High resolution ammonite stratigraphy of the Charmouth Mudstone Formation (Lower Jurassic: Sinemurian-Lower Pliensbachian) in south-west England, UK

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Key-words: ammonites, high-resolution stratigraphy, correlation, Jurassic, Sinemurian, Pliensbachian, Somerset, Dorset, Devon.

ABSTRACT: The "Lower Lias" mudrocks of the Charmouth Mudstone Formation in West Dorset coast are world famous for their ammonite faunas, which range from mid Lower Sinemurian (Semicostatum Chronozone) to Lower Pliensbachian (topmost Davoei Chronozone) in age. The succession includes significant non-sequences, however, and as certain other intervals yield only crushed and relatively poorly preserved material, much of the sequence of ammonite faunas of this interval in south-west England has remained poorly understood. Inland, however, although it has been realised for many years that some of the missing horizons reappear, the Formation is very poorly exposed and as a consequence little has been known about its detailed stratigraphy and palaeontology. The systematic recording over 40 years by Mr H.C. Prudden (Montacute) of temporary excavations in East Somerset (around 20 km north of the Dorset coast), combined with material collected by others from similar exposures has now, however, revealed a virtually complete sequence of ammonite faunas through the interval represented by the Formation including from many of the which are missing on the Dorset coast. In particular, only one subchronozone remains to be conclusively proven in the region, the terminal Sinemurian, Aplanatum Subchronozone (Raricostatum Chronozone). This faunal succession is correlated with that on the coast to provide a detailed synthesis of the sequence of ammonite biohorizons in the region, which is correlated with a contemporary Standard Zonation and high-resolution biohorizonal/ zonule scheme for interval in North-West Europe. The significance for regional and international correlations of the Lower Lias is also discussed.

INTRODUCTION

The Lower Lias mudrocks of the West Dorset and East Devon are well exposed in coastal sections between Lyme Regis and Seatown and have been studied in great detail, most famously by Lang (1914, 1928; Lang *et al*. 1923; Lang and Spath 1926) with latter reviews including Wilson *et al*. (1958), Getty (1980), Hesselbo and Jenkyns (1995) and Simms *in* Simms *et al*. (2004: 60-82). Observations on the sequence of ammonite faunas are included in Page (1992, 1994, 2002) including a precise bracketing of the several significant non-sequences in the succession, several of which were first recognised by Lang. Tracing the coastal sequence northwards and inland into Marshwood Vale, however, Lang (1932) realised that some of the intervals missing on the coast began to appear. Later mapping by the Geological Survey of England and Wales confirmed these observations and provided tantalising sugge-

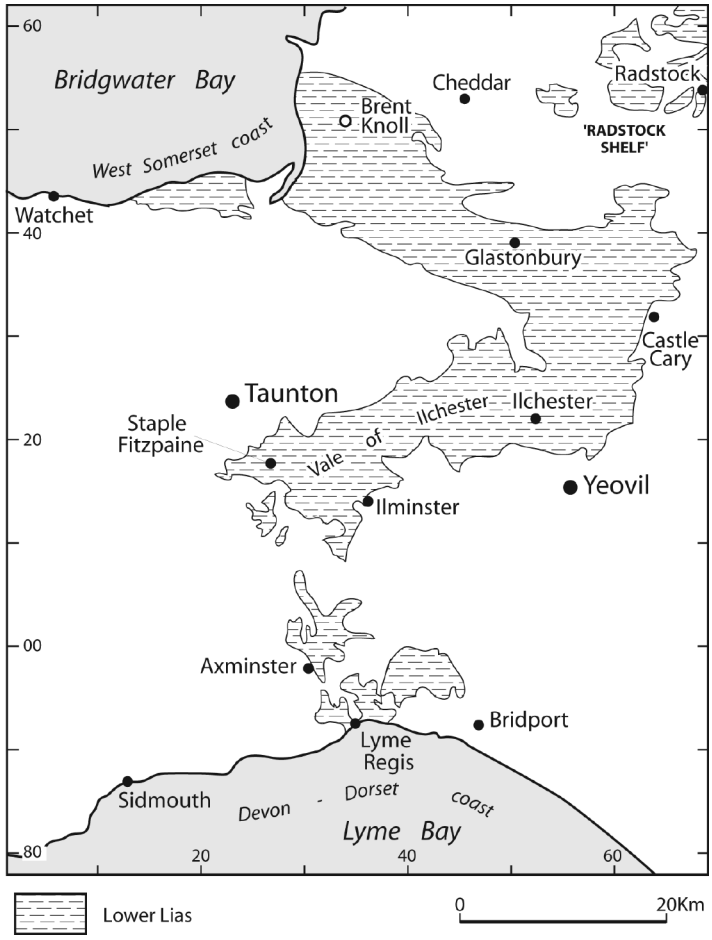

Fig. 1. Outcrop of the Lower Lias (Hettangian-Lower Pliensbachian) in SW England (modified from British Geological Survey 1:625,000 Sheet; 1979).

stions of even more complete sequences northwards into south Somerset and the Vale of Ilchester (Fig. 1), although paucity of exposure meant a more systematic review was not possible (Kellaway and Wilson 1941; Wilson *et al.* 1958).

In the latter area, in particular, only scattered records of exposures of the Charmouth Mudstone Formation and its faunas have been reported (*e.g.* in Woodward 1893, 1905; Ussher 1906; Kellaway and Wilson 1941; Wilson *et al.* 1958; Donovan 1989; Hollingworth *et al.* 1990; Bristow and Westhead 1993; and Bristow *et al.* 1999). As a result correlation charts such as that of Getty *in* Cope *et al.* (Column HS2, 1980) have been based on the slimmest of data. From the 1970s, however, engineering works as part of pipeline and road construction projects have created a series of temporary exposures which have been systematically recorded and sampled by H. C. Prudden (Montacute, formerly of Yeovil College).

