**A REVIEW OF THE AMMONITE FAUNAS AND STANDARD ZONATION OF THE HETTANGIAN AND LOWER SINEMURIAN SUCCESSION (LOWER JURASSIC) OF THE EAST DEVON COAST (SOUTH WEST ENGLAND)**

K. N. PAGE


The classical Jurassic sequence for which the coast of Dorset (south-west England) is famed, begins in East Devon. Faunal records for the lower part of the Hettangian (Planorbid and the lower part of the Liasicus chronozones) in this region are based solely on sections in the latter county and it is only from the higher part of the Lower Sinemurian (Semicostatum and Turneri chronozones) that records from Dorset become more important. The Planorbis and Liasicus chronozones of the early Hettangian yield characteristic *Psiloceras, Caloceras, Waubeniceras, Psilophyllites* and *Alsaites*. In the Angulata Chronzone, typical faunas of *Schlothaueria* spp. also include very rare forms with Mediterranean affinities such as *Angulaticeras* (*Charmaasieceras*) *marmoerum* (Wähner) and early Arietitinae (*Schreibnabchites* Bloos). The overlying basal Sinemurian Conybeari Subchronozone (Bucklandi Chronzone) is relatively well developed with characteristic *Metophioceras, Vernicoeras* and *A* (*Charmaasieceras*) and although records from higher levels in the chronozone are less complete, good faunas of typical *Coroniceras* and *Arietites* have been recorded. The Semicostatum and Turneri chronozones are better known in Dorset, although equivalent strata are present in Devon, albeit not always well exposed within extensive landslip systems. Typical faunas from these levels include *Arnioceras, Paracoroniceras, Parnasiusceras, Euagassiceras, Agassiceras, Caenisites, Microderoceras, Cymbites, Promicroceras* and early *Epilophioceras*.

**INTRODUCTION**

The Lyme Regis district has long been famed for its fossiliferous exposures of Lower Jurassic rocks. Exposures are present in coastal cliffs and foreshore, both to the east of the town, within Dorset, and to the west, mainly in Devon. Indeed, the classical Jurassic sequence for which the Dorset coast is famous, commences in Devon, and it is only in the latter county that the basal part of the sequence is seen, including the boundary with the underlying Triassic System.

The aim of this work is to provide an up-to-date review of this classic, earliest Jurassic sequence, with full revision of all recorded ammonite faunas and correlations, combined with new information from recent studies. As the succession west of Lyme Regis, towards Axmouth, is more completely accessible, research has been concentrated in this area, but as some lateral variation does exist in the sequence, additional faunas recorded from east of Lyme Regis are explicitly stated as such.

The former exposures lie almost entirely within the Axmouth to Lyme Regis Undercliffs National Nature Reserve (Figure 1). The reserve is protected for its geological and ecological features through the National Parks and Access to the Countryside Act 1949, the Wildlife and Countryside Act 1981, as amended by the Countryside and Rights of Way Act 2001, and the Conservation (Natural Habitats) Regulations, 1994 and advice regarding access and sampling protocols should be sought from English Nature, Devon Team, Renslade House, Bonhay Road, Exeter, Devon EX4 3AW, U.K.

**LITHOSTRATIGRAPHY**

*Nomenclature and general characteristics of the sequence*

Until recently there has been little standardised lithostratigraphical terminology for the Lias Group in Britain (cf. Getty in Cope et al., 1980), excepting a plethora of geographically restricted new names, generated by the British Geological Survey during remapping of areas in central and northern England. A review and rationalisation of this terminology for England and Wales has been proposed by Cox et al. (1999 - also available on http://www.bgs.ac.uk) and this scheme is largely followed here. At a formal level, an essentially bipartite division has been adopted for Hettangian-Sinemurian deposits in England, with a lower or Blue Lias Formation and an upper Charmouth Mudstone Formation. The former is not readily separable into members in Devon and Dorset, although the latter has a well established subdivision, following Lang (in Lang et al., 1923, and Lang and Spath, 1926), with a lower, or Shales-with-Beef Member and an upper Black Ven Marls Member.

The Blue Lias Formation immediately overlies a distinct planar surface at the top of the Libsrock Formation of the Triassic Penarth Group, with well developed *Diploracerinburrows* and, locally, desiccation cracks - the so-called "Sun Bed" (as recently redescribed by Wignall, 2001). The establishment of the well-known mudrock-limestone rhythms of the "Blue Lias" sequence, commences immediately above this level, although the first psilocradid ammonites, indicating the base of the Jurassic System, are not recorded until Bed 1125 of Lang (1924), around 2.5 m above the base of the formation.

Many of the limestones, especially in the higher part of the Blue Lias Formation sequence, were given names by quarrymen when the beds were worked along the foreshore for cement and building stone. These names were recorded by Lang (1924) and incorporated in his descriptions and some are utilised below. He also provides useful advice on recognising individual beds in the cliff and foreshore. Lang’s bed numbers are also retained, including his use of the prefix “H" (= "Hettangian") for the lower part of the sequence.

There has been much discussion on the origin of the limestones, particularly regarding a depositional vs. diagenetic origin, going back to De la Beche (1839). As discussed by House (1985), Weedon (1986) and Weedon et al. (1999), this cyclicity is
Psiloceras erugatum of stratigraphical nomenclature at the level of subchronozone time scale, the use of biohorizons to characterise a sequence of 1985b; Page, 1995a). As well as establishing a high-resolution a possible resolution of as little as 120,000 years (Callomon, particular, permits the recognition of stratigraphical "events" at useful fauna. In the Sinemurian, the use of biohorizons in which represent discrete beds with a distinctive and correlatively were termed "zonules" by Phelps, 1985) and "biohorizons", typically used as subdivisions of subchronozones (and as such changes as senior synonyms of zonal indices are recognised "chronozone" or "subchronozone". Standard subzones are now standard zones in this paper are therefore quoted explicitly as to emphasise the true nature of the units being used, all biozones and NOT biozones as incorrectly implied by authors such as Whittaker (1991). To minimise this risk of confusion and to emphasise the true nature of the units being used, all standard zones in this paper are therefore quoted explicitly as "chronozone" or "subchronozone". Standard subzones are now subdivided into even finer, high resolution units, often known collectively as "horizons" (Callomon, 1985a, b; Page, 1995a). The latter include the "Horizons" of French authors, which are typically used as subdivisions of subchronozones (and as such were termed "zonules" by Phelps, 1985) and "biohorizons", which represent discrete beds with a distinctive and correlative useful fauna. In the Sinemurian, the use of biohorizons in particular, permits the recognition of stratigraphical "events" at a possible resolution of as little as 120,000 years (Callomon, 1985b; Page, 1995a). As well as establishing a high-resolution time scale, the use of biohorizons to characterise a sequence of faunas or events at a basin or regional scale assists the stabilisation of stratigraphical nomenclature at the level of subchronozone and chronozone throughout a whole faunal province. As these units are formally defined, they are quoted as, for example, Psiloceras erugatum Biohorizon, or simply erugatum Biohorizon.

