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THE SEDIMENTOLOGY AND BIOSTRATIGRAPHY OF A TEMPORARY EXPOSURE OF BLACKDOWN GREENSAND (LOWER CRETACEOUS, UPPER ALBIAN) AT BLACKBOROUGH, DEVON

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A temporary exposure of Lower Cretaceous Blackdown Greensand at Blackborough, Devon, yielded a rich molluscan fauna that permits approximate recognition of the subdivisions established by Downes (1882). The new faunal data refine the previously inferred biozonation of the succession, which is assigned to the *Hysteroceras varicosum* and *?Callihoplites auritus* subzones of the *Mortoniceras (M.) inflatum* Zone (Upper Albian). Sedimentological and faunal evidence are used to infer deposition as a shallow-marine sand-bar complex that was influenced by weak tides and periodic storms.

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INTRODUCTION

The informal term `Blackdown Greensand' (eg. Rawson *et al.,* 1978) describes a 30 m+ Cretaceous sequence of decalcified sands with layers of cherty sandstone concretions (Tresise, 1960; Taylor *et al,* 1983) that is famous for the exquisite siliceous preservation of its fossils. The Greensand unconformably overlies Triassic and Jurassic strata (Durrance and Laming, 1982), and forms the outlier of the Blackdown Hills in east Devon. Early accounts of the succession by Fitton (1836) and Downes (1880, 1882) were aided by extensive mine workings for whetstones (scythe stones), mostly along the brow of the escarpment which extends from Blackborough and nearby Ponchydown to North Hill [ST 098 064] (Ussher, 1906; Stanes and Edwards, 1993). However, Downes (1882) noted that this local industry was then already in sharp decline, and its subsequent demise and consequent loss of exposures has largely prevented further research. The descriptions given by Jukes-Browne and Hill (1900) and Ussher (1906) reiterated the work of Fitton and Downes, and contain little new information.

Downes (1882) divided the Blackdown Greensand at Blackdown into twelve numbered beds (1 to 12, oldest to youngest), and recorded their lithology and fauna, but the loss of exposures has prevented evaluation of his work. Hitherto, old museum collections and Downes' (1882) account of relative faunal abundance and distribution are all that have been available for palaeontological study of the Blackdown Greensand (eg. Taylor *et al.,* 1983).

In January 1993, a temporary section [ST 0998 0947] at Blackborough, Devon (Figure 1) was excavated in order to investigate the industrial archaeology and geology of the Blackdown Greensand. This provided the first opportunity for *in situ* examination of the Blackdown Greensand since the work of Downes (1880, 1882), and the results of detailed sedimentological and biostratigraphical investigation are presented here. Biostratigraphical interpretations are based on the ammonite zonal scheme of Owen (1979, Table 1). Material from the section has been assigned temporary BGS registration numbers (TNN 1455-1564), and subsequently returned to Mr G. Bate for donation to 'All Hallows Museum', Honiton, Devon.

DESCRIPTION OF THE EXPOSURE AND SEDIMENTOLOGY

The temporary section (Figure 1) exposed c. 7 m of glauconitic, fine-grained arkosic sandstone, with a few thin beds and laminae of medium- to coarse- grained sandstone and sandy claystone. Sporadic, large siliceous concretions, with conical upper surfaces and hummocky bases form crudely defined layers. The homogeneous, poorly cemented sandstone, typically with a muddy matrix, varies in colour from pale greenish grey and pale pinkish grey to yellow-brown, and also shows yellow-orange mottling. The detrital mineralogy is dominated by monocrystalline quartz and glauconite, with some potassium feldspar and minor amounts of mica and igneous and metamorphic rock fragments. Chalcedonic quartz and potassium feldspar are locally dominant authigenic minerals, with carbonate cements and kaolinite also important in parts. Rounded glauconite grains could have originated as faecal pellets rather than through abrasion. Lack of significant compaction textures indicates early cementation, with much of the present-day porosity being secondary in nature. Rarely developed, less argillaceous sandstones contain sets of low-angle cross-bedding c. 0.7 m thick. Bioturbation is extensive, consisting of clay-lined simple burrows.

