jurassic micropaleontology of the grand banks

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Ciências da Terra (UNL)	Lisboa	N.º 5	pp. 85-96 figs. 1-3, 1 pl.	1979

RESUMO

Palavras-chave: Jurássico — Micropaleontologia — Foraminíferos — Grand Banks

Os foraminíferos jurássicos dos sedimentos marinhos do Grand Banks (cuja espessura atinge 3 km) definem oito associações biostratigráficas de idade Pliensbaquiano a Titónico. A sedimentação marinha, geralmente de pequena profundidade, seria equilibrada pela subsidência, que não ultrapassava cerca de 4 cm/10^3 anos.

Durante o Jurássico superior a subsidência deixou de se fazer sentir no Grand Banks central; a região emergiu, tendo sido submetida a erosão até os tempos albianos.

As associações de foraminíferos jurássicos lembram bastante as do «Velho Mundo»; elas são o resultado de paleogeografia atlântica homogénea desde as bacias neríticas da Europa até à bordadura da América do Norte. As diferenças em relação às microfaunas jurássicas portuguesas resultam de simples diferenças de fácies.

RÉSUMÉ

Mots-clés: Jurassique — Micropaléontologie — Foraminifères — Grand Banks

Les foraminifères jurassiques dans les dêpots marins (3 km d'épaisseur) du Grand Banks constituent huit associations biostratigraphiques d'âge Pliensbachien à Tithonique. La sédimentation marine était en équilibre avec la subsidence, de l'ordre de 4 cm/10^3, et les depôts marins sont génerallement de petite profondeur. Pendant le Jurassique supérieur la subsidence s'arrêterait sur le Grand Banks central; la région était emergée et soumise à l'erosion jusqu'á l'Albien.

Les associations de foraminifères jurassiques ressemblent bien celles du «Old World»; elles répresentent le résultat d'une paléogéographie atlantique homogène depuis les bassins néritiques de l'Europe jusqu'en bordure de l'Amerique du Nord. Les différences par rapport aux microfaunes jurassiques portugaises sont le résultat de différences de faciès sedimentaires.

ABSTRACT

Key-words: Jurassic — Micropaleontology — Foraminifera — Grand Banks

Jurassic foraminifera in the marine deposits (up to 3 km thick) of the Grand Banks of Newfoundland define eight biostratigraphic zones of Pliensbachian through Tithonian age. Jurassic marine deposition (~ 4 cm/10^3y) kept pace with subsidence resulting in a relatively continuous, shallow marine sedimentation pattern. Central Grand Banks subsidence ceased in Late Jurassic time and the area became emergent with erosion taking place until Albian time.

Grand Banks Jurassic foraminiferal assemblages are of a distinctly Old World affinity reflecting the contracted early Atlantic paleogeography. Compositional differences with Portuguese Middle-Late Jurassic microfauna are probably related to differences in depositional history of the Portuguese and Grand Banks Basin.

BIOSTRATIGRAPHY

Biostratigraphic studies of cuttings and side-wall core samples from eight exploratory wells on the Grand Banks of Newfoundland, Canada (fig. 1) demonstrate the presence of over 10,000 feet (3050 m) of predominantly marine Jurassic sediments.

The oldest Mesozoic sediments on the Grand Banks consist of red beds, evaporites and dolomites dated by pollen and spores as of Late Triassic through Sinemurian (?Early Pliensbachian) age (JANSA et al., 1975, 1977). This sedimentary sequence is devoid of foraminifers (except possibly in the uppermost carbonates), reflecting nonmarine to marginal marine conditions.

The overlying Jurassic strata made up of clastics and some carbonates contain a relatively rich record of diversified foraminiferal assemblages largely indicative of «shelf» conditions. Eight zones have been recognized of Pliensbachian through Tithonian age. Most of the zones are based on the stratigraphically highest occurrence of taxa and consequently lower zone boundaries are defined by the top of the immediately underlying zone. Details on the taxonomy and age assignment of the zones are in F. GRADSTEIN (1976). The Jurassic biostratigraphy of four individual wells is discussed in F. GRADSTEIN et al. (1975, 1976) and L. JANSA et al. (1975, 1977). The zones allow a detailed well to well correlation, vital to an understanding of regional geology. There is no lithostratigraphic framework available on which the zonation may be superimposed. This hampers a regional facies analysis.