**Hettangian zonation and the base of the Jurassic system**

The base of the Jurassic system is drawn at the base of the Psiloceras ammonoid Chronozone following Oppel (1856-1858), the chronozone, as conventionally interpreted, marking the first occurrence of ammonites in North West Europe, after the re-establishment of fully marine conditions towards the end of the Triassic Period. Recent work by Bloos and Page (1997, 2000a) and (Page and Bloos, 1998) has demonstrated that the lowest of these faunas is characterised by Psiloceras erugatum (Phillips), marking an erugatum Biohorizon.


**Sinemurian zonation**

As historically one of the best known exposures of the Hettangian-Sinemurian boundary in Britain, sections on either side of Lyme Regis have inevitably been important to discussions of the definition of the stage boundary, including a proposal as a stratotype (Donovan in Morton, 1971). The subsequent discovery of expanded and stratigraphically more complete sections at this level on the West Somerset coast (Page, 1992, 1995b), however, led to the latter’s formal designation as the Global Stratotype Section and Point (GSSP) for the boundary (Page et al., 2000; Page, 2001; Bloos and Page, 2002). The base of the Sinemurian Stage is taken at the first occurrence of abundant arietitid ammonites, including Vermiceras quantoxense Bloos & Page, characterising a quantoxense Biohorizon at the base of the Conybearei Subchronozone of the Bucklandi Chronozone.

The North-West European Province scheme for the Sinemurian of Donovan in Dean et al. (1961) remains in use, with only minor changes as senior synonyms of zonal indices are recognised (Getty in Cope et al., 1980; Page, 1992, in press; Mouterde and Corna, 1997). Page (in press) reviews the current biohorizonal framework for the stage, based on Page (1992, 1995a, b) and Bloos and Page (2000b).

**Distribution of key exposures**

The occurrence of outcrops of Jurassic rocks as far west into Devon as Culverhole Point was noted by de la Beche (1822, p. 42) and the first measured section of the Blue Lias in the district was provided by the same author in 1826 (p. 26; also 1839, p. 223) at Seven Rock Point (see below). Further notable accounts include Wright (1860, pp. 401-2; 1878, pp. 38-9), Woodward (1893, also in Woodward and Ussher, 1906, 1911) but the most completely described sections remain those of W.D. Lang (in Lang et al., 1925, 1924, in Lang and Spath, 1926). Hesselbo and Jenkyns (1995, figs 8 and 9), provide a recent diagrammatic section with explanatory notes, although bed by bed details are not included. The most well known section in Devon is that between Pinhay Bay and Lyme Regis itself, but several other significant localities are also present, as listed below:

(a) Culverhole Point, west [SY 273893]. The top of the Triassic sequence, including the Lilstock Formation at the top of the Penarth Group (Bhaetian) is well exposed in the cliff and landslipped masses, although the overlying Blue Lias Formation, does not appear to be visible in situ at present, being concealed
Figure 2. The sequence of ammonite faunas in the Blue Lias Formation of the East Devon coast. The provenance of taxa in brackets are not specified by Lang (1924), and could include records from Dorset. Bed numbers follow Lang (1924). Abbreviations as follows: LF = Lilstock Formation, CMF = Charnwood Mudstone Formation, Scipion. = Scipionianum, Ly. = Lyra, Semicostat. = Semicostatum, Complan. = Complanata, Extra. = Extratodosa.
beneath the western part of landslips. However, loose blocks are present on the shore.

(b) Dowlands foreshore [SY 285893–c.293894]. A small periclinal structure on the foreshore below Dowlands Cliffs, shows a section in the Blue Lias Formation at the level of beds 41 to 53 of Lang (1924), although slightly thinner and varying in detail from the same interval immediately west of Lyme Regis – faunas including *Coroniceras*, *Arietites*, *Arnioceras* and *Charmasseiceras* indicate the Rotiforme and Bucklandi subchronozones of the Bucklandi Chronozone, Bed 47 in particular being well exposed. This is the western-most *in situ* exposure of Jurassic rocks at beach level and certainly that referred to by most earlier workers as “Culverhole” (e.g. Woodward and Ussher, 1906, 1911; although some of the exposures recorded by De la Beche (1822, 1826) could be concealed beneath a major landslip of 1839). Eastwards from the Blue Lias exposures, towards Charton Bay, isolated blocks/outcrops of Sinemurian rocks are caught up amongst landsliped Cretaceous chalk and “Upper Greensand” on the foreshore, at least three small sections being visible. Faunas present indicate the following subchronozones: Sauzeanum (level of Bed 70 in western outcrop), ?Brooki (level uncertain, in central outcrop) and Birchi (level of Bed 76 in eastern outcrop) (further details are included in relevant sections below). In addition there also appears to be evidence of the early Obrusum Chronozone (Obrusum Subchronozone) amongst loose material.

(c) Charton Bay [SY 297899]. Cliff exposures in the Blue Anchor Formation are overlain by the Penarth Group, although the latter, especially the Lias Formation (“White Lias” auct.) is seen mainly in degraded undercliff exposures to the east, frequently much disturbed by landslips. The Blue Lias Formation is also present, mainly seen as landslipped debris, although also as small outcrops. Most significantly, the Lias Formation-Blue Lias Formation and the Triassic-Jurassic boundary are very well exposed in large slipped blocks at beach level, to the west of the Blue Anchor Formation cliff (Figure 3). The section ranges up to at least the lower Liasicus Chronozone. Palaeontological observations elsewhere in Charton Bay include evidence of the Portlocki Subchronozone (including *Psilophyllites hagenowi* (Dunker) from the “North side of the road from Rousdon to the shore at Humble Point”; Lang collection, NHM, London (NHM), C55427-31) and levels as high as the early Bucklandi Chronozone in loose blocks (including *Metophioceras* sp.).

