport Sand Formation below.

Interpretation

The informal stratal names used for parts of beds 2–6 originate with Hudleston (in Hudleston and Woodward, 1886), Buckman (1893a), Richardson (1915, 1916a), or Parsons (1980a). The 'Spissa Bed' (Bed 3) was so named by Parsons (1980a) based on Richardson's (1916a) term '*Astarte spissa* Bed' that Richardson equated with Buckman's (1893a) 'soft green-grained white marl' (Bed 9) at Frogden Quarry. Here and elsewhere in the area, this bed has yielded an extensive and superbly preserved ammonite fauna (Parsons, 1974a) including the type material of Buckman's (1921) early sphaeroceratid genus *Frogdenites* (Figure 2.35). The Cadomense Bed (Hudleston in Hudleston and Woodward, 1885 – who used the term for the whole of Bed 6 in the above section) takes its name from the small, lappetted strigoceratid ammonite *Cadomoceras cadomense* (Defrance). This bed has also yielded a notable gastropod fauna, which, together with other Frogden Quarry specimens, was described and figured by Hudleston (1887).

The ammonite faunas enable recognition of the Lower Bajocian Ovalis, Laeviuscula, Sauzei and Humphriesianum zones, and the Upper Bajocian Subfurcatum Zone (Figure 2.34). Those of the Sauzei Zone are found only as a reworked element in Bed 4a where they represent what Callomon and Cope (1995) described as a lag-relict. Older faunas of the Laeviuscula Zone are also reworked into this bed. The section at Frogden Quarry has played a definitive role in recognition of ammonite biohorizons in the Humphriesianum and Subfurcatum zones (Callomon and Chandler, 1990; Callomon and Cope, 1995) (Figure 2.34). All three subzones of the Humphriesianum Zone are recognized: the Romani Subzone (the oldest) in Bed 4b, although not fully developed compared with the **Milborne Wick Section** (see GCR site report, this volume); the Humphriesianum Subzone in Bed 4c; and the Blagdeni Subzone in Bed 5a. Ammonites in beds 5b–6 indicate the overlying Subfurcatum Zone. Parsons (1976a) designated Bed 5b as 'typical British horizon' for the Banksi Subzone, with the Sherborne area of Dorset as its type area, and beds 6b and 6d as 'typical British horizons' for the Polygyralis and Baculata subzones respectively. Bed 7 is assigned to the overlying Garantiana Zone by analogy with other local sections (e.g. **Sandford Lane Quarry** and **Louse Hill Quarry**, see GCR site reports, this volume) (Callomon and Cope, 1995).

The succession shows many of the characteristic features of the Inferior Oolite Formation in Dorset and Somerset, such as ammonites preserved at all angles to the bedding (Bed 4b) and erosion planes that cut through large body fossils (base Bed 5b) (see **Seavington St Mary Quarry** GCR site report, this volume, for discussion).

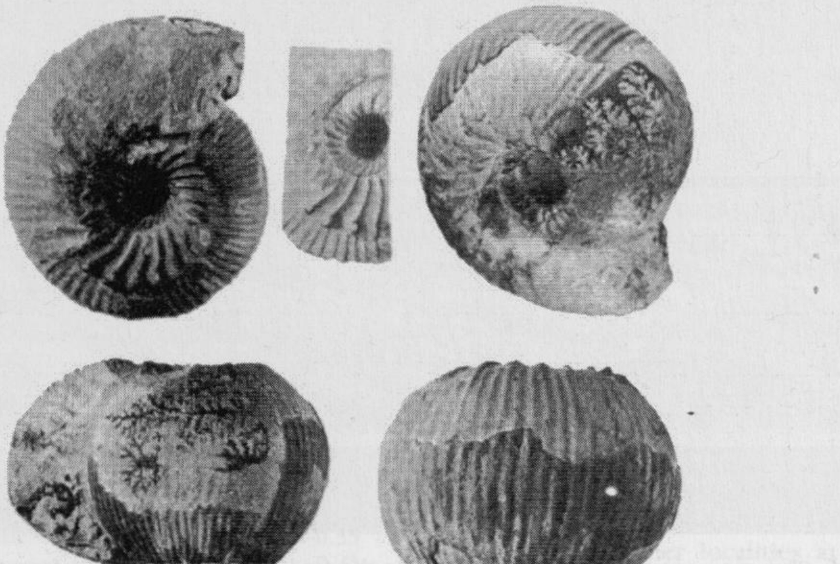

Figure 2.35 *Frogdenites spiniger* S.S. Buckman, type species of the genus which takes its name from Frogden Quarry, as illustrated by Buckman (1921, pl. 215). The specimen is shown at natural size.

Conclusions

Frogden Quarry is regarded as an internationally important geological locality that has yielded a prolific ammonite fauna, largely described by S.S. Buckman and including the type specimens of many taxa. It is particularly important for the Humphriesianum and Subfurcatum zones that straddle the Lower–Upper Bajocian substage boundary and are not well represented elsewhere. Frogden Quarry is the source of much of the known ammonite fauna of these two zones. The site is thus of considerable national and international importance as a primary site for classification and correlation of the middle part of the Bajocian Stage.

GOATHILL, DORSET (ST 672 175)

B.M. Cox

Introduction

The quarry at Goathill near Milborne Port, Sherborne, Dorset exposes the Fuller's Earth Rock Member of the Fuller's Earth Formation (Figure 2.36). It is the type locality of the Linguifera Bed, which is the middle subdivision of the Fuller's Earth Rock Member as recognized by Torrens (1966, 1980b) in the Sherborne area (see Figure 2.4). The underlying Thornford Beds are also seen, although they are better known and were exposed more fully at **Troll Quarry** (see GCR site report, this volume), *c.* 12 km farther south-west. The highest strata exposed at Goathill are the Ornithella Beds, which are recognized throughout the entire Dorset–Somerset outcrop of the Fuller's Earth Rock Member (Arkell, 1933). The Linguifera Bed was first noted by Torrens (1964) in excavations for a water pipeline trench in Sherborne where it was a 1 m-thick, hard, nodular limestone, crowded with brachiopods. It was later named by him after the brachiopod '*Terebratula' linguifera* Davidson (Torrens, 1966). The quarry at Goathill is located on the hanging-wall of the Poyntington Fault as mapped by Fowler (1944) and Bristow *et al.* (1995); exposures immediately to the east are of the Inferior Oolite Formation (Torrens, 1969a).

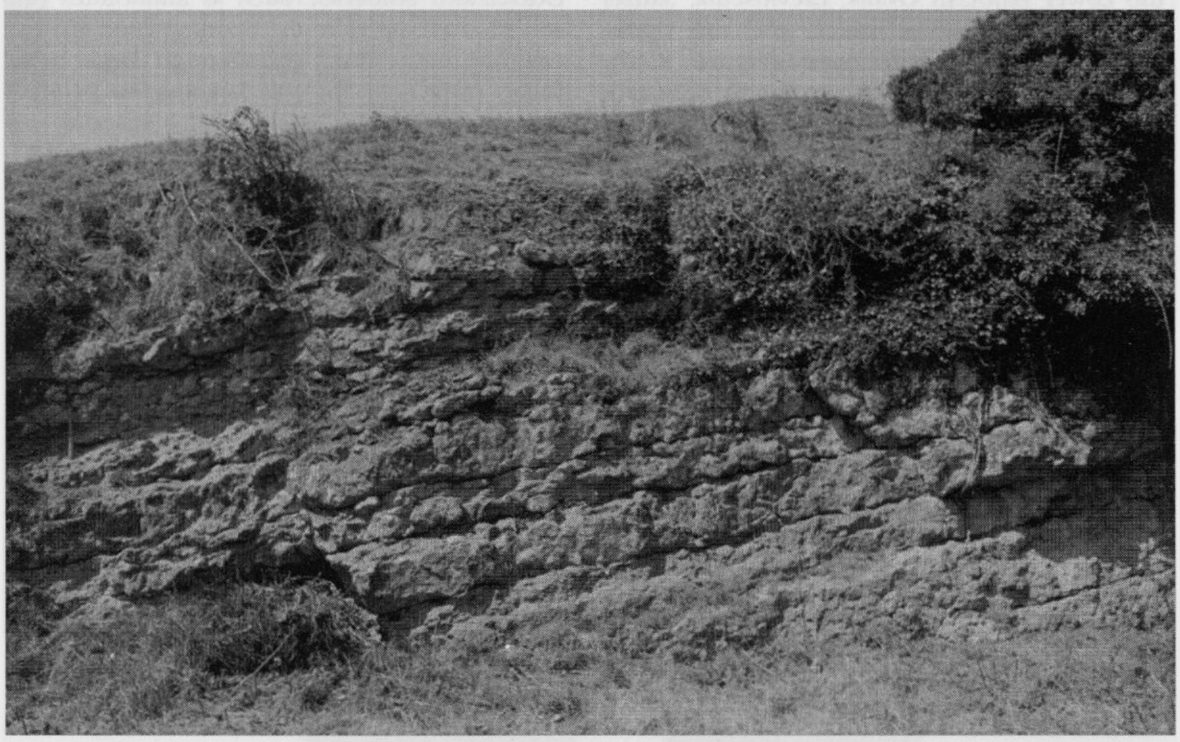

Figure 2.36 The quarry at Goathill (the hammer, to the far left, is resting on the Linguifera Bed). (Photo: British Geological Survey, No. A15157; reproduced with the permission of the Director, British Geological Survey, © NERC, 1990.)

Description

The site was mentioned by Richardson *et al.* (1911), White (1923) and McKerrow (1953) but not described in detail until Torrens (1966) on which the following section and faunal records are largely based.

	Thickness (m)
Fuller's Earth Formation	
Fuller's Earth Rock Member	
Ornithella Beds	
11: Limestone with brachiopods (*Rhynchonelloidella* and *Wattonithyris*); large *Ornithella bathonica* (Rollier) common at base)	0.15
10: Marl with brachiopods (as in Bed 11); belemnite fragments; bivalves including *Catinula*, *Liostrea*, *Modiolus* and *Pleuromya*; serpulids; ammonites (including *Procerites* and *Choffatia*)	0.15
9: Limestone with very common rhynchonellid brachiopods	0.3
Linguifera Bed	
8: Limestone, rubbly, very fossiliferous with macroconch and microconch *Morrisiceras* and indeterminate oppeliids; belemnite fragments; echinoids (*Collyrites* and *Holectypus*); brachiopods (*Kallirhynchia*, *Ornithella*, *Rhynchonelloidella*, *Rugitela* and '*Terebratula*' *linguifera*); bivalves including *Anisocardia fullonicus* Cox, *Catinula* sp., *Chlamys* (*Radulopecten*) sp., *Entolium corneolum* (Young and Bird), *Goniomya intersectans* (Wm Smith), *Gresslya peregrina* (Phillips), *Inoperna plicata* J. Sowerby, *Limatula cerealis* Arkell, *Modiolus anatinus* Wm Smith, *Pholadomya lirata* (J. Sowerby), *Pleuromya alduini* (Brongniart), *P. calceiformis* (Phillips), *P. marginata* (Agassiz), *P. subelongata* (d'Orbigny), *Pseudolimea duplicata* (J. de C. Sowerby), *Pseudotrapezium* cf. *cordiforme* (Deshayes), *Rollierella minima* (J. Sowerby), *Thracia depressa* (J. de C. Sowerby), *Trigonia* sp.; gastropods including *Amberlya*	0.69–0.76
Thornford Beds	
7: Limestone, massive	0.35
6: Limestone	0.23–0.25
5: Limestone with *Ornithella*	0.35
4: Limestone, softer and more marly than above; small *Ornithella*, belemnite fragment	0.30–0.35
3: Limestone	0.23
2: Limestone	0.30
1: Limestone	seen to 0.61

A similar thickness of strata (*c.* 4 m) was described here more recently by Bristow *et al.* (1995) who noted that the limestones were extensively veined by calcite and limonite, and dipped 15° west, as a result of their proximity to the Poyntington Fault.

Interpretation

When Torrens (1964) first drew attention to the brachiopod-rich bed subsequently named the 'Linguifera Bed', it was known to occur between the Thornford Beds and Ornithella Beds of the Fuller's Earth Rock Member between Thornford and Goathill in north Dorset. Later, Torrens (1966) confirmed that it could be traced between Goathill and Whistle Bridge, south of Yeovil, Somerset, a distance of *c.* 12 km. It dies out a short distance to the north of the quarry at Goathill. This tripartite division of the Fuller's Earth Rock Member in the Sherborne area was endorsed by Torrens (1980b). Farther north (see **Laycock Railway Cutting** GCR site report, this volume), only the Ornithella Beds are still recognizable and the remainder of the succession is referred instead to the Milborne Beds, a term first used by Buckman (1918, 1921) (see **Troll Quarry** GCR site report, this volume). Although the section recorded by Bristow *et al.* (1995) is comparable with that of Torrens (1966) given above, and despite the fact that the quarry at Goathill is the type locality of the Linguifera Bed (albeit designated as such in Torrens' (1966) unpublished PhD thesis), they assigned most of the strata (down to and including Bed 4 of Torrens) to the Ornithella Beds. They made no mention of the Linguifera Bed, although the latter is clearly recognizable in their description, which recorded 3.2 m of Ornithella Beds resting on 0.9 m of Milborne Beds. Their use of the term Ornithella Beds extends its scope, at the expense of the Milborne Beds, beyond that of any previous usage.

Each of the three subdivisions of the Fuller's Earth Rock Member here have a distinctive brachiopod fauna (Figure 2.37) that is evident amongst the extensive collections reported by McKerrow (1953). The brachiopods of the Ornithella Beds are characterized particularly by large *Ornithella bathonica* comparable with populations from other localities at the same horizon. As might be expected, the brachiopod fauna of the Linguifera Bed is characterized by

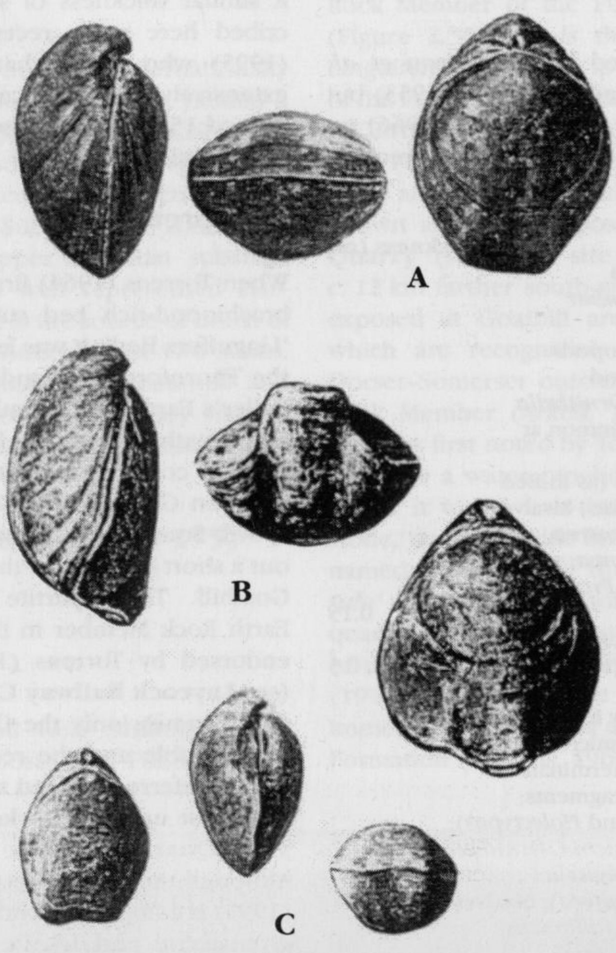

Figure 2.37 (A) *Ornithella bathonica* (Rollier), lectotype from the Fuller's Earth Rock Member, near Bath; (B) '*Terebratula*' *linguifera* Davidson, Fuller's Earth Rock Member, Haydon, Dorset; (C) *Ornithella haydonensis* Muir-Wood; holotype from the Fuller's Earth Rock Member, Haydon, Dorset. (Reproduced respectively from Muir-Wood, 1936, pl. 5, figs 7a–c; pl. 3, figs 12a–c; and pl. 5, figs 1a–c; courtesy of the Palaeontographical Society.) All specimens are shown at natural size.

its eponymous taxon '*Terebratula*' *linguifera*, although, according to Torrens (1966), this species is much scarcer here than at other localities farther west, possibly because it is sited near the bed's northern limit. The brachiopod fauna of the underlying Thornford Beds (notably beds 4 and 5) is dominated by an abundance of the dwarf species *Ornithella haydonensis* Muir-Wood. McKerrow (1953) suggested that differing ecological conditions were responsible for the dwarf forms amongst his collection but, in fact, they represent a quite separate and older fauna. According to Torrens (1966), McKerrow's material was not collected from the quarry at Goathill itself, but from brash in the field immediately to the north where there was an intermixing of forms from the different beds. Sylvester-Bradley (in discussion of McKerrow, 1953) had already suggested that in the neighbourhood of Goathill, there were several horizons, each with a different brachiopod fauna.

The ammonite fauna from the Linguifera Bed includes rather poorly preserved macroconchs of the tulitid genus *Morrisiceras*, which indicate the Middle Bathonian Morrisi Zone. This zone is better known at **Laycock Railway Cutting**, **Shepton Montague** and, particularly, **Bruton Railway Cutting** (see GCR site reports, this volume). The associated microconchs were named *Holzbergia* by Torrens (1970) who cited specimens from Goathill; these forms had been attributed earlier to *Berbericeras* (Arkell, 1958a). In contrast, the ammonites of the Ornithella Beds are large perisphinctids. As well as the *Procerites* reported by Torrens (1966), *Choffatia* has also been recorded (Arkell, 1958a; Torrens, 1966, 1980b). These forms characterize the basal part of the Middle Bathonian Bremeri Zone (the basal part of the Hodsoni Zone of Torrens, 1980b) (see **Bruton Railway Cutting** GCR site report, this volume, for a discussion of zonation).

