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Preface: The planktonic foraminifera of the Jurassic

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Abstract Planktonic foraminifera originated in late Early Jurassic and, for reasons poorly understood, only underwent proliferation of species and geographic spreading from mid-Cretaceous onwards. Their evolutionary development in the oceans and adjacent seaways since early mid-Cretaceous has spurned a large volume of increasingly sophisticated literature. Specimens of this diverse group are now routinely subject to a wide variety of taxonomic, biostratigraphic, geochemical and molecular research. This microfossil group now plays a major role in studies on Cretaceous and Cenozoic palaeoclimatology and palaeoceanography. This global attention is in striking contrast to the interest and research effort put in their Jurassic and earliest Cretaceous forerunners.

Keywords Jurassic planktonic foraminifera · Introduction · Historical background

Why is there not a large body of sophisticated palaeobiological and -geological literature on Jurassic and earliest Cretaceous planktonic foraminifera? There are several plausible answers.

A quick and easy answer is that the aragonitic tests of these microfossils hamper fossilisation. Indeed, a majority of samples in wells or outcrop sections may lack specimens of these taxa. On the other hand, some Jurassic marly shale sections, like in wells on the Grand Banks of Newfoundland, in outcrops in Portugal and in Dagestan may contain abundant (65–125 μm size, and some larger size) free specimens. Thin-sections of Jurassic limestones in Poland, the Balkan countries and N. Africa may also abound with tiny shells of these taxa, but do not lend itself to taxonomy. A problem is that we do not really understand why geographic and stratigraphic distribution is irregular and patchy.

One answer may come from palaeobiological and evolutionary reasoning, i.e. that organisms at their closeness to origination from their ancestor have low frequencies and a restricted biogeographical distribution. Early planktonic foraminifers from the Jurassic are known to be usually of low frequency and only seldomly reach sporadic mass occurrences. In this context, it is not so much surprising that Jurassic foraminifers were only rarely encountered in samples.

A second consideration is that Jurassic planktonic foraminifera are limited to low and mid latitude marine basins of Pangaea, adjacent to the true oceans. The Jurassic oceans themselves were empty of planktonic foraminifera.

Worldwide sampling by the ocean drilling campaigns since the late sixties of the last century did not improve this situation because Jurassic strata are less frequently recovered from scientific drilling. The reason for this is obvious. Reviews by Gradstein (1983) and Riegraf and Luterbacher (1989) from the North- and South Atlantic Oceans demonstrated the existence of diverse and locally-rich benthic foraminiferal faunas during the Late Jurassic but only a subordinate occurrence or total absence of planktonic foraminifera. This fact is taken up in this issue.

For reasons explained in the current study, no Jurassic planktonic foraminifera have been found along the western coasts of the Americas. Figure 1 with red stars gives

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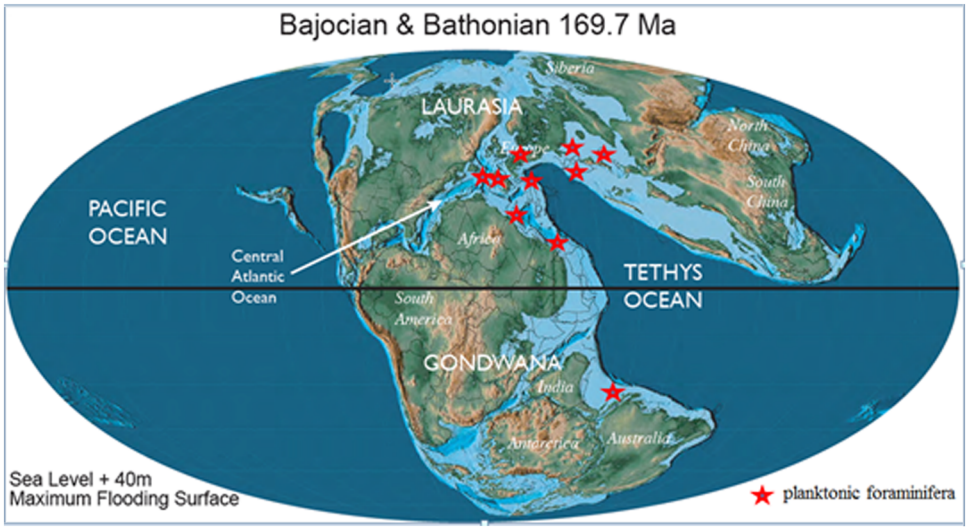