The Jurassic micropaleontological record starts with the *Involutina liassica* zone (1) dated approximately Pliensbachian. Taxa which are restricted to the zone are *Brizalina liassica* TERQUEM, *Involutina liassica* (JONES), *Lingulina tenera* BORNEMANN, *Marginulina prima prima* d'ORBIGNY, *Frondicularia bicostata* d'ORBIGNY, *Berthelinella involuta* (TERQUEM), *Epistomina* sp. 12 GRADSTEIN, 1976, and the ostracod *Ogmoconcha* sp.

The zone (2) of *Lenticulina d'orbignyi* delineates Toarcian-Aalenian sediments. It is based on the stratigraphically highest occurrence of the zonal name species, and *Nodosaria columnaris* FRANKE and the ostracod *Kinkelinella* sp. 1 (APOSTOLESCU). *Garantella* aff. *rudia* KAPTARENKO only appears in the upper part of the zone. Other taxa recognized in this zone are *Nodosaria regularis* TERQUEM, *Lenticulina* sp. cf. *L. toarcensis* PAYARD, *Citharinella* sp. cf. *C. deslonchampsi* (TERQUEM), and the ostracods *Kinkelinella sermoisensis* (APOSTOLESCU) and *Cytherella toarcensis* BIZON.

The *Garantella* zone (3), present with several species of this easily recognizable genus and many specimens, defines the overlying zone assigned a Bajocian-(early) Bathonian age. Characteristic taxa are *Garantella ampasindavaensis* ESPITALIÉ and SIGAL, *G.* aff. *rudia* KAPTARENKO, *G. ornata* HOFKER, *G. sera* PAZDRO and *G. stellata* KAPTARENKO. Another species restricted to the *Garantella* zone is *Reinholdella epistominoides* KAPTARENKO; *Globigerina balakhmatovae* MOROZOVA and *G. bathoniana* PAZDROVA range through at least part of this zone and throughout the overlying one.

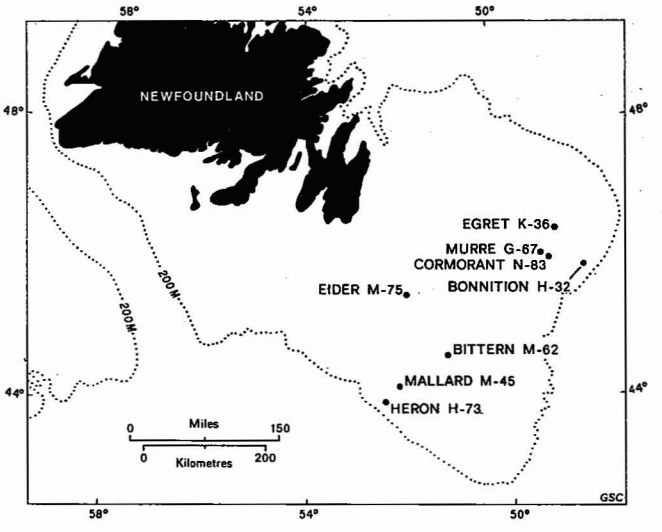

Fig. 1 — Location of eight exploratory wells on the Grand Banks of Newfoundland, Canada, which yielded Jurassic Foraminifera. The wells are Amoco IOE Murre G-67, and Eider M-75, Amoco Imp. Cormorant N-83, Bittern M-62 and Heron H-73, and Amoco Imp. Skelly Egret K-36 and Mallard M-45

Immediately overlying the *Garantella* zone occurs the «*Globigerina*» *bathoniana* zone (4) with the zonal designator, *G. balakhmatovae* MOROZOVA and *Reinholdella media* KAPTARENKO. The zone is based on the stratigraphically highest occurrence of these three taxa ands has been dated as of (late) Bathonian age.