The abundant glauconite and obliteration of most sedimentary structures by extensive bioturbation (hampering interpretation of the section) suggest slow depositional rates in a marine environment. The bioturbation is interpreted as dwelling (domichnia) and feeding structures (fodinichnia), with the clay lining plastered onto the walls of the burrows for support. The presence of cross-bedding indicates that the sediment surface was affected by tractional currents of sufficient magnitude to generate dune-sized bedforms. A single palaeocurrent measurement indicates flow towards the south-east. The thickly interlaminated to thinly interbedded claystones and sandstones were probably deposited during alternate periods of calm and agitated conditions, possibly related to tidal current activity. Sporadic claystone rip-up clasts indicate high energy conditions which, together with the layers of fragmented shells, might represent storm deposits. However, the absence of other features indicative of storms (eg. hummocky cross-stratification), suggests that tidal processes were probably more important, with clays deposited during periods of slack water. Overall, deposition in shallow water is favoured, with sand probably accumulating as part of an offshore to shoreface bar.

BIOSTRATIGRAPHY

Material was collected from four horizons (A to D of Figure 1), and the fauna of each is detailed in Table 1.

HORIZON		FAUNA
D	Gastropoda:	Cosnia cosnensis (de Loriol)
	Bivalvia:	Callistina plana (J Sowerby)
		Glycymeris(Glycymerita) sublaevis(J de C Sowerby)*
		Rutitrigonia eccentrica (Parkinson)
C	Gastropoda:	Turritella(Torquesia)granulata** J de C Sowerby
	Bivalvia:	Amphidonte obliquatum (Putteney)
		Callistina plana
		Corbula elegans J de C Sowerby
		Nicaniella formosa (J de C Sowerby)
		Yaadia (Quadratotrigonia) daedalea(Parkinson)
B	Gastropoda:	Drepanocheilus calcarata* (J de C Sowerby)
		D. neglecta(Tate)
		Murex' calcar J de C Sowerby
		Pictavia rotundata(J Sowerby)
		?Resabulum rusticum (J de C Sowerby) (juv.)
		Turritella(Torquesia)granulata
	Bivalvia:	Amphidonte obliquatum**
		Birostrina concentrica (Parkinson)
		?Callistina plana
		Corbula truncataJ de C Sowerby
		Cucullaea(Idonearca) glabra(Parkinson)
		Geltena angulata (J de C Sowerby)
		?Liopistha (Psilomya) gigantea(J Sowerby)
		?Mutiella?canaliculata (J de C Sowerby)
		Nanonavis carinata (J Sowerby)
		Nicaniella formosa
		Nucula(Leionucula) impressa(J Sowerby)
		Pinnasp.
		Pleuromya' laeviscula (J de C Sowerby)
		Protocardia hillana(J Sowerby)
		?Pterotrigonia scabricola (Lycett)
		Thetis laevigata (J Sowerby)
	Ammonoidea:	Hysterocerasvaricosum (J de C Sowerby)
A	Gastropoda:	Drepanocheilus calcarata
		Turritella(Torquesia)granulata
	Bivalvia:	Amphidonte obliquatum
		Birostrina subsulcata (Wiltshire)
		Corbula elegans
		Geltena angulata
		Gkcymeris(Glycymerita) umbonatus(J Sowerby)*
		Mesosacella lineata (J de C Sowerby)
		?Nucula antiquata (J de C Sowerby)
		N. (Leionucula) impressa
		Protocardia hillana
		Pterotrigonia aliformis (Parkinson)
	Ammonoidea:	Anahoplites?
	Echinoidea:	Cardiaster?

TABLE 1. The fauna of the temporary section of Blackdown Greensand. Horizons 'A' to 'D' are shown on Figure 1. (: common; **: very common)*

The fauna from Horizon A, covering the lowest 0.46 m of the section, is suggestive of Downes' (1882) Bed 7, in which he reported abundant *Glycymeris (Glycymerita) umbonatus,* although he did not record *Pterotrigonia aliformis* above his Bed 6 nor *Turritella (Torquesia) granulata* below Bed 8. The presence of *Birostrina subsulcata* in this inferred Bed 7 fauna is a possible indication of the basalH. *varicosum* Subzone, in the *Mortoniceras (M.) inflatum* Zone, because Downes (1882) recorded *B. sulcata* in the underlying beds 5 and 6. In the Upper Albian, *B. sulcata* appears at the base of the *Dipoloceras cristatum* Subzone, but reverts to *B. concentrica* in the basal *H. varicosum* Subzone (Owen, 1984). The morphologically transitional *B. subsulcata* occurs at these change-over levels (Owen, 1984).