Conclusions

The quarry at Goathill is the type locality of the Linguifera Bed, a brachiopod-rich limestone forming the middle subdivision of the Fuller's Earth Rock Member in the Sherborne area. The underlying Thornford Beds and overlying Ornithella Beds are also exposed. The Linguifera Bed extends for *c.* 12 km from just north of Goathill to south of Yeovil. Ammonites indicate that it belongs to the Middle Bathonian Morrisi Zone and correlates with the upper part of the Milborne Beds of areas farther north. The site is thus an important one for regional correlation of the Fuller's Earth Rock Member, which is, itself, one of the best developments of Middle Bathonian strata in Europe.

HOLWAY HILL QUARRY, DORSET (ST 638 211)

B.M. Cox

Introduction

The GCR site known as 'Holway Hill Quarry' comprises an old quarry face that now marks the southern boundary of the grounds of a residential property, *c.* 1.5 km south of the village of Corton Denham, on the lane to Sherborne, Dorset. It shows a relatively thick development of Aalenian strata, compared with some other sections in the Sherborne area, and has been designated as the type section of the Corton Denham Member of the Inferior Oolite Formation (Parsons, 1980a). It includes two local marker beds – the Ringens Bed and the Brebissoni Bed – which take their names from species of brachiopod.

Description

The section at Holway Hill Quarry was first described by Buckman (1893a), later by Richardson (1916a), and subsequently cited by Kellaway and Wilson (1941) and Wilson *et al.* (1958). The maximum thickness of strata recorded in the quarry is 4.3 m (Buckman, 1893a). The following record of the section, through just under 3 m of strata, is based on that lodged in English Nature files. The lithostratigraphical classification follows Parsons (1980a) and Bristow *et al.* (1995).

	Thickness (m)
Inferior Oolite Formation	
Corton Denham Member	
5: *Ringens Bed*: Biosparite, hard, brown, blue-hearted; profuse *Homoeorhynchia ringens* (von Buch)	seen to 0.48
4: Marl and limestone, soft, rubbly; weathered and conspicuous in quarry face	0.18
3: *Brebissoni Bed*: Limestone, sandy, weakly nodular, hard, brown, shelly, bioclastic; moderately burrowed with small, ramifying burrows; ammonites, mainly as distorted internal moulds of body chambers including *Brasilia*, common towards impersistent brown marl at base	0.76–0.90
2: Limestone, sandy, hard, brown, in several massive courses; intensely burrowed with large diameter, sub-vertical to vertical burrows filled with orange sandy material; thin marl at base	0.70–0.76
1: Biosparite, hard, blue-hearted weathering brown, shelly	seen to 0.50

Interpretation

The Ringens Bed, at the top of the section at Holway Hill Quarry, was first noted by Buckman (1893a) and is named after the rhynchonellid brachiopod *Homoeorhynchia ringens* (von Buch) (Figure 2.38). It overlies the Brebissoni Bed – a modification of Richardson's (1916a) *Pseudoglossothyris brebissoni* [Deslongchamps] Bed – named after a species of terebratulid brachiopod (Parsons, 1980a). The section thus shows the stratigraphical relationship between these two beds, which have generally not been seen together in other local sections (see **Louse Hill Quarry** and **Halfway House Cutting and Quarry** GCR site reports, this volume).

Figure 2.38 *Homoeorbynchia ringens* (von Buch) as illustrated by Davidson (1878). The specimen on which these figures are based in fact came from **Halfway House Cutting and Quarry** (see GCR site report, this volume). The specimen is shown at natural size.

The Corton Denham Member, of which this is the type section, was proposed by Parsons (1980a) (as Corton Denham Beds) for the 'grey beds' of Richardson (1932), originally described near the village of Corton Denham; the village is itself sited on the underlying Bridport Sand Formation of the (Lower Jurassic) Lias Group (Bristow *et al.*, 1995). The member is not now well exposed but has been recovered in cored boreholes. According to Bristow *et al.* (1995), it comprises a lower division of pale-grey, burrowed and bioturbated limestones with sandy, calcareous mudstone partings, and an upper division of olive-grey, calcareous mudstones with only thin interbedded limestones. Extensive burrowing and irregular bed boundaries give the limestones a pseudo-nodular fabric. The base of the member and junction with the Bridport Sand Formation is marked by a progressive downward increase in the amount of matrix sand in the limestones.

Ammonites of the genus *Brasilia* indicate that the strata at this site belong to the Aalenian Bradfordensis Zone, although Bed 1 may be of the next oldest Murchisonae Zone (Parsons, 1980a). Additional faunal, mainly bivalve, records were reported by Richardson (1916a).

Conclusions

The section at Holway Hill Quarry exposes two faunal marker horizons – the Ringens Bed and the Brebissoni Bed – which are important for local and regional classification and correlation of the Inferior Oolite Formation. It also provides a type section for the Corton Denham Member of the latter formation. Ammonites indicate the Aalenian Stage, which is more fully developed here than at other localities in this area. The site is thus an important one for regional classification and correlation of some of the oldest Middle Jurassic strata.

MILBORNE WICK SECTION, SOMERSET (ST 662 205)

B.M. Cox

Introduction

The Inferior Oolite Formation section generally known as 'Milborne Wick Lane', south-west of Milborne Wick in Somerset, was first reported by Buckman (1893a, section XVII) and has retained an important place in the study of Bajocian stratigraphy since that time. It is particularly famous for its abundant and well-preserved ammonite faunas of the Romani Subzone (Lower Bajocian Humphriesianum Zone). Fossil material from this section has found its way into numerous museums, abroad as well as in Britain (Parsons, 1976a). The stratigraphy at the site and in adjacent temporary excavations has been reviewed by Huxtable (1996).

Description

The following description, including bed numbers and ammonite names, is based on that recorded by Parsons (1976a) with additional data from Buckman (1893a), Richardson (1916a) and Page (unpublished English Nature records). The lithostratigraphical classification follows Bristow *et al.* (1995).

	Thickness (m)
Inferior Oolite Formation	
Sherborne Building Stone Member	
6: Limestone, sandy, hard, crystalline, pale-yellow; pebbles derived from Bed 5; *Ctenostreon* and eroded; limonite-coated fossils at base, resting on planed surface	seen to 0.90
Miller's Hill Member	
5: Limestone, marly, soft, white with numerous yellow limonite ooids and black dendritic manganiferous staining; very fossiliferous with many shells replaced by pink calcite; ammonites including *Chondroceras evolvescens* (Waagen), *C. gervillii* (J. Sowerby), *Phaulostephanus* cf. *paululum* S.S. Buckman, *Stephanoceras* (*S.*) cf. *scalare* (Mascke emend. Weisert), *S.* (*Normannites*) *crassicostatum* (Westermann), *S.* (*N.*) *mitis* (Westermann), *S.* (*N.*) cf. *portitor* (Maubeuge), *S.* (*Germanites?*) *bicostatus* Westermann, *Teloceras blagdeniformis* (Roche), *Dorsetensia deltafalcata* (Quenstedt), *D. edouardiana* (d'Orbigny), *D. liostraca* S.S. Buckman, *D. regrediens* Haug, *Lissoceras* (*L.*) *oolithicum*	

Thickness (m)

5 (cont.): (d'Orbigny), *Oppelia* (*O.*) *subradiata* (J. Sowerby), *O.* (*O.*) aff. *skrodzkii* Brasil, *O.* (*Oecostraustes*) *genicularis* Waagen, *Poecilomorphus* (*P.*) *cycloides* (d'Orbigny), *P.* (*Micropecilomorphus*) *vicetinus* (Parona) and *Stegoxyites* (*S.*) aff. *parcicarinatus* S.S. Buckman; abundant bivalves including *Astarte spissa* S.S. Buckman, nuculaceans, *Oxytoma*, pectinids, *Pleuromya*, *Posidonomya*, *Unicardium*; also cerithiid and pleurotomariid gastropods; belemnites; brachiopods (*Sphaeroidothyris*); occasional small 'button' corals — 0.07–0.10

4: Limestone, hard; yellow-brown ooids set in pale blue-grey matrix; less fossiliferous than Bed 5; ammonites including *Stephanoceras* (*Normannites*) *formosum* (S.S. Buckman), *S.* (*N.*) *portitor*, *Dorsetensia liostraca* S.S. Buckman, *Oppelia* (*O.*) *subradiata* and *Stegoxyites* (*S.*) *parcicarinatus*; brachiopods (*Sphaeroidothyris*); bivalves (particularly in layer about middle of bed); non-sequence at base marked by conglomerate with material derived from Bed 3 — 0.20–0.25

3: Marl, soft, white, speckled with green glauconite grains; ammonites including *Kumatostephanus* (*K.*) cf. *perjucundus* S.S. Buckman, *K.* (*Gerzenites*?) *rugosus* Westermann, ?*Labyrinthoceras* sp. nov., *Skirroceras bayleanum* (Oppel), *S. skolex* (S.S. Buckman), *Emileia* (*E.*) *polyschides* (Waagen), *E.* (*Otoites*) *contractus* (S.S. Buckman *non* J. Sowerby) and *Papilliceras arenatus* (Quenstedt emend. S.S. Buckman); pleurotomariid gastropods — 0.10–0.15

2b: Limestone, blue-green, richly glauconitic, forming relatively soft, irregularly preserved top to Bed 2a; ammonites including *Kumatostephanus* (*Gerzenites*?) cf. *rugosus*, *Mollistephanus* (*M.*) sp., *Emileia* (*E.*) sp., *E.* (*Otoites*) sp., *Witchellia* (*W.*) *laeviuscula* (J. Sowerby) and *W.* (*Pelekodites*) aff. *macra* (S.S. Buckman); *Astarte spissa*, nautiloids and lignite fragments — 0–0.10

Corton Denham Member

2a: Limestone, blue, hard in two or three layers; less glauconitic than Bed 2b; ammonites including *Emileia* (*E.*) cf. *brocchii* (J. Sowerby) and *Shirbuirnia* (*Stiphromorphites*) cf. *nodatipinguis* S.S. Buckman. — 0.45–0.60

1: Limestone, hard, sandy, sparsely glauconitic, interbedded with soft, sandy marl; ammonites including *Witchellia* (*W.*) aff. *zugophorus* (S.S. Buckman); bivalves including 'myids' — seen to 3.0

Both Buckman (1893a) and Richardson (1916a) recorded a further two metres of beds at the base of the section. Between them, these authors also noted belemnites, nautiloids, lignite and *Astarte spissa* in Bed 2, but it is not clear if the records relate to Bed 2a or 2b of the above section.

Interpretation

According to Parsons (1976a), there has been some confusion concerning the Milborne Wick section in past literature because Richardson (1916a) considered that Buckman (1893a) had been overzealous in splitting up beds 3–5 of the above section; Richardson believed that they were all of the same age and lithology. However, Parsons (1976a) concluded that there was no doubt that Buckman was correct because, of these three beds, only Bed 3 contained glauconite grains and also its ammonite fauna proved it to be significantly older than the overlying beds. Incidentally, both Buckman (1893a) and Richardson (1916a) numbered the beds from the top down such that, for example, Bed 1 in the above section is their Bed 6 and Bed 2 (a and b) is their Bed 5.

The succession belongs almost entirely to the Lower Bajocian Substage. The three youngest zones of that substage are well substantiated on the basis of the ammonite faunas, specimens of which were figured by Buckman (1909–1930). Beds 1, 2a and 2b are assigned to the Laeviuscula Zone and Subzone, Bed 3 to the Sauzei Zone, and beds 4 and 5 to the Humphriesianum Zone, Romani Subzone (Parsons, 1976a; Figure 2.39). The Romani Subzone, with a type area and horizon in south-east France and index ammonite *Witchellia romani* (Oppel) (*Dorsetensia* (*D.*) *romani* in Rioult *et al.*, 1997), was confirmed in the British zonal sequence by Parsons (1976a, 1980a). Callomon and Chandler (1990) subsequently substituted the more commonly occurring *Poecilomorphus cycloides* (d'Orbigny) as the index taxon for this interval (following Sturani's (1971) usage) but later, Callomon and Cope (1995) reverted to the earlier nomenclature. The base of Bed 6 marks a non-sequence, which probably spans the younger subzones of the Humphriesianum Zone as well as the Upper Bajocian Subfurcatum Zone (Bristow *et al.*,

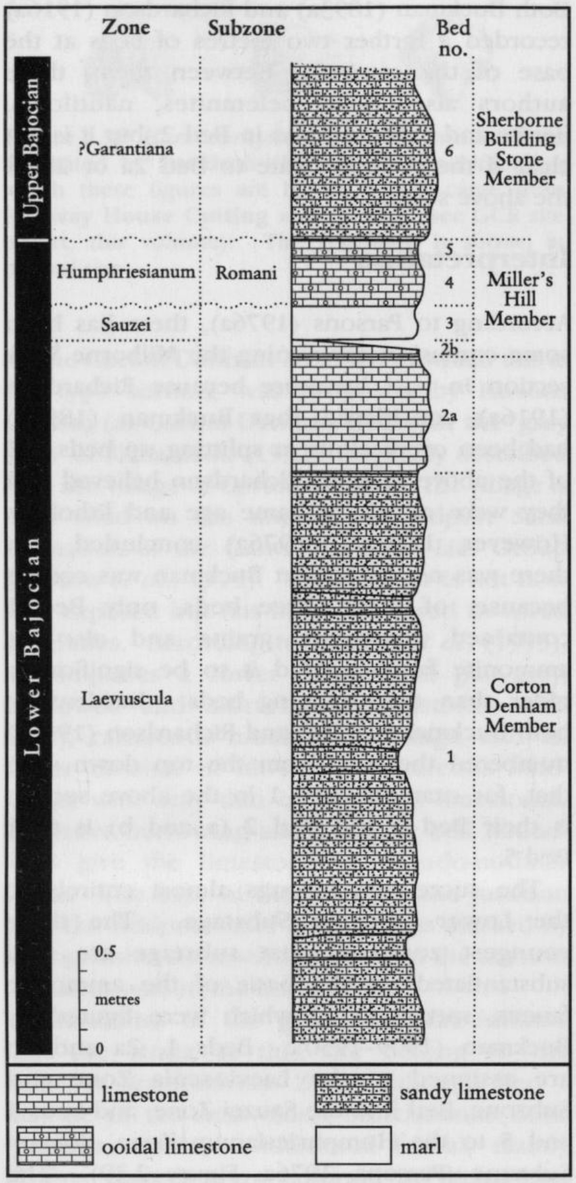

Figure 2.39 Graphic section of the Inferior Oolite Formation at the Milborne Wick Section. For lithologies, see text.

1995), and Bed 6 itself may belong to the Garantiana Zone.

The Milborne Wick Section is sited on the gradient known as 'Miller's Hill', which rises from the western side of the village of Milborne Wick. Barton *et al.* (1993) and Bristow *et al.* (1995) recognized a distinctive member within the Inferior Oolite Formation in this area, and named it the 'Miller's Hill Beds' ('Miller's Hill Member' herein). Characterized by glauconitic sands, limestones and calcarenites with clasts of phosphatic limestone and abundant ammonite fragments, the base of this member is defined by an erosion surface. It is underlain by the Corton Denham Member (based on Parsons' (1980a) Corton Denham Beds for Richardson's (1932) 'grey-beds'), and overlain by the Sherborne Building Stone Member (based on the Sherborne Building Stone of Buckman, 1893a). Bed 5 was called the '*Astarte spissa* Bed' by Richardson (1916a) but should not be confused with the 'Spissa Bed' of Parsons (1980a), which occurs at a lower stratigraphical level, equivalent to Bed 2b at the GCR site.

The locality of the Milborne Wick Section is the north-easternmost of a cluster of GCR sites near Sherborne (see also **Bradford Abbas Railway Cutting**, **Louse Hill Quarry**, **Halfway House Cutting and Quarry**, **Sandford Lane Quarry**, **Frogden Quarry** and **Holway Hill Quarry** GCR site reports, this volume) where the Inferior Oolite Formation is rather thicker than elsewhere in Dorset and Somerset (see Figure 2.29). According to Bristow *et al.* (1995), this local thickening is related to deposition in a half-graben with a depocentre located approximately 10 km south of the Mere Fault (see Figure 2.29). The fault-controlled basin was starved of sediment during deposition of the Miller's Hill Member, and Bristow *et al.* (1995) considered that the inferred slow rate of deposition and the member's widespread iron mineralization, now contained as glauconite, reflected an important tectonic event.

Conclusions

The Milborne Wick Section has yielded a prolific and well-preserved ammonite fauna characteristic of the Romani Subzone of the Lower Bajocian Humphriesianum Zone. With other sites in the Sherborne area, it constitutes one of the most important localities in Britain for this stratigraphical interval. Known in the geological literature for over 100 years and represented in the collections of many museums both in Britain and abroad, it remains a key site for Bajocian stratigraphy as well as providing an insight into the palaeogeography and depositional history of the Wessex Basin.

