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Article

Revision of the stratigraphy of the Inferior Oolite at Frogden Quarry, Oborne, Dorset, UK

Robert B. Chandler, John Whicher, Martin Dodge and Volker Dietze

With 9 figures

Abstract: The stratigraphy of part of the Inferior Oolite Formation at Frogden Quarry, Dorset, U.K. is revised based on new ammonite evidence. In the Lower Inferior Oolite Formation the Oborne Ironshot Member is erected to include beds 4 to 5 of the section (Sauzei and Humphriesianum zones). Oborne is designated as the type locality. For part of the Upper Inferior Oolite Formation of the Inferior Oolite Group in the Sherborne area of Dorset a new formal lithostratigraphical scheme is proposed, with the Sherborne Limestone Member at the base (including the basal *Acanthothyris* Beds, Sherborne Building Stone Beds and Redhole Lane Beds) followed by the Combe Limestone Member. The Sherborne Limestone Member is shown to belong to one ammonite faunal horizon, Bj-24a *Garantiana dichotoma*, of the Garantiana Zone. In the Combe Limestone Member a new ammonite faunal horizon Bj-24b *Garantiana subgaranti* is described for the first time in England. Faunal horizons Bj-25 *Garantiana tetragona* and Bj-26 *Parkinsonia rarecostata* are confirmed in the Sherborne area. A mechanism is suggested for the deposition of the Sherborne Limestone Member.

Key words: Ammonites, Dorset, Frogden Quarry, *Garantiana*, Inferior Oolite.

1. Introduction

Frogden Quarry, Sherborne, Dorset, UK, is a Site of Special Scientific Interest (SSSI). It was first described by workers in the 19th century (Buckman 1893; Hudleston & Woodward 1885) and is the location for a number of ammonite type specimens later figured by Buckman (1913-1930). Our present understanding of the area is due in no small way to the researches of Colin F. Parsons (1945-2008) to whom we are indebted. Parsons' early work (e.g. Parsons 1974, 1976, 1980) was separated from a resumption of his interest in geology by some thirty years and towards the end of his life he set about refining and advancing his findings. Much of that information is relevant here but remained unpublished at his death. In work available only on his website Parsons proposed the lithostratigraphical units introduced here for the Upper Bajocian. Further studies followed, Callomon & Chandler (1990), Callomon & Cope (1995) and recently Chandler et al. (2013), in which Frogden Quarry was designated as the type locality and horizon for the Green Grained White Marl (bed 3, see Fig. 1). Due to the abundance of well-preserved large ammonites in the lower beds (3-6), it has attracted the attention of fossil collectors for many years. Little has been published about the overlying Upper Bajocian, including the rather unfossiliferous Sherborne Limestone Member (the Sherborne Building Stone of previous authors) of which only a few metres were exposed in the face of the SSSI (ST 648183).

Quarrying north of the old SSSI face for the extraction of stone has been in progress for the last eight years and has advanced a considerable distance into the hillside exposing some 15-20 m of stone above bed

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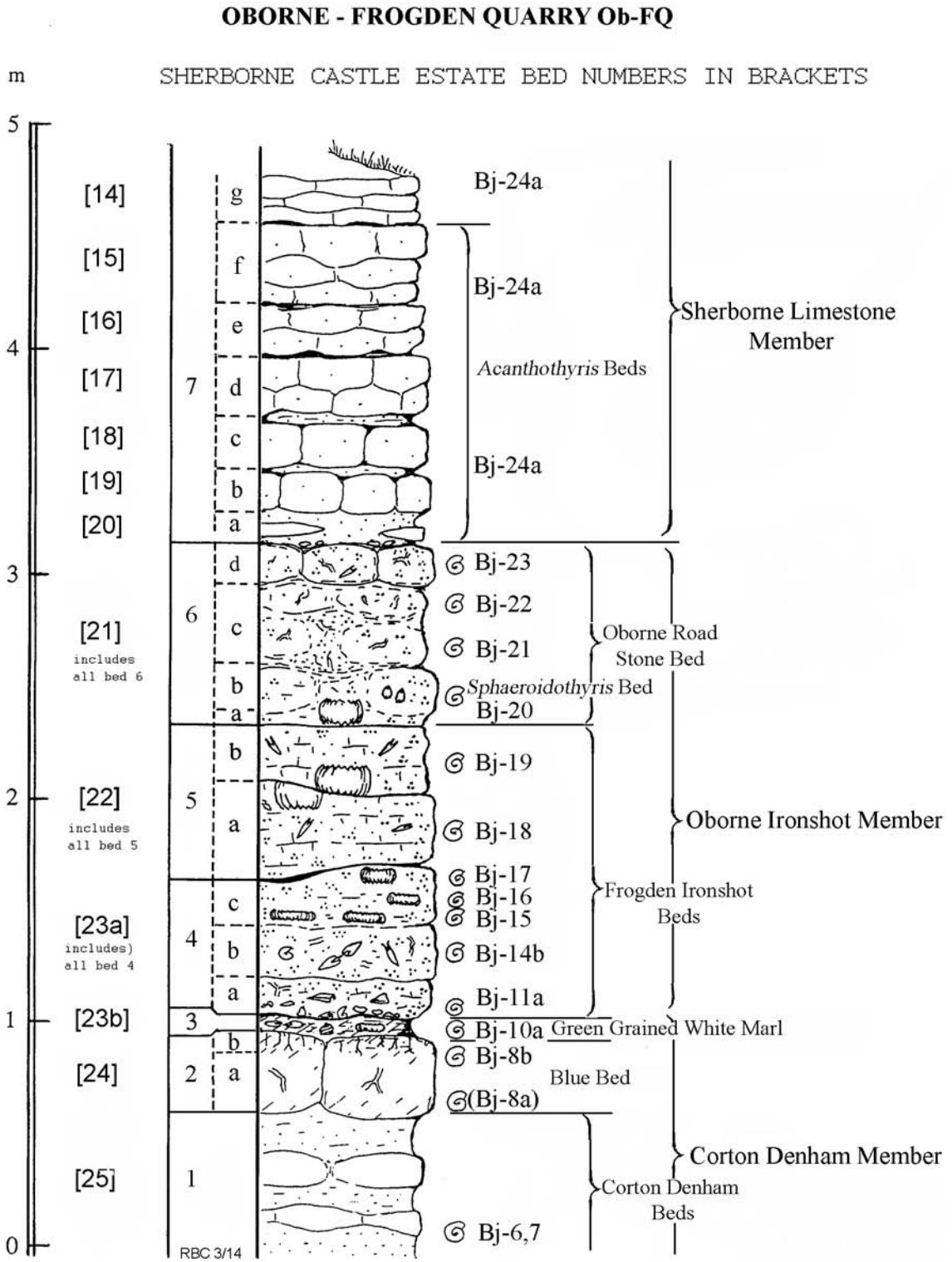


Fig. 1. Diagrammatic representation through the Inferior Oolite at Oborne, Frogden Quarry (Ob-FQ). Sherborne Stone bed numbers in square brackets. Revised after Callomon & Cope (1995).