This intensive work has more than quadrupled the known records of the formation in the area and together with other records by M. Harvey (Chilthorne Domer) and the author have now at last permitted a systematic assessment of the succession of ammonite faunas present. In particular, many levels have been identified which are missing in major non-sequences in the more famous sections on the Devon and Dorset coasts and provide important insights into the nature of ammonite faunas at levels not known elsewhere in SW England.

LITHOSTRATIGRAPHIC FRAMEWORK

The term "Charmouth Mudstone Formation" was proposed by Cox *et al.* (1998, available at www.bgs.ac.uk) as a both a replacement for the informal term "Lower Lias clays" which permeates much of the earlier literature (*e.g.* in Getty 1980) and as a unifying term for a plethora of new names generated by British Geolo-gical Survey mapping in the 1980s and 1990s (*e.g.* in Bristow and Westhead 1993, and Bristow *et al.* 1999). Although Cox *et al.* (1998) did not formally divide the formation into members, the present study and additional observations for boreholes near Bath to the NE (pers. obs. courtesy of R. Gallois and Geotechnical Engineering, 2003) indicates that a threefold subdivision is appropriate, with a lower Black Ven Mudstone Member (including the "Shales-with-Beef" and "Black Ven Marls" of Lang, the "Stonebarrow Pyritic Member" of Page *in* Simms *et al.* 2004 and the "Helwell Marls" of Palmer 1972), followed by a Stonebarrow Marl Member (="Belemnite Marls" of Lang and the "belemnitiferous marls" of Wilson *et al.* 1958 in E Somerset) and the Seatown Marl Member (="Green Ammonite Beds" of Lang and the "micaceous marls" of Wilson *et al.* 1958). Highly condensed, relatively shallow water facies are known locally around Carboniferous limestone massifs to the NE of the area, most famously on the "Radstock Shelf" (as reviewed by Donovan and Kellaway 1984). A systematic review of the faunas from this area is now needed, however, and will form the basis of an independent study.

THE SUCCESSION OF AMMONITE FAUNAS IN THE CHARMOUTH MUDSTONE FORMATION OF SW ENGLAND

Zonal terminology and frameworks

As discussed at length elsewhere (Callomon 1985; Page 1995, 2003, *etc.*) Jurassic ammonite-correlated Standard Zones are chronozones and are here used in this sense. The basic subchronozonal framework for the Sinemurian and Lower Pliensbachian follows Dean *et al.* (1961), but has been refined in the UK through the establishment of a sequence of biohorizons for the Sinemurian by Page (1992) and zonules for the Lower Pliensbachian by Phelps (1985). These frameworks are reviewed by Page (2003).

To ease communication, successive biohorizons of the Sinemurian Stage are here numbered Sn1 to Sn71 with Lower Plienbachian zonules noted as PbZ1 to PbZ23. This style of notation is analogous to that used by Callomon and Chandler (1990) in their review of the Aalenian and Bajocian, but must not be confused with the numbering of subzonal boundaries and arbitrary subdivisions of authors such as Jenkyn's *et al.* (2002). Note that the labelling of certain units as, for example Sn17a and Sn17b, should not be taken as representing sub-biohorizons but is necessary for the incorporation of newly recognised, additional biohorizons without disrupting a consecutive numbering system and confusing future usage. Although it will ultimately be possible to recognise biohorizons in the Pliensbachian, further sampling is necessary in the UK and such units are not, therefore, used or proposed here. As discussed by Page (1995), both subdivisions are here considered to have a chronostratigraphical meaning – zonules in the sense of Phelps (1985) as subdivisions of subchronozones and biohorizons as "events" (see also Callomon 1985).

Specimens collected by H. C. Prudden are indicated by HCP and the majority are now housed in the National Museum of Wales, Cardiff; records by M. Harvey are indicated by MH and by the author as KNP. Repositories include Somerset County Museum, Taunton (SCM) and the National Museum of Wales, Cardiff (NMW). Determinations by M. J. Simms (Royal Ulster Museum) are indicated by MJS; all other determinations are by KNP unless otherwise stated. National map grid references are provided. Figures 2-5 illustrate the correlation of the E Somerset faunas by locality and include a revised high-resolution correlation for the Devon-Dorset coast.

Lower Sinemurian, Semicostatum Chronozone (Fig. 2)

Although the base of the Charmouth Mudstone Formation lies within the Semicostatum Chronozone throughout most of the region it often appears to be associated with a minor non sequence. On the West Somerset coast near Watchet, however, the sequence appears to relatively complete and the base of the Formation is best drawn at the boundary between the local "Doniford Shales" (of Palmer 1972), which shows transitional features between the mudrock-limestone alternations of the underlying Blue Lias Formation below and Charmouth Mudstone facies above, here termed the "Helwell Marls" by Palmer. The lowest fauna in the "Helwell Marls" represents Sn16, with Sn17a above, and the highest of the "Doniford Shales" is Sn15b – indicating that the base of the Formation lies within the Lyra Subchronozone at the base of the Chronozone.

