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Reference

Stratigraphic potential of the Upper Triassic benthic foraminifers

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Abstract - A succession of unusually rich, well-preserved and diversified Carnian-Norian benthic foraminiferal assemblages has been found in an isolated limestone remnant of the Panthalassa Ocean (Black Marble Quarry, Wallowa terrane, Oregon). Foraminifers, including about 75% of well-known Tethyan species, show there a comparable stratigraphic distribution with Tethyan localities. The apparent synchronous occurrence of similar forms on both sides of the Panthalassa Ocean highlights the strong potential of foraminifers as stratigraphic tools for the Upper Triassic global correlations.

Keywords: Upper Triassic, benthic foraminifers, Panthalassa, Wallowa terrane.

Introduction

Upper Triassic high-resolution biochronological data are generally based on ammonites, conodonts, radiolarians or Halobia bivalves. Nevertheless, these fossils, normally abundant in slope and basins facies are rare to absent in most shallow-water deposits of isolated, epeiric and “rimmed” carbonate platforms. In such deposits, palynomorphs and foraminifers are, at a fewer level of resolution, good substitutes. However, commonly, like in our study area, Upper Triassic rocks are too altered by metamorphism to yield valuable palynological data and foraminifers represent the only fossils having the ability to provide a reliable stratigraphical resolution.

Foraminiferal studies on the Upper Triassic carbonate rocks of Tethys are numerous and have led to the construction of consistent stratigraphic and systematic frameworks. In contrast, foraminiferal investigations on coeval carbonate rocks of the wide Panthalassa Ocean are scarce, hampering biostratigraphic correlations between Tethyan and Panthalassan faunal provinces. This paper is a preliminary report on our ongoing research regarding the Upper Triassic foraminifers from the Wallowa terrane, notably aiming at defining their potential as tools for global stratigraphic correlations.

Geological overview and study area

The North America Cordillera is made up of numerous displaced terranes originated in the Panthalassa and accreted to the American continental margin during Mesozoic and Early Cenozoic time (Coney et al., 1980). The Wallowa terrane (Fig. 1), remain of a volcanic island-arc, is one of the four distinct tectonostratigraphic terranes structuring the Blue Mountains Province (Vallier et al., 1977; Silberling et al., 1984). It presents fossiliferous Upper Triassic carbonate deposits having close similarities with those from the Tethyan Realm (Stanley & Senowbar-Daryan, 1986; Stanley et al., 2008). After a long volcanic, accretional and tectonical history (Armstrong et al., 1977; Brooks & Vallier, 1978; Avé Lallemant et al., 1985; Manduca et al., 1993; Wyld & Wright, 2001; Gray & Oldow, 2005; Dorsey & LaMaskin, 2007; Dorsey & LaMaskin, 2008), the Early Permian to Late Jurassic, eight kilometer thick, Wallowa terrane stratigraphic succession is almost completely covered by the Mio-Pliocene Columbia River Basalt. Hence, the Wallowa terrane appears isolated or dismantled and crops out only in areas where tectonic, river incision or uplift and erosion of the basalt cover have exposed rocks (i.e., in the Wallowa Mountains, the Snake River Canyon and the Seven Devils Mountains).

The foraminiferal associations described below come from the Black Marble Quarry (BMQ), a lagoonal stratigraphic succession isolated in the Northern Wallowa Mountains (N 45°22’24”, W 117°21’14”) (Fig. 1 & 2). It is a thick-bedded, distinctive dark, bituminous-like micritic limestone regarded as the most fossiliferous locality in the entire region. The different levels include in situ colonial corals, chambered demosponges, hemispherical, chaetetid-like “stromatoporoid” sponges Heptastylis, branching hydroids Spongiomorpha, spireferid brachiopods and diverse mollusks, bryozoans, ostracods and echinoderms (e.g., Stanley, 1979). According to the literature, ammonites (Smith & Allen, 1941), reef-builders organisms (Stanley, 1979; Follo, 1986), foraminifers (Kristan-Tollmann & Tollmann, 1983; Stanley et al., 2008) and Wallowaconchid bivalves, that are only known in Norian age deposits (Yancey et al., 2005), point to a Carnian to Norian age for the whole sedimentary sequence. An upper Middle Norian age was assigned according to a preliminary report of Heterastridium conglobatum Reuss uncovered during preparation of a wallowaconchid bivalve (Yancey & Stanley, 1999). We here clarify this erroneous assignment based upon subsequent study which failed to confirm the identification.