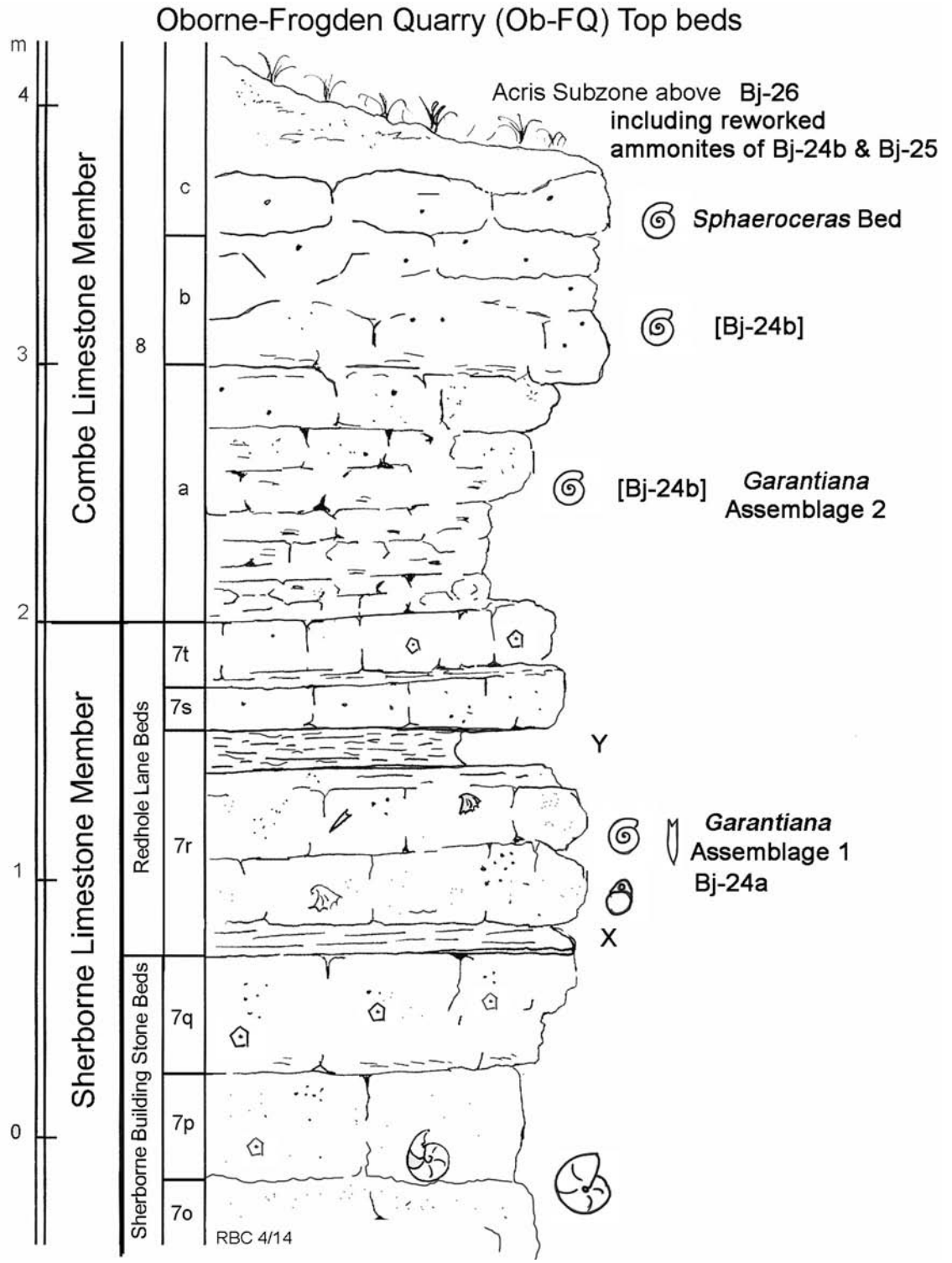


Fig. 2. Diagrammatic representation through the top beds of the Sherborne Limestone and Combe Limestone Member, Inferior Oolite at Oborne at Frogden Quarry (Ob-FQ).

6 of the part section given here (Fig. 1). These upper beds have now been subjected to further subdivision by fossil content and lithology (Fig. 2). An account of the succession (beds 1-7) in terms of ammonite faunal horizons was given by Callomon & Chandler (1990) and repeated with updates and additions by Callomon & Cope (1995). In these accounts bed 7 was dated provisionally as ammonite faunal horizon (Bj-24), with brackets indicating uncertainty. A chart of faunal horizons is given as Fig 3. It is now possible to precisely date the Sherborne Limestone Member at Frogden Quarry and to cast light on its age at other nearby locations and suggest a possible mechanism for deposition. A map of the area is given as Fig. 4 with locations indicated by codes. New information is also added to the account of the lower beds (1-6). In May 2013 it was possible to examine the top beds of the section at two points; a track descending into the quarry and an area to the west, cleared of top soil ready for further stone extraction. Together these two areas have provided new evidence for the age of bed 7.

Abbreviations and terminology: Faunal horizons given in brackets indicate a degree of uncertainty and are still in the process of research. Common, occurs, rare (c), (o), (r). [M] and [m] macroconch and microconch respectively. SSSI Site of Special Scientific Interest. Locality names given in full on first use thereafter, Frogden for Oborne, Frogden Quarry, Sandford Lane for Sherborne, Sandford Lane. The use of aff. follows the recommendations of Bengtson (1988). The zonal scheme is modified from Callomon & Cope (1995). We retain the Sauzei Zone undivided as we have inadequate data in Dorset for a Propinquans Zone with two attendant subzones (Rioult et al. 1997). The Niortense Zone replaces the Subfurcatum Zone following Dietl (1981). We use the Acris Subzone as the base of the Parkinsoni Zone in line with most continental authors (e.g. Westermann 1967; Gabilly et. al. 1971; Dietze et. al. 2007).

2. The section

2.1. Lower Inferior Oolite

A full account of the section for beds 1-6 was given by Callomon & Cope (1995). Only additions and corrections to that account are included here.

From below:

Corton Denham Member

Corton Denham Beds

Bed 1. Concavum to Ovale zones. Hard blue-grey silty stone in lenticular courses, some 0.4 m thick and separated by nodular grey siltstone of varying hardness; intensely burrowed, the channels filled by grey-brown fine matrix; fossils common at some levels but in a poor state of preservation.

Aalenian

Concavum Zone, Aa-14. Seen in the base of the quarry. *Graphoceras concavum* (J. Sowerby, 1815) (o).

Lower Bajocian

Discites Zone, (Bj-1 to 3). *Hyperlioceras* [M] (o) and *Euhoploceras* [M] (o) in fragmentary condition.

Ovale Zone, (Bj-6). *Fissilobiceras* aff. *ovale* (Quenstedt, 1886) [M] (o), *F. fissilobatum* (Waagen, 1867) [M] (o), '*Emileia*' aff. *crater* S. Buckman, 1920 [M] (o), *Sonninia* (*Euhoploceras*) spp.

A further refinement of age is presently not possible due to lack of exposure. Seen to about 2 m in total

…Irregular parting...

Blue Bed

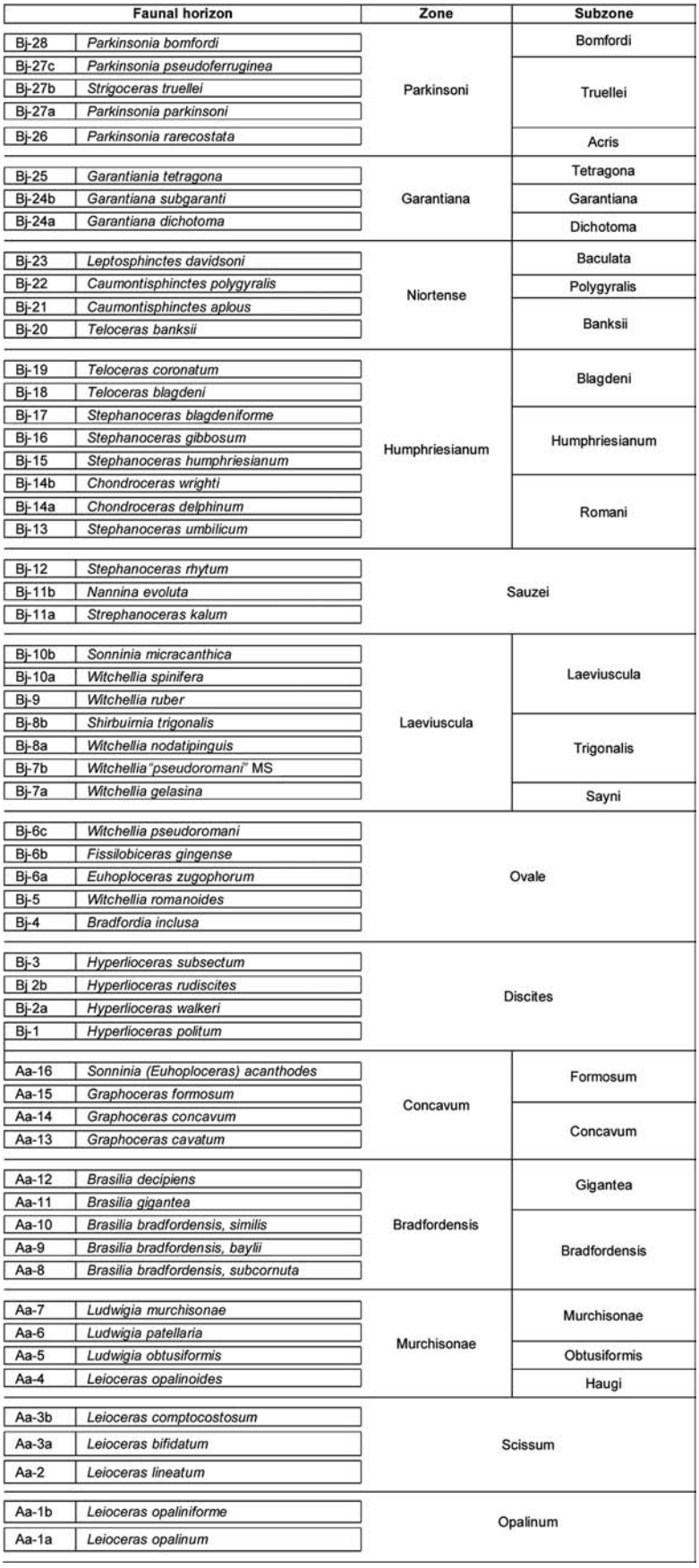
Bed 2. Laeviuscula Zone, Trigonalis Subzone. Very hard blue, intensely burrowed siltstone in two bands.

