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Nannofacies analysis as a tool to reconstruct paleoenvironmental changes during the Early Toarcian anoxic event

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Abstract

The black shales of lower Toarcian (Schistes Carton in France, Jet Rock in England, Posidonia Shale in Germany) are sediments formed by fine alternations of millimetric to sub/millimetric clear and dark laminae. A study of polished core surfaces (Dotternhausen core, SW Germany) was carried out in SEM in order to characterize the micro-fabrics of different laminae and their content in nannofossils. Two main intervals were recognized where fabrics and nannofossil content are significantly different. In the clay-rich interval, characterized by high wt.%TOC and a large negative carbon isotope excursion (both in carbonates and organic matter) the dominant micro-fabrics are well foliated or lumpy, giving evidence of the absence or reduction of benthic life. Nannofossils are scarce and only concentrated in discrete laminae separated by large, abiotic intervals. Assemblages are indicative of a deep nutricline, but sporadic nutrient inputs occurred, as demonstrated by fluctuation in abundance of specimens of the Biscutaceae. Nutrients were probably delivered to the German basin *via* riverine influx. Different sized framboids of pyrite were recognized in this interval, the smallest ones (~2 μm) being probably precipitated in an anoxic and sulphidic water column. The clay-rich interval was likely deposited during low sea level in a restricted basin. These conditions were followed by a sea-level rise and better water-mass circulation within the German basin. Sedimentation records an increase in carbonate deposition, organic matter content decreased, and carbon isotopes came back to pre-excursion values. Micro-fabrics became less markedly laminated, pyrite framboids nearly disappeared, and rich and diversified nannofossil assemblages are recorded. Sea-water conditions were probably highly fluctuating, as indicated by alternation of intervals dominated in turn by *Schizosphaerella* spp., flourishing under generally oligotrophic conditions, where nutrients were temporarily available in surface waters due to storms, and by *Crepidolithus* spp., a deep-dweller. The results of this work fit well with a silled-basin model.

Keywords: Laminated sediments; Nannofacies; Calcareous nannofossils; SW German basin; Early Toarcian

1. Introduction

An increasing interest is devoted to the study of the Early Toarcian anoxic event and much effort has being done to understand the causes and mechanisms driving such event. Studies on geochemistry (Hesselbo et al., 2000; Schouten et al., 2000; Röhl et al., 2001; Schmid-Röhl et al., 2002; Jenkyns et al., 2002) indicate an important negative excursion in δ^{13}C values recorded both in bulk rock, organic matter and fossil wood. Conversely, the δ^{13}C record from belemnite rostra does not show the large negative excursion (McArthur et al., 2000; van de Schootbrugge et al., 2005). Two models are discussed by the different authors to explain such isotope anomaly, namely a Küspert (1982) mechanism

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(recycling of DIC from the deeper layers of a stratified water column; Saelen et al., 1996; Schouten et al., 2000; van de Schootbrugge et al., 2005), and a mechanism implying methane release in the atmosphere/hydrosphere system and its subsequent oxidation to isotopically light CO_2 (Hesselbo et al., 2000; Jenkyns et al., 2002; McElwain et al., 2005; Kemp et al., 2005). Some of the previous studies measured bulk rock isotopes in considering that bulk carbonates were produced by nannofossils (Saelen et al., 1996; Röhl et al., 2001; Schmid-Röhl et al., 2002; van de Schootbrugge et al., 2005). However, studies on absolute and relative nannofossil abundances indicate that the carbonate fraction provided by nannofossils is variable in rocks of Toarcian age and very limited during the negative carbon isotope excursion (Bucefalo Palliani et al., 2002; Mattioli and Pittet, 2002; Mattioli et al., 2004).

Nannofossil assemblages of Toarcian age are increasingly used to interpret paleoenvironmental conditions in the photic zone of ancient oceans (Bucefalo Palliani et al., 1998, 2002; Erba, 2004; Mattioli and Pittet, 2004; Tremolada et al., 2005), and in particular to decipher nutricline depth as function of stratification *vs.* mixing of surface waters. Different taxa seem to flourish under peculiar ecological conditions, and changes in assemblage composition translate environmental fluctuations with a certain degree of confidence.