In contrast, on the Devon-Dorset coast the base of the Formation lies within the succeeding Scipionanum Subchronozone with a non-sequence below and remnants of a Lyra Subchronozone fauna preserved in a condensed interval at the top of the Blue Lias Formation (Page 2002). The Lyra Subchronozone is also known inland in E Somerset, for instance at Babcary (HCP coll., Getty 1980), but it is not currently clear if it is in Blue Lias or Charmouth Mudstone facies. The Scipionanum Subchronozone is poorly known throughout most of the area as ammonites are typically poorly preserved in the dominant mudrock facies. The basal Sn18 Biohorizon appears to be missing in the non-sequence on the Devon-Dorset coast and the lowest faunas of the Formation are poorly characterised but include the Sn19 (Page 1992, 2002). Inland records are rare, but appear to include typical forms of *Arnioceras* with a short smooth stage nears Chilton Cantelo (ST509730) and *Agassiceras* sp. associated with *Arnioceras* near Ilchester (ST531216; MH coll.). *Ar. "geometricum"* (Oppel) and "*Epammonites"* at the FAA Yeovilton airbase (ST5423 area) as recorded by Wilson *et al.* (1958, p.32) may also represent the same Subchronozone. The Sauzeanum Subchronozone on the Devon-Dorset coast includes biohorizons Sn20-Sn23 and is also known near Ilchester

(HCP coll.; Getty 1980), Hatch Beauchamp (with *Euagassiceras* sp., HCP coll. ST304187) possibly near Broadway [HCP coll., with "*Ar. semicostatum*" (Young and Bird) (MJS det.); ST302187] and at Knole (ST479249, with *Pararnioceras* ex gr. *alcinoeforme* Spath sensu Page 1992).

ZONATION		BIOHORIZON	DEVON-DORSET COAST	EAST SOMERSET	
Turneri Chronozone	Birchi (Sn27-31)		BVM 81k-81n		
		Sn31: cf. *bordoti*	BVM 80-81j		
			BVM 77-79		
		Sn30: *subturneri*	BVM 76b	Marston Magna (BVM)	Chilthorne Domer (BVM)
			BVM 75b-76		
		Sn29: *birchi*	BVM 75a (upper)	Ilchester / ?Limington / Warnham (BVM)	
			BVM 75a, part?		
		Sn28: *pseudobonnardi*	BVM 75a (lower)		
			BVM 74s-w		
		Sn27: *obtusiformis*	BVM 74r		
	Brooki (Sn24-26)		BVM 74g-q		Pilton / West Bradley (BVM)
		Sn26: *hartmanni*	BVM 74e-f		
			BVM 74d/e, part?		
		Sn25: *brooki*	BVM 74c-d	Knole / Queen Camel (BVM)	
			BVM 74a-b		
		Sn24: *sulcifer*	BVM 73		
Semicostatum Chronozone	Sauzea-num (Sn20-23)		BVM 72/73, part?	Ilchester / Hatch Beauchamp / ?Broadway / Knole (BVM)	
		Sn23: *semicostatum*	BVM 71-72		
			BVM 70d-h		
		Sn22: *alcinoeiforme*	BVM 70c		
			BVM 70a-b		
		Sn21: *Euagassiceras* sp.	BVM 64-69		
			BVM 57-63		
		Sn20: cf. *resupinatum*	BVM 56		
	Scipiona-num (Sn18-19)		BVM 54-55	Chilton / Ilchester (BVM)	
		Sn19: *pseudokridion*	BVM 53		
			BVM 50-52		
		Sn18	Non sequence		
	Lyra (Sn15a-17b)			Babcary (BLF or BVM?)	
		Sn17b			
			BVM 48-49		
		Sn15a-17a			

Fig. 2. High resolution correlation of the Charmouth Mudstone Formation in SW England: Lower Sinemurian (Semicostatum-Turneri chronozones) (Bed numbers for Devon-Dorset coast after Lang *et al*. 1923 and Lang and Spath 1926; see text for further locality detail for E. Somerset).

Turneri Chronozone (Fig. 2)

The Turneri Chronozone has a much wider record in SW England than the Semicostatum, as the presence of concretionary limestone beds locally preserves faunas which might otherwise have been destroyed by near surface weathering of mudrocks. On the Dorset and Devon coasts the base of the lower, Brooki Subchronozone includes biohorizons Sn24-Sn26 (Page 1992, 2002). In E Somerset, scattered records of *Caenisites* ex gr. *turneri* (J. de C. Sowerby) may represent the same Subchronozone, as at the Glastonbury Festival site near Pilton (ST590394 area; KNP rec.), Dimmer Landfill site (ST 611 311; HCP coll.) and at West Bradley (including NGR598340, with *Ca*. aff. *turneri*). *Ca. brooki* (J. Sowerby) itself is also recorded, as at Knole (ST492250; HCP coll.) and Queen Camel (ST601241; HCP coll., MJS det.) and probably indicates Sn25. *Arnioceras* cf. *ceratoides* (Quenstedt) and *Ar*. cf. *nodulosum* (J. Buckman) from Chilton Cantelo (ST563224) were considered by Wilson *et al.* (1958, p. 32) to indicate the Brooki Subchronozone.

On the Devon and Dorset coasts, the lower part of the overlying Birchi Subchronozone includes biohorizons Sn27-Sn31 (Page 1992, 2002). Sn29 is recognisable in E Somerset on the basis of faunas with *Microderoceras birchi* (Quenstedt), *Caenisites* and *Cymbites,* including near Ilchester (ST522121), possibly at Limington (ST524217; MJS det.; see also Green *in* Wilson *et al*. 1958) and Wornham (ST530214) (all HCP coll.). *Ca.* cf. *subturneri* Spath (including microconch forms resembling *Ca. turneri* (Sowerby)), *Mi. inexpectans* Spath, *Promicroceras* ex gr. *capricornoides* (Quenstedt) and *Cymbites* indicate Sn30 at Marston Magna in (ST530209), Knole (ST480247) and at Podimore (ST550253) (all HCP coll.). Another fauna from Chilthorne Domer includes large *Caenisites*, with *Microderoceras* (including *Mi*. cf. *birchi*) and *Pr. capricornoides* and appears to include elements of both Sn29 and Sn30 (ST5120 area).