(d) Pinhay Cliffs and foreshore [c. SY 312901-318907]. The Blue Lias Formation emerges on the foreshore, towards the west of this area, from below the toe of landslips. The shore includes the contact with the underlying Lias Formation, albeit somewhat difficult to study due to extensive marine growth and scattered boulders, and ranges up to at least the higher part of the Conybeari Subzone, including Bed 29. On the west side of Pinhay Bay, the first high cliffs in Blue Lias Formation appear, ranging from at least the Angulata Chronozone upwards, although the Planorbis Chronozone may also be present, at least on the foreshore (Lang collection (NHM), includes *Psiloceras* sp., from Bed H29, “West of Pinney Gorge”: C55465).

(e) Pinhay Bay to Devonshire Head [SY 318908-332914]. In
the middle of Pinhay Bay the Lilstock Formation is faulted into position in the lower part of the cliff, and also traceable on the foreshore to the east. This exposure is well known and has been recently redescribed by Wignall (2001). Eastwards from Pinhay Bay, and around Seven Rock Point to Lyme Regis, is the most complete and well known Blue Lias Formation section in the district, exposed both in the cliff and on the foreshore, and described in most accounts of the district (e.g. De la Beche, 1826, 1839; Woodward, 1893, in Woodward and Ussher, 1906, 1911; Lang, 1924; Hesselbo and Jenkyns, 1995; Figure 2). The sequence begins in Pinhay Bay, immediately above the Lilstock Formation exposure in the cliff, where the Planorbis Chronzone is accessible, with care, just above beach level. Gradually higher levels reach shore level towards Seven Rock Point, including the Hettangian-Sinemurian boundary (Figure 4) and ultimately the Birchi Subchronzone (Bucklandi Chronzone). The point is developed around an anticlinal structure, and the succession is repeated on its eastern side, where the Hettangian-Sinemurian exposure is once again crossed, although no levels below Angulata Chronzone are exposed east of the point (as mapped in detail by Lang, 1924).

The cliffs immediately below the Devon-Dorset county boundary, at Devonshire Head (an area variably known as West Cliff or Mortehoe Beach) usually show, depending on beach level, the upper part of the Conybari Subchronzone at beach level and an excellent, albeit difficult of access, section through the remainder of the Blue Lias Formation above. Crucially, higher in the cliff, a complete section through the Shales-with-Beef Member is present (Semicosatum to Birchi chronozones), as referred to by Lang et al. (1925). The highest levels clearly seen in-situ here, include the Birchi Nodular and Birchi Tabular beds and traces of the overlying basal Black Ven Marls Member (Birchi Subchronzone). The Birchi Tabular Bed contributes to the development of a conspicuous platform in the undercliff at this point.

The Succession of Ammonite Faunas in the Jurassic of the East Devon Coast

The sections on the Devon coast, west of Lyme Regis, form one of the most important and famous British geological sites and have been important to the development of Jurassic studies not only in Britain but also internationally. Unfortunately, however, due to the area’s close proximity to Lyme Regis and Charmouth, the centre of an international trading network in palaeontological heritage, there is now an intense attrition of the available resource and obtaining new material for research from certain levels is consequently very difficult. The results presented here represent, therefore, the cumulative results of many years of sampling by the author combined with early records by Lang and more recent contributions from other sources. Significantly, Lang continued to collect in the Blue Lias of the district long after the publication of his 1924 paper, generating a steady supply of specimens to the Natural History Museum (NHM) in London until at least the 1950’s and these results are incorporated below. The composite sequence of these faunas is shown on Figure 2.

The location of cited specimens is as follows: NHM = W.D. Lang collection (unless otherwise stated), Natural History Museum, London; SMC = author’s collection, Sedgwick Museum, Cambridge; BCM = author’s coll., Bristol City Museum and Art Gallery; NMW = M. Foster collection, National Museum of Wales, Cardiff. Earlier correlations of the Jurassic sequence of the district include Palmer (1972) and Getty in Cope et al. (1980) and the later revision by Page (1992).

Hettangian Stage

Planorbis Chronzone, Planorbis Subchronzone. The earliest known psilococerids are from Bed H25 of Lang (1924). Specimens from foreshore exposures on the west side of Seven Rock Point, include small crushed and poorly preserved forms, associated with a horizon of burrows filled with greyish white marl, around 2-5 cm below the base of Bed H26. As umbilical nodes or plications are not present, the specimens are not referable to Psiloceras erugatum; they are also too evolve for typical S. planorbis and much smaller than mature P. sampsoni. Assignment to Neophyllites is consequently most likely, although not confirmable as no sutures, spiral grooves or sharp umbilical walls (cf. Bloos and Page, 2000a) are discernable in the available material. Unfortunately, Lang’s oldest ammonite from the same level (1924, p. 184) does not appear to survive in the NHM collections.

Psiloceratids are also present in Bed H26, including on the lower surface, as recorded by Lang (1924). Lang’s specimens do not seem to be present in the NHM, but specimens seen on the lower surface in Pinhay Bay (Locality e) and Charmouth Bay (Locality c, Figure 1) are small and evolve and may well also be Neophyllites. If this determination is correct, beds H25-H26 broadly correlate with the initians and antecedens biohorizons of Page and Bloos (1998) and Bloos and Page (2000a).

From the available evidence in Pinhay and Charton bays, the base of the Jurassic System remains placed with some uncertainty within Bed H25. The apparent absence of the basal Jurassic erugatum fauna/biohorizon, however, may be genuine, and the burrowed horizon below the first ammonites may well be a small non-sequence. Circumstantial evidence for such a gap is provided within Bed H25. The apparent absence of the basal Jurassic base of the Jurassic System remains placed with some uncertainty of Page and Bloos (1998) and Bloos and Page (2000a).

