The Albian – Cenomanian boundary at Eggardon Hill, Dorset (England): an anomaly resolved ?

THE ALBIAN – CENOMANIAN BOUNDARY, EGGARDON HILL, DORSET, UK

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WOODS, M. A., WOOD, C. J. WILKINSON, I. P. and LOTT, G. K. 2009. The Albian – Cenomanian boundary at Eggardon Hill, Dorset (England): an anomaly resolved? *Proceedings of the Geologists' Association*, **XXX**, 000 – 000. Re-examination of the classic exposures of the Eggardon Grit (topmost Upper Greensand Formation) at Eggardon Hill, Dorset shows that the upper part of this unit has a more complex stratigraphy than has been previously recognised. The Eggardon Grit Member, as described herein, is capped by a hardground and associated conglomerate, and is entirely of Late Albian age. The hardground is probably the lateral equivalent of the Small Cove Hardground, which marks the top of the Upper Greensand succession in southeast Devon. The conglomerate is overlain by a thin sandy limestone containing Early Cenomanian ammonites. This limestone is almost certainly the horizon of the Early Cenomanian ammonite fauna that has previously been attributed to the top of the Eggardon Grit. The limestone is regarded as a thin lateral equivalent of the Beer Head Limestone Formation (formerly Cenomanian Limestone) exposed on the southeast Devon coast. The fauna of the limestone at Eggardon suggests that it is probably the age equivalent to the two lowest subdivisions of the Beer Head Limestone in southeast Devon, with a remanié fauna of

the Pounds Pool Sandy Limestone Member combined with indigenous macrofossils of the Hooken Nodular Limestone Member. The next highest subdivision of the Beer Head Limestone in southeast Devon (Little Beach Bioclastic Limestone Member), equates with the ammonite-rich phosphatic conglomerate of the 'Chalk Basement Bed', which caps the Beer Head Limestone at Eggardon, and which was previously regarded as the base of the Chalk Group on Eggardon Hill.

Petrographic analysis of the Eggardon Grit shows that lithologically it should more correctly be described as a sandy limestone rather than sandstone. The original stratigraphical definition of the unit should probably be modified to exclude the softer, nodular calcareous sandstones that have traditionally been included in the lower part of the member.

Without the apparently clear evidence of unbroken sedimentation across the Albian – Cenomanian boundary, suggested by the previous interpretation of the Eggardon succession, it is harder to argue for this being a prevalent feature of Upper Greensand stratigraphy in southwest England. Correlation of the Eggardon succession with successions in Dorset and southeast Devon reveals a widespread regional break in sedimentation at the Albian – Cenomanian boundary. The sand-rich facies above this unconformity represent the true base of the Chalk Group, rather than the 'Chalk Basement Bed' of previous interpretations.

Selected elements of regionally important Upper Greensand ammonite faunas previously reported from Shapwick Quarry, near Lyme Regis, and Babcombe Copse, near Newton Abbot, are newly figured herein.

Key Words: Eggardon Hill, Upper Greensand, Albian – Cenomanian boundary, lithostratigraphy, biostratigraphy

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1. INTRODUCTION

Picturesque Eggardon Hill, near Bridport, Dorset, in southwest England, is a classic geological locality (Jukes-Browne & Hill, 1900; Wilson *et al*., 1958; Kennedy, 1970; Fig. 1). The lower slopes contain the stratotype exposures of the Eggardon Grit Member (Hopson *et al*., 2008), which locally forms the youngest part of the arenaceous Upper Greensand Formation (Fig. 2). It is overlain by the fine-grained, pale grey or white, coccolith-rich limestone of the Chalk Group, which forms the main mass of Eggardon Hill. Where the contact between the Upper Greensand and Chalk is exposed across southern England, an exclusively Albian age can either be proved or inferred for the Upper Greensand, and a major erosion surface and facies change usually marks the junction with the Cenomanian strata that form the lower part of the Chalk Group.

The only places in southern England where strong evidence has been presented for a Cenomanian age for the youngest Upper Greensand are the Babcombe Copse Quarry in the Bovey Basin, southwest of the Haldon Hills, near Newton Abbot, and Eggardon Hill (Kennedy, 1970; Hamblin & Wood, 1976; Selwood *et al*., 1984; Fig. 1). The Cenomanian age of the highest part of the Upper Greensand in the Bovey Basin (Cullum Sands with Cherts Member; Selwood *et al*., 1984, fig. 21) is not disputed. It is based on records of the ammonites *Mantelliceras*, *Hyphoplites* and *Hypoturrilites*? in cherts from the Cullum Sands with Cherts Member at Babcombe Copse [SX 869 766] (Hamblin & Wood, 1976; Selwood *et al*., 1984). Re-examination of this fauna suggests that the *Mantelliceras* is *M*. aff. *saxbii* (Sharpe), and the *Hypoturrilites*? is *Turrilites* aff. *wiestii* Sharpe; the *Hyphoplites* could not be found. The revised identifications confirm a Cenomanian age for the Cullum Sands with Cherts, and suggest a stratigraphical range up to the higher part of the *M. dixoni* Zone (Fig. 3). In the Haldon Hills succession, the Albian – Cenomanian boundary is poorly defined by the upward appearance of cherts above the Ashcombe Gravels Member. Here, there is no distinct unconformity surface or major facies change at the Albian – Cenomanian boundary. The Haldon Hills are inferred to be close to the Late Albian basin margin (Hancock & Rawson, 1992, maps K3, K4a), a situation where a strong unconformity might normally be expected. The absence of such a well-marked surface may indicate active fault control at the basin margin and/or rapid reworking of hiatal surfaces by influxes of sediments derived from rejuvenation of very nearby source areas. Proximity to actively eroding massifs would also have maintained a greater local supply of sand-rich facies during Early Cenomanian marine transgression, masking the distinct facies change that is usually seen at the base of the Upper Cretaceous.

However, Eggardon Hill is anomalous, since it is surrounded by localities where the earliest macrofossil evidence for the Cenomanian is in conglomeratic units that are now assigned to the basal Chalk Group (see Interpretation); for example at Askerswell [SY 529 923] to the south, at Toller Porcorum [SY 567 982] to the northeast, at Beaminster [ST 470 032] to the northwest and Compton Valence [SY 592 931] to the east (Kennedy, 1970). A basal Cenomanian age for the Upper Greensand at Eggardon would have to involve a very localised source of clastic sediment and more-or-less unbroken deposition at a time of widespread regional erosion. This is possible if there are local tectonic structures that were active during deposition of the Eggardon Grit.

New fieldwork by MAW and CJW around Eggardon Hill in summer 2005, and in the Hooke valley, Dorset, by MAW in spring 2009, aimed finally to resolve the age of the Eggardon Grit. This paper describes the results of this work. The Late Albian biozonal scheme referred to in this paper follows Owen & Mutterlose (2006). The relationship of this scheme to that recently proposed by Kennedy & Latil (2007) is shown in Fig. 4. New fossil material and thin sections relating to this investigation are deposited in the collections of the British Geological Survey, Keyworth, Nottingham. Author citations for fossil species are given at the first mention in the text.

2. PREVIOUS RESEARCH

Jukes-Browne & Hill (1900) briefly mentioned the fossil-rich bluffs formed by the Eggardon Grit at Eggardon Hill, and comprehensive descriptions of the succession thereabouts were published by Wilson *et al*. (1958) and Kennedy (1970). Based on ammonite evidence from outcrops of the Eggardon Grit around Bridport, Wilson *et al*. (1958) stated that the member straddled the Albian – Cenomanian boundary. Specific ammonite evidence for a Cenomanian age for the upper part of the Eggardon Grit at

Eggardon Hill was presented by Kennedy (1970) and Drummond (1970); Carter & Hart (1977, fig. 40) later suggested that there was microfossil evidence for a Cenomanian age for a substantial part of the Upper Greensand in Dorset and southeast Devon, and that all but the basal part (the ‘Exogyra Sandstone’) of the Upper Greensand succession at Eggardon described by Wilson *et al.* (1958) was Cenomanian. However, Carter & Hart’s conclusion was difficult to sustain in the light of the Late Albian ammonite fauna (*Stoliczkaia dispar* Zone) from just below the top of the Upper Greensand at Shapwick Quarry [SY 3118 9180], in Dorset, listed by Hamblin & Wood (1976) and in part figured herein (Fig. 3). The microfossil evidence for a Cenomanian age may in part have been affected by a local northward incursion of warmer (‘Tethyan’) waters in the Late Albian, as evidenced in Devon by the unusual coral, rudist bivalve and orbitolinid foraminifera fauna of the undoubted pre-Cenomanian succession of the Haldon Hills, and in the coastal succession by large, strongly ornamented oysters (e.g. *Costagyra digitata* (J. Sowerby)) (Hamblin & Wood, 1976; Selwood *et al*., 1984; Nicholas & Hart, 2004). In a later interpretation, Wright & Kennedy (1984, p. 12) stated that some of the fauna from the Eggardon Grit described as indigenous by previous workers (e.g. Kennedy, 1970), may in fact be from conglomeratic basal Chalk Group strata that immediately overlie the Eggardon Grit.

3. STRATIGRAPHY & MACROPALAEONTOLOGY

The highest *c*. 12 m of the Upper Greensand Formation are intermittently exposed around Eggardon Hill, and extends from the basal Chalk Group down to an oyster-rich sandstone horizon referred to as the Exogyra Sandstone in previous accounts (e.g.

Drummond, 1970; Kennedy, 1970; Bristow *et al*., 1995). The same interval was reported by Wilson *et al*. (1958) as just over 12 m thick. The succession currently visible at Eggardon Hill is shown on Figure 5. It is a composite succession pieced together from examination of four key sections around Eggardon Hill [section 1: SY 53796 95254; section 2: SY 53426 95118; section 3: SY 53839 94843; section 4: SY 53768 94942]. Supplementary observations were also made at [SY 53651 95068 and SY 53650 95067].

The Exogyra Sandstone at the base of the outcropping succession (Unit 8 of Fig. 5) is a nodular and very glauconite-rich sandstone, with abundant oysters (*Amphidonte*, *Rhynchostreon*? = *Exogyra columba* auctt.) and the bivalve *Neithea gibbosa* (Pulteney). This sandstone equates with the top of the Shaftesbury Sandstone Member of the Shaftesbury district (Bristow *et al*.,1995), as extrapolated to and shown on the newly revised 1:50 000 geological map of the Bridport district (Sheet 327; British Geological Survey, 2005). Wilson *et al*. (1958) recorded *c*. 4.2 m of this sandstone, but currently only 0.7 m are visible. The 3 m interval immediately above the currently visible part of the Exogyra Sandstone is unexposed, but could include strata assigned to the Exogyra Sandstone by Wilson *et al*. (1958).