Material and methods

Field work was conducted during summer of 2007, 2008
and 2009. Additionally to the collected material, we include some samples from Stuart Ashbaugh (BSc, University of Montana). Our study is based on an analysis of more than 500 thin sections from the Wallowa terrane, including about 200 thin sections from the BMQ. The extreme maturation of the organic matter has prevented any palynological preservation and attempt to extract conodonts failed. Foraminiferal assemblages and inferred age

Kristan-Tollmann & Tollmann (1983) first illustrated foraminifers from the BMQ. They only mentioned “Angulodiscus eomesozoicus” and “Diplotremina? sp.”, considering the quarry to be Carnian in age. Our study of the BMQ shows that foraminifers are there far more abundant and diversified. In fact, including 28 genera from 18 families and about 25% of new species, the BMQ holds the most complete and best preserved Upper Triassic Tethyan-type assemblage ever found in America (study in progress).

Foraminifers only teem within the firsts 44 meters of the BMQ succession (see Fig. 2). Along this portion, the foraminiferal assemblages are dominated by abundant aragonitic foraminifers, Textularoidea, rich Ammodiscidae, Duostominidae, Polymorphinidae, Oberhauserellidae and common Lagenidae. Above, the depositional setting, more energetic, seems hostile to most foraminifers and only Duostominids persist.

Although there are no lithological changes within the firsts 44 meters of the BMQ, a rapid succession of foraminiferal assemblages occur. In the lowermost part of the quarry, the association of Lamelliconus multispirus (Oberhauser), L. cucullatus di Bari & Laghi, L. depressus di Bari & Laghi,
Aulotortus ex gr. sinuosus (Weynschenk) and A. prae-gaschei (Koehn-Zaninetti) with reliable Tethyan Carnian guide fossils such as Glomospira kuthani (Salaj), Gsollbergella spirolocaliformis (Oravecz-Scheffer), Semime-androspira ex gr. karnica-planispira (Oravecz-Scheffer) and Piollina bronnimanni Martini, Rettori, Urošević & Zaninetti clearly attests a Carnian age (Salaj et al., 1983; Rettori, 1995; Rettori et al., 1998). At the top of the first 15 meters of the succession, these typical Carnian foraminifers, less and less diversified, suddenly disappear giving way to Norian forms. Indeed, within this interval, together with the appearance of Wallowaconchid bivalves, the foraminiferal assemblages evolve bed by bed and record the appearance of “Triasina oberhauseri” Koehn-Zaninetti & Brönnimann, Trocholina acuta Oberhauser, T. umbo Frentzen, Gandinella apenninica Ciaparica & Zaninetti and Aulotortus tumidus (Kristan-Tollmann). In the middle and upper part of the succession, the assemblages are characterized by a high diversification in Aulotortidae represented by Aulotortus communis (Kristan), A. impressus (Kristan-Tollmann), A. tenax (Kristan), A. friedli (Kristan-Tollmann), A. minutus (Koehn-Zaninetti) and ?Auloconus permodiscoïdes (Oberhauser), species known to be major constituent of Norian foraminiferal assemblages of Tethys (see Koehn-Zaninetti, 1969; Piller, 1978; Zaninetti et al., 1992; Velić, 2007). This interval of few meters, where the trend gradually reverses with a notable diversification of Aulotortidae that completely replace Lamelliconinae, most likely comprises the Carnian-Norian boundary (Rigaud et al., in prep.).

According to Tethyan data, it is noteworthy that in the BMQ, Norian forms such as Trocholines and “Triasina oberhauseri” Koehn-Zaninetti & Brönnimann are also encountered concurrently with Carnian guide foraminifers. The co-occurrence of Carnian and Norian forms observed in the BMQ has never been mentioned in any Upper Triassic deposits. We draw attention to the stratigraphic range of such forms that seems to span the Carnian-Norian boundary interval in the Panthalassa Ocean. Based on this observation, we demonstrate that some stratigraphic disparities could exist between Tethys and Panthalassa.

**Upper Triassic foraminifers: a potential tool for global stratigraphic correlations?**

In North America, Triassic foraminifers have been described in the Lower Triassic (Schell & Clark, 1960; Schroeder, 1968), in the Middle Triassic (Tappan, 1951; Gażdzicki & Stanley, 1983) and in the Upper Triassic (Gażdzicki & Reid, 1983; Kristan-Tollmann & Tollmann, 1983; Igo & Adachi, 1992). Foraminifers are reported from accreted terranes of Alaska, Yukon, Washington and Oregon as well as along the American paleomargin of Idaho, Wyoming and Nevada. As Kristan-Tollmann & Tollmann (1983) and Kristan-Tollmann (1988) first discussed, North American Triassic foraminifers reveal strong similarities with those of the Tethys. Furthermore, as for the BMQ, these foraminifers, the majority of which are well-calibrated by ammonites and/or conodonts, show compatible stratigraphic distribution with their Tethyan counterparts. It is here important to be noticed that the Norian foraminifer assemblages found in the BMQ present some resemblances with the foraminiferal assemblage of Lime Peak, Yukon (Gażdzicki & Reid, 1983).