2a, Bj-8a. At the base adhering to the lower surface: *Emileia* aff. *contrahens* S. Buckman, 1927 [M] (o), *'E'*. aff. *crater* [M] (r), *Sonninia* (*Papilliceras*) aff. *papillata* (S. Buckman, 1920) [M] (o), *Stephanoceras* aff. *richardsoni* (Dietze et al., 2001) [M] (o). 0.25 m

2b, Bj-8b. The upper half of the bed adheres strongly to bed 3 (GGWM) which fills hollows and irregularities in its surface. Of note is the occurrence at the top of the bed of a single specimen of *Pseudoshirbuirnia stephani* (S. Buckman, 1883) [M] alongside *Witchellia albida* (S. Buckman, 1926) [M] (c), *W. sayni* Dorn, 1935 [M] (o) and *Euhoploceras* sp. [M] (o). 0.10-0.25 m

The assemblage in the top of bed 2b appears to be close in age to that at the base of bed 4 at nearby Redhole Lane (Huxtable 2000) where it is absent over some parts of the area we have excavated, but up to 0.30 m thick at others. At Redhole Lane two separate horizons can be discriminated directly above bed 3, the Blue Bed, the lower part with only *P. stephani* and above a level with *Shirbuirnia trigonalis* S. Buckman 1924 [M] and *P. stephani* together. A single well preserved example of *S. trigonalis* was found in Blue Bed matrix in a different area of Redhole Lane. Either the Blue Bed lithology extends upwards locally or there are already rare examples of *S. trigonalis* in the lower horizon here. 0.5 m

Fig. 3. The ammonite faunal horizons of the Inferior Oolite (Aalenian-Bajocian) of Dorset and Somerset, UK. The labelling of some horizons with additional letters (a, b, c) reflects the insertion of further horizons after Callomon & Chandler (1990) but does not denote any reduction of rank or importance. Zones and subzones are shown on the right.



Faunal horizon		Zone	Subzone
Bj-28	*Parkinsonia bomfordi*	Parkinsoni	Bomfordi
Bj-27c	*Parkinsonia pseudoferruginea*		Truellei
Bj-27b	*Strigoceras truellei*		
Bj-27a	*Parkinsonia parkinsoni*		
Bj-26	*Parkinsonia rarecostata*		Acris
Bj-25	*Garantiania tetragona*	Garantiana	Tetragona
Bj-24b	*Garantiana subgaranti*		Garantiana
Bj-24a	*Garantiana dichotoma*		Dichotoma
Bj-23	*Leptosphinctes davidsoni*	Niortense	Baculata
Bj-22	*Caumontisphinctes polygyralis*		Polygyralis
Bj-21	*Caumontisphinctes aplous*		Banksii
Bj-20	*Teloceras banksii*		
Bj-19	*Teloceras coronatum*	Humphriesianum	Blagdeni
Bj-18	*Teloceras blagdeni*		
Bj-17	*Stephanoceras blagdeniforme*		Humphriesianum
Bj-16	*Stephanoceras gibbosum*		
Bj-15	*Stephanoceras humphriesianum*		
Bj-14b	*Chondroceras wrighti*		Romani
Bj-14a	*Chondroceras delphinum*		
Bj-13	*Stephanoceras umbilicum*		
Bj-12	*Stephanoceras rhytum*	Sauzei	
Bj-11b	*Nannina evoluta*		
Bj-11a	*Strephanoceras kalum*		
Bj-10b	*Sonninia micracanthica*	Laeviuscula	Laeviuscula
Bj-10a	*Witchellia spinifera*		
Bj-9	*Witchellia ruber*		
Bj-8b	*Shirbuirnia trigonalis*		Trigonalis
Bj-8a	*Witchellia nodatipinguis*		
Bj-7b	*Witchellia "pseudoromani"* MS		
Bj-7a	*Witchellia gelasina*		Sayni
Bj-6c	*Witchellia pseudoromani*	Ovale	
Bj-6b	*Fissilobiceras gingense*		
Bj-6a	*Euhoploceras zugophorum*		
Bj-5	*Witchellia romanoides*		
Bj-4	*Bradfordia inclusa*		
Bj-3	*Hyperlioceras subsectum*	Discites	
Bj 2b	*Hyperlioceras rudiscites*		
Bj-2a	*Hyperlioceras walkeri*		
Bj-1	*Hyperlioceras politum*		
Aa-16	*Sonninia (Euhoploceras) acanthodes*	Concavum	Formosum
Aa-15	*Graphoceras formosum*		
Aa-14	*Graphoceras concavum*		Concavum
Aa-13	*Graphoceras cavatum*		
Aa-12	*Brasilia decipiens*	Bradfordensis	Gigantea
Aa-11	*Brasilia gigantea*		
Aa-10	*Brasilia bradfordensis, similis*		Bradfordensis
Aa-9	*Brasilia bradfordensis, baylii*		
Aa-8	*Brasilia bradfordensis, subcornuta*		
Aa-7	*Ludwigia murchisonae*	Murchisonae	Murchisonae
Aa-6	*Ludwigia patellaria*		
Aa-5	*Ludwigia obtusiformis*		Obtusiformis
Aa-4	*Leioceras opalinoides*		Haugi
Aa-3b	*Leioceras comptocostosum*	Scissum	
Aa-3a	*Leioceras bifidatum*		
Aa-2	*Leioceras lineatum*		
Aa-1b	*Leioceras opaliniforme*	Opalinum	
Aa-1a	*Leioceras opalinum*		

Fig. 3.

Green Grained White Marl

Bed 3: Laeviuscula Zone, Bj-10a. A description has been given recently in Chandler et al. (2013) that demonstrates the diachronous nature of this bed. The oldest part of the bed is seen at Frogden and Oborne Wood and is typified by the abundance of *Witchellia* and extreme rarity of *Kumatostephanus*. On the east side of the valley at Mill Close Farm the same deposit is seen again but here abundant *Kumatostephanus* occur alongside rare *Witchellia laeviuscula* (Sowerby, 1824) indicating a later Laeviuscula Zone age. The assemblage in total contains elements of both the Laeviuscula and Sauzei zones. This assemblage is close, if not the same as in the Blaukalk of the area from Neuffen to Eningen unter Achalm in the Middle Swabian Alb (pers. observation VD), the type area and horizon of the Sauzei Zone (Parsons 1974). The explanation for these local differences in age at Oborne is tectonic and was discussed by Chandler et al. (2013). 0.01-0.15 m.

Oborne Ironshot Member

Frogden Ironshot Bed

Beds 4 to 5. Sauzei to Humphriesianum zones. In previous descriptions (Parsons 1980; Callomon & Cope 1995) beds 4 and 5 have not been referred to by name. In an account by Cox (in Cox & Sumbler 2002) beds 4 to 6 are included in the Miller's Hill Member; however, Chandler et al. (2013) have provided reasons for rejecting this. Bed 4 is divisible into three parts of which Bed 4c of Frogden is undoubtedly the type locality and horizon of *Stephanoceras humphriesianum* (Sowerby, 1825) and this bed of ironshot oolite is very characteristic of the Oborne area. We therefore erect the Frogden Ironshot Bed as a term to include beds 4 to 5 (Sauzei and Humphriesianum zones) of Oborne, with Frogden as type locality.

Bed 4a, Sauzei Zone, Bj-11a. The surface of this conglomeratic bed is burrowed and covered in limonite crust, fragments of derived ammonites in Green Grained White Marl matrix are common. The most characteristic feature is of ammonites planed through on the upper surface, mostly complete but corroded, some 13 to 20 cm diameter. They closely resemble *Stephanoceras kalum* (S. Buckman, 1921) [M] and *S. leptogyrale* (S. Buckman, 1924) [M] and match closely those found at the top of bed 4a at Redhole Lane and at Sandford Lane, bed 6b. 0.00-0.20 m.

Bed 4b. Humphriesianum Zone, Romani Subzone, Bj-14b. This horizon contains specimens already close to *S. humphriesianum* (o) alongside *Chondroceras wrighti* S. Buckman, 1923 [M] (c), *C. grandiforme* S. Buckman, 1922 [M] (o), *Poecilomorphus primiferus* S. Buckman, 1927 [M] (c), *P. cycloides* (d'Orbigny, 1844) [M] (c), *Dorsetensia edouardiana* (d'Orbigny, 1846) [m] (o), *D. romani* (Oppel, 1862) [m] (o), *D. complanata* (S. Buckman, 1892) [m] (o) and large *D. liostraca* (S. Buckman, 1892) [M] (o) and *D. tecta* (S. Buckman, 1892) [M] (o). *Teloceras labrum* S. Buckman, 1922 [M] (o) is present. 0.20-0.25 m.