Above the unexposed interval is a 1 m unit of highly glauconitic sandstone with many pale, clay-lined burrows (Unit 7b of Fig. 5), overlain by *c*. 3.6 m of intermittently exposed fine-grained, orange-green weathering sandstone with beds of chert and hard, silica-cemented sandstone (units 5, 6 & 7a of Fig. 5) containing echinoid fragments and *Neithea gibbosa*. This interval corresponds to the ‘Chert Beds’ of Wilson *et al*. (1958), which they recorded as being *c*. 4.2 m thick. This interval equates with the

Boyne Hollow Chert Member of the Shaftesbury district (Bristow *et al*.,1995), which is locally shown on the most recent 1:50 000 scale geological map of the Bridport district (British Geological Survey, 2005), and also with the Whitecliff Chert Member of the Devon coast (Fig. 9).

Overlying the chert-bearing succession is a distinctive interval, 1.2 to 1.4 m thick, largely comprising sharply defined rounded patches of hard, fine-grained sandstone, in a coarser-grained sandstone matrix (Unit 4 of Fig. 5; Fig. 6(c)). This unit was identified as forming the basal part (0.9 – 1.0 m thick) of the Eggardon Grit by Wilson *et al*. (1958), who described it as “Quartz sand full of silicified nodules of very fine quartz sand.” These ‘nodules’ might represent indurated burrow infills.
A glauconitised hardground surface occurs 0.15 m below the top of the sandstone unit, overlain by coarse-grained sandstone containing *Neithea gibbosa*.

The top of the Upper Greensand Formation at Eggardon Hill is a massive, hard, feature-forming interval, up to 1.8 m thick (Unit 3 of Fig. 5), corresponding to the higher part of the Eggardon Grit of Wilson *et al*. (1958). At outcrop, this unit appears to be coarse-grained, glauconitic sandstone but, in thin section, is clearly a sandy limestone (see below; Fig. 8). This unit forms conspicuous bluffs, seen around the southern and western flanks of Eggardon Hill, which overhang the softer, more easily weathered nodular sandstone below (Fig. 6(a)). Two subdivisions of this unit can be recognised. The lowest 0.65 m of sandy limestone is slightly less well cemented (Unit 3b of Fig. 5), and is capped by a well developed burrowed surface. This interval is strongly burrowed with cross-bedding developed at the base. Above this, the upper subdivision comprises well-cemented, shell-rich sandy limestone, 0.65 – 0.95 m thick, which is less abundantly burrowed and has locally developed cross-bedding at the base (Unit 3a of Fig 5). The numerous shell fragments include the brachiopod ?*Cyclothyris* (juv.), the bivalves ?*Costagyra digitata* (J. Sowerby), *Entolium orbiculare* (J. Sowerby), *Merklinia aspera* (Lamarck), *Mimachlamys robinaldina* (d'Orbigny), *Neithea gibbosa*, *N. aequicostata* (Lamarck), *N. quinquecostata* (J. Sowerby), *N.* (*Neithella*) *notabilis* (Muenster *in* Goldfuss) and the echinoid *Pseudholaster bicarinatus*? (Agassiz). The top of Unit 3a is a well developed, phosphatised and glauconitised hardground, in places very irregular, with up to 160 mm of relief.

The top of the Upper Greensand is marked by a 0.1 to 0.2 m thick pebble bed (Unit 2 of Fig. 5), formed of rounded, reddish coloured pebbles (30 to 50 mm in size) of glauconitic sandstone with iron-stained quartz grains. Some are encrusted with bryozoans and serpulids. This thin interval is softer than the underlying sandstone, and weathers back at an oblique angle (Fig. 6(b)). The fauna from the pebble bed includes the bivalves *Merklinia aspera*, *Mimachlamys robinaldina*, *Linotrigonia* (*Oistotrigonia*) *spinosa*? (Parkinson), *Entolium orbiculare*, *Neithea* sp., *Pycnodonte*?, a nautiloid (abraded internal mould) and the echinoid *Holaster* sp.

Immediately above the pebble bed that caps the Upper Greensand is a thin (0.1 to 0.35 m thick), hard bed of distinctively pale-weathering, creamy-grey coloured, sandy, bioclastic limestone (Unit 1 of Fig. 5). The limestone contains scattered grains of translucent quartz and some glauconite. The unit has a very distinctive appearance at outcrop, its vertical weathering profile contrasting with the oblique profile of the underlying pebble bed (Fig. 6(b)). The fauna from the limestone includes the bivalves

Entolium orbiculare, '*Inoceramus*' ex gr. *crippsi* Mantell and *Merklinia aspera* and the echinoids *Discoides subuculus* (Leske) and *Holaster* sp. Large specimens of *Merklinia aspera* appear to be particularly characteristic of the limestone. The lowest part of this thin limestone is less well-cemented and relatively fossil-rich, and the fauna from this level includes the ammonites *Mantelliceras couloni* (d'Orbigny), *M. mantelli*? (J. Sowerby) and *Schloenbachia varians* (J. Sowerby) (Fig. 3). Some post-mortem reworking of this fauna is suggested by abrasion, iron-staining and weak phosphatisation. The top of the unit is a planar hardground surface, overlain by a concentration of phosphatised fossils in soft, creamy white chalk. This fauna includes the ammonites *Acanthoceras rhotomagense* (Brongniart), *Schloenbachia varians* and *Scaphites equalis* (J. Sowerby).

4. MICROPALAEONTOLOGY

Thin sections of the Eggardon Grit (Unit 3), and overlying pebble bed (Unit 2) and sandy limestone (Unit 1), contain age-diagnostic foraminifera that provide further evidence for the position of the Albian – Cenomanian boundary in the Eggardon Hill succession (Fig. 7).

Foraminifera are rare in the lower part of Unit 3 (Unit 3b of Fig. 5). They include *Arenobulimina chapmani* Cushman, *Dorothia filiformis* (Berthelin), *Hedbergella brittonensis* Loeblich & Tappan, *Lenticulina* sp., *Marssonella ozawai* Cushman, *M. trochus* (d'Orbigny), *Spiroplectinata annectens* Parker & Jones and *Textularia*. The presence of *Marssonella ozawai* with *Dorothia filiformis* and *Arenobulimina chapmani* indicate a Late Albian age within the *Stoliczkaia dispar* (ammonite) Zone.

Foraminifera are much more abundant in the upper part of Unit 3 (Unit 3a of Fig. 5), with numerous, small and fragmentary specimens, including *Arenobulimina* cf. *chapmani*, *Eggerella* sp., *Gyroidinoides* sp., *Marssonella ozawai*, *Orbitolina sefini* Henson and *Tritaxia* sp. The concurrent range of *Marssonella ozawai* and *Arenobulimina* cf. *chapmani* is indicative of upper *Callihoplites auritus* through to the highest *S. dispar* Zone (= Zone 6 of Carter & Hart (1977), but below Zone 6a). These two species confirm a latest Albian age. *Orbitolina sefini* suggests a position approximately coeval with the Woodlands Sand Member in the Haldon Upper Greensand succession (Schroeder *et al*., 1986), but this could be reworked.

Rather long-ranging foraminifera occur in the pebble bed (Unit 2 of Fig. 5), including *Arenobulimina chapmani*, *Dorothia filiformis*, *Gavelinella* sp., *Hedbergella brittonensis*, *H. delrioensis* (Carsey), *Heterohelix* sp., *Lenticulina* sp., *Lingulogavelinella jarzevae*? (Vasilenko), *Marssonella ozawai*, *Quinqueloculina antiqua* (Franke), *Spiroplectinata annectens* and *Textularia* sp. The concurrent range of *A. chapmani* and *M. ozawai* indicates the Late Albian *S. dispar* Zone. *L. jarzevae* is rare and patchily distributed in the *dispar* Zone, although more consistently present in uppermost *dispar* through into the basal Cenomanian *Mantelliceras mantelli* Zone (*Neostlingoceras carcitanense* Subzone).

Better evidence for the Cenomanian is indicated by the foraminifera of Unit 1, which contains *Ammobaculites/Haplophragmoides*, *Hagenowina anglica* (Cushman), *Dentalina* sp., *Gaudryina austinana* Cushman, *Gaudryina* sp. cf. *gradata* (Berthelin), *Gavelinella* cf. *berthelini* (Keller), *Gyroidinoides* sp., *Hedbergella brittonensis*, *H.*

delrioensis, *H. planispira* (Tappan), *Lingulogavelinella jarzevae*, *Marsonella ozawai*, *Plectina mariae* (Franke), *Quinqueloculina antiqua*, *?Spiroplectamina annectens* and *Textularia* sp. Many of these species range across the Albian – Cenomanian boundary. However, specimens of *Plectina mariae* and *Hagenowina anglica* indicate the Cenomanian, with *Q. antiqua* and *M. ozawai* suggesting a position no higher than the lower part of the *Mantelliceras saxbii* Subzone of the *M. mantelli* Zone, above which *L. jarzevae* is rare and patchily distributed.

5. THIN SECTION PETROGRAPHIC ANALYSIS

Samples from the upper part of the Eggardon Grit (units 2 & 3; Fig. 5) and overlying limestone (Unit 1; Fig. 5) were examined in thin section (Fig. 8). The lithology of the pebbles in the pebble bed (Unit 2) is similar to that of the immediately underlying interval (Unit 3), both being characterised by abundant fine to very coarse, well-rounded, detrital siliciclastic grains and common glauconite in a spar carbonate cement. The siliciclastic grains are predominantly monocrystalline quartz, with some polycrystalline quartz and rare partially leached potassic feldspars. Although traditionally described as sandstone, Unit 3 of the Eggardon Grit is petrographically a coarse-grained sandy limestone. The pervasive calcite cement is undoubtedly what makes this part of the Eggardon Grit such a feature-forming horizon.

In contrast, the sample from the sandy limestone (Unit 1) immediately above the pebble bed contains significantly fewer siliciclastic grains, is more sparsely glauconitic, and contains abundant foraminifera. These features indicate that it is lithologically distinct from the Eggardon Grit (units 2 & 3).

6. INTERPRETATION

Lithostratigraphical, petrographical and palaeontological data from the Eggardon succession suggest that Cenomanian faunas previously attributed to the Eggardon Grit at Eggardon Hill are actually from a lithologically distinct unit above a major erosion surface that marks the base of the Chalk Group. This interpretation provides a much clearer framework for understanding the stratigraphy of Eggardon Hill and nearby localities. The rationale for this interpretation is discussed below.

