Palaeogeography, Palaeoclimatology, Palaeoecology 270 (2008) 258–272

Contents lists available at ScienceDirect

Palaeogeography, Palaeoclimatology, Palaeoecology

journal homepage: www.elsevier.com/locate/palaeo

The occurrence and preservation of ammonites in the Blue Lias Formation (lower Jurassic) of Devon and Dorset, England and their palaeoecological, sedimentological and diagenetic significance

C.R.C. Paul [a,*], Peter A. Allison [b], Carlton E. Brett [c]

[a] Department of Earth Sciences, University of Bristol, Wills Memorial Building, Queens Road, Bristol BS8 1RJ, UK
[b] Department of Earth Science and Engineering, Imperial College London, South Kensington Campus, London SW7 2AZ, UK
[c] Department of Geology, University of Cincinnati, Cincinnati, Ohio, 45221-0013, USA

ARTICLE INFO

Article history:
Received 27 November 2006
Accepted 24 January 2008

Keywords:
Ammonites
Blue Lias Formation
Lower Jurassic
Sedimentology
Diagenesis
Palaeoecology

ABSTRACT

More than two thirds of beds in the lowest Jurassic, Blue Lias Formation lack ammonites, which are commonly preserved in irregular or planar-bedded, bioturbated limestones, very rarely in laminated limestones and almost never in laminated black shales. Ammonites are preserved in 3D in nodular and planar-bedded limestones and at any orientation to bedding. Co-occurrence with macrobenthos and absence from beds without benthos suggest that Blue Lias ammonites were nektobenthonic. Scour structures and imbrication of ammonites in the Best Bed imply presence of traction currents. Lack of epifauna on large cephalopod shells (and other fossils) implies rapid deposition in event beds. Blue Lias deposition was episodic, not slow and continuous as the fine grain size implies. Undistorted trace fossils, uncrushed ammonites and stable isotope values all suggest early cementation of limestone beds from pore waters of a similar composition to contemporary Jurassic sea water. A clear diagenetic trend exists, with limestones having least, and laminated black shales most, modified stable isotope values. Contrast between trace fossil fills and host sediment demonstrates that Blue Lias rhythms are primary, but limestone beds have been diagenetically cemented.

1. Introduction

As part of a wider study of the Blue Lias Formation, Allison et al. (in press) examined two individual limestone beds crowded with ammonites, which they interpreted as concentration lagerstätten. Variations in the preservation and attitude of the ammonites in these beds led us to examine all the beds of the Blue Lias for ammonites, especially as an analysis of Lang's classic paper on the Blue Lias (Lang, 1924) revealed that he recorded ammonites from only 20% of the sedimentary units he recognized. This, in turn, raises the question of whether ammonites occur in the beds as a result of original palaeoecological conditions or as a result of special conditions of preservation. It was soon discovered that the occurrence and preservation of the ammonites (and associated fauna) often reveal at least as much about the palaeoecology, deposition and diagenesis of the Blue Lias as they do about the correlation of the beds, whereas stratigraphic utility is the main characteristic of ammonites in the minds of most palaeontologists.

This paper documents the biostratinomy and diagenesis of the ammonite-bearing beds in the Blue Lias. It also considers the implications of preservation of the ammonites for the paleoecology of the Blue Lias. One would not expect ammonites, which were nektonic, to interact with sediments (the theme of this special issue). Nevertheless, a surprising amount of palaeoecological and sedimentological information can be gleaned from their occurrence and preservation. We believe that the results presented here are of general significance.

1.1. Location

The Blue Lias Formation crops out in several exposures between The Slabs, near Corbin Rocks, Devon and Canary Ledges, Church Bay, Lyme Regis, Dorset (Fig. 1). For this paper we have concentrated our data gathering along the more or less continuously exposed section from the top of the underlying White Lias near the head of Pinhay Bay (National Grid Reference SY3208), round to Seven Rock Point (SY332913), where the topmost part of the section is accessible. Additional data have been derived from other exposures where necessary. The type section is in the railway cutting at Saltford, near Bath, but is now largely obscured (Gallois, 2006). Sections on the north and south coasts of the Bristol Channel are thicker, but locally less accessible and/or complicated by faulting. Although relatively condensed, the section in Pinhay Bay is probably the best continuous section in the Blue Lias Formation in Britain. It lies in Hallam's (1960)

* Corresponding author.
E-mail address: glcrcp@bristol.ac.uk (C.R.C. Paul).