Bed 4c. Humphriesianum Subzone, Bj-15 to 17. Bed 4c is further sub-divisible. The lowest horizon 4ci (Bj-15) contains numerous *S. humphriesianum* some up to 0.4 m in diameter. There are two horizons above (Bj-16 & 17) containing less common ammonites mostly as internal moulds in sandy limestone preservation. At nearby Mill Close Farm horizon 4c is present but less well developed. Above this horizon here is a bed rich in ammonites belonging to *Stemmatoceras*. Complete specimens with mouth border range in size from about 15 to 30 cm in adults, somewhat smaller than the largest *S. humphriesianum* from the sub-adjacent horizon Bj-15. They are very consistent in morphology possessing regular widely spaced ribs with tubercles on the ventral flanks of the inner whorls. The venter is rather quadrate and depressed in most specimens. The age is close to Bj-16. 0.20-0.40 m.

Details of the succession for bed 5 and 6 are given by Callomon & Cope (1995) and include an error. Bed 5 belongs in its entirety to the Humphriesianum Zone (Bj-18 and 19) as shown in their section (p. 72, fig. 12), however in the text (p. 71) bed 5b is included in the 'Banksi Subzone' misspelling of Banksii in faunal horizon chart p. 62. Our findings confirm that the assemblage contains the typical species of Bj-19 listed below.

Bed 5. Divisible into two parts. Hard sandy limestone with limonite crusts, some pyrite, ooliths in clouds.

Bed 5a. Blagdeni Subzone, Bj-18. Abundant decalcified specimens of *Teloceras blagdeni* (J. Sowerby, 1818), *Stephanoceras gibbosum* (S.Buckman, 1928) [M], (o) and *Stemmatoceras* spp. [M] (o) occur. The parting with the bed above is very undulating and planes through the ammonites exposed at its surface. 0.35-0.50 m.

Bed 5b. Blagdeni Subzone, Bj-19. Limestone, sandy as below *T. blagdeni*, [M] (c), *T.* aff *banksii* (J. Sowerby, 1818) [M], (c). In places the bed divides into two levels. 0.20-0.35 m.

Oborne Road Stone Bed

Bed 6. Oborne Road Stone Bed, Niortense Zone. Limestone, bioturbated and intensely burrowed, very ferruginous in parts divisible into four courses separated by muddy, wavy partings.

Bed 6a. Banksii Subzone, Bj-20. Sandy rotted, bioturbated limestone, very large decalcified *T. banksii* on the lower surface lying at all angles, some very large and planed through. Absent in some parts of the quarry and thicker than the account given by Callomon & Cope (1995). 0.05-0.30 m.

Bed 6b. Banksii Subzone, *Sphaeroidothyris* Bed, Bj-20. Stone as below, undulating and sandy and hard near the top with a prominent horizon of well-preserved fossils. The brachiopod *Sphaeroidothyris* is common throughout with nests in the upper part. A range of variability occurs in specimens of the genus *Cadomites* between *C. homalogaster* S. Buckman, 1925 and *C. deslongchampsi* (d'Orbigny, 1846). 0.10-0.25 m.

Bed 6c. Polygyralis Subzone, Bj-22. As above but much softer and few fossils other than scarce brachiopods throughout. *Caumontisphinctes polygyralis* S. Buckman, 1920 [M]. 0.30-0.40 m.

Bed 6d. *Cadomense* Bed. Baculata Subzone, Bj-23. Hard, brown stone, soft and rotted at the top, fossils common. This horizon is not present throughout the quarry. It was termed the *Cadomense* Bed owing to the occurrence of *Cadomoceras cadomense* (Defrance in De Blainville, 1840). There are large examples (20 cm) of *Leptosphinctes davidsoni* (S.

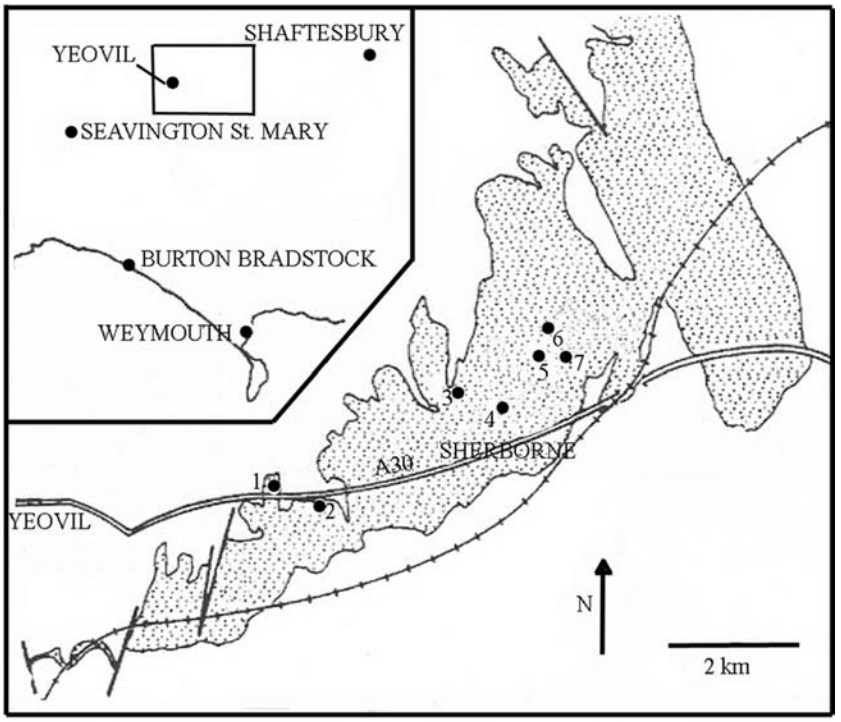


Fig. 4. Sketch map of the Sherborne district, showing the outcrop of the Inferior Oolite (dotted) and the location of the main exposures described in the text. Locality 1 Halfway House (ST603164), 2 Louse (Lows) Hill quarry (ST610161), 3 Sandford Lane quarry (ST629178), 4 Redhole Lane (ST637185), 5 Frogden quarry (ST648184), 6 Oborne Wood (ST648187), 7 Mill Close Farm (ST655184).

Buckman, 1881) [M] (o) in middle of bed. At the top in soft rotted red limonitic stone *Garantiana baculata* (Quenstedt, 1857) [M], (o) *Strenoceras niortense* (d'Orbigny, 1846) [m] (o), *Oppelia* spp. [M] (o). 0.00-0.30 m.

2.2. Upper Inferior Oolite

The Upper Inferior Oolite of the Sherborne district (Milborne Wick to Sandford Lane (see Fig. 4), has previously been divided into three informal units: the 'Sherborne Building Stone' (Richardson 1932), the 'Rubbly beds' (Buckman 1893) and the 'Crackment Limestones' (White 1923). Only the first two of these will be considered here and with some modification and subdivision they form the basis of the formal members erected here. The Sherborne Limestone Member is subdivided into the *Acanthothyris* Beds at their base, followed by the Sherborne Building Stone Beds and Redhole Lane Beds then the Combe Limestone Member.

Sherborne Limestone Member

The beds previously known as the 'Sherborne Building Stone' (Richardson 1932) or 'Building-stone', and including the 'stone used for lime' (Buckman 1893), comprise the Sherborne Limestone Member, Bed 7. The lower boundary of the Upper Inferior Oolite Formation in the Sherborne area is taken at a well-defined break in the succession and a marked changed in lithology, with an iron-stained conglomerate at the base of the *Acanthothyris* Beds of the Sherborne Limestone Member. These beds rest on 'ironshot', beds of the Niortense Zone at Frogden (Parsons 1976), whilst at Sandford Lane they lie directly above the erosion surface at the top of the Sauzei Zone (Parsons 1974). The type locality is here designated as Frogden where more than 10 m of the member is exposed. Parsons (pers. com.) preferred to select Sandford Lane as the type locality where some 3.0 m of massive, sparsely glauconitic and oolitic, sandy, recrystallized biomicrite, with subsidiary marl partings can be examined (Buckman 1893; Richardson 1932), however in Parsons' day the favourable exposure now available at Frogden did not exist. Richardson (1932: 73) had previously recorded 7.5 m at Redhole Lane west of Frogden. The entire Sherborne Limestone Member is relatively poor in macrofossils but clusters of *Sphaeroidothyris* occur, solitary