Dating the Eggardon Hill succession

Many of the macrofossils collected from the Eggardon succession are non age-diagnostic, although *Neithea gibbosa*, seen at various levels below the pebble bed, is typically common in the Late Albian. However, microfossil data indicates that Unit 3 of the Eggardon succession, beneath the pebble bed, unequivocally belongs to the Late Albian *S. dispar* Zone, although lacking evidence for the latest part of this zone (equivalent to Zone 6a of Carter & Hart's (1977) foraminiferal scheme).

No age-diagnostic macrofossils were collected from the pebble bed (Unit 2), but microfossil data shows that an age range from the Late Albian to Early Cenomanian is possible. Both macrofossil and microfossil data support an Early Cenomanian age for the pale coloured sandy limestone (Unit 1) above the pebble bed. The record of *Mantelliceras couloni* in the base of Unit 1 is indicative of the Early Cenomanian, *Mantelliceras mantelli* Zone, upper *Neostlingoceras carcitanense* Subzone.

Schloenbachia and '*Inoceramus*' *crippsi*, from the same level, are also not found prior to the Cenomanian. This is consistent with microfossil data that suggest an age no younger than the *M. saxbii* Subzone of the *M. mantelli* Zone. Therefore, the Albian – Cenomanian boundary in the Eggardon succession is probably marked by the top of the major hardground and associated pebble bed that immediately underlies Unit 1 (Figs 2, 5).

The phosphatised ammonite fauna overlying the planar hardground at the top of Unit 1 equates with the 'Chalk Basement Bed' of Kennedy's (1970, fig. 9) log of the Eggardon Hill succession. Kennedy (1970) recorded that this phosphatised fauna included *Acanthoceras rhotomagense* and *Scaphites* (both collected during the current fieldwork), and was indicative of the upper *A. rhotomagense* Zone (*Turrilites acutus* Subzone) and the *A. jukesbrownei* Zone; unphosphatised ammonites indicated the *A. jukesbrownei* Zone.

Lithostratigraphical interpretation of the Eggardon Hill succession

Since the limestone of Unit 1 is lithologically and faunally distinct from the underlying succession, is separated from it by a significant depositional hiatus, and can clearly be distinguished as a separate interval at outcrop (Fig. 6(b)), it is regarded as a discrete, geologically younger unit than the Eggardon Grit. Lithologically and biostratigraphically, Unit 1 at Eggardon can be equated with the lower part of the Beer Head Limestone Formation of southeast Devon, although its precise correlation with the components of this succession is unclear. The lower part of the Beer Head Limestone comprises sandy limestone (containing quartz grains, some potassic feldspar and relatively rare grains of glauconite) and rubbly, bioclastic limestone (Jarvis & Woodroof, 1984) that compare closely with the lithology of Unit 1. The *N. carcitanense* Subzone macrofossil fauna of Unit 1 suggests correlation with the basal subdivision of the Beer Head Limestone Formation (traditionally termed 'Cenomanian Limestone Bed A1' and renamed Pounds Pool Sandy Limestone Member by Jarvis and Woodroof ; Jarvis & Woodroof, 1984; Mortimore *et al.*, 2001). However, this fauna is confined to the base of Unit 1 at Eggardon, and the ammonites present appear to be reworked. Furthermore, the relative abundance of *Merklinia aspera* throughout Unit 1 suggests affinity with the higher part of the Hooken Nodular Limestone Member ('Cenomanian Limestone Bed A2') of the southeast Devon succession, which is assigned to the *M. dixoni* Zone (Fig. 2). Unit 1 is therefore interpreted as having a derived fauna equivalent to that of the Pounds Pool Sandy Limestone, and an indigenous fauna that is more tentatively equated with that of the Hooken Nodular Limestone. Microfossil data supports a *M. mantelli* Zone age for Unit 1, but does not provide evidence of the *M. dixoni* Zone. However, not all of the macrofossil fauna that is typical of the Pounds Pool Sandy Limestone and Hooken Nodular Limestone was recorded in Unit 1. This may reflect unrepresentative collecting due to the strong cementation and often difficult access to Unit 1. It is also possible that the fauna reflects an unusual palaeoecological setting for Eggardon Hill, which appears to represent the easternmost occurrence of the Beer Head Limestone, the next nearest records being inland at Chardstock, 25 km WNW (Fig. 1), and at a similar distance WSW on the coast at Humble Point (Kennedy, 1970).

Despite the potential for atypical depositional conditions affecting the relatively remote development of Beer Head Limestone at Eggardon Hill, support for the general correlation presented herein is provided by the unphosphatised Basement Bed macrofauna above Unit 1 at Eggardon Hill. This fauna equates with the indigenous fauna of the Little Beach Bioclastic Limestone Member, overlying the Hooken Nodular Limestone in southeast Devon (Kennedy, 1970; Mortimore *et al*., 2001; Fig. 2). The overlying Grey Chalk Subgroup and basal White Chalk Subgroup at Eggardon Hill is coeval with the highest part of the Beer Head Limestone Formation (Humble Point Hardground and Pinnacles Glauconitic Limestone Member), but is developed in typical soft chalk facies.

The hardground at the top of Unit 3 and associated pebble bed (Unit 2), that is inferred to mark the Albian – Cenomanian boundary at Eggardon Hill, probably equates with the Small Cove Hardground of Jarvis & Woodroof (1984), which separates the Upper Greensand Formation and Beer Head Limestone Formation on the southeast Devon coast (Figs 2 & 9). By analogy with the southeast Devon succession, the hardground at the top of the Beer Head Limestone at Eggardon (Unit 1) is probably equivalent to the King's Hole Hardground of Jarvis & Woodroof (1984). Lower down in the Eggardon succession, the hardground seen just below the base of Unit 3 could equate with the Whitecliff Hardground of Edwards *et al*. (2004), which marks the top of the Whitecliff Chert Member (formerly 'Chert Beds') on the southeast Devon coast (Figs. 2 & 9). This possibility, and particularly the significant facies change above this surface at Eggardon (Fig. 5), suggests that the term Eggardon Grit should perhaps be largely restricted to the massive, feature-forming sandy limestone of Unit 3, rather than including the much softer immediately underlying pebbly sandstones (Unit 4) as proposed by Wilson *et al*. (1958). The possible identification of the Whitecliff Hardground at the base of the Eggardon Grit in the

Eggardon succession would suggest that the Bindon Sandstone (formerly ‘Top Sandstones’) of southeast Devon (Gallois, 2004) is broadly coeval with the Eggardon Grit (Fig. 9).

Correlation

The current work has only investigated the stratigraphy of the Eggardon Grit at Eggardon Hill, principally because this succession previously had the best documented occurrence of Cenomanian faunas in alleged Eggardon Grit. The question remains as to whether all previous records of Cenomanian faunas in the ‘Upper Greensand’ of southwest England are in fact from lithostratigraphically distinct units above a regionally developed Albian – Cenomanian hiatus.

There is some evidence for extending the interpretation of Upper Greensand deposition at Eggardon to other localities. At Hutchin’s Pit [ST 216 003] (= Reeds Farm Pit of Mortimore *et al*., 2001), Wilmington, in southeast Devon, Wright and Kennedy (1984) reported that an upper *N. carcitanense* Subzone fauna (with *Mantelliceras couloni*) similarly occurs above a hardground at the top of the Eggardon Grit. This hardground may equate with that developed at the top of Unit 3 at Eggardon.

At Snowdon Hill Quarry [ST 312 089], near Chard, a complex cobble conglomerate occurs at the top of the Eggardon Grit (Kennedy, 1970). The conglomerate resembles the Small Cove Hardground that caps inferred Late Albian Upper Greensand on the southeast Devon coast (Mortimore *et al*., 2001). Remnants of a sandy limestone with Early Cenomanian fossils occur in pockets within the conglomerate above a phosphatised surface and below the Chalk Basement Bed. Here, the Albian – Cenomanian boundary is marked by the junction between the conglomerate and residual sandy limestone, the latter probably representing the remnants of an originally more extensive horizon. Like the Eggardon succession, the fauna of the sandy limestone suggests a correlation with the oldest part of the Beer Head Limestone Formation (Pounds Pool Sandy Limestone) of southeast Devon.

Bristow *et al*. (1999, fig. 27) described and illustrated the correlation of the Melbury Sandstone in the Wincanton district, a unit characterised by Cenomanian fossils of similar age to that of Unit 1 at Eggardon. An erosion surface overlain by a conglomeratic unit occurs at the base of the Melbury Sandstone (Fig. 9). The Melbury Sandstone is equivalent to the Glauconitic Marl at the base of the Chalk Group in southeastern England (Bristow *et al*., 1997). Like the Melbury Sandstone, the Glauconitic Marl is immediately underlain by an erosion surface, but unlike the situation at Eggardon, this erosion surface is also coincident with a clearly visible facies change. At a meeting of the Geological Society Stratigraphy Commission at the BGS in 1999, it was agreed that the erosion surface should be used to define the base of the Chalk Group, rather than the incoming of carbonate-rich lithofacies. Consequently, the Melbury Sandstone is now regarded as the basal unit of the Chalk Group in southwest England (Rawson *et al*., 2001; Mortimore *et al*., 2001, fig. 3.40; Hopson, 2005). The Melbury Sandstone broadly equates with the well known Rye Hill Sand at Rye Hill Farm [ST 8485 4017] (horizon incorrectly labelled on fig 4 of Kennedy, 1970; Mortimore *et al*., 2001), and with other Cenomanian sandstones seen in the Wincanton district at Shute [ST 8403 4054], Dead Maid Quarry [ST 803 323] and Zeals [ST 7856 3134] (Bristow *et al*., 1991; Woods & Bristow, 1995; Bristow *et* *al*., 1999). At all of these localities Cenomanian sands occur above an erosion surface and conglomeratic bed, traditionally known as the Cornstones or Popple Bed (Bristow *et al*., 1999, fig. 27), although the precise biozonal assignment within the Early Cenomanian may be laterally variable (Fig. 9). Across southeast England, the erosion surface at the base of the Glauconitic Marl marks the Albian – Cenomanian boundary, and, based on material reviewed by Woods and Bristow (1995), this is also probably true for the erosion surface at the base of the Melbury Sandstone.