In a diverse fauna from Horizon B, 2.26 m above the base of the section, *Hysteroceras varicosum* is indicative of the *H. varicosum* Subzone (Spath, 1934; Owen 1972), to which *Birostrina concentrica* is mainly restricted in the Upper Albian (Owen, 1984). In the Shaftesbury area, abundant *Amphidonte obliquatum* characterises the Upper Greensand and is similarly assigned to the *H. varicosum* Subzone (Bristow *et al.,* 1995). The frequency of *Drepanocheilus calcarata* is suggestive of Downes' (1882) Bed 8, although *Turritella (Torquesia) granulata,* in which this Bed is supposedly rich, was not especially abundant (see below).

A low-diversity fauna from Horizon C, c. 3.2 m above the section base, is associated with an horizon of siliceous concretions. *Amphidonte obliquatum* is much less common than in the underlying fauna. The abundance of *Turritella (Torquesia) granulata* suggests Downes (1882) Bed 8, although the lithology is more suggestive of his Bed 9, which he described as 'a thin layer of concretions used for scythe stones'.

In the highest fauna (Horizon D), collected 4.43 m above the section base, *Amphidonte obliquatum* is notably absent. No age-diagnostic taxa are present, *but Glycymeris (Glycymerita) sublaevis* occurs in Downes' (1882) beds 11 and 12, with *Rutitrigonia eccentrica* apparently restricted to Bed 11. The latter bed is typically c. 5.4 m thick (Downes, 1882), and presumably forms the remainder of the temporary section at Blackborough. Downes (1882) noted that *Birostrina concentrica* did not range above Bed 10. Since this bivalve species becomes extinct elsewhere at the top of the *H. varicosum* Subzone (Owen, 1984), it seems possible that the highest collected fauna belongs to the *Callihoplites auritus Subzone.*

CORRELATION

The faunal evidence suggests the presence of Downes' (1882) beds 7 to 11, and that these units belong to the *H. varicosum* and possibly *C. auritus* subzones of the *Mortoniceras (M) inflatum* Zone (Upper Albian). A similar age is ascribed to the Foxmould (Upper Greensand) of the Devon coast (Hancock, 1969), and the correlation of this unit with the Blackdown Greensand (Rawson *et al.,* 1978) is thus confirmed. Hancock (1969) assigned the Blackdown Greensand to the '*varicosum* and/or *orbignyi* subzones'. Comparison with records of *Birostrina sulcata* elsewhere (Owen, 1984) suggests that part of the Blackdown succession (below the level of the temporary section at Blackborough) belongs to the basal Upper Albian (pre- *varicosum* Subzone).

Farther west, the molluscan fauna of the lower beds of the Upper Greensand around Haldon compares with that of the higher part of the Blackdown Greensand (Downes, 1882). The Basal Shell Bed of the Telegraph Hill Sands, at the base of the Haldon Upper Greensand, has also been ascribed to the *H. varicosum* or *C. auritus* Subzone (Hamblin and Wood, 1976). Eastwards, coeval Upper Greensand deposits around Shaftesbury are the Cann Sand and Shaftesbury Sandstone of Bristow *et al.* (1995).

CONCLUSIONS

The sedimentological evidence suggests that the Blackdown Greensand represents part of a shallow-marine sand-bar complex, that was influenced by weak tides and rare storms. The occurrence of diverse, robustly ornamented trigoniids and gastropods preserving delicate spinose projections (e.g. *'Murex' calcar)* is consistent with a fluctuating hydrodynamic regime. Individual beds appear to show some variation in thickness compared to the typical values recorded by Downes (1882). Downes' (1882) record of *B. sulcata* from Bed 10 at Blackdown is not substantiated. The highest sulcate morphotype *of Birostrina (B. subsulcata)* at Blackborough is from the presumed equivalent of Downes (1882) Bed 7, and *Turritella (Torquesia) granulata* probably ranges lower than stated by Downes (1882). A thin concretionary horizon, inferred to repreknt Downes' (1882) Bed 8 on faunal criteria, compares with Downes' (1882) description of Bed 9. This anomaly might be accounted for by lateral variations in faunal abundance or diachronous development of concretionary horizons.