Fig. 1 Middle Jurassic global palaeogeographic reconstruction (map from Scotese, 2014, Paleomap Project). *Red stars* provide approximate position of areas with known occurrence of common to abundant planktonic foraminifera

approximate position of (all coastal) areas with known occurrence of common to abundant planktonic foraminifera in mid Jurassic time. This situation is not much different later in Jurassic. The figure does not claim to be entirely accurate or complete, but clearly shows the empty oceans and lack of this biota along the western coasts of the Americas.

This palaeobiogeography is in striking contrast to the palaeogeographic distribution of the post-Jurassic, calcitic siblings of this diverse group, which are truly pelagic and distributed almost globally, except in the Arctic realm.

Although the Jurassic Period by tradition is the 'playground' of ammonite specialists, several microfossil groups play key roles in zonation and correlation of strata, like calcareous nannofossils and dinoflagellates, but not planktonic foraminifera.

Another consideration is the state and communication of taxonomy. The taxonomy of Jurassic planktonic foraminifera is subject to considerable 'species' splitting and critical literature is not available in English, but only in Russian or French. Although this should not be a limiting factor, it does not help with understanding the species concept and evolution.

Readers of this series of articles on Jurassic planktonic foraminifera, in this issue of the Swiss Journal of Palaeontology, will immediately notice that no new data have come forward on the earliest (Toarcian) evolution of this group. We simply lack samples. For the same reason, the transition between Jurassic and Cretaceous also is still 'murky'. Critical sampling of these intervals is politically and logistically difficult and expensive. At this stage it is appropriate to briefly shine light on some bright spots in research history, outlined in the annotated time line listing of a majority of studies dealt with in Gradstein, 2017b (The planktonic foraminifera of the Jurassic—Part III Annotated historical review and references, this issue).

One of the oldest studies on planktonic foraminifera is by R. Haeusler, who in 1881, in an incomplete and limited manner, described the species *Globigerina helvetojurassica* from the Birmenstorfer Schichten of Canton Aargau, Switzerland. Several attempts to formalize the taxonomy on this enigmatic taxon failed, as dealt with and illustrated in the first study of this issue (Gradstein, 2017a, New and Emended Species of Jurassic Planktonic Foraminifera, this issue).

Our new and current understanding of this old taxon is to a large extent due to the excellent and generous assistance of Christian Meyer, Walter Etter and co-author Michael Knappertsbusch of the Basel Natural History Museum. To obtain topotypes of the 1881 species by Haeusler, these specialists (Fig 2) organized a field trip

Fig. 2 Group photo in April 2016 of the party sampling the type locality of *Globuligerina helvetojurassica* (Haeusler) in the Birmenstorfer Schichten, Eisengraben, Canton Aargau, Switzerland. From L to R: Cyrill Voegelin, Marc Wilmer, Felix Gradstein, Michael Knappertsbusch and Walter Etter

Fig. 3 T. N. Gorbachik in her office at the Department of Paleontology of the Moscow State University. The photograph is from 1988

Fig. 4 T.N. Gorbachik and K.I. Kuznetsova at a micropalaeontological meeting in Kiev, late 1980s

with Gradstein in April 2016 to the Birmenstorfer Schichten in the Eisengraben Section of Canton Aargau. The assistance by Maria Rose Petrizzo in Milan, Italy to process the Birmenstorfer samples should also be mentioned here. The quality of the free specimens obtained is excellent, and this without any treatment with acetic acid, but conventional soaking, washing and sieving (see Plate 16 in Gradstein et al. The planktonic foraminifera of the Jurassic—Part I Material and Taxonomy, this issue).