The use of a Plicatulum “Horizon” (effectively a “zonule”) for the higher part of the Planorbis Subchronzone follows Corna and Moutierde (1997) and is equivalent to the Plicatulum Subchronzone” of Hillebrandt (1990). The former usage is retained here but including a plicatulum Biohorizon, following Bloos and Page (2000a) and Page (in press). Lang (1924, p. 183) recorded a typical fauna of this interval around 0.18 m above the base of Bed H29, including C. cf. planorbis (Quenstedt) and P. ex grp. sampsoni (Portlock) and this level is therefore taken to mark the base of the unit. The former specimen has not been found, but the latter is a typical relatively large (95 mm diameter) and evolve form (NHM C25659).

Johnstoni Subchronzone. Caloceras faunas are currently poorly characterised in East Devon, the lowest seen to date include relatively strongly ribbed forms embedded in the top of Bed H42 on the west side of Seven Rock Point. Beds H43 and the top surface of H44 also yield Caloceras. The former was compared to “C. belcheri (Portlock)” by Spath (1924, p. 191, NHM C25638), but is small and not clearly determinable, but the latter is comparable to Caloceras sp. 2 of the biohorizon of the same name (Page, 1994), a form with straighter, sharper and closer ribs than C. johnstoni, but not as closely ribbed as C. intermediurn (Portlock), with which it was originally compared (Spath, 1924, including NHM C55406-7 and C25654).

The affinities of the forms of beds H42 and H43 are unclear, but do not appear to represent the Caloceras sp. 1 Biohorizon - it is therefore likely that the base of the subchronzone lies at a lower level, between beds H30 and H41 of Lang.

Later, post 1924, collections by Lang include Caloceras from higher levels, specifically H53 and H54. The former includes a close ribbed fragment comparable to true C. intermediurn (NHM C55409; C55408 is a coarser nucleus from the same level), apparently proving the intermediurn Biohorizon at the top of the subchronzone. The specimen reported to be from Bed H54, NHM C55410, however, is strongly ribbed and shows greater morphological affinities to C. johnstoni itself. If the bed number is not incorrectly recorded, it must therefore represent an unusually coarse variant of C. intermediurn.

Spath noted better preserved Caloceras spp. in NHM collections (pre-Lang), reported to be from quarries at Uplyme - or at least more readily extractable specimens from partially weathered exposures (Spath, 1924). Most significantly, these specimens include the holotypes of “C.” giganteum Spath (p. 192; NHM
K. N. Page

C26287) and C. wrighiti (p. 192, figured by Wright, 1878, pl. 19, figs 1-2). The former is not a Caloceras, however, it is a large (septate to c. 260 mm), evolve Waebneroceras s.l. macroconch from the Liasicus Chronozone, a form apparently unknown on the coast.

Liasicus Chronozone, Portlocki Subchronozone. In East Devon, the lowest Waebneroceras s.l. is recorded by Lang (1924, p. 183) in Bed H57 and although fragmentary, shows sharp curved ribbing typical of W. (Curvicerca) cf. prometheus, suggesting the prometheus Biohorizon at the base of the Portlocki Subchronozone (including NHM C25635).

A good fauna of the higher part of the Portlocki Subchronozone is known from Bed H67, probably including representatives of several biohorizons. From around 0.05 m to at least 0.15 m above the top of Bed H66, a dark shale with very thin seams of “beef”" yields common crushed Psilophyllites bagenouyi (Dunker) (=H67a, part) indicating the bagenouyi Biohorizon (including the specimen figured by Spath, 1924, pl. 18, fig. 1a, = NHM C25423; also NHM C25423 and C25622-2563).

Poorly characterised schlotheimids including “Waebneroceras, sp. cf. tateus” (NHM C52621) and “W. sp.” (not specifically associated from beds higher than Bed H67) are known by a single specimen donated to the NHM in 1945 (C55433). Although these cannot be readily assigned to a named biohorizon, Bed H67d, however, (i.e. the topmost 0.13 m of H67), yields frequent Waebneroceras s.l., including specimens with slightly prorsiradial ribbing referable to W. portlocki (Wright) and larger (?macroconch) forms comparable to “W. portlocki morphotype extracostatum (Wähner)” of Guérin-Franiatte (1990, e.g. Pl. 11, fig. 2, “W. cf. megastomata (Walner)” of Spath, 1924, p. 195) (NHM C55411, C5616-7, C25619-20 and BCM 96-2-4), a species of Kammerkärteries. The top surface of Bed H68 on the west side of Seven Rock Point shows common embedded Waebneroceras cf. schroderi Lange, distinguishable from W. portlocki by a more radial ribbing style (possibly including BCM 96-2-7). This fauna was missed by Lang (1924), but is represented by a single specimen donated to the NHM in 1945 (C55435).

Assignment of these two levels to, respectively, the cf. similis Biohorizon of Spath, 1924, pl. 18, figs 2a, b, = NHM 5609. Although crushed shells are occasionally visible on bedding surfaces of the dark shales at this level, specimens are also preserved partially uncrushed as limestone internal moulds in the upper part of the bed. Macroconch fragments, similar to the holotype, are commonest with a characteristic compressed triserial section, although a distinctive coarse-ribbed microconch is also present (BCM 96-2-6). Beds 3-5 yield occasional Schlotheimia macroconchs from Church Cliffs, north-east of Lyme Regis, which characterise the species considerably better than the holotype (e.g. NHM C40568, C55446-7, C55450-2). Although levels from Bed H91 upwards east of Lyme Regis are clearly represented in Lang’s collections in the NHM, the exact provenance of faunas from these beds is generally not stated by Lang (1924) or Spath (1924) and records therefore include a mixture of Devon and Dorset faunas.

As ex gr. similis may also be present on the base of Bed 1a (e.g. BCM 08-768 and possibly 96-2-13), but higher levels in Bed 1 (probably even in Bed 1a) yields a new fauna, where it is well exposed on the foreshore on the west side of Seven Rock Point. S. sp. cf. complanata von Koenen, is present in Bed 11 (BCM 96-2-11), but the bulk of the macroconchs have more persistent, relatively sharp, close ribbing, often to at least 120 mm, and are therefore comparable to true S. similis, a form characteristic of the higher part of the Complanata Subchronozone in West Somerset and Germany (Bloos and Page, 2000b). Macroconch whorl sections are less compressed than similis and include specimens resembling S. stenorhyncha (Lang). Again, the bulk of Lang’s material from this level was collected post-1924 from north east of Lyme Regis (including C40324-6, C55410, C55435, C55453-9, C56461-2, C56464 from beds 1a-1k). Additional material from Devon includes BCM 96-2-15. Beds 3-5 yield occasional Schlotheimia which may have close affinities with those of Bed 1 below but are not yet well characterised, although include S. angulosa Lange – a form typical of the Complanata Subchronozone (BCM 08-770) – and NHM C25600 a fragmentary schlotheimiid from the same level.

