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MICROFAUNAL DIVERSITY AND DIAGENESIS IN THE MUSCHELKALK FACIES

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ABSTRACT

Foraminifera from the Triassic Muschelkalk facies are rare and their diversity is low. The recorded species are mainly Lagenidae characterized by hyaline calcite walls. Other foraminifera (Involutinidae, Duostominidae), well known in the Trias of the Alpine facies province (Tethys), seemed not to occur in the German facies province possibly because of anomalous conditions of the bottom waters. However, recent work has shown that foraminifera of the Alpine facies province occur also, however rarely and not always well preserved, in the Muschelkalk of Sardinia, Germany, Luxemburg and South Tunisia. Their infrequency and poor preservation are explained as the result of diagenetic changes in the course of fossilization combined with a very low rate of sedimentation, rather than of adverse living conditions.

RESUMEN

Los foraminíferos del Muschelkalk son raros y su diversidad baja. Las especies registradas corresponden mayoritariamente a Lagenidae caracterizados por tabiques de calcita hialina. Otros foraminíferos (Involutinidae, Duostominidae), bien conocidos en el Trías Alpino

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(Tethys), parecen no encontrarse en las facies germánicas posiblemente debido a condiciones anómalas en las aguas de fondo. No obstante, trabajos recientes han demostrado que estos foraminíferos de facies Alpina también aparecen, aunque raramente y no siempre bien conservados, en el Muschelkalk de Cerdeña, Alemania, Luxemburgo y Sur de Túnez. La escasez y deficiente conservación se explica como resultado de los cambios diagenéticos habidos en el transcurso de la fosilización, combinados con una muy baja tasa de sedimentación, más que de las adversas condiciones de vida.

INTRODUCTION

Foraminifera in the German facies of Middle Triassic age are generally considered as absent or very poorly represented. If present they are normally represented by the biostratigraphically insignificant Lagenidae (mainly «*Frondicularia*» spp.). In the Alpine facies (Tethys), foraminifera are comparatively diversified and represented by age — significant associations (ZANINETTI, 1976). However, *Glomospirella* and *Agathammina* have been reported from the Grès à Voltzia (Upper Buntsandstein) of the Vosges (France) (KOEHN-ZANINETTI *et al.*, 1969) and the sessile *Tolypammina* in the oolic facies of the Lettenkohle (Uppermost Muschelkalk) of Luxemburg (COUREL, 1978).

The reasons for the microfaunistic differences between the German and the Alpine Triassic facies have never been explicitly explained. However is has been suggested, on the grounds of sedimentological, paleoenvironmental and paleoecological interpretations for the epicontinental deposits, that confined enviroments and anomalous salinities of the waters would be the main causes.

The above mentioned ecologic factors, associated with the turbidity of the waters (high clay content) could explain the absence of dasycladacean algae in the internal areas of the epicontinental seas and conversely their occurrence near the Tethys edges (Spain, Sardinia, Southern France and Poland); but they cannot explain the absence of foraminifera which do not necessarily depend on well oxygenated and clear waters. In addition, the occurence of stenohaline organisms such as echinoderms in both the German and Alpine realms, apparently excludes, at least in the horizons in which they are contained, an anomalous salinity of the waters.

The discovery of «alpine» foraminifera in the Muschelkalk facies of Sardinia, Germany, Luxemburg and South Tunisia shows that they were able to live under adverse conditions in epicontinental seas. Their infrequent occurence, however, requires an explanation.

The samples investigated come from the outcrops and quarries of Punta del Lavatoio, Monte Santa Giusta, Contrada Renuzzo (Sardinia);

Sommenberg, Saar, Kleiber, Keisberg near Kronak, Weisslensburg near Eschembach (Germany); Bettendorf (Luxemburg) and Jebel el Rehash (South Tunisia).

CHARACTERS OF THE MUSCHELKALK LIMESTONE

Microsparite mudstone, locally highly bioturbated, is the dominant fabric of the Muschelkalk carbonates. Siliciclastic material of mud or silt-size is often abundant. The microfossils commonly reported are ostracods, echinoderm ossicles and «*Frondicularia*».