One of the pioneers of the study of Jurassic planktonic foraminifera was Tatjana N. Gorbachik. We are grateful for her deep insight in the taxonomy of taxa. She was one of the first to employ the scanning electron microscope to provide details of wall structure and texture. She keenly

Fig. 5 T.N. Gorbachik (orange vest) and K.I. Kuznetsova on a geological excursion to Caucasus in October 1987

engaged in the study of this group to provide insight in its stratigraphic and geographic distribution. We were finishing this research project when the very sad news of her death reached us. This study honours her outstanding contribution to Jurassic micropalaeontology. Five of her studies are listed in Gradstein, 2017b (The planktonic foraminifera of the Jurassic—Part III Annotated historical review and references, this issue).

A second outstanding specialist in Jurassic micropalaeontology was Kirilla I. Kuznetsova (†, 2005), employed at the Geological Institute of the Russian Academy of Sciences. Based on material collected during a long-term study of Jurassic sediments in palaeobiogeographic areas from the Arctic to the Mediterranean, she constructed stratigraphic scales with foraminifera for the Jurassic. She also worked on important problems of evolution, morphology, taxonomy, and phylogeny of Jurassic foraminifers. In this series of articles we refer to several of her key research contributions. Kuznetsova and Gorbachik worked closely together in Jurassic micropalaeontology.

In Fig. 3, taken in 1994, T. N. Gorbachik is in her office at the Department of Paleontology of the Moscow State University. Figure 4 shows T. N. Gorbachik and K.I. Kuznetsova at a micropalaeontological meeting in Kiev, in the late eighties of the last century. In Fig. 5, T. N. Gorbachik and K. I. Kuznetsova are shown on a geological excursion to the Caucasus in October 1987.

Figure 6a, b are scans of part of the front pages of two key micropalaeontological studies undertaken by these two researchers. This was at a time when researchers exchanged paper reprints, and thus also kindly exchanged best wishes. The scan also shows a partial copy of the front page of the reprint that Jurassic micropalaeontologist Olga Pazdrowa from Poland sent to Gradstein. I never met either Tatjana or Kirilla Kuznetsova or Olga, but the reprints (and also specimens) exchange was lively and much appreciated