Up to now, in contrast with Tethyan localities, foraminifers were thought to be rare in the terranes of North America (Gażdzicki & Reid, 1983). Our preliminary study, however, evidences that foraminifers were common and well-distributed, at least throughout the Wallowa terrane carbonate platform. Foraminifers are currently assumed to be facies dependant in both modern and ancient carbonate platforms (Piller, 1978; Martini et al., 2004; Gischler & Möder, 2009). Accordingly, in the Wallowa terrane, the foraminifer assemblages of the BMQ are partly encountered in others Upper Carnian to Norian lagoonal sedimentary successions: at the Lostine River (Oregon), Kinney Creek (Idaho) and the Mission Creek Quarry (Idaho) (see Fig. 1). At the scale of the Wallowa terrane, the wide distribution of these Carnian to Norian assemblages gets them into position of tools for further local...
biostratigraphic correlations.

In Tethys, calibrated, more or less reliable stratigraphic subdivisions of the foraminiferal distribution exist (Salaj, 1969; Salaj, 1977; Trifonova, 1978; Salaj et al., 1983; Trifonova, 1984; Oravec-Scheffler, 1987; Salaj et al., 1988; He Yan & Norling, 1991; Kamoun et al., 1997). However, since most accurate works on Carnian-Norian stratigraphy lack a foraminiferal control, the foraminifer stratigraphic value has not been fully evaluated yet. According to the literature, the Upper Triassic foraminifer radiation was a rapid evolutionary process that led to the diversification of several, stratigraphically significant foraminifers. As far as concerned the suborder Involutinina, the major constituent of the BMQ assemblage, a rapid radiation took place from the Late Ladinian, and especially during the Carnian, represented by the explosion of Lamellicioninae, and then, along the Norian, characterized by the diversification of Aulotortidae (Zaninetti, 1976). This two-step diversification is recorded along the BMQ sedimentary series and help to corroborate the Carnian to Norian age of the succession.

Rich in the BMQ, the Carnian and Norian foraminifer assemblages record from the quarry are common and well distributed in coeval deposits of the Western and the Eastern Tethyan domain (Salaj, 1969; Brönnimann et al., 1970; Zaninetti, 1976; Piller, 1978; Salaj et al., 1983; He Yan and Wang Lijun, 1990; Zaninetti et al., 1992; di Bari & Laghi, 1994; Rettori et al., 1998), demonstrating their widespread and probably global distribution in the Upper Triassic seas. For example, the BMQ Carnian foraminifer assemblages show strong similarities with those found in the type locality of the Calcare del Predl, Northeastern Italy (Rettori et al., 1998) and are close to those from the Global Stratotype Section and Point (GSSP) Ladinian-Carnian boundary candidate Prati di Stuores/Stuores Wiesen section of Northern Italy (Broglio Loriga et al., 1998; Broglio Loriga et al., 1999; Mietto et al., 2007).

As a consequence: 1) since the foraminiferal associations found in the BMQ are rich, easily recognizable, most probably worldwide distributed, and 2) taking into account the strong similitude of stratigraphic distributions between Tethys and America, we postulate that the BMQ foraminifer assemblages, well-calibrated in the Tethys domain, might be use in global correlations as indicator of the Carnian and Norian stages and may help to define the Carnian-Norian boundary.

**Conclusion**

Ammonites, conodonts, radiolarians and Halobia bivalves are markers for Late Triassic stratigraphical subdivisions. The only drawback is that shallow-water carbonates, in which these organisms are generally sporadic, are frequent in outcrops of this age. As a consequence, it is essential to erect another global biostratigraphic marker, common in shallow-water deposit.

Similar Carnian and Norian foraminifer assemblages are recognized in distant areas all over the Tethys and Panthalassa where they mostly lived in tropical shallow-water environments as a major component of the carbonate platforms. Even if world foraminiferal distribution and stratigraphic repartition must be clarified, since these foraminifer associations are common, widely distributed and well identifiable, they must be considered as relevant biostratigraphic tools.

Considering the whole Triassic, the Carnian-Norian shallow-water carbonates of Panthalassa are the most significant in term of their richness and diversity in foraminifers (i.e., in America: Rigaud et al., in prep.; and in Japan: Chablaïs et al., in prep.), offering good opportunities for future prospects.

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