

# The stratigraphy of the Inferior Oolite at South Main Road Quarry, Dundry, Avon

R. B. Chandler<sup>1</sup>, J. H. Callomon<sup>2</sup>, A. King<sup>3</sup>, K. Jeffreys<sup>3</sup>, M. Varah<sup>4</sup> & A. Bentley<sup>5</sup>

CHANDLER, R. B., CALLOMON, J. H., KING, A., JEFFREYS, K., VARAH, M. & BENTLEY, A. 2006. The stratigraphy of the Inferior Oolite at South Main Road Quarry, Dundry, Avon. *Proceedings of the Geologists' Association*, **117**, 345–375. A new section opened on the site of the former South Main Road Quarry, Dundry, Avon, is described. The biostratigraphy of the ammonite succession has been revised through careful bed-by-bed collecting and is presented in a range chart. It is recast in the form of a sequence of discrete ammonite faunal horizons as has become customary in the classical areas of Somerset and Dorset first described in this way by Buckman. One new ammonite faunal horizon has been identified in the Lower Bajocian: Bj-10b, *Sonninia micracanthica* (Buckman). This carries several of what have been regarded in the past as leading guide-fossils of the Sauzei Zone. But it is now seen to be also the type horizon of the index of the Laeviuscula Zone, *Witchellia laeviuscula*. It is therefore retained in the Laeviuscula Zone as its youngest horizon on grounds of nomenclatural stability. The basal boundary of the overlying Sauzei Zone is drawn above it and its lowest ammonite horizon renamed, Bj-11a, *Stephanoceras kalum* (Buckman). The systematics of some important species based on types from Dundry are reviewed briefly and the origins and phylogeny of some important ammonite genera of the Ovale to Sauzei Zones are discussed. The succession of forms of *Witchellia* is now separated as a phyletic subfamily *Witchelliinae* subf. nov. within the polyphyletic clade of the *Sonniniidae*. A new species of *Emileia*, *E. dundriensis*, is described from the Laeviuscula Zone. The nautiloids are also reviewed briefly.

**Key words:** ammonite, biostratigraphy, Dundry, *Emileia*, *E. dundriensis* sp. nov., faunal horizon, Inferior Oolite, Jurassic, South Main Road Quarry, *Witchelliinae* subf. nov., *Witchellia laeviuscula*

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## 1. INTRODUCTION

The outlier of Inferior Oolite capping Dundry Hill, near Bristol, has attracted much attention since the earliest times. In 1799 it provided one of the earliest tests of William Smith's new theory of stratigraphy (see, for example, Winchester, 2001, p. 136) and is shown with remarkable precision on his great geological map of England (Smith, 1815). The subsequent history of exploration was given by Buckman & Wilson (1896; largely repeated, with the addition of maps, in 1898). This seminal review presented the first detailed modern description, a work that laid the foundations for all subsequent accounts. The numerous sections exposed at the time were described in detail and the fossils, particularly the ammonites, listed bed by bed. The geochronology of the successions was then expressed in terms of the hemeral chronostratigraphical classification based on ammonites introduced by Buckman (1893) in his famous

paper on the Inferior Oolite of Sherborne in Dorset, on a biostratigraphical time-scale of a finesse now having few rivals (see review in Callomon, 1995a). As in Dorset, the ammonites served to show not only the ages of the beds that are present at Dundry but also of those that are not: the existence of non-sequences within the succession on the time-scale of the evolution of the ammonites. One of these, in particular, is of major importance, giving rise to a detectably angular unconformity over a distance of only 2 km. Attributed to what Buckman called the Bajocian Denudation, followed by the Vesulian Transgression (Arkell, 1933), it can be followed all over southern England and into France, marking the boundary between the Middle and Upper Inferior Oolite. (We retain for convenience the threefold division of the Inferior Oolite of Wessex, first introduced by Witchell (1882), consolidated by Arkell (1933) and maintained in the Geological Society's *Correlation Charts* (Parsons, 1980)).

The most recent revision of the area was that of Parsons (1979, 1980), who re-examined the four principal sections that were still accessible out of the many described by Buckman and Wilson: Rackledown quarry [ST 572 654], Barnes Batch Spinney [ST 557 659], Grove Farm [ST 551 671] and South Main Road quarry [ST 567 655]. New collections added something to the ammonite biochronology, and the numerous lithostratigraphical terms for individual beds that had crept in over the years, some introduced by Parsons himself, could be rationalized. The classification proposed by him is followed here. Formal chronostratigraphical classification was reviewed in the framework of standard Zones and Subzones, the naming and delimitation of several of which had to be modified. Additional collections of ammonites made by one of us (JHC) led to some further refinement of the biostratigraphy in the framework of a revised catalogue of the characteristic ammonite faunal horizons of the Inferior Oolite of Dorset and Somerset (the revived modern analogue of Buckman's hemeral chronology: Callomon & Chandler, 1990). Slight faulting due to hill-top cambering was described in the revised Bristol Memoir (Kellaway & Welch, 1993, and see notes below).

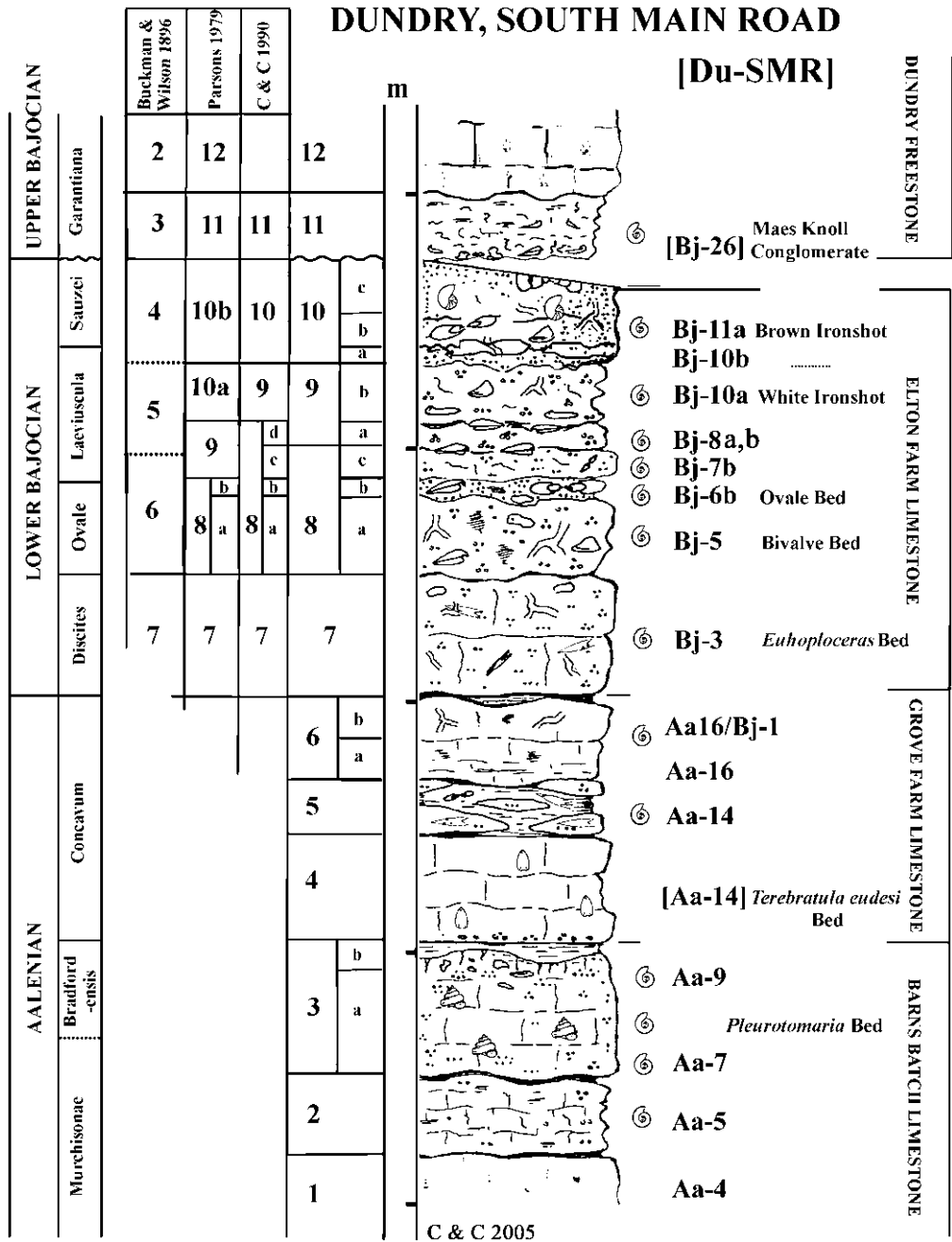
Besides its stratigraphical importance, the area has long been famous for its superbly preserved fossils. They have found their way into almost every museum, and Dundry is the type locality of numerous species in the literature, going back to the Sowerbys' *Mineral Conchology*. Particularly important are the ammonites from the so-called Brown and White Ironshot limestones in the Laeviuscula and Sauzei Zones of the middle Lower Bajocian. This part of the succession remains one of the stratigraphically least well-understood parts of the Middle Jurassic, both in Britain and in the rest of Europe. Dundry is one of the few places where it is both well represented and richly fossiliferous, yet unresolved problems remain because of the thin, highly condensed development of the strata there.

As part of a recent national initiative by English Nature – 'FACE LIFT' – to make degraded but geologically important sections accessible again, the site at the former South Main Road quarry, already a registered Site of Special Scientific Interest (SSSI), was chosen for restoration. It is given here a locality-code designation Du-SMR for short. It is also one of the two sections at Dundry to be selected for description in the Geological Conservation Review (GCR) of the Joint Nature Conservation Committee (Cox & Sumbler, 2002), the other being Barnes Batch Spinney. (The GCR account gives an excellent summary of both the litho- and chronostratigraphy but is based only on earlier published accounts.) The quarry had become heavily overgrown and filled with refuse, leaving little opportunity for further systematic collection and stratigraphical study. The floor level of the old quarry had lain just below the Brown and White Ironshot limestones. In these, the Laeviuscula and Sauzei Zones attain here their maximum residual development on

Dundry Hill below the Vesulian Unconformity. The face was cleared mechanically and excavated (temporarily) to a depth adequate to display previously unexposed lower rocks down to the Murchisonae Zone, of Aalenian age, and upwards to expose the lower part of the Upper Inferior Oolite, of Upper Bajocian age, lying above the Vesulian Unconformity. The section is now cleared of vegetation and well exposed; a new perimeter-fence safely encloses the site and re-profiled scree-slopes permit collection of fossil specimens. To help conserve the face, visitors are asked not to hammer or to collect directly from the rock exposures (signs are posted on-site). Permission to visit the site should be obtained from the owner at Upton Farm, Dundry, which is located approximately 0.5 km NNE of the quarry. Access from the road is via a stile located at the downslope end of the site.

The recent excavations have enabled us to record the entire section anew and correlation with those of the other nearby sites recorded by Parsons (1979), as well as with those at some localities further afield in Dorset and Somerset. The section is shown graphically in Figure 1. Beds were numbered from the oldest exposed upwards. Numbers used in previous accounts are also shown. The fauna was collected bed by bed. Details of occurrences are collected in a range chart shown in Figure 2, to reduce repetition of the names in the text. Only species from the Lower Bajocian are shown, for the Aalenian lower beds yielded nothing significantly new: the few forms recorded are listed in the text. The taxa listed in the range charts record those collected in the present work, together with some additional items collected in previous years by two of us (JHC, 1972; AB, 1971–92). They include many species already listed by previous authors, but not all: the repetitions serve to confirm the older records and, in many cases, to extend the known ranges or to narrow down the precise stratigraphical levels at which some species recorded previously occur.

The assemblages of ammonites collected bed by bed were assigned to **faunal horizons** ( $\varphi$ ) following the methods of Callomon & Chandler (1990), using as the starting point their labelling as given in a subsequently revised list for those of the Inferior Oolite (Callomon, 1995b). It emerged that yet further additions and modifications have become necessary. One of these has serious consequences for the standard zonation as a whole, involving the boundary of the Laeviuscula and Sauzei Zones. The currently recognizable succession of faunal horizons over the range of strata in the Lower Bajocian seen at Dundry is shown in Figure 3. It is discussed in more detail below. A biochronology of fossil assemblages shown in this way implies that each assemblage is taken to be indivisibly isochronous, hence to be regarded as effectively the record of a geological instant separated from its neighbours by gaps of unknown duration. New discoveries can therefore be slotted into these gaps as they are made, making it necessary to modify the system of labelling.



**Fig. 1.** Diagrammatic representation of the section in weathering profile. Besides the bed numbering adopted here, three previous schemes (Buckman & Wilson, 1896; Parsons, 1979; Callomon & Chandler, 1990) are also shown. The lithostratigraphic classification follows that of Parsons (1980). Symbols Aa-4 ... Bj-1 ... label the faunal horizons of the ammonite biostratigraphy (see text and Fig. 3).

To retain the basic framework of rising numerical succession introduced in 1990, this is most simply done by adding letters as suffixes, e.g. Bj-10a, Bj-10b for the original Bj-10, to reflect the insertion of a new horizon

between Bj-9 and Bj-11. Such letters do not imply inferior hierarchical status through subdivision but reflect merely the insertion of newcomers into the succession. The assignment of the ammonite faunas as

| Standard STAGES:                            |  | AALENIAN |      |          |        | LOWER BAJOCIAN |         |             |            |       |          |        |        |        |        | UB    |
|---|--|----------|------|----------|--------|----------------|---------|-------------|------------|-------|----------|--------|--------|--------|--------|-------|
| Standard Zones:                             |  | Formosum |      | Discites |        | Ovale          |         | Laeviuscula |            |       |          | Sauz.  |        |        |        |       |
| Faunal horizons                             |  | Aa-16    | Bj-1 | Bj-3     | (Bj-4) | Bj-5           | [Bj-6a] | Bj-6b       | [Bj-6c-7a] | Bj-7b | Bj-8a, b | [Bj-9] | Bj-10a | Bj-10b | Bj-11a | Bj-26 |
| Beds  |  | 6a       | 6b   | 7        |        | 8a             |         | 8b          |            | 8c    | 9a       | 9b     | 10a    | 10b-c  |        | 11    |
| VESULIAN UNCONFORMITY                       |  |          |      |          |        |                |         |             |            |       |          |        |        |        |        |       |
| 1. GRAPHOCERATIDAE                          |  |          |      |          |        |                |         |             |            |       |          |        |        |        |        |       |
| Graphoceras decorum Buckman                 |  |          | •    |          |        |                |         |             |            |       |          |        |        |        |        |       |
| G. limitatum Buckman                        |  |          | •    |          |        |                |         |             |            |       |          |        |        |        |        |       |
| G. stigmatosum Buckman                      |  |          | •    |          |        |                |         |             |            |       |          |        |        |        |        |       |
| Hyperlioceras politum (Buckman)             |  |          | •    | •        |        |                |         |             |            |       |          |        |        |        |        |       |
| H.rudidiscites Buckman                      |  |          |      | •        |        |                |         |             |            |       |          |        |        |        |        |       |
| H. deflexum Buckman                         |  |          |      |          | •      |                |         |             |            |       |          |        |        |        |        |       |
| H. liodiscites Buckman                      |  |          |      |          | •      |                |         |             |            |       |          |        |        |        |        |       |
| H. subsectum Buckman                        |  |          |      |          | •      |                |         |             |            |       |          |        |        |        |        |       |
| 2. HAMMATOCERATIDAE                         |  |          |      |          |        |                |         |             |            |       |          |        |        |        |        |       |
| Fissiloboceras *fissilobatum (Waagen)       |  |          |      |          |        | •              |         | •           |            |       |          |        |        |        |        |       |
| F. ovale (Quenstedt)                        |  |          |      |          |        |                |         | •           |            |       |          |        |        |        |        |       |
| 3. SONNINIIDAE                              |  |          |      |          |        |                |         |             |            |       |          |        |        |        |        |       |
| Sonninia (Euhoploceras) irregularis Buckman |  |          |      | •        |        |                |         |             |            |       |          |        |        |        |        |       |
| S. (E.) marginata Buckman                   |  |          | •    | •        |        |                |         |             |            |       |          |        |        |        |        |       |
| S. (E.) modesta Buckman                     |  |          |      | •        |        |                |         |             |            |       |          |        |        |        |        |       |
| S. (E.) polyacantha (Waagen)                |  |          |      |          |        | •              |         |             |            |       |          |        |        |        |        |       |
| S. (E.) cf. adicra (Waagen) et Buckman      |  |          |      |          |        | •              |         | •           |            |       | •        |        |        |        |        |       |
| S. (E.) cf. acanthera (Buckman)             |  |          |      |          |        |                |         | •           |            |       | •        |        |        |        |        |       |
| S. (E. ?) jugifera (Waagen)                 |  |          |      |          |        | •              |         |             |            |       | •        |        |        |        |        |       |
| S. (E.) papilionacea Hiltemann              |  |          |      |          |        |                |         |             |            |       | •        |        |        |        |        |       |
| S. (E.) undifer (Buckman)                   |  |          |      |          |        |                |         |             |            |       | •        |        |        |        |        |       |
| S. (s.l.) corrugata (J. de C. Sowerby) [m]  |  |          |      |          |        |                |         |             |            |       |          | •      |        |        |        |       |
| S. (Papilliceras) *papillata Buckman        |  |          |      |          |        |                |         |             |            |       | •        |        |        |        |        |       |
| S. (P.) cf. or aff. arenata (Quenstedt)     |  |          |      |          |        |                |         |             |            |       | •        |        |        |        |        |       |
| S. (P.) micracantha Buckman                 |  |          |      |          |        |                |         |             |            |       |          |        |        |        | •+     |       |
| S. (P.) mesacantha (Waagen) - Buckman       |  |          |      |          |        |                |         |             |            |       |          |        |        |        | •      |       |
| S. (Sonninia) *propinquans Bayle            |  |          |      |          |        |                |         |             |            |       |          |        |        |        |        | •     |
| S. (Sonninites) *felix Buckman              |  |          |      |          |        |                |         |             |            |       |          |        |        |        | •      | •     |
| Shirbuirnia? gingensis (Waagen)             |  |          |      |          |        |                |         | •           |            |       |          |        |        |        | •      |       |
| Sh?. rudis (Quenstedt)                      |  |          |      |          |        |                |         | •           |            |       |          |        |        |        |        |       |
| Sh?. platymorpha Buckman & aff.             |  |          |      |          |        |                |         |             |            |       |          |        |        |        | •      |       |
| Pseudoshirbuirnia *stephani (Buckman)       |  |          |      |          |        |                |         |             |            |       | •        | •      |        |        |        |       |
| 4. WITCHELLIINAE Subfamily nov.             |  |          |      |          |        |                |         |             |            |       |          |        |        |        |        |       |
| Fontannesia sp.                             |  |          | •    |          |        |                |         |             |            |       |          |        |        |        |        |       |
| Witchellia romanoides (Douvillé)            |  |          |      |          |        |                |         | •           |            |       | •        | •      |        |        |        |       |
| W. albida (Buckman) & sp. aff.              |  |          |      |          |        |                |         | •+          |            |       |          |        |        |        | •      |       |
| W. pavimentaria (Buckman)                   |  |          |      |          |        |                |         |             |            |       | •        | •      |        |        |        |       |
| W. cf. connata (Buckman)                    |  |          |      |          |        |                |         | •           |            |       | •        |        |        |        |        |       |
| W. pseudoromanoides Dietze et al., 2003     |  |          |      |          |        |                |         |             |            |       | •        |        |        |        |        |       |
| W. *laeviuscula (Sowerby)                   |  |          |      |          |        |                |         |             |            |       | •        |        |        |        |        |       |
| W. plena (Buckman)                          |  |          |      |          |        |                |         |             |            |       |          |        | •      |        | •+     |       |
| W. patefactor Buckman                       |  |          |      |          |        |                |         |             |            |       | •        |        |        |        |        |       |
| W. spinifera Buckman                        |  |          |      |          |        |                |         |             |            |       | •        |        |        |        |        |       |
| W. glauca Buckman                           |  |          |      |          |        |                |         |             |            |       | •        |        |        |        |        |       |
| W. actinophora Buckman                      |  |          |      |          |        |                |         |             |            |       | •        |        |        |        |        |       |
| W. falcata (Buckman)                        |  |          |      |          |        |                |         |             |            |       | •        |        |        |        |        |       |
| W. (Pelekodites) *pelekus Buckman [m]       |  |          |      |          |        |                |         | •+          |            |       |          |        |        |        |        |       |
| W. (P.) aurifer (Buckman) [m]               |  |          |      |          |        |                |         |             |            |       |          |        |        | •+     |        |       |

recorded in Figures 1 and 2 to their faunal horizons is also indicated there and we believe that this represents the ultimate level of chronostratigraphical resolution of the succession at Dundry achievable now by means of fossils.