Bed Nos.	Quarry Nos	unit m.	Lithology	Notes	Unit	
8c	1	>3.9	Overburden	*Parkinsonia* Bj-26 with reworked fossils of Bj-24b & Bj-25	Combe Limestone Member	
8c	2	0.25	Rubble and stone, hard grey band.	Horizons with *Sphaeroceras*		
8b	3	0.5	Limestone and sandy, yellow.			
8a	4	0.45	Limestone, rubbly, sandy with marl	*Garantiana* assemblage 2		
7t	5a	0.15	Sandy stone		Sherborne Limestone Member	Redhole Lane Beds
7s	5b	0.25	Limestone, blocky grey stone	Small well preserved Nautilus beds 7s to 8.		
			? Bentonite horizon 'Y'			
7r	6a	0.2	Limestone, mottled, grey blocky, sandy.	Bed 7q&r. *Garantiana* assemblage 1.		
			? Bentonite horizon 'X'			
7q	6b	0.4	Limestone, mottled sandy stone			Sherborne Building Stone Beds
7p	7a	0.3	Limestone, mottled, blocky, mid grey.			
7o	7b	0.35	Limestone, mottled, blocky, mid grey.	Beds 7a-b one bed in parts of quarry		
7n	8	0.5	Limestone, sandy blocky with central grey band.	Nautiloids smaller than below, incomplete and distorted.		
7m	9	0.35	Blocky, grey at top, sandy downwards.	Very large nautiloids occur in 7l to7m		
7l	10	0.90	Limestone, mottled, blocky, planned surface between 7k and l.	Lobster and plant remains occur 0.3 m from base. A channel of 1m width and 10 m length found during quarrying		
7k	11a	0.45	Mottled, blocky limestone.			
7j	11b	0.4	Mottled, blocky limestone.	Two equal courses in some areas		
7i	12	1.1	Mottled, blocky limestone.			
7h	13	0.4	Hard grey massive	*Garantiana* sp. Two specimens, crushed. *Ctenostreon* sp.		
7g	14	0.6	Hard grey massive.			*Acanthothyris* Beds
7f	15	0.15	Hard grey rubble with iron staining			
7e	16	0.2	Hard grey rubble with iron staining.			
7d	17	0.1	Grey limestone, broken.			
7c	18	0.15	Hard grey rubble, irony in parts.			
7b	19	0.2	Hard grey, somewhat ironshot.	Basal conglomerate		
7a	20	0.1	Fractured, limestone grey when fresh	Basal conglomerate		

Fig. 5. Table of details for stone units of bed 7, Sherborne Limestone Member and Combe Limestone Member. Marl layers and rubble between beds has been omitted. The table does not represent the total thickness of the section. By kind permission of Sherborne Stone.

Rhynchonelloidella sp. and moulds of infaunal bivalves. Although generally massive, some lithostratigraphical subdivision can be made.

The Frogden SSSI was cleaned in the 1970s and exposed about 1.5 m of *Acanthothyris* Beds of the Sherborne Limestone Member labelled by Callomon & Cope (1995) provisionally as (Bj-24). Further evidence was obtained from nearby quarries and boreholes (Parsons 1980) indicating that an additional 10 m more of stone above that seen at Frogden was also included in the Garantiana Zone. A more precise age determination was not possible due to the extreme rarity of identifiable ammonites in many of the known sections. The new extension of Frogden quarry has now exposed some 15 to 20 m of stone above bed 6. For the present we retain the entire thickness of the Sherborne Limestone Member as bed 7 with alpha-numeric subdivisions denoting individual beds. A chart of these divisions is given as Fig. 5.

At Frogden, the Sherborne Limestone Member consists of thick bedded honey-yellow to brown bioclastic lime-

Fig. 6. Ammonites from bed 7r, Garantiana Zone, Dichotoma Subzone. Ammonite faunal horizon Bj-24a. A black dot indicates the last preserved suture. 1A-C. *Garantiana* aff. *trauthi* Bentz [M] WC0370. 2A-B. *Garantiana trauthi* Bentz [M], WC0363. 3A-B. *Garantiana* aff. *baculata* (Quenstedt) [M] WC0366. 4A-B. *Garantiana* aff. *platyrryma* (Buckman) [M], WC0364. 5A-B. *Garantiana trauthi* Bentz [M], WC0367. 6A-B. *Leptosphinctes otiophorus* (Buckman) [m] WC0368. 7A-B. *Spiroceras* aff. *annulatum* (Deshayes) [M], WC0361. 8A-B. *Garantiana platyrryma* (Buckman) [M], WC0365. 9A-B. *Leptosphinctes* aff. *garnieri* Pavia [M], WC0369. Scale bar = 2cm.

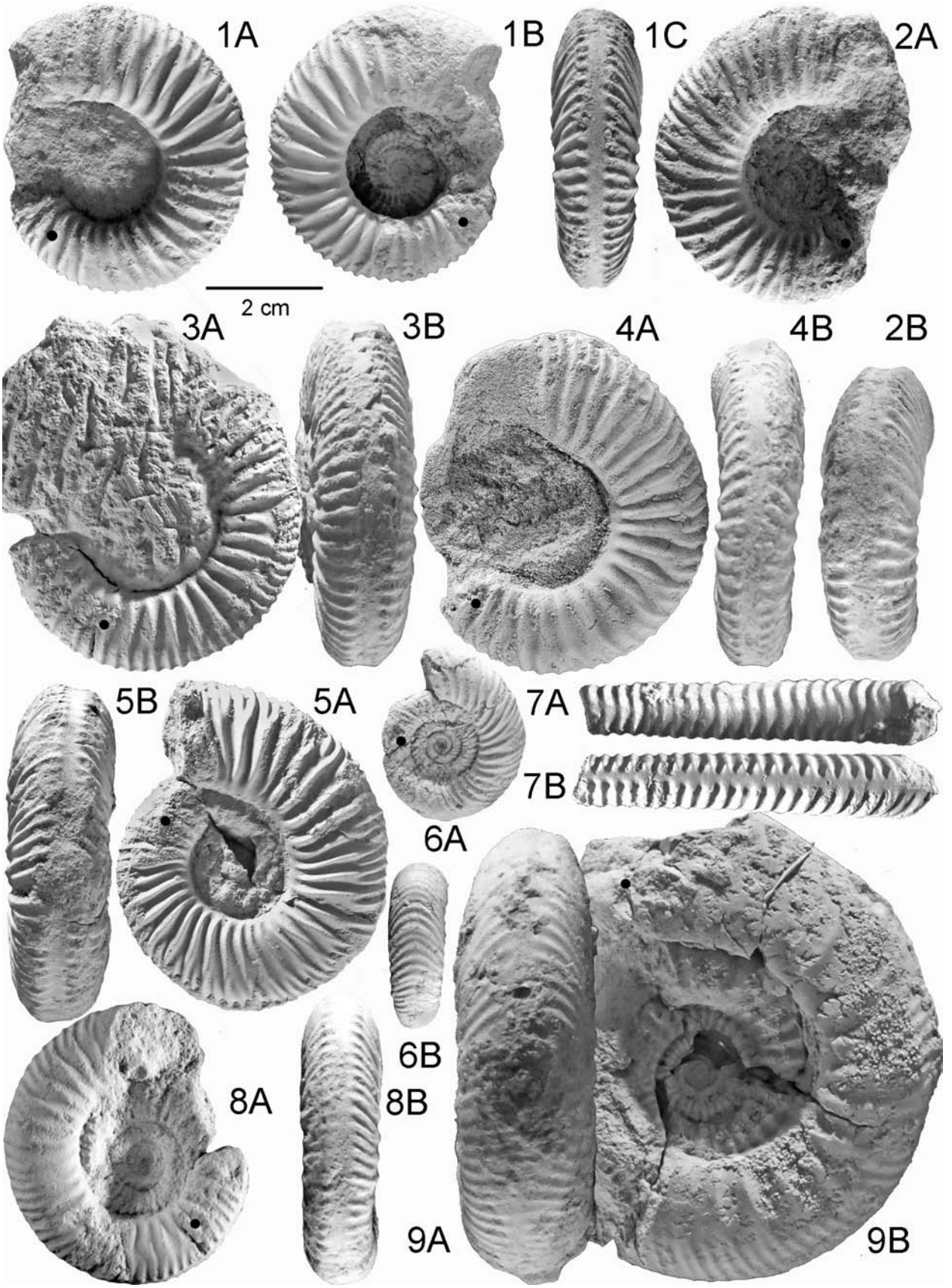


Fig. 6.

stones that are usually grey when fresh, in which the grain size is that of very fine lime sand with broken, tiny particles of echinoderm debris. There are minor grain size differences between beds but the overall lithology is similar throughout. A study of the lithology of these beds has been undertaken by one of us (MD). The stone beds vary in thickness locally and are separated by thin mud seams or degraded limestone. Some beds thicken or disappear in parts of the quarry. Of particular interest are two horizons near the top of the Sherborne Limestone (here designated 7r'X' and 7r'Y'). On exposure these levels weather into a finely laminated yellow stone but are white-cream when fresh, extremely fine grained and plastic, resembling tooth-paste. One of us (MD) reports that at least nine similar horizons have been identified in the total thickness of the Sherborne Limestone Member below 'X' and 'Y'. At present it is only possible to examine 'X' and 'Y' in situ. A discussion of their possible origin is given below. Several flattened ammonites attributable to *Garantiana* sp. have been found within the bulk of bed 7 at Frogden.

