The late Triassic and early Jurassic succession at Southam Cement Works, Warwickshire

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Abstract. Southam Cement Works Quarry, Long Itchington, exposes beds ranging from the Cotham Member of the late Triassic Lilstock Formation up into the Rugby Limestone Member of the early Jurassic Blue Lias Formation. The lithologies and fauna are described and interpreted in the context of Triassic and Jurassic palaeoenvironmental change.

Warwickshire's Jurassic outcrop is dominated by a broad low-lying terrain formed by argillaceous rocks of the early Jurassic (Hettangian up to Pliensbachian) Blue Lias and Charmouth Mudstone formations. The Charmouth Mudstone Formation is poorly exposed, however the upper part of the Blue Lias Formation (Rugby Limestone Member; Ambrose, 2001) has been extensively quarried for the cement industry. Largely inaccessible sections occur in several disused pits, as at Rugby and near Harbury.

Currently (2002) the only working quarry is at Long Itchington, [NGR SP420630] 10 km E.S.E. of Leamington Spa (Fig. 1). Here, the deep, extensive excavation at Southam Cement Works exposes early Jurassic mudstones and limestones of the Blue Lias Formation (Saltford Shale and Rugby Limestone members; Hettangian up to Sinemurian; *liasicus* up to *bucklandi* Zone). Limestones of the underlying latest Triassic (Rhaetian) Langport Member of the upper Lilstock Formation ('White Lias') are also exploited and are crushed for roadstone. The quarry originated in the latter part of the nineteenth century (Woodward, 1893) and has been identified as a RIGS (Regionally Important Geological Site) by the Warwickshire Geological Conservation Group. Access is restricted since the closure of Rugby Cement's adjacent factory.

Partial descriptions of the succession have been given by Clements (1975), Old *et al* (1987), Swift (1995) and Ambrose (2001). Swift (1999) provided photographs of the Langport Member succession in the quarry. The sedimentology of the Blue Lias was investigated by Weedon (1986) and Wignall and Hallam (1991). Aspects of the palaeontology and ichnology have been documented by Clements (1975), Gilliland (1992) and Swift and Martill (1999). Jones and Gould (1999) featured Long Itchington material in their important study of oyster (*Gryphaea*) growth and evolution. Additionally, the site has been mentioned by several other workers including Nuttall (1916), Arkell (1947) and Hallam (1968). Rocks and fossils from the site are held in the collections of Warwickshire Museum.

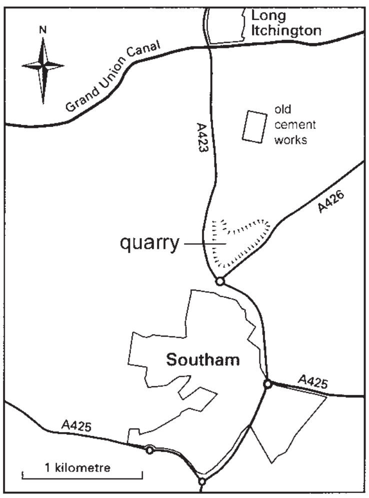

Figure 1. Location of Southam Cement Works Quarry

Lilstock Formation (Langport Member)

The main quarry floor is a broadly planar (but in places hummocky) iron-stained surface, marking the eroded top of the Langport Member. Various pits and trench sections within the quarry floor expose the full thickness (about 2.5 m) of the Langport Member, below which lies an unknown thickness of grey-green mudstones of the Cotham Member (lower Lilstock Formation). Only the topmost 0.5 m or so of this latter member is exposed at present but a sump opened in the base of the quarry some years ago showed at least 7 m of the Cotham Member (A. Swift, *pers comm*).

The base of the Langport Member is marked by a seam of the oyster-like bivalve *Atreta intusstriata* (Emmrich). This shell bed encloses bored and *Atreta*-encrusted limestone pebbles; some of cryptalgal appearance and resembling the stromatolitic 'landscape marble' of the Bristol area. Grazing traces attributable to regular echinoids (*Gnathichnus pentax* Bromley) have been identified on several pebbles. Above the *Atreta* shell layer, the lower half of the member is dominated by pale-grey to cream coloured, irregularly bedded, stylolitic, fine-grained limestones (micrites) with a few thin shale seams. Many of the beds are burrowed, and recognisable trace fossils include small U-burrows (*Arenicolites*). Some units are quite fossiliferous, yielding small bivalves (including *Gervillella* sp., *Plagiostoma* sp. and *Plicatula* cf. *hettangiensis* Terquem), gastropods, echinoid spines and occasional solitary corals (*Montlivaltia rhaetica* Tomes). The top metre of the member is largely a poorly sorted breccio-conglomerate of micrite/bioclastic limestone blocks in a cemented micritic matrix (Fig. 2). Shallow, channel-like structures occur in this upper division.