LAYCOCK RAILWAY CUTTING, SOMERSET (ST 678 213)

B.M. Cox

Introduction

Laycock Railway Cutting, on the main Salisbury to Exeter line, lies between the villages of Stowell and Milborne Wick in Somerset, and *c.* 4 km north of the quarry at **Goathill** (see GCR site report, this volume). Like the latter site, it exposes the Fuller's Earth Rock Member (Figure 2.40) but only the Ornithella Beds at the top of the succession are common to both localities. The cutting is sited beyond the northern limit of the Linguifera Bed, of which **Goathill** is the type locality, and the beds below the Ornithella Beds are classified as Milborne Beds. These take their name from nearby Milborne Wick (Buckman, 1918, 1921). From the early descriptions of the *c.* 300 m-long cutting (Woodward, 1894; White, 1923), it is clear that the whole of the Fuller's Earth Rock Member was once exposed here with a trace of Upper Fuller's Earth Member to the north-east, and up to about a metre of Lower Fuller's Earth Member (Acuminata Beds) to the south-west (but see 'Interpretation' below).

Description

The *c.* 10 m section given below is based on that reported by Woodward (1894) and White (1923).

	Thickness (m)
Fuller's Earth Formation	
Fuller's Earth Rock Member	
Ornithella Beds	
Limestone, grey and brown, 'earthy', rubbly on top; crowded with brachiopods (*Ornithella*)	2.4–2.7
Milborne Beds	
Limestone, buff-coloured, 'earthy', more massive than above; shelly in places with fossils weathering-out on joint surfaces	2.7–3.0
Marl, dark bluish-grey, with indurated bands of pale bluish-grey 'earthy' limestone; casts of *Pleuromya* in life position; *Pholadomya* fairly common	c. 4.6
Lower Fuller's Earth Member	
Acuminata Beds	
Clay, poorly exposed	seen

Figure 2.40 Fuller's Earth Formation exposed on the south side of Laycock Railway Cutting. (Photo: British Geological Survey, No. A15155; reproduced with the permission of the Director, British Geological Survey, © NERC, 1990.)

Tulitid ammonites (both *Tulites* and *Morrisiceras*) and the echinoid *Collyrites* were also reported.

When Torrens (1966) investigated this site, a major part of the Milborne Beds was well exposed in long faces on both sides of the cutting. However, he did not see the Ornithella Beds and concluded that they must have been formerly exposed in a higher part of the cutting, which may not have been seen for nearly 50 years. The following *c.* 4.6 m section is based on Torrens' (1966) detailed record of part of the Milborne Beds measured on the south side of the cutting. More recently, Bristow *et al.* (1995) reported up to 7 m of exposed beds at this locality but gave no measured section other than a reclassification of Woodward's (1894) record (see 'Interpretation' below).

	Thickness (m)
Fuller's Earth Formation	
Fuller's Earth Rock Member	
Milborne Beds	
18: Rock in subsoil; *Tulites* in basal 0.15 m, *Morrisiceras* above	0.46–0.76
17: Limestone, rubbly; *Tulites*	0.3-0.46
16: Limestone, marly, softer than above; *Tulites*	0.15
15: Limestone, rubbly, prominent; *Tulites* and corals (*Montlivaltia* and *Diastopora*)	0.3–0.46
14: Limestone, marly; brachiopods (*Ornithella* and *Rhynchonelloidella*); bivalves (*Catinula* and *Modiolus anatinus* Wm Smith); and gastropods (*Globularia*? and *Pleurotomaria* cf. *cotswoldensis* Cox and Arkell)	0.46
13: Limestone; 12: Marl parting; 11: Limestone; — oppeliid ammonite (*Oxycerites*), *Ornithella* and *Pholadomya lirata* (J. Sowerby); *Tulites* at base	0.15–0.23
12: Marl parting	0.05
11: Limestone	0.23
10: Limestone, bedded, rather fractured; *Ornithella*, *Catinula* and *Pholadomya* spp.	0.3–0.38
9: Limestone; *Tulites*	0.23
8: Limestone, bedded, rather fractured; *Tulites* and nautiloid	0.15
7: Limestone with corals (*Montlivaltia*)	0.23
6: Marl parting; *Pleuromya calceiformis* (Phillips)	0.03
5: Limestone; *Tulites* and *Pleuromya* cf. *marginata* (Agassiz)	0.25
4: Marl parting, very conspicuous; *Pholadomya lirata*	0.05
3: Limestone, rather fractured	0.13
2: Limestone	0.3
1: Limestone	seen

Interpretation

Laycock Railway Cutting lies near the southern limit of the Milborne Beds but within their historical type area (Buckman, 1918, 1921). As a subdivision of the Fuller's Earth Rock Member, they extend at least as far north as Bath. The lithology of these beds and that of their partial correlative, the Thornford Beds, is described in the **Troll Quarry** see GCR site report (this volume). Although in their typical development these two units are lithologically distinct, in some cases their differentiation is more subjective (Torrens, 1966). Contrary to all other accounts, Bristow *et al.* (1995) removed Woodward's (1894) and White's (1923) lowest interbedded marl and limestone unit (see first section above) from the Fuller's Earth Rock Member (Milborne Beds) and included it instead with the underlying Lower Fuller's Earth Member (Acuminata Beds), apparently on the basis of *Praeexogyra acuminata* (J. Sowerby) specimens collected from loose material but deduced to have come from the top of this unit (Taylor, 1990).

The tulitid ammonite faunas enable recognition of the Middle Bathonian Subcontractus and Morrisi zones. Arkell (1952) recorded several species of *Tulites* from here, and macroconch *Tulites* and rarer microconchs were recorded by Torrens (1966) from Bed 5 up to the basal part of Bed 18 in the section given above. These are diagnostic of the Subcontractus Zone (see also **Troll Quarry** GCR site report, this volume). The subsequent appearance of the genus *Morrisiceras* in the lower part of Bed 18 marks the base of the Morrisi Zone. Arkell (1954b) recorded a number of species from here, and Page (1996a) described Laycock Railway Cutting as a formerly rich source of *M.* ex gr. *morrisi* in Milborne Beds facies. *Tulites* and *Morrisiceras* are mutually exclusive in their stratigraphical ranges and the Subcontractus–Morrisi zonal boundary is therefore readily recognized. Elsewhere (see **Goathill**, **Shepton Montague** and **Bruton Railway Cutting** GCR site reports, this volume), the basal part of the next youngest zone is characterized by large perisphinctid ammonites that occur in the basal part of the Ornithella Beds, but no ammonites were reported by the early authors who saw this interval at Laycock Railway Cutting. Although Taylor (1990) reported a *Procerites* amongst ex-situ material in the cutting, this was inferred to be from the Lower Fuller's Earth Member.

As at **Goathill** (see GCR site report, this volume), the brachiopods recorded from the Ornithella Beds at Laycock Railway Cutting are distinct from those of the underlying beds. They are large forms referred to as *Ornithella ornithocephala* (J. Sowerby) by Richardson (in White, 1923) but almost certainly belonging to the group of *O. bathonica* (Rollier). Those of the Milborne Beds are the small species *Ornithella haydonensis* Muir-Wood as recorded from the correlative Thornford Beds at **Goathill** (see Figure 2.37).

Conclusions

Laycock Railway Cutting is one of several localities in the south Somerset–north Dorset area that exposes the Fuller's Earth Rock Member but it is the only one where the member has been seen in its entirety. It includes an ammonitiferous development of the Milborne Beds in their historical type area; the ammonites indicate the Middle Bathonian Subcontractus and Morrisi zones. A little farther south, the Milborne Beds are replaced by the Thornford Beds and Linguifera Bed (see **Goathill** GCR site report, this volume). The site is thus an important one for regional classification and correlation of the Fuller's Earth Rock Member within the Bathonian succession of Wessex.

SHEPTON MONTAGUE, SOMERSET (ST 686 316)

B.M. Cox

Introduction

The cutting at Shepton Montague, Somerset, on the disused railway north of Wincanton is famous for its exposure of the Fuller's Earth Rock Member and underlying Lower Fuller's Earth Member (Acuminata Beds) of the Fuller's Earth Formation (Parsons, 1879; Woodward, 1894; Arkell, 1933). Torrens (1966) described it as 'probably the most important Fuller's Earth Rock section still in existence'. The Milborne Beds and Ornithella Beds, into which the Fuller's Earth Rock Member is divided in areas farther south (see **Laycock Railway Cutting** GCR site report, this volume), are recognized here but, in addition, a further subdivision (Rugitela Beds) is present at the top of the member. The locality is considered to be near the southern limit of this last-named unit, which takes its name from a genus of brachiopod (Sylvester-Bradley and Hodson, 1957). As well as brachiopods, the cutting at Shepton Montague has yielded zonally diagnostic ammonite faunas and many other fossils.

Description

The exposure, although overgrown at the time of writing, extends for some 350 m. The following section, including bed numbers, is based on that measured by Torrens (1966), which itself included additional data from unpublished notes by W.J. Arkell and L. Richardson.

	Thickness (m)
Fuller's Earth Formation	
Fuller's Earth Rock Member	
Rugitela Beds	
20: Marl and subsoil; bivalves including common *Catinula knorri mendipensis* Sylvester-Bradley MS, *Lopha* sp., *Modiolus anatinus* Wm Smith and *Pleuromya alduini* (Brongniart); belemnite fragments; and brachiopods (*Rhynchonelloidella* and *Wattonithyris*)	0.61
Ornithella Beds	
19: Limestone	0.15
18: Marl; bivalves (*Goniomya intersectans* (Wm Smith), *Pholadomya lirata* (J. Sowerby), *Pleuromya alduini*, *P. calceiformis* (Phillips)); brachiopods (*Rhynchonelloidella*)	0.61
17: Limestone	0.13
16: Marl with *Rhynchonelloidella* (including common juveniles)	0.30
15: Limestone, hard, impersistent	*c.* 0.30
14: Marl passing into limestone; nautiloid and brachiopods (*Ornithella bathonica* (Rollier) and *Rhynchonelloidella*)	0.41
13: Limestone, rubbly; *Ornithella bathonica* (particularly common in top 0.15 m) and *Wattonithyris*; ammonites (*Procerites*) near top; bivalves (*Catinula* sp., *Modiolus anatinus*, *Rollierella minima* (J. Sowerby)); corals (*Diastopora michelini* (de Blainville))	0.30
12: Limestone, marly; perisphinctid ammonites including *Procerites* cf. *quercinus* (Terquem and Jourdy) at base, '*Subgrossouvria*' and '*Siemiradzkia*', oppeliid ammonites; brachiopods including *Ornithella bathonica* and *Wattonithyris*; bivalves including *Catinula* sp., *Chlamys* (*Radulopecten*) sp., *Pleuromya alduini*, *Praeexogyra* cf. *acuminata* (J. Sowerby), *Rollierella* sp. and *Thracia depressa* (J. de C. Sowerby); echinoids (*Holectypus depressus* Leske); crustacean fragment	0.30

		Thickness (m)
Milborne Beds		
11:	Limestone, hard, prominent, shell-fragmental; ammonites (macroconch *Morrisiceras*); brachiopods (*Wattonithyris*); bivalves (*Catinula* and *Limatula cerealis* Arkell); marl parting with microconch *Morrisiceras* at base	0.18–0.23
10:	Limestone, marly; parting at base	0.10–0.15
9:	Limestone, marly; ammonites (including *Choffatia* and *Morrisiceras*); brachiopods	0.10–0.15
8:	Limestone, prominent in north-west of cutting, elsewhere softer and more marly; ammonites (macroconch and microconch *Morrisiceras*); brachiopods (*Wattonithyris*)	0.10–0.15
7:	Limestone; ammonites (*Tulites modiolaris* (Wm Smith)); bivalves (*Modiolus anatinus*); echinoids (*Acrosalenia*)	0.30–0.36
6:	Limestone; corals (*Montlivaltia*); ammonites (*Tulites modiolaris*); bivalves (*Homomya gibbosa* (J. Sowerby) and *Modiolus anatinus*)	0.25–0.30
5:	Parting with *Ornithella haydonensis*,	
4:	Parting, sandy; *Tulites*, } *Catinula* and *Wattonithyris*	0.30–0.36
3:	Parting with *O. haydonensis*,	
2:	Limestone; corals (*Montlivaltia*); ammonites (*Tulites modiolaris*)	0.36
1:	Limestone	seen
Clay, buff with occasional thin bands of argillaceous limestone		1.83
Lower Fuller's Earth Member		
Acuminata Beds		
Clay with abundant *Praeexogyra acuminata*		1.83

Evidence of the Acuminata Beds, which are not now well exposed, is provided by numerous specimens of *P. acuminata* amongst material excavated from rabbit burrows in the overgrown lower beds of the cutting at Shepton Montague. When recorded by Torrens (1966), the alternating marls and limestones of the Ornithella Beds were easily traced from one end of the cutting to the other but the underlying Milborne Beds were, at first sight, divisible only into an upper rubbly part and a lower more massive part with indistinct bedding planes, variable bed thicknesses, and small faults (Torrens, 1966). Exposure is presently less good and the section is generally degraded.

Interpretation

The term 'Acuminata Beds' originated with Richardson (1910) who used the term '*Ostrea acuminata*-Clays' for the beds, rich in the oyster *Praeexogyra acuminata*, just below the Fuller's Earth Rock Member in Somerset. Arkell (1934) wrote of a *c*. 1.5–2.1 m-thick bed with enormous numbers of *P. acuminata* extending from just north of Sherborne, Dorset, through Somerset, beyond the Mendips and along the side of the Cotswold scarp at least as far north as Wotton-under-Edge, a distance of at least 80 km. He reported that within this area, the oyster showed little morphological variation from Sowerby's (1816) type material from Bath, and he figured material from the Shepton Montague railway cutting as examples (Figure 2.41). Torrens (1980b) applied the term 'Acuminata Beds' to the whole of this north Dorset–Gloucestershire area where they comprise up to 9 m of predominantly mudstone in which the *P. acuminata* are often concentrated in discrete oyster lumachelles. Penn *et al*. (1979) who investigated cored boreholes in north Somerset (Frome to Bath) preferred to abandon the term 'Acuminata Beds' and name a specific laterally persistent lumachelle within this package of strata as the 'Acuminata Bed' (shown in Figure 2.4). This occurs a few metres below the base of the Fuller's Earth Rock Member (or its equivalents) in an area from Frome, Somerset northwards into the Cotswolds as far as the Cirencester area. Use of the term 'Acuminata Bed' is somewhat unfortunate as a second laterally persistent *P. acuminata*-rich bed (shown in Figure 3.4, Chapter 3) occurs within the Lower Fuller's Earth Member at a slightly lower stratigraphical level. This latter bed extends from just north of Bath as far as Burford, Gloucestershire (Wyatt, 1996a; Sumbler, 1999).

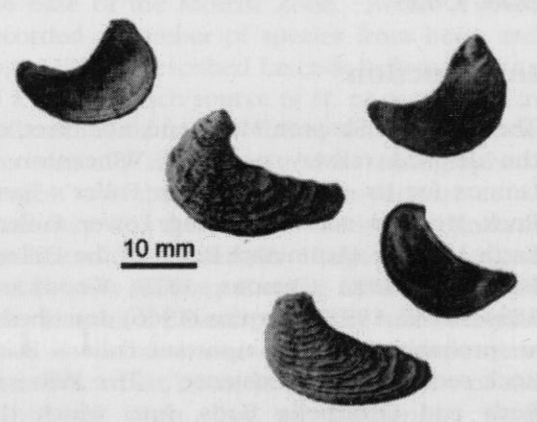

Figure 2.41 Specimens of *Praeexogyra acuminata* (J. Sowerby) from Shepton Montague railway cutting as figured by Arkell (1934, pl. 2, figs 30–4).

Farther north, neither of these two beds are specifically recognized although the upper one may correlate with concentrations of *P. acuminata*, which form a so-called 'Acuminata Marble' at the base of the Eyford Member of the Fuller's Earth Formation as seen at **Hampen Railway Cutting** (see GCR site report, this volume) (Sumbler, 1999). At present, the term 'Acuminata Beds' is still used in north Dorset and south Somerset (e.g. Bristow *et al.*, 1995, 1999) but not farther north in the Cotswold area (e.g. Sumbler *et al.*, 2000; see also Figure 2.4; and Chapter 3). The unit appears to die out just south of Sherborne; Torrens (1966) reported its absence at **Troll Quarry** (see GCR site report, this volume). Another laterally persistent marker bed (the Echinata Bed), rich in the bivalve *Meleagrinella echinata* (Wm Smith), was identified by Penn *et al.* (1979) and Penn and Wyatt (1979) in the Frome–Bath area where it occurs about midway between the Acuminata Bed and the base of the Fuller's Earth Rock Member. It has been recognized extensively northwards into the Cotswolds (Wyatt, 1996a; Sumbler, 1999) and southwards, within the Acuminata Beds, to beyond Shepton Montague (Richardson, 1909c; Bristow *et al.*, 1999) (see Figure 2.4; and Figure 3.4, Chapter 3). However, records of the Acuminata Beds at the Shepton Montague railway cutting are too inadequate to enable the Echinata Bed to be identified there.

The Ornithella and Rugitela beds of the overlying Fuller's Earth Rock Member were named after their characteristic brachiopod genera by Sylvester-Bradley and Hodson (1957) when they described an exposure at Whatley near Frome about 16 km to the north of Shepton Montague. The term 'Ornithella Beds' has since been restricted to only the upper part of the unit originally described by Sylvester-Bradley and Hodson (1957); the lower part is referred to the Milborne Beds, a term first used by Buckman (1918, 1921) (see **Troll Quarry** GCR site report, this volume). This tripartite division of the Fuller's Earth Rock Member is widely recognized in Somerset but not farther south in the Sherborne area of Dorset.