Acanthothyris Beds

The lowest beds within the Sherborne Limestone Member consist of brown, sandy biomicrites, interbedded with thick, brown marls, here formally named the *Acanthothyris* Beds, after the common occurrence of *A. obornensis* (Buckman & Walker 1889). At Frogden, the type locality, they are 1.5 m thick and consist of five sandy limestone courses (c. 0.20 m thick), interbedded with sandy marls. Beneath this there is a brown, ferruginous, rubbly limestone and marl, with a basal conglomerate, totalling 0.30 m. A very similar sequence has been recorded from Oborne Wood (Parsons 1976) and at Sandford Lane where the limestone courses are slightly thicker, totalling 1.45 m.

Sherborne Building Stone Beds

Parsons (1976) suggested two further names to enable subdivision of the Sherborne Limestone Member. The lower massive part he intended to call the Building-stone Beds, here modified to Sherborne Building Stone Beds to reflect its local geographical importance, following Buckman's (1893) original usage. A notable exception to the lack of fossils is the irregular but common occurrence of nautiloids throughout. The largest specimens are without the shell but essentially complete. Gigantic specimens up to 0.75 m occur in the lower part (Beds 7h-n), the largest being in beds 7l-m. Those in the upper part are distorted and fragmented and often incomplete indicating exhumation and reburial. The body chamber of one nautilus from bed 7l contains a solitary coral, *Montlivaltia*, and a number of gastropods preserved in calcite. Several specimens of the macrurous crustacean *Glyphea regleyana* (Desmarest, 1822) have been found in association with *Thalassinoides* burrows in bed 7l. Plant remains are also present.

Redhole Lane Beds

Towards the top of the quarry, about 12 m above bed 6, diagnostic ammonites occur in bed 7r between horizons 7r'X' and 7r'Y" within the Sherborne Limestone Member. The thin bedded limestones previously known as the 'stone used for lime' (Buckman 1893), which are less massive than the underlying Building-stone sensu stricto, Parsons called the Redhole Lane Beds, whose proposal we accept. At Frogden they are about 2.0 m thick.

Bed 7r. Garantiana Zone, Dichotoma Subzone. Bj-24a. Fig. 6.1-9.

Garantiana trauthi Bentz, 1928 [M] (r) and sp. aff., *Garantiana* aff. *baculata* (Quenstedt, 1857) [M] (r), *G. platyryma* (S. Buckman, 1921) [M] (o) and sp. aff., *Lectosphinctes otiophorus* (S. Buckman, 1920) [m] (r), *L.* aff. *garnieri* Pavia, 1973 [M] (r), *Spiroceras* aff. *annulatum* (Deshayes, 1831). 0.30 m.

Scarce specimens of *Garantiana* have been obtained from the overlying beds 7s and t but are indeterminate beyond generic level.

Combe Limestone Member

Above the Sherborne Limestone Member in the Sherborne area there is a change of lithology to broken limestone and marl. At the base the pieces of limestone are small (0.10-0.15 m) with a gradual coarsening upward into continuous beds of broken limestone seen to the level of the field brash in the quarry. This unit previously known as the 'Rubbly beds' is formally named here as the Combe Limestone Member after the excellent exposures on either side of the 'Combe' (Sandford Lane, Buckman 1893). The term 'Rubbly beds' is rejected as it has a prior use in the Portland Beds (Blake 1880), as well as for other beds in the Inferior Oolite of the Bath district (Richardson 1907). Redhole Lane quarry is here chosen as type locality. The maximum thickness of this unit is unknown, although in excess of 5.6 m have been recorded from Redhole Lane (Richardson 1932) and at least 4.0 m was recorded at Coldharbour (Chandler et al. 1999) above the floor of the temporary exposure which was already some way up into the Combe Limestone Member.

We have provisionally numbered the beds of the Combe Limestone Member as bed 8a and b and have included the very top layer of strata below soil level as 8c. About 1.0 m

Fig. 7. Ammonites from beds 8a and b, Garantiana Zone, ?Garantiana Subzone. Ammonite faunal horizon [Bj-24b]. A black dot indicates the last preserved suture. 1A-B. *Garantiana* (*Pseudogarantiana*) aff. *dichotoma* (Bentz) [m] coarse ribbed variety, WC0382. 2A-B. *Garantiana* (*Pseudogarantiana*) aff. *minima* (Wetzel) [m] medium ribbed variety, WC0383. 3A-B. *Garantiana* (*Pseudogarantiana*) aff. *minima* (Wetzel) [m] fine ribbed variety. WC0384. 4A-B. *Garantiana* ex gr. *suevica* Wetzel [M], WC0385. 5A-C. *Sphaeroceras* aff. *globus* Buckman [M] WC0386. 6. *Sphaeroceras auritum tutthum* (Buckman) [m] WC0387. 7A-B. *Oecotraustes genicularis* Waagen [m], WC0388. Scale bar = 1cm.

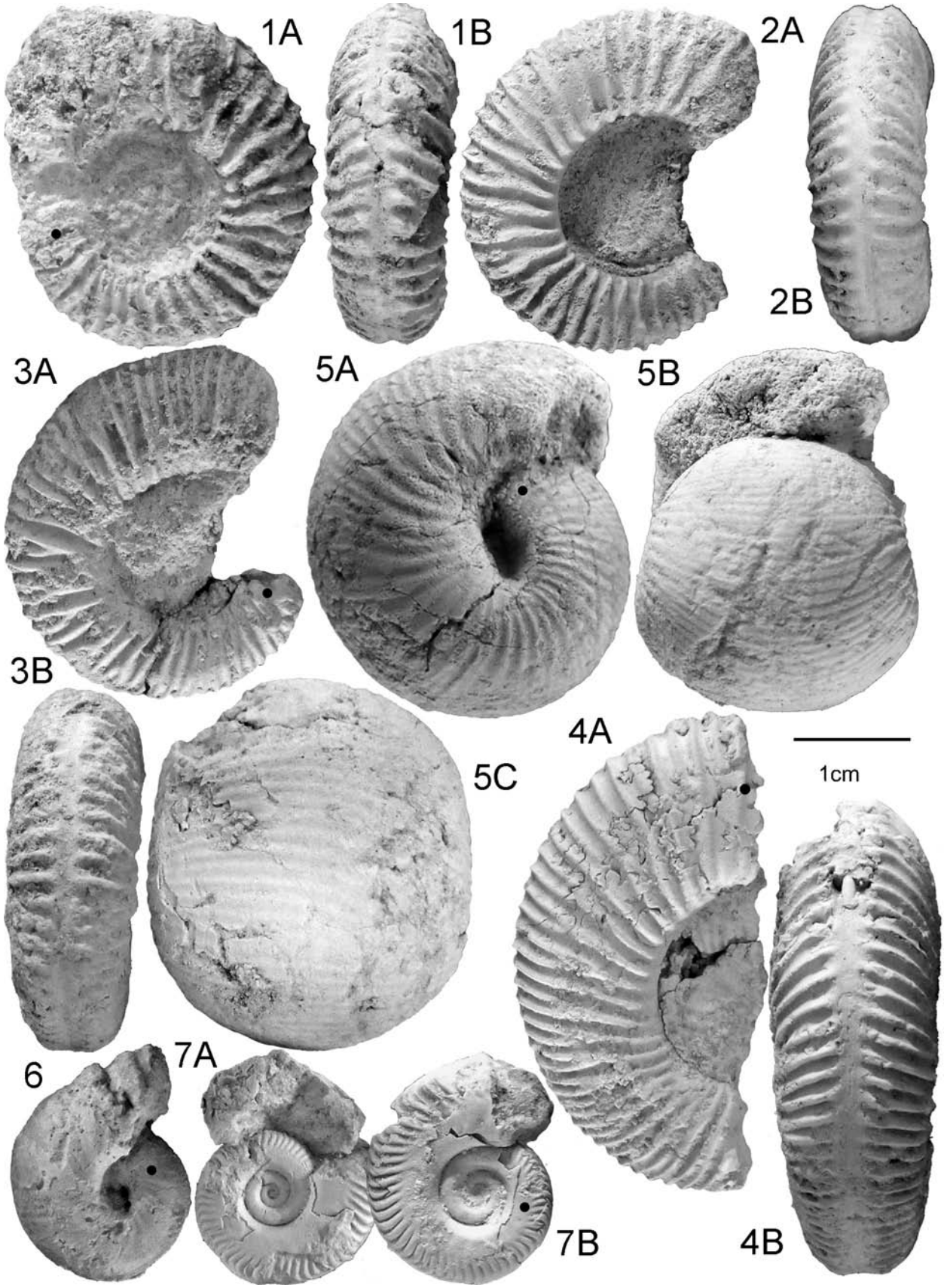


Fig. 7.

of the section that forms the top of the quarry was measured at two locations.