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doi:10.1016/j.palaeo.2008.07.013

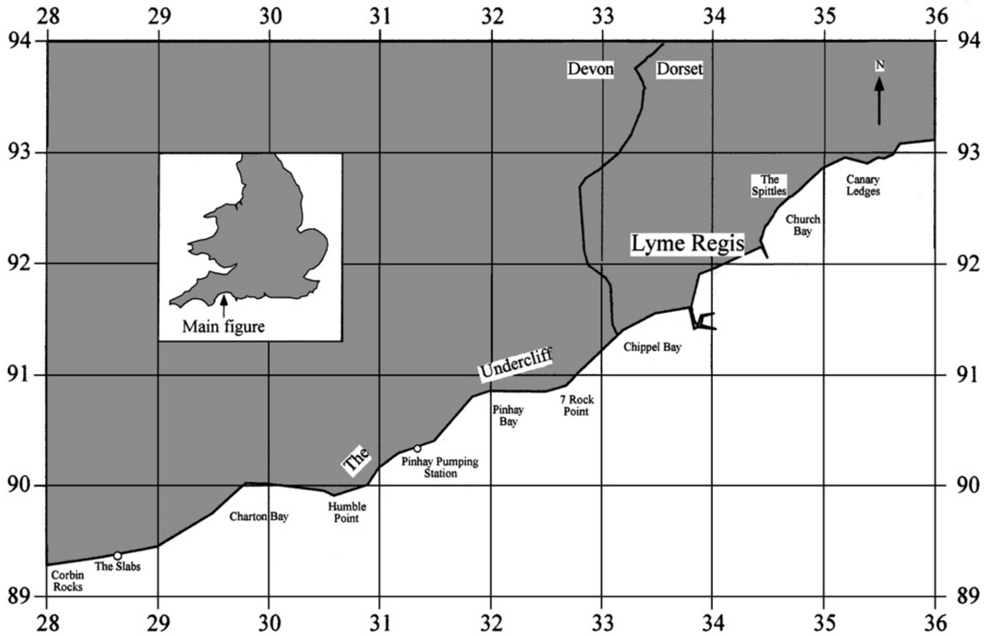

Fig. 1. Outline map showing locations mentioned in the text (scale: 1 km National Grid line spacing).

offshore facies and probably represents deeper water than the sections in South Wales. Water depth probably increased up section.

1.2. Stratigraphy

The Blue Lias Formation is currently thought to span the Triassic–Jurassic boundary. At present there is no agreed criterion on which to define the base of the Jurassic (see for example, Hodges, 1994; Warrington et al., 1994; Lucas et al., 2006). However, one of the highest stratigraphic levels proposed coincides with the first appearance of the ammonite *Psiloceras planorbis* (Sowerby). No ammonites are known to occur in the Blue Lias below this level in Britain. As we are principally concerned with ammonite-bearing horizons within the formation, the sections we discuss lie entirely within the lowermost Jurassic. The conventional stratigraphy of the Jurassic part of the formation is shown in Fig. 2.

1.3. Blue Lias Formation

The Blue Lias Formation (Figs. 3 and 4) typically consists of pale grey limestone beds separated by marl and/or shale beds. The limestone beds are typically impure micrite mudstones to wackestones, whereas the more siliciclastic-rich beds in between may include one or more horizons of pale grey calcareous marl, dark grey marl, or laminated black shale (Fig. 5). The last lithology may contain thin (mm scale) layers of beef (fibrous calcite layers). Fossils are generally more common in the limestones than in the more siliciclastic units, especially the laminated black shales. The succession is rhythmic (Fig. 5), with each rhythm having a sharp base overlain by laminated black shale, which usually grades up into dark grey marl, then pale grey marl, commonly with concretionary to tabular micritic limestone, and typically back into dark grey marl before the base of the next rhythm. The rhythms are not always symmetrical and in many cases the only evidence for the upper dark marl is the fill of trace fossils, especially *Rhizocorallium* as shown in Fig. 5, rhythm B. In such cases the laminated black shale rests directly on pale grey marl or limestone. The pale marls may be bioturbated and fossiliferous. In some, but not all, rhythms they are cemented into hard limestone beds, so that the number of limestone beds is significantly lower than the number of sedimentary rhythms (Fig. 4). In the upper part of the formation these hard, ledge-forming limestones were given names by quarrymen in the early 1900s (Fig. 4); for example, bed 19 was called Specketty, in reference to the abundant cross-sections of spar-filled rhynchonellid brachiopods. This bed is well exposed on the foreshore

Lithostratigraphy			Biostratigraphy		Chronostratigraphy	
	Formations	Members	Zones	Subzones	Stages	
Lower Lias	Charmouth Mudstone Formation	Shales-with-Beef Member	Caenisites turneri	Microderoceras birchi	Sinemurian	Lower Jurassic
				Caenisites brooki		
			Arnioceras semicostatum	Euagassizeras sauzeanum		
	Blue Lias Formation			Agassiziceras scipionianum		
				Cornoceras reynesi		
			Arietites bucklandi	Arietites bucklandi		
				Coroniceras rotiforme		
				Metophioceras conybeari		
			Schlotheimia angulata	Schlotheimia complanata	Hettangian	
				Schlotheimia extranodosa		
			Alsatites liasicus	Alsatites laqueus		
				Waehneroceras portlocki		
			Psiloceras planorbis	Caloceras johnstoni		
				Psiloceras planorbis		

Fig. 2. Standard litho-, bio-, and chrono-stratigraphy of the lower part of the Lower Lias in Devon–Dorset, U.K.