The above evidence shows that most occurrences of Cenomanian sandstones in southwest England, formerly regarded as topmost Upper Greensand, are likely to in fact represent sand-rich basal Chalk Group, and be underlain by a widely developed erosion surface marking the Albian – Cenomanian boundary. The evidence from Eggardon Hill is that the facies change at this erosion surface, whilst petrographically distinct, can be subtle at outcrop, so that in the absence of exposure of the erosion surface, the impression is given of more-or-less unbroken Upper Greensand sedimentation up to the base of the Chalk Basement Bed. At the other extreme in the Shaftesbury district, the Melbury Sandstone passes laterally into the Bookham Conglomerate, which in turn is immediately overlain by the Chalk Basement Bed (Bristow *et al*., 1995, fig. 48; Fig. 9). The occurrence of the Bookham Conglomerate is controlled by a structural high known as the Mid-Dorset Swell (Drummond, 1970), and contains a derived Albian fauna and an indigenous Early Cenomanian fauna (Bristow *et al*., 1995, 1999). In this situation there is no separate Early Cenomanian unit, analagous to Bed 1 at Eggardon, intervening between the conglomerate and Chalk Basement Bed; the extent of erosion is such that any pre-existing unit that was present must have been subsequently reworked into a single conglomeratic horizon. In effect this represents a further stage in the evolution of the conglomerate seen at Snowdon Hill.

The Bookham succession might be the clue to interpreting Eggardon Grit successions seen in the Hooke valley, near Beaminster (Jukes-Browne & Hill, 1900; Kennedy, 1970, fig. 7). At these localities a single bed of phosphatic conglomerate containing Cenomanian fossils caps the Eggardon Grit (Kennedy, 1970; Fig. 9). Jukes-Browne & Hill (1900, p. 174) recorded that there was no major depositional break within the top of the Upper Greensand below the Chalk Basement Bed, although Kennedy (1970) subsequently appeared to suggest the presence of a sharp boundary at the base of the phosphatic conglomerate. In fact, recent fieldwork in the area (by MAW in 2009) showed that a major erosion surface, with at least 350 mm of relief, occurs below the conglomerate (Fig. 6(f)) at Toller Whelme [SY 56881 98254], and that where the conglomerate is relatively thick (as at Toller Whelme), strongly phosphatised clasts tend to be concentrated towards the top. The non-phosphatised clasts resemble the lithology of the pale limestone (Unit 1) at Eggardon Hill, and, immediately below the conglomerate, the quartz grains at the top of the Eggardon Grit are strongly iron-stained, like those at the top of Unit 3 at Eggardon Hill. All this evidence suggests that the Hooke valley conglomerate in part represents the eroded equivalent of Unit 1 at Eggardon; erosion of Unit 1 appears to have been followed by protracted erosional winnowing that caused the complex phosphatisation described by Kennedy (1970). The erosion and phosphatisation is presumed to have occurred during the late *M. dixoni* and *C. inerme* zones, zones for which there is no definitive evidence at Eggardon or in the Hooke valley; this interval corresponds to the period of formation of the King's Hole Hardground on the southeast Devon coast and a planar hardground surface beneath the Chalk Basement Bed at Eggardon (Fig. 2). It could be argued that the Cenomanian fossils of these conglomerates were derived from underlying Eggardon Grit. Accepting this is difficult, given the complete absence of documented sections proving that these fossils could be indigenous to the Eggardon Grit, and the large body of evidence pointing to a Late Albian age for the top of the Upper Greensand below the Small Cove Hardground and its lateral equivalents.

On the south Dorset coast, Garrison *et al*. (1987, figs 9 & 10, table 2) described a series of variably condensed sections extending from the Exogyra Rock (= Exogyra Sandstone of this account) to the Chalk Basement Bed. Here the pattern of sedimentation has been affected by local structures, including the Mid-Dorset Swell. It is not immediately obvious how these sections relate to Eggardon, however, a possible interpretation can be deduced by identification and correlation of laterally persistent hiatus surfaces recognised at Eggardon and in southeast Devon. Three major surfaces of widespread occurrence occur in the southeast Devon Upper Greensand Formation: the Culverhole Hardgrounds at the base of the Whitecliff Chert Member, the Whitecliff Hardground at the base of the Bindon Sandstone Member, and the Small Cove Hardground at the top of the Bindon Sandstone Member (Gallois, 2004; Jarvis & Woodroof, 1984; Fig. 9). All three of these horizons seem to be present at Eggardon. The Culverhole Hardgrounds broadly equate with the Exogyra Sandstone. The latter occurs immediately below the base of the Whitecliff Chert Member at Eggardon, and the paired hardgrounds of the former occur at and immediately above the base of the member in southeast Devon. Both horizons are also characterised by an abundance of *Rhynchostreon*, *Amphidonte* and *Neithea* (Woods, 1999). As previously stated, the Whitecliff and Small Cove hardgrounds are probably represented respectively at Eggardon by the phosphatised surface near the top of Bed 4, and the hardground and pebble bed capping Bed 3 (Fig. 9).

In the south Dorset coast sections described by Garrison *et al*. (1987), there are probable correlatives of the three surfaces seen at Eggardon and in southeast Devon (Fig. 9). The Exogyra Rock, with abundant *Rhynchostreon*, *Amphidonte obliquatum* and *Neithea gibbosa* is recognised in all the sections. Higher in the south Dorset succession there is an ammonite-rich phosphatic nodule horizon (the 'Dispar Zone Ammonite Bed'). In thicker successions (e.g. Lulworth Cove; Fig. 9) this horizon is capped by an omission surface, marking an upward lithological change from soft glauconitic 'loam' with interbedded calcareous concretions, to calcareous sandstone. The calcareous sandstone is regarded as equivalent to the Eggardon Grit (Garrison *et al*., 1987, table 2), and locally (e.g. Lulworth Cove) contains cherts on the south Dorset coast. As pointed out by Gallois (2004), the development of chert is not in itself stratigraphically significant, since the Bindon Sandstone in southeast Devon shows laterally variable development of chert above the Whitecliff Chert Member. The Ammonite Bed and associated omission surface may equate with the hardground near the top of Bed 4 at Eggardon, and with the Whitecliff Hardground in southeast Devon. Both surfaces mark a significant upward facies change into hard, calcareous sandstone, and the horizon of the Ammonite Bed fauna within the *dispar* Zone (*M*. (*D*.) *perinflatum* Subzone; Owen, 1975, Wright and Kennedy, 1984) is stratigraphically below the *A*. (*P*.) *briacensis* Subzone fauna reported from the Bindon Sandstone Member above the Whitecliff Hardground at Shapwick Quarry, near Lyme Regis (Hamblin and Wood, 1976; Owen (*pers. comm*.) in Gallois, 2004). Therefore, the chert-free glauconitic 'loams' and sandstones between the Exogyra Rock and

Ammonite Bed in south Dorset probably equate with the Whitecliff Chert Member of southeast Devon and the Boyne Hollow Chert Member of the Shaftesbury and Wincanton districts (Fig. 9).

At Punfield Cove, near Swanage (Fig. 1), on the crest of the Mid-Dorset Swell, there is extreme condensation of the succession between the Exogyra Rock and Chalk Basement Bed. Here, the phosphatic fauna of the Dispar Zone Ammonite Bed occurs in calcareous glauconitic sandstone nodules, forming a pebble bed associated with a hardground developed in the immediately underlying Exogyra Rock (Wright & Kennedy, 1984; Garrison *et al*., 1987, fig. 11). This situation can be interpreted as representing the coalescence of the Whitecliff and Small Cove hardgrounds, and, as reported by Kennedy (1970), the elimination of the equivalent of the Whitecliff Chert Member. The conglomerate at Punfield Cove is analagous to the Bookham Conglomerate; both have reworked upper *dispar* Zone ammonites (Wright & Kennedy, 1984; Bristow *et al*., 1995) but whilst at Bookham Farm there is evidence for the conglomerate incorporating Early Cenomanian strata, this has not as yet been established for Punfield. Garrison *et al*. (1987) suggested that Punfield may have experienced a longer period of reworking than localities further west; Early Cenomanian fossils that appear to occur in the conglomerate and underlying Exogyra Rock are burrow infillings within the hardround complex.

6. CONCLUSIONS

Petrographically, the Eggardon Grit Member is a coarse-grained, sandy limestone, rather than a sandstone as traditionally interpreted. The base of the Eggardon Grit at its stratotype locality is redefined to coincide with the planar hardground near the top of Unit 4 (Fig. 5), the latter capping 1.25 m of nodular calcareous sandstone that has previously been ascribed to the base of the unit. The top of the Eggardon Grit is marked by a well developed hardground and pebble bed (Unit 2, Fig. 5) at Eggardon Hill, or by a major erosion surface at Toller Whelme, in the Hooke valley, Dorset. Microfossil data show that the top of the Eggardon Grit Member at Eggardon Hill is Late Albian in age. The Eggardon Grit is overlain at Eggardon Hill by a thin, lithologically distinct limestone (Unit 1, Fig. 5), the base of which contains a remanié Early Cenomanian, *Mantelliceras mantelli* Zone, upper *Neostlingoceras carcitanense* Subzone fauna. The bivalve *Merklinia aspera* is abundant throughout this limestone, and by analogy with the southeast Devon succession, provides tentative evidence for the slightly younger upper *M. mantelli* Zone and *M. dixoni* Zone. This limestone is herein assigned to the lower part of the Beer Head Limestone Formation of Jarvis & Woodroof (1984). The previously reported Early Cenomanian fauna from the top of the Eggardon Grit at Eggardon Hill (Kennedy, 1970) was probably collected from this limestone horizon. There is, therefore, no macrofaunal evidence for the top of the Eggardon Grit (as here interpreted) at Eggardon Hill being of Early Cenomanian age.

It is presumed that the limestone overlying the Eggardon Grit at its type locality must represent a chance occurrence/preservation of a thin Beer Head Limestone succession. Elsewhere this unit has either been largely or completely reworked into a widely developed conglomeratic bed that underlies the Chalk Basement Bed (e.g. Snowdon Hill Quarry, Toller Whelme, Bookham Farm (Bookham Conglomerate) and Punfield Cove, near Swanage), or is developed in more expanded sandstone facies (e.g. Melbury Sandstone) underlain by a conglomerate (Cornstones / Popple Bed) at the base of the Chalk Group. All these successions support the idea of a widely developed stratigraphical break at the Albian – Cenomanian boundary. It is not possible to completely refute the existence of unbroken sedimentation across the Albian – Cenomanian boundary without comprehensive reinvestigation of all coeval successions in Dorset, but the reinterpretation of the Eggardon succession now makes this a less probable general scenario for the region; any such successions that do exist are more likely to be a result of unusual local sedimentation history.