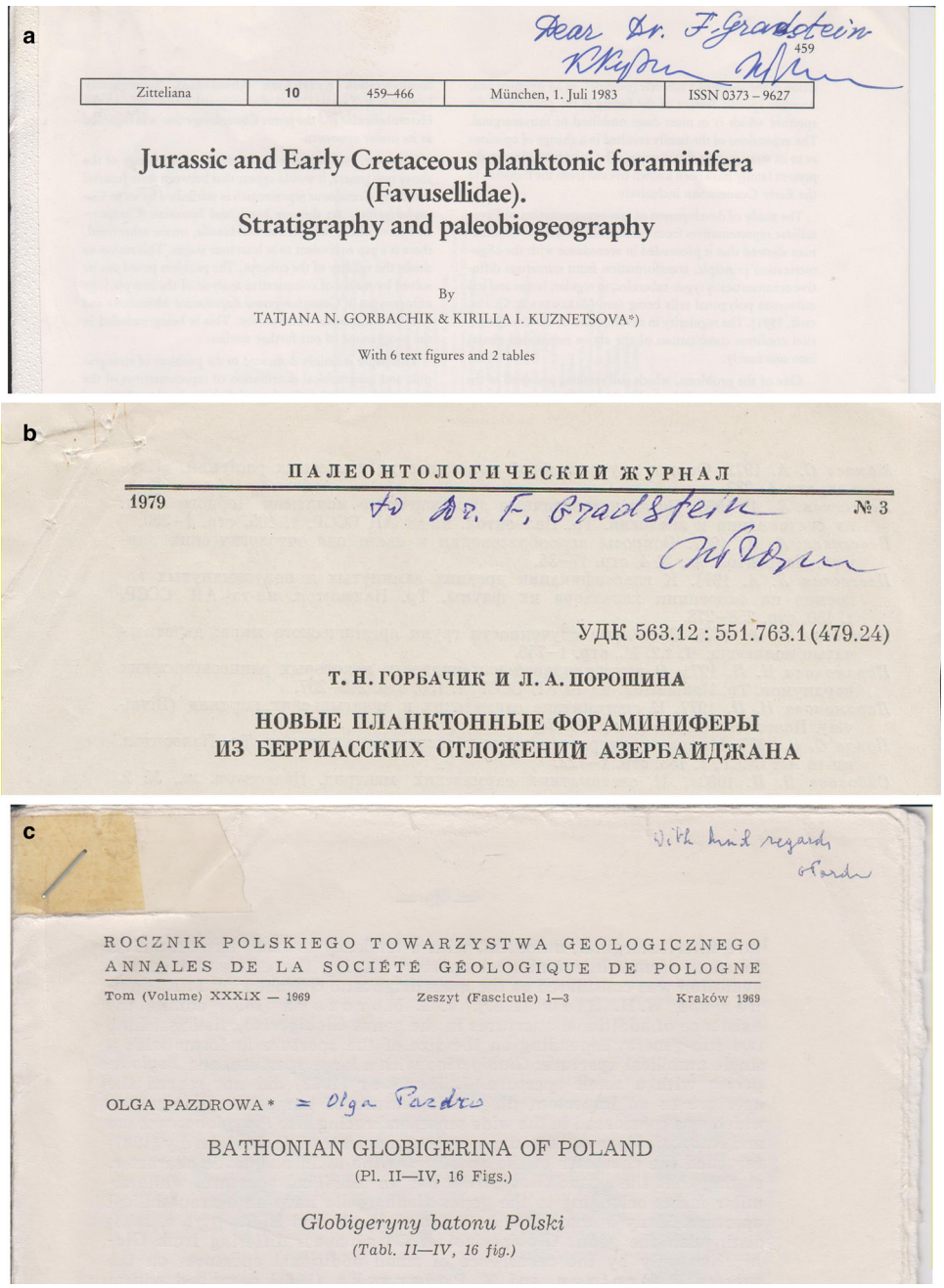

Fig. 6 **a**, **b** and **c** Part of the front pages of reprints of key studies on Jurassic planktonic foraminifera sent to Gradstein by T. N. Gorbachik and O. Pazdrowa

at both sides, at a time when the Cold War and Iron Curtain were still upon us.

Moreover, we mentioned the pioneering study in Switzerland in 1881 of Haeusler on one of the first described planktonic foraminifera (Gorbachik and Kuznetsova 1983; Gorbachik and Poroshina 1979; Pazdrowa 1969). To this, we should add the important research on Jurassic planktonic foraminifera of his fellow countryman Roland Wernli, who later worked closely together with our co-author Agnes Görög on the taxonomy, biostratigraphy and biogeography. Five of Wernli's senior authored studies, with emphasis on thin-section taxonomy, are listed in Gradstein (2017b, The planktonic foraminifera of the Jurassic—Part III Annotated historical review and references, this issue) two of which detail the stratigraphically oldest assemblages known of this group. Figure 7 shows a partial copy of the front page of the Toarcian record study, released in 1988, now 29 years ago. It is an almost stunning situation that since 1988, not a single study has been published detailing other Toarcian or even older records of this group of microfossils. New methodology with controlled acetic acid generation of free specimens from limestones may provide more insight in the unique data generated by Roland Wernli. We are trying to obtain some

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Les protoglobigérines (foraminifères) du Toarcien et de l'Aalénien du Domuz Dag (Taurus Occidental, Turquie)

Par Roland Wernli[1])

ABSTRACT

The most ancient protoglobigerinids are described from thin sections of the Ammonitico-Rosso limestones (Turkey). The Toarcian forms are small with consecutively built tests. On the other hand the protoglobigerinids of Aalenian age are bigger and display thicker wall due to concurrently built tests.

Fig. 7 Partial front page of the study (in French) by Wernli (1988) describing the oldest record of Jurassic planktonic foraminifera

Fig. 8 Localities with Jurassic planktonic foraminifera (in 1976 observed for the first time in Jurassic strata in N. America), including epistominids, garantellids and reinholdellids. The biota distribution extends from the Grand Banks of Newfoundland to the 'Old World'; re-illustrated from Gradstein (1976)

of Wernli's (1988) sample material (samples from Poisson 1977).

