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Photic zone palaeoenvironments of the Kimmeridge Clay Formation (Upper Jurassic, UK) suggested by calcareous nannoplankton palaeoecology

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Abstract

Nannoplankton abundance data has revealed significant and systematic population fluxes through all representative lithologies and cycle types of the Kimmeridge Clay Formation (KCF), and also through intervals in which lithology is visually homogeneous. The majority of KCF samples yielded nannofossil assemblages of low species richness (1 to 10) and marked unevenness, independent of preservational state. All samples were dominated by coccoliths of one family, the Watznaueriaceae. While assemblage unevenness is characteristic of nannofossil populations, such low species richness is atypical, particularly when compared with coeval assemblages of similar latitude. Such anomalously low nannofossil diversity may be explained as a response to nutrient-rich euphotic environments. We postulate that consistently high trophic conditions supported the eurytopic watznaueriaceans but excluded most normal open-ocean taxa. The switching of dominance within this group most likely reflects different adaptations within an r-selected ecological strategy, related to nutrient concentration. Lowest diversities were recorded in mudstone/oil-shale lithologies where *Watznaueria britannica* is the dominant species, suggesting adaptation to the highest nutrient concentrations. *Watznaueria barnesiae/fossacincta* is particularly dominant in coccolith stone bands, where diversity is slightly higher, suggesting adaptation to lower high nutrient levels. *Cyclagelosphaera margerelii* appears to be the most extremely r-selected species, exploiting unusual (very high trophic/lowered sea-level?) conditions that excluded even *W. britannica*.

Keywords: Upper Jurassic; Kimmeridge Clay Formation; Watznaueriaceae; Palaeoenvironment; Palaeoecology; Calcareous nannofossils

1. Introduction

The Kimmeridge Clay Formation (KCF) of Dorset, southern England is a 620-m-thick sequence representing c. 4 myr (Kent and Gradstein, 1985) of essentially continuous Late Jurassic sedimentation. It predominantly comprises dark, organic-rich mudstones and oil-shales, and in the North Sea the KCF sensu lato forms the most important single hydrocarbon source-rock. The formation is interrupted by infrequent, but laterally persistent, pale limestone and dolostone beds, known as 'stone bands'. Some of these stone bands are finely laminated and are formed predominantly of coccoliths and coccospheres, providing spectacular evidence of ancient coccolithophore blooms, which have attracted much interest (Noël, 1973; Gallois, 1976; Gallois and Medd, 1979; Young and Bown, 1991; Lees et al., 2004).

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The organic matter of the KCF has been shown to be overwhelmingly algal in origin, and coccoliths as one of the major sources of carbonate (Pearson, 2000). Consequently, phytoplankton production played an important role in producing the lithological signal of changing clay, carbonate and organic matter sedimentation that constitutes the KCF record of environmental change.

Coccolithophores are a major phytoplankton group with an excellent fossil record and thus potentially provide a record of changing conditions in the photic zone. However, interpretation requires knowledge of the ecology of individual fossil species that can only be developed by studying changes in assemblages relative to other evidence of environmental change. The objectives of this study were thus both to develop knowledge of controls on Late Jurassic coccolithophore ecology and to apply it to better constrain models of development of the KCF.

Much of the KCF displays metre- to several-metre-scale lithological cyclicity involving clays, bituminous shales, oil-shales and coccolith limestones (A-B-C-D

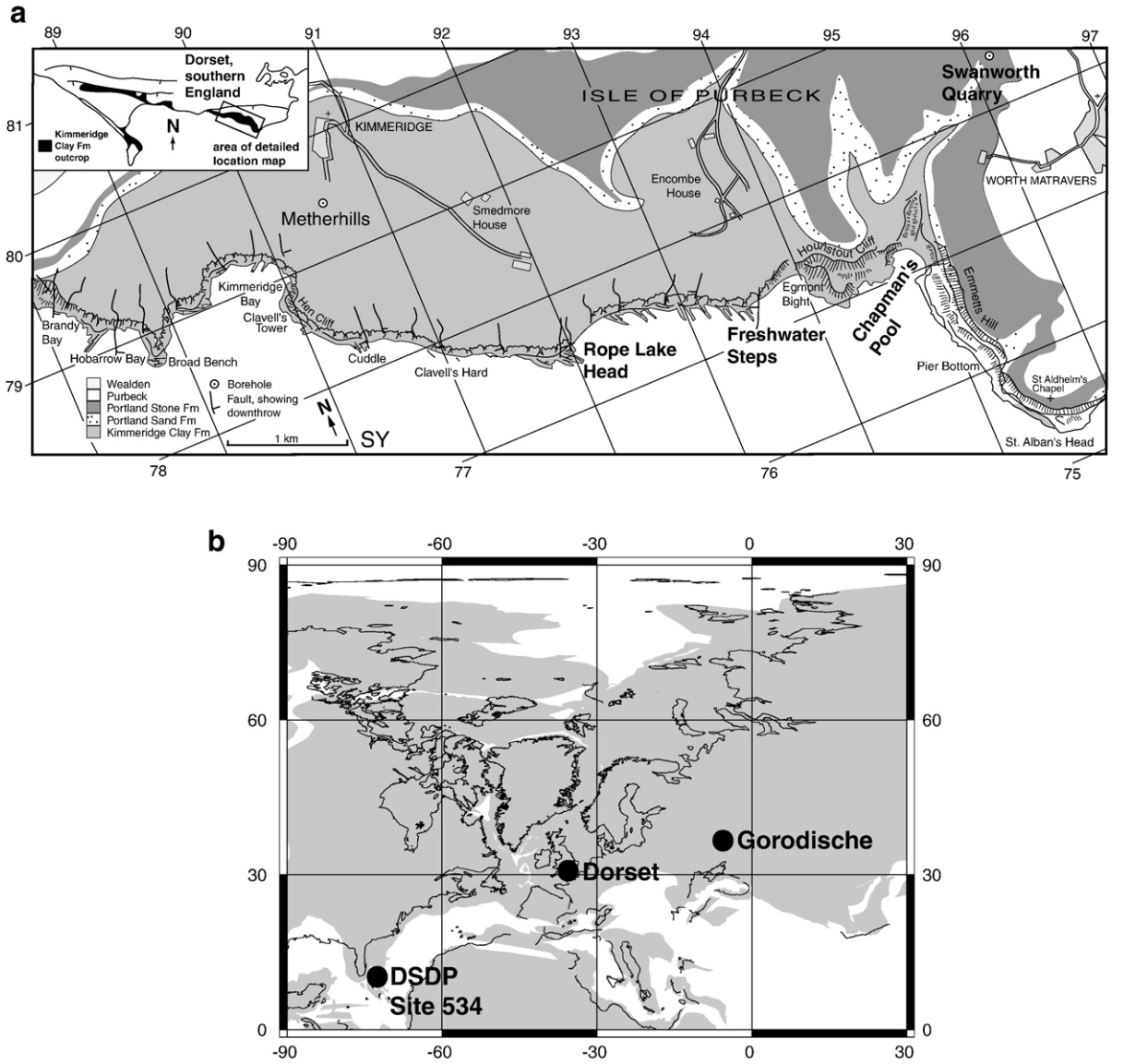

Fig. 1. (a) Map showing locations of studied boreholes (SQ1, SQ2) and coastal outcrop section (Rope Lake Head–Freshwater Steps–Chapman's Pool), Dorset, southern England; (b) Late Jurassic reconstruction showing position of Dorset locations relative to Gorodische (Volga Basin, SE Russia) and DSDP Site 534 (Blake–Bahama Basin, western Atlantic). Plates in grey, present-day coastlines in black.