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Monsoon as a cause of radiolarite in the Tethyan realm

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ABSTRACT

The radiolaritic facies (red/green cherts with radiolarians) is a very characteristic feature of the Tethyan realm. For a long time, its presence has been interpreted as a consequence of depth of an oceanic environment. It is now preferable to consider it as high productivity sediment. We here underline the interpretation inferring the role of monsoons for such productivity according to the relative position of lands at that time.

1. Introduction

Radiolarite facies are one of the characteristic features of the Tethyan Mesozoic realm, specifically in the Alpine–Himalayan orogenic belt.

During most of the Mesozoic period, the Tethyan Ocean was widely open and its greatest length was parallel to equator and close to tropical waters. Its southern edge was bordered by parallel basins and ridges, both narrow and elongated on the Arabian plate margin, while the north-western part showed a more complex pattern of smaller basins and platforms. The stratigraphy of these basins is strongly characterized by the abundance of radiolaritic facies.

Radiolaritic facies in the Tethyan realm have been thoroughly studied for 30 years. Surveys have been presented by De Wever and Dercourt (1985), Baumgartner (1987, 2013), Baumgartner et al. (1995), De Wever et al. (1994, 2001).

Since radiolarites are sometimes found associated with an ophiolitic complex, it had been proposed at the beginning of the nineteenth century (Steinmann, 1905, 1927) to be genetically associated with the silica released by volcanic activity. This idea endured for decades, even though nowadays there are no siliceous sediments along mid-ocean ridges.

Since then, this facies had initially been interpreted as a result of deposition at greater depths below the CCD (Bernoulli and Jenkyns, 1974; Bosellini and Winterer, 1975). Later, it was proposed that radiolarites would preferably be comparable with zones of high bioproductivity (and elevated CCD) such as those related with upwellings (Baumgartner, 2013; Bernoulli and Jenkyns, 2009; De Wever et al., 1994; Jenkyns and Winterer, 1982). An alternative tectonic model for the genesis of radiolarites has also been proposed (Muttoni et al., 2005), in which the siliceous deposits are controlled primarily by plate motion across oceanic zonal circulation patterns.

These siliceous facies have also been compared with some Cenozoic marine diatomaceous deposits from Peru (Pisco Formation), California (Monterey Formation) and from Sicily (Tripoli Formation). However, the main question remaining is: why these radiolaritic facies did not exist during later Cenozoic times?

We deal here successively with the contribution of radiolarians to siliceous deposits in modern oceans, and

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use these elements to understand what the conditions during pre-Cenozoic times in the Tethyan realm were like. The primary aim of this study is to discuss the importance of monsoon-driven upwelling for radiolarite deposition in the Mesozoic. We analyze the stratigraphic distribution of Mesozoic radiolarites with emphasis on the area from southern Turkey to Oman. This area is particularly interesting, because the radiolarites were deposited along the east coast of the continent; a location that is incompatible with trade winds governed upwelling.

2. Distribution of Tethyan Mesozoic radiolarites in space and time

In the Tethyan realm, radiolarites are common from Middle Jurassic to Upper Jurassic, but are also present in several places in Triassic and Cretaceous, or even Permian times (e.g., De Wever et al., 1988a,b, 1990, see Fig. 1). Conversely, Mesozoic radiolarites are missing in the central Atlantic. The most complete Mesozoic radiolarite successions (Fig. 1), reaching up to the Upper Cretaceous, are known from the Pindos–Olonos Zone in Greece (De Wever and Thiébault, 1981), Turkey (Uzuncimen et al., 2011), through Iran (Gharib and De Wever, 2010; Robin et al., 2010) and Oman (Blechschmidt et al., 2004; De Wever et al., 1988b, 1990), and continue further east to Tibet (e.g., Ziabrev et al., 2004).

The stratigraphic record (Fig. 1) shows that, regardless of the high ocean fertility, two other conditions must be fulfilled for radiolaritic facies. The first condition is sufficient depositional depth of at least a few 100 meters to allow pelagic sedimentation. The oldest radiolarites overlying shallow-water deposits are systematically related to a rifting event, as is for example the case in the Middle Triassic of the western Neotethys. The second condition is low sediment input from adjacent carbonate platforms or land areas that would dilute or completely replace autochthonous pelagic sedimentation. On Fig. 1, the columns for continental margin basins present their distal facies, but discontinuous record of radiolarites due to occasionally high input of extrabasinal material is still obvious (see, e.g., the columns for the Pichakun and Hawasina basins).