Intercalations of wackestone, packstone or grainstone made up of coquinas, locally oligotypic, occur in some horizons. The grains are peloids, fecal pellets, seldom ooids or coated grains and mainly debris or tests of pelecypods, gastropods, cephalopods, brachiopods and ostracods, echinoderm plates and spines, sponge spicules, fish remains and conodonts. Dasycladacean and solenoporacean algae occur only in the peritethysian facies. Encrusting foraminifera and algae, forming frequently oncolites, occur locally.

Intergranular and intragranular cements consist of clear coarse-calcite sometimes associated with thin yellowish rims of bladed calcite. They fill the moulds and cavities of the tests locally with geopetal structures.

Common neomorphic processes affect most of the skeletal remains and the matrix as well. The latter is always made up of microsparite with irregular patches of sparite.

The grainstone facies are locally affected by selective dolomitization so that it is often impossible to recognize the nature of the grains.

Pressure-solution structures are widespread and generally parallel to the bedding. They range from irregular thin solution seams to evolved structures associated with concentration of insoluble residue and locally with diagenetic dolomitization (DAMIANI & GANDIN, 1974; SCHWARZ, 1975).

The foraminifera so far reported are mainly represented by «*Frondicularia*» («*F. woodwardi*» auct.) and other Lagenidae, though rare ghosts of *Glomospirella, Involutina* and *Agathammina* have recently been reported from the Middle Triassic sequences of Punta del Lavatoio and Contrada Renuzzo (Sardinia) (GANDIN, 1979; BAGNOLI *et al.*, 1985).

PRESERVATION OF THE FORAMINIFERA TESTS

The foraminifera found in the Muschelkalk facies are commonly badly preserved. Their recognition in thin section was made possible

using a translucent plastic paper and/or the microscope condenser as proposed by DELGADO (1977). Without this help, most of them are not visible.

They occur both in the mudstone and granular facies mainly as microsparite ghosts, dense dark rims outlining the original shape and structure.

Both micritization and recrystallization affect most of the foraminifera tests though in different ways.

The behavior of hyaline tests during diagenesis appears to be connected with the mineralogy of the walls: the calcite tests of *«Frondicularia»* and other Lagenidae always retain their primary texture and typical pseudouniaxial interference figure, seen under crossed nichols, never exhibiting a micritization coating (Pl. I, 1-2).

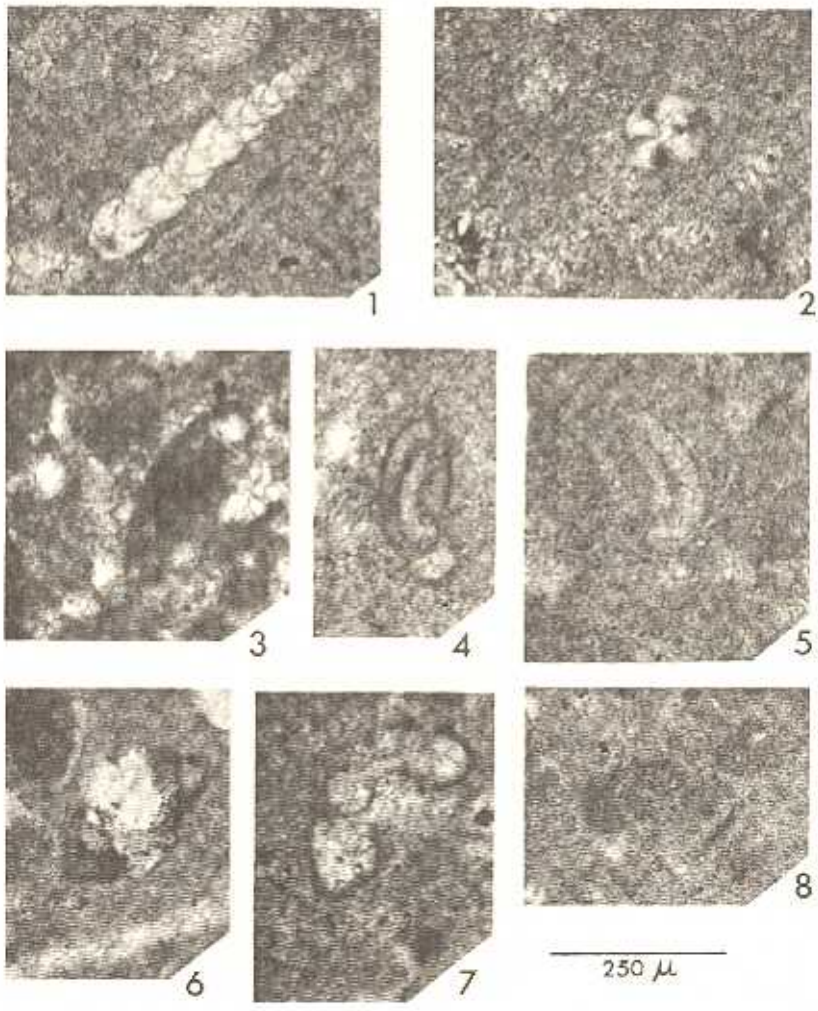
On the other hand, the hyaline aragonitic tests can be changed by a more or less extensive micritization (Pl. II, 1-3) and, owing to the instability of aragonite, can be subjected recrystallization (Pl. II, 1) or dissolution, leaving as cast subsequently filled by secondary coarse calcite (Pl. I, 8; II, 4). Furthermore, if micritization as well as the filling of the chambers by lime-mud, occurs before recrystallization or dissolution, the shape and some of the original structure may be preserved (Pl. II, 4). An early dissolution or an extensive micritization leads to the obliteration of the whole test (Pl. II, 6).