Upper Sinemurian, Obtusum Chronozone (Fig. 3)

Well preserved Obtusum Zone faunas are known from calcareous concretions throughout most of the district. Although the lower part of the Chronozone is well exposed on the Dorset coast west and east of Charmouth, higher levels are only known inland, in particular in E Somerset. On the coast, the lower, Obtusum Subchronozone includes the biohorizons Sn32-Sn35, but although recognisable in E Somerset, assignment to specific biohorizons is not always clear. Records of *As.* ex gr. *confusum* Spath, for instance, at Limington (ST539211; HCP. Coll.) and possibly near Glastonbury (Beckery Reservoir, ST492387; HCP coll., with *Promicroceras*, and *Xipheroceras*) would broadly indicate the Sn32-34 interval and "*As. obtusum"* (J. Sowerby) with *Promicroceras*, *Xipheroceras* and *Cymbites* north of Chilthorne Domer may include elements of Sn35 (ST520206 area; MH coll.). The presence of *Ar.* ex gr. *semicostatoides* Spath near Horton (ST3214 area; SCM) in apparent association with *Asteroceras* sp. cf. gr. *confusum* Spath may indicate Sn34.

The Stellare Subchronozone is widely recognised in the region, with the lower part best seen on the Dorset coast (Sn36-40; Page 1992), but with higher levels are only known in Somerset due to the second significant non-sequence in the former area. Equivalent levels in E Somerset have yielded *Epophioceras* cf. *longicella* (Quenstedt) from near Horton (ST3214 area; SCM) and "*Galaticeras"*, *Promicroceras* and *Cymbites* from Broadway (ST302153; HCP coll.) probably indicating Sn36 and *As.* ex gr. *stellare* (J. Sowerby) and *Xipheroceras* sp. from Chard Junction (ST340020 area; HCP coll., MJS det.) and Dimmer Camp, near Castle Cary (ST615314; Hollingworth *et al.* 1990) suggesting the Sn39-Sn40 interval.

Higher faunas are only known from E Somerset, however, the most famous of which is that of the "Marston Marble" (Wilson *et al* 1958, p.33), a concretionary level packed with white-shelled *Promicroceras "marstonense"* Spath and with frequent *Asteroceras* ex gr. "*blakei*" Spath. The latter include *As. smithi* (J. de C. Sowerby 1823) (pl.406, p.148), the senior synonym of this group, but with a lost type and now requiring nomenclatural stabilisation. This fauna is broadly equivalent to the *blakei*

ZONATION		BIOHORIZON	DORSET COAST	EAST SOMERSET
Obtusum Chronozone	Denotatus (Sn44-47)		Non sequence	
		Sn47: aff. *glaber*		
		Sn46: *denotatus*		Dimmer (BVM)
		Sn45: *fowleri*		Chilthorne Domer (BVM)
		Sn44: cf. *undaries*		
	Stellare (Sn36-43)			
		Sn43: *sagittarium*		
		Sn42: aff. *arnouldi*		Chilthorne Domer (BVM)
		Sn41: *blakei*		Marston Manga /Tintinhull/ Beckley/ Chilthorne Domer (BVM)
			BVM 89	
		Sn40: *stellare*	BVM 88f	Chard Junction/ Dimmer (BVM)
			BVM 88a-e	
		Sn39: cf. *landrioti*	BVM 86c-87	
			BVM 86a-b	
		Sn38: *margaritoides*	BVM 85	
			BVM 84g	
		Sn37: aff. *margaritoides*	BVM 84e-f	
			BVM 84d	
		Sn36: *"Galaticeras"*	BVM 84a-c	Horton/ Broadway (BVM)
	Obtusum (Sn32-35)		(BVM 83h/84a, part?)	
		Sn35: *obtusum*	BVM 83h	?Chilthorne Domer (BVM)
			(BVM 83g/h, part?)	
		Sn34: *semicostatoides*	BVM 83g	?Horton (BVM)
			(BVM 83f/g, part?)	
		Sn33: cf. *confusum*	BVM 83f	Limington/ Beckery (BVM)
			BVM 83a-e	
		Sn32: aff. *confusum*	BVM 81o-82	

Fig. 3. High resolution correlation of the Charmouth Mudstone Formation in SW England: Upper Sinemurian (Obtusum Chronozone) (Bed numbers for Dorset coast after Lang and Spath 1926; see text for further locality detail for E. Somerset).

Biohorizon (Sn41) of Page (1992) which may ultimately be sub-divisable based on records from Somerset and elsewhere. The Marston Marble also yielded the type specimens of *Promicroceras planicosta* (J. Sowerby) as figured by Sowerby (1812, pl. 523, pp 167-168), suggesting that the species is a senior synonym of *Pr. marstonense* and probably distinct from the earlier forms of the Sn38-40 interval which are typically assigned to this species.

The *As. smithi / planicosta* s.s. fauna is widely recorded including at Tintinhull (ST493216; HCP coll.), Glastonbury Reservoir, Beckley (ST492384; HCP coll.) and west of Chilthorne Domer (ST515191 area; MH coll.). The latter record also includes *Aegasteroceras*, suggesting a slightly higher fauna may also be present, possibly close to the Sn43. A record of a transitional form between *Asteroceras* and *Aegasteroceras* from near Chilthorne Domer (MH coll.), associated with *Promicroceras* and *Xipheroceras* cf. *ziphus* (Zieten), is highly suggestive of the intervening Sn42. This fauna has only been confirmed at one other locality in the UK, in north Lincolnshire (Page 1992).