On a general note, we like to mention that the current study in the Swiss Journal of Palaeontology would not have been possible without the benefit of yet another pioneering publication; this by Mike Simmons and colleagues on 'The Jurassic Favusellacea, the earliest Globigerinina', published in 1997 by Chapman and Hall, under sponsorship of the British Micropalaeontological Society. This study deals with unique type material, much of it stored in the Geological Musea and Geological Institutes in Moscow and London. The current series of articles kindly obtained permission from the authors to re-publish several of the original plates.

Starting in 1974, senior author Gradstein, for his professional career in Canada, studied foraminifera with students in newly drilled exploration wells by Imperial Oil (Esso Canada), Amoco and others on the Grand Banks of Newfoundland. Logically, conjugate strata that nicely outcrop in Portugal were also investigated, both for micropalaeontology, ammonite stratigraphy and sedimentology. A first communication on this subject was published in 1976 in the Proceedings of the First Benthic Foraminifera conference in Halifax, N.S., Canada (Gradstein 1976). Figure 8 shows a simple palaeobiogeographic distribution of the Jurassic planktonic and some benthonic foraminifera, including epistominids, garantellids and reinholdellids. The offshore East Canada microfossil record at that time was and still is

Fig. 9 The type section of the Tojeira Formation, Montejunto area, Portugal in 1984. In 2016 the section had substantially grown over, as may be seen on Fig. 3a (in Gradstein et al. The planktonic foraminifera of the Jurassic—Part I Material and Taxonomy, this issue)

Fig. 10 Gradstein and Stam at lunch in 1984 during sampling of the Tojeira Formation, Montejunto, Portugal

Fig. 11 Andrew Gale (with brown hat; co-author and professor emeritus at Portsmouth University, UK), Holly Turner (PhD student in carbon isotopes and dinoflagellates of Gale and Gradstein at Portsmouth University, UK) and David Watkins (professor in nannofossils and stratigraphy at U of Nebraska, Lincoln, USA) in the type section of the Tojeira Formation, Montejunto area, Portugal (April 2016)

unique to North America. The microfossil distribution extends from the Grand Banks to the 'Old World'. About 10 years later Stam (1986) studied the planktonic foraminifera in more detail. Despite the fact that wall texture research of Jurassic planktonic foraminifera was not yet advanced, this PhD study provided new insight in taxonomy and palaeoecology, albeit as seen through the eyes of a lumper. Figure 3 shows the (at that time assigned to Upper Oxfordian) Tojeira Formation on the flanks of the Montejunto massiv, the location of abundant free specimens of Jurassic planktonic foraminifera. Figure 4 shows Gradstein and Stam during sampling of the Tojeira sections in 1984.

In 2016, during our visit of the Tojeira type locality to re-sample it, for study of dinoflagellates, nannofossils, and Carbon isotopes, the section had substantially grown over. Our re-sampling was successful, but required more measuring and digging. Figure 5 shows co-author Andrew Gale (with brown hat), nannofossil specialist David Watkins and PhD student Holly Turner (Kimmeridgian Carbon isotopes and dinoflagellates), taking in the general setting of the strata beneath the overgrowth.

The small ammonites-rich Kimmeridgian Tojeira sediments are unique, in that the marly shales contain abundant planktonic foraminifera with up to six or more taxa, subject of study in this series of articles (see Turner et al., The age of the Tojeira Formation (Kimmeridgian, Late Jurassic), Montejunto, west-central Portugal, this issue). A majority of sections in other areas may only yield 1 or 2 taxa, often with a small number of (tiny) specimens. Why this is, is not well understood, but the, undoubtedly nutrient rich, coastal embayment facing the Atlantic Ocean was advantageous to populations of this group. Figure 5 in Gradstein et al. (The planktonic foraminifera of the Jurassic—Part I Material and Taxonomy, this issue) sketches the setting in a geologic cross-section (Figs. 9, 10, 11).

This brief sketch of organizational and scientific background to the study on the planktonic foraminifera of the Jurassic points to promising directions for new research. It is our wish that this scientific contribution to Jurassic micropalaeontology may bear fruit, and create interest for further study. Much has still to be learned. Our understanding of the earliest evolution of planktonic foraminifera is limited and their origin (or multiple origins) from benthic foraminifera is a mystery. We are grateful to chief editor of the Swiss Journal of Palaeontology Daniel Marty to advice on this thematic series of articles and provide vital support with editing and publication.

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