In this account no attempt is made at a systematic revision of the ammonites at specific or generic level or to place into synonymy nominal taxa that are probably merely sexual anti-dimorphs. The names in the lists are

those of the nominal (morpho)species that it has been possible to identify. Some additional palaeontological notes are given as appropriate in a later section below. There is a considerable number of older nominal species in the literature whose types came from Dundry. Some go back to the Sowerbys' *Mineral Conchology* (1818–1825), but the majority were introduced by S. S. Buckman in his *Type Ammonites* (1913–1930) (abbreviated to *TA* hereafter). These were

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|--|----------|------|----------------|----------------|-------------|---------------------|-------|----------|-------|--------|--------|--------|-------|
| Standard Zones:  | Formosum |      | Discites       | Ovale          | Laeviuscula |                     |       |          | Sauz. |        |        |        |       |
| Faunal horizons  | Aa-16    | Bj-1 | Bj-3<br>(Bj-2) | Bj-5<br>(Bj-4) | Bj-6a       | Bj-6b<br>[Bj-6c-7a] | Bj-7b | Bj-8a, b | Bj-9  | Bj-10a | Bj-10b | Bj-11a | Bj-26 |
| Beds   | 6a       | 6b   | 7              | 8a             | 8b          |                     | 8c    | 9a       | 9b    | 10a    | 10b-c  |        | 11    |
| VESULIAN UNCONFORMITY  |          |      |                |                |             |                     |       |          |       |        |        |        |       |
| 5. STRIGOCERATIDAE   |          |      |                |                |             |                     |       |          |       |        |        |        |       |
| <i>Strigoceras compressum</i> (Etheridge)                            |          |      |                | •              |             |                     |       |          |       |        | •      |        |       |
| <i>S. languidum</i> (Buckman)  |          |      |                |                |             |                     | •     |          |       |        |        |        |       |
| <i>Cadomoceras</i> sp. [m]   |          |      |                |                |             |                     |       |          |       | •      |        |        |       |
| 6. LISSOCERATIDAE  |          |      |                |                |             |                     |       |          |       |        |        |        |       |
| <i>Lissoceras</i> aff. <i>semicostulatum</i> Buckman                 |          |      |                |                |             |                     |       | •        |       |        |        |        |       |
| 7. BRADFORDIINAE   |          |      |                |                |             |                     |       |          |       |        |        |        |       |
| <i>Bradfordia</i> cf. <i>inclusa</i> Buckman                         |          |      |                |                |             |                     |       |          |       | •      |        |        |       |
| <i>B. (Iokastelia)</i> sp.   |          |      |                |                |             |                     |       | •        |       | •      |        |        |       |
| <i>B. (Amblyoxyites)</i> * <i>amblys</i> Buckman                     |          |      |                |                |             |                     |       |          |       | •      |        |        |       |
| <i>B. (A.)</i> cf. <i>praeradiata</i> (Douvill )                     |          |      |                |                |             |                     |       | •        |       |        |        |        |       |
| 8. OPPELIIDAE  |          |      |                |                |             |                     |       |          |       |        |        |        |       |
| <i>Protoecotraustes</i> * <i>spiniger</i> (Buckman) [m]              |          |      |                |                |             |                     |       |          |       |        | •      | •      |       |
| 9. STEPHANOCERATIDAE   |          |      |                |                |             |                     |       |          |       |        |        |        |       |
| <i>Stephanoceras perfectum</i> (Buckman)                             |          | •    | •              |                |             |                     |       |          |       |        |        |        |       |
| <i>St. (*Skirroceras)</i> <i>macrum</i> (Quenstedt)                  |          |      |                |                |             |                     |       |          |       |        | •      | •      |       |
| <i>St. (Sk.) bayleanum</i> (Oppel)                                   |          |      |                |                |             |                     |       |          |       | •      | •      | •      |       |
| <i>St. (Sk.) kalum</i> (Buckman)                                     |          |      |                |                |             |                     |       |          |       |        | •      | •      |       |
| <i>St. (Sk.) leptogyrale</i> Buckman                                 |          |      |                |                |             |                     |       |          |       |        | •      | •      |       |
| <i>St. (Normannites)</i> <i>braikenridgii</i> (J. Sowerby) [m] & sp. |          |      |                |                |             |                     |       |          |       | •      | •      | +      |       |
| * <i>Mollistephanus mollis</i> Buckman                               |          |      |                |                |             |                     |       | •        |       |        |        |        |       |
| <i>Kumatostephanus perjucundus</i> (Buckman)                         |          |      |                |                |             |                     |       |          |       |        | •      |        |       |
| <i>K. *kumaterus</i> Buckman   |          |      |                |                |             |                     |       |          |       |        | •      | +      |       |
| 10. OTOITIDAE  |          |      |                |                |             |                     |       |          |       |        |        |        |       |
| <i>Docidoceras</i> * <i>cylindroides</i> Buckman                     |          |      | •              |                |             |                     |       |          |       |        |        |        |       |
| <i>D.</i> aff. <i>trilobitoides</i> Buckman [m]                      |          |      | •              | •              |             |                     |       | •        |       |        |        |        |       |
| <i>Emileia dundriensis</i> sp. nov.                                  |          |      |                |                |             |                     |       | •        | •     |        |        |        |       |
| <i>E. vagabunda</i> Buckman and sp. aff.                             |          |      |                |                |             |                     |       | •        |       |        |        |        |       |
| <i>E. polyschides</i> (Waagen)                                       |          |      |                |                |             |                     |       |          | •     | •      | •      |        |       |
| <i>E. polymera</i> (Waagen)  |          |      |                |                |             |                     |       |          | •     | •      | •      | •      |       |
| <i>E. bulligera</i> Buckman  |          |      |                |                |             |                     |       |          |       | •      | •      |        |       |
| <i>E. (Otoites)</i> <i>cricki</i> or <i>douvill </i> Parsons [m]     |          |      |                | •              | +           |                     |       | •        | •     |        |        |        |       |
| <i>E. (O.) contracta</i> (Sowerby) [m]                               |          |      |                |                |             |                     |       |          |       | •      |        |        |       |
| <i>E. (O.) fortis</i> Westermann [m]                                 |          |      |                |                |             |                     |       |          |       | •      | •      | •      |       |
| <i>E. (*O.) sauzei</i> (d'Orbigny) & aff., cf. [m]                   |          |      |                |                |             |                     |       |          |       |        |        | •      |       |
| <i>Emileites</i> * <i>malenotatus</i> Buckman                        |          |      |                | •              |             |                     |       |          | +     |        |        |        |       |
| <i>E. catamorphus</i> (Buckman)                                      |          |      |                | •              |             |                     |       |          |       |        |        |        |       |
| 11. SPHAEROCERATIDAE   |          |      |                |                |             |                     |       |          |       |        |        |        |       |
| <i>Labyrinthoceras meniscum</i> (Waagen)                             |          |      |                |                |             |                     |       |          |       | •      | •      |        |       |
| <i>L. amphilaepes</i> Buckman  |          |      |                |                |             |                     |       |          |       |        | •      | +      |       |
| <i>L. intricatum</i> Buckman   |          |      |                |                |             |                     |       |          |       |        |        | •      |       |
| <i>Frogdenites</i> * <i>spiniger</i> Buckman                         |          |      |                |                |             |                     |       |          |       | •      |        |        |       |
| <i>F. profectus</i> Buckman  |          |      |                |                |             |                     |       |          |       |        | •      | +      |       |

**Fig. 2.** Range chart of the ammonite distribution in the section at Dundry SMR quarry. Taxonomic names are used in the morphospecific and morphogeneric senses embodied in the conventional literature of the past, just to record the forms found. Species whose types are microconchs indicated as [m]; all others are macroconchs, [M], not marked. Some simplifications at the generic level and rearrangements at the family group level have been included: these are discussed in the text. Asterisks (\*) attached to names of species indicate type species of the genus in which placed. Plus symbol (+), type horizon of a species for which Dundry is the type locality. Relative abundances are indicated by the sizes of the dots: small, occurs but rare (R: at least one specimen); medium, fairly common (O: 2-4 specimens); large: common (C: 4+specimens).

discussed by Parsons (1979). Identifications in the present work were by direct comparison with type material wherever possible. Relative abundances may be indicated as common (C), occurs (O) or rare (R): see caption to Figure 2.

The newly collected ammonites and associated fossils have been registered as part of the Sedgwick

Museum collection, Cambridge and are at present with one of us (RBC). Some other material collected elsewhere at Dundry (AB) is also indicated. Nautiloids collected during this study are deposited at Somerset County Museum (Taunton Castle). References to some other collections include Bristol City Museum (BCM).

| Zone        | Subzone     | Ammonite faunal horizons                 |
|-------------|-------------|--|
| Sauzei      |             | Bj-12 <i>Stephanoceras rhytum</i>        |
|             |             | Bj-11b <i>Nannina evoluta</i>            |
|             |             | Bj-11a <i>Stephanoceras kalum</i> (nn)   |
| Laeviuscula | Laeviuscula | Bj-10b <i>Sonninia micracanthica</i> (n) |
|             |             | Bj-10a <i>Witchellia spinifera</i> (nn)  |
|             |             | Bj-9 <i>Witchellia rubra</i>             |
|             | Trigonalis  | Bj-8b <i>Shirburnia trigonalis</i>       |
|             |             | Bj-8a <i>Euhoplceras nodatipingue</i>    |
|             |             | Bj-7b <i>Witchellia pseudoromanoides</i> |
| Ovale       |             | Bj-7a <i>Witchellia gelasina</i>         |
|             |             | Bj-6c <i>Witchellia pseudoromani</i> MS  |
|             |             | Bj-6b <i>Shirburnia gingensis</i>        |
|             |             | Bj-6a <i>Euhoplceras zugophorum</i>      |
|             |             | Bj-5 <i>Witchellia romanoides</i>        |
|             |             | Bj-4 <i>Bradfordia inclusa</i>           |
| Discites    |             | Bj-3 <i>Hyperlioceras subsectum</i>      |
|             |             | Bj-2b <i>Hyperlioceras rudidiscites</i>  |
|             |             | Bj-2a <i>Hyperlioceras walkeri</i>       |
|             |             | Bj-1 <i>Hyperlioceras politum</i>        |

**Fig. 3.** The ammonite faunal horizons of the English Lower Bajocian. This scheme differs slightly from previous ones (Callomon, 1995b; Cox & Sumbler, 2002): *n*, new; *nn*, unchanged but renamed after a more appropriate index (see text). Where the basal line of a box representing a biohorizon (a biostratigraphical unit) coincides with a line marking the boundary between two standard Zones or Subzones (a chronostratigraphical time-plane) that biohorizon is taken to *define* the zonal boundary typologically in a type section. The two cases here are the horizons Bj-1, Discites Zone, and Bj-11a, Sauzei Zone. In the other cases the zonal boundary is taken to *lie between* two biohorizons but not so far to be defined in a type section.

2. STRUCTURE

The quarry faces directly southwest. The face is little more than 30 m long, straight and cut back into a steep

3. THE SECTION

The section is shown in Figure 1. A full listing of ammonites is shown in Figure 2 and the text gives the names of only a few of the elements that particularly characterize the faunal horizons to which beds are assigned. Bed numbers as used by Parsons (1979) are shown as (P).

The upper part of the succession is slumped and distorted. Thicknesses for the Upper Bajocian are approximate and based partly on nearby sections. From above:

Upper Inferior Oolite: Upper Bajocian  
Parkinsoni Zone

|                                       |   |          |
|---------------------------------------|---|----------|
| <b>Bed 13.</b> CORALLINE BEDS         | Limestones, cream, broken and slipped, not examined in detail.<br>Coral and sponge debris (C).<br><i>indistinct parting</i> | c. 1.8 m |
| <b>Bed 12 (P12).</b> DUNDRY FREESTONE | Limestones, yellow, marly, well-bedded, broken and distorted,<br>not examined in detail.<br><i>indistinct parting</i>       | c. 2.0 m |

section of the hillside. The beds have been subjected to considerable slumping through cambering over a prolonged period of time, arising from the position of the Inferior Oolite as a residual hard cap on top of the hill overlying soft Liassic clay formations that make up the major part of the hill. The highest beds, of very broken and slumped limestones of the Upper Inferior Oolite, consisting of Coralline Beds over Dundry Freestone, of Late Bajocian age, are separated from the Lower Bajocian by a spectacular flat erosion surface (Fig. 1). In places the slumped topmost Coralline Beds have come to rest on the Brown Ironshot or even Ovale Bed of the Middle Inferior Oolite, cutting out both the Dundry Freestone and its basal Maes Knoll Conglomerate. There is a suggestion of solifluctional deposits that could have even a periglacial origin. A mixture of drape and block faulting mantles the hillslopes for some 30 m down from the summit, basically due to spring-sapping into the Aalenian/Toarcian clays undercutting the limestone capping. In the barnyard of Elton Farm, across the road from the quarry and some 6 m lower down, *Hyperlioceras* spp. and *Witchellia* spp. have been collected from the rubble.

Slumping has also cut down into the Middle Inferior Oolite, below the erosion plane, for a conspicuous feature of the exposure are the discontinuities in the outcrop along the quarry face of the Brown Ironshot at its top and some of the beds below. The excavation revealed a series of NW–SE-trending fractures, roughly parallel to the quarry face, with strata dipping at about 20° southwest. Slice-blocks of strata appear to have been displaced stepwise upwards along these fractures, so that the Brown Ironshot is now higher-lying on the downslope side in front of the fractures than on the upslope side behind them. In addition, minor cracks running NE–SW have divided the succession into blocks that lie now at slightly different heights along the face.

The material from the Brown Ironshot described here came from two large blocks, each about 2 m by 1.5 m, taken one from each end of the quarry face.



## Acris Subzone

**Bed 11(P11).** MAES KNOLL CONGLOMERATE

Limestones, ferruginous, very rubbly, marly, much fossil debris. Large astartid bivalves, heavily encrusted with serpulids and other epifauna.

c. 0.20 m

φ *Bj-26*

*Parkinsonia rarecostata* (Buckman) [m] (JHC coll., and Parsons *cit.*, BCM); *Garantiana cf. longidoides* Gauthier, Trévisan & Joron, 2000 [M] (= *G. longidens* Buckman non Quenstedt) (AB coll. from West End, above Grove Farm); *Parkinsonia cf. parkinsoni* (Sowerby) [m] (AB coll., and BCM in similar preservation). This fauna is similar to that of the top of the Astarte Bed of south Dorset (Chandler *et al.*, 2001) and hence probably of the same age. Determinable material is rare.

*Vesulian Unconformity*: sharp erosion-plane, completely flat, occasionally bored, rare epifaunal oysters but no hard-ground encrustation or laminated crust. Large ammonites and nautili in the top of the bed below planed flat in section

**Middle Inferior Oolite: Lower Bajocian**

Beds 7–10 (P 7–10): ELTON FARM LIMESTONE  
Sauzei Zone

**Bed 10 (P10b).** Brown Ironshot

Limestone, hard, massive, brown when weathered, oosparitic, densely finely to coarsely iron-oolitic giving the rock a purplish hue; intensely bioturbated. Divisible into three horizons based principally on ammonites, the smaller ones at all angles, and separated by rather unfossiliferous stone.

0.36 m

10c

Moderately bioturbated with muddy clouds and dense regions of shiny coated limonitic ooids and mud chips, the matrix becoming lighter in colour downwards. Large nautiloids and ammonites, often planed through at the upper surface of the bed. The sections of such shells seen on the erosion surface are filled with sediment identical to that of the surrounding matrix but are not sparitic within the chambers.