Uncrushed typical Alsaites laqueolus = is, however, present in the district, indicating the succeeding laqueolus Biohorizon (= laqueolus “Horizon” Zone of Mouterde and Corna, 1997), but the specimens recorded by Spath is from inland at Uplyme and from an uncertain horizon (1924, p. 201; NHM).

Angulata Chronozone, Extranaoda Subchronozone. The base of the Angulata Chronozone is drawn at the first occurrence of Schlotheimia sp. in Bed H84 (Lang collection, 1949, NHM C55436; quoted by Callomon and Cope, 1995, p. 50, “spath MS”). The sole specimen is a septate fragment of a relatively evolve macroconch with strong ventral ribbing (septate to at least 140 mm). Traces of the venter of the inner whorls are consistent with S. ex gr. extranodosa, as figured by Lange (1951), but more material is needed to confirm this identification. Contrary to Smith (1989), as quoted by Hesselbo and Jenkyns (1995, p. 113), there is therefore no compelling evidence of a significant non-sequence at the base of the Angulata Chronozone.
**Depressa Subchronozone.** Bed 7 (Lang’s “Lower Skulls”) yields a third schlotheimid fauna, retained in the Complanata Subchronozone by Page (1995b) and assigned to a “Schlotheimia sp. 1 Biohorizon” (now superseded by the biohorizonal sequence of Page, in press, based on the West Somerset coast sections described in Bloos and Page, 2000b). Although presently poorly characterised, the fauna on Seven Rock Point includes very large *Schlotheimia* characterised, the fauna on Seven Rock Point includes very large specimens from Seven Rock Point (NHM C55492) comparable to *S. vaihingensis* Bloos has also been recovered from this level (Page, 1995a, p. 447; author’s collection). The latter species also occurs in the upper part of the Complanata Subchronozone in southern Germany (Bloos, 1994). The specimen of *S. sp. aff. depressa* (Quenstedt) figured by Wright (1878, figs 3, 4; Spat, 1924, p. 198) - a characteristic form with a sub-quadrate section and relatively fine wiry ribbing. Occasional coarsely ribbed microconchs with a higher whorl section show some similarities to *S. princeps* Buckman (including NHM C25589 and C55496) and others show some resemblance to *S. lymente* Spat (1924, p. 189; e.g. NHM C55473-4, C55494), a species based on a microconch from the Lyme Regis district figured by Wright (1878) from an unrecorded level.

Notable very rare elements of the *pseudomoreana* Biohorizon fauna include specimens of Tethyan species, including *Schreinbachites* sp. (author’s collection and NHM C25596) and, very significantly, a single *Angulaticeras* (Charmasiceras) *marmoreum* (Wähner) (BCM) - the latter is the indicator species of the Marmorea Chronozone at the top of the Hettangian in Mediterranean Province areas (Bloos, 1985).

The highest *Schlotheimia* specimens recorded in-situ in East Devon are very poorly preserved and indeterminate from the top surface of Bed 17 (Page, 1992, p. 136, 1995b, p. 407) (Figure 4).

**Sinemurian Stage- Lower Sinemurian Substage**

**Bucklandi Chronozone, Conybeari Subchronozone.** The lowest Sinemurian ammonites known from East Devon and West Dorset are very poorly preserved traces of small, crushed arietids in Bed 18 (basal Bed 18d of Lang, 1924), only around 0.25 m above the last *Schlotheimia* seen, on the top surface of Bed 17. It is tempting to assign this fauna to the basal Sinemurian *quantovense* Biohorizon (= rougemonti Biohorizon of Page, 1992, 1995b), as fully described in West Somerset by Bloos and Page (2000b), but specimens are too poorly preserved to confirm their identity. Large *Metophioceras* ex grp. *brevidorsale* (Quenstedt) (= *M. longidomus* (Quenstedt) in Page, 1992, p. 136) recovered from concretions on the base of Bed 19, around Seven Rock Point (SMC, possibly also NMW), were previously believed to be the first Sinemurian faunas in the Lyme Regis district (Palmer, 1972; Page, 1992). This fauna is typical of the basal Sinemurian throughout much of north-west Europe and has been provisionally assigned to the *conybearoides* Biohorizon of Bloos and Page (2000b) and Page et al. (2000) (equivalent to the *longidomus* “Horizon” of Page (1992) and the *Metophioceras* sp. 2 Biohorizon of Page (1995b) (Figure 4).

*Spath* (1924) noted a fauna in loose blocks, which included closely ribbed forms, similar to *M. longidomus*, to which he assigned the name *M. gracile* Spat (1924, p. 203) – it is conceivable that these forms are also from Bed 19, and they certainly recall specimens of the poorly characterised *Metophioceras* sp. 1 Biohorizon on the West Somerset coast (Page, 1995b; Bloos and Page, 2000b). If this assumption is correct, it is possible that Bed 19 may include faunas of both the *Metophioceras* sp. 1 and the *conybearoides* bihorizons, although further confirmation is required.

A poorly characterised arietitid, probably assignable to *Metophioceras* or *Verniceras* was noted by Lang in Bed 21 (1924, p. 180) but a cast of a sharp-ribbed small form from the lower surface of Bed 23 (NHM C25585) is highly suggestive of *Epanonmites*, and would therefore suggest the presence of the *rotarius* Biohorizon.

The top surface of Bed 23, however, yields the next stratigraphically diagnostic fauna, which is best characterised in Bed 24 (Bed 24c) and probably also Bed 25, and includes *M. ex grp. rowllewi* (Reynès) (including NHM C25582 and C25580; SMC 94-a-a (from a loose block at Seven Rock Point) and 96-2-7 (A) from *in-situ* below Pinhay Cliffs), *M. caesar* (Reynès) (including NHM C25581 and C55477) and *Angulaticeras* (Charmasiceras) sp. Specimens from this level were recorded by Lang (1924, p. 180) and Spath (1924, p. 203) as including “*M. sp. cf. Janus Spath*”, and were therefore assigned to a *Janus* Biohorizon by Page (1992, p. 136), and later to the *rotarius* Biohorizon (1995b) – re-examination of Lang’s collections, however, confirms that the assemblage is typical of the *rowllewi*
Biohorizon, although some of the M. ex grp. *rouvilliet* from Bed 24c (e.g. NHM C25582 and C25580) have a greater tendency to develop backward sloping (rursiradiate) *fanus*-style ribbing than specimens from an equivalent level on the West Somerset coast.