The microgranular tests appear either as dense peloids, where at times it is possible to recognize relics of the sparite filling of the chamber (Pl, I, 3) or as thin dense microsparitic rings vanishing into the microspar fabric of the matrix (Pl. I, 4-7; Pl. II, 7, 9).

According to BATHURST (1971) the walls of recent microgranular and agglutinated foraminifera can be easily micritized probably owing

PLATE I.—*1-2. Calcite test of* «Frondicularia woodwardi» *retaining the primary texture and the pseudouniaxial interference figure under cross nichols (2). Contrada Renuzzo, Sardinia. 3. Micritized test of a microgranular form* (Agathammina?) *with relics of the original structure marked by the calcite filling of the chamber. Keisberg, Germany. 4-5-6. A dense microsparitic ring marks the shape of the* Agathammina *tests, locally dissolving into the matrix. (4-5) Contrada Renuzzo, Sardinia; (6) Weisslensburg Quarry, Germany. 7. Micritized test of* Diplotremina? *Monte Santa Giusta Sardinia. 8. Ghost of foraminifera test replaced by fine-grained spar and filled by lime-mud. Jebel el Rehash, South Tunisia.*

1-2. Concha calcítica de «Frondicularia woodwardi» *que conserva la textura primaria y la figura pseudouniáxica de interferencia en nicoles cruzados. Contrada Renuzzo, Cerdeña. 3. Concha micritizada de una forma microgranular* (Agathammina?) *con restos de la estructura primaria visibles gracias al relleno calcítico de la cámara. Keisberg, Alemania. 4-5-6. Conchas de* Agathammina *realzadas por anillos micríticos densos que pasan localmente a la matriz. Contrada Renuzzo, Cerdeña (4, 5). Cantera Weisslensburg, Alemania. 7. Concha micritizada de* Diplotremina? *Monte Santa Giusta, Cerdeña. 8. Fantasmas de conchas de Foraminífero reemplazadas por esparita de grano fino y rellena de micrita. Jebel el Relash, Sur de Túnez.*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to the organic-matter content of the wall, and, under a prolonged early-diagenetic stage, they tend to become structureless peloids or micrite.

Moreover the mineralogic composition of the tests also appears to control the nature of the replacing micrite: PURDY (1968) has shown that aragonitic tests are replaced by aragonite micrite whereas high-Mg calcite tests maintain the original mineralogy. Thus a different behaviour with regard to recrystallization and micritization of the tests is to be expected. Actually it is possible that after a deep micritization process the aragonitic froms «dissolve» into the sediment whereas the dense fine-grained peloids and rings would represent calcitic precursors. The ghosts of foraminifera composed of spar-grains (Pl. II, 8) could finally represent replaced aragonitic tests.

In conclusion, the preservation of most of the foraminifera tests in carbonate deposits —and thus the diversity of their associations— appears to depend on the magnitude both of micritization and recrystallization.