Epistomina coronata TERQUEM, *E. mosquensis* UHLIG, *E. regularis* TERQUEM, *E. uhligi* MJATLIUK and *Lenticulina quenstedti* (GUEMBEL) have their lower range in this interval or possibly in part in the *Garantella* zone.

A Callovian age for Grand Banks sediments follows the recognition of the *Reinholdella crebra* var. zone (5) which has been based on the stratigraphically highest occurrence of the zone marker (a variety of *R. crebra* PAZDRO) and of *Epistomina regularis* TERQUEM, *E. coronata* TERQUEM, *Frondicularia franconica* GUEMBEL, *Neoflabellina (?) deslongchampsi* (TERQUEM), *Saracenaria triquetra* (GUEMBEL) and *Globigerina oxfordiana* GRIGELIS.

The highest stratigraphical occurrence of *Epistomina mosquensis* UHLIG, *E. uhligi* MJATLIUK, *E. soldanii* OHM, *Gaudryina heersumensis* LUTZE, *Lenticulina quenstedti* (GUEMBEL), *Paalzowella feifeli* (PAALZOW) and *Valvulina meentzeni* (KLINGLER) defines the Oxfordian-Kimmeridgian zone of *E. mosquensis* (6).

In several Grand Banks wells the uppermost Jurassic is in (very) shallow marine facies typified by some species of larger foraminifers. Two zones have been established: The *Pseudocyclammina jaccardi* zone (7) and the *Anchispirocyclina lusitanica* zone (8). The *Pseudocyclammina jaccardi* zone of late Oxfordian-early Kimmeridgian age is based on the range of *P. jaccardi* (SCHRODT). *Epistomina uhligi* MJATLIUK also occurs. The zone correlates to the *E. mosquensis* zone which in the Murre G 67 well contains some specimens of *E. uhligi*, *E. mosquensis*, and *P.* aff. *jaccardi*.

The *Anchispirocyclina lusitanica* zone (8) has been based on the range in Grand Banks wells of *A. lusitanica* (EGGER). The Tithonian age interpretation of this zone (GRADSTEIN, 1976) has recently been further substantiated on the Grand Banks from the determination of late Tithonian calpionellid species which occur with the zone marker (P. Ascoli and H. Remane, pers. comm.).

REGIONAL STRATIGRAPHY

Jurassic sedimentation rates at the well sites are in the order of 4 to 10 cm/1000 yr, which is not particularly high for continental margins. From the relatively continuous Jurassic sedimentation (as far as known) and its inferred shallow water nature it follows that sedimentation kept pace with subsidence. However, as may be observed from figure 2 which displays the stratigraphic distribution in Grand Banks wells of sediments dated through foraminifers, part of Upper Jurassic and most or all of Lower Cretaceous sediments may be missing.

Seismostratigraphy shows that this hiatus corresponds to a conspicuous unconformity which separates folded Jurassic strata preserved in northeast-southwest trending «sub-basins» from an overlying succession of transgressive post-Aptian rocks (Amoco and Imperial, 1973; UPSHAW et al., 1974; GRADSTEIN et al., 1975). Grand Banks subsidence apparently ceased at the end of Jurassic time and the area emerged in the Tithonian to Albian period. In the East Newfoundland Basin, to the northeast of the Grand Banks, and to the southwest in the Scotian Basin, marine environments prevailed during that time, with locally thick sediments being accumulated. A transitional facies developed in the Egret K-36 well (figs. 1, 2), where Early Cretaceous and also Kimmeridgian sediments are of brackish water nature with a predominance of ostracods, *Chara* sporangia and few foraminifers.

BIOGEOGRAPHY

Jurassic fomaminiferal assemblages from the Grand Banks and adjacent Scotian Shelf as well (the latter studied by P. ASCOLI, 1976) have strong affinities to coeval assemblages known from Europe and Africa. The Grand Banks has many species in common with the «Old World» that are not known from elsewhere in North America (GRADSTEIN, 1976).