0.08 m

*layer of sparsely fossiliferous oolitic stone*

10b

Oolite, more buff than above, breaking into cubes along joints. At the base, –0.25 m below the erosion surface, a level of large *Stephanoceratids* and *Otoitids*

0.18 m

Beds 10b–c faunally not divisible:

φ *Bj-11a*

*Sonninia propinquans* Bayle; *Sonninites felix* Buckman; *Stephanoceras kahum* (Buckman) (Fig. 8.1); *Emileia bulligera* Buckman; *Labyrinthoceras meniscus* (Waagen) (= *perexpansum* Buckman)

*layer of sparsely fossiliferous stone*

## Laeviuscula Zone and Subzone

**Bed 10a**

Oolite, similar to above. At the base of the bed occurred besides ammonites large nautiloids and bivalves: *Camptonectes* spp. (C), *Plagiostoma* spp. (C) and *Ctenostreon pectiniforme* (Schloth.) (C) *Sonninia* (*Papilliceras*) *micracanthica* Buckman (Figs 9.1, 10), *mesacantha* (Waagen) sensu Buckman, a prominent layer at –0.30 m below the erosion plane, 0.05 m above the base (Figs 9.1, 10); *Kumatostephanus kumaterus* Buckman (Fig. 8.2); *Witchellia laeviuscula* (Sowerby) (Figs 4.1–4.3, 5.1, 5.2), the type horizon; *Protoecotraustes spiniger* Buckman.

0.10 m

φ *Bj-10b*

This record indicates a considerably greater thickness of rock for bed 10 as a whole than that measured by Parsons, which may perhaps reflect the incoming of a part of the bed not seen by him. He seems to have missed the layer of large *Papilliceras* at the base, which may have been missing at the point he was examining. This is the highest bed characterized by ammonites of the genus *Witchellia*, of which a succession of distinguishable faunas can be recognized. The composition of these faunas is indicated in Figure 2.

*indistinct gradational transition*

The beds below the Brown Ironshot, commonly referred to as the White Ironshot, are lithologically barely distinguishable from those above when fresh, leading Parsons (1980) to abandon the term. But when weathered there is a clear but gradational change

|                                     |  |           |
|-------------------------------------|--|-----------|
|                                     | of hardness and colour downwards, from firm brown sparitic oolite to cream, more marly, softer limestone. This gradational transition suggests a break in sedimentation rather than an erosional non-sequence. The sediments would have remained unconsolidated and hence vulnerable to bioturbation by burrowers, strong enough to mix sediments of different microgranular facies below and above the break, but not strong enough to upset the relative stratigraphic positions of the macrofossils, the ammonites. |           |
| <b>Bed 9 (P10a). White Ironshot</b> | Limestone, marly, fine-grained, grey to cream or almost white on weathering; oomicritic, the limonitic ironshot oololiths of variable density and size, ranging in colour from brown to cream; strongly bioturbated, somewhat nodular. Divisible into several courses, separated by inconspicuous undulating partings that become detectable only on weathering, characterized by distinct faunal assemblages, especially of well-layered large bivalves.  |           |
| 9b                                  | Limestone, locally with relatively sparse, shiny light-brown oololiths in cream matrix. Many large, thick-shelled sparry bivalves, a layer of <i>Gervillella</i> at the base.  | c. 0.20 m |
| φ <i>Bj-10a</i>                     | <i>Witchellia spinifera</i> Buckman and spp. (cf. Figs 4.4, 5.4), including already as rare variant <i>Witchellia laeviuscula</i> (Sowerby); <i>Emileia vagabunda</i> Buckman; <i>Frogdenites gibberulus</i> (Buckman).<br><i>irregular parting, below layer of bivalves at the base;</i><br><i>non-sequence</i>   |           |
| Trigonalis Subzone                  |  |           |
| 9a                                  | White Ironshot continued, light grey, sometimes somewhat greenish, glauconitic, rubbly or nodular, oolitic, the brown oololiths larger than in the beds below, in clouds, standing out in greater contrast against the lighter matrix. Large bivalves, calcitic tests, a layer of large <i>Plagiostoma hersilia</i> (d'Orbigny) at the base. This bed was formerly shown as bed 8d in Callomon & Chandler (1990).  | c. 0.15 m |
| φ <i>Bj-8a, b</i>                   | <i>Sonninia (Euhoploceras)</i> cf. <i>adicra</i> (Waagen); <i>Pseudoshirburnia stephani</i> (Buckman); <i>Mollistephanus mollis</i> Buckman; <i>Emileia dundriensis</i> sp. nov. (Figs 6.3, 7.1, 7.3), in a layer at the boundary between the base of bed 9 and the top of bed 8; <i>Emileites malenotatus</i> Buckman.<br><i>undulating boundary, locally marked by a clay parting; change in lithology; non-sequence</i>   |           |
| <b>Bed 8 (P 8–9 pars)</b>           | Limestones, finely, more or less densely ironshot oolitic, darker and harder than the beds above. Divisible into three parts differing in details of lithology and with distinct ammonite faunas (beds 8a–c in Callomon & Chandler, 1990).   |           |
| 8c (P9 pars)                        | Limestone, grey, densely and finely iron-oolitic, deeply burrowed, hard and massive, ammonites throughout but sparse, preserved at all angles.   | c. 0.15 m |
| φ <i>Bj-7b</i>                      | <i>W. pseudoromanoides</i> Dietze, Chandler & Schweigert, 2003; <i>Witchellia pavimentaria</i> Buckman; <i>Otoites douvillei</i> Parsons   |           |
| Ovale Zone                          |  |           |
| 8b (P8b): Ovale Bed                 | Limestone, grey, densely finely iron-oolitic, intensely bioturbated, in part decalcified, cavernous, soft, with large pockets or lenses of brown clay or marl; occasional limestone pebbles. Huge bivalves, including a layer of very large <i>Plagiostoma hersilia</i> , many belemnites, large ammonites commonly as marly bodychambers only.  | c. 0.05 m |
| φ <i>Bj-6b</i>                      | <i>Witchellia</i> aff. <i>romanoides</i> Douvillé (Fig. 6.2); <i>Fissiloboceras ovale</i> (Quenstedt) and <i>F. fissilobatum</i> (Waagen) (C) (Fig. 6.1).<br><i>irregular surface</i>  |           |
| 8a (P8a)                            | Limestone, densely but finely iron-oolitic, harder than the bed above, heavily burrowed, irregular, cavernous, with ferruginous clay pockets; many fine-grained concretionary pebbles. Less fossiliferous, but large bivalves common.  | 0.30 m    |
| φ <i>Bj-5</i>                       | <i>Witchellia romanoides</i> (Douvillé) (C); <i>Sonninia (Euhoploceras)</i> cf. <i>jugifera</i> (Waagen); <i>Emileites</i> cf. or aff. <i>catamorphus</i> (Buckman).<br><i>undulating parting</i>  |           |



## Discites Zone

**Bed 7 (P7)**

φ Bj-3

*Euhoploceras* Bed. Limestone, reddish, soft, sandy, somewhat nodular near top. Fossils preserved as internal limonitic moulds. *Hyperlioceras subsectum* (Buckman); *Sonninia (Euhoploceras) modesta* Buckman; *Docidoceras cylindroides* Buckman.  
*undulating parting*

0.30 m

*Gervillella* marl. Soft ferruginous marl, brown. Abundant internal moulds of *Gervillella* spp. This was the lowest bed seen by Parsons at South Main Road, but he continued the section downwards at Barns Batch and used the same consecutive numbering for both sections.

0.05 m

**Lower Inferior Oolite: Aalenian**

Beds 4–6 (P4–6): GROVE FARM LIMESTONE

Concavum Zone, Concavum and

Formosum Subzones

**Bed 6**

φ Aa-16/Bj-1

Limestone, hard, fine-grained, with scattered bivalves and belemnite debris, divisible into two courses by an indistinct parting. Ammonites as fragments. Parsons' record of Barns Batch (1979, p. 144) indicates a slightly later age (Bj-1 to Bj-2a) for the fauna of bed 6.

0.15 m

*Graphoceras limitatum* Buckman; *Hyperlioceras politum* (Buckman); *Sonninia (Euhoploceras) marginata* Buckman.

*undulating parting***Bed 5**

[φ Aa-15]

Limestone, silty, sparsely fossiliferous and vertically burrowed. *Graphoceras formosum* Buckman, *t.* Parsons, 1979]; *Bakevella* sp.

0.15 m

*flat parting***Bed 4**

[φ Aa-14]

*Terebratula eudesi* Bed. Limestone, hard, pinkish, with *Sphaeroidothyris eudesi* (Oppel), otherwise rather unfossiliferous apart from a few indeterminate graphoceratids. In the lower part, small oncolitic pebbles.

0.30 m

*t.* Buckman & Wilson 1896, and Parsons, 1979]*flat parting*

Beds 1–3: BARNES BATCH LIMESTONE

Bradfordensis Zone and Subzone

**Bed 3**

3b (P3b)

φ Aa-9

Divisible into three parts at Barnes Batch Spinney (Parsons, 1979, p. 145), based on fossil content; divisible into only two at South Main Road.

0.05 m

Oncolite Bed. Marl, cream-coloured, conglomeratic, with oncolitic 'Snuff-boxes' and belemnites.

*Brasilia bradfordensis* (Buckman).*wavy parting*

Murchisonae Zone and Subzone

3a (P3a)

φ Aa-7

*Pleurotomaria* Bed. Limestone, hard but very broken up, with gastropods and occasional well-preserved ammonites.

0.30 m

*Ludwigia murchisonae* (J. de C. Sowerby).*iron crust parting*

Obtusiformis Subzone

**Bed 2 (P2)**

φ Aa-5

Siltstone, calcareous, ferruginous and brown. Some 0.12 m below the top lies a conglomerate layer recemented by fine-grained orange marl, with broken *Ludwigia* spp., some quite large. There is a similar succession at Barns Batch and West End (AB, and see Parsons, 1979, p. 145).

0.30 m

*Ludwigia obtusiformis* (Buckman).*indistinct parting*

Haugi Subzone

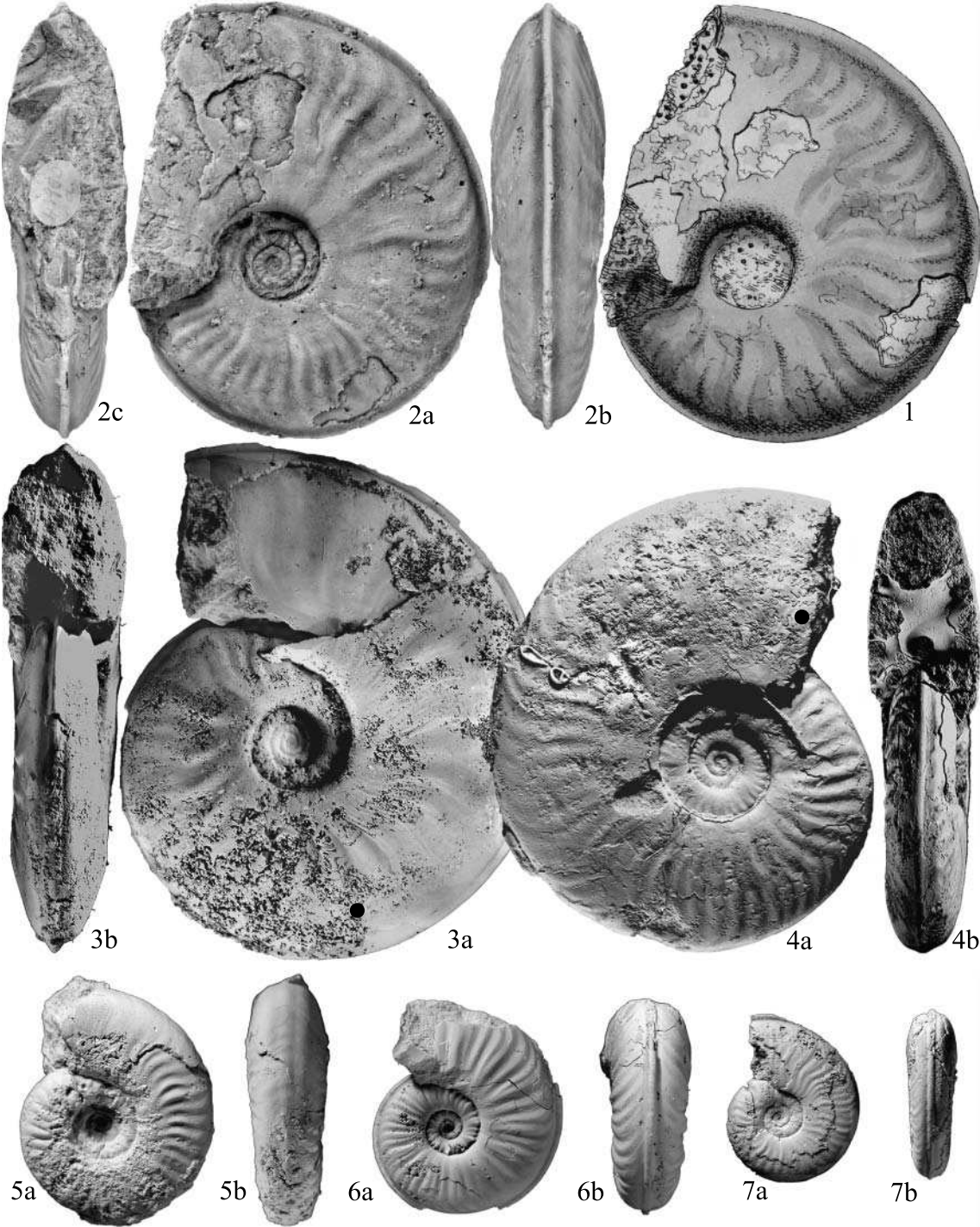
**Bed 1 (P1)**

φ Aa-4

As above but more sandy. Ammonites occur as internal moulds but are rare. *Zeilleria anglica* (Oppel), *Pleuromya* spp. seen to *Leioceras substratum* (Buckman); *L. (Cylloceras) crassicoatum* (Rieber)

0.5 m

*base of excavation*



#### 4. AMMONITE BIOSTRATIGRAPHY AND STANDARD CHRONOSTRATIGRAPHY

The classification of the rocks in a succession according to their ages is usually made in the framework of the traditional standard chronostratigraphical calendar (Buckman, 1898). Its lowest time-units are the Ages and Chrons, whose reciprocal rock units in the Inferior Oolite are the Stages and Zones shown at the left in Figure 1. But whereas the passage of time was everywhere complete and continuous, the history of events recorded in the rocks was not. To identify those events recorded and those lost in non-sequences therefore calls for the use of the best geological clocks available, those with the highest power of time resolution. Here, these are the ammonites, while the readings of the clock are expressed in their biostratigraphy.

##### Ammonite biochronology

Following Buckman, discussion of the geochronology of the Inferior Oolite at Dundry best proceeds bottom-upwards from a base in the most closely time-resolved biostratigraphical units, the faunal biohorizons. Here, these are ammonite biozones, beds whose characteristic fossil assemblages change perceptibly in stratigraphical succession and, hence, in time, as a reflection of the genotypic evolution of the organisms of which the fossils are the remains. The achievable finesse of time-resolution depends therefore on the ability to distinguish such stratigraphically successive assemblages found in a section, as does the precision of time correlation by means of guide fossils over distances. Two beds at different localities whose fossil assemblages cannot be distinguished must be regarded as effectively isochronous. Conversely, a biohorizon, being biostratigraphically not further subdivisible, must – on this time-scale – be regarded as internally instantly isochronous. A succession of such biohorizons therefore resembles a succession of snapshots of the evolutionary progress of the characteristic fossils at moments in time ('hemerae'), separated by time intervals of unknown duration.

One of Buckman's first discoveries was the incompleteness of the lithostratigraphic record on the time-scale of ammonite hemeral resolution. Two horizons – A, C – at one locality, typically represented by two

contiguous beds separated by a more or less conspicuous parting, would be found elsewhere to be separated by a third horizon, B, intercalated between A and C. Beds of the age of B are therefore missing at the first locality. The characteristic fossils could indicate not only the ages of the beds present in a section but also those of beds not present – the non-sequences, the gaps in the record whose durations and importance could not be deduced from the lithostratigraphy alone.

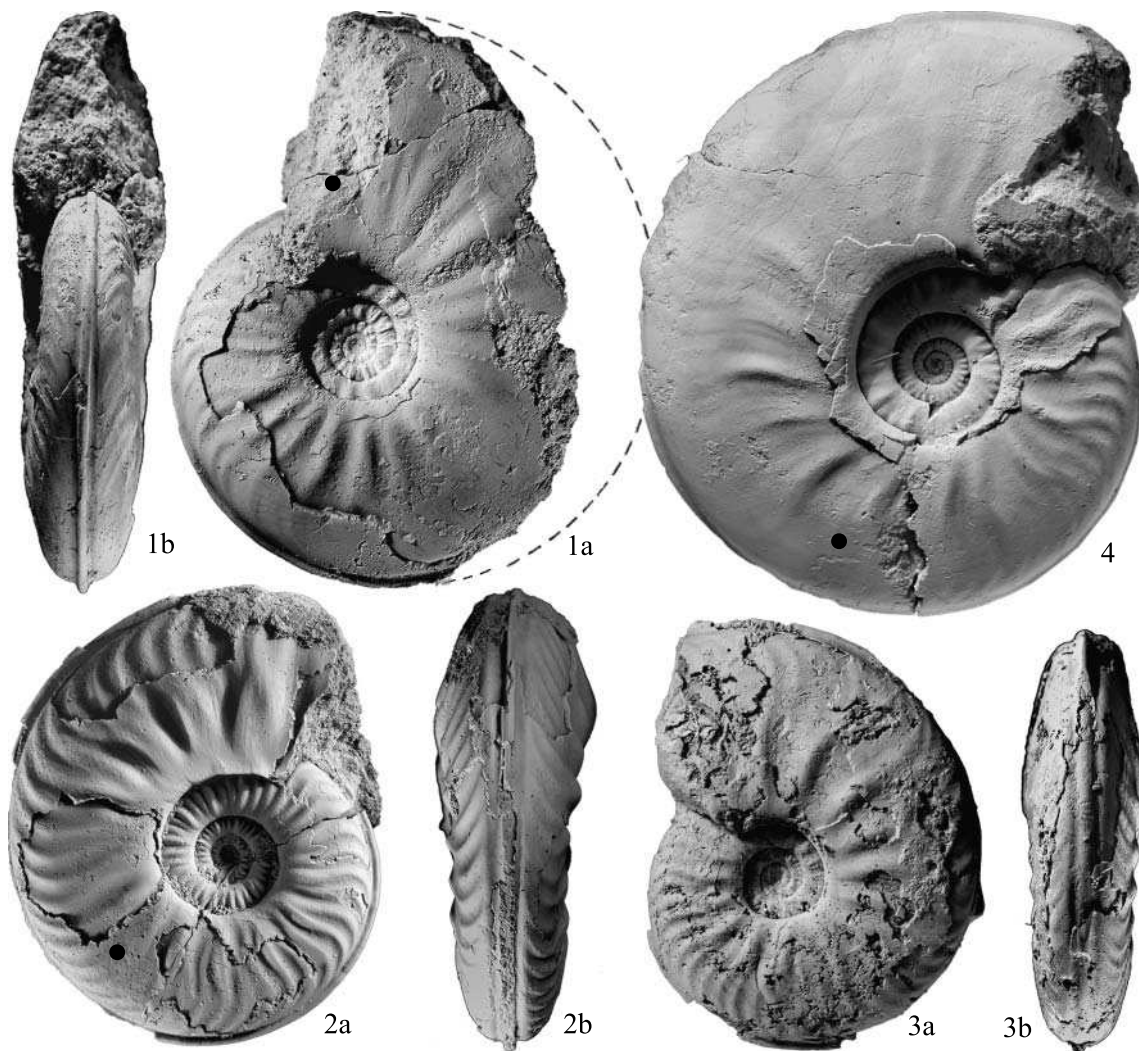
However, this creates a practical problem. To be applicable universally, this method of dating beds by means of their ammonite biohorizons requires an ideal, completely known succession of these horizons as a scale of reference. But as the known succession can be built up only piecemeal by correlation of many incomplete successions – those horizons B – the known succession can never be wholly complete. New horizons are still being continually discovered and inserted.