Records by Lang (1932) as cited by Page (1992, p.145) appear to suggest that post Sn40 faunas already occur inland in Dorset, in Marshwood Vale as *As. "marstonense"* Spath is recorded in association with *Ar.* gr. *semicostatoides*, *Angulaticeras* and *Promicroceras*. These correlations need confirmation, however, as early *As.* ex gr. *stellare* of horizons Sn36-Sn38 could potentially be confused with later *As. marstonenese*. Inland records of *Aegasteroceras* in the same area, in association with "*As*. cf. *margaritoides"* and *Promicroceras,* may also suggest a high level, but as before, confirmation is required as pathological *Asteroceras* can have a tendancy to loose their keel and hence can become *Aegasteroceras*-like.

The Denotatus Subchronozone at the top of the Obtusum Chronozone is only known from Dimmer Camp (ST612304; HCP coll.) where very rare *Eparietites* sp. cf. *denotatus* (Young and Bird) has been recovered, indicating Sn46. This is the first record of the subchronozone in the region.

Oxynotum Chronozone (Fig. 4)

The Chronozone is entirely missing in a significant non-sequence within the Black Ven Mudrocks Member on the Dorset Coast but is well developed in E Somerset, especially the upper Oxynotum Subchronozone. The lower, Simpsoni Subchronozone appears to be locally present as probable *Gagaticeras* spp., including *G.* cf. *gagateum* (Young and Bird) has been recovered at Dimmer Camp (ST612304) and at Glastonbury Reservoir, Beckley (ST492384), indicating either the *exortum* or the *gagateum* biohorizon (Sn48 or Sn 49) (both HCP coll.). The succeeding Oxynotum Subchronozone is well represented by pyritic faunas in the Castle Cary area of E Somerset, including in the banks of the River Brue and within the Dimmer Camp landfill site (Hollingworth *et al.* 1990), where two biohorizons are recognisable (Sn51 with *Oxynoticeras* grp. *oxynotum* (Quenstedt), *Gleviceras*, *Cheltonia acciptris* S. Buckman and rare *Angulaticeras* and Sn52 with *Bifericeras bifer* (Quenstedt), *Ox.* gr. *oxynotum* (Quenstedt), *Gleviceras* sp., *Ch. acciptris* and *Palaeoechioceras pierrei* (Spath)) (Page 1992).

Oxynoticeras sp., ?*Gagaticeras* sp. and ?*Bifericeras* from north of Chilthorne Domer (ST513191 area; MH coll.) may suggest a mixed Simpsoni-Oxynotum subchronozone fauna although *Palaeoechioceras* and *Bifericeras* from Puckington (ST370187; HCP) are most likely to represent the latter. The Oxynotum Subchronozone was also well developed with *B. bifer, O. oxynotum*, *Paracymbites* and "*Eoderoceras"* (Woodward 1893; Donovan 1989). A record of *Palaeoechioceras spirale* (Trueman and Williams) may, however, indicate that the base of the succeeding Raricostatum Chronozone was also present (Sn54).

Raricostatum Chronozone (Fig. 4)

Biohorizon Sn54 at the base of the Densinodulum Subchronozone is represented by *Palaeoechioceras* cf *typus* (Trueman and Williams) at Dimmer Camp (Hollingworth *et al.* 1990; Page 1992) but absent on the Dorset coast, as is Sn55. In contrast, Sn53-Sn60 are well represented on the coast above the non-sequence. Scattered records of *Crucilobiceras* sp. cf. *densinodulum* (Quenstedt), in E Somerset probably indicated the Densinodulum Subchronozone, including at Ash (ST490213; HCP coll.), near Chilthorne Domer (ST520195 area; MH coll.) and at Isle Abbots (ST348199; HCP coll.). The species is also recorded in-situ at Dimmer Camp (Hollingworth *et al.* 1990). *C.* cf. *crucilobatum* Spath from Broadway, however (ST317158; HCP coll.), probably indicates the succeeding Raricostatum Subchronozone.

Only the lower part of the Raricostatum Subchronozone is preserved on the Dorset coast and