An example of the «Old World» affinity is provided by Middle and Upper Jurassic foraminifers belonging in the genera «*Globigerina*», *Garantella*,*Reinholdella*, *Epistomina* and the Jurassic complex arenaceous foraminifers. The Jurassic globigerinids, the earliest planktonic foraminifers, might be expected to have a wide dispersal in the Jurassic seaways. *Garantella*, *Reinholdella*, and *Epistomina* are bottom-dwellers, as are the complex arenaceous foraminifers. The latter are confined to shallow and very shallow marine environment.

This group of foraminifers which occurs with many species and abundant individuals in Grand Banks Middle

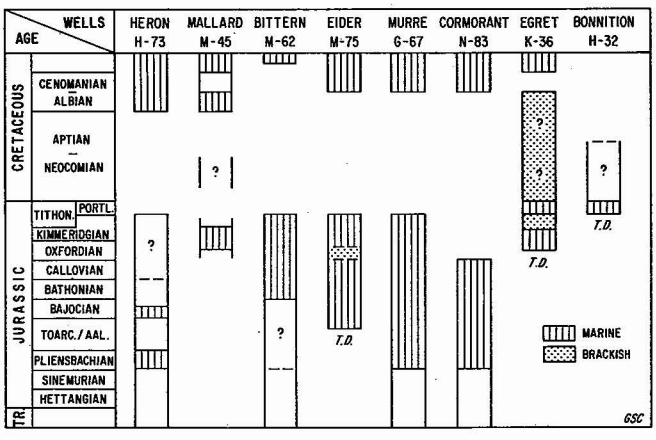

Fig. 2 — Stratigraphic distribution of Foraminifera bearing Mesozoic sediments in eight Grand Banks wells. Regional transgressions are in Pliensbachian (Early Jurassic) and Albian-Cenomanian (Middle Cretaceous) times

and Upper Jurassic deposits, are well known from Europe and also Africa to some extent, but not elsewhere from North America (fig. 3). An exception is the occurrence of a few taxa of complex arenaceous foraminifers and one or two *Epistomina* species in the Upper Jurassic of the Gulf Coast and Caribbean region.

The well known predrift reconstruction of the *circum*--Atlantic region in Jurassic time (*e. g.* WILSON, 1975, fig. 4) indicates a slightly lower-latitude position of the Grand Banks and a geographic proximity of the area to the Mediterranean region (Tethyan realm). The Tethyan and «Old World» affinity of the Grand Banks fauna may be explained, to a large extent, from this Jurassic paleogeography. The land-mass of the Appalachian and the adjacent Canadian Shield west of it delineate the western margin of the Jurassic Grand Banks marine realm.

The inferred juxtaposition in Jurassic time of the Grand Banks and Portugal, possibly without much of an incipient deep basin in between (WILSON, 1975) might lead to the speculation of substantial agreement in composition of coeval foraminiferal faunas. On the contrary, preliminary interpretation based on a comparison of literature data from the Jurassic of Portugal (ZBYSZEWSKI et al., 1966; RUGET and SIGAL, 1970; RAMALHO, 1971; RAMALHO and REY, 1975), indicates a substantial difference in foraminiferal fauna composition in Middle and to a lesser extent in Late Jurassic time.

No globigerinids and very few epistominids, abundant in Grand Banks Middle Jurassic strata, are known from Portugal, whereas the Grand Banks Middle-Upper Jurassis sediments have about five times less complex arenaceous taxa and few or no algae. Early Jurassic faunal similarities at present are subject of a detailed investigation by J. Exton, England, and the author.