According to Torrens (1966), the topmost bed of the Milborne Beds is the prominent shelly limestone (Bed 11), which was the only bed that he could trace laterally with ease. The small brachiopod *Ornithella haydonensis* is very common in beds 3–5 and is ubiquitous in the top part of the Milborne Beds (see **Laycock Railway Cutting** GCR site report, this volume). The presence of corals (in beds 2 and 6) is also typical of the Milborne Beds (see **Laycock Railway Cutting** GCR site report, this volume). The ammonite fauna of the Milborne Beds comprises the tulitid genera *Tulites* and *Morrisiceras*, which are mutually exclusive in their stratigraphical ranges (see **Bruton Railway Cutting** GCR site report, this volume). The changeover of these genera, indicating the Subcontractus–Morrisi zonal boundary, occurs at the boundary between beds 7 and 8; indeed, Torrens (1966) admitted that this bed boundary had been drawn at the change in ammonite faunas (*Tulites* in Bed 7 and below, and *Morrisiceras* above) rather than at a lithological change. The fauna of beds 8–11 distinguishes them from the beds above and below. As well as macroconch and microconch *Morrisiceras*, small specimens of the brachiopod *Wattonithyris* are also characteristic.

As elsewhere (see **Goathill** and **Laycock Railway Cutting** GCR site reports, this volume), the characteristic fauna of the Ornithella Beds is the large brachiopod *Ornithella bathonica*, which occurs in beds 12–14. Bed 12, the basal bed of the Ornithella Beds, is also notable for large specimens of *Procerites*; this ammonite also occurs in the top part of Bed 13. Specimens reported by Arkell (1958b), including one figured as *P.* cf. *wattonensis* Arkell, came from one of these beds. These perisphinctid faunas are considered to be indicative of the basal Bremeri Zone (see **Bruton Railway Cutting** GCR site report, this volume, for a discussion of zonation). The boundary between the Ornithella and Rugitela beds at this locality was drawn by Torrens (1966) below the first appearance of the oyster *Catinula knorri mendipensis*, a specimen of which was figured from here by Arkell (1934, pl. 2, fig. 5) as *C. matisconensis* (Lissajous).

Conclusions

The disused railway cutting at Shepton Montague exposes an almost complete section through the Fuller's Earth Rock Member of the Fuller's Earth Formation in an area where the member is internationally renowned as one of the best developments of Middle Bathonian rocks in Europe. Underlain by the Acuminata Beds of the Lower Fuller's Earth Member, the Fuller's Earth Rock Member here is divided into the Milborne Beds, Ornithella Beds and Rugitela Beds. It is the southernmost well-documented exposure of the last-named unit whose type area is farther north near Frome. The member has yielded a rich fauna including zonally diagnostic ammonites, and specimens from here are well represented in published literature. Together with the other Fuller's Earth Rock Member sites in this area (see **Troll Quarry**, **Goathill**, **Laycock Railway Cutting** and **Bruton Railway Cutting** GCR site reports, this volume), the section has enabled the lithological and palaeontological characterization of these beds to be well understood. The site is thus an important one for understanding the classification and correlation of the Bathonian rocks of Wessex, and of the Bathonian Stage further afield.

GODMINSTER LANE QUARRY AND RAILWAY CUTTING, SOMERSET (ST 681 345)

B.M. Cox

Introduction

The GCR site known as 'Godminster Lane Quarry and Railway Cutting' comprises the railway cutting more generally known as 'Lusty Cutting' or 'Bruton Cutting', together with the adjoining quarry on the northern side. The latter is not, incidentally, that known in the literature as 'Lusty Quarry', which is sited near the railway bridge *c*. 150 m farther west. The cutting lies to the west of Bruton Station in Somerset, on the line between Westbury and Taunton. It is located in the so-called 'Cole Syncline' (Figure 2.42), a geological structure that preserves an Aalenian–Upper Bajocian Inferior Oolite succession, which is nearly as complete as that in the Sherborne area, *c*. 15 km farther south (see Figure 2.29). North of the latter area, the older beds of the Inferior Oolite Formation are otherwise progressively cut out by overstep towards the Mendip Hills. At **Doulting Railway Cutting** (*c*. 10 km farther north) and **Vallis Vale** (*c*. 20 km farther north), the Inferior Oolite Formation is restricted to the Upper Bajocian Substage.

Description

The following section of the railway cutting (including bed numbers) is based on that recorded by Richardson (1916a) who described the succession in the adjoining quarry as being 'precisely the same'. The lithostratigraphical terms are from Richardson (1916a) and Parsons (1980a), but following Bristow *et al*. (1999), Bed 2 (the Ragstone of Richardson, 1916a and the Ragstones of Parsons, 1980a) is classified as Hadspen Stone.

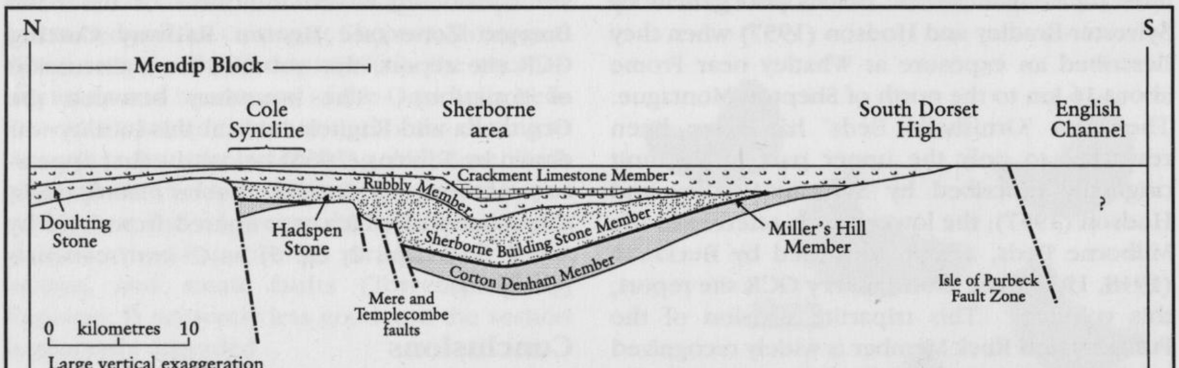

Figure 2.42 Diagrammatic reconstructed cross-section through the Inferior Oolite Formation in part of Wessex in Late Bajocian times, illustrating the syndepositional development and fault-control of the so-called 'Cole Syncline'. The top of the Crackment Limestone Member is taken as the horizontal datum. (After Bristow *et al*., 1995, fig. 21.)

	Thickness (m)
Inferior Oolite Formation	
Doulting Stone	
1: Limestone, fairly well bedded	seen to 1.8
Hadspen Stone	
2: Limestone; the brachiopod *Acanthothiris spinosa* (Linnaeus)	1.5
Pecten Bed	
3: Limestone, grey; upper surface level; abundant pectinacean bivalves (*Entolium demissum* (Phillips)); sonniniid and otoitid ammonites and small *Gryphaea*; irregular base 'joined to' Bed 4	–
4: Limestone, grey, rather sandy; fossils including sonniniid ammonites, belemnites, common 'myid' bivalves, *Gervillia*, terebratulid brachiopods	0.4
4a: Marl, grey and brown	0.025
4b: Limestone, hard, grey	*c*. 0.15
5: Marl, brown	0.05
6: Limestone	0.15
7: Marl, brown, sandy; terebratulid brachiopods	0.05
Ammonite Bed	
8: Limestone crowded with ammonites including *Graphoceras*; bivalves; terebratulid brachiopods	0.6
Conglomerate Bed	
9: Limestone, bluish-grey-hearted, 'iron-shot'; numerous large limonite-coated and bored pebbles; bivalves (*Pseudolimea*, pectinaceans); corals (*Montlivaltia*)	0.55
Lias Group	
Bridport Sand Formation	
10: Sandstone	0.18
11: Sandstone with sand partings	seen

Richardson (1916a) gave no thickness for the 'Pecten Bed' (Bed 3) but in the nearby Lusty and Sunny Hill quarries, he recorded 1.75 m and 1.47 m respectively. In the quarry, now occupied by houses, adjoining the railway cutting, he reported that Bed 9 (the 'Conglomerate Bed') was the lowest stratum seen; its irregular upper surface made a marked, seemingly very level, feature at the western end of the quarry. He also reported a layer of oysters between the 'Pecten Bed' and overlying Hadspen Stone, describing the latter, overlain by the better-bedded Doulting Stone, as 'curiously rubbly'.

Interpretation

Bristow *et al*. (1999) considered that the so-called 'Cole Syncline' (Richardson, 1916a), in which a relatively complete Inferior Oolite Formation is preserved, is probably a shallow, east-trending graben or half-graben. It interrupts a general progressive northward overstep of the Aalenian and Lower Bajocian strata by Upper Bajocian sediments between the Sherborne area (see Figure 2.29) and the Mendip Hills.

Richardson's (1916a) original description of the section was classified according to Buckman's scheme of 'hemerae' (see Chapter 1), but the ammonite identifications and consequent zonal interpretation have since been revised by Parsons (1979, 1980a). As in the Sherborne area (e.g. see **Bradford Abbas Railway Cutting** GCR site report, this volume), the succession is interrupted by major non-sequences. The oldest Aalenian stratum, which is separated from the Lower Jurassic Bridport Sand Formation by a non-sequence, is the conglomeratic Bed 9, which has yielded ammonites of the Murchisonae Zone (Parsons 1979, 1980a). The younger Bradfordensis Zone is unrepresented but the succeeding 'Ammonite Bed' (Bed 8) has yielded ammonites of both the Concavum and Discites zones, and therefore straddles the Aalenian–Bajocian stage boundary. Morton and Chandler (1994) recognized ammonite biohorizons Aa-15 (*Graphoceras formosum*), Aa-16 (*Euhoploceras acanthodes*), Bj-1 (*Hyperlioceras politum*) and Bj-2b (*Hyperlioceras rudidiscites*) within this interval. The succeeding Ovalis, Laeviuscula and Sauzei zones are represented in the overlying limestones and marls, and 'Pecten Bed'. Ammonites from the limestones and marls (beds 4–7) include species of *Fissilobiceras*, '*Sonninia*' and *Witchellia*, and those from the 'Pecten Bed' (Bed 3) include species of *Emileia*, *Euhoploceras*, *Lissoceras*, *Mollistephanus*, *Shirbuirnia* and *Witchellia*. As current research on the ammonite faunas of these Aalenian–Bajocian successions in Dorset–Somerset progresses, there will no doubt be amendments to the ammonite taxonomy and further recognition and refinement of Callomon and Chandler's (1990) ammonite biohorizons (see Chapter 1).

Although Parsons (1980a) identified a representative of the Humphriesianum Zone at the nearby Lusty Quarry (Richardson, 1916a), no evidence of this zone nor the succeeding Subfurcatum Zone has been reported at the GCR site and it seems probable that there is a substantial non-sequence at the Lower–Upper Bajocian boundary as elsewhere in this region. It is not clear on what evidence Parsons (1980a) zoned the Upper Bajocian Hadspen Stone and Doulting Stone unless by analogy with **Doulting**

Railway Cutting (see GCR site report, this volume) and/or unpublished records, but both the Garantiana Zone and the overlying Parkinsoni Zone were reported. Although both are building stones, the Hadspen Stone differs from the Doulting Stone (see **Doulting Railway Cutting** GCR site report, this volume) in being ferruginous and highly fossiliferous.

Conclusions

The Godminster Lane Quarry and Railway Cutting provide exposures of Aalenian–Bajocian strata that are fortuitously preserved in the geological structure traditionally known as the 'Cole Syncline' but which is more correctly described as a graben or half-graben. Generally, north of the Sherborne area, the Aalenian and Lower Bajocian successions are progressively cut out by the Upper Bajocian succession, which oversteps them towards the Mendip Hills, but in the Cole Syncline these older beds are still preserved. Northwards, the Lower and Middle Bajocian substages are not seen again until the Cotswolds and Dundry Hill (see Chapter 3). Although interrupted by substantial non-sequences, the section shows an ammonitiferous succession across the Aalenian–Bajocian stage boundary, and several of the ammonite biohorizons, crucial for documenting this boundary and enabling international correlation, have been recognized.

BRUTON RAILWAY CUTTING, SOMERSET (ST 688 347)

B.M. Cox

Introduction

The cutting adjoining the railway station at Bruton, Somerset, exposes the Fuller's Earth Rock Member of the Fuller's Earth Formation. The Milborne Beds, Ornithella Beds and Rugitela Beds, into which the Fuller's Earth Rock Member is divided in Somerset (see Figure 2.4), are all present (Figure 2.43). Bruton Railway Cutting is famous for its ammonite fauna of tulitids, perisphinctids and rare oppeliids. The

Figure 2.43 Exposure of the Fuller's Earth Rock Member behind the westbound platform at Bruton Railway Station in Bruton Railway Cutting. Marls and muddy limestones of the Rugitela Beds overlie limestones and marls of the Ornithella Beds; the hammer-head marks the boundary. (Photo: British Geological Survey, No. A15537; reproduced with the permission of the Director, British Geological Survey, © NERC, 1996.)

tulitid genera *Tulites* and *Morrisiceras* are, respectively, diagnostic of the Middle Bathonian Subcontractus and Morrisi zones (see also **Troll Quarry** GCR site report, this volume). When Torrens (1974) proposed the south side of the cutting at Bruton Railway Station as the type section of the Morrisi Zone (Torrens, 1965), the zonal fauna was known in detail only from southern England. He considered Bruton Railway Cutting to be an ideal type section because of its richness in ammonites and its probable permanence (the cutting lies on the line between Westbury and Taunton). The abrupt changes in the succession of ammonite faunas here enable the lower and upper boundaries of the Morrisi Zone to be placed precisely. As elsewhere along its outcrop in southern England, the zone is only 0.6 m thick, but there is no evidence of any major non-sequence at the top of the zone in this region (Torrens, 1974).

Description

The Bruton Railway Cutting GCR site includes both sides of the now partly overgrown cutting at Bruton Railway Station, but it is the longer section on the south side that was recorded by Torrens (1974) and proposed as the type section of the Morrisi Zone. The following section is based on his account together with that given in Torrens (1966). Bed numbers follow Torrens (1974). The presence of the Fuller's Earth Rock Member in the cutting had been noted earlier by Davidson (1878), Parsons (1879) and Richardson (1909c). Most recently, the section has been described briefly by Bristow *et al.* (1999).

	Thickness (m)
Fuller's Earth Formation	
Fuller's Earth Rock Member	
Rugitela Beds	
6: Marls and limestone; *Catinula knorri* (Voltz) common at base	0.23
Ornithella Beds	
5: Alternating thin marls and limestones; ammonites including *Procerites* (common 0.45 m above base) and *Oxycerites*; brachiopods including *Ornithella bathonica* (Rollier) (very abundant between 0.45 m and 1.35 m above base), *Rhynchonelloidella* and *Wattonithyris*; bivalves including *Anisocardia fullonica* Cox, *Inoperna plicata* J. Sowerby, *Limatula cerealis* Arkell, *Modiolus anatinus* (Wm Smith), *Pleuromya alduini* (Brongniart), *Pseudolimea duplicata* (J. de C. Sowerby); echinoids including *Holectypus*	*c.* 3.0
Milborne Beds	
4: Limestone, shelly; ammonites including *Morrisiceras morrisi* (Oppel), *M. sphaera* (S.S. Buckman) and oppeliids; bivalves (*Pleuromya subelongata* (d'Orbigny)); gastropods (*Pleurotomaria*)	0.23
3: Limestone, marly, softer than Bed 4; microconch and macroconch *Morrisiceras*; *Wattonithyris*; *Gresslya peregrina* (Phillips) and *Pleuromya subelongata*	0.10
2: Limestone, rubbly; *Morrisiceras*, *Rhynchonelloidella*, *Wattonithyris*, *Catinula* and *Gresslya peregrina*	0.30
1: Limestone, rubbly; *Tulites modiolaris* (Wm Smith) common; *Gresslya peregrina* and *Modiolus anatinus*	seen to 0.30

Interpretation

The tripartite division of the Fuller's Earth Rock Member in Somerset has already been discussed (see **Shepton Montague** GCR site report, this volume). Shepton Montague is sited *c.* 2.5 km south of Bruton Railway Cutting.

At both sections, the ammonite fauna enables recognition of three of the standard ammonite-based zones of the Bathonian Stage (Torrens, 1974, 1980b; Page, 1996a). At Bruton Railway Cutting, the presence of *Tulites* in the basal bed identifies the Subcontractus Zone. The base of the overlying Morrisi Zone is taken at the base of Bed 2. This zone is characterized by the genus *Morrisiceras*, the range of which does not overlap with that of *Tulites*. Page (1996a) referred the *Morrisiceras* from beds 3 and 4 at Bruton Railway Cutting to *M.* ex gr. *morrisi*, in which he included *M. sphaera*. Both *Tulites* and *Morrisiceras* are tulitids, the most typical and common forms of which are the cadicone–sphaerocone macroconchs. The corresponding microconchs are quite different, being small, lappetted, planulate serpenticones (Donovan *et al.*, 1981). For these 'partners' of *Tulites* and *Morrisiceras*, Torrens (1970) introduced, respectively, the names *Trolliceras* (see **Troll Quarry** GCR site report, this volume) and *Holzbergia*. Although Torrens (1974) proposed the site as type section for the Morrisi Zone, Page (1996a) referred to it as a reference section, the type area being south-west Germany.