All these principles are eminently illustrated at Dundry. The first analysis by means of faunal horizons (hemerae) was by Buckman himself (in Buckman & Wilson, 1896, table VI). The frame of reference was at the time a succession of 14 hemerae for the whole of the Inferior Oolite of Dorset and Somerset (Buckman, 1893). Of these, horizons of nine of them could be identified more or less firmly at Dundry. Of the 11 in the Aalenian–Lower Bajocian part of the Inferior Oolite of interest here, six could be identified and evidence of the highest two, under the Vesulian transgressive deposits (bed 11) could be definitely shown to be missing, cut out by erosion. In a review of the state of play nearly a century later (Callomon & Chandler, 1990; Callomon, 1995a), the number for the whole of the Inferior Oolite had grown from 14 to 56. The horizons were now numbered, Aa-1–Aa-16 in the Aalenian, Bj-1–Bj-28 in the Bajocian and Bt-1–Bt-3 in the basal Bathonian part of the Inferior Oolite. The list of 1995 included horizons newly identified after 1990 and inserted with addition of labels a, b ... into the 1990 scheme solely to save having to renumber the whole series. The name of a leading member of the fossil assemblage characterizing a horizon is taken to label it.

The currently recognized succession in the Lower Bajocian is summarized in Figure 3, which indicates also the zonation taken to its lowest level in the standard hierarchy, that of Subzone. The figure

**Fig. 4.** (1–3) *Witchellia laeviuscula* (J. de C. Sowerby): 1, photograph of the lectotype (Sowerby, 1824, pl. 451, fig.1); 2, lectotype, new figures courtesy of the Natural History Museum, London, Sowerby collection, BM 43950a; 3, topo- or chorotype, Dundry SMR bed 10a, *S. micracanthica* horizon Bj-10b, SM X40052; variant resembling the type in coiling on inner whorls but becoming smooth and uncoiling earlier. (4) *W. aff. laeviuscula*, Osborne, near Sherborne, Dorset, Green-grained Marl, bed 3, horizon Bj-10a, SM X.40073; variant of the *W. spinifera* assemblage resembling the type of *W. laeviuscula* in sculpture but showing the finer ribbing on the nucleus in a more evolute umbilicus. (5) *Pelekodites pelekus* Buckman, [m], topotype of type species, Dundry-SMR bed 8a, *W. romanoides* horizon Bj-5, SM X40084. (6) *Sonninia* cf. or aff. *corrugata* (J. de C. Sowerby) [m], bed 9a, horizon Bj-8a,b, SM X40086; note the spinose nucleus, the strongly differentiated keel on the rounded venter of a more inflated adult bodychamber distinguishing it from *Witchellia* or *Pelekodites*, and uncoiling umbilical seam indicating the adult stage of a small species. (7) *Pelekodites* sp. [m], bed 9b, *W. spinifera* horizon, SM X40085. All figures natural size. Black spots here and later mark the last septum of the phragmocone.





**Fig. 5.** (1–3) *Wittichella laeviuscula* (J. de C. Sowerby): 1, topo- or chorotype, Dundry SMR bed 10a, *S. micracanthica* horizon Bj-10b, SM X40071; variant resembling the lectotype in section and coiling, showing the coarse primary ribbing on the innermost whorl; 2, source same as 5.1, Bj-10b, SM X40074; variant at the coarsest end of the range of variability in sculpture, the analogue of Buckman's *W. falcata* (1926, pl. 688) from the *W. spinifera* assemblage below (horizon Bj-10a: cf. Fig. 9.3); 3, source same as 5.1, SM X40072; another specimen like the type but more inflated. (4) *W. aff. laeviuscula*, another specimen from the Green-grained Marl of Osborne, bed 3, (horizon Bj-10a), SM X40070, for comparison with Figure 5.1, showing the finer ribbing on the more evolute umbilicus. All figures natural size.

includes one horizon newly discovered at Dundry, Bj-10b, with the consequent renaming of those between which it has been intercalated. It also illustrates how the time resolution achievable by means of ammonites as guide fossils significantly surpasses that expressed in terms of just standard zonal chronostratigraphy.

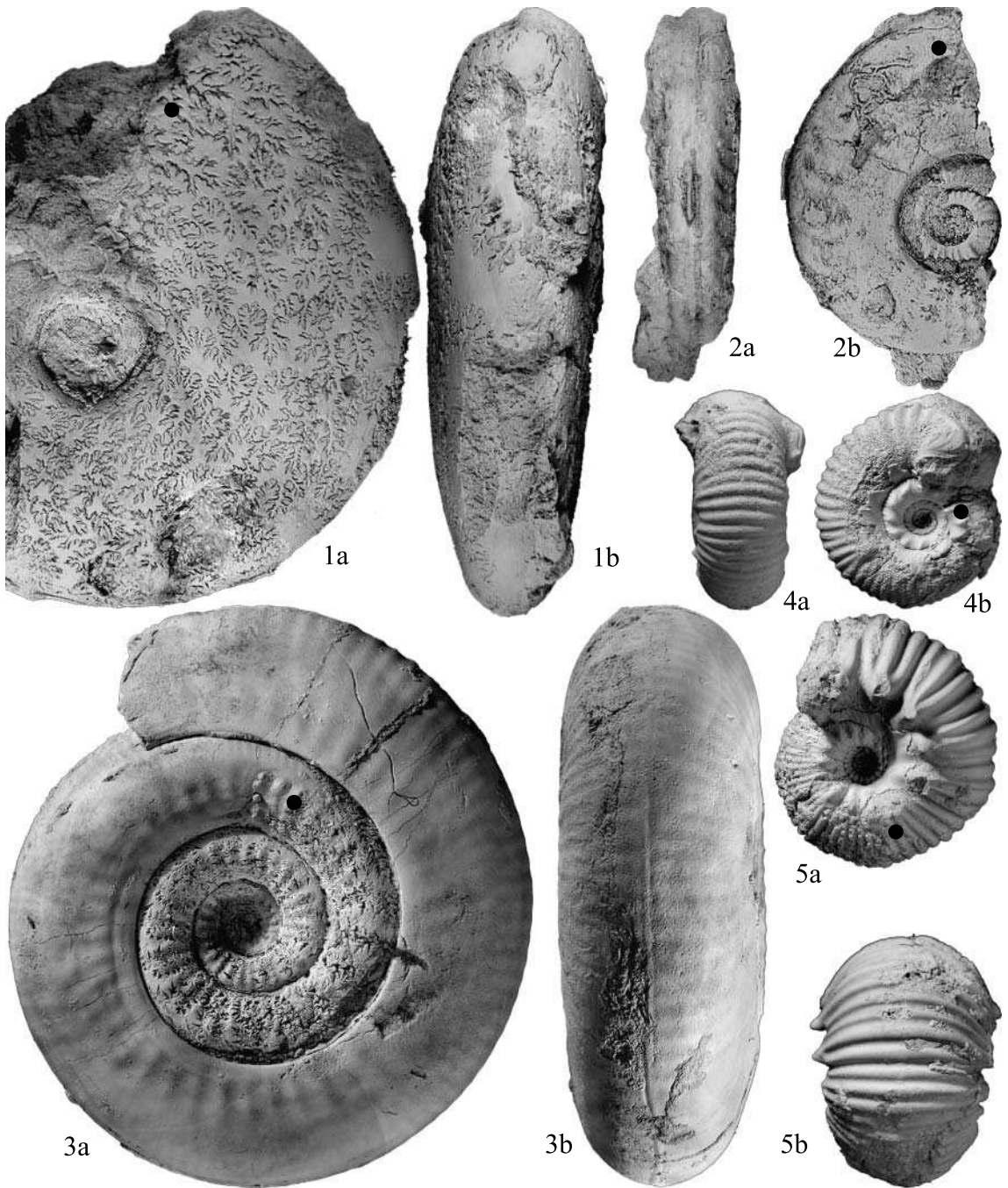
#### Faunal horizons and standard chronostratigraphy

Standard chronostratigraphical units – Stages, Zones and Subzones – are defined by their bounding time-

planes. Biohorizons lie within these units and hence characterize time-planes that lie between those defining the Zones and Subzones. Their positions can therefore influence the definitions of the standard units. Some important examples have now arisen through new discoveries at Dundry, and the Zones and ammonite horizons present at Dundry as shown in Figure 1 are summarized below, in ascending order.

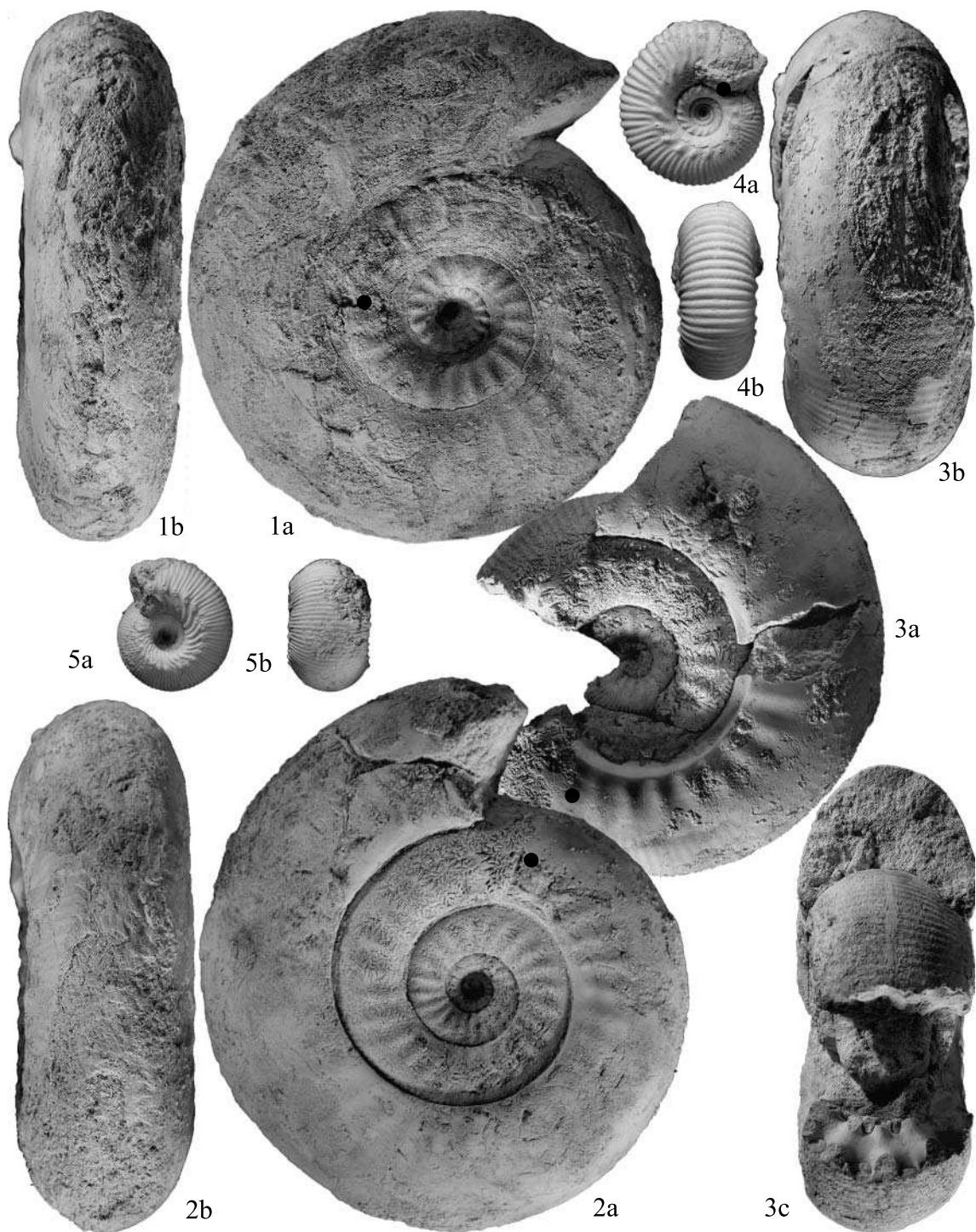
#### Aalenian

The succession at Dundry adds little of significance to the general record of the Aalenian. The best-documented record in Britain is at Horn Park, near



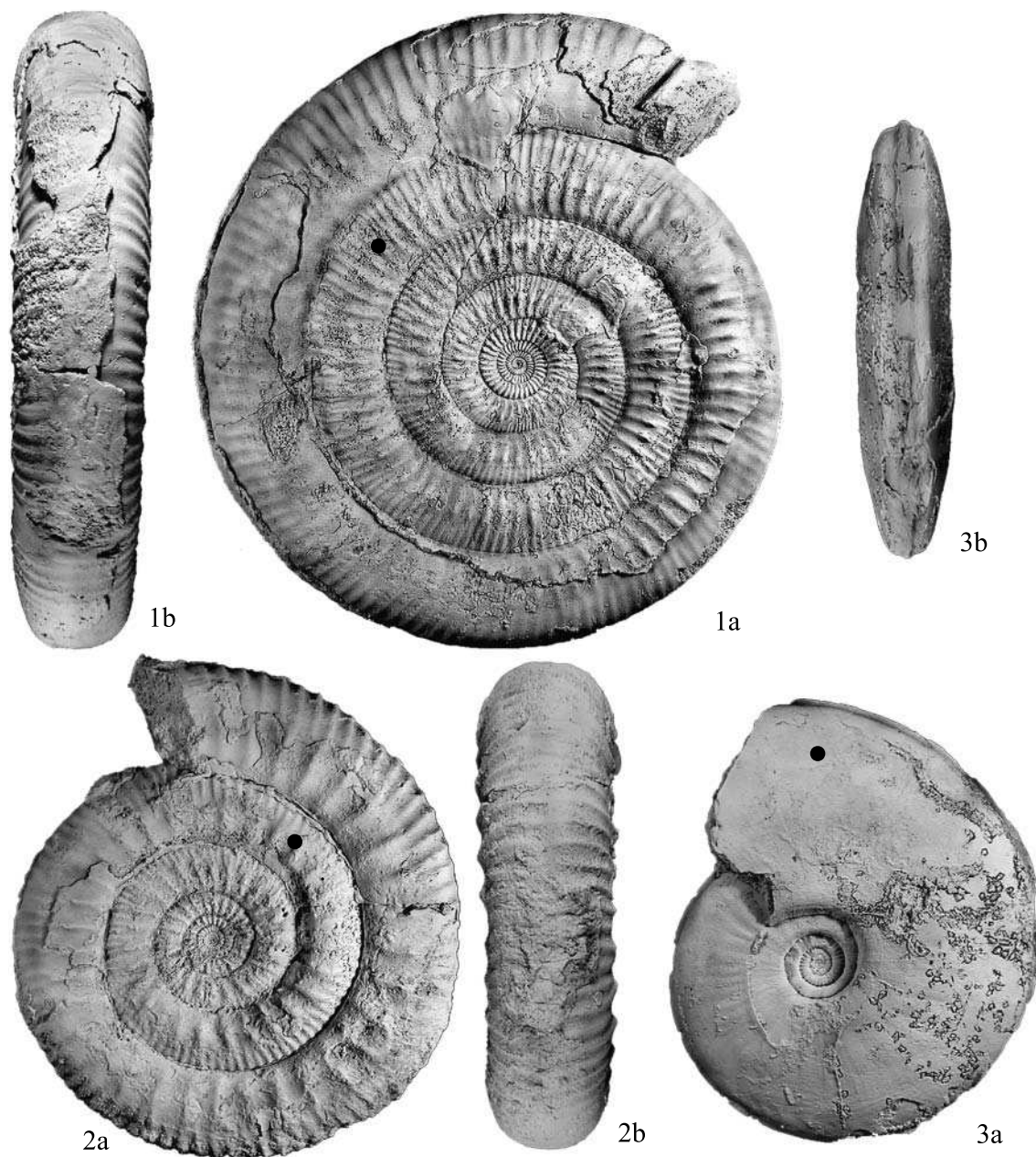
**Fig. 6.** (1) *Fissilobicerias fissilobatum* (Waagen), *ovale* sensu Buckman, Dundry SMR, the Ovale Bed, 8b, Ovale Zone, *Sh. gingensis* horizon Bj-6b, SM X29243; to show the characteristically fissilobate septal suture. (2) *Witchellia* aff. *romanoides* Douvillé, evolute variant showing inner whorls, source as Figure 6.1, SM X29216. (3) *Emileia dundriensis* sp. nov., paratype 3, Dundry SMR, boundary between bed 8c and 9a, Laeviuscula Zone, Trigonalis Subzone, *Eu. nodatipingue* horizon Bj-8a, SM X29102. (4) *Otoites* or *Trilobiticeras cricki* Parsons, bed 8c, horizon Bj-7b, SM X40082. (5) *Otoites fortis* Westermann, bed 10b/c, the Brown Ironshot proper, Sauzei Zone, *St. kahum* horizon Bj-11a, SM X40078. Figures 6.1–6.3 half natural size,  $\times 0.5$ ; figures 6.4, 6.5, natural size,  $\times 1$ .