Blue Lias Formation

The benches and walls of the main quarry expose the Saltford Shale Member (c. 15 m), overlain by the lower part of the Rugby Limestone Member (*c*. 25 m) (Fig. 3). The basal Hettangian *planorbis* ammonite zone is unproven (Old *et al*., 1987) and the Saltford Shale Member (*liasicus* up to *angulata* Zone) rests sharply on the eroded surface of the Langport Member. Runnel-like depressions on this surface preserve a veneer of black mudstone containing oysters, echinoid spines and bored limestone pebbles. Above, the Saltford Shale is dominated by dark grey laminated mudstone with a few beds, lenses and nodules of fine-grained limestone. Sharp-based siltstone lenticles about 7.5 m above the base of the shale preserve arthropod 'resting' and burrow traces (*Isopodichnus*). A layer of small oyster and serpulid-encrusted limestone nodules occurs about 2.5 m higher. Nodules and lenticles of laminated silty limestone towards the top of the member occasionally preserve concentrations of spar/sediment-filled schlotheimiid ammonites (including the zonal species *Schlotheimia angulata* (Schlotheim)), together with small bivalves (?nuculids), fish scales and other fine-grained skeletal debris. The ammonites are commonly imbricated (Fig. 4). Some are encrusted with oysters that display xenomorphic sculpture. Warwickshire Museum's holdings of Saltford Shale material from this site also include nautiloids and partly articulated ichthyosaur, plesiosaur and fish remains. Wignall and Hallam (1991) recorded minute high-spired gastropods.

The overlying Rugby Limestone Member marks the development of typical 'Blue Lias' facies - regularly alternating limestone, marl and shaly mudstone beds (Fig. 3). The limestones are mostly pale grey in colour, laterally persistent and seldom more than 0.25 m thick. They are fine-grained, commonly sharp-based, bioturbated, and often highly fossiliferous. Enclosed fossils are largely uncrushed. Among the ammonites, schlotheimiids dominate the lower beds (*angulata* Zone) and are replaced upwards by species of *Vermiceras* and *Coroniceras* (*bucklandi* Zone; Clements, 1975). Nautiloids (*Cenoceras* sp.; commonly oyster encrusted) are common. The bivalve fauna is dominated by *Plagiostoma giganteum* J. Sowerby and *Antiquilima succincta* (Schlotheim) (sometimes disarticulated and oyster-encrusted), together with small *Gryphaea arcuata* Lamarck and *Liostrea* sp.. Pleurotomariid gastropods are recorded. Rhynchonellid brachiopods (*Calcirhynchia calcaria* S.S. Buckman) are abundant in the so-called Rhynchonella Bed, approximately 8 m above the base of the member. Crinoid debris and fossil wood occur in some beds. Clements (1975) provided additional details of fossils. Trace fossils in the limestones include *Chondrites*, *Thalassinoides*, *Kulindrichnus* and *Diplocraterion*. The latter are very common at several levels, notably within the Worm Bed (Clements, 1975) some 10 m above the base of the member. The dark grey marls and mudstones yield rich microfaunas dominated by ostracods, foraminifera, echinoid debris and holothurian sclerites (Clements, 1975). The true shales tend to be poorly fossiliferous.

Figure 3. Southern end of Southam Cement Works Quarry. Sections in the foreground are about 2.5 m high and expose pale limestones of the Langport Member. The main cliff exposes alternating pale limestones and darker mudstones of the Rugby Limestone Member, above dark mudstones of the Saltford Shale Member. This is nearly 40 m high.

Figure 2. Loose block of conglomeratic Langport Member limestone. Ruler is 15 cm long.