The base of the next highest zone is taken at the base of Bed 5. When Torrens (1974) first published a description of the section, he assigned beds 5 and 6 to a 'Retrocostatum' Zone, which was tentatively based on the index taxon *Probecticoceras retrocostatum* (de Grossouvre).

He considered that this zone generally seemed to be characterized more by the absence of certain genera and species of the zones above and below than by its own characteristic assemblage. Nevertheless, he reported that in southern England the basal part of the zone was crowded with large perisphinctids (notably *Procerites*) such as occur in the rubbly limestone facies of the Ornithella Beds of the Fuller's Earth Rock Member. Such a fauna is relatively common in Bed 5 at Bruton Railway Cutting (see also **Shepton Montague** GCR site report, this volume). The naming of this zonal interval has since undergone two changes. First, Torrens (1980b) replaced the index taxon by *Procerites hodsoni* Arkell mainly because, in France, *Prohecticoceras retrocostatum* was used as an index taxon of a zone of partly different age, and because the species was less common in its eponymous zone than in the overlying zone. Torrens (1980b) listed a number of reasons why *Procerites hodsoni* was a suitable replacement index species not least of which was the fact that it seemed to be a distinctly recognizable 'proceritid' in a group that often shows morphological diversity at any one level as great as it is in successive beds. The Hodsoni Zone thus became well established in the British Bathonian succession. Secondly, recognition by Callomon and Cope (1995) of subzones in common with those of the slightly different zonation used farther south in Europe (Figure 2.44) prompted Page (1996a) to extend the usage of the latter zonation to the British succession. Thus, the interval covered by the Bullatimorphus and Fortecostatum subzones of the Hodsoni Zone (Callomon and Cope, 1995) can be referred instead to the Bremeri Zone (Page, 1996a). By analogy with the ammonite records from the Bullatimorphus Subzone in

Zonation traditionally used in Britain and other areas of North West Europe (the 'Subboreal Province') with more recently recognized subzones[1]			Zonation used further south in Europe (the 'Submediterranean Province') but also, herein, for Britain[2]		
Sub-stage	Zone	Subzone	Subzone	Zone	Sub-stage
Upper Bathonian	Discus	Discus	Discus	Discus	Upper Bathonian
		Hollandi	Hollandi		
	Orbis[3]		Hannoveranus	Retrocostatum	
			Blanazense		
	Hodsoni[4]	Quercinus	Quercinus		
		Fortecostatum	Fortecostatum	Bremeri	Middle Bathonian
		Bullatimorphus	Bullatimorphus		
Middle Bathonian	Morrisi	—	—	Morrisi	
	Subcontractus	—	—	Subcontractus	
	Progracilis	—	Progracilis	Progracilis	
			Orbignyi		

Figure 2.44 Comparison of the zonation of the Middle–Upper Bathonian used herein with that previously used in Britain. (Modified from Page, 1996a.) ([1] = Follows Torrens (1980b) emend.; Dietl and Callomon (1988); and Callomon and Cope (1995); Dietl and Callomon (1988) also divided the Orbis Zone into Blanazense and Hannoveranus subzones in the Subboreal Province of Germany; [2] = Follows Mangold (1991); and Mangold and Rioult (1997) but, following Page (1996a), the *Procerites quercinus* Biohorizon, at the base of the Blazanense Subzone, is elevated to a full Subzone; [3] = Aspidoides Zone of Torrens (1965, 1974, 1980b); [4] = 'Retrocostatum' Zone of Torrens (1974).)

France and despite the lack of the subzonal index species, Page (1996a) concluded that the common *Procerites* and rare *Oxycerites* found 0.45 m above the base of Bed 5 at Bruton Railway Cutting could be accommodated in that subzone.

Conclusions

The Fuller's Earth Rock Member in Dorset and Somerset shows one of the best developments of Middle Bathonian rocks in Europe (see also **Troll Quarry** GCR site report, this volume). The section at Bruton Railway Cutting, where the upper part of the Milborne Beds has yielded the ammonite *Morrisiceras*, provides a primary reference – if not the type – section for the Morrisi Zone. The lower and upper boundaries of the zone, which is here only 0.6 m thick, are well constrained because of marked and abrupt changes in the ammonite succession; these make this the best section in England for demonstrating the palaeontological differentiation of the Subcontractus and Morrisi zones. The site is thus a most important one for regional, national and international correlation.

DOULTING RAILWAY CUTTING, SOMERSET (ST 645 424–ST 652 424)

B.M. Cox

Introduction

Doulting Railway Cutting, near Shepton Mallet, Somerset, exposes both Bajocian and Bathonian strata (Figure 2.45), and features in both the Aalenian–Bajocian and Bathonian GCR blocks. The strata comprise the Doulting Conglomerate, Garantiana Beds, Doulting Stone and Anabacia Limestone, overlain by the Fullonicus Limestone and Knorri Beds of the Fuller's Earth Formation (see Figures 2.3 and 2.4). The Bajocian–Bathonian stage boundary lies within the Anabacia Limestone. The cutting is the type section for the Fullonicus Limestone (named by Torrens (1980b) after a species of ammonite; Figure 2.46C) which is here the basal unit of the Lower Fuller's Earth Member, Fuller's Earth Formation and Great Oolite Group. The cutting also lies within the type area of the Doulting Conglomerate, Doulting Stone, Anabacia Limestone (named by Richardson (1907a) after a genus of button coral (now *Chomatoseris*); Figure 2.46A) and Knorri Beds (named by Richardson (1916a) after a species of small oyster; Figure 2.46B). The Anabacia Limestone and Fullonicus Limestone have yielded ammonite faunas indicative of the Lower Bathonian Zigzag Zone and its component subzones. The underlying part of the Inferior Oolite Formation has yielded Upper Bajocian ammonite faunas. As elsewhere in the Mendips area (see **Vallis Vale** GCR site report, this volume), the Aalenian and Lower Bajocian successions are missing; the Doulting Conglomerate unconformably overlies the Lower Jurassic (Toarcian) Lias Group.

Description

The section was described by Richardson (1907a) and Torrens (in Donovan (1969)) on which the following details are largely based (Figure 2.45). The lithostratigraphical classification has been amended following Parsons (1975a, 1980a) and Bristow *et al.* (1999) such that the lower part of the Doulting Stone as recognized by Richardson (1907a) and Torrens in Donovan (1969) (Bed 1a herein) is reclassified as Garantiana Beds (= Ragstone of Parsons, 1975a; Ragstones of Parsons, 1980a). The strata dip gently eastwards such that the stratigraphically lowest are exposed in the western part of the cutting, which totals *c.* 730 m in length. Exposure is presently patchy owing to vegetation cover.

	Thickness (m)
Great Oolite Group	
Fuller's Earth Formation	
Lower Fuller's Earth Member	
Knorri Beds	
4: Clay, brown-yellow; brachiopods including *Acanthothiris doultingensis* Richardson and Walker and *Wattonithyris midfordensis* Muir-Wood; *Catinula knorri* (Voltz); gradational base	0.60–0.75
Fullonicus Limestone	
3i: Cementstone, white, argillaceous; abundant *Procerites fullonicus* (S.S. Buckman)	
3h: Marl, brown; common *Pholadomya lirata* (J. Sowerby)	
3g: Cementstone, white, argillaceous; occasional *C. knorri*	
3f: Marl, brown; occasional *C. knorri*	
3e: Cementstone, white, argillaceous	
3d: Marl, brown; occasional *C. knorri*	
3c: Cementstone, white, argillaceous; *Procerites* sp.	
3b: Marl, brown; *Pholadomya lirata* and *Procerites* sp.	total 0.90

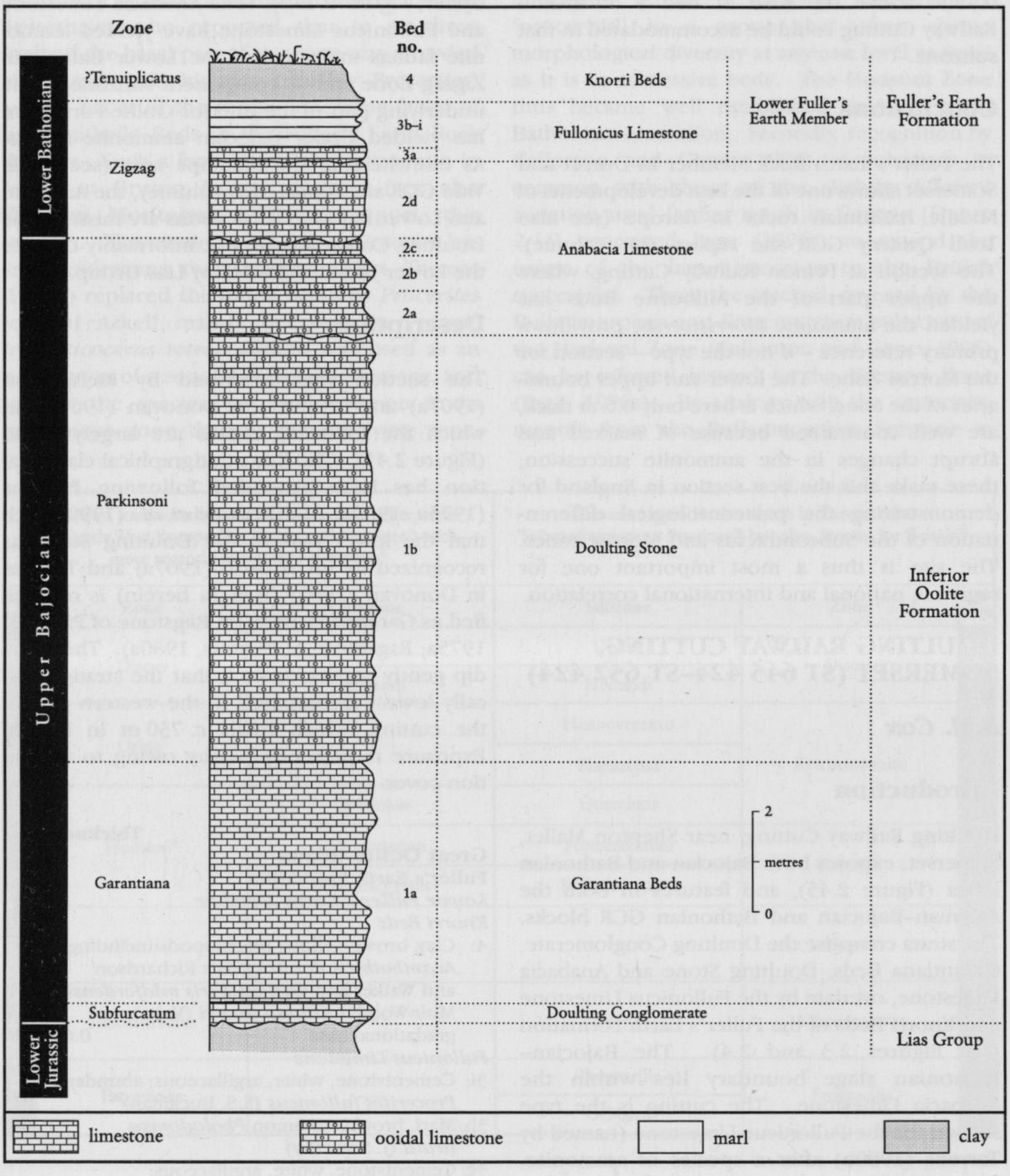

Figure 2.45 Graphic section of the Middle Jurassic succession at Doulting Railway Cutting. For lithologies, see text. Not all non-sequences shown.

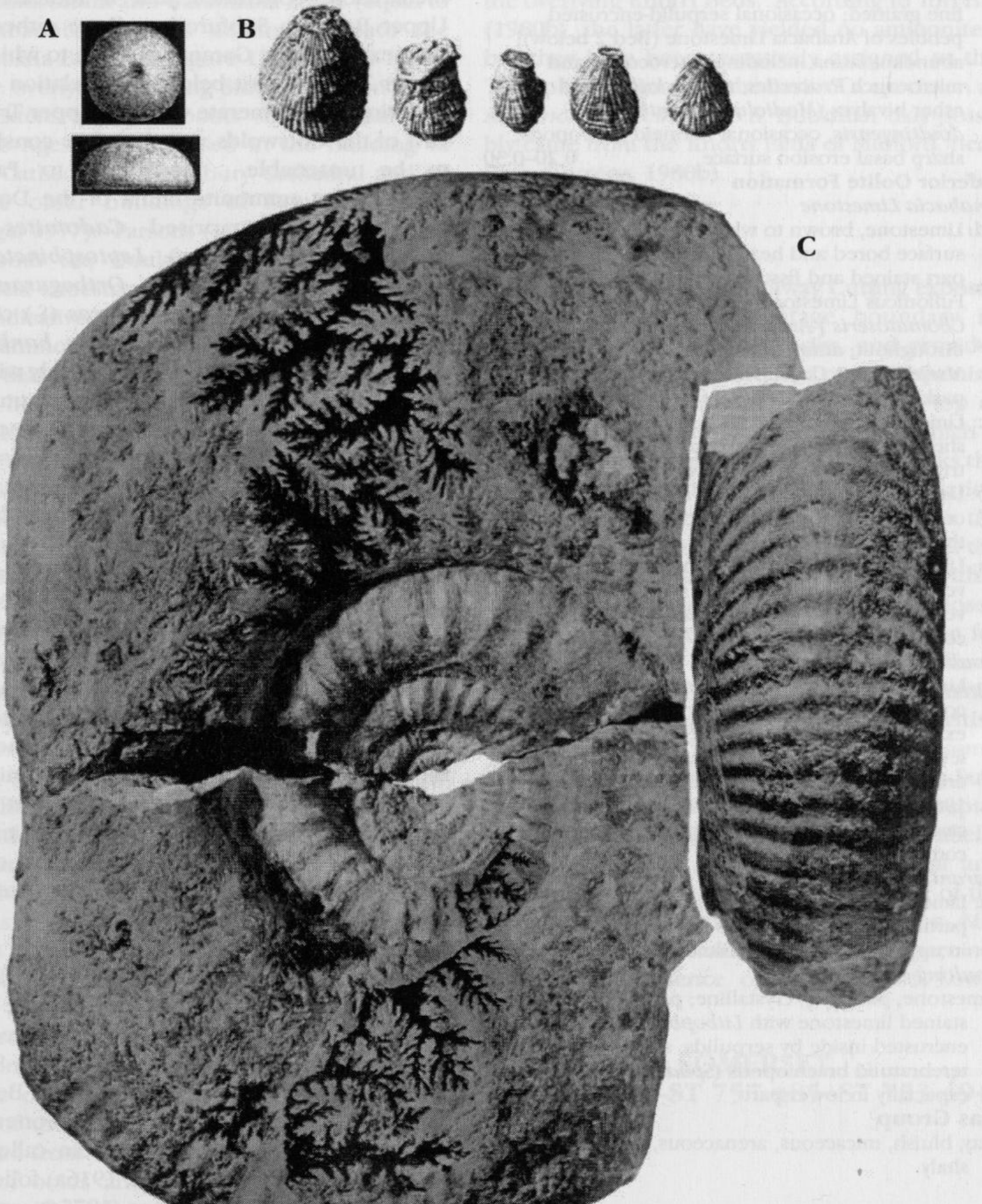

Figure 2.46 (A) *Chomatoseris* [*'Anabacia'*] *porpites* (Wm Smith) (reproduced from Milne Edwards and Haime, 1851, pl. 25, figs 3,3a; courtesy of the Palaeontographical Society); (B) *Catinula knorri* (Voltz) from quarries at Doulting (reproduced from Arkell, 1934, pl. 2, figs 8–12; courtesy of the Cotteswold Naturalists' Field Club); (C) holotype of *Procerites fullonicus* (S.S. Buckman) from Combe Hay near Bath (reproduced from Arkell, 1958a, pl. 24, figs 1a,b; courtesy of the Palaeontographical Society). All specimens are shown at *c.* 90% of natural size.