**Fig. 7.** (1–3) *Emileia dundriensis* sp. nov., Dundry SMR, base of bed 9a, Laeviuscula Zone, Trigonalis Subzone, *Eu. nodatipingue* horizon Bj-8a: 1, holotype, SM X29101; 2, paratype 1, SM X29100; 3, paratype 2, more inflated variant, SM X40068. (4) *Otoites* or *Trilobiticeras douvillei* Parsons, bed 8c or 9a, horizon Bj-7b, SM X40081; compare with Fig. 6.4. (5) *Frogdenites* cf. *spiniger* Buckman, bed 9b, horizon Bj-10a, SM X40087. Figures 7.1–7.3  $\times 0.5$ ; 7.4,  $7.5 \times 1$ .

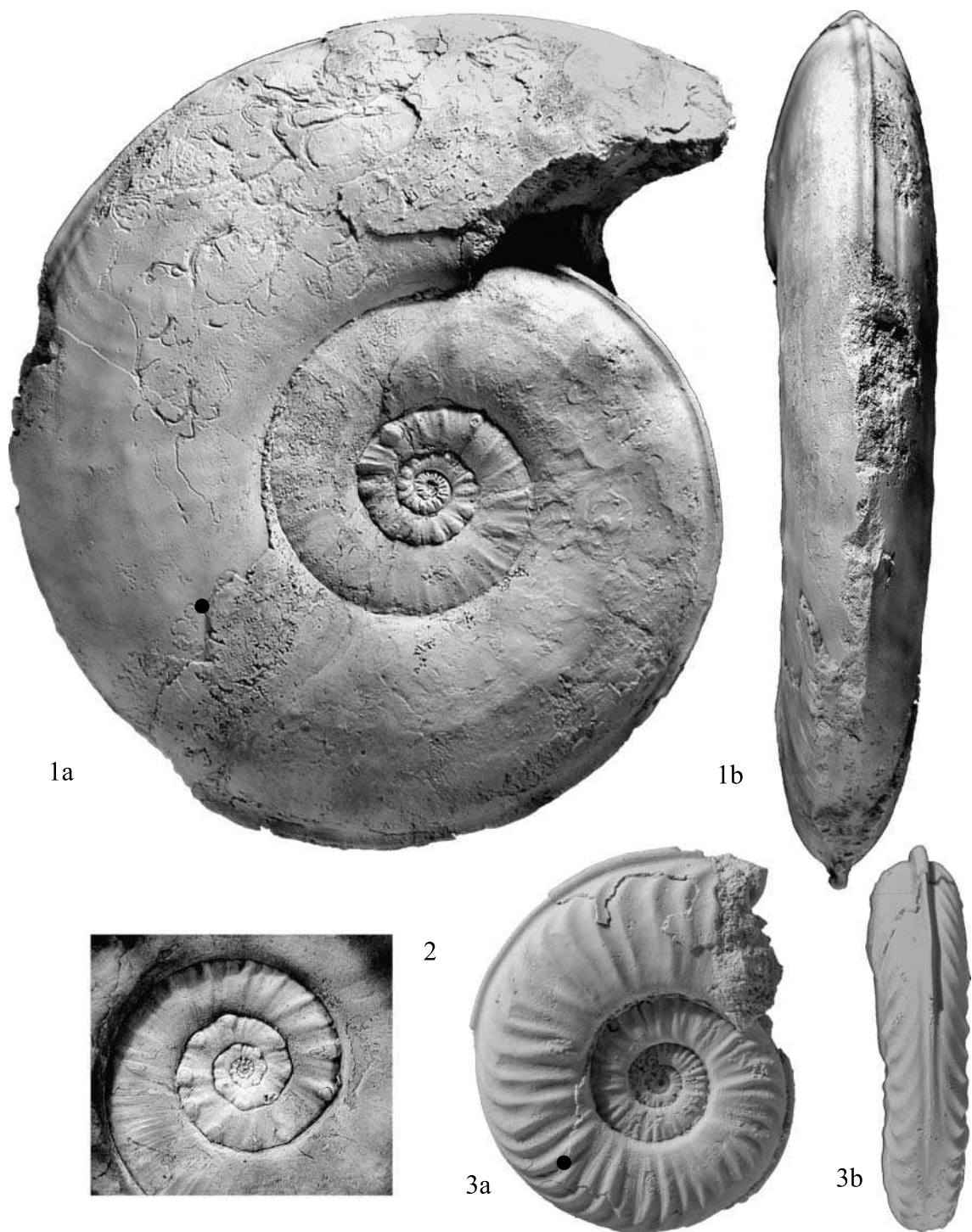




**Fig. 8.** (1) *Stephanoceras kalum* (Buckman), Dundry SMR bed 10b, lowest Sauzei Zone, *St. kalum* horizon Bj-11a, SM X27974. (2) *Kumatostephanus kumaterus* Buckman, SMR bed 10a, highest Laeviuscula Zone, *S. micracantha* horizon Bj-10b, to illustrate the differences between *Stephanoceras* and *Kumatostephanus*. SM X29244. (3) *Witchellia* cf. *rubra* (Buckman), bed 10a, same horizon as *W. laeviuscula* s.s. and Figure 8.2, Bj-10b, SM X27971; the type horizon lies lower, in Bj-9. All figures  $\times 0.5$ .

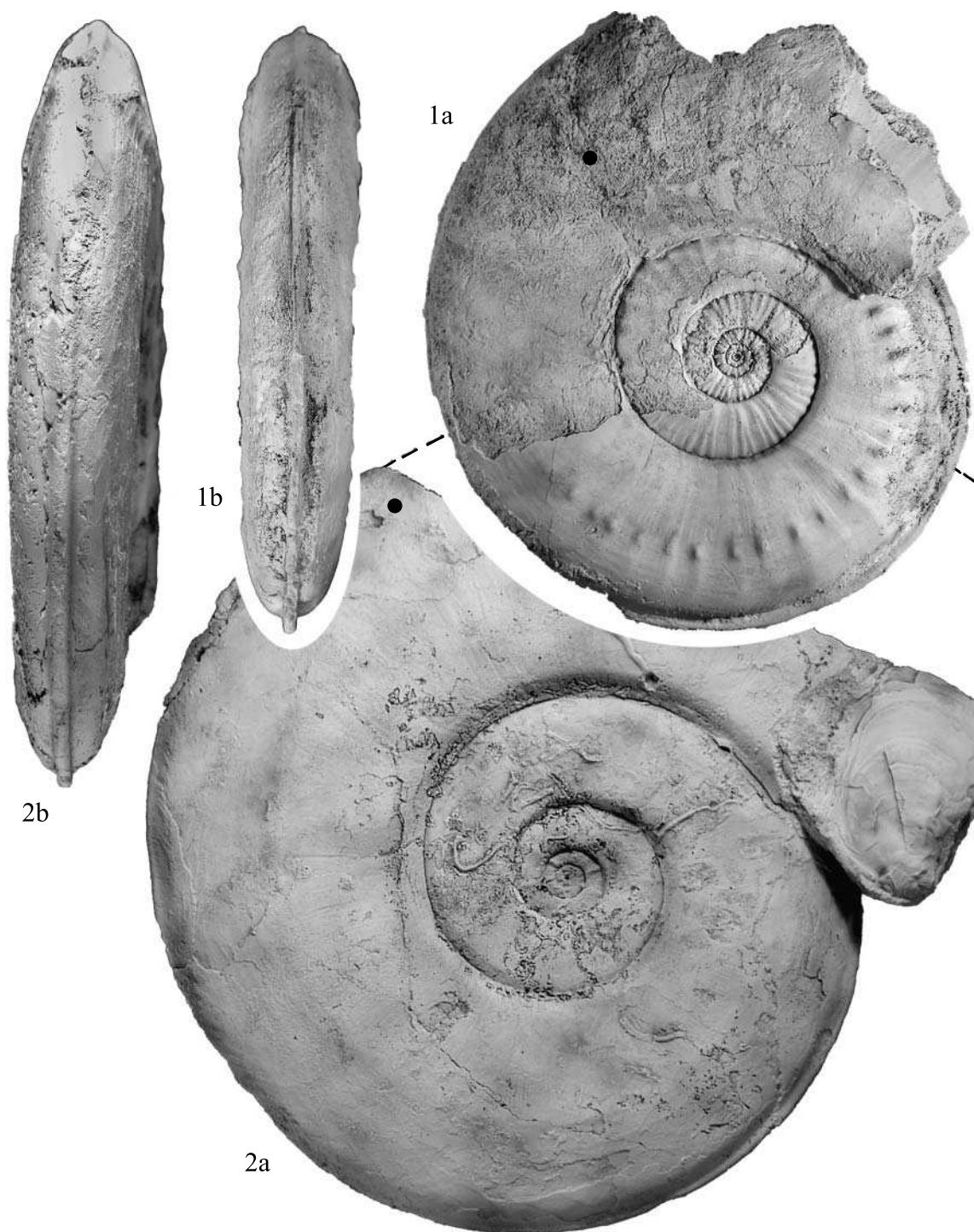
Beaminster in Dorset, and this provides the current standard of reference (Chandler, 1997). What is known at Dundry was reviewed by Parsons (1979). Ammonites are not abundant and the identifications of some of the horizons are tentative. But the non-

sequence between beds 3 and 4 seems firmly established. The giant forms of *Brasilia* (*B. gigantea*, *decipiens* and spp.) characteristic of Aa-10–Aa-12 are missing even in old collections from Dundry in the museums.



**Fig. 9.** (1, 2) *Sonninia* [*Papilliceras*] *micracantha* (Buckman), chorotype, Dundry SMR, bed 10a, topmost Laeviuscula Zone, *S. micracantha* horizon Bj-10b: 1, SM X29274; 2, nucleus of another specimen, from Frogden quarry, Osborne, near Sherborne, the Green-grained Marl, uppermost part, bed 3b, horizon Bj-10b, SM X40089. (3) *Witchellia* cf. *falcata* Buckman, Dundry SMR, bed 9b, *W. spinifera* horizon Bj-10a, SM X40077; the evolute and coarsely-ribbed extreme in the range of variability of the *spinifera* assemblage: cf. Fig. 5.2. Figures 9.1, 9.2  $\times 0.5$ ; 9.3  $\times 1$ .





**Fig. 10.** (1, 2) *Sonninia micracanthica* (Buckman), chorotypes, Dundry SMR, bed 10a, horizon Bj-10b, as Figs 9.1, 9.2: 1, SM X29241; variant with well-developed papillae; 2, SM X29284; variant almost wholly smooth, without papillae. All figures  $\times 0.5$ .

### Lower Bajocian: *Discites* Zone

The assignment of the *Euhoplceras* Bed, 7, to Bj-3 of the upper *Discites* Zone is firm. One of the late, typically smooth and discoidal forms of *Hyperlioceras* with minute umbilicus was illustrated by Parsons (1979, pl. 1, fig.1) and new finds confirm the age. The disappearance of *Hyperlioceras* in the British succession seems to be sharp and isochronous and is therefore taken to mark the boundary between the *Discites* Zone and the overlying *Ovale* Zone, between the horizons Bj-3 and Bj-4. The negative evidence of such 'disappearances' is, of course, always vulnerable to subsequent discoveries and, in fact, there are indications that *Hyperlioceras* may have persisted as rare stragglers in higher beds. However, at Dundry, drawing the boundary sharply between *Discites* and *Ovale* Zones between beds 7 and 8 presents no problems.

### *Ovale* Zone

The horizon Bj-4 is missing. It is based on what Buckman called the 'post-*discitae*' beds at Stoke Knap on Waddon Hill, also near Beaminster (1910, pp. 76–77; Callomon & Chandler, 1990, fig. 2, beds 5f, g). It is characterized by the common occurrence of *Bradfordia liomphala* Buckman, after which it was named (his *Bradfordia* hemera of 1930, p. 36). A similar common occurrence of this genus at this level has also been recorded in France (Rioullet *et al.*, 1997, p. 46). It may also be the type horizon of *Fissiloboceras ovale* (Quenstedt), which certainly occurs in it. This is discussed further below.

The name 'Ovalis Bed', bed 8b here, goes back to Buckman (1893, p. 493), who described what appeared to be the same bed at Sandford Lane, Sherborne (his section XI, bed 8, below the famous Sandford Lane Fossil Bed) and recorded from it as its characteristic species '*Sonninia ovalis*', = *Ammonites sowerbyi ovalis* Quenstedt, 1886, from Swabia. Three years later it had become at Dundry more explicitly the '*fissilobatum-ovalis* horizon' (Buckman & Wilson, 1896, pp. 708–9). The history of the subsequent evolution of this horizon into the *Ovale* Zone of today is somewhat tortuous and need not be repeated here. Many of the details may be found in Parsons (1974) and in a recent review based on large new collections of the critical species from their type area in southern Germany (Dietze *et al.*, 2005). The evolution of the classification was beset by uncertainties of two kinds.

The first is that of the interpretation and hence the identification of the ammonites involved and of their type horizons. Quenstedt's species had itself been poorly characterized in Germany, as its type specimen consists of little more than half a septate whorl of a very large, smooth shell, otherwise characterless but for a very complex, deeply incised septal suture-line, not refigured until quite recently. The modern interpretation is discussed further below. The second source of uncertainty lies in the sense of the terms 'zone' and 'index' as used by subsequent authors: 'zone' either to indicate merely a biozone, that of its

'index species', meaning no more than 'the beds with' that species; or to specify the rock-equivalent of Buckman's 'hemera' (1930), often in the sense of 'faunal horizon'; or to mean standard chronostratigraphical Zone or Subzone in the modern sense as used here, in which the function of the index is purely that of name giving, to label the Zone. The only absolute requirement is that the index species does at least occur in its eponymous Zone – which may involve questions of its correct identification. As in so many other cases in the past, it may therefore be difficult to assign priority uniquely to one author or date.

Modern usage of the term '*Ovale* Zone' seems now to have settled down. It goes back to the first clear statement in France (Gabilly *et al.*, 1971, p.10) of a subdivision now into three Subzones of a then still traditional Sowerbyi Zone of Oppel (1862) and Waagen (1867): *Discites*, *Ovale* and *Laeviuscula* in ascending order. The *Discites* Zone was promoted to full zonal status by Parsons (1974). He also gave good reasons why *Sonninia sowerbyi* – type probably from the Sauzei Zone of Dundry – should be abandoned as index, a case in which the index does not occur in its nominal Zone (see below). This left a *Laeviuscula* Zone divided into *Ovale* and *Laeviuscula* Subzones, a scheme maintained up to 1980 in the Geological Society's *Correlation Charts* (Parsons, 1980). Much new information in subsequent years led to a resurrection of the *Trigonalis* Subzone, between the *Laeviuscula* and *Ovale* Subzones, going back to Buckman's *Shirburnia* hemera of 1910, followed by Spath (1936) and Arkell (1947, 1954) and adopted in the most recent compilation in France (Rioullet *et al.*, 1997); and the promotion in Britain of the *Ovale* Subzone to full Zone (Callomon & Chandler, 1990). Most of this new evidence came from the region of Sherborne and from Bruton. The contributions from Dundry have been limited because of the gaps in the biostratigraphical record there and the relative scarcity of complete, large adult ammonites essential for closer identifications in that difficult group, the *Sonniniidae*. This part of the Lower Bajocian remains one of the least well-understood in the whole of the Inferior Oolite.

### Bed 8a

Horizon Bj-5. The lower part of bed 8, the Bivalve Bed of Parsons (1979), sees the incoming of the first abundant *Witchellia*, *W. romanoides* (Haug) [M], together with its presumed antidimorph, *Pelekodites pelekus* Buckman [m]. This is the first of the four successive faunas of *Witchellia* that can be distinguished at Dundry. The type of *W. romanoides* came from the region of Toulon, in southern France, and a typical example from Dundry was figured by Parsons (1979, pl. 1, figs 3, 5). Also characteristic, as of the *Ovale* Zone as a whole, are the small *Emileia*-like forms of genus *Emileites*. Their similarly dwarf microconchs, transitional between *Trilobitoceras* of the *Discites* Zone and *Otoites* of the *Laeviuscula* Zone, have also been

described by Parsons (1977) (see Figs 6.4, 7.4 here). *Fissilobicerias ovale* also persists.

#### Bed 8b

Horizon Bj-6b, the Ovale Bed. This has been mentioned already. It is one of the few beds at Dundry below the Sauzei Zone to have yielded large, complete adult macroconchs in any abundance, but their identification has been uncertain for the reasons given above. Buckman's interpretation of '*Soninia ovalis*' was therefore adopted unchanged by Callomon & Chandler (1990, with illustrations of Dundry specimens). In the meantime, the German succession has been clarified (Dietze *et al.*, 2005) and a more appropriate generic assignment is to *Fissilobicerias* Buckman, 1919, collinear with but not directly related to *Soninia*. Species of this genus can have relatively long ranges. The type of *F. ovale* (Quenstedt) may have come from the top of the Discites Zone, horizon Bj-3 or just above, but the species certainly ranges up into the Ovale Zone both at Dundry and in Germany. The type species of the genus, *F. fissilobatum* (Waagen, 1867), whose type horizon lies in the Laeviuscula Zone above, also ranges down into the Ovale Zone. The majority of forms in the Ovale Bed, including those figured by Callomon & Chandler, belong in fact to some other group of Soninids, close to – but not identical with – *S. (?Euhoploceras) jugifera* (Waagen). The horizon with the same fauna as that of the Ovale Bed has been recognized clearly also at Bruton and at Sherborne: it therefore makes a fine marker for correlation. At Bruton it lies between two further horizons, Bj-6a and Bj-6c, that have not been recognized at Dundry, suggesting further non-sequences.

#### Laeviuscula Zone. Bed 8c

Horizon Bj-7b. The ammonites from this next higher bed are still not very well understood but differ significantly from those in the beds below and above. They are characterized by a new assemblage of *Witchelliae* that resembles one recently described from Swabia as *W. pseudoromanoides* Dietze, Chandler & Schweigert (2003). The only other locality at which it has so far been recognized in Britain is at Bruton. The slightly earlier assemblage at Bruton, Bj-7a, has so far also not been recognized at Dundry, supporting the supposition of a non-sequence between beds 8b and 8c.