The western borders of the central Neotethys are the main paleogeographical distribution area of radiolarites along continental margin displaying the longest record known. These basins form a continuous elongated belt, which extends from the Hawasina region (Oman, Fig. 2) in the south, through Pichakun (south Iran, Neyriz series), Kermanshah (western Iran) and ends with the Koçali Basin (Turkey). The approximate length of these basins covered more than 3000 km with widths of two or three hundred kilometers. These "gutters" have been compared with the Gulf of Baja California (western part of Mexico) and the

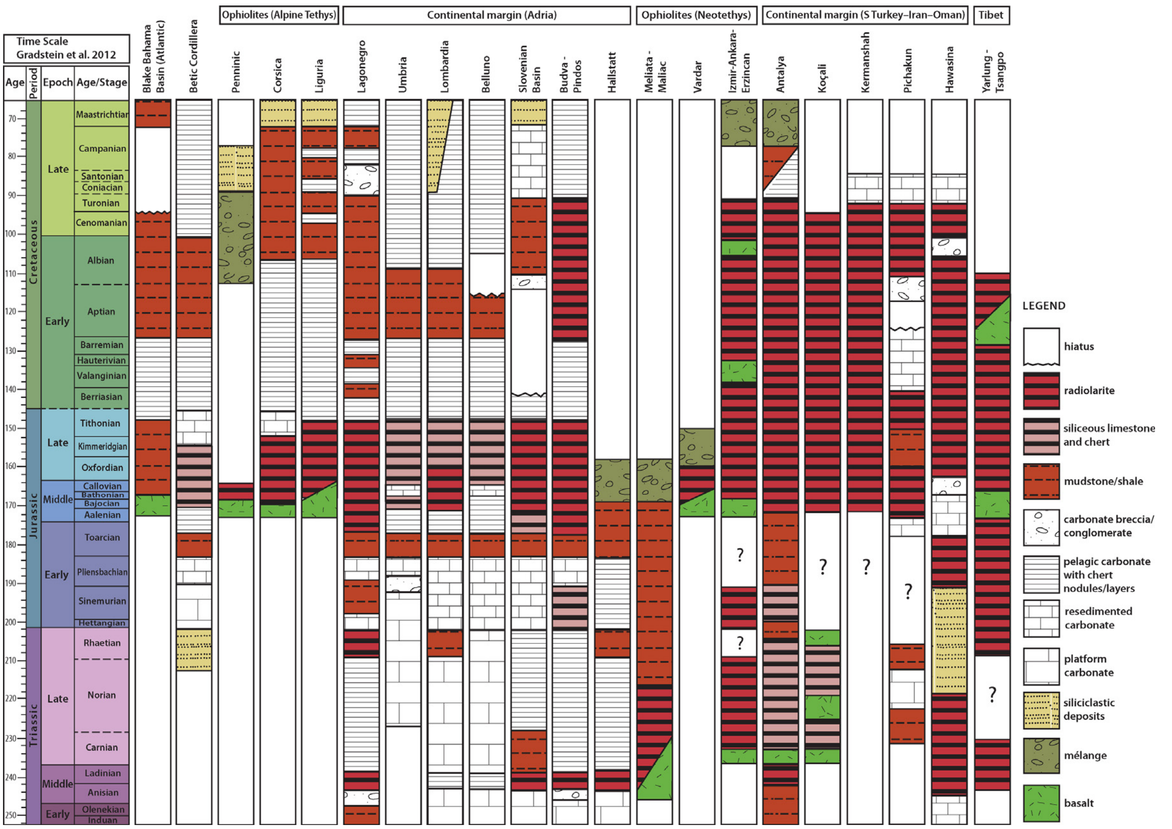

Fig. 1. (Color online.) Chronostratigraphic view showing distribution of silica-rich pelagic lithofacies through the Mesozoic. Time scale after Gradstein et al. (2012). References for the compilation of schematic lithological columns are given in annex, in the electronic supplementary material.