The base of Bed 27 has yielded the very early coniceratid, *Cononiceras* sp. nov. all. *rotator* (Reynes) sensu Page (1992), on the east side of Seven Rock Point (authors collection, SMC) and forms the stratotype for the *rotator* Biohorizon of Page (1992, p. 136 – as “cf. *rotator* Horizon”; Page, 1995b, p. +48). Very significantly, this genus is characteristic of the Rotiforme Subchronozone above, but its first occurrence in south west England actually predates the index fossil of the earlier Conybeari Subchronozone, *Metaphioceras conybeari* (J. Sowerby). Large *Angulaticeras* (*Charmasseiceras*) are also present at this level.

*M. conybeari* is abundant in the upper part of Bed 29 (the “Top Tape” of Lang, 1924) which forms spectacular and readily recognisable surfaces on either side of the syncline that forms Seven Rock Point, covered with traces of large ammonites up to at least 40 cm in diameter (including SMC 08-811, 835, 837, 859, 94-4-16 to 20, 96-2-8; also NHM C40494, C55476, C55478). Associated are much rarer *Verniceras* aff. *spiratissimum* (Quenstedt) sensu Page (1992) (authors collection, SMC) and *Angulaticeras* (*Charmasseiceras*) sp. – a single small *Coroniceras* sp. has also now been recovered. Spath (1924) recognised other “underscribed” forms at this level (1924, p. 203), although most are likely to be simply varients of *M. conybeari*. This bed at Seven Rock Point forms the stratotype for the *conybeari* Biohorizon of Page (1992, 1995b). Specimens from the same bed below Pinhay Cliffs include SMC 91-6-5, 96-2-3.

**Rotiforme Subchronozone.** A small evolute *Coroniceras* sp. from Bed 30, recorded as “C. cf. *schloenbachii* (Reynes)” by Lang (1924, p. 179; NHM C25579) is consistent with forms of the *silvestri* Biohorizon at the base of the Rotiforme Subchronozone on the West Somerset coast (sensu Bloos and Page, in press). The occurrence of giant *Coroniceras defnieri* (Oppel) on the base of Bed 31 (including SMC and NMW1529), on the east side of Seven Rock Point indicates the succeeding *defnieri* Biohorizon and this level in Westcliff was designated as the stratotype for the biohorizon by Page (1992, p. 137).

The top surface of Bed 31, however, contains a different fauna, including strong ribbed *C. rotiforme* (J. de C. Sowerby) (including SMC94-4-12) and was therefore assigned to the *rotiforme* Biohorizon by Page (1992). Additional material from the junction of beds 31 and 32 in Lang’s collection, and therefore possibly from north east of Lyme Regis, includes forms with straighter and weaker ribs than typical *C. rotiforme*, and more akin to *C. defnieri* (including NHM C55479 and C55481) and a third specimen is more evolute and *Verniceras*-like (NHM C55480). As typical coarsely ribbed *C. rotiforme* is also recorded in Bed 32 (NHM C25577), north-east of Lyme Regis, it would appear that the top surface of Bed 31 yields a fauna intermediate between the *defnieri* and *rotiforme* biozones.

Higher levels in the subchronozone are less well known in the Lyme Regis district, although *Coroniceras* sp. is recorded in Bed 32 (NHM C25578), and a specimen from the base of Bed 55, shows some similarities to *C. ex grp. *caprotinum* (d’Orbigny) (SMC 08-2354, from Westcliff) although other specimens from the same bed are less diagnostic (e.g. NHM C25576, SMC 92-2-17). Bed 36, probably 36a-b, has yielded a fauna (recorded by Lang, 1924) which includes a fragment of a large *Coroniceras* sp. consistent with *C. ex grp. *caprotinum* sensu Guerin-Franati non d’Orbigny (NHM C25570) and coniceratid nuclei consistent with the same species (but recorded by Lang as “Arnioceratoides”; 1924, p. 178; NHM C25571-5). Together the fauna of beds 35-36b represent a level which is likely to include the *caprotinum* Biohorizon of Page (1992). A diverse selection of *Coroniceras* spp. in the M. Foster collection (NMW) appear to provide evidence of further faunas, although in-situ confirmation is required.

---

**Figure 6.** *Correlation of the Hettangian succession of the East Devon coast.* Zones are used in the sense of subdivisions of subchronozones; biohorizonal sequence follows Page (in press). Dotted lines indicated uncertainty, verticle hatching indicates non-sequence and asterix (*) indicates confirmed presence of biohorizon.

**Bucklandi Subchronozone.** Bed 42, probable Bed 42f, near Seven Rock Point, has yielded a single large, relatively evolute coniceratid (SMC), showing some affinities to *Coroniceras* ex grp. *coronaries* of the early Bucklandi Subchronozone.

Beds 45-47 yield a fauna of large *Arietites* spp., as already suggested by early records, and quoted by Lang (1924, p. 177) but recently spectacularly confirmed by M. Foster (NMW, including 0129, 0241, 249, 0312, 0717, 1029, 1519, 1535, 1540, 1543, 1541, 1544, 1545 and 1547 from between Whitilands shore and Devonshire Head). Forms close to *A. bucklandi* and *A. cf. *quadratium* are present, although currently, no clear sequence of species can be determined. The presence of *Arnioceras* sp. in beds 46c (probably including NHM C2556-61) and 46c (including NHM C25546-55 and possibly also C25543-5), however, as recorded by Lang (1924, p. 177), suggests a level at around that of the *tsis* and *scoutophorise* biohorizons of Page (1992, pp. 138-139). A few fragments from these levels could conceivably include the inner whorls of *Arietites* as they have an Epammonites-style of ribbing.