Interpretation of environments

The succession was deposited near the south-western end of the East Midlands Shelf, north west of the partly emergent London Platform. The Vale of Moreton Axis lay a few tens of kilometres to the southwest of Long Itchington (Ambrose, 2001), marking the eastern margin of the Severn Basin. The Langport Member is largely absent in the Severn depocentre, suggesting emergence in latest Triassic times (Swift, 1995). Thus, the Warwickshire outcrop may equate to part of a central English embayment. The basal *Atreta* bed marks the establishment of a mollusc-dominated fauna during the initial stages of the transgression recorded by the Langport Member. Above, the *Arenicolites*-burrowed surfaces and corals indicate shallow-water conditions. While of marine aspect, the low faunal diversity may suggest slightly abnormal salinities. The micrites may signify that warm, calcium carbonate-rich, predominantly low-energy Bahamian-type environments prevailed during deposition of the Langport Member (Hallam, 1960).

The matrix-supported conglomeratic limestones within the higher part of the Langport Member succession resemble muddy debris flows. Similar beds in the Langport Member of S W England signify reworking of partly lithified rock in a shallow marine or emergent setting, attesting to late Rhaetian eustatic sea-level fall (Wignall, 2001). Long Itchington material may have a similar origin, but requires further investigation.

Deposition of the Blue Lias Formation was initiated during a phase of eustatic sea-level rise (Hallam, 2001), marking establishment of the shallow, epicontinental Jurassic sea over extensive areas of southern Britain. Following localised sediment starvation (*planorbis* Zone) and generation of a basal shell/pebble bed, the Saltford Shale Member of eastern Warwickshire marks a mid-Hettangian transgressive pulse onto the London Platform (Donovan, Horton and Ivimey-Cook, 1979). Its dark, laminated and poorly fossiliferous character indicates deposition in generally anoxic environments, punctuated by brief oxygenation events. Wignall and Hallam (1991) attributed the anoxia to rapid deepening, resulting in poor circulation beneath a stratified water column. Siltstone lenticles, reworked limestone nodules and imbricated ammonite concentrations (Fig. 4) demonstrate weak current influence and a possible mechanism for periodic oxygenation. Storm generation is supported by the abundance of comparable storm beds ('tempestites') in shallow water facies of the British Lower Jurassic (Hallam, 1997).

Sedimentary environments of the present day German Bight (North Sea) were taken as a reasonable analogue for those of the British early Jurassic by Elliott (1997) and Hallam (1997). In the German Bight, thin, silty, storm-flow deposits are well developed within mud facies slightly below maximum storm wave base, at depths of around 20-30 m (Aigner, 1985). A comparable bathymetry seems plausible for the deposition of the Saltford Shale at Long Itchington.

The rapid transition to the relatively fossiliferous and calcareous beds of the Rugby Limestone Member marks overall increased benthic oxygenation. Relative shallowing is supported by the cessation of sediment onlap onto the London Platform at this time (Donovan *et al.*, 1979). The cyclic alternations of limestone, marl and shale constitute the well-known 'Blue Lias' facies of the British early Jurassic. Weedon (1986) studied the petrology of these beds at several sites including Long Itchington. He concluded that the limestones are diagenetically 'overprinted' calcareous, marly sediments (also see Hallam, 1964). Darker marls and shales were taken to signify periodically increased terrigenous mud influx, that drowned carbonate production and resulted in poorer oxygenation at the sea floor.

Weedon (1986) presented evidence to suggest that the rhythms resulted from changes in orbital precession and obliquity, affecting climate (Milankovitch cyclicity). He took the shaly intervals to signify wetter phases and increased runoff.

Figure 4. Fragmented limestone nodule from the Saltford Shale Member enclosing imbricated schlotheimiid ammonites (Warwickshire Museum Collection). The pencil provides scale.

However, Hallam (1986) drew attention to the wholly diagenetic origin of at least some Blue Lias limestones, potentially weakening the case for Milankovitch cyclicity. Interestingly, Elliott (1997) established the presence of taphonomic and palaeoecological rhythms in the Blue Lias, which are out of phase with the lithological cyclicity. He also documented several previously undetected sedimentary hiatuses, further weakening the Milankovitch model. Elliott's work did not extend to Long Itchington, where there is scope for further investigation along these lines.

The rich ichnofauna and macrofauna of the Rugby Member limestones at Long Itchington indicate greater benthic oxygenation. The dominant epifauna suggests that the calcareous substrates were firm and cohesive. The abundance of bivalves is consistent with a generally shallow marine environment (Hallam, 1997), although common ammonites and absence of micritisation suggest an offshore, possibly subphotic setting. Oxygen isotope profiles obtained from growth increments on *Gryphaea* shells indicate an annual temperature cycle of warmer and cooler conditions (Jones and Gould, 1999).

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