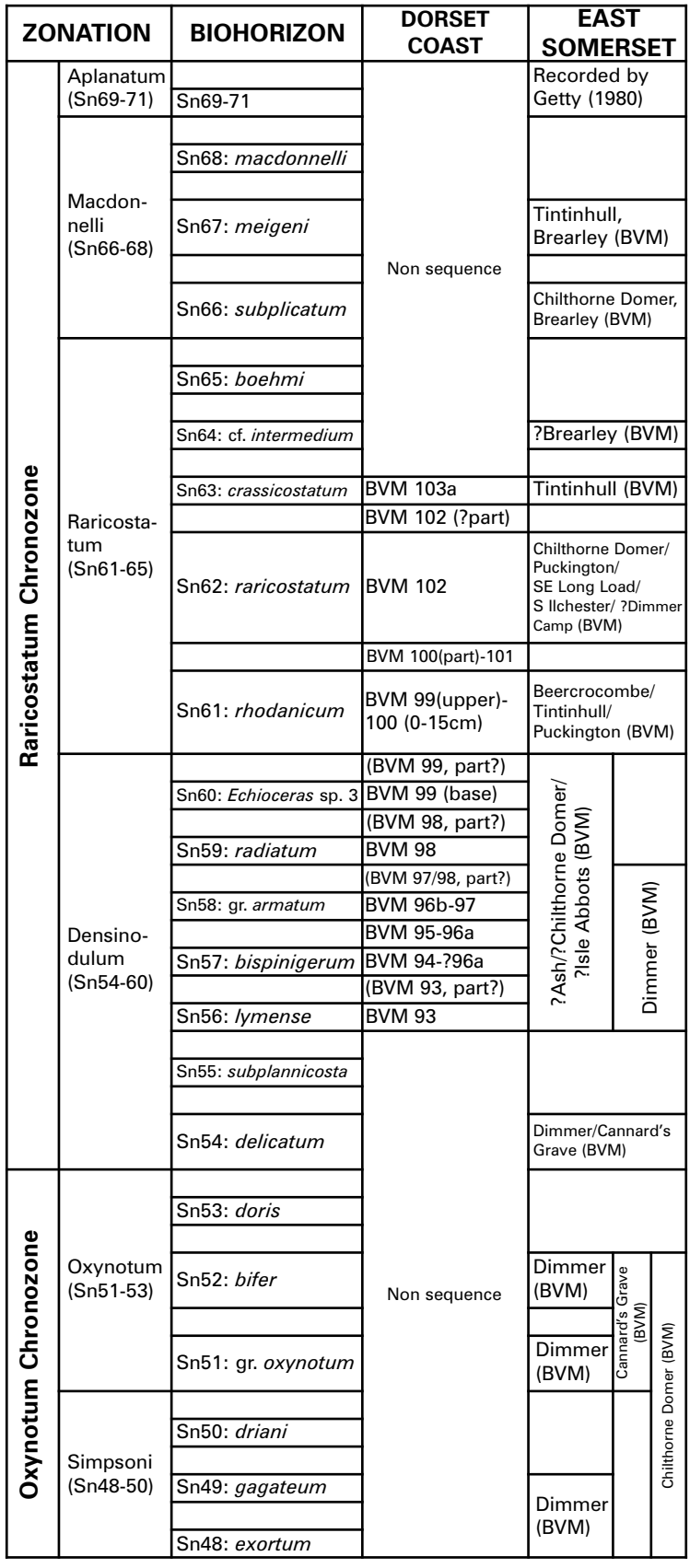

Fig. 4. High resolution correlation of the Charmouth Mudstone Formation in SW England: Upper Sinemurian (Oxynotum-Raricostatum chronozones) (Bed numbers for Dorset coast after Lang and Spath 1926; see text for further locality detail for E. Somerset).

includes Sn61 and Sn62 although specimens from the uppermost levels (Bed 103a) are already approaching *Echioceras crassicostatum* (Trueman and Williams) of Sn63. Sn61 is also recognisable in E Somerset on the basis of *Ec*. ex gr. *rhodanicum* (Dumortier) (including *Ec* cf. *aeneum* (Trueman and Williams) at Beercrocombe (ST316193), Tintinhull/Ash (ST490213), Chard Junction (ST344046) and at Puckington (ST373189) (all HCP coll.). *Ec*. ex gr. *raricostatum* (Zieten) near Chilthorne Domer (ST520195 area; MH coll.), Puckington (NGR378186; HCP coll.), SE of Long Load (ST478223; HCP coll.), S of Ilchester (ST516199; HCP coll.) and at Dimmer Camp (Hollingworth *et al*. 1990) indicates Sn62. Sn63 is also proven near Tintinhull (ST491214; HCP coll.) with *Ec*. *crassicostatum*. No higher Sinemurian levels are recorded on the coast but the sequence continues in east Somerset and a possible *Ec*. ex gr. *intermedium* (Trueman and Williams) near Brearley (ST48216 area; HCP coll.) may indicate Sn64.

The lower part of the succeeding Macdonnelli Subchronozone is recorded near Chilthorne Domer (ST520195 area) and includes *Leptechioceras planum* (Trueman and Williams) (MH coll.) in nodular preservation, indicating the *subplicatum* Biohorizon (Sn66). The latter is also known in mudrock preservation near Brearley (as above). All later Raricostatum Chronozone assemblages, however, appear to be preserved crushed in shales and this may account for the few available records as only nodular faunas are likely to have survived near surface weathering and Pleistocene cryoturbation. These include *Leptechioceras* cf. *meigeni* (Hug) with occasional *Eoderoceras* at Tintinhull

(ST494206, HCP coll., SCM) and Brearley (as above) and possible *Le*. cf. *macdonnelli* (Portlock), also at Brearley, probably indicates Sn67 and Sn68. Although the terminal Sinemurian Aplanatum Subchronozone has remained elusive in the area, Getty (1980) records its presence, but without providing further details. The enigmatic and very rare *Epideroceras exharedatum* S. Buckman from the Dorset coast from a level between the last observed *Echioceras* and the first typical *Apoderoceras* faunas (Page 1992, Bed 103b), may represent a remanié fauna of the same subchronozone but the more delicate and diagnostic echioceratids do not seem to have been preserved.