*Angulaticeras* (*Charmasseiceras*) sp. or spp. is also recorded in beds 41, 42d (including NHM C25568-9), 42f, 44 (including NHM C25562-6) and 46 (including NHM C25540-2) by Lang (1924), mainly as fragmentary small specimens, and compared to *Ch. ex grp. *barmassei* by Spath (1924, p. 199). A specimen of this group from this “Lyme Regis” was figured by Wright (1880, pl. 20, figs 1-3). The large loose “*Scholettia* allied to *grenouglii*” observed by Spath (1924, p. 198) west of Lyme Regis, are also likely to be mainly Conybeari-Bucklandi Chronozone *A. (Charmasseiceras)* and not Hettangian as they then believed. Further examples of *A. (Charmasseiceras)* sp. from these levels are also present in the Foster collection (e.g. NMW 1562 and 1570).

The top of the subchronozone includes Bed 47 (= “Glass Bottle” of Lang, 1924), as “large *B. bucklandi*” is noted by the Geological Survey at this level (Lang, 1924, p. 177) – this fauna would include at least some of the large *Arietites* seen welded into
or onto the surface of large blocks on the shore around Seven Rock Point and eastwards (e.g. Figure 5), recorded by Spath (1924, p. 203) as "Coroniceras [= Arietites] of the bucklandi-solarium-pingue groups". Bed 47 is well exposed within the Dowlands foreshore pericline, where further Arietites spp. are common, welded into the top surface of the bed. Typical specimens include Epameritites-like inner whorls (including SMC 92-2-14). Angulaticeras (Charmasseiceras) and Arnioceras are also present.

Spath noted fragmentary specimens, probably from the upper part of Bed 47 or Bed 48, comparable to Arietites meridonialis and Coroniceras of the bisulcatus-multicostatum group (1924, p. 204), suggesting that levels including the multicostatum Biohorizon, at the top of the Bucklandi Subchronozone may also be represented. The presence of the latter biohorizon somewhere in the sequence is confirmed by a fragment of C. multicostatum collected loose below Westcliff (SMC 92-2-11). Spath's ?Paracoroniceras sp. (NHM C255539) (1924, p. 177) is, however, a fragment of an indeterminate large Arietites or Coroniceras.

Semicostatum Chronzone, Lyra Subchronozone. Beds 48 to 49 around Lyme Regis yields remnants of a Lyra Subzone fauna characterised by Paracoroniceras spp. and Arnioceras spp. (including "A. aff. geometricus (Oppel)" and "A. ceratitoides (Quenstedt)" in Bed 48) (Lang, 1924, p. 177). The former include P. cf. crossi (Wright) (NMW 0067) and forms resembling P. cf. charlesi (Donovan) (NMW 0041) amongst material collected by M. Foster from Devonshire Head, presumably all ex Bed 49 (probably also NMW 1435, 0046, 0969 and 0978), suggesting that the Crossi Zone, at least, is represented at this level.

There are indications of other levels in the Lyra Subchronozone in beds 48-49, including further Paracoroniceras species and possible late arietitids, although there may be some mixing with Bucklandi Chronzone taxa faunas from below. There is clear evidence of sedimentological condensation at this level, including glauconite, limestone intraclasts and phosphate nodules in Bed 49, which may even be locally absent (= "Grey Ledge" of Lang, 1924; Hallam, 1960; Hesselbo and Jenkyns, 1995, p. 113). Nevertheless, the current picture of the ammonite sequence of beds 47-49 is somewhat cryptic and further in situ sampling is therefore needed.

Scipionianum Subchronozone. Scipionianum Subchronozone faunas are crushed and poorly preserved on the Devon-Dorset coast and Lang (1924) did not specify whether his faunas were collected in Devon or Dorset. Indications in the text, however, suggest that his material may have come primarily from the foreshore below Black Ven, east of Lyme Regis, where sampling would be easier and safer.

The base of the subchronozone in the district is placed at the base of Bed 50, where Agassiceras is first recorded, associated with abundant Arnioceras (including A. cf. obliquecostatum Zieten and A. cf. nodulosum (J. Buckman) according to Spath, 1924, p. 206). Agassiceras colesi (J. Buckman) is first recorded in Bed 52a and ranges up to 52f, and "Euagassiceras spp." including E. striaries (Quenstedt), is first recorded in bed 52d (Lang, 1924; Spath, 1924, p. 208). Arnioceras is generally abundant throughout (full details can be found in the cited sources). According to Corna et al. (1997, p. 11), E. striaries is typical of the upper part of the Scipionianum Subchronozone in France, specifically within a Nodulatum "Horizon". Although these faunas are not explicitly recorded in Devon, they will be present in the cliffs west of Lyme Regis and visible in fallen blocks. The fauna of Table Ledge (Bed 53), however, marking the top of the subchronozone, is frequently seen in fallen blocks in the latter area, and includes Arnioceras pseudokridion Spath, a species based on type material from east of Lyme Regis (Spath, 1924, p. 207, pl.18, figs 4a,b), indicating the pseudokridion Biohorizon in the upper part of the Scipionianum Subchronozone (Page, 1992).

The apparent absence of forms typical of the early Scipionianum Subchronozone, including Arnioceras acuticarinatum and Agassiceras scipionianum itself - respectively a biohorizonal index in Page (1992) and a zonule index (Corna et al. 1997), suggests that the non-sequence at the top of Bed 49 also includes the basal part of the subchronozone above, as already suspected by Spath (1924).

Sauzenianum Subchronozone. As for the Scipionianum Subchronozone, the faunas of the Sauzenanum Subchronozone recorded by Lang et al. (1923) are likely to have been collected primarily from the foreshore below Black Ven, which therefore effectively include the stratotypes of the cf. resupinatum and Euagassiceras biohorizons of Page (1992). Occasionally elements of these faunas are mainly seen in fallen blocks of shale from beds 54-72, west of Lyme Regis, and include typical Euagassiceras spp. (e.g. SMC 95-12-17) and Arnioceras spp. In addition, occasional blocks of limestone crowded with uncrushed Arnioceras spp., but also including rare Euagassiceras, are frequently seen on the beach on the east side of Pinhay Bay (SMC 95-12-11 to 13, 95-12-16). This fauna is likely to have come from a level between beds 54 and 69 of Lang et al. (1923), although biohorizonal assignment is currently unclear, as those authors do not record a bed of this character in situ east of Lyme Regis.