	Thickness (m)
3a: Limestone, yellow, iron-stained, rubbly, fine grained; occasional serpulid-encrusted pebbles of Anabacia Limestone (Bed 2 below); abundant fauna including macroconch and microconch *Procerites*, rare *C. knorri* and other bivalves (*Modiolus*), *Acanthothiris doultingensis*, occasional nerineid gastropods; sharp basal erosion surface	0.20–0.30
Inferior Oolite Formation	
Anabacia Limestone	
2d: Limestone, brown to white, rubbly, ooidal; top surface bored and heavily iron-stained; upper part stained and fissured with material from Fullonicus Limestone (Bed 3 above); *Chomatoseris* ['*Anabacia*'] *porpites* (Wm Smith) throughout; ammonites in top 0.30 m including *Morphoceras*, *Oxycerites* and *Zigzagiceras*; parkinsoniin ammonites below	1.60
2c: Limestone, white or brown, ooidal; full of shell casts including *Chomatoseris porpites*, trigoniid bivalves and *Parkinsonia*	0.15–0.30
2b: Limestone, brown to white, rubbly, densely ooidal; top surface deeply bored with long, thin, vertical borings	0.60–0.70
2a: Limestone, brown-white, densely ooidal, vertically jointed; bored top surface; upper part very fossiliferous; *Chomatoseris porpites* common throughout	0.90
Doulting Stone	
1b: Limestone, massive, false-bedded; top surface covered with oysters in growth position and extensive *Lithophaga* borings; ooidal in topmost few centimetres; shell-fragmental below with crinoids (sparry crinoidal limestone of Cain, 1968); bored horizons and shell beds rich in casts of trigoniid and other bivalves, and less common gastropods	8.60
Garantiana Beds	
1a: Limestone, less massive than 1b, with marly partings; pectinid bivalves (*Entolium*) abundant in upper part; large nautiloid	4.80
Doulting Conglomerate	
Limestone, pale-grey, crystalline; pebbles of yellow-stained limestone with *Lithophaga* borings encrusted inside by serpulids; abundant terebratulid brachiopods (*Sphaeroidothyris*) especially in lower part	0.40
Lias Group	
Clay, bluish, micaceous, arenaceous, shaly	seen to 0.60

Interpretation

When Richardson (1907a) first described the section, he referred to the conglomeratic bed at the base of the Inferior Oolite Formation as the 'Upper Trigonia Grit', believing that it was the same as the well-known bed of that name in the Cotswolds (see Chapter 3). Richardson (1916a) maintained this correlation but Parsons' (1975a) subsequent reassessment of the ammonite fauna, including specimens not seen by Richardson, concluded that it indicated the Upper Bajocian Subfurcatum Zone rather than the next youngest Garantiana Zone to which the Upper Trigonia Grit belongs; correlation of the Doulting Conglomerate with the Upper Trigonia Grit of the Cotswolds was therefore considered to be untenable. According to Parsons (1975a), the ammonite fauna of the Doulting Conglomerate comprised *Cadomites deslongchampsi* (d'Orbigny), *Leptosphinctes* aff. *davidsoni* (S.S. Buckman), *Orthogarantiana* sp., *Stephanoceras* sp., *Strenoceras* (*S.*) cf. *subfurcatum* (Zieten) and *Teloceras banksi* (J. Sowerby), and could be reconciled only with the Banksi Subzone of the basal Subfurcatum Zone in which the co-occurrence of stephanoceratid and perisphinctid ammonites is typical. The Banksi Subzone is generally accepted as marking the base of the Upper Bajocian Substage (Callomon and Chandler, 1990; see Figure 1.3, Chapter 1). In Richardson's defence, Parsons (1975a) reported that there was little reason to doubt Richardson's (1907a, 1916a) assessment of the ammonites as belonging to the Garantiana Zone on the basis of the specimens available to him at that time, if one assumed that a specimen of *Stephanoceras* was reworked. The fact that the ammonite fauna of the Upper Trigonia Grit in the Cotswolds indicates the upper part of the Garantiana Zone (Acris Subzone) implies that the Late Bajocian transgression north of the Mendips occurred at a slightly later date than south of the Mendips (Parsons, 1975a).

Above the Doulting Conglomerate and representing the Garantiana Zone, Parsons (1975a, 1980a) separated a unit of less massive limestones with marl partings (Bed 1a of section) from the base of the overlying Doulting Stone. Referred to as the 'Ragstone' or 'Rag Bed' by Parsons (1975a) and the 'Ragstones' by Parsons (1980a), this unit is herein called the 'Garantiana Beds' (Richardson, 1916a) following Bristow *et al.* (1999). Parsons (1975a) reported an ammonite fauna of *Prorsisphinctes* sp. and *Spiroceras* sp. in the Doulting area and deduced these to be forms of the upper part of the Garantiana Zone because of the close similarity of *P.* ('*Glyphosphinctes*') *glyphus* (S.S. Buckman), of which the Ragstone is the alleged type horizon (Buckman, 1925), and *P.* ('*Stomphosphinctes*') *stomphus* (S.S. Buckman), which is known to characterize the upper Garantiana Zone elsewhere (see **Burton Cliff and Cliff Hill Road**

Section GCR site report, this volume). Much of the Subfurcatum and Garantiana zones (equal to six subzones) is thus missing beneath the Garantiana Beds (see Figure 1.3, Chapter 1).

The overlying Doulting Stone has been quarried extensively hereabouts since at least the Middle Ages and was used in the building of Wells Cathedral, Glastonbury Cathedral and all of the older buildings of Doulting village (Savage, 1977). Parsons (1975a, 1980a) implied that both the Doulting Stone and overlying Anabacia Limestone had yielded ammonite faunas indicative of the Parkinsoni Zone but the only ammonites specifically mentioned were those that Torrens (in Donovan, 1969) reported from his beds 2c and 2d of the Anabacia Limestone where the macroconch/microconch pair *Parkinsonia convergens* (S.S. Buckman) and *P. pachypleura* (S.S. Buckman) in the lower part of Bed 2d indicate already the basal Lower Bathonian Zigzag Zone, Convergens Subzone (Torrens, 1974; Page, 1996a). The ammonite fauna in the highest part of Bed 2d, including *Bigotites* sp., *Morphoceras* sp. (including '*Ebrayiceras*' cf. *jactatum* S.S. Buckman), *Oxycerites yeovilensis* Rollier and *Zigzagiceras plenum* Arkell, indicates the next youngest Macrescens Subzone (Torrens in Donovan, 1969; Page, 1996a). The Bajocian–Bathonian stage boundary is arbitrarily taken at the base of Bed 2d. Richardson (1907a) had used the term 'Anabacia Limestone' in a more restricted sense than herein, preferring to recognize the upper part as a separate unit that he called the 'Rubbly Beds'. However, Torrens (1980b) proposed that this term should be abandoned because the beds were not lithologically distinct from Richardson's Anabacia Limestone and they also contained the latter's characteristic button coral.

The overlying Fullonicus Limestone, at the base of the Fuller's Earth Formation, is distinguished from the Anabacia Limestone by a total lack of ooids and a micritic matrix (Torrens, 1980b). The erosive nature of its basal boundary is indicated by pebbles of the Inferior Oolite Formation in its basal bed. Its perisphinctid ammonite fauna of macroconch and microconch variants of *Procerites fullonicus* (S.S. Buckman) (the latter referred to as '*Siemiradzkia*') is one of the two main ammonite faunas recognized in the Yeovilensis Subzone, the youngest of the three subzones of the Zigzag Zone in Britain (Torrens, 1974; Page, 1996a). This *fullonicus* fauna is associated with the small oyster *Catinula knorri*, which occurs in abundance in the overlying Knorri Beds. According to Torrens (1980b), the latter have yielded no ammonites, but they have been tentatively assigned to the Tenuiplicatus Zone on the basis of a specimen of *Asphinctites recinctus* S.S. Buckman that possibly came from the Knorri Beds of Midford, near Bath (Torrens, 1980b).

Conclusions

The section at Doulting Railway Cutting exposes the Bajocian–Bathonian stage boundary in ammonitiferous limestone facies, and provides one of the most important Lower Bathonian exposures in southern England. At the top of the Anabacia Limestone, a hardground, which is probably correlatable over wide areas, marks the boundary between the Inferior Oolite Formation and the Great Oolite Group. The cutting is the type locality for the Fullonicus Limestone, at the base of the Great Oolite Group, and lies within the type area of several of the other exposed stratal units. It is thus an important section for local and regional lithostratigraphy. The fauna that it has yielded, including ammonites characteristic of the oldest documented British Bathonian ammonite assemblage (*Parkinsonia convergens* Biohorizon of the Convergens Subzone and Zigzag Zone; see Figure 1.4, Chapter 1), enables correlation with areas further afield, and thus endows the site with national and international significance. The influence of the Mendip Axis on sedimentation in the Mid Jurassic Epoch is clearly demonstrated here not least by the absence of Aalenian and Lower Bajocian strata.

VALLIS VALE, SOMERSET (ST 760 495–ST 757 485–ST 753 494)

B.M. Cox

Introduction

The sections at the GCR site known as 'Vallis Vale' near Frome, Somerset, expose the major angular unconformity between Jurassic and Carboniferous strata, which is a famous feature of the eastern Mendip Hills. According to Prosser and King (1999), they constitute 'one of the most historically important unconformity sites in the SSSI coverage'. Eroded by the Mells and Egford streams that join the River Frome just north of Frome, Vallis Vale is steep-sided and about 30 m deep (Macfadyen, 1970). Triassic (Rhaetian) and Lower Jurassic (Lias Group) strata are seen in places to overlie Lower Carboniferous (Dinantian) limestones that have been extensively quarried in the past. The older Mesozoic sediments are overlain, and in places overstepped, by Middle Jurassic (Upper Bajocian) strata that come to rest on the Carboniferous Limestone. This major unconformity of Upper Bajocian strata on Carboniferous strata has been famous since the early days of geology (e.g. Conybeare and Phillips, 1822) and was illustrated by De la Beche (1846) in the first [British] Geological Survey memoir (Figure 2.47), as well as by later authors including Richardson (1907a) and Arkell (1933).

Description

The Middle Jurassic succession has been reported at a number of localities within the GCR site, which extends for over a kilometre in a crude Y-shape from Bedlam in the north-west to Hapsford in the north-east, and towards Egford in the south. The Jurassic beds dip very gently north-eastwards; those of the Carboniferous dip north-westwards at about 30° (Savage, 1977). The following section, including bed numbers, is based on that recorded by Richardson (1907a). It was measured on the central spur of high ground that runs southwards between Bedlam and Hapsford, and which forms the western side of Vallis Vale proper.

	Thickness (m)
Inferior Oolite Formation	
1: Limestone, ooidal, thinly bedded or flaggy	2.75
2: Limestone	0.35
3: Rubble	0–0.05
4: Limestone, massive	0.53
5: Rubble	0–0.05
6: Limestone, massive	0.40
7: Rubble	0.05–0.10
8: Limestone, massive, rubbly at top and base, coarsely ooidal	0.75
9: Clay	0–0.05
10: Limestone, massive, relatively hard and forming prominent rib; chert fragments; *Ctenostreon pectiniforme* (Schlotheim) very common; *Trichites* fragments; pentacrinoid columnals; serpulids; rhynchonellid brachiopods	0.48
11: Limestone with irregular clay partings forming three tiers; top tier bored and with encrusting oysters; brachiopods including *Acanthothiris spinosa* (Schlotheim) (common) and *Stiphrothyris tumida* (Davidson); echinoids including *Acrosalenia*, '*Cidaris*', *Clypeus*,	

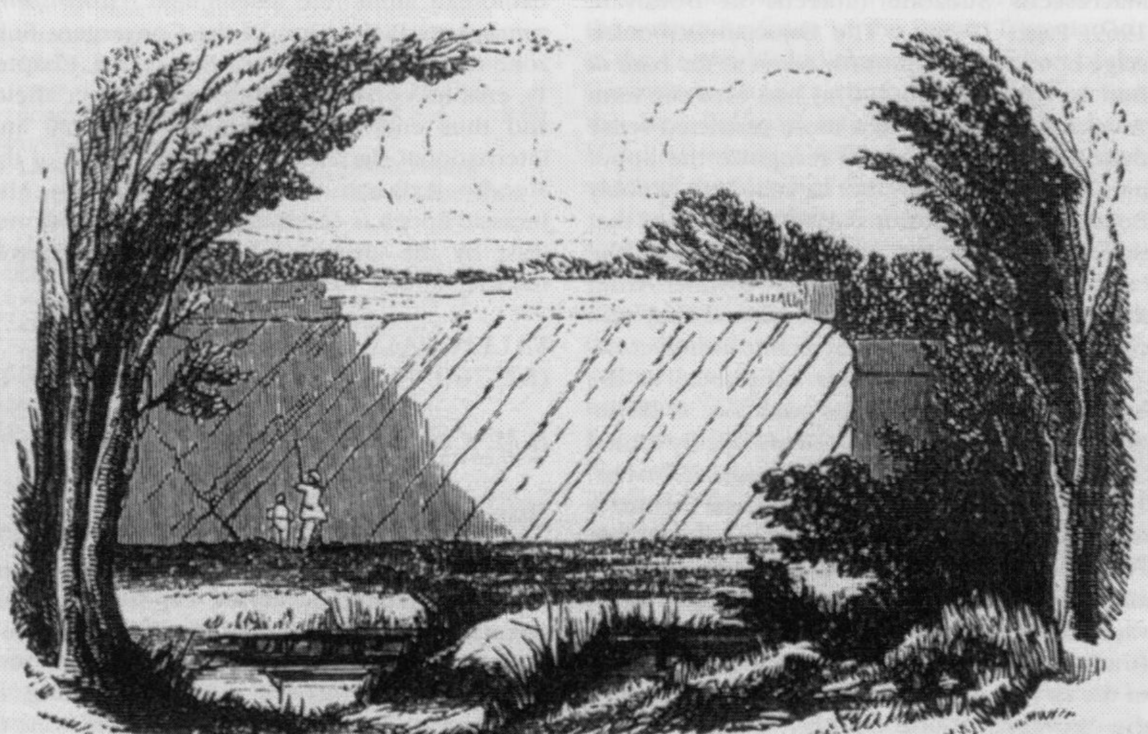

Figure 2.47 The unconformity between the Inferior Oolite Formation and the Carboniferous Limestone at Vallis Vale as illustrated by De la Beche (1846).

	Thickness (m)
11 (cont.): *Holectypus* and *Trochotoma*; bivalves including *Pholadomya murchisoni* (J. Sowerby)	0.75
12: Marl, brown, earthy	0.03–0.08
13: Limestone, yellowish, massive; poorly fossiliferous with rare bivalves (including *Pseudolimea*); brachiopods (including *Acanthothiris*); echinoids (including *Clypeus* and *Pseudodiadema*)	1.20
Vallis Limestone Formation (Carboniferous)	
14: Limestone, highly inclined, with evenly planed, bored and oyster-encrusted surface	

Interpretation

The Carboniferous Limestone exposed beneath the Middle Jurassic strata in the northern part of the site (as represented by the above section) is assigned to the Vallis Limestone Formation (Clifton Down Group) but in the south, the older Black Rock Limestone Formation (Black Rock Group) is present (Savage, 1977). According to Macfadyen (1970), these formations range from Zone Z2 up to Zone S1 of Reynolds and Vaughan (1911) and span the Courceyan, Chadian and Arundian stages of George *et al.* (1976; Green, 1992; Kellaway and Welch, 1993). Further information on the Lower Carboniferous geology at Vallis Vale may be found in Busby (1925), Welch (1933), Kellaway and Welch (1955), Butler (1973) and the companion GCR volume on British Lower Carboniferous stratigraphy (Cossey *et al.*, in prep.).

The eroded upper surface of the Carboniferous beds is remarkably flat and even, and is a product of a marine transgression in Late Bajocian times – an event that is recognized widely in southern and eastern England (see Chapter 3). Bradshaw and Cripps (1992) suggested that the sea-level rise and consequent transgression may have been initially matched or even exceeded in parts of the British area by epeirogenic upwarp. The Mendip area is the site of a well-known E–W-trending Palaeozoic structure (the Mendip ridge or 'axis' comprising at least four anticlinal folds arranged en echelon), which formed a 'high' or 'swell' in the Mesozoic Era (Welch, 1933; Green, 1992). In the eastern Mendip Hills, the unconformity surface is oyster-encrusted and conspicuously bored by organisms that colonized the rocky floor of the Late Bajocian (Inferior Oolite Formation) sea. The preserved fauna of this so-called 'rockground' is dominated by cemented and boring fixo-sessile benthos adapted to a high-energy environment (Bromley, 1975; Cole and Palmer, 1999). According to these authors, the fauna can be classified, according to their mode of life, into encrusters, borers and nestlers. The dominant encruster is the oyster *Liostrea*. The borers are represented by the club-shaped ichnospecies *Gastrochaenolites*, in which the bivalve *Hiatella* is often found nestling, and the cylindrical worm boring *Trypanites*. Gastropods, remains of which are occasionally found in the latter, are thought to have adopted a nestling habit or possibly were accidental occupants having fallen into the borings. The preserved Bajocian fauna is thus an in-situ life assemblage of low species-diversity. Vagrant and less robust species would probably have inhabited the rocky sea-floor but they did not survive as fossils (Cole and Palmer, 1999).

Richardson (1907a) assigned the Bajocian strata here to the Doulting Beds, a unit comprising the Doulting Conglomerate, Garantiana Beds, Doulting Stone and Anabacia Limestone at **Doulting Railway Cutting** (see GCR site report, this volume), a little south of the Mendip Hills. Although some of these individual units have been recognized as far north as Midford (Parsons, 1980a), they cannot be adequately differentiated everywhere in the Mendips area. Recent work by the British Geological Survey in Wessex has favoured use of the term 'Inferior Oolite Formation' (e.g. Bristow *et al.*, 1999). The Inferior Oolite Formation in the area of the Mendip Hills is equivalent to only the uppermost part of the Inferior Oolite Formation (i.e. the Upper Inferior Oolite) of the Cotswolds, which is there called the 'Salperton Limestone Formation' (Barron *et al.*, 1997; see Chapter 3).

Conclusions

The sections in the Vallis Vale GCR site provide natural exposures of a major angular unconformity between Palaeozoic and Mesozoic rocks. At its maximum development, almost horizontal strata of Late Bajocian (Mid Jurassic) age overlie a planed and bored surface of more steeply dipping Dinantian (Early Carboniferous) strata. The unconformity represents a break of some 170 million years in Earth history. Known to the early writers on geology, the site has been widely reported in the literature for over 150 years and therefore has an important place in the history of geology as well as being of stratigraphical and palaeogeographical interest.