ZONATION		ZONULE	DORSET COAST	EAST SOMERSET	
M.	Stokesi (part)	PbZ24-Z27	?SnM 132a (39)		
Davoei Chronozone	Figulinum (PbZ22-Z23)	PbZ23: Figulinum	SnM 128i-131b (31-38)		
		PbZ22: Angulatum	SnM 125b-128h (20-31 base)	Ash (SwM)	
	Capricornus (PbZ19-Z21)	PbZ21: Crescens	SnM 123m-125b (15b-20)	Horton/ Limington (SwM)	
		PbZ20: Capricornus	SnM 122g-m (13a-15a)	Ash/Barrington/ Horton/Long Load/ Tintinhull Forts/ Chilthorne Domer (SwM)	
		PbZ19: Lataecosta	SnM 122g (lower) (13a, part)	Tintinhull/Martock/ Ilton/Sparkford Bypass (SwM)	
	Maculatum (PbZ17-Z18)	PbZ18: Maculatum	SnM 122c-g (9-12)	Horton/Ashill/ Tintinhull Forts/ ?Sparkford Bypass (SwM)	
		PbZ17: Sparsicosta	SnM 122a (7-8, part?)		
Ibex Chronozone	Luridum (PbZ14-Z16)	PbZ16: Luridum	Non sequence	?Ilminster/ ?Chilthorne Domer/ Howbridge (all SwM?)	
		PbZ15: Crassum	SwM 120d (part) - 121 (5c-6)		
		PbZ14: Rotundum	SwM 120 (part) (5b)		
	Valdani (PbZ9-Z13)	PbZ13: Alisiense	SwM 120c-d (base)(4b-5a)		Rimpton (SwM)
		PbZ12: Actaeon	SwM 120a-b (4a1, 4a2)		
		PbZ11: Valdani	SwM 119 (part) (304b)	?Ash (SwM)	
		PbZ10: Maugenesti	SwM 118d-119 (303a-304a)	Tintinhull/ Ash (SwM)	
		PbZ9: Arietiforme	SwM 118 (part?)		
	Masseanum (PbZ8)	PbZ8: Masseanum	SwM 118c (part)	?Tintinhull (SwM)	
Jamesoni Chronozone	Jamesoni (PbZ6-Z7)	PbZ7: Pettos	SwM 118b	Combe St. Nicholas (SwM)	
		PbZ6: Jamesoni	SwM 115 (part)-118a		
	Brevispina (PbZ4-Z5)	PbZ5: Submuticum	SwM 112-115	Rimpton/ Ash (SwM)	Chilthorne Domer (SwM)
		PbZ4: Brevispina			
	Polymorphus (PbZ3)	PbZ3: Polymorphus	SwM 110-111		
	Taylori (PbZ1-Z2)	PbZ2: Taylori	SwM 107-109	Chilthorne Covert/ Chilthorne Domer (SwM)	
		PbZ1: Nodogigas	BVM ?104-SwM 105	Marston Manga (SwM)	

Fig. 5. High resolution correlation of the Charmouth Mudstone Formation in SW England: Lower Pliensbachian. (Bed numbers for Devon-Dorset coast after Lang 1928 and Phelps 1985-latter bracketed; see text for further locality detail for E. Somerset).

Lower Pliensbachian Substage, Jamesoni Chronozone (Fig. 5)

The Chronozone is represented by poorly preserved faunas in the Stonebarrow Marls Member on the Dorset coast although zonules PbZ1 and probably PbZ2 (Taylori Subchronozone), PbZ3 (Polymorphus Subchronozone), PbZ4-PbZ5 (not separable; Brevispina Subchronozone), PbZ6 and PbZ7 (Jamesoni Subchronozone) are recognisable. Records from E Somerset are few, suggesting that preservation is equally poor in more northerly areas, but include *Apoderoceras* from Marston Magna (ST600223, HCP coll.; also 596224; Wilson *et al.* 1958, p.34), *Phricoderoceras taylori* (Sowerby) from Chilthorne Covert (ST515198; HCP coll.; MJS det.), *Phricoderoceras* sp. from Chilthorne Domer (ST520195 area; MH coll.) would indicate PbZ1 and PbZ2. "*Ph.* aff. *taylori*" associated with "*Gemellaroceras"* and *Tragophylloceras undulatum* (Smith) at Tintinhull (ST496264 area; Wilson *et al.* 1958, p.33), and with "?*Platypleuroceras* sp.", *Tra. undulatum* and "*Metoxynoticeras"* NW of Chilthorne Domer (ST198191 area; Wilson *et al.* 1958, p.34), may, however, represent higher faunas. *Uptonia* cf. *jamesoni* (Sowerby) from Combe St. Nicholas (ST314127; HCP coll., MJS det.) indicates PbZ6. *Polymorphites* from Chilthorne Domer (ST520195 area; MH coll.) could indicate either

the Polymorphus or Brevispina subchronozones. Records in Wilson *et al.* (1958, p.33-34) appear to confirm the latter subchronozone at Rimpton (ST617225 area) and Ash (ST482205 and ST48-2295) on the basis of *Platypleuroceras* spp. [including "*P. birchoides* (Quenstedt)"] and "*Gemellaroceras*".

Ibex Chronozone (Fig. 5)

The faunas of the Ibex and Davoei chronozones on the Dorset coast were described in detail by Phelps (1984) and only minor adjustment into the modified Zonule scheme of Dommergues *at al.* (1997) is needed. Faunas indicate the zonules PbZ8 and PbZ10-PbZ13 of the Masseanum and Valdani subchronozones and although PbZ9 is not currently recorded, this is possibly due to collection failure. In E Somerset, the Masseanum Subchronozone is not clearly proven, although ?*Tropidoceras* sp. at Tintinhull (4920 area; HCP coll.) hints at its presence. The Valdani Subchronozone is frequently encountered, however, with *Ac*. cf. *maugenesti* (d'Orbigny) and *Tragophylloceras* cf. *undulatum* at Tintinhull (ST40120) and *Ac. maugenesti* (ST482205 area; Wilson *et al.* 1958, p.33) indicating PbZ10 and *Ac*. cf. *valdani* (d'Orbigny) with *Tra.* cf. *undulatum* at Ash (ST493202) (both HCP coll.) probably indicating PbZ11. *Ac.* sp. and *Tra.* ex gr. *undulatum* at Rimpton (ST608218; HCP coll.) also indicate the Subchronozone.