In contrast, the alcinoiforme Biohorizon of Page (1992, p. 141) is well developed in East Devon, the best faunas having been obtained from small sections, possible landslipped, on the shore below Dowlands cliffs, in the western outcrop of the
Shales-with-Beef Member. The fauna is dominated by large Pararhizoceras alcinoeforme. Spath, typically preserved as internal moulds partly embedded in limestone nodules. The type of this species, named by Spath (in Lang et al., 1923, p. 73; Lang, 1924, p. 208) almost certainly came from Black Ven foreshore. Arnioceras is also present at this level, which corresponds to Bed 7.1-7.4, Caenites (sup.) from the central Shales-with-Beef Member outcrop on Dowlands foreshore, may be from the Brocki Subchronozone, although further information on the succession of species at this level elsewhere is needed to clarify correlations - certainly no Microderoceras or Promicroceras, thereby proving higher levels, have been seen to date in this exposure.

Birchi Subchronozone. The lowest horizon of the Birchi Subchronozone, the oboutiformis Biohorizon, is likely to be present in Bed 74r of Lang et al. (1923) in the cliffs west of Lyme Regis, although the typical fauna is not yet explicitly recorded. In contrast, however, higher parts of the subchronozone are well known in East Devon, both in fallen blocks and, in one instance at least, in situ. The Birchi Nodular Bed of Lang et al. (1923) (= Bed 75a), yields two distinctive faunas in septarian concretion preservation in East Devon and West Dorset, as discussed by Page (1992, p. 142-143). The presumed lowest fauna is only recorded in East Devon, in situ in West Cliff, and in loose blocks on the beach below. The assemblage is dominated by abundant evolute Epiphotoceras pseudobonnardi (Spath), a very early ancestor of the Echioceratidae of the Upper Sinemurian. Associated are common Cymbites sp. and Microceroceras cf. gigas Buckman (1928, pl. 762 A, B) non Quenstedt. The lower part of Bed 75a in Westcliff is the defined stratotype for this biohorizon (Page, 1992; the fauna including SMC 95-12-18; 08-833, 834, 840). This fauna characterises a Biohorizon of Page (1992) equivalent to beds 71-72 of Lang et al. (1923).

Turneri Chronozone, Brocki Subchronozone. Lang et al. (1923) described in detail the sequence of faunas in the Brooki Subchronozone of the West Dorset coast, east of Lyme Regis, which formed the basis for the sequence of biohorizons proposed by Page (1992). Elements of these faunas are to be expected in fallen blocks on the beach west of Lyme Regis, originating from Bed 74r of Lang et al. (1923) - the “Pararhizoceras alcinoe Bed”. A large Etagassiceras sp. from the same locality, may have come from a level just above the “alcino Bed”. Blocks and fragments of limestone nodules in this area include abundant Arnioceras ex grp. semicostatum (Young and Bird), and are also seen from time to time west of Lyme Regis, below West Cliff. The fauna suggests a level close to the cf. semicostatum Biohorizon of Page (1992) equivalent to beds 71-72 of Lang et al. (1923).

The area provides SMC 95-12-15 and probably also 94-4-2. birchi occasionally occur, at least in Dorset. This fauna characterises a Caenisites subturneri Biohorizon (Page, 1992, p. 143). Elements of this fauna from Westcliff, include SMC 95-12-15 and probably also 94-4-2. Bed 76a, the Birchi Tabular Bed, is prominent in the cliff west of Lyme Regis, straddling the Devon-Dorset county boundary. This Biohorizon. The Obtusum Chronozone, Obtusum Subchronozone (part). There is very little evidence of Obtusum Chronozone faunas in East Devon, although fragmentary early Asteroceras have occasionally been recovered loose on the beach, below Dowlands cliffs. No younger ammonite faunas are recorded on the East Devon coast.

CONCLUSION AND CONCLUDING REMARKS

The East Devon coast displays a superbly exposed early Jurassic succession, from the basal Hettangian to close to the top of the Lower Sinemurian. Slight higher levels, up to at least the early Obtusum Chronozone, the lowest part of the Upper Sinemurian, are also present beneath a Cretaceous unconformity, but only seen as loose blocks at beach level.

The area provides SMC 95-12-15 and probably also 94-4-2. birchi occasionally occur, at least in Dorset. This fauna characterises a Caenisites subturneri Biohorizon (Page, 1992, p. 143). Elements of this fauna from Westcliff, include SMC 95-12-15 and probably also 94-4-2. Bed 76a, the Birchi Tabular Bed, is prominent in the cliff west of Lyme Regis, straddling the Devon-Dorset county boundary. This Biohorizon. The Obtusum Chronozone, Obtusum Subchronozone (part). There is very little evidence of Obtusum Chronozone faunas in East Devon, although fragmentary early Asteroceras have occasionally been recovered loose on the beach, below Dowlands cliffs. No younger ammonite faunas are recorded on the East Devon coast.

The East Devon coast displays a superbly exposed early Jurassic succession, from the basal Hettangian to close to the top of the Lower Sinemurian. Slight higher levels, up to at least the early Obtusum Chronozone, the lowest part of the Upper Sinemurian, are also present beneath a Cretaceous unconformity, but only seen as loose blocks at beach level.

ACKNOWLEDGEMENTS

A. Knott (Site Manager, English Nature) has greatly assisted with access to the reserve. M. Foster (Uplyme) kindly made available for study his collections from the district and R. Edmonds (Dorset County Council) reported the discovery of faunas from the Shales-with-Beef Member on Dowlands foreshore. G. Bloos (Staatliches Museum für Naturkunde, Stuttgart) assisted with the determinations of Liasicus and Angulata chronozone faunas and provided invaluable comments on the text. S. Baker assisted with access to Natural History Museum collections. R.E. Page, J.M. Page and J.K. Page have assisted in the field. D. Appleton, C. Dixon, L. Heape, T. Lawton, M. Low, P. St. Pierre and L. Pilbeam have also assisted, on Dowlands foreshore. I also wish to thank J.H.
Callomon, who as a referee, provided useful and stimulating comments. This paper forms a contribution towards IGCP project 458 - “Triassic-Jurassic boundary events”.

References

BLOOS, G. 1983. The Zone of Schlotheimina marmorea (Lower Lias) – Hettangian or Sinemurian. Newsletters in Stratigraphy, 12, 123-131.