Another characteristic species of about this age appears to be *Witchellia sayni* Haug, 1893, based on an assemblage from a thin bed not closely dated near Toulon, in southern France. It differs so strikingly from the forms found below and above that it was used as index of a further tentative subdivision of the Laeviuscula Zone, a Sayni Subzone, by one of the authors in a previous publication (Callomon, 1995b), as forms closely resembling the type do occur in horizons Bj-7. But the detailed studies of the more abundant material of *W. pseudoromanoides* showed that the variability of a contemporaneous assemblage of this genus could be much wider than had been

thought and that, conversely, individual morphs resembling *W. sayni* might have longer ranges than supposed. It seems best to delay the confirmation of a Sayni Subzone until more is known about *Witchelliae* of this age in Britain.

#### Bed 9a

Horizons Bj-8a, Bj-8b. These are based on the faunas of the Sherborne area. Bj-8a is based on a well-characterized fauna from the so-called Blue Bed of Redhole Lane, Clatcombe (Huxtable, 2000, fig. 3, bed 3, now subdivided into 3a and 3b), named after *Euhoploceras nodatipingue* (Buckman) and yielding abundant *Mollistephanus mollis* Buckman (hence his *mollis* hemera for the age of this horizon). Bj-8b is named after the unmistakable *Shirburnia trigonalis* Buckman, index of the Trigonalis Subzone and type species of *Shirburnia*, whose types came from the famous Fossil Bed of Sandford Lane quarry (Buckman, 1893, p. 492, section IX, bed 6c). *Sh. trigonalis*, known previously only from Sandford Lane and Bearnaraig Bay on the Isle of Skye (Morton, 1975, pl. 6, fig. 4), has recently been found also at Redhole Lane. Here it occurs above (but not in) the Blue Bed at a slightly higher level (bed 3c) in the non-sequence below bed 4 at a locality some distance to the north of the section described by Huxtable. It has now also been found at Cockroad Farm, west of Beaminster (Sandoval & Chandler, 2000, p. 500, fig. 5, bed 4). Figure 2 shows, however, that bed 9a yields many of the other species of horizon Bj-8b, e.g. *Euhoploceras adicrum* and *Pseudoshirburnia stephani*, but only a few characteristic of Bj-8a. One of the forms found among these is a new species of *Emileia*, *E. dundriensis* sp. nov. described below (Figs 6.3, 7.1–7.3). The type series occurred in a layer at the base of bed 9a. A number of specimens of the same species, hitherto undescribed, have come from beds 3a–b at Redhole Lane, the type horizon of Bj-8a, but not higher, serving to date the species. It seems therefore that bed 9a yields representatives of both horizons Bj-8a and Bj-8b but that these cannot be separated here. New evidence from the type locality at Sandford Lane, Sherborne, indicates moreover that Bj-8b may itself be further divisible.

#### Bed 9b, Laeviuscula Subzone

This is the principal component of the White Ironshot. The abundant *Witchelliae* (see Figs 4, 5, 9 here *partim*) leave the identification of this horizon in no doubt. It correlates precisely with that of the so-called Green-grained Marl of Osborne, near Sherborne, exemplified by the succession in the famous Frogden Quarry first described by Buckman (1893, section XV, p. 500, bed 9), from which he illustrated in his *Type Ammonites* nearly the full range of variability of *Witchellia* at that level (*W. spinifera*, *patefactor*, *platymorpha*, *glauca*, *falcata*, *actinophera*, recorded from Dundry in Fig. 2). This section at Frogden was redescribed more recently (Parsons, 1976, in part; Callomon & Chandler, 1990, fig. 4, middle; beds



renumbered following Parsons, the Green-grained Marl now bed 3; and faunal horizons assigned). An almost identical temporary section at nearby Osborne Wood was also described by Parsons (1976), who gave an extensive faunal list; and by Huxtable (2004), who chose to renumber the beds yet again.

It was assigned the label Bj-10, *Witchellia laeviuscula* (J. de C. Sowerby, 1824), in the belief that it was the type horizon of that species even though it was not the type locality, which is Dundry. This belief was supported by Buckman's illustration of a specimen from Frogden under the name *laeviuscula* (1927, *TA* 7, pl. 745, reproduced by Arkell in the *Treatise*, 1957, as fig. 311.7a, b) that certainly resembles the type closely. But whereas the variability of the assemblage in the Green-grained Marl, a good approximation to an isochronous palaeo-biospecies, had been well mapped by Buckman, that of the type from Dundry had not. One can not therefore be absolutely sure of the correlation, for individual morphospecies can have considerable ranges, especially rather featureless ones such as *W. laeviuscula*.

This has now been rectified. It turns out that the true type horizon of *W. laeviuscula* at Dundry lies slightly higher, in bed 10a, new, at the base of what had always been called the Brown Ironshot (see above). There is sufficient material to show that the range of variability of *W. laeviuscula* s.s. is similar to that of '*W. laeviuscula*' from the Green-grained Marl but that its forms differ from those of the latter recognizably and consistently in some characters. The associated fauna of other groups also differs significantly. The two assemblages of *Witchellia* therefore characterize two distinct faunal horizons and call for new labels: that of the Green-grained Marl becomes Bj-10a, that of *W. laeviuscula* s.s., Bj-10b (see Fig. 3). To retain *W. laeviuscula* now as nominal index for either of the two horizons would lead to confusion, for if cited it might be unclear whether this referred to the previous use of the name for what is now Bj-10a, or to the 'true' horizon, Bj-10b. It is best therefore to rename both horizons:

- Bj-10b, higher: *Sonninia micracanthica* (Buckman) (see below);
- Bj-10a, lower: *Witchellia spinifera* Buckman, where *W. spinifera* is simply the oldest of the available names for the variants of the biospecies of *Witchellia* in the Green-grained Marl.

The Green-grained Marl of Osborne is underlain by another 'Blue Bed', bed 2, which is the type horizon of a further fauna of *Witchelliae*, *W. ruber* Buckman, 1926. The type (*TA* 6, pl. 642) by itself also bears a resemblance to that of *W. laeviuscula*, but a more extensive collection of topotypes in the Natural History Museum, London, shows the assemblage to differ consistently and recognizably from those both of Bj-10a and Bj-10b. Its horizon was therefore given a separate identity, Bj-9. It has not been recognized at Dundry so far and this may reflect either collection-failure in the lower part of bed 9 or another stratal

non-sequence. (At Osborne, the base of the Blue Bed, bed 2, yields very large *Ps. fastigata* and *Fissiloboceras*, indicating the presence there of Bj-8 at least in part, although typical *Ps. stephani* has not yet been found.)

#### Bed 10a

Horizon Bj-10b, the lower Brown Ironshot. The boundary between the Brown and White Ironshots has in the past been somewhat unclear, for there is no sharp lithological break, especially in fresh sections. The difficulty in deciding where to draw the boundary had been stressed already by Parsons. Collections tended to be made therefore without closer regard as to from where precisely in these beds the specimens came. The larger exposures in the present excavations have made it possible to collect more carefully and to recognize (at least) two distinct horizons in what had been recorded previously as simply a single bed, bed 10. The ammonite faunas are recorded in Figure 2. That of the upper part, now beds 10b-c, is little changed from what had been recorded in the past. However, as already indicated, that of the lower part, bed 10a, is distinct. Besides being the type horizon of *W. laeviuscula*, it is also marked by the occurrence of another abundant and striking species, *Sonninia micracanthica* (Buckman) (see Figs 9, 10 and systematic notes further below). It occurred in a distinct layer in the bed. Its type locality is also at Dundry but in a different quarry, that at North Main Road, just 1 km to the north of Du-SMR, and had not hitherto been recorded from anywhere else. It has, however, now been found also at Frogden in lenticular patches (bed 3c) where the Green-grained Marl is preserved to higher levels below the erosion horizon that there underlies the Humphriesianum Zone, confirming its stratigraphical position above Bj-10a. It seems to be confined to this horizon and therefore makes an excellent marker.

#### Sauzei Zone

Beds 10b-c, Bj-11a, the Brown Ironshot proper. This has been the source of many large collections in the past, to the records of which there is little to add here. It has always been taken to epitomize the Sauzei Zone in its most typical and fossiliferous development in southern England and has been discussed in some detail by Parsons (1979). It occurs in very similar development at Sandford Lane, Sherborne (Buckman, 1893, p. 492, beds 6a, b in descending order) and at Clatcombe, Redhole Lane (Parsons, 1974), where it could be further subdivided into three parts (Huxtable, 2000, fig. 3, beds 4a, b, c) corresponding more or less to a tripartite description already made by Buckman himself (1893, p. 498, section XIV, beds 4, 3, 2 in ascending order). The fauna of bed 4c is distinct from that of 4a, characterized by an abundance of small sonninitids to which Buckman gave the name *Nannina* (1927, *TA* 7, pl. 752; type *N. evoluta*, from Clatcombe, bed 4c). It was therefore differentiated in a separate horizon Bj-11b (see Fig. 3). This horizon has not been



identified at Dundry where, if ever present, it has been cut out by the Vesulian erosion-plane.

The faunal element of Bj-11a that seems particularly characteristic is one of the spectacular ultraserpenticone stephanoceratids represented by *St. [Kallistephanus] kalum* (Buckman), type from Sandford Lane (see Fig. 8). This horizon had previously been named after *Otoites sauzei* (d'Orbigny) as index – the same as that of the Sauzei Zone as a whole, retained unchanged from the original description of the undivided horizon Bj-11 (Callomon & Chandler, 1990). But there continue to be unresolved uncertainties about both the systematic and hence the stratigraphic interpretations of this species, which will not be discussed here. While this need not affect the naming of the Zone (although French authors are proposing to do even that, changing it to Propinquans Zone – Rioult *et al.*, 1997, p. 47), it would be misleading to continue to use *O. sauzei* as index of a faunal horizon, with its implication of ultimate biostratigraphical precision. It is therefore proposed to rename the horizon as that of *St. kalum* (see Fig. 3). The sonninids in it certainly do include *S. propinquans* Bayle, 1878, the type species of *Sonninia*.

#### *The boundary between the Laeviuscula and Sauzei Zones*

The differentiation of the *S. micracanthica* horizon Bj-10b raises directly the question of where the boundary should be drawn. On the one hand, this horizon is now seen to be the type horizon of *Witchellia laeviuscula*, taken in the past in Britain to epitomize the Laeviuscula Zone and its then top horizon Bj-10. On the other, it contains several of the faunal elements taken elsewhere in Europe to characterize the lower Sauzei Zone.

In Hungary, where the Sauzei Zone is greatly expanded, Galacz (1989) has shown that it is possible to distinguish (at least) three faunal assemblages. The lowest is characterized by *Kumatostephanus*, the next by large *Stephanoceras* (*Skirroceras*) spp. and most of the other familiar elements listed here from the higher parts of bed 10 at Dundry, the third by – amongst others – *Sonninia alsatica* and *Nannina evoluta*. This corresponds closely to horizons Bj-10b, B11-a and B11-b, respectively, here. Galacz proposed these faunal distinctions to be the basis for a subdivision of the Sauzei Zone into three Subzones: Kumaterus Subzone, Sauzei Subzone and Hebridica Subzone. We prefer to retain them at the status of faunal horizons for the time being. However, in Galacz's classification, Bj-10b – which does see the first appearance of *K. kumaterus* (see Fig. 8) – would be already in the Sauzei Zone. *K. kumaterus*, or closely similar forms, ranges up into the higher parts of the succession, including Bj-11a at Dundry, which is truly in the Sauzei Zone on any definition. To avoid possible confusion between a *K. kumaterus* horizon marking the first appearance of the genus and a Kumaterus Subzone of the Sauzei Zone, we choose to name horizon Bj-10b after another

species, *Sonninia micracanthica*. (A recent revision of the succession in France (Rioult *et al.*, 1997) brings little of note to the discussion, for these authors do not recognize a separate horizon between Bj-10a and Bj-11a. Their Sauzei Zone begins with a horizon of *Sonninia patella* (Waagen) in a Patella Subzone of the Propinquans Zone, which seems to contain all the elements of Bj-11a.)

The choice is therefore between (a) inclusion of horizon Bj-10b, the type horizon of *W. laeviuscula*, still in the Laeviuscula Subzone of the Laeviuscula Zone, and the first appearance of *Kumatostephanus* therefore earlier than in the Sauzei Zone; or (b) the inclusion of the horizon Bj-10b already in the Sauzei Zone, with the type horizon of *W. laeviuscula* then outside its nominal Zone. We prefer the former – as shown in Figures 2 and 3.

## 5. PALAEONTOLOGY

### Notes on the ammonite faunas (JHC & RBC)

The species now known from the South Main Road quarry are summarized in Figure 2, excluding some whose identifications are more tentative. The identifications are those of **morphospecies**, based on comparisons of specimen both with each other and with figures of nominal species already in the literature – 'snap', 'not-snap', or 'perhaps snap' – for this is the most efficient way of conveying a description of what has been found. The rows show that many of these species have stratigraphically vertical ranges, while the columns show that there are often several closely similar ones found horizontally side by side in the same bed. The enormous number of such 'species' that have been created, especially for the ammonites of the Inferior Oolite, is legendary. It is also unnatural, for as more material accumulates, the impression that there lived side by side large numbers of closely related 'true' species – grouped into genera – gives way to the realization that these are merely variants of **biospecies**, the natural units, sometimes also called **chronospecies**. The formal reclassification of morphospecies into biospecies is beyond the present scope.

Some rationalization is, however, possible at the next higher levels of taxonomy, those of the genus and family groups. Once again, many of the nominal genera in the literature were introduced merely as subjective groupings of morphospecies according to their perceived morphological similarities: they are **morphogenera**. The 'natural' function of the genus in a biospecific classification, however, becomes that of a segment of an evolving lineage, a branch of a family tree, made up of a vertical succession of chronospecies or **transients**: a **phylogenus**. Branches of a tree themselves divide into clusters of smaller branches, ultimately into twigs, and it is for such clusters of smaller branches sharing a common origin – clades – that the categories of the family group are introduced. In attempts to map such family trees, which is largely

what makes the palaeobiology of fossils interesting, it is essential to work from the lowest level upwards: to reconstruct the biostratigraphy of the fossils at the time-resolution of those basic units, the evolving biospecies. These basic biostratigraphic units are their faunal horizons, and it is their characterization that gives the recording of sections, such as that at Dundry South Main Road quarry, in such detail its whole point.

The classification shown in Figure 2 is a compromise between conventional, morphotaxonomy on the one hand and 'natural', phylogenetic taxonomy on the other. It reflects the fact that the relationship between these contrasting classifications continues to be conjectural in many ways. Although the present classification is certainly more soundly based than in Buckman's time, a century ago, there are still many uncertainties deriving from gaps in the record. Locally there are stratigraphical gaps, non-sequences such as those revealed in the present study. These are increasingly being filled. But more generally, biological evolution is a world-wide process. The 'centres of evolution' of the groups found at Dundry were rarely, if ever, at Dundry. Many of the phylogenera found there, such as *Sonninia* and *Witchellia*, appear in Britain suddenly, cryptogenically, presumably as immigrants: their predecessors could well have been evolving in Argentina or Alaska. This classification is therefore based largely on the state of knowledge in Britain and Europe.

The category of genus in Figure 2 is therefore used as time-ranging receptacle for groups of conventional morphospecies. In assessing what such groups might really mean, a good first working assumption is that all the members of such a group at any one horizon are merely variants of a single biospecies. The test lies in the effect of new material: whether it accentuates the differences between taxa as previously recorded or whether it fills the gaps between them. All the genera shown here are at any one stratigraphical level almost certainly monobiospecific, their nominal morphospecies being no more than intrabiospecific variants. The morphological variability of some ammonite biospecies – the knobby ones – thus revealed can be spectacular, stretching the limits of credulity (see *Sonninia*, below). In others – the smooth ones – it is much more constrained (*Fissilobicerias*, below). The faunas of Dundry show clear examples of both.

In some cases, species are also assigned to subgenera. These are residual conventional categories retained for subgroups of morphospecies under names for them that are merely more familiar historically. A special problem in ammonites derives from their sexual dimorphism. This morphological expression can be so extreme that, depending on the case, sometimes in the past it was incorporated in taxonomy at levels ranging from the (morpho)specific to that of the family. Coupling antidimorphic pairs of morphospecies now at intraspecific level can still present problems even today. The distinction is therefore retained here at

specific level in cases in which dimorphs have, in the past, been given separate specific names, or sometimes at subgeneric or generic level in cases of greatest uncertainty. The distinction of dimorphs is then indicated by the conventional symbols [M], [m], for macroconchs (females) and microconchs (males), respectively. For convenience in what follows, the ammonites from Dundry are discussed by families and include only those of wider significance. Assignment to rank of subfamily or full family is still somewhat arbitrary.

Whatever the remaining uncertainties, it can be confidently asserted that the true biospecific and hence phyletic diversities at any one horizon in Figure 2 reach their highest values at no more than 12, Bj-10b and 10, Bj-8a, b, in the Laeviuscula Zone. Nomenclatural and bibliographical data of genera and families may be found in the *Treatise* (Arkell, 1957).

The following abbreviations or technical terms are used – HT: holotype; LT: lectotype; PT: paratype; chorotype: specimen from the same area and horizon as the type but from another nearby locality; s.s., s.l.: *sensu stricto*, *sensu lato*, respectively. 'TA' refers to Buckman's 'Type Ammonites'.