Key horizons in the Upper Greensand of southeast Devon (Culverhole Hardgrounds, Whitecliff Hardground and Small Cove Hardground) appear to be traceable into the Eggardon succession, and more speculatively into the south Dorset coast successions with the Dispar Zone Ammonite Bed between Lulworth Cove and Swanage described by Garrison *et al*. (1987).

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REFERENCES

Bristow, C. R., Barton, C. M., Freshney, E. C, Wood, C. J., Evans, D. J., Ivimey-Cook, H. C. & Taylor, R. T. 1995. Geology of the country around Shaftesbury. *Memoir of the British Geological Survey,* Sheet 313 (England & Wales).

Bristow, C. R, Barton, C. M., Westhead, R. K., Freshney, E. C., Cox, B. M. & Woods, M. A. 1999. The Wincanton district – a concise account of the Geology. *Memoir of the British Geological Survey,* Sheet 297 (England & Wales).

Bristow, C. R., Cox, B. M., Woods, M. A., Prudden, H. C., Sole, D., Edmunds, M. & Callomon, J. H. C. 1991. The geology of the A303 trunk road between Wincanton, Somerset and Mere, Wiltshire. *Proceedings of the Dorset Natural History and Archaeological Society*, **113**, 139 – 143.

Bristow, C. R. Mortimore, R. N. & Wood, C. J. 1997. Lithostratigraphy for mapping the Chalk of southern England. *Proceedings of the Geologists' Association*, **108**, 293 – 315.

British Geological Survey. 2005. Bridport. England and Wales Sheet 327. Bedrock and Superficial Deposits. 1:50 000. (Keyworth, Nottingham: British Geological Survey).

Carter, D. J. & Hart, M. B**.** 1977. Aspects of mid-Cretaceous stratigraphical micropalaeontology. *Bulletin of the British Museum of Natural History* [Geology Series], **29**, 135 pp.

Drummond, P. V. O. 1970. The Mid-Dorset Swell. Evidence of Albian – Cenomanian movements in Wessex. *Proceedings of the Geologists' Association*, **81**, 679–714.

Edwards, R. A., Gallois, R. W. & Hamblin, R. J. O. 2004. Geology of the Sidmouth district. *Sheet Explanation of the British Geological Survey*, Sheets 226 and 340 (England & Wales).

Gallois, R. W. 2004. The stratigraphy of the Upper Greensand (Cretaceous) of southwest England. *Geoscience in south-west England*, **11**, 21 – 29.

Garrison, R. E, Kennedy, W. J. & Palmer, T. J. 1987. Early lithification and hardgrounds in Upper Albian and Cenomanian calcarenites, Southwest England. *Cretaceous Research*, **8**, 103 – 140.

Hamblin, R. J. O. & Wood, C. J. 1976. The Cretaceous (Albian - Cenomanian) stratigraphy of the Haldon Hills, south Devon, England. *Newsletters on Stratigraphy*, **4**, 135–149.

Hancock, J. M. & Rawson, P. F**.** 1992. Cretaceous. *In* Cope, J. C. W., Ingham, J. K. & Rawson, P. F. (eds). *Atlas of Palaeogeography and Lithofacies*. Memoir **13**. Geological Society, London, 131–139.

Hopson, P. M. 2005. A stratigraphical framework for the Upper Cretaceous Chalk of England and Scotland with statements on the Chalk of Northern Ireland and the UK Offshore sector. *British Geological Survey Research Report*, RR/05/01.

Hopson, P. M., Wilkinson, I. P. & Woods, M. A. 2008. The Lower Cretaceous of England: An overview of the terminology utilised within the British Geological Survey. *British Geological Survey Research Report* RR/08/03.

Jarvis, I. & Woodroof, P. B. 1984. Stratigraphy of the Cenomanian and basal Turonian (Upper Cretaceous) between Branscombe and Seaton, SE Devon, England. *Proceedings of the Geologists' Association*, **95**, 193–215.

Jukes-Browne, A. J. & Hill, W. 1900. The Cretaceous rocks of Britain. Vol. 1 - The Gault and Upper Greensand of England. *Memoir of the Geological Survey of the United Kingdom*.

Kennedy, W. J**.** 1970. A correlation of the uppermost Albian and the Cenomanian of South-West England. *Proceedings of the Geologists' Association*, **81**, 613–677.

Kennedy, W. J. & Latil, J.-L. 2007. The Upper Albian ammonite succession in the Montlaux section, Hautes-Alpes, France. *Acta Geologica Polonica*, **57**, 453 – 478.

Mortimore, R. N., Wood, C. J. & Gallois, R. W. 2001. *British Upper Cretaceous Stratigraphy*, Geological Conservation Review Series, No. **23**, Joint Nature Conservation Committee, Peterborough.

Nicholas, C. & Hart, M. B. 2004. Mid-Cretaceous orbitolinids, from the Decoy Basin, Newton Abbot (Devon). *Geoscience in south-west England*, **11**, 10 – 14.

Owen, H. G. 1975. The stratigraphy of the Gault and Upper Greensand of the Weald. *Proceedings of the Geologists' Association*, **86**, 475 – 498.

Owen, H. G. 1989. Late Albian (*Stoliczkaia dispar* Zone) ammonites from Misburg, Hannover. *Geologisches Jahrbuch*, **A113**, 373 – 395.

Owen, H. G. & Mutterlose, J. 2006. Late Albian ammonites from offshore Suriname: implications for biostratigraphy and palaeobiogeography. *Cretaceous Research*, **27**, 717 – 727.

Rawson, P. F., Allen, P. & Gale, A. S. 2001. The Chalk Group – a revised lithostratigraphy. *Geoscientist*, **11**, 21.

Schroeder, R., Simmons, M. D., Hart, M. B. and Williams, C. L. 1986. A note on the occurrence of *Orbitolina* (*Orbitolina*) *sefini* Henson, 1948 (Foraminiferida) in the Upper Greensand of S. W. England. *Cretaceous Research*, **7**, 381 – 387.

Selwood, E. B., Edwards, R. A., Simpson, S., Chesher, J. A., Hamblin, R. J. O., Henson, M. R., Riddolls, B. W., Waters, R. A. 1984. The geology of the country around Newton Abbot. *Memoir of the British Geological Survey* (Sheet 339, England & Wales).

Wilson, V., Welch, F. B. A., Robbie, J. A., Green, G. W**.** 1958. Geology of the country around Bridport and Yeovil. *Memoir of the Geological Survey of Great Britain* (Sheet 327 & 312, England & Wales).

Woods, M. A. 1999. Upper Greensand and Chalk macrofossils from the Sidmouth sheet: 1:10 000 quarter sheets: ST10SW, ST19NW, SY28NW, NE. *British Geological Survey Technical Report*, WH/99/89R.

Woods, M. A. & Bristow, C. R. 1995. A biostratigraphical review of the Gault, Upper Greensand and Chalk of the Wincanton (297) district, Wiltshire. *British Geological Survey Technical Report*, WA/95/60.

Wright, C. W. & Kennedy, W. J. 1984. The Ammonoidea of the Lower Chalk. Part I. *Monograph of the Palaeontographical Society*. London: 1–126, pls 1–40 (Publ. No. 567, part of Vol. **137** for 1983).

Figure 1. Map of the study area. The key reference section ('section 3' in text) shown on the detailed inset map for Eggardon Hill exposes the typical Eggardon Grit succession described in Figure 5, and is within an area currently designated as being publically accessible. The grid references of other localities are given in the text. Based upon OS material © Crown Copyright. All rights reserved. Licence 100017897/ 2009.

Figure 2. The stratigraphy of the Upper Greensand and Chalk Group of the southeast Devon coastal succession compared to that at Eggardon Hill described by Kennedy (1970) and in this study. The positions of the subzonal boundaries within the *S. dispar* Zone with respect to lithostratigraphy is in part speculative. A *briacensis* Subzone fauna is known from the higher part of the Bindon Sandstone Member (Gallois, 2004; the horizon of this fauna is probably Bed 3 of this member rather than Bed 4 as stated by Gallois), and the Boyne Hollow Chert Member contains *Idiohamites* aff. *elegantulus* Spath, suggesting at least partial assignment to the *perinflatum* Subzone (Owen, 1989). Dating evidence for the Beer Head Limestone is taken from Mortimore *et al*. (2001). Biozonation for the Albian follows Owen and Mutterlose (2006), and that for the Cenomanian follows Mortimore *et al*. (2001).

Figure 3. Late Albian and Early Cenomanian ammonites from the Upper Greensand Formation of Shapwick Quarry [SY 311 918] and Babcombe Copse [SX 869 766], and basal Chalk Group (Beer Head Limestone Formation) of Eggardon Hill. *Stoliczkaia* (*Stoliczkaia*) *dispar* (d'Orbigny) from the Bindon Sandstone Member at Shapwick Quarry. (a) venter and (b) side view of GSM 116464; *Discohoplites* aff.

valbonnensis (Hébert & Munier-Chalmas) from the Bindon Sandstone Member at Shapwick Quarry. (c) side view and (d) venter of CJW 6561 & 6562; *Callihoplites* sp. juv. cf. *tetragonus* (Seeley) or *seeleyi* Spath form the Bindon Sandstone Member at Shapwick Quarry. (e) CJW 6541 and (f) cast of CJW 6541; *Mantelliceras* aff. *saxbii* (Sharpe) from the Cullum Sands with Cherts Member, Babcombe Copse. (g) side view and (h) venter of cast of CJW 4392; *Turrilites* aff. *wiestii* Sharpe from the Cullum Sands with Cherts Member, Babcombe Copse. (i) cast of CJW 4390; *Mantelliceras couloni* (d'Orbigny) from the Beer Head Limestone Formation at Eggardon Hill. (j) venter and (k) side view of WMD 11229; (f) *Schloenbachia varians* (J. Sowerby) in block of Beer Head Limestone Formation from Eggardon Hill (WMD 11247). Scale bars are 10 mm.

Figure 4. Comparison of the ammonite biozonal schemes of Owen & Mutterlose (2006) and Kennedy & Latil (2007) for the latest Albian.

Figure 5. Composite lithological log and key macrofossils of the succession currently visible around Eggardon Hill.