Bed 8a. Garantiana Zone, ?Garantiana Subzone [Bj-24b]. This horizon has previously been recorded in SW Germany and is here described in Dorset for the first time; PARSONS had recognized this horizon at Sandford Lane already. At 0.2-0.4 m above the base of the Combe Limestone Member the following fossils occur (Fig. 7.1-7.):
Garantiana (*Pseudogarantiana*) aff. *dichotoma* BENTZ, 1928 [m] (r), *G.* (*Ps.*) aff. *minima* WETZEL, 1924 [m] (r), *G.* ex gr. *suevica* WETZEL, 1911 [M] (r), *Sphaeroceras* aff. *globus* S. BUCKMAN, 1927 [M] (r), *Sphaeroceras auritum tutthum* S. BUCKMAN, 1921 [m] (c), *Oecotraustes genicularis* WAAGEN, 1869 [m] (r). 1.0 m.
Bed 8b. Garantiana Zone, ?Garantiana Subzone [Bj-24b]. About 0.30 m above the top of bed 8a is a thin, 0.05 m band of very hard bioclastic stone, blue when fresh with abundant tiny *Sphaeroceras* spp. There may also be a second similar band above but it cannot be confirmed due to slumping. 0.50 m.
Bed 8c. Parkinsoni Zone, Acris Subzone [Bj-26]. This includes the highest part of the section visible, the top of which is at the base of the soil. There is no clear change from the bedding below but there is a distinct change in the assemblage of fossils including the first *Parkinsonia*. Most of the fossils are in a reworked state including ammonites of Garantiana and Tetragona subzones Bj-24b & Bj-25. Fig. 8.1-2 and Fig. 9.1-6. *Parkinsonia rarecostata* S. BUCKMAN, 1912 [m] (c), *P. bradstockenisis* DIETZE, 2000 [M] (c), *Prorsisphinctes* spp. [M] (c). *Garantiana subgaranti* WETZEL [M] (r), *G. wetzeli* TRAUTH [M] (r), *G.* aff. *ipfensis* (DIETZE et al., 2002) [M] (r), *Garantiana longidoides* (GAUTHIER, TRÉVISAN & JORON, 2000) [M] (c), *Oppelia* ?*subcostata* (J. BUCKMAN, 1881) [M] (o). 0-0.25 m.

3. Discussion

We conclude that the entire thickness of the Sherborne Limestone Member at Frogden is within one ammonite faunal horizon Bj-24a, *G. dichotoma* of the Garantiana Zone, Dichotoma Subzone. The overlying Combe Limestone Member is partly within the Garantiana Zone but extends into the Acris Subzone of the Parkinsoni Zone (sensu WESTERMANN 1967; GABILLY et. al. 1971). There is evidence for rocks of the Garantiana and Tetragona subzones in bed 8c, but unfortunately we did not find enough well preserved characteristic ammonites. But we know from PARSONS' unpublished manuscript on the Garantiana Zone of the area and ammonites collected by him, that these subzones are well developed in the Combe Limestone Member of the nearby Sandford Lane quarry (3-5 m above the Sandford Lane Fossil Bed). Locations in the Sherborne area show considerable variations in the thickness of deposits preserved for the early Upper Inferior Oolite. It was deposited in the Wessex Basin, which underwent active faulting during the period of deposition (SELLWOOD & JENKYNS 1975; JENKYNS & SENIOR 1991). This resulted in the formation of hollows and fissures in the sea floor which gave the sediments that filled these a degree of protection from the intermittent erosion that was disturbing or removing part or all of the more vulnerable neighbouring deposits. The Sherborne Limestone and Combe members together total in excess of about 30 m in the Sherborne area, with different parts of the succession being present or absent at closely neighbouring localities.

The Garantiana Zone originates from BUCKMAN (1893). Sandford Lane is the type locality. The zone is defined as the point at which *Strenoceras* has disappeared and is replaced by *Pseudogarantiana* (see KRYMHOLTS et al. 1988). At Sandford Lane we have identified a level in the lower part of the Sherborne Limestone Member but just above the *Acanthothyris* Beds containing ammonites which belong to the *G. dichotoma /trauthi* group which places these strata as Dichotoma Subzone (Bj-24).

These observations demonstrate that most of the Sherborne Limestone Member, seen at Frogden, is missing at Sandford Lane, as ammonites occurring just above the *Acanthothyris* Beds at Sandford Lane closely match those in bed 7r to 8a of Frogden in the Redhole Lane Beds near the top of the exposure. There is thus a significant non-conformity between the *Acanthothyris* Beds and the Redhole Lane Beds at Sandford Lane. Alternatively ammonites at Sandford Lane may be slightly earlier than those of the Redhole Lane Beds of Frogden but so close in age that the ammonites cannot be discriminated. At Louse Hill and Bradford Abbas only a few kilometres to the west, the Sherborne Limestone Member is absent, replaced by a thin (0.01-

Fig. 8. Ammonites from bed 8c, Parkinsoni Zone, Acris Subzone. Ammonite faunal horizon Bj-26. including ammonites of the Garantiana and Tetragona subzones, ammonite faunal horizons Bj-24b & Bj-25. A black dot indicates the last preserved suture. 1A-B *Garantiana subgaranti* TRAUTH [M], WC0389. 2A-B. *Oppelia* ?*subcostata* (J. BUCKMAN) [M], WC0390. Scale bar = 1cm.

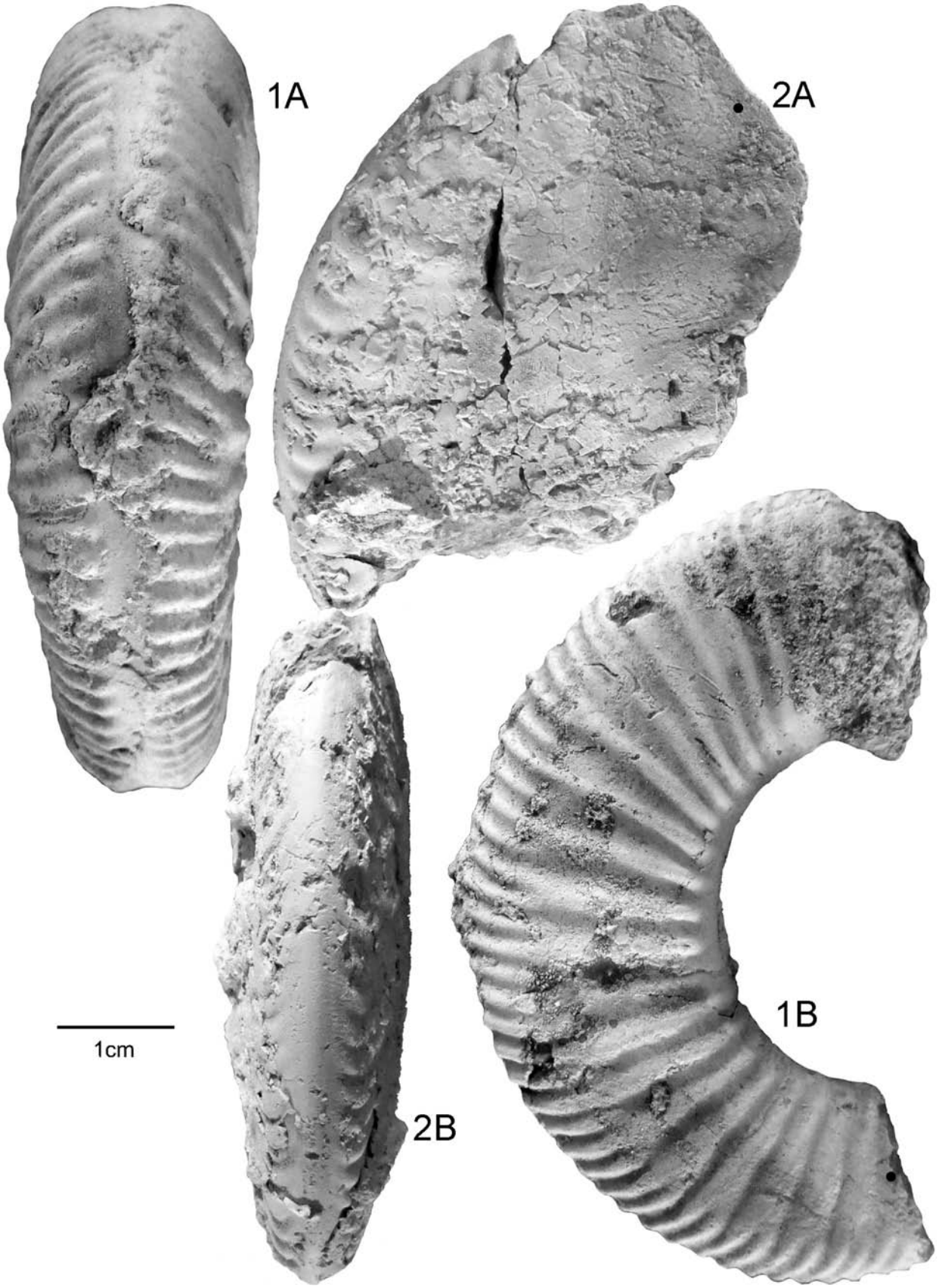


Fig. 8.