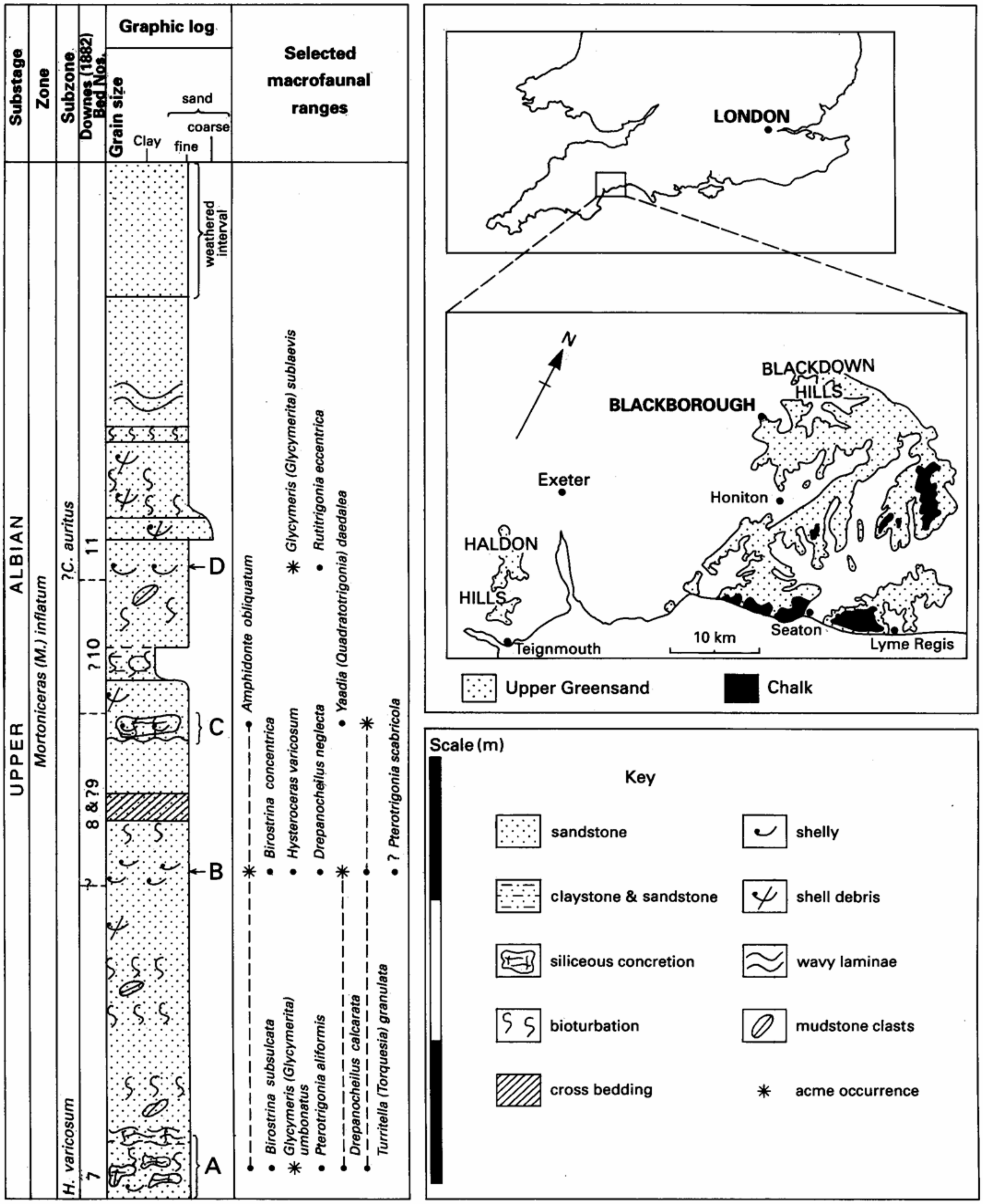

Figure 1. Location, lithostratigraphy and biostratigraphy of the temporary exposure at Blackborough. A to D are faunal horizons discussed in the text, and detailed in Table 1.

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