1. The extent of the process of recrystallization appears to be linked to the problem of the mineralogy of the carbonate production during Triassic times. The Triassic limestones are everywhere composed of microsparite probably as a result of the aragonitic mineralogy of the original lime-muds (SCHWARZ, 1975). Moreover this assump-

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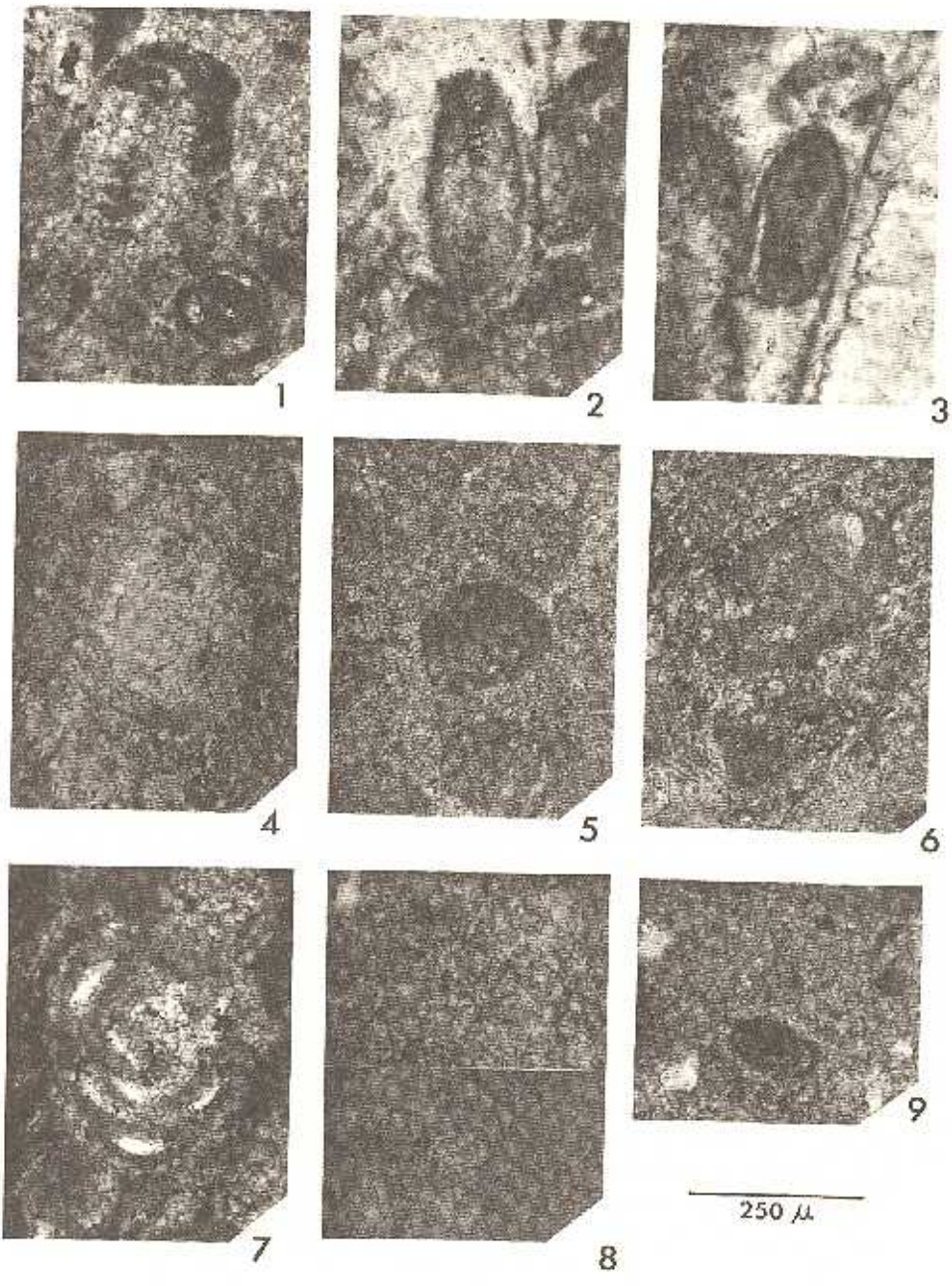
PLATE II.—*1-3. Micritized and recrystallized* Involutina *tests. Micritization and/or the filling of the chamber by lime-mud preserve some of the original structure. (1) Monte Santa Giusta, Sardinia; (2-3) Sommenberg (Saar), Germany. 4. The lime-mud filling of the chamber permits to recognise in a patch of coarse calcite the ghost of a foraminifer (Involutinidae?). Monte Santa Giusta, Sardinia. 5-6. Dense micrite peloids after micritized foraminifera. The spar filling of the chamber is the only trace of the original structure. (5) Jebel el Rehash, South Tunisia; (6) Monte Santa Giusta, Sardinia. 7. Micritized test of* Glomospirella *with spar filling of the chamber. Jebel el Rehash, South Tunisia. 8. Organized cement grains let to recognise the ghosts of small tests of* Glomospirella. *Punta del Lavatoio, Sardinia. 9. Small* Glomospirella *test marked by a thin, dense micritic coating of the walls. Bettendorf, Luxemburg.*

