Earth-Science Reviews 99 (2010) 31–49

Contents lists available at ScienceDirect

Earth-Science Reviews

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

Environmental significance of foraminiferal assemblages dominated by small-sized *Ammodiscus* and *Trochammina* in Triassic and Jurassic delta-influenced deposits

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ARTICLE INFO

Article history:
Received 13 March 2009
Accepted 8 February 2010
Available online 16 February 2010

Keywords:
foraminifera
low diversity
agglutinated
small-sized
low salinity
reduced oxygen
Triassic and Jurassic

ABSTRACT

The sediment packages analyzed for benthic foraminifera consist of mudstones with interbedded sandstones deposited in shallow delta-influenced shelf to deltaic environments. The sections are located in Spitsbergen, the Barents Sea, northern North Sea and Yorkshire, and range in age from Late Triassic to Middle Jurassic. Salient features of the foraminiferal successions are: (1) The assemblages consist entirely or dominantly of agglutinated taxa. (2) The faunal diversities are extremely low. (3) The dominant genera are *Ammodiscus* and *Trochammina*. (4) The species are generally of small size compared to usual dimensions within the genera.

The features listed above suggest that the assemblages were adapted to restricted conditions (clearly divergent from those of a normal marine shelf), where the main limiting factors were low salinity and reduced amount of dissolved oxygen in unstable, storm-influenced environments. Evidence for environmental conditions is obtained from modern analogues, although the large evolutionary changes in foraminifera during post-Jurassic time make it difficult to find such analogues. Additional information is derived from functional morphology, sedimentary features and paleogeography.

The analyzed sediment packages show close faunal similarities suggesting opening of a marine pathway, which connected the paleo-Arctic Ocean with the western European shelf seas in Early Jurassic. A depositional biofacies model of the small-sized *Ammodiscus–Trochammina* assemblages envisages a delta-influenced shelf environment, where high freshwater influx would have created a density-stratified water column with a tendency to develop hypoxic conditions in its deeper parts. The depth interval between fair-weather and storm wave base (the offshore-transition zone) is indicated as the habitat of the small-sized *Ammodiscus–Trochammina* assemblages. In this zone, benthic biota would have been stressed by intermittent periods with moderate hypoxia combined with lowered salinity and storm impacts.

Contents

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doi:10.1016/j.earscirev.2010.02.002

1. Introduction

1.1. Background and purpose of study

Benthic foraminiferal successions heavily dominated by *Ammodiscus* and *Trochammina* are known from several Late Triassic to Middle Jurassic sediment packages along the Atlantic margin of northwestern Europe, from the North Sea up to the Arctic (Nagy et al., 1990; Bremer et al., 2003). Several of the successions are typified by small dimensions of these and other taxa, extremely low species diversities and, with a few exceptions, by consisting entirely of agglutinated forms. The present study examines geographically widely spaced assemblages of this type, recognized in several sediment packages as follows (Figs. 1 and 2): The Knorringfjellet Formation of Spitsbergen studied at Festningen, in central Spitsbergen and on Wilhelmøya; the Ragnarok Formation of the Mjølnir impact crater in the western Barents Sea; the lower Rannoch Formation of the Gullfaks Field in the northern North Sea; the Yons Nab Beds on the Yorkshire coast of northeast England.

The above-listed sedimentary successions are composed mainly of mudstones and sandstones interbedded in varying proportions. In the literature, these successions are attributed to shallow shelf, deltaic and coastal marine environments of restricted nature, based on sedimentary features combined with foraminiferal biofacies. Until recently, low salinity shallow water conditions were regarded as the main restricting factor in these environments (Nagy et al., 1990), although tendency to hypoxic conditions in a stratified water column was suggested as an additional factor affecting depositional conditions of the Knorringfellet Formation (Nagy and Berge, 2008).

The objectives of the present study are: (1) Outlining the regional and stratigraphic occurrence of small-sized *Ammodiscus* and *Trochammina* assemblages. (2) Comparison of these assemblages in order to delineate their common features. (3) An assessment of the environmental significance of small-sized agglutinated assemblages. (4) To contribute to the knowledge of delta-influenced and marginal marine foraminiferal assemblages, which have received little attention in spite of the high geological importance of shallow shelf to coastal marine deposits.

1.2. Main features of Jurassic foraminiferal facies

1.2.1. Normal marine shelf assemblages

Assemblages of this type consist entirely or dominantly of calcareous foraminifera, belonging mainly to Nodosariacea, although agglutinated taxa can also form a significant component. High species diversities are typical. There are numerous studies dealing with assemblages of this type from various sedimentary successions e.g.: Exton (1979), Pliensbachian and Toarcian of Portugal; Pietrzenuk (1961), Sinemurian and Toarcian of northeastern Germany; Copestake and Johnson (1989), Hettangian to Toarcian of North Wales; Barnard et al. (1981), Callovian and Oxfordian (Oxford Clay), England; Norling (1972), Pliensbachian of Western Scania, Sweden.

The main faunal proxies for normal marine shelf assemblages of the Northern North Sea Basin, were calculated by Nagy et al. (1990) in two sediment packages. (1) The Ladys Walk Shale Member in the Moray Firth Basin is of Late Sinemurian to Early Pliensbachian age. It comprises 3 foraminiferal assemblage units with average alpha diversities from 4.9 to 7.3 and proportion of calcareous taxa from 73 to 99%. (2) The Amundsen Formation of the Statfjord area includes 6 assemblage units with average alpha values ranging from 4.0 to 8.4 and frequency of calcareous taxa varying from 0.3 to 38%. In both successions the dominant genera are *Marginulina*, *Mesodentalina*, *Lenticulina* and *Dentalina*. The alpha diversities are generally well above 5, corresponding to the values of modern normal marine shelves.

1.2.2. Delta-influenced assemblages

Paralic foraminiferal assemblages dominated by large-sized *Ammodiscus* were reported by Løfaldli and Nagy (1980) from the Toarcian to Bathonian Kongsøya Formation sampled on Kong Karls Land (easternmost part of the Svalbard Archipelago). Dominant species are the robust *Ammodiscus asper* (Terquem, 1862) and the medium-sized *A. limitatus* (Terquem, 1864). The diversities are extremely low, with number of species per sample varying from 1 to 3. Several samples are barren and thin coal seams are present in the section. The assemblages are attributed to shallow, strongly hyposaline, well-oxygenated waters in lagoonal or estuarine settings.

The varied foraminiferal succession of the Middle Jurassic Safa Formation of Sinai has been analyzed by Ghandour and Maejima (2007) who distinguished two agglutinated biofacies. (1) The medium diversity *Ammobaculites* biofacies is referred to brackish prodelta environments dominated by *Trochammina* and *Verneuilinoides* in addition to the nominate genus. (2) The low diversity *Ammodiscus–Glomospira* biofacies is ascribed to brackish delta plain and estuarine conditions dominated by *Miliammina* in addition to the nominate taxa.