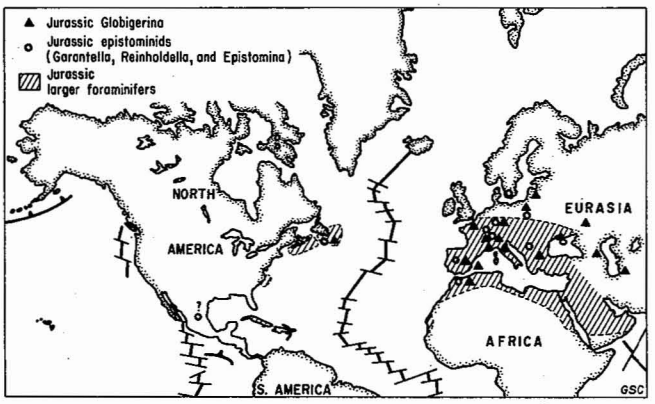

Fig. 3 — Distribution of selected Grand Banks Jurassic Foraminifera in North and South America, Eurasia and North Africa (modified map based on many sources detailed in GRADSTEIN, 1976)

These differences in faunal composition likely reflect pronounced differences in depositional history of the two regions, especially so in Middle Jurassic time, when rifting may have ocurred. The poverty in Grand Banks strata of complex arenaceous taxa and the lack of algae may be explained from a geographically more marginal position of the Grand Banks relative to Portugal in the Jurassic Tethyan seaway.

ACKNOWLEDGEMENTS

I like to thank J. Exton, England for additional taxonomic information on Grand Banks Lower Jurassic fauna and C. Ruget, M. Ramalho and J. Rey for interesting discussion and reprints of their studies on Jurassic micropaleontology of Portugal. P. Ascoli and R. Fillon suggested improvements to the text of the manuscript.

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OBSERVATIONS ET RÉPONSES

Mr. BOILLOT — La courbe de subsidence que vous avez presentée pour le Grand Bank de Terre Neuve suggère: a) une subsidence exponentielle (refroidissement lithospherique) de l'Hettangien à l'Oxfordien inférieur; b) un arrêt de la subsidence (2e rifting?) de l'Oxfordien supérieur à l'Albien inférieur; c) une nouvelle subsidence exponentielle à partir de l'Albien (refroidissement lithospherique). Pouvez vous préciser cette évolution, d'un très grand interêt pour les comparaisons avec la marge ouest-portugaise?

Mr. GRADSTEIN — La courbe le subsidence presentée n'est pas complète. Il faut ajouter des données d'autres sondages, particulièrement pour le Trias supérieur et le Crétacé inférieur. En général la courbe pour le «shelf» canadien est une courbe exponentielle non interrompue. L'arrêt du Jurassique supérieur au Crétacé inférieur est un phenomène local du Grand Bank Central.

Mr. MOUGENOT — Je suis surpris que dans les forages du Grand Bank vous ne trouviez pas, comme au Portugal, une discontinuité entre le Callovien et l'Oxfordien.

Mr. GRADSTEIN — La discontinuité du Grand Bank est située entre le Jurassique sup. (Callovien-Tithonique) et le Crétacé moyen (Albien). Nous n'avons pas trouvé l'evidence d'une discontinuité dans le Jurassique supérieur comparable à celle du Bassin Lusitanien.

Mr. PALAIN — Sur une de vos diapositives donnant la sucession stratigraphique vous avez indiqué par un figuré ondulé, signe de disconformité, le contact entre l'Hettangien et ce qui est dessous. A quoi correspond ce contact? Puisque nous sommes sur le problème de la base de la série du Mésozoïque, pourriez-vous nous dire si vous avez trouvé de la microfaune et dans le cas contraire pourquoi ces fossiles manquent?

Mr. GRADSTEIN — 1) C'est le contact des sédiments dévoniens immediatement superposés par dolomites du Jurassique inférieur.

2) La première indication de conditions marines normales est dans la zone à *Involutina liassica*, interpretée comme d'âge Pliensbachien. Il n'y a pas de foraminifères au dessous dans le Grand Bank.

DOCUMENTAÇÃO FOTOGRÁFICA

PLATE 1

Three foraminiferal species from the Garantella zone (Middle Jurassic) *in* Amoco JOE Eider M-75, Grand Banks.

Figure 1 — *Garantella ornata* (HOFLER); × 150
Figure 2 — Idem
Figures 3, 4 — *Garantella stellata* KAPTARENKO; × 150
Figures 5, 6 — «*Globigerina*» *bathoniana* PAZDROVA; × 500

PLATE 1