1-3. Conchas de Involutina *micritizadas y recristalizadas. La micritización y/o relleno de la cámara por micrita conserva en parte la estructura original. (1) Monte Santa Giusta, Cerdeña; (2-3) Sommenberg, Saar, Alemania. 4. El relleno micrítico de la cámara permite reconocer el fantasma de un Foraminífero (Involutinidae?) en una porción de calcita gruesa. Monte Santa Giusta, Cerdeña. 5-6. Peloides de micrita densa procedentes de Foraminíferos micritizados. El único resto de la estructura original es el relleno esparítico de la cámara. (5) Jebel el Rehash, Sur de Túnez. (6) Monte Santa Giusta, Cerdeña. 7. Concha micritizada de* Glomospirella *con relleno esparítico de la cámara. Jebel el Rehash, Sur de Túnez. 8. Fantasmas de pequeñas conchas de* Glomospirella *reconocibles gracias a los granos de cemento ordenados. Punta del Lavatoio, Cerdeña. 9. Pequeña concha de* Glomospirella *visible gracias a una fina y densa película de micrita sobre las paredes. Bettendorf, Luxemburgo.*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tion is consistent with the low sea level during the Triassic according to SANDBERG (1983).

2. The extent of the micritization results from the duration of this process, i.e. of the early-diagenetic stage. The rate of subsidence, controlling the duration of the early-diagenetic stage in submarine environment, therefore appears to be the ultimate factor of control on the foraminiferal preservation.

Consequently a low rate of subsidence, consistent with the reduced thickness of the Germanic sequences in regard to the Alpine ones, can explain the obliteration of most of the foraminifera in the epicontinental setting and their preservation on the fastly subsiding Tethysian borders.

DISCUSSION

The Middle Triassic carbonate deposits of the German realm appear to have been mainly muds. The poorly represented granular facies consist of bioclastic grains, the oolitic or intraclastic ones being very infrequent.

The general depositional setting corresponds to a shallow, yet under the wave base, very quiet, environment, where high-energy episodes and a more rapid deposition are connected with storms and/or tsunami (GANDIN, 1979; DURINGER & GALL, 1982) or to the local occurrence of shell banks or oolitic bars (SCHWARZ, 1975).

The general occurrence in the epicontinental Middle Triassic carbonates of intense bioturbation and concentration of fossils in few horizons, suggests a confined environment and a relatively anomalous salinity. However, the relative diversity of some associations and the abundance of echinoderms in the fossiliferous horizons suggest that at least temporarely and locally the life conditions would be more or less normal as far as temperature and salinity are concerned.

In such a low-energy depositional setting the prolonged activity of micritization can achieve the obliteration and destruction of most of the skeletal remains. The only resisting remains can be the calcite crystalline tests of pelecypods, brachiopods, echinoderms, ostracods and hyaline foraminifera (Lagenidae).

However, in the high-energy environment the micritization activity cannot attain the complete obliteration of the skeletal remains. In fact in the granular facies, rather well-diversified faunas can be found, among them foraminifera with microgranular and hyaline (aragonite or calcite) tests which are better preserved as a consequence their of more rapid deposition and burial.

The agglutinated and microgranular tests appear to be the most easily harmed, possibly owing to the occurrence of a considerable amount of organic matter in their walls whereas the hyaline calcite (Lagenidae) shells could withstand unchanged the diagenetic processes.

All these evidences suggest a confined setting and a rather normal-marine salinity of the Middle Triassic epicontinental German realm, where as a consequence of a very low rate of subsidence, consistent with the stability of the intercratonic basin, most of the carbonate skeletal material was completely destroyed by the activity of micritizing bacteria, fungi and algae.

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