Figure 6. The Upper Greensand Formation and basal Chalk Group at Eggardon Hill (a – e) and Toller Whelme (f). (a) Feature-forming bluffs of Eggardon Grit (units 2 & 3) capped by Beer Head Limestone (Unit 1). The sharp undercut marks the contact with Unit 4. Height of bluff is *c*. 2 m; (b) Beer Head Limestone Formation (Unit 1), above pebble bed (Unit 2), which, in turn, overlies the main feature-forming interval of Eggardon Grit Member (Unit 3); (c) Unit 4 showing typical nodular character and contact with base of Unit 3 in top left hand corner; (d) close-up of pebble bed (Unit

2); coin is 25 mm in diameter; (e) contact (marked by hammer head) of Beer Head Limestone (Unit 1) and the overlying ‘Basement Bed’ of Chalk Group; (f) major erosion surface (arrowed) capping Eggardon Grit. Hammer length in (b), (c), (e) and (f) is *c*. 0.3 m.

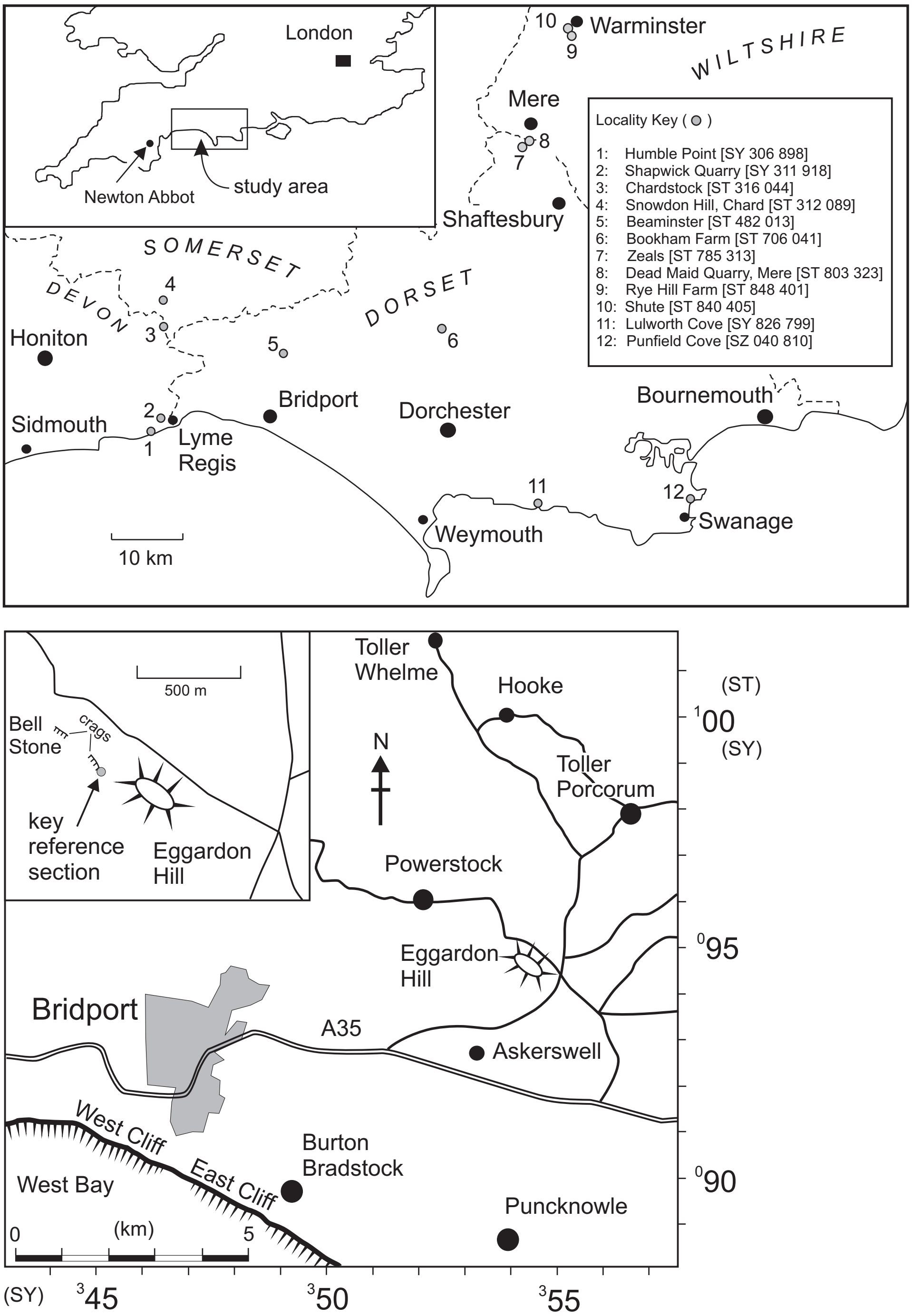
Figure 7. Foraminifera from the Upper Greensand Formation (Eggardon Grit Member) and Beer Head Limestone Formation at Eggardon Hill. Scale Bar: (a) – (g) 0.5 mm, (h) 1.0 mm.

(a) *Hagenowina anglica* (Cushman) (MPK 13787), (b) *Dorothia filiformis* (Berthelin) (MPK 13788), and (c) *Quinqueloculina antiqua* (Franke) (MPK 13789) from sample WMD14226, Beer Head Limestone Member; (d) *Lingulogavelinella jarzevae* (Vasilenko) (MPK 13790) from sample WMD14227, Upper part of unit 3a, Eggardon Grit Member; (e) *Dorothia filiformis* (Berthelin) (MPK13794) from sample WMD14228, unit 3b, Eggardon Grit Member; (f) *Arenobulimina chapmani* Cushman (MPK 13791) and (g) *Marssonella ozawai* Cushman (MPK 13792) from sample WMD14229, the Pebble Bed, Unit 2, Eggardon Grit Member; (h) fragment tentatively identified as *Orbitolina* sp (MPK 13793) from sample WMD14227, Upper part of unit 3a, Eggardon Grit Member.

Figure 8. Thin section views of (a) Unit 1 (Beer Head Limestone, sample no. WMD 11645) and (b) Unit 3 (Eggardon Grit; sample no. WMD 11646.). Field of view is 8mm (left to right). Calcite cement stained pale pink. Pore space stained blue. Darker pink stained areas are either bioclastic carbonate fragments or micropeloidal carbonate.

Key mineral grain symbols: Q (quartz); K (potassium feldspar); G (glauconite).

Figure 9. Correlation of key successions in the Upper Greensand and basal Chalk Group of Dorset and southeast Devon. For locality details see Figure 1.



(Figure 1)

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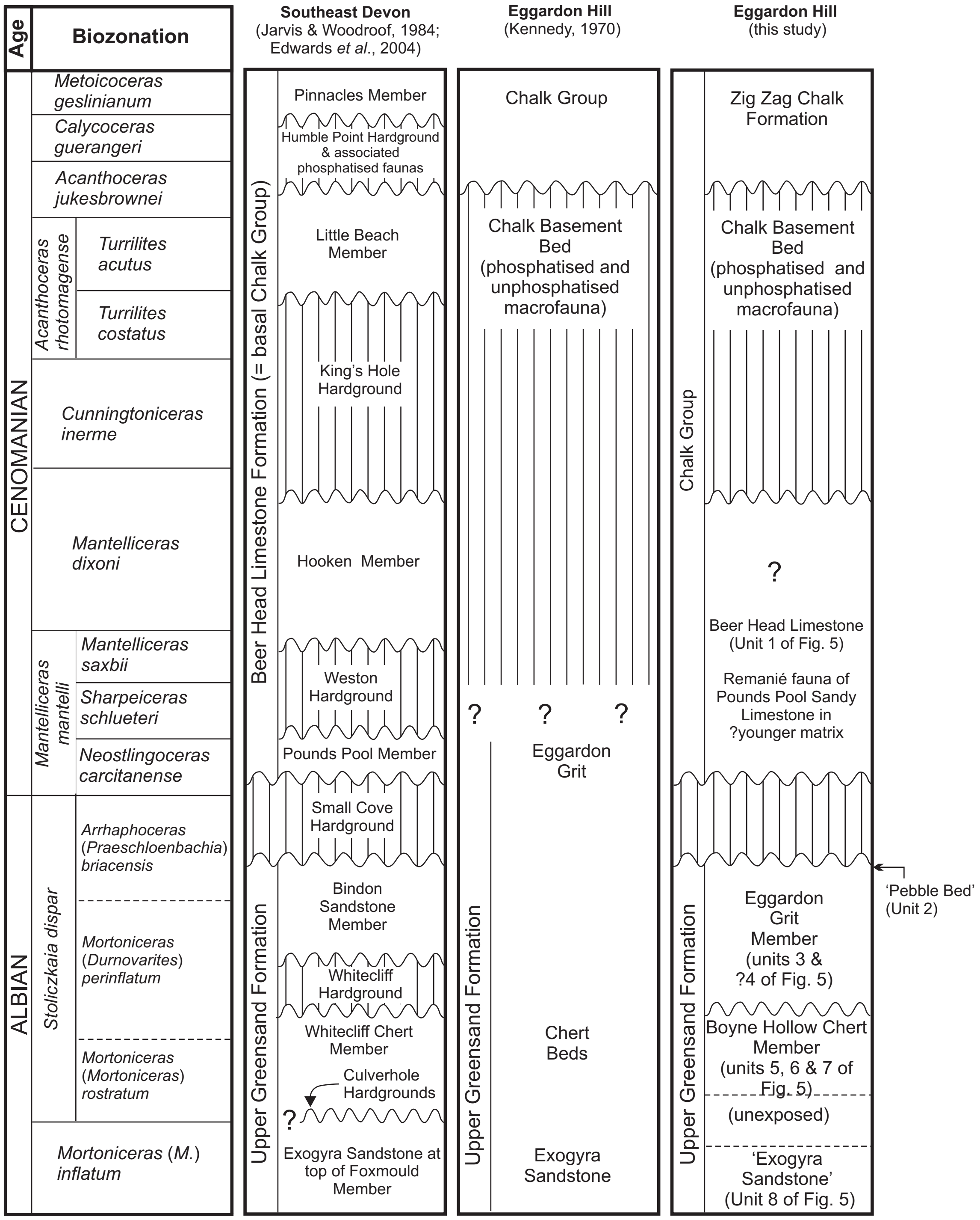

(Figure 2)