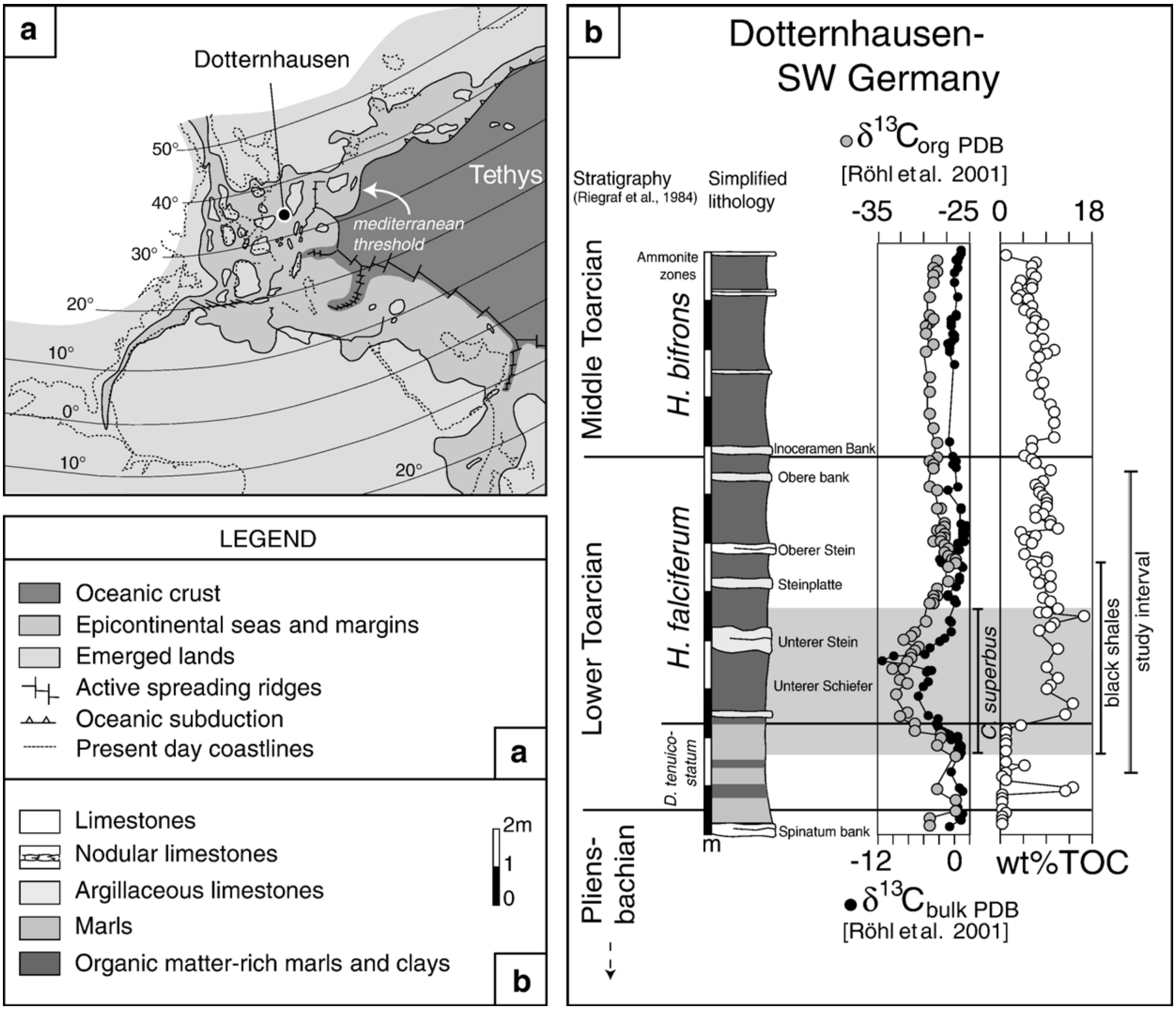

Fig. 1. (a) Paleogeography of the western Tethys in the Toarcian and location of the Dotternhausen core (Modified after Bassoullet et al., 1993). (b) Litho- and biostratigraphy of the Dotternhausen core. Ammonite zones are from Riegraf, 1984. The *C. superbus* nannofossil zone is placed according to Mattioli et al. (2004). The stratigraphic position of main carbonate banks is also displayed. Carbon isotope values measured on bulk rock and organic matter, and Total Organic Carbon (TOC) are after Röhl et al., 2001.