HINTON HILL, WELLOW, SOMERSET (ST 757 582)

B.M. Cox

Introduction

The roadside cutting on Hinton Hill between Hinton Charterhouse and Wellow, *c.* 6 km south of Bath, exposes the Combe Down Oolite and Twinhoe members of the Great Oolite Formation (see Figure 2.4). The Twinhoe Ironshot (Cox and Arkell, 1950; Green and Donovan, 1969), which constitutes the basal part of the Twinhoe Member, is the stratum of special interest. It is a distinctive 'iron-shot', pisoidal limestone, less than 2 m thick, which has yielded an abundant bivalve and brachiopod fauna, as well as zonally diagnostic Upper Bathonian ammonites. Restricted to the Bath area, the Twinhoe Ironshot is the only major source of ammonites from the Great Oolite Formation limestones of that region (Torrens, 1974, 1980b). The site is a replacement for Wellow (or Twinhoe) Quarry (ST 7400 5914) (Cox, 1941), which, as the type locality of the Twinhoe Ironshot, was originally selected as the representative GCR site but is now infilled and the land restored to agricultural use.

Description

At the time of its selection as a replacement for the GCR site at Wellow Quarry, the Hinton Hill road cutting (south side) was described as overgrown and wooded but with small exposures of the Combe Down Oolite Member overlain by at least 1.5 m of Twinhoe Ironshot (unpublished English Nature records, 1992). There was also some evidence of small-scale quarrying activity. It was anticipated that relatively little site clearance would also expose the overlying Freshford facies of the Twinhoe Member and therefore a complete Twinhoe Ironshot, the maximum known thickness of which is about 1.8 m. Arkell (1958b) had earlier figured an ammonite from the cutting, and Hawkins (1977) had reported that the Twinhoe Ironshot was possibly visible there in winter.

The Combe Down Oolite Member is predominantly a false-bedded, shell-fragmental oolite but it is very variable especially towards the base (Green and Donovan, 1969). When weathered, it is white. Bedding is often massive with individual beds up to *c.* 2.5 m thick. The total thickness in the Wellow area is *c.* 8 m (Green and Donovan, 1969). The Twinhoe Ironshot overlies it disconformably, and the upper surface is either planed and bored and/or oyster-covered, or irregular and hummocky with a ferruginous crust. By contrast, the Twinhoe Ironshot is rubbly with poorly defined bedding. According to Hawkins (1977), it is a biomicrite with ferruginized pisoids; these are rounded intraclasts of oomicrite and biomicrite with a layered, probably algal, coating. In hand specimen, the pisoids appear as shiny, dark-brown grains, 1–2 mm long, set in a cream-coloured matrix. Typical photomicrographs of thin sections of both the Twinhoe Ironshot and Combe Down Oolite Member were illustrated by Green and Donovan (1969).

The Twinhoe Ironshot is richly fossiliferous and the road cutting at Hinton Hill has yielded bivalves, brachiopods and ammonites (unpublished English Nature records, 1992). Green and Donovan (1969) did not think it necessary to distinguish between the different localities from which particular taxa in their extensive list of fossils from the Twinhoe Ironshot came, although they admitted some local variations in the abundance of different species. They reported species of corals (*Chomatoseris*, *Isastrea*, *Montlivaltia*, *Thamnasteria*), serpulids, brachiopods (*Acanthothiris*, *Avonothyris*, *Burmirhynchia*, *Kallirhynchia*, *Kutchirhynchia*?, *Kutchithyris*, *Obovothyris*, *Parvirhynchia*, *Ptyctothyris*?, *Rhynchonella*, *Rhynchonelloidella*, *Rugitela*, *Tubithyris*?, *Wattonithyris*), bivalves (*Camptonectes*, *Catinula*, *Chlamys*, *Cucullaea*, *Entolium*, *Gervillella*, *Gresslya*, *Homomya*, *Inoperna*, *Lithophaga*, *Lopha*, *Meleagrinella*, *Modiolus*, *Nanogyra*, *Osteomya*, *Pholadomya*, *Pinna*, *Pleuromya*, *Plagiostoma*, *Praeexogyra*, *Protocardia*, *Pseudolimea*, *Pseudotrapezium*, *Pteroperna*, *Rollierella*, *Thracia*, *Trigonia*), ammonites (oppeliids and perisphinctids – see 'Interpretation' below), belemnites (*Belemnopsis*) and echinoids (*Acrosalenia*, *Clypeus* or *Pygurus*, *Diplopodia*, *Holectypus*, *Nucleolites*, *Trochotiara*).

The overlying Freshford facies of the Twinhoe Member is a massive, cream-coloured, pisoidal, marly, shell-fragmental limestone but can vary both laterally and vertically from strongly pisoidal rock to marl (Green and Donovan, 1969). The pisoids are a pale-orange colour and are much paler than those of the Twinhoe Ironshot though of about the same size.

Interpretation

According to Green and Donovan (1969), deposition of the Combe Down Oolite Member took place on a flat or gently shelving area of Fuller's Earth Formation mud (Upper Fuller's Earth Member), and ended with a break in sedimentation and perhaps emergence, as indicated by its hardened and bored upper surface. The Great Oolite Formation, of which the Combe Down Oolite is the basal member, dies out suddenly a little farther to the south of Wellow, a fact that was first established by Lonsdale (1832) but the detail and implications of which have challenged geologists ever since. The Twinhoe Ironshot occurs only near this southern limit and is thus confined to the margin of an extensive area of carbonate shelf deposition. Green and Donovan (1969) concluded, on both lithological and faunal grounds, that the Twinhoe Member, of which the Twinhoe Ironshot is the basal part, was deposited in quieter and probably deeper waters than the Combe Down Oolite Member, and that the Twinhoe Ironshot was deposited in the deepest water. They compared the depositional environment of these members with those described by Kinsman (1964) for the Recent sediments of the Persian Gulf where oolite deltas, relating to a shallow marginal area rather than rivers, are flanked by tidal channels. The deltas lie between high-water mark and a depth of one fathom. Such an analogy compares closely with the views of Klein (1965) who concluded, on the basis of sedimentological studies, that the Combe Down Oolite Member was a limestone deposited by migrating channels on tidal flats. By contrast, the Twinhoe Ironshot closely resembles the character of beds deposited below three fathoms in the Persian Gulf (Kinsman, 1964). Penn and Wyatt (1979) similarly concluded that the ubiquitous occurrence of beds of Twinhoe Member facies between oolites to the north (Great Oolite Formation) and a clay–mudstone sequence (Frome Clay Formation) to the south is consistent with deposition in a zone where the seabed deepened from a very shallow shelf-sea subject to vigorous wave activity to an area of deeper, quieter water in which deposition of calcareous mud predominated. Using data from cored boreholes, Penn and Wyatt (1979) demonstrated the complexity of the interdigitation of facies as shown in Figure 2.48. According to these authors, the Twinhoe Ironshot correlates southwards with the higher of two interbedded limestone–mudstone units, rich in the brachiopod *Rhynchonelloidella smithi* (Davidson), that occur in the lower part of the Frome Clay Formation (Upper Smithi Limestone herein; see Figure 2.4).

The ammonite fauna of the Twinhoe Ironshot comprises the oppeliids *Oxycerites orbis* (Giebel) (common) (Figure 2.49) and *Paroecotraustes maubeugei* Stephanov, and the perisphinctid genus *Procerites* including *P. twinhoensis* Arkell (Arkell, 1951a, 1958b; Torrens, 1974; Page, 1996a). The specimen from Hinton Hill figured by Arkell (1958b) as *Procerites imitator* (S.S. Buckman) has been re-identified as a possible *Homoeoplanulites* by Page (1996a) who also recorded '*Paroecotraustes*' cf. *variabilis* Elmi from here. This famous and well-documented fauna has for many years been considered to be a classic assemblage of the Upper Bathonian Aspidoides Zone (Arkell,1951b; Torrens, 1974, 1980b), which was renamed the 'Orbis Zone' by Dietl (1982) following the discovery that *Oxycerites aspidoides* (Oppel), which gave its name to the Aspidoides Zone, is an ammonite of the Bajocian–Bathonian boundary beds. Torrens (1980b) described the Twinhoe Ironshot assemblage as the only ammonite fauna of that zone known in Britain. It belongs to the Blanazense Subzone, the older of two subzones recognized within the Orbis Zone elsewhere in the Subboreal Province by Dietl and Callomon (1988). These subzones can equally well be referred to the Retrocostatum Zone of the Submediterranean zonation (see Figure 2.44; Mangold and Rioult, 1997).

Conclusions

The roadside cutting at Hinton Hill exposes the Twinhoe Ironshot in its type area, which occupies a narrow belt at the southern limit of the carbonate sediments of the Great Oolite Formation. A little farther south, these sediments are replaced by a clay–mudstone succession (Frome Clay Formation). This southward disappearance of the famous oolites of the Bath area has fascinated and challenged geologists for many years. Not only is the Twinhoe Ironshot, with its ferruginized pisoids,

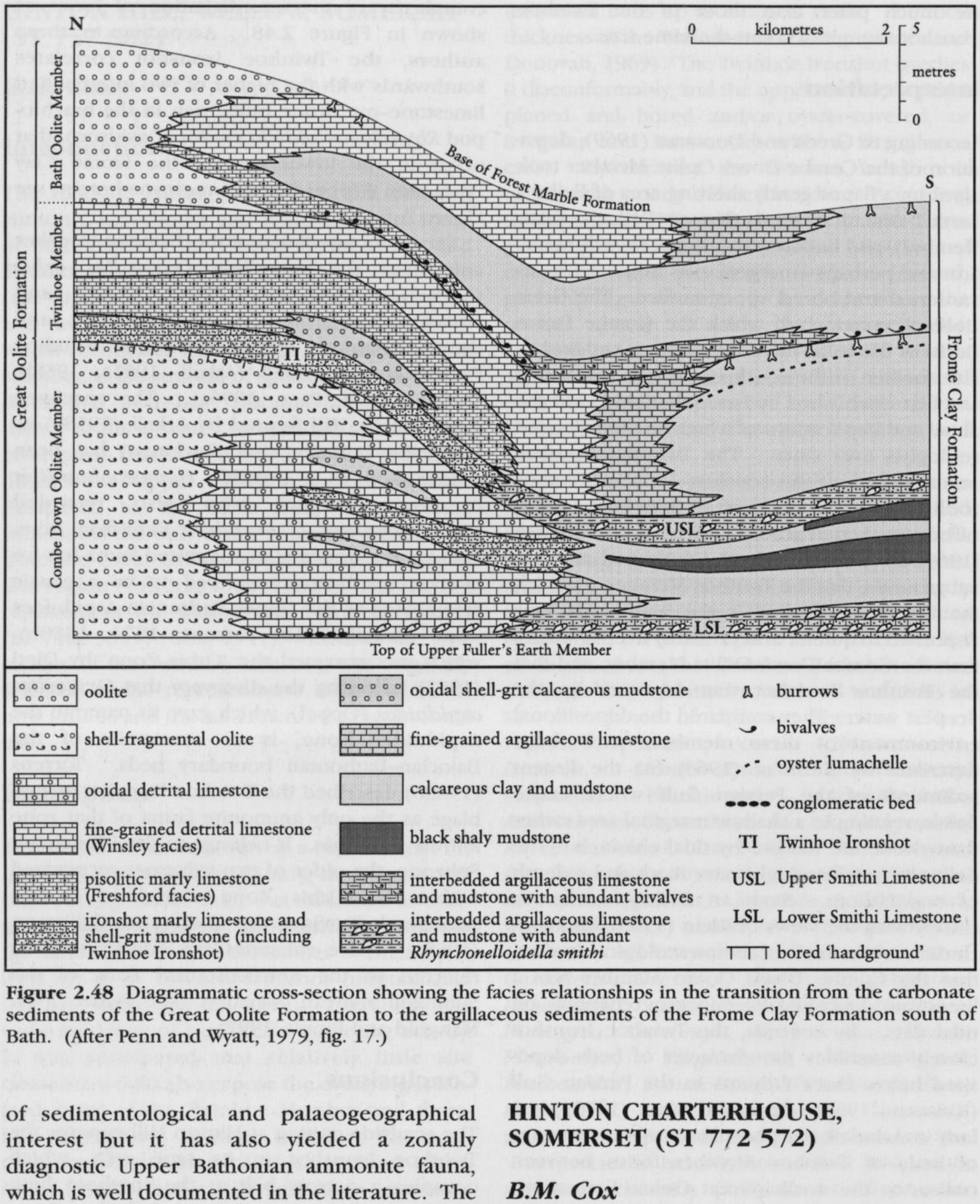

Figure 2.48 Diagrammatic cross-section showing the facies relationships in the transition from the carbonate sediments of the Great Oolite Formation to the argillaceous sediments of the Frome Clay Formation south of Bath. (After Penn and Wyatt, 1979, fig. 17.)

of sedimentological and palaeogeographical interest but it has also yielded a zonally diagnostic Upper Bathonian ammonite fauna, which is well documented in the literature. The type locality of the Twinhoe Ironshot at Wellow (or Twinhoe) Quarry is no longer visible and the cutting at Hinton Hill now provides the best extant exposure of a stratum that is of outstanding importance and significance in the local, regional, national and international classification and correlation of the Upper Bathonian Substage.

HINTON CHARTERHOUSE, SOMERSET (ST 772 572)

B.M. Cox

Introduction

The disused sand pit at Hinton Charterhouse, *c.* 6 km south of Bath, is the type locality of the Hinton Sand, a distinctive, arenaceous unit within the clays and limestones of the Forest Marble Formation of which it may be considered

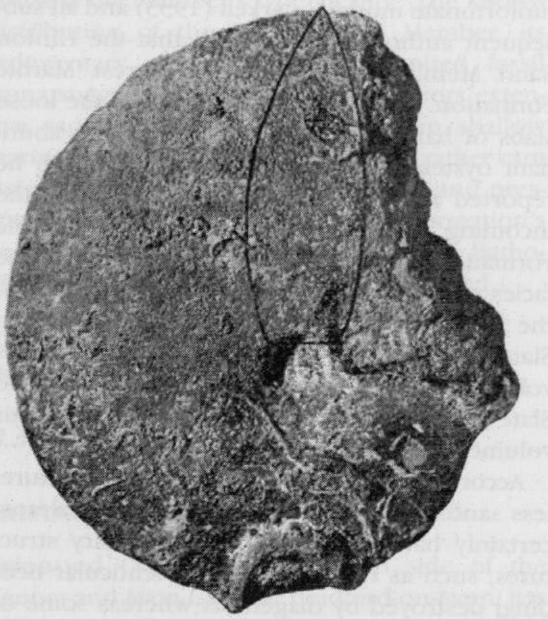

Figure 2.49 *Oxycerites orbis* (Giebel) from the Twinhoe Ironshot of Wellow (or Twinhoe) Quarry as figured by Arkell (1951b, text-fig. 17), but shown at *c.* 60% natural size. (Courtesy of the Palaeontographical Society.)

a member. Sandy beds in the middle to upper part of this formation have been recorded as far south as the Sherborne area of Dorset (Woodward, 1894; Torrens, 1980b) and as far north as the Oxford area (Arkell, 1933, 1947b), but they are by no means continuous and are generally not sufficiently well defined to warrant differentiation as separate lithostratigraphical units. The name 'Hinton Sand' originated with William Smith who, in 1799, produced a geological map of the Bath area as well as a manuscript table of the different stratal units. The latter referred to a unit of 'Sand and Stone', which later became the Hinton Sands and Sandstones' (Townsend, 1813; Judd, 1897). At Hinton Charterhouse, the Hinton Sand Member occurs as a lenticular body, up to about 10 m thick, just above the middle of the Forest Marble Formation succession (Penn and Wyatt, 1979). Its lateral extent is not well constrained but Holloway (1981) believed that it extended eastwards for at least 1.5 km. Penn and Wyatt (1979) reported similar lenses at approximately the same stratigraphical level between Hinton Charterhouse and Frome, which appears to be the area of their maximum development.

Description

The pit at Hinton Charterhouse has been described by Cox (1941) who reported about 6 m of pale-buff, fine-grained sands and sandstones with discontinuous beds (*c.* 0.6 m thick) and sporadic doggers (up to 1.2 m × 3.5 m) of hard, concretionary sandstone (Figure 2.50). Clay lenses and galls occurred in thin bands towards the base, and lignite fragments, annelid tracks and a sparse bivalve fauna including *Catinula* cf. *ancliffensis* Cox and Arkell, *Gervillella* sp., *Pseudolimea* cf. *duplicata* J. de C. Sowerby and *Placunopsis socialis* Morris and Lycett were also noted. At the top of the section, Cox (1941) reported slabs of hard, calcareous sandstone with many oysters on their upper surface, together with *Placunopsis* and ooids. Hawkins' (1977) later description reported only 3 m of exposed beds but in 1978, the Nature Conservancy Council re-excavated the section to a thickness of nearly 8 m. The north face of this excavation was described by Holloway (1981) on which the following section, including bed numbers, is largely based.

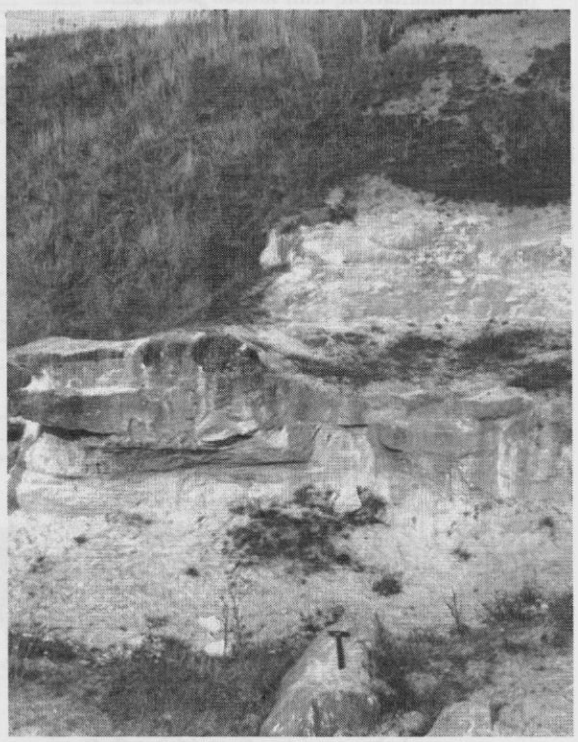

Figure 2.50 North face of the sand pit at Hinton Charterhouse showing sandstone doggers in the Hinton Sand Member. (Photo: British Geological Survey, No. A9739; reproduced with the permission of the Director, British Geological Survey, © NERC, 1961.)