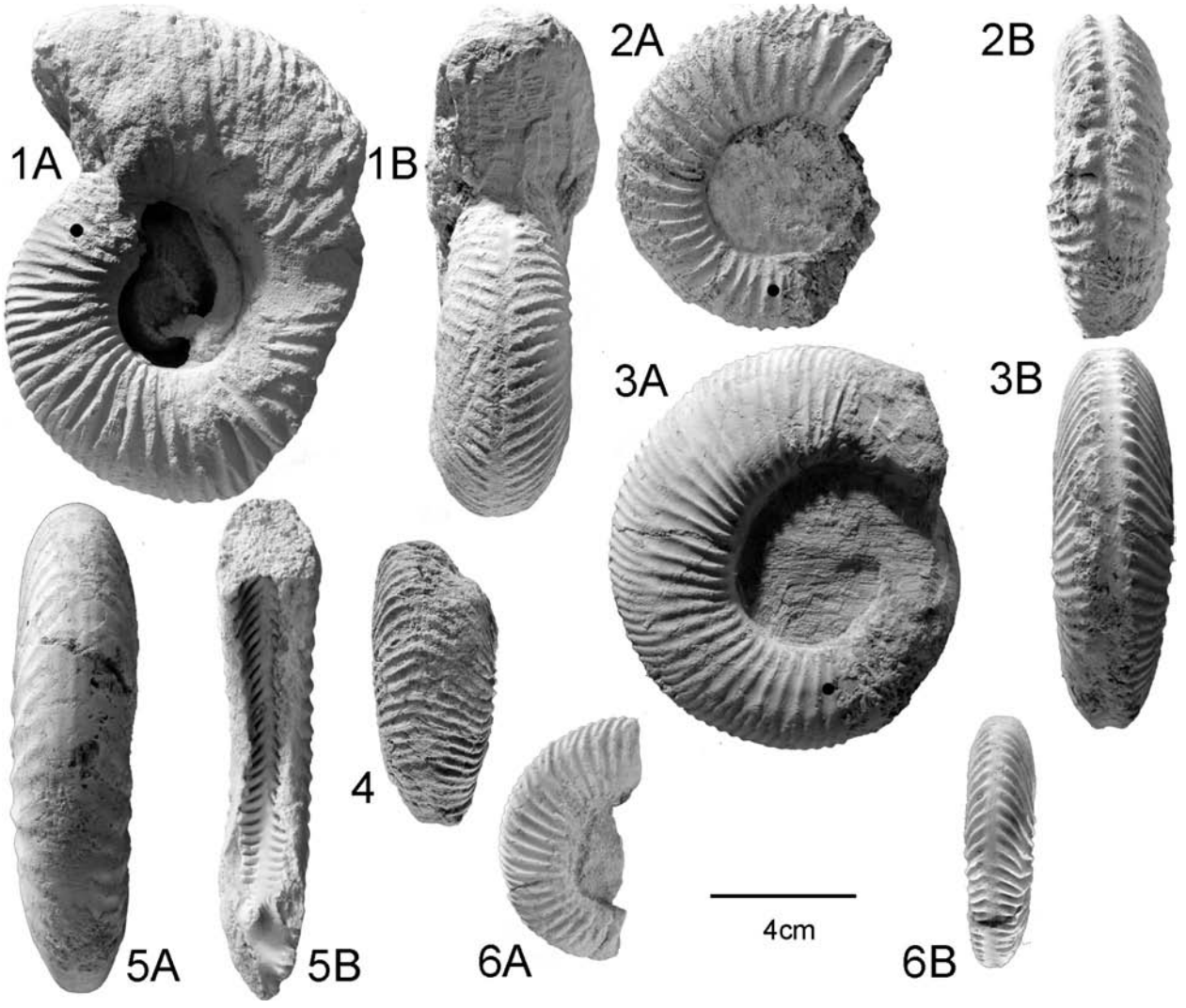


Fig. 9. Ammonites from bed 8c, Parkinsoni Zone, Acris Subzone Bj-26, including ammonites of Garantiana and Tetragona subzones. Ammonite faunal horizons Bj-24b & Bj-25. A black dot indicates the last preserved suture. 1A, B. *Garantiana longidoides* (Gauthier, Trévisan & Joron) [M], WC0372. 2A, B. *Garantiana* aff. *ipfensis* (Dietze et al.) [M], WC0374. 3A, B. *Garantiana longidoides* (Gauthier, Trévisan & Joron) [slim variant], WC0373. 4A, B. *Garantiana wetzeli* Trauth [M], WC0371. 5A, B. *Parkinsonia rarecostata* Buckman [m], WC0376. 6A, B. *Parkinsonia rarecostata* Buckman [m], WC0375. Scale bar = 4cm.

0.20 m) lenticular limestone, the *Astarte* Bed, with 'snuff-box' oncoliths lying above a thin Irony Bed representing the residue of at least part of the Humphriesianum and Niortense zones, all that is left of beds 4 to 6 as seen at Frogden. The Parkinsoni Zone, Bj-27a rests directly on these beds. Directly north-west of this area, at Halfway House, massive beds of the Truellei Subzone Bj-27b rest directly upon the *Astarte* Bed. What is seen of the Inferior Oolite at each locality is a 'snap-shot' of only part of the succession, the result of much localised tectonics, penecontemporaneous erosion and changes in sediment supply.

One of us, M D has prepared large slabs of Sherborne Building Stone cut at various orientations, making it possible to examine the finer structure of the rock. At certain levels, e.g. bed 7l, there is evidence of extensive bioturbation. The upper surface of the bed is covered in large lateral *Thalassinoides* burrows associated with *Glyphea regleyana* fragments. In cross-section burrows appear as a circular infill of fine pale sediment. A nautilus body chamber, cut in cross section, was seen to contain a large number of

fossils in calcitic preservation in complete contrast to the surrounding rock. This suggests that the general absence of fossils throughout the Sherborne Building Stone may be due to taphonomic factors. During quarrying a channel was discovered in bed 7l one metre or so wide and some ten metres long. It was filled by clay and rubble and aligned NW-SE. This structure may be a scour channel.

Within some units of the Sherborne Limestone Member there are rounded clasts of distorted fine-grained stone, some with irony bedding lines passing through the lumps that are scattered along the bedding. These are probably compression structures produced by early diagenetic calcium sequestration producing irregularities in hardness. Compression and dewatering then result in the preferential preservation of the lumps with the drapes of compressed beds over them.

The erosion surfaces that typify beds 1-6 are entirely absent from the Sherborne Limestone Member. The sediments of the area are affected by syn-sedimentary faulting as described by Chandler et al. (2013). Frogden has minor faults at the western end of the present workings with a SW-NE direction. Strata to the SW side can be seen to thicken considerably, most evident in beds 7k and 7l. The area lies a few hundred metres from the Oborne Graben, active in the Middle Jurassic. Some account must be given for the large increase in sedimentation rate and supply following the deposition of the Niortense Zone. We suggest that lime sand on the sea floor may have been mobilized by movements in faults resulting in increased sediment flow or mini turbidity events resulting in large intermittent sediment flows onto the descending fault block. Within each fault-bounded area in which the Sherborne Limestone Member occurs the beds show gentle lateral variations in thickness but large-scale cross-bedding of these thicker beds has not been observed apart from in the Hadspen Stone near Bruton (ST 656316). The laminated 'paste' levels between beds 7q and 7s of the Redhole Lane Beds may be bentonites of volcanic origin or pressure solution partings (Bathurst 1987). Further investigation is being undertaken and it may turn out to be the first record of volcanic horizons in Bajocian of the region and could be used to provide a radiometric age for one faunal horizon within the Garantiana Zone.

The ammonite assemblages have also cast light on the age of the lower beds 1-3. Bed 1 is confirmed as being Aalenian, Concavum Zone to Bajocian, Ovale Zone in age. The top of bed 2, the Blue Bed, is proved to be Bj-8, equivalent in age to the middle part of the Sandford Lane Fossil Bed (6c). There is a significant lithological change between Sandford Lane, where bed 6c (Bj-8b) is cream limestones packed with well-preserved macro-fossils and Frogden and Redhole Lane where it is hard silt cemented by lime sand. The Sauzei Zone, so well represented in the nearby locations of Sandford Lane and Redhole Lane is at Frogden only a thin conglomerate (bed 4a) representing Bj-11a.

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