PbZ14 and PbZ15 of the succeeding Luridum Subchronozone are well represented on the Dorset coast although PbZ16 at its top is absent in a non-sequence. In E Somerset, the Subchronozone is barely recorded, however, although *Li.* cf. *cheltiense* (Murchison) near Ilminster (ST355144; HCP coll.) may confirm its presence and there are also suggestions in the Tintinhull-Chilthorne Domer area (HCP and MH coll.) based on the presence of *Liparoceras* (*Li*.). Other possible records by Wilson *et al.* (1958, pp 33-34) include *Beaniceras* sp. S of Howbridge (ST395197 area) and ?*Liparoceras* sp. at Kingsbury Episcopi (ST430216 area).

Davoei Chronozone (Fig. 5)

A complete Davoei Chronozone sucession (PbZ17-23) is well represented on the Dorset coast – as recorded in detail by Phelps (1985), with faunas well illustrated by Spath (1938). In E Somerset the record is also very complete, although the basal PbZ17 of the Maculatum Subchronozone is not currently recorded. *Androgynoceras maculatum* (Young and Bird) indicated the succeeding PbZ18, however, at Horton (ST326144; HCP coll.), Ashill (ST338159; MJS det.), Tintinhull Forts (ST478187; MJS det.), possibly on the Sparkford bypass (ST600262) (all HCP coll.) and at Rimpton (ST011219 area; Wilson *et al*. 1958, p. 34).

Faunas of the Capricornus Subchronozone are particularly in widespread in Somerset, and include *An.* ex gr. *lataecosta* (Sowerby) (including morph *hybridiforme* Spath), *Tr. loscombi* (Sowerby) and *Prodactylioceras* cf. *rectiradiatum* (Wingrave) of PbZ19, for instance at Tintinhull (ST477212 and 498206), Martock (ST464215), Ilton (ST356173) and on the Sparkford Bypass, Ilton (ST600262) (all HCP coll.). PbZ20 is also well represented, including at Ash (ST480207), Barrington (ST390188), Horton (ST326144; MJS det), Long Load (ST467236), Tintinhull Forts (ST490198) and near Chilthorne Domer (ST515194 area; MJS det.) (all HCP coll.). The typical fauna includes *An. capricornus* (Schlotheim) and possibly also *Prodactylioceras* sp., *Li.* (*Becheiceras*) *bechei* (Sowerby) and *Lytoceras fimbriatus* (Sowerby). Faunas of PbZ21 at the top of the Subchronozone include *An. crescens*, *Li. (Becheiceras)* sp., *Prodactylioceras davoei* (Sowerby) and *Lytoceras* sp and have been recorded at Horton (ST3214 area?) and Limington (ST538209) (both HCP coll.).

The Figulinum Subchronozone at the top of the Davoei Chronozone is currently not well known in E Somerset, but includes *Oistoceras.* spp. from Gore (ST591194; Wilson *et al.* 1958, p. 34) and *Oistoceras.* sp. cf. *angulatum* (Quenstedt) from Ash (NGR480204; HCP coll.) – the latter possibly suggesting PbZ23.

Upper Pliensbachian, Margaritatus Chronozone (M in Fig. 5)

The top 60 cm or so of the Seatown Mudstone Member and hence the Formation on the Dorset coast has yielded *Amaltheus bifurcatus* Howarth, with *Protogrammoceras occidentale* Dommergues, and *Li.* (*Becheiceras*) immediately below, indicating, in part at least, PbZ24 at the base of the Stokesi Subchronozone (Margaritatus Chronozone) and hence the base of the Upper Pliensbachian. The age of the top of the Formation in E Somerset is unclear and the sequence passes upwards into the Dyrham Silts Formation of Cox *et al.* (1998; www.bgs.gov.uk).

CONCLUDING REMARKS

The detailed records from the Charmouth Mudstone Formation in E Somerset gathered by H. C. Prudden and others reveals one of the most complete and expanded Upper Sinemurian to Lower Pliensbachian sequences known in Europe and is only really comparable to the considerably less fossiliferous sections on the North Yorkshire and Cleveland coast in Robin Hoods Bay and north of Staithes (Page 1992; Phelps 1985; Page *in* Simms *et al.* 2004, pp. 250-262). The facies in Somerset, however, being more calcareous and less diagenetically altered than those in Yorkshire, are more suitable for a range of analysis including high-resolution geochemical and micropalaeontological studies. The primary issue, however, remains lack of permanent exposure and ideally a cored borehole section would be required to provide continuous sampling possibilities. Although differing slightly in lithological detail, such a borehole sequence does already exist in West Somerset (Whittaker and Green 1984, pp. 121-130) in the British Geological Survey collections at Keyworth, Nottingham. Remarkably, however, no detailed assessment of this sequence has ever been published.

Acknowledgements

H. C. Prudden (Montacute) is thanked for generously making available a unique resource of detailed site records and specimens and assisting with the costs of visiting the National Museum of Wales – without his records this review would not have been possible. Additional material was kindly provided by Michael Harvey (Chilthorne Domer). Stephen Howe assisted with access to collections in the National Museum of Wales and Paul Davies to Lang's collections in the Natural History Museum, London. Ramues Gallois (Exeter) and Geotechnical Engineering Ltd. are thanked for access to borehole cores from Bath. Figure 1 was produced by John Abrahams, SEOES, University of Plymouth. Presentation of this paper has been subsidised by the Fundación María-José Bello-Villalba.

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