	Thickness (m)
Forest Marble Formation	
Hinton Sand Member	
1: Sandstone, hard, concretionary, showing fine parallel-lamination	seen to 0.31
2: Sand, structureless, and sandstone	1.83
3: Sandstone, concretionary	0.21
4: Sand, structureless, and sandstone	1.41
5: Mud-flake conglomerate; basal erosion surface	0.21
6: Sand, structureless	0.04
7: Mud-flake conglomerate; basal erosion surface	0.32
8: Sand, structureless	0.03
9: Mud-flake conglomerate; basal erosion surface	0.10
10: Sand, structureless, and sandstone	0.52
11: Mud-flake conglomerate; basal erosion surface	0.18
12: Sand, structureless, and sandstone	0.17
13: Mud-flake conglomerate	0.08
14: Sand, structureless	0.04
15: Mud-flake conglomerate; basal erosion surface with 0.11-m deep channel into underlying bed	0.08–0.19
16: Sand, structureless	0.03–0.14
17: Sandstone, hard, concretionary	0.21
18: Sand and sandstone; small-scale trough cross-bedding	0.28
19: Sand and sandstone; thin bands showing parallel lamination; thin lenses of mud-flake conglomerate towards base	seen to 1.72

The mud-flake conglomerates comprise flat, brown-weathering intraclasts of clay and finely interlayered clay and sand set in a fine sand matrix. The clasts are typically 15 mm long and 3 mm thick, and are grain-supported. Occasional coarser clasts may be obliquely imbricated. Most of the conglomerate horizons were continuous across the cleared face (Holloway, 1981).

Interpretation

Although the Hinton Sand Member had been included in the Forest Marble Formation by Townsend (1813), Lonsdale (1832) and Woodward (1894), Buckman (1927b) raised the possibility that it might rather be equivalent to certain sandy beds of the overlying Cornbrash Formation. He associated the two by combining the Hinton Sand Member of Hinton and the Cornbrash Formation of Corscombe, Dorset, in a stratal unit called the 'Hintonian', giving the Upper Cornbrash brachiopod *Ornithella arenaria* S.S. Buckman as a characteristic fossil. Arkell (1931) recommended that the term 'Hintonian' should be dropped because of Buckman's miscorrelation that he described as an 'unfortunate muddle'. Arkell (1933) and all subsequent authors have affirmed that the Hinton Sand Member belongs in the Forest Marble Formation. According to Cox (1941), the loose slabs of hard calcareous sandstone with abundant oysters on their upper surface, which he reported at the top of the section, suggest the incoming of the more typical Forest Marble Formation facies. Cox (1941) compared the facies of the Hinton Sand Member with that of the Aalenian or Lower Bajocian Collyweston Slate (see **Collyweston** GCR site report, this volume) and the Middle Bathonian Stonesfield Slate (see **Stonesfield** GCR site report, this volume).

According to Holloway (1981), the structureless sands at Hinton Charterhouse have almost certainly had their original sedimentary structures, such as ripple marks and lenticular bedding, destroyed by diagenesis whereas some of the concretionary, cemented sandstones still show some parallel lamination. These sedimentary structures, together with the limited fauna of bivalves, indicate a shallow-water, marine depositional environment. The sands are well sorted, which led Penn and Wyatt (1979) to suggest that they had experienced lengthy winnowing in moderate currents. At times, these were sufficiently vigorous to erode clays deposited in adjacent areas of quieter-water deposition as evidenced by the mud-flake conglomerates. The erosive bases of the latter may indicate washover processes operating upon some kind of shallow marine shoals (Holloway, 1981). The Hinton Sand Member was deposited in a number of elongate sand bodies, the known distribution of which suggested to Penn and Wyatt (1979) that the member represents extensive sand banks rather than linear sand-bars or channel deposits.

Conclusions

Although sandy lithologies are fairly widespread in the middle to upper part of the Forest Marble Formation, well-developed sands and sandstones are unusual. These latter lithologies reach their maximum development in the Hinton Charterhouse area, south of Bath, where they occur as lenticular bodies up to 10 m thick. Known as the 'Hinton Sand', a name that originated with William Smith who mapped the Bath area in the late 18th century, the sands here constitute a member of the Forest Marble Formation. The sand pit at Hinton Charterhouse is the member's type locality. The known distribution of the Hinton Sand Member, its sedimentary structures and its limited fossil fauna suggest that it probably represents extensive sand banks that accumulated in shallow marine waters. The site thus shows a rather rare facies of the Forest Marble Formation and presents interesting insights into the formation's depositional history as well as the Late Bathonian palaeogeography of southern England.

GRIPWOOD QUARRY, WILTSHIRE (ST 822 603)

B.M. Cox

Introduction

Gripwood Quarry, on the south side of the Kennet and Avon Canal at Bradford-on-Avon, has been open for over a century although not worked for many years. Referred to by Cox (1941) as the 'Upper Westwood (or Woodside) Quarry', it originally exploited the oolite/freestone (Bradford Ground or Bethel Stone) of the Ancliff Oolite (Upper Rags Member, Forest Marble Formation) (see Figure 2.2). At the time of Cox's account, the underground galleries from which the beds had been worked were already being used for the cultivation of mushrooms, an industry that was apparently pursued in the disused quarry until recently. However, the site is most famous for the *c.* 3 m-thick Bradford Clay, which overlies the Upper Rags Member (Lonsdale, 1832; Cunnington, 1860). The Bradford Clay, of which Gripwood Quarry is considered to be the type locality (Cave, 1977), is renowned for its rich fossil content, particularly brachiopods and crinoids.

Description

The following section of Gripwood Quarry is based on that recorded by Woodward (1894) who described it as the best exposure of the Bradford Clay that he had seen. Bed numbers are those used by Woodward (1894), and his sketch of the section is shown in Figure 2.51.

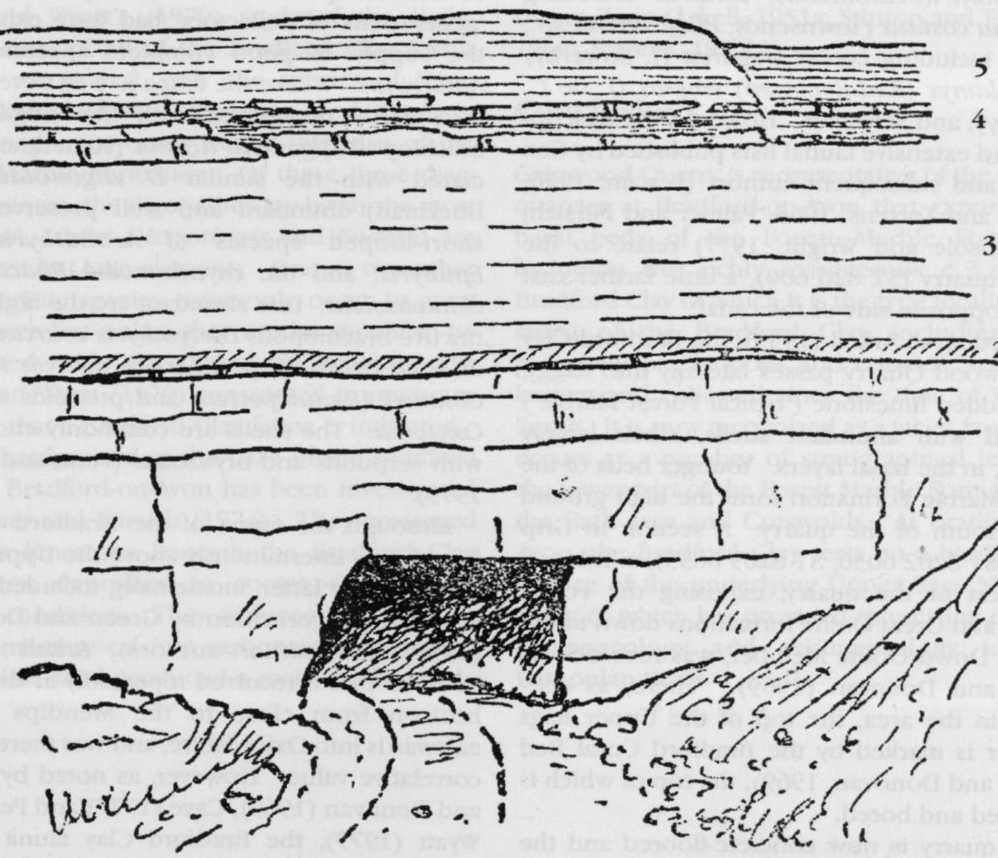

Figure 2.51 Woodward's (1894) sketch of the section at Gripwood Quarry showing an entrance into the underground galleries where the Ancliff Oolite of the Upper Rags Member (Forest Marble Formation) was worked.

	Thickness (m)
Forest Marble Formation	
5: Clay and thin stone	
4: False-bedded ooidal limestone	1.8
Bradford Clay	
3: Clay, grey, marly; rare fossils	*c.* 2.4–2.7
2: Fossil bed: clay, marly, locally cemented; impersistent, 0.15–0.20 m shelly limestone at base; crinoids, terebratulid and rhynchonellid brachiopods, bivalves and serpulids	0.4–0.6
Upper Rags Member	
1: Oolite, shelly, and limestone, brown, hard, marly, ooidal	

Cox (1941) recorded the following brachiopod fauna from slipped masses of the Bradford Clay: *Avonothyris bradfordiensis* (Davidson), *Cryptorhynchia bradfordensis* S.S. Buckman, *Dictyothyris coarctata* (Parkinson), *Digonella digona* (J. Sowerby), *Kallirhynchia* sp., *Rhactorhynchia rostrata* (J. de C. Sowerby), *R. farcta* (Linneaus), *R. diducta* S.S. Buckman and *Rhynchonelloidella curvivarians* (S.S. Buckman). As well as brachiopods, Woodward's (1894) fossil list included the crinoid *Apiocrinus parkinsoni* (Schlotheim); bivalves including *Oxytoma costata* (Townsend), *Plagiostoma* sp.; oysters including *Lopha gregarea* (J. Sowerby) and *Chlamys* (*Radulopecten*) *vagans* (J. de C. Sowerby); and serpulids. However, the descriptions and extensive faunal lists published by Cox (1941) and subsequent authors (Periam, 1956; Stinton and Torrens, 1968; Palmer and Fürsich, 1974; Insole and Wright, 1977) relate to the nearby quarry (ST 826 600), a little farther east on the opposite side of the canal.

According to Arkell (1933), the Bradford Clay at Gripwood Quarry passes laterally into flaggy, false-bedded limestone ('typical Forest Marble') but still with abundant shells, albeit largely broken, in the basal layers. Younger beds of the Forest Marble Formation form the high ground to the south of the quarry. A section in Grip Wood (ST 8202 6036, ST 8209 6033), a little farther west of the quarry, exposing the Forest Marble and Great Oolite formations down to the Combe Down Oolite Member, was recorded by Green and Donovan (1969). There, as elsewhere in the area, the top of the Upper Rags Member is marked by the Bradford Coral Bed (Green and Donovan, 1969), the top of which is hardened and bored.

The quarry is now concrete-floored and the faces heavily overgrown with fairly mature woodland. However, up to *c.* 5 m of massive, cross-bedded, cream-coloured, well-sorted, generally coarse- to medium-grained, shell-fragmental oolite (Upper Rags Member) are patchily exposed on the northern face, and entrances to the old underground galleries are visible on the southern face.

Interpretation

According to Arkell (1933), the Bradford Clay fossil assemblage, mainly comprising colonies of brachiopods, including, in addition to those listed above, *Avonothyris langtonensis* (Davidson), *Epithyris bathonica* S.S. Buckman, *Eudesia cardium* (Lamarck), *Kutchirhynchia morieri* (Davidson), *Rhactorhynchia obsoleta* Davidson, and numerous, small, undescribed rhynchonellids, as well as the echinoid '*Cidaris*' *bradfordensis* Wright, represents a fauna that lived in clear marine waters upon an eroded surface of the underlying Upper Rags Member. He envisaged that this fauna had been choked and killed by an influx of mud that laid the crinoids undisturbed full-length on the sea floor amongst the brachiopods. Cox (1941) noted that 'generations of collectors' had long exhausted the supply of good complete specimens of *Apiocrinus*. Where the fauna is well developed, it is easily recognized with the long-looped brachiopod *Digonella digona* (sometimes associated with the similar *D. digonoides* S.S. Buckman) abundant and well preserved, the short-looped species of *Avonothyris* and *Epithyris*, and the rhynchonellid *Rhactorhynchia obsoleta*. Less abundant are the highly distinctive brachiopods *Dictyothyris coarctata* and *Eudesia cardium*, pectinacean bivalves such as *Chlamys* (*Radulopecten*) and pterioids such as *Oxytoma*. The shells are commonly encrusted with serpulids and bryozoans (Penn and Wyatt, 1979).

Although the fauna of the Bradford Clay is found only intermittently above the Upper Rags Member (the latter, incidentally, included in the Great Oolite Formation by Green and Donovan (1969) and earlier authors), Arkell (1933) believed that it recurred repeatedly at the same horizon from close to the Mendips north-eastwards into Oxfordshire, and was therefore of correlative value. However, as noted by Green and Donovan (1969), Cave (1977) and Penn and Wyatt (1979), the Bradford Clay fauna is not confined to the stratigraphical level of the type locality but recurs at different horizons within the Forest Marble Formation. Indeed, Arkell (1947b) reported it sporadically near the top of the Forest Marble Formation from Gloucestershire into Oxfordshire. In fact, the Bradford Clay of the type locality is merely one of a number of laterally impersistent clay beds within the lower part of the Forest Marble Formation, any one of which is likely to yield the fauna like that of the Bradford Clay (Cave, 1977). The latter can be mapped for about 1.6 km west of Bradford-on-Avon and then it abruptly wedges out. The 'Bradford Clay fauna' has been noted in limestones and clays in the lower part of the Forest Marble Formation (including the Upper Rags Member) throughout the Bath area (Green and Donovan, 1969; Penn and Wyatt, 1979) and farther afield in the Cotswolds (e.g. Elliott, 1973) but it is not invariably present, even where the beds above the Upper Rags Member are clay. Farther south, in Dorset, the Boueti Bed at the base of the Forest Marble Formation (see **Shipmoor Point–Butterstreet Cove and Tidmoor Point–East Fleet Coast** GCR site report, this volume) has faunal elements in common (Arkell, 1933; Callomon and Cope, 1995). According to Penn and Wyatt's (1979) study of the Bath–Frome area, of all of the Bradford Clay fossils already mentioned, only the species of *Digonella*, *Dictyothyris coarctata* and *Eudesia cardium* do not occur below the base of the Forest Marble Formation. Of these three diagnostic genera, the digonellids are by far the most abundant, whilst *Dictyothyris* and *Eudesia* are persistent but rare elements. One or two other characteristic species commonly occur in great abundance but unless they can be shown to be associated with the diagnostic brachiopods, Penn and Wyatt (1979) considered it unwise to assume that a Bradford Clay fauna is indicated.

The hardground at the base of the Bradford Clay at Bradford-on-Avon has been investigated by Palmer and Fürsich (1974). They envisaged that the limestone beneath the Bradford Clay had been deposited in current-swept, fully marine conditions. They deduced that selective synsedimentary calcium carbonate cementation of the lime-sand produced a rocky sea-floor. As lithification continued, the uncemented sediment beneath the lithified layers was partly removed to form crevices, and the exposed hard surfaces were colonized by boring and encrusting animals. Periods of shell accumulation on the hardground alternated with periods of bioerosion; the soft floors of crevices started to lithify and the crevices themselves started to fill with shell material. Eventually, clay deposition buried the hardground and its associated fauna. Palmer and Fürsich (1974) described the upper surface fauna as an *Apiocrinus*/oyster-dominated community and the crevice community as dominated by serpulids and encrusting bryozoans, accompanied by the brachiopod *Moorellina*, the bivalve *Plicatula* and encrusting calcisponges. They attributed the development of these two separate communities to a combination of crevice/cavity size, light intensity, degree of water turbulence, and competition for food and space.

The Bradford Clay of Bradford-on-Avon has yielded rare ammonites of the genus *Clydoniceras* and is thereby attributed to the Hollandi Subzone of the Upper Bathonian Discus Zone (Arkell, 1951a; Stinton and Torrens, 1968; Torrens, 1980b).

Conclusions

Gripwood Quarry is representative of the several quarries at Bradford-on-Avon that exposed the basal beds of the Forest Marble Formation including the richly fossiliferous *c.* 3 m-thick Bradford Clay of which it is the type locality. The fauna of the Bradford Clay, including well-preserved brachiopods and crinoids, has been known and collected since the time of William Smith. It is now recognized as a facies fauna that occurs at a number of stratigraphical levels in the lower part of the Forest Marble Formation of the Bath area and Cotswolds. At Bradford-on-Avon, the Bradford Clay rests on a hardground surface of the underlying Upper Rags Member, study of which has provided interesting data on palaeoecology and sedimentology in Late Bathonian times.