#### Family **Hammatoceratidae** Buckman, 1887

Genus *Fissilobicerias* Buckman, 1919

(Fig. 6.1a, b)

This is the only genus of note here, recorded previously in Britain as of unknown origins and uncertain affinities, occurring in the Ovale and Laeviuscula Zones, Bj-4–Bj-8. It has been reviewed in detail recently in a re-description of its type species, *F. fissilobatum* (Waagen, 1867) in its type area, southern Germany (Dietze *et al.*, 2005). Its occurrence at Dundry is discussed in § 4 above. Because of its overall resemblance to some *Sonniniidae* it has long been lumped together with other similar genera in the family Sonnniidae (of which more below) as a sort of catch-all receptacle of despair (e.g. Arkell, 1957, *Treatise*). Much new information now shows it to be a member of an independent, very conservative phyletic line going back well beyond the first cryptogenic appearance of *Sonninia*. The macroconch shells are large, involute, moderately carinate or keeled (without floor) on the venter and smooth on middle and outer whorls with steep umbilical margins, as in many sonnniids. The inner whorls are evolute, keeled and mildly costate, the ribbing sometimes accentuated into subdued nodes or even tubercles, but never as spinose as commonly found in *Sonninia* s.l. The microconchs have yet to be positively identified. However, the decisive discriminant lies in the septal sutures. These are deeply incised and of interdigitating filigree complexity, almost wholly filling the whorl-sides when exposed on internal moulds – hence the name of the type species (see Fig. 6). Also in contrast with the Sonnniidae is the low variability of isochronous assemblages, the biospecies, and the almost unchanging temporal persistence of the basic morphology, i.e. the long ranges of successive chronospecies. In Britain,

the line can be followed via forms described by Buckman as '*Euaptetoceras*' *infernense* (Roman), (TA 5, pl. 396A, [M]) from the Discites Zone down at least to '*Parammatoceras*' *obtectum* Buckman, 1925 (TA 5, pl. 555) of the lower Concavum Zone, Aa-14–Aa-15. Upwards, the youngest member so far of this highly conservative lineage appears to be *Fissiloboceras furticarinatum* (Quenstedt, 1856) (lectotype designated and refigured by Schlegelmilch, 1985, p. 62, pl. 19, fig. 1).

A longstanding problem in nomenclature has also been recently resolved. The name of the index of the Ovale Zone, *Fiss. ovale* (Quenstedt), goes back to *Ammonites sowerbyi ovalis* Quenstedt, 1886. It had been uncertain whether the third name *ovalis* was to be interpreted as that of a variety of *Amm. sowerbyi*, in which case it had no status in formal nomenclature, or whether it was to be regarded as a subspecies of *Amm. sowerbyi*, in which case it was thrice preoccupied, going back to *Amm. alternans ovalis* Quenstedt, 1845. A ruling by the International Commission on Zoological Nomenclature (2005) has now declared that (a) the third names have subspecific status and are therefore formally available and, under its plenary powers, that (b) the name *Amm. sowerbyi ovalis* Quenstedt, 1886, and hence *Fiss. ovale* and the name of the Ovale Zone, shall retain full separate availability despite being originally a junior homonym in the genus *Ammonites*.

Family **Sonniniidae** Buckman, 1892

Subfamily **Sonniniinae** Buckman

Genus *Sonninia* Bayle, 1879

The taxonomic treatment of this family, also recently reviewed in some detail by Dietze *et al.* (2005), raises all the problems of horizontal, biospecific vs. vertical, morphospecific classifications in their extreme form. The family is represented by what are among the most abundant and well-preserved ammonites from the Inferior Oolite of England and its equivalents in continental Europe. There have been many attempts over more than a century to classify them, frequently in monographs of considerable length. Yet, no consensus has emerged: the accounts rarely rise above the level of stamp-collecting. There are two good reasons. The first is past failure to recognize what must be the widest ranges of morphological variability in a biospecies of any group of ammonites at all. The second is once again the lack of precise stratigraphical control of the material available at the necessary level of time resolution, that of the biohorizon. (A third, less sound reason is the failure by authors to take into account the basic requirements of ammonite taxonomy in any form: the distinctions between adult, juvenile and incomplete shells – a lamentable failure that persists widely even today.)

The first attempt to solve the problem was by Buckman (1892–94) in the more restricted group of forms he included in the genus *Sonninia* itself, of which he had at his disposal a huge collection from the Bradford Abbas Fossil Bed, best exposed in a famous

quarry at Coombe near the family farm at East Hill. From this collection he figured some 110 specimens on 40 plates, for which he created 69 new named species. But even he realized that these 'species' could not be 'real' in any natural sense (p. 288): 'The series of specimens is generally so extraordinarily complete, that division into species is often purely arbitrary. The "species" are simply different gradations in development; ...'. One could hardly improve on that today. Accordingly, Westermann (1966) went to the opposite extreme and lumped 65 of these Bradford Abbas species into one and added a further 16 from other beds and places, including France and Germany, united under the oldest name, *Sonninia adicra* (Waa-gen, 1867). The justification was that at the level of stratigraphical subdivision known at the time, all 81 of these 'species' belonged to one and the same 'chronodeme', that of the (then) Discites Subzone of the Sowerbyi Zone. Four of Buckman's morphospecies, already separated by that author himself as the 'dwarf *S. subdecorata* group', were also retained by Westermann as distinct because they 'may represent the corresponding microconchiate dimorph', a distinction that later studies have served only to confirm.

Much subsequent work in Dorset at the level of biostratigraphic resolution being attempted here at Dundry has established that Westermann's 'chronodeme' spans in fact a range of 12 biohorizons, Aa-16 to Bj-8b (Sandoval & Chandler, 2000). These authors confirm that all the forms coming from any single faunal horizon have such an intergrading range of morphology that they constitute in it but a single highly variable biospecies, albeit dimorphic as already recognized previously. They cast the variability and its time-evolution for descriptive purposes in terms of three broad lines of morphological similarity that can be traced vertically over the whole range into the lower Laeviuscula Zone. They chose three of Buckman's morphospecies to exemplify these three strands and combined them all in a single phylogenus *Euhoploceras* Buckman, 1913. The type species *Eu. [Sonninia] acanthode* (Buckman, 1889), from Aa-16, epitomizes the most coarsely sculptured forms, strongly ribbed to the end. The least-sculptured forms, becoming smooth on the middle and outer whorls, are represented by *Eu. modestum*; intermediate forms, retaining strongly-ribbed inner to middle whorls, by *Eu. marginatum*. Both of these are listed also from Dundry (Fig. 2). The successor at Dundry of the *acanthode* strand is *Eu. adicrum*.

New problems now arise in attempting to extend this kind of taxonomy upwards, into the higher levels of the Laeviuscula Zone and thence into the Sauzei Zone. New styles of morphology arise and these have been incorporated in the past into further generic morphogroups. Those of relevance here and defined by type species based on interpretable and hence identifiable type specimens include *Papilliceras* Buckman, 1920 (type species *P. papillatum*, type horizon said to be

Sauzei Zone, Sandford Lane, Bj-11a, but most probably earlier, Trigonalis Subzone, Bj-8b) and *Sonninia* Bayle, 1879 s.s. itself (type species *S. propinquans* (Bayle, 1878), type horizon in the Sauzei Zone of Normandy, Bj-11a). The new 'papillate' character may be seen here in Figure 10.1. It first appears in the lower Laeviuscula Zone (e.g. '*Fissilobicerus*' [sic] *phlyctaenodes* Buckman, 1923, *TA* 4, pl. 387, Bj-8b). The difficulties arise again because, depending on the horizon, isochronous assemblages can intergrade between all these 'genera', including *Euhoploceras*. Even merely different ontogenetic stages of the same specimen can belong to up to three different 'genera'. Thus, the inner and middle whorls of the holotype of *Papilliceras papillatum* itself are those typical of *Euhoploceras*: only the outer whorl becomes papillate. In other species, the papillate stage is confined to the middle whorls. Most, perhaps all, *Sonninia* from the Sauzei Zone are not papillate at all. The only option is to extend to these higher faunas the same treatment as that adopted for the lower ones in the Discites Zone: to use one proper phylogenetic name for the whole lot and to divide them into morphogeneric groups of morphospecies as convenient. And if this treatment is now to encompass all the forms of the phylogenus, from first appearance to last, the choice has to be the one with the oldest name, which is *Sonninia* Bayle, 1879. The morphogeneric groups, including now *Euhoploceras*, may then be retained as (morpho)subgenera of *Sonninia*, and this is the scheme adopted in Figure 2.

The microconchs have been known for a long time but hardly ever differentiated. The earliest are that 'dwarf *S. subdecorata* group' already singled out by Buckman, and similar forms can then be followed upwards into the Sauzei Zone. The dimorphic size-ratio is around 5:1. The difficulty, already mentioned long ago (Callomon, 1963, p. 31), was that in the mature adults the final mouth-border is rarely preserved. But new material makes it now almost certain that, in contrast to other *Sonniniidae*, the microconchs of *Sonninia* itself did not bear lappets on the adult peristome.

Notes on some individual species follow.

(1) *Sonninia micracanthica* (S. Buckman, 1925) (*TA* 6, pl. 611, as *Papilliceras*; Figs 9.1–2; 10.1–2).

The holotype is a phragmocone, probably complete, of diameter 180 mm. Its age was given as '*propinquans*' hemera and it came from the Brown Ironshot of Dundry – North Main Road quarry. The characteristic features of the species are its planulate coiling with an open, evolute umbilical area and compressed, alticariniate whorl-section; fine ribbing, weakly (Fig. 10.1) to quite strongly tuberculate (Fig. 9.1), confined to the innermost whorls, rapidly fading to leave the middle and outer whorls almost smooth; and dense but delicate papillae at mid flank confined, when present at all, to the outer middle whorl (Fig. 10.1). The nearest other species described so far is *S. [Ammonites] arenata* (Quenstedt, 1886) (pl. 60, fig. 10; refigured by Dorn,

1935, pl. 7, fig. 1, and Schlegelmilch, 1985, pl. 16, fig. 4). It may well be a senior synonym of *S. micracanthica* but neither its place of origin nor its stratigraphical level are known precisely and there appear to be no topotypes. Some further specimens in Stuttgart from elsewhere in the Swabian Brown Jura are also close but of similarly imprecise origin. In view of its use now as marker of a new faunal horizon at Dundry, it seems safer to retain *S. micracanthica* as a separate biospecific taxon for the time being. Another English specimen that is almost certainly conspecific was figured by Buckman as *Papilliceras mesacanthum* (Waagen) (1925, *TA* 5, pl. 557), from the Irony Bed of Bradford Abbas, but this is highly condensed and of variable age even at Bradford Abbas, so that it contributes nothing to the dating of *S. micracanthica*, rather the reverse. Moreover, the true *S. mesacantha* is distinct.

Some biometric data:

| Specimen           | $D_{\max}$ | $D_{ph}$ | bch    | $D$ | $h$  | $w$  | $u$  |
|--------------------|------------|----------|--------|-----|------|------|------|
| Fig. 9.2 (#40089)  | 320        | 320      | (wh s) | 170 | 0.40 | 0.24 | 0.35 |
| Fig. 10.2 (#29284) | 275        | 275      | (wh s) | 160 | 0.40 | 0.18 | 0.30 |
| Osborne (#29312)   | 260        | 260      | (wh s) | 180 | 0.40 | 0.24 | 0.36 |
| Osborne (#40015)   | 240        | 240      | (wh s) | 215 | 0.37 | 0.19 | 0.35 |
| BA (GSM 47564)     | 295        | 205      | 0.7    | 165 | 0.40 | 0.21 | 0.32 |
| Fig. 9.1 (#29274)  | 270        | 200      | 0.45   | 190 | 0.39 | 0.19 | 0.38 |
| Fig. 10.1 (#29241) | 220        | 185      | 0.25   | 190 | 0.27 | 0.19 | 0.36 |
| HT (GSM 47782)     | 180        | 180      | (wh s) | 180 | 0.37 | 0.24 | 0.35 |

$D_{\max}$ : maximum preserved diameter;  $D_{ph}$ : diameter at end of phragmocone, in mm; bch: length of bodychamber preserved, as fraction of a whorl; wh s: wholly septate;  $h$ : coefficient of whorl-height,  $H/D$ ;  $w$ : of whorl breadth;  $u$ : of umbilical width, all at diameter  $D$ . Specimen numbers: GSM, British Geological Survey collection, Keyworth; GSM 47564: *Papilliceras mesacanthum* (Waagen) – Buckman, *TA* 5, pl. 557, from the Irony Bed of Bradford Abbas (BA); others, Sedgwick Museum, Cambridge, series X. Arranged in order of decreasing phragmocone diameters.

Another closely similar assemblage has been described from Skye in Scotland by Morton (1975) under the names *S. (Papilliceras) arenata* or *mesacantha*. Its resemblance to the *S. micracanthica*–*arenata* assemblage from Bj-10b of Somerset–Dorset is striking: the same compressed, evolute whorl-section; very similar ribbing confined to the innermost whorls, with a similarly variable tuberculation, the middle and outer whorls becoming wholly smooth except for a striking row of dense, delicate papillae in some variants running along the whorl-side at mid-height. But the Scottish specimens are significantly smaller: maximum size 130–180 mm, septate to 90–120 mm, in the four adults figured by Morton. They characterise his fauna (biohorizon?) 5 (Morton, 1976, p. 28), assigned to the Sauzei Zone. But in consequence of the more precise definition of the Laeviuscula/Sauzei Zone boundary proposed here at Dundry, the Scottish fauna may still be of Laeviuscula age.

The *Sonninia* from the overlying fauna at Dundry, Bj-11a, *S. propinquans*, are quite distinct. They become involute in the middle-outer whorls of the macroconchs and the inner whorls are much more strongly ribbed to larger diameters. The ribbing is coarser, the



primaries dividing in irregular, swollen bullae near the umbilical margin, in some variants briefly carrying well-spaced strong tubercles on the innermost whorls. The differences between *S. micracanthica-arenata* as illustrated here and *S. propinquans* are well brought out in two specimens from Bj-11a at Sandford Lane figured by Buckman (1922, *TA* 4, pl. 298, and 1924, 4, pl. 528 as *S. alsatica* Haug). A third may be the other specimen from Dundry–North Main Road described by Buckman (1926, *TA* 6, pl. 412A only) as *S. corrugata*. The inner whorls of a strongly tuberculate variant are represented by *S. subtrigona* Buckman, 1910 (p. 93, pl. 11, figs 4–6). The variability of *S. propinquans* remains to be mapped and it may turn out to include an even older species, *S. patella* (Waagen, 1867; LT refigured by Schlegelmilch, 1985, pl. 18, fig. 2). The beds with fauna Bj-11a in Somerset–Dorset widely overlie a marked unconformity, so there remains room for further faunal horizons between Bj-10b and Bj-11a.

(2) *Sonninia sowerbyi* (Miller MS in J. Sowerby, 1818)

(*Min. Conch.* 2, 235, pl. 213).

Text reproduced and lectotype refigured in Buckman & Woodward (1908), legend to pl. 3, left and middle figures; also refigured by Arkell, 1956, pl. 34, figs 2a, b. The type (BCM Ca5081) is a wholly septate nucleus and came undoubtedly from the Brown Ironshot of Dundry. It was taken for a long time as the epitome of early sonninitids, hence index of Oppel's (1862) and Waagen's (1867) Sowerbyi Zone, which accommodated stratigraphically everything between the Murchisonae Zone (today in the Aalenian) and the Sauzei Zone. But its precise age was uncertain. As is now known, the Brown Ironshot contains (at least) two faunal horizons, and of the Sonninitids found in these, *S. micracanthica* in Bj-10b and *S. propinquans* in Bj-11a, *S. sowerbyi* most closely resembles the former, as far as can be told from the highly incomplete preservation of the type. So both *S. arenata* and *S. micracanthica* may, in fact, be junior synonyms of *S. sowerbyi*. But as such a relationship – based on a single specimen – must remain conjectural, there is no point in now trying to reintroduce it formally.

(3) *Sonninia corrugata* (J. de C. Sowerby, 1824)

(*Min. Conch.* 5, 74, pl. 451, fig. 3).

This is another often-cited Dundry species based on a barely identifiable nucleus, well re-illustrated by Buckman & Woodward (1908, pl. 6, figs 4a, b). It is a wholly septate nucleus of diameter about 30 mm, but the preserved shell hides the sutures so that its status as microconch or nucleus of a macroconch cannot be tested. There are no other signs of maturity, such as uncoiling of the umbilical suture, although the coiling and ribbing as a whole suggest a microconch. It was confidently assigned to the undivided 'Brown Ironshot' by Buckman (Buckman & Wilson, 1896; Buckman, 1923, *TA* 4, pl. 412 only, 'topotype'), in which he

was followed by Parsons (1979, table 4). But on re-examination of the specimen in the Natural History Museum (43951a), its matrix suggests that it may have come somewhat lower down, from a part of the White Ironshot. Figure 4.6 shows a microconch that resembles it very closely, from bed 9a, Trigonalis Subzone. It seems best to set the species aside as another *taxon dubium* in the framework of precision in which ammonite taxonomy is being refined today.

#### Genus or subgenus *Sonninites* Buckman, 1923

The holotype of the type species, *S. felix* (*TA* 5, pl. 423A, Sauzei Zone, Bj-11a), shows the distinguishing characters well: compressed, flat-sided, involute whorl-section, with sharp umbilical edge on a vertical to even overhanging umbilical wall, subdued ribbing on the nucleus hardly if ever tuberculate, becoming wholly smooth quite early but retaining a characteristic radial striation of the test, and low intraspecific variability. The paratype (pl. 423B) is almost certainly the microconch. *Sonninites simulans* Buckman (1926, *TA* 6, pl. 631) shows the intermediate whorls well. The genus then rises almost unchanged into the higher Sauzei Zone, certainly as high as Bj-12, bed 9b-c at Burton Bradstock (Callomon in Callomon & Cope, 1995, p. 66). It has also been found on Skye, in the sharply delimited 'Torvaig fauna' (Morton, 1975, pl. 16, figs 1, 2, pl. 17, figs 3, 4, and other collections; 1976, fauna 6).

The separation of this group from *Sonninia* s.s. by Buckman may be well founded but confirmation must await a more detailed study of intraspecific variability in the abundant new material from the Sauzei Zone of Sandford Lane, to see whether its type species intergrades into the *Sonninia* s.s. of the *propinquans* group. Preliminary investigation suggest that it does. It may also characterize an as yet unresolved separate bio-horizon lying between *S. micracanthica* below and *S. propinquans* above. In the meantime, therefore, we retain it as a subgenus in *Sonninia* s.s.

#### Genus *Shirbuirnia* Buckman, 1910

The history of this group has been tortuous because of the usual problems of delimitation of nominal taxa based on inadequately documented type material. These problems have now been resolved largely through new collecting in Dorset and Swabia (Dietze *et al.*, 2005). Representatives have been found at Dundry (Fig. 2) but have contributed little to the systematics. The main uncertainty arose because the genus was originally based on two species, *Sh. trigonalis* Buckman, 1910 and *Sh. stephani* (Buckman, 1883). The former was for various reasons selected as type species by Arkell (1954). Correct identification depends rather heavily on the middle to outer whorls of large specimens, which, in the appropriate levels of the White Ironshot at Dundry, are not preserved. Conversely, the bed that does yield large specimens, the Ovale Bed, 8b, in the Ovale Zone, produces forms that are not easily placed. Besides undoubted *Fissiloboceras ovale* itself

there are similarly large, smooth forms one of which was illustrated previously by Callomon & Chandler (1990, pl. 1, fig. 5). It brings out clearly one of the main differences from *Fissilobicerias*, the much simpler septal suture. These forms resemble the commonest ones found at Gingen, in southern Germany, named *Amm. gingensis* by Waagen (1867). They have also been recently redescribed (Dietze *et al.*, 2005) and assigned to *Shirbuirnia* for want of a better alternative. If correct, this would enlarge the scope and extend the range of *Shirbuirnia* downwards into the Ovale Zone from its previously cryptogenic appearance in the Trigonalis Subzone above, Bj-8a/b.