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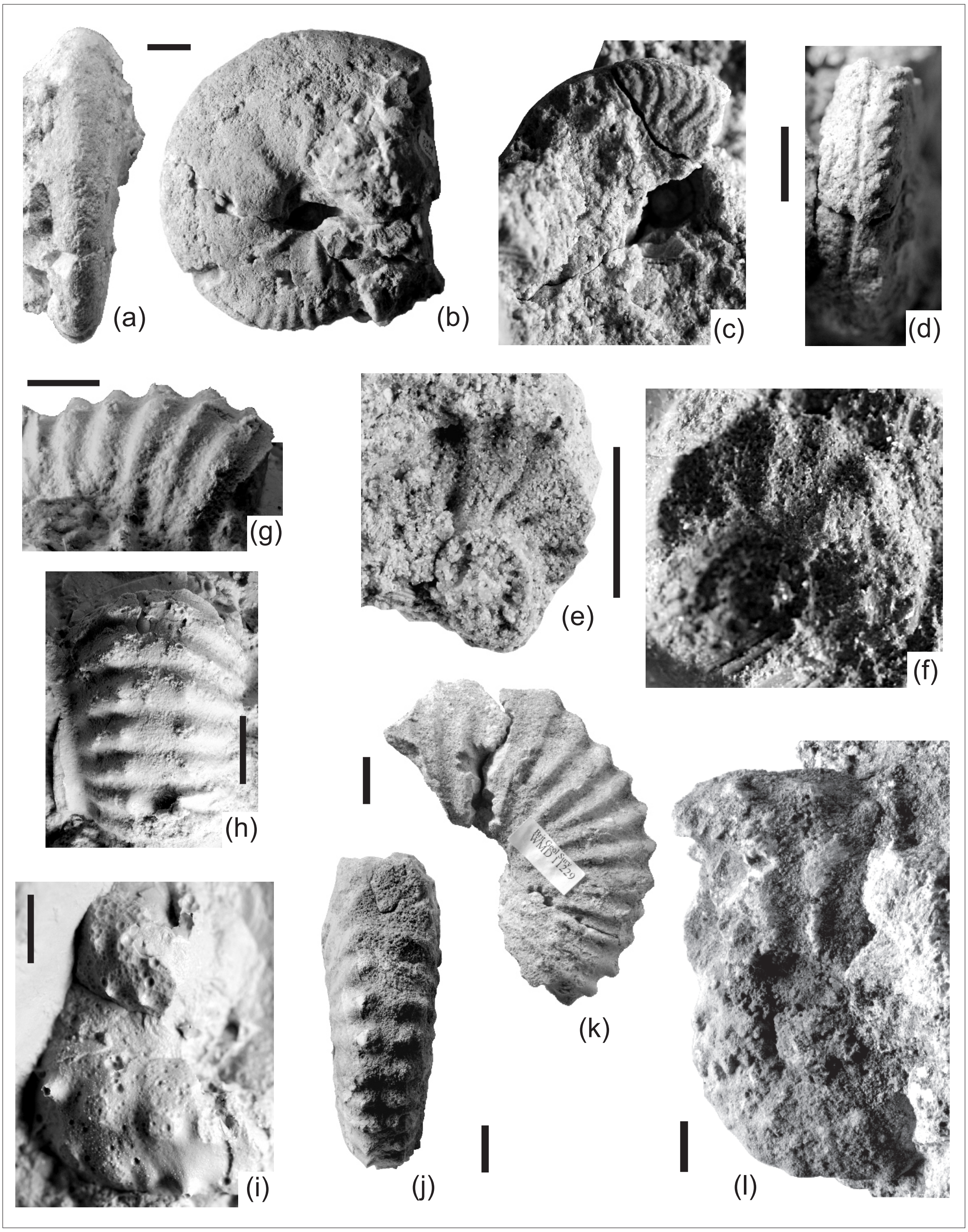

(Figure 3)
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Owen & Mutterlose (2006)

Zone	Subzone
Stoliczkaia dispar	*Arrhaphoceras* (*Praeschloenbachia*) *briacensis*
	Mortoniceras (*Durnovarites*) *perinflatum*
	Mortoniceras (*Mortoniceras*) *rostratum*

Kennedy & Latil (2007)

Zone
Arrhaphoceras (*P.*) *briacensis*
Mortoniceras (*Subschloenbachia*) *perinflatum*
Mortoniceras (*Subschloenbachia*) *rostratum*
Mortoniceras (*Mortoniceras*) *fallax*

(Figure 4)

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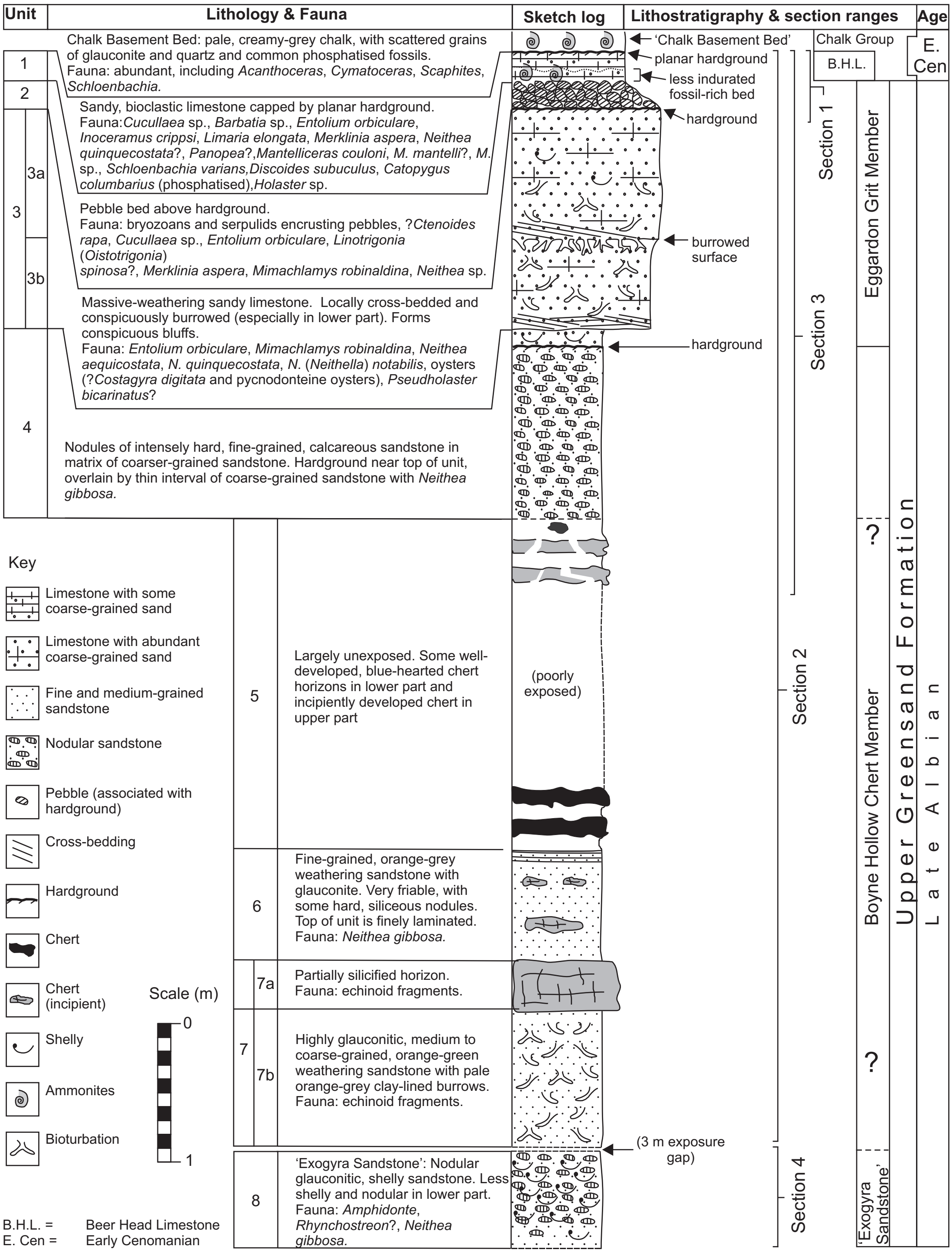

(Figure 5)

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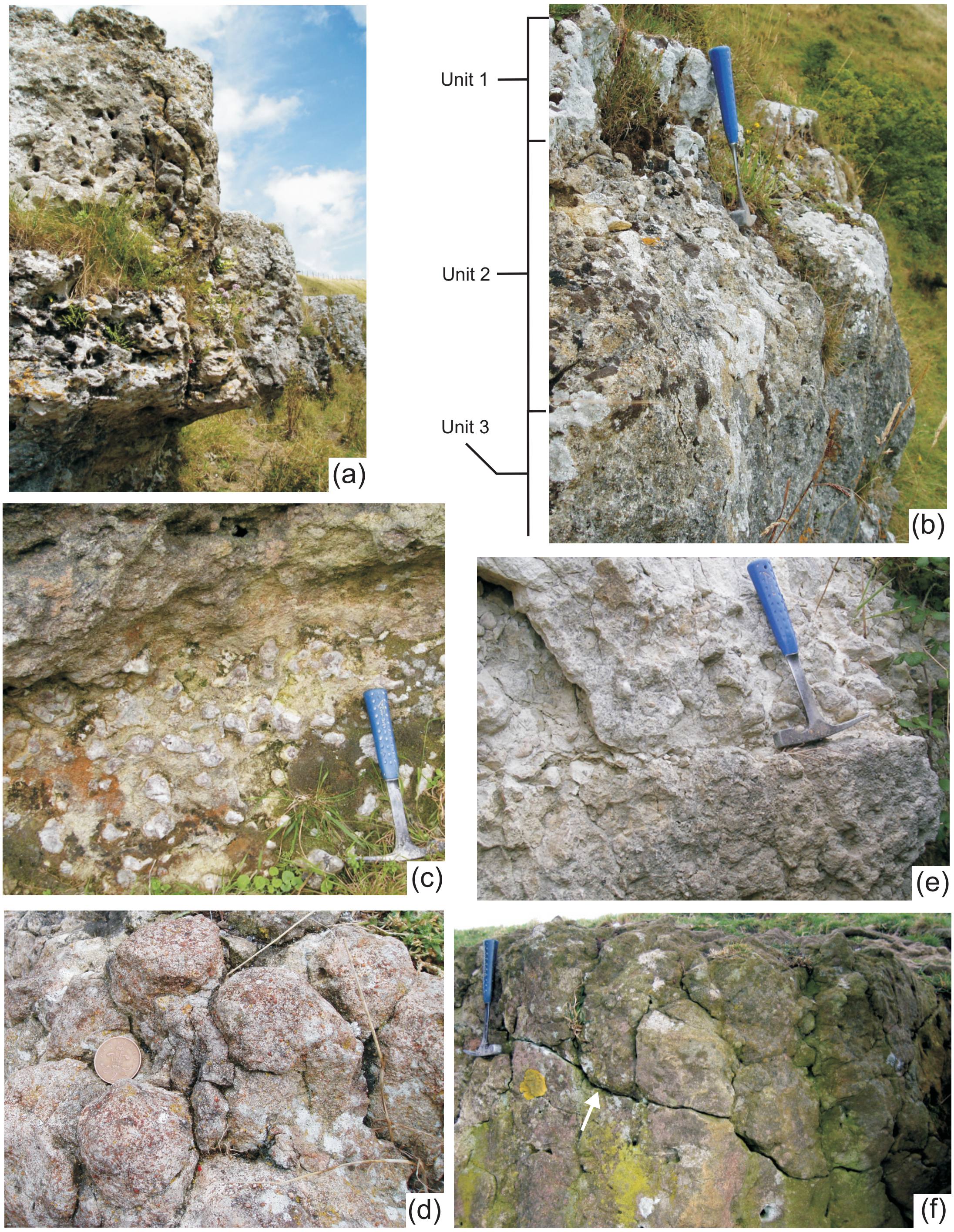