#### Genus *Pseudoshirbuirnia* Dietze *et al.*, 2005

This genus was introduced recently for the forms previously epitomized by the other syntype species of *Shirbuirnia*, *Sh. [Amaltheus] stephani* (Buckman, 1881). The two groups are radically different and seemed to have been united originally on the strength of only one shared character, a carinate venter on a triangular cross-section in the adult bodychamber of (some) macroconchs. The most striking feature of *Pseudoshirbuirnia* is the simple septal suture of low relief on a straight base-line, with a strongly asymmetric bifid lateral lobe. *Ps. stephani* was for a long time known from only one level and locality in Britain, that of the famous Sandford Lane Fossil Bed near Sherborne. New collecting has yielded it also from Dundry (Parsons, 1979, pl. 1, figs 4, 6, and here) and in Dorset, at Beaminster and at Redhole Lane, near Sherborne, where it is abundant at about the boundary between Bj-8a and Bj-8b. The closely related *Ps. fastigata* Buckman (1924, *TA* 5, pl. 460), from Sandford Lane, has also been found in Skye (M. Edmunds and RBC. coll.) but not at Redhole Lane, suggesting that *Ps. stephani* and *Ps. fastigata* differ slightly in ages. Further afield, the genus has been recorded from eastern France (*Sonn. kluepfeli* Gillet, 1937, pl. 3, fig. 5) and northern Germany (Hiltermann, 1939), but it is most abundant in Swabia, again around Gingen, where it characterizes a separate *stephani* biohorizon, suggesting that this was closer to its true 'home'. Its vertical range has also been extended somewhat, which raises the question as to whether it is the direct ancestor of that closely homoeomorphic group, that of '*Dorsetensia*' *liostraca*, *subtecta* Buckman, so characteristic of the lower Humphriesianum Zone.

Subfamily **Witchellinae** subfam. nov. Callomon & Chandler, here

That the forms long known as *Witchellia* seem somehow to stand aside from the other sonniniids collectively included in the Sonniniidae has long been recognized. But with so many morphological features in common, it was not clear where to draw any consistent dividing lines. Three relatively recent insights now make this possible.

First, the horizontal variability of biospecies has been characterized horizon by horizon, bringing out

the persistent elements of morphology that distinguish those of *Witchellia* from the other Sonniniidae, leading among them their relatively small sizes. Thus, all the eight morphospecies of *Witchellia* listed from bed 9b (Bj-10a) in Figure 2 are, with little doubt, only variants of a single biospecies.

Second, the form of their dimorphism is consistent and clear. In contrast to most, if perhaps not all, the other sonniniids, their adult microconchs have strongly lappeted apertures, sometimes expressed in spectacularly spatulate form. They have been classified conventionally under the generic heading *Pelekodites* Buckman (1923, *TA* 4, pl. 399, type species *P. pelekus*, type locality Dundry, horizon Bj-5 – see Fig. 2 and § 4 above), the oldest of several available names. The antimorph of the assemblage from Bj-10a mentioned above is '*Maceratites*' *aurifer* [sic] Buckman, 1928 (*TA* 7, pl. 766, type also from Dundry). The dimorphic size-ratio is modest, between 2:1 and 3:1.

Third, their evolution has been mapped vertically over an uninterrupted succession of at least ten faunal horizons, nowhere more clearly than in Britain: for details at Dundry, see § 4 above. In the course of this they changed relatively little, both in sculpture and intraspecific variability. The oldest undoubted member of the lineage recorded is that of *W. romanoides* in Bj-5. The most plausible ancestors may lie in the pair *Fontannesia* Buckman, 1902 (type *Dumortieria grammoceroides* Haug, 1887) [M] – *Nannoceras* Buckman, 1923 (type *N. nannomorphum*) [m], from the Discites Zone, in which they stand apart from all the other sonniniids in exactly the same way as *Witchellia* does in higher horizons. Particularly striking is the similarity of the lappeted microconchs, which include the better-known *N. boweri* (Buckman, 1883). (For the best description, see Buckman, 1905, *Supplement*, p. clxxxvii and pl. 24). Whether the relation of *Witchellia* to *Fontannesia* is by direct descent or from a common immediate ancestor cannot be decided yet. But it seems sufficiently close to place both groups in the same subfamily. The youngest member of the lineage seems to lie in the pair *Witchellia romani* (Oppel, 1856) [M] – *Pelekodites deltafalcatus* (Quenstedt, 1857) [m], from the Romani Subzone of the Humphriesianum Zone, Bj-14.

The type assemblage in its type horizon at its type locality of the type species of the genus *Witchellia* and of the index species of the Laeviuscula Zone having now been firmly characterized, it seems an appropriate moment to formally recognize the lineage to which *Witchellia* belongs and which it so clearly epitomizes by giving it subfamilial rank, the Witchellinae, as a separate branch within the clade of the Sonniniidae.

#### Family **Stephanoceratidae** Neumayr

A proper phylogenetic analysis of this family is also still outstanding, faced by the same basic problem that bedevilled the Sonniniidae: the delimitation of what are highly variable biospecies. The number of morpho-generic taxa in the literature is almost as great as that



in the Sonniniidae. Some of these are retained in Figure 2 for convenience. But some distinctions can now be made. *St.* (*Normannites*) distinguishes the microconchs. *Mollistephanus* stands consistently aside over a considerable stratigraphical range (Chandler & Dietze, 2004), marked by its diminutive size. *Kumatostephanus* is also distinct and has some range. Its first appearance was thought previously to mark the base of the Sauzei Zone and *K. kumaterus* was chosen to be index of the lowest of a threefold subdivision into Subzones of the Sauzei Zone by Galacz (1989), but the more precise redefinition of the Laeviuscula–Sauzei Zone boundary proposed here puts the origins of the genus still in the Laeviuscula Zone (see § 4 above). One species that stands out as apparently closely time-diagnostic is *St. kalum* (Fig. 8.1), now chosen to label horizon Bj-11a, the lowest in the Sauzei Zone (see § 4 above). It epitomizes the most serpentine stephanoceratids known, conventionally cited as *Skirroceras*. It may even intergrade into the most extreme form, '*Oecostephanus dolichoecus* Buckman, 1921 (*TA* 3, pl. 265), also from 'Dundry, ironshot bed', with its bodychamber of 2.2 whorls, although no further specimens as extreme as the type have been found. The microconch of *St. kalum* is probably *Normannites braickenridgii* (J. Sowerby, 1818), the similarly most evolute form, whose type came from the Brown Iron-shot of Dundry (refigured by Buckman, 1913, *TA* 2, pl. 81; 1914, pl. 81\*).

#### Family *Otoitidae* Mascke

The family is represented at Du-SMR by *Emileia* [M] and *Otoites* [m]. Parsons (1974) and others began the attempt to indicate the relationship between these two 'genera' as being no more than that of antidimorphs by subsuming *Otoites* Mascke, 1907 into *Emileia* Buckman, 1898 as junior subgenus. The distinction is here retained at generic level merely on grounds of convenience and convention. Many morphospecies have been described in the past, but both a precise biostratigraphy and the mapping of the considerable variability of individual chronospecies remain to be established. The early forms of *Otoites* s.l. from the Ovale and lower Laeviuscula Zone were described by Parsons (1977), but the many questions that remain both at this level and in later forms cannot be dealt with here. Two specimens from bed 8c, Bj-7b, are shown here in Figures 6.4 and 7.4. The more familiar picture of these microconchs is represented by its type species, *Otoites sauzei* (d'Orbigny), as re-illustrated for instance by Arkell (1956, 1957). But no syntype specimen closely resembling d'Orbigny's figure has been found and satisfactory efforts to designate a neotype are still incomplete (Pavia, 1994). The uncertainties this creates have been mentioned in the stratigraphical section above but are not important here. Specimens resembling d'Orbigny's figure in all respects except size do occur in the Sauzei Zone at Dundry and elsewhere in Britain and, even if they turn out to be merely variants of *O. contractus* (J. de C.

Sowerby, 1825, neotype in Buckman, 1920, *TA* 3, pl. 158, from the Sauzei Zone of Sandford Lane), that is no reason for changing the name of the Zone. An example of the later forms, from the earliest Sauzei Zone Bj-11a, is shown here in Figure 6.5.

#### Genus *Emileia* Buckman, 1898

The forms of this genus mark one of the most prominent members of the faunas of the Sauzei Zone the world over. The type of the type species, *E. brocchi* (J. Sowerby, 1818), from 'near Sherborne', was refigured by Buckman (1927, *TA* 6, pl. 710A, B) together with a chorotype (Buckman, 1927, *TA* 6, pl. 710C, D) from Sandford Lane. It marks also the earliest level known until recently, horizon Bj-8b, at which these typical forms with sphaeroconic, involute inner whorls make their first appearance. Earlier forms are now emerging. One of these was discovered at Dundry, at the boundary between beds 8c and 9a, horizons Bj-7b/8a. This is described below.

*Emileia dundriensis* sp. nov. Callomon & Chandler,  
here  
(Figs 6.3a,b, 7.1–7.3)

#### Material

The holotype, Fig. 7.1a, b (Sedgwick Museum, Cambridge, X 29101) and three paratypes (PT-1, Figs 7.2a, b, SM X 29100; PT-2, Figs 7.3a, b, X 40068; PT-3, Fig. 6.3a,b X 29102, all currently with RBC).

#### Horizon and locality

South Main Road Quarry, Dundry, base of bed 9a, faunal horizon Bj-8a, Lower Bajocian, Laeviuscula Zone. Found also at Clatcombe, near Sherborne, Red-hole Lane, bed 3b, type locality and horizon of Bj-8a (SM X 29301).

#### Description

All four specimens are adult macroconchs of medium size for the genus, preserved as internal moulds, the HT and PT-1 complete with mouth border, PT-3 reaching just to the beginning of the final constriction preceding the peristome. Cadicone, subcoronate inner whorls becoming planulate and evolute, the adult bodychamber contracting gently with uncoiling of the umbilical seam. The umbilicus is relatively open at all stages and becomes shallow on the outer whorls, with low, rounded shoulders. Measurements are given below. PT-2, being broken open, gives access to the inner whorls. Their measurements reflect the changes in coiling. The shell termination is preceded on the internal mould by a broad constriction left by an inward thickening collar on the lost test and the gently forward curved peristome opens slightly to a trumpet-shaped lip. The primary ribbing is subdued, rounded, slightly projected, of moderate density, and fades on the final bodychamber without changing style. The secondary ribbing, where first visible, is also subdued,

arising inconspicuously from the primaries, and persists to variable degrees on the venter. The septal sutures are elaborate and typical of the genus.

#### Dimensions

| Specimen       | $D_{\max}$ | $D_{\text{ph}}$ | bch  | $D$ | $h$  | $w$  | $u$  |
|----------------|------------|-----------------|------|-----|------|------|------|
| HT (#X29101)   | 170        | 90              | 1.25 | 90  | 0.39 | 0.48 | 0.38 |
|                |            |                 |      | 70  | 0.33 | 0.54 | 0.28 |
| PT-1 (#X29100) | 170        | 105             | 0.95 | 105 | 0.30 | 0.45 | 0.40 |
|                |            |                 |      | 85  | 0.32 | 0.50 | 0.39 |
|                |            |                 |      | 45  | 0.36 | 0.55 | 0.40 |
| PT-2 (#X40068) | 150        | 115             | 0.6  | 110 | 0.33 | 0.49 | 0.35 |
|                |            |                 |      | 90  | 0.39 | 0.55 | 0.30 |
|                |            |                 |      | 35  | 0.47 | 0.82 | 0.24 |
| PT-3 (#X29102) | 175        | 100             | 1.2  | 100 | 0.30 | 0.51 | 0.44 |
|                |            |                 |      | 85  | 0.31 | 0.58 | 0.46 |
|                |            |                 |      | 65  | 0.30 | 0.53 | 0.37 |

$D_{\max}$ : maximum preserved diameter;  $D_{\text{ph}}$ : diameter at end of phragmocone, in mm; bch: length of bodychamber preserved, as fraction of a whorl; wh s: wholly septate;  $h$ : coefficient of whorl-height,  $H/D$ ;  $w$ : of whorl breadth;  $u$ : of umbilical width, all at diameter  $D$ . Specimen numbers as registered in the collections of the Sedgwick Museum, Cambridge.

#### Comparisons

The notable features differentiating *E. dundriensis* from most other species of the genus are its size and evolute coiling. Common later forms from the Laeviuscula Zone, e.g. *E. brocchi* (J. Sowerby) (see above) or *E. contrahens* Buckman, 1927 (TA 7, pl. 744A, B), and from the Sauzei Zone, e.g. *E. bulligera* Buckman, 1927 (TA 7, pl. 732A-c) or *E. vagabunda* Buckman, 1927 (TA 7, pl. 723A, B), are mostly much larger, with diameters c. 300 mm and phragmocones to correspondingly large diameters; are more depressed in whorl-section; and have much narrower, deeper umbilici. They are also more strongly variocostate, the adult bodychamber departing radically in style of coiling from that of the phragmocone.

No other species like the present have so far been described. It recalls perhaps the style of its probable ancestors, *Docidoceras* in the Discites Zone.

#### Notes on the nautiloids (AK)

Nautiloids are remarkably common in the Inferior Oolite of Dorset and Somerset but have not received much attention in the past. One of us is currently reviewing these forms.

Three species of nautiloid have been recorded previously from Dundry (Foord & Crick, 1890; Foord, 1891): *C. (Cenoceras) ornatum* (Foord & Crick), *Metacenoceras obesum* (J. Sowerby), and *Pseudaganides polygonalis* (J. de C. Sowerby). A record of *Metacenoceras clausum* (d'Orbigny) from Dundry (Foord & Crick, 1890, p. 285; Foord, 1891, p. 227) is questionable (Tintant, 1984, p. 34). However, given the extensive nautiloid faunas known from equivalent strata in Dorset, it is likely that further work at Dundry will yield additional species.

Several specimens of *Cenoceras ornatum* (Foord & Crick) were encountered in the Brown Ironshot (bed 10, Sauzei Zone), two of them at the upper planed-off junction. This species has a moderately expanding shell with compressed sides, slightly inflated mid-laterally, and a broad, flattened venter. The umbilicus is slightly open and exposes a portion of two inner whorls, its sides steep with rounded margin. There are about 18–20 septa per whorl, the sutures having shallow lateral and ventral lobes. These shells can reach a very large size: Foord (1891, p. 209) recorded a specimen from Sherborne, Dorset with a diameter of some 60 cm. The largest specimen now found at Dundry, made up of the phragmocone and part of the body-chamber, has a diameter of 28 cm.

Two specimens assigned to *Metacenoceras* cf. *obesum* (J. Sowerby) were found in the White Ironshot (Bj-10, Laeviuscula Zone) below. These have very rapidly expanding shells with rounded sides, of greatest width near the umbilical margin, and very broad, flattened venter and a small, occluded umbilicus. The whorl section is subquadrate, about twice as wide as high. There are numerous septa, 20 to 24 per whorl; sutures are nearly straight with a very broad and shallow lateral lobe. The largest phragmocone seen reaches a diameter of nearly 16 cm. Several other very rapidly expanding nautiloids occur in the Inferior Oolite of Somerset and Dorset. *M. rotundum* (Crick, 1898) has a different whorl section and is less camerate; *M. perinflatum* (Foord & Crick, 1890) has a rounded venter with semilunate section and slightly curved sutures; *Cenoceras smithi* (Foord & Crick, 1890) has a rounded venter, the siphuncle is ventral of centre and the external shell bears distinct longitudinal and transverse ornament.

## 6. CONCLUSIONS

The Inferior Oolite of Dundry has been famous for its fossils since the earliest days. The emphasis has been on its ammonites, to our knowledge of which it has made major contributions. Some 26 nominal species going back to 1818 have their type localities at Dundry. Their study can be resolved into three phases. In the first, the emphasis was largely on the purely taxonomic description of the enormously rich and diverse forms found, many of increasingly international importance. The names here are those of the Sowerbys in their *Mineral Conchology* (1818–25), epitomizing the encyclopaedic era of natural history, and of S. S. Buckman (the years 1905–1929), the first to study comprehensively the ammonites of the Jurassic in Britain. These authors accounted for 23 of those species. The second phase focused on the growing use of ammonites as geological clocks for dating rocks, particularly those of the Inferior Oolite, by means of their biostratigraphy. The pioneer here was undoubtedly also Buckman, starting with his seminal study of the Inferior Oolite of Sherborne (1893),

rapidly extended to Dundry (1896). It introduced the first standard chronostratigraphical classification of the Aalenian and Bajocian Stages in Britain. The corollary was the inverse, the use of their biostratigraphy to study the time evolution of the ammonites, their palaeobiology as Buckman called it. The third phase was the first modern revision of the Inferior Oolite begun by Parsons (1974–1980), including the succession at Dundry (1979). It incorporated many advances made since Buckman's time both in biostratigraphy and ammonite taxonomy, but particularly in the latter, building on the monumental synthesis by Arkell in the ammonoid volume of the *Treatise* (1957). The present study marks some steps towards what may be the final stage.

On the one hand, it has taken the biostratigraphical documentation of the ammonite record now close to the limits of time resolution achievable by means of fossils, that of characteristic faunal horizons. Its consequence is the identification of the ages of the beds that are present at Dundry. But, perhaps even more significantly, it identifies the ages of the beds that are not present, the non-sequences – an approach also going back to Buckman a century ago.

On the other hand, the amplified knowledge of the ammonite faunas makes possible an attempt at a major recasting of their taxonomy as a whole, from a purely

morphological description in terms of morphospecies to a natural classification based on their evolution, deduced from the succession in time of the natural units of evolution, the biospecies. The stratigraphical and palaeontological discussions of the results from Dundry serve well to illustrate the progress being made.

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