(Figure 6)
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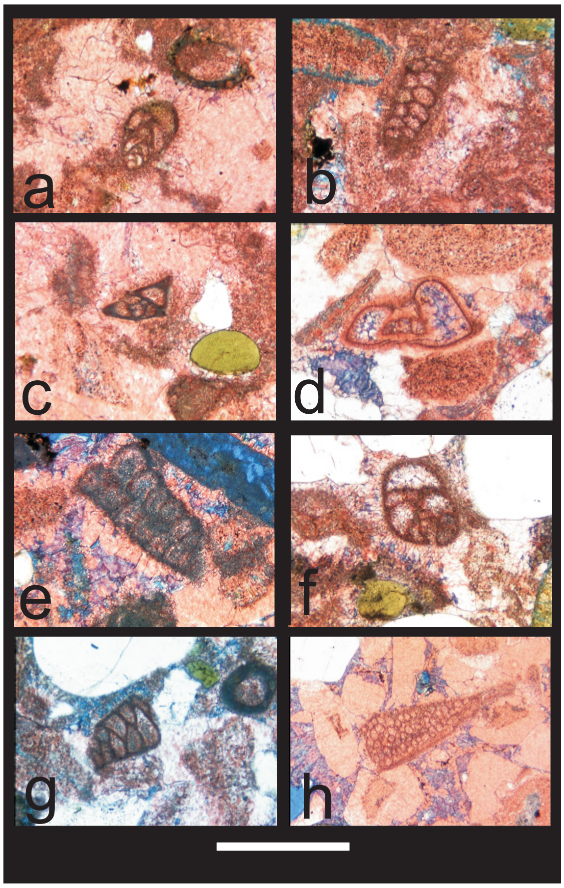

(Figure 7)

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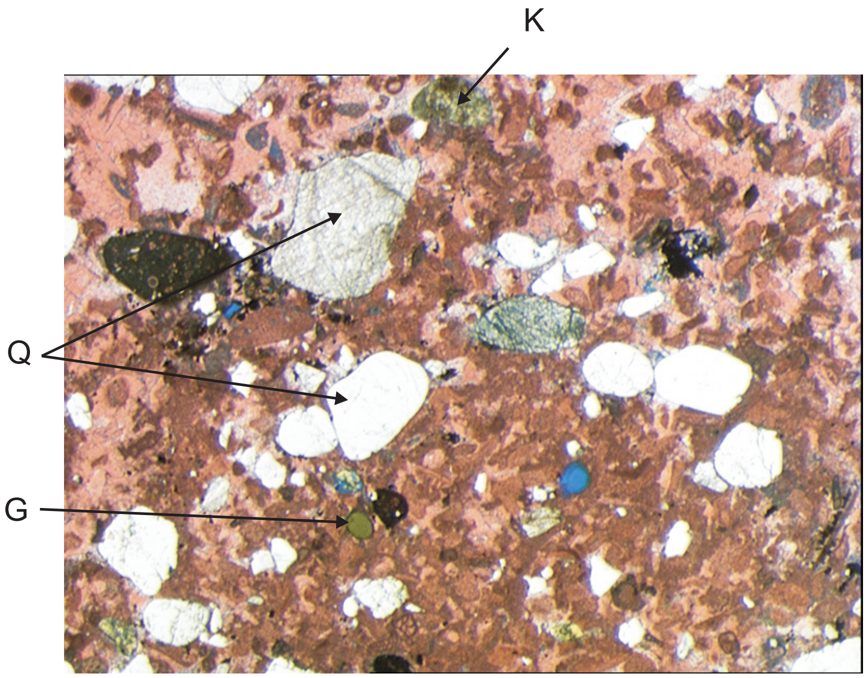
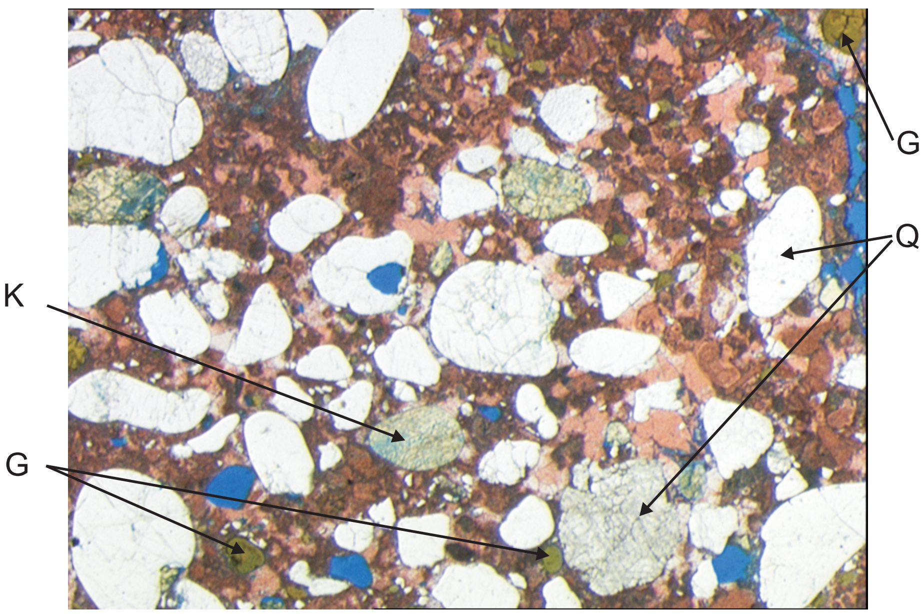


(a)



(b)

(Figure 8)

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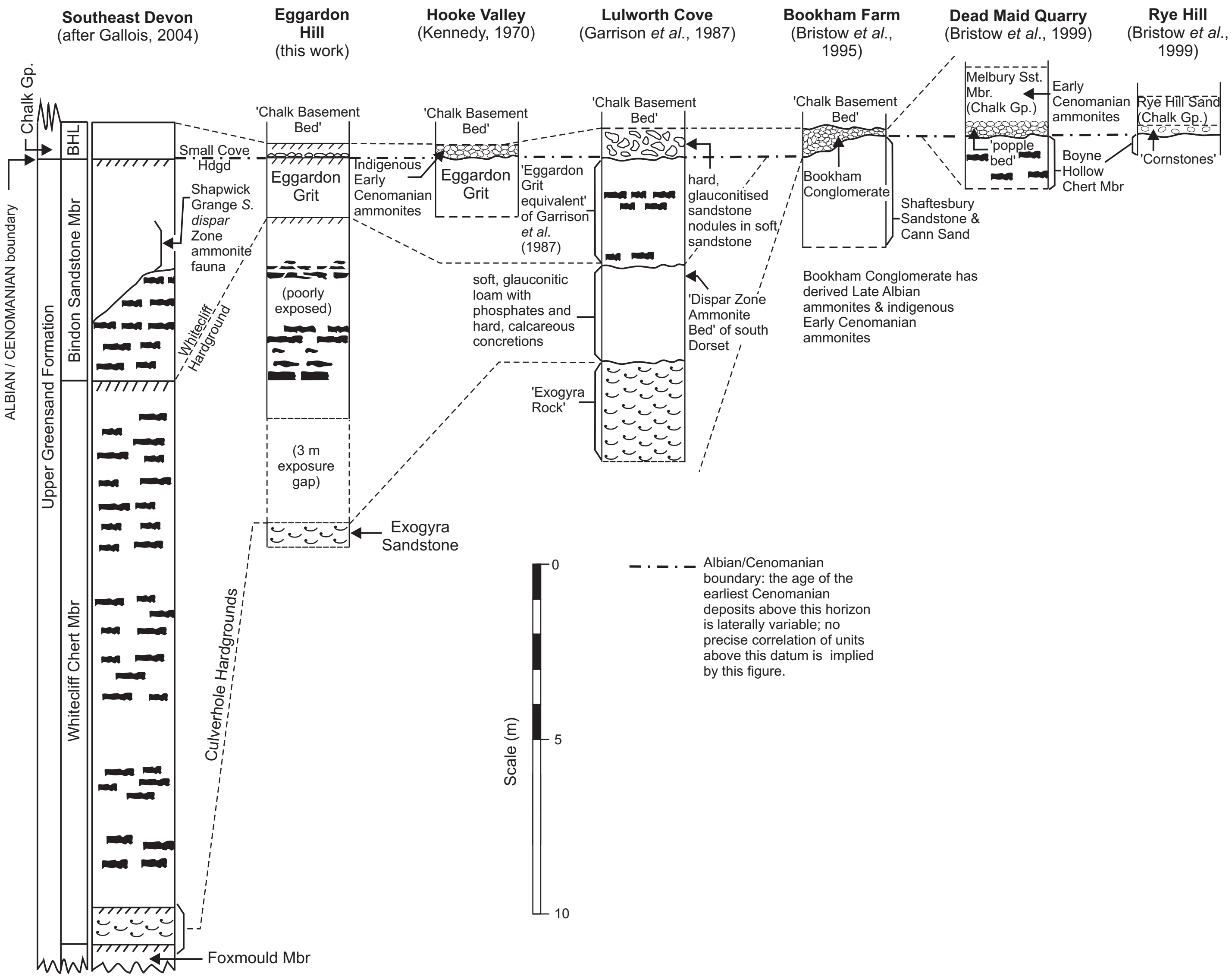

(Figure 9)

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