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Research paper

Environmental controls on growth of early scleractinian patch reefs (Middle Triassic; Silesia; Poland)

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Abstract

Anisian scleractinian corals are known from the Lower and Middle Muschelkalk of the Cracow-Silesian region, but in bioherms they occur only in the western part, i.e., in the Upper Silesian area, in the higher part of the Lower Muschelkalk (Karchowice Beds). Silesian reefs of Anisian (middle Pelsonian-early Illyrian) age are, so far, the oldest *in situ* coral reefs following the Permian/Triassic extinction. In Anisian time, Silesian corals formed a Tethys marginal reefal rim, separating offshore Tethyan open marine waters from the backreef area (Germanic Basin). The shallow-water coral-bearing facies capped sponge buildups, following a general shallowing trend in the basin. Final emersion in the early Illyrian halted coral reef growth. Anisian scleractinian corals appear to have been zooxanthellate, as suggested in Morycowa, 1988.

Keywords: Patch reefs; Scleractinian corals; Middle Triassic; Peri-Tethys; Upper Silesia; Poland

1. Introduction

Scleractinian corals are long known from the Lower and Middle Muschelkalk of the Cracow-Silesian region (e.g., Beyrich, 1852; Eck, 1865; Weissermel, 1926; Schmidt, 1928; Assmann, 1937; Morycowa, 1974, 1988, 1990; Morycowa and Szulc, 2007), but as reef components they occur only in the Upper Silesian area (Fig. 1), in the higher part of the Lower Muschelkalk, i.e., Karchowice Beds (Karchowice Formation after Bodzioch, 1997b).

The age of the Karchowice Beds, established by conodonts (e.g., Zawidzka, 1975; Narkiewicz and Szulc, 2004) and magnetostratigraphy (Nawrocki and Szulc, 2000), is Anisian, and more precisely, the interval from middle Pelsonian to early Illyrian time.

Coral reefs occurring in these sediments vary in dimension, morphology, and abundance (Fig. 2A and E). The most frequent scleractinians and reef constructors were branching *Volzeia szulci* Morycowa, lamellar *Pamiroseris silesiaca* (Beyrich) and *Eckastraea prisca* (Weissermel). Associated fauna are typically sponges, bivalves, gastropods, polychaetes, brachiopods, echinoderms (mainly crinoids), and ostracods (see Bodzioch, 1997a). Foraminiferids and microorganisms (*incertae sedis*) occasionally occur.

In the stratigraphically older Lower Muschelkalk, Gorazdze Beds (Weissermel, 1926; Assmann, 1937; Niedzwiedzki, personal com.) as well as in the Diplopora Dolomite (Middle Muschelkalk; e.g., Weissermel, 1926; Morycowa, 1988), scleractinians have been found only sporadically, as dispersed coralla or only their casts.

We provide more information on these oldest scleractinian reefs and present two examples of reefs, one from Tarnow Opolski (Fig. 2A and B) and the other from Kamien Slaski (Fig. 2E) as representative forms of Silesian reefs.

2. Materials and methods

The specimens and thin sections are housed in the Geological Museum of Institute of Geological Sciences, Jagiellonian University (coll.: UJ 34P). Only the thin sections of "*Coelocoenia* (?) *assmanni* Weisermel" (=here *Koilocoenia assmanni*) belong to the Weissermel collection, X 10136, BGR, Berlin).

We investigated macroscopic and microscopic samples of coral-bearing sediments in outcrop, as well as thin sections. Mineralogical analyses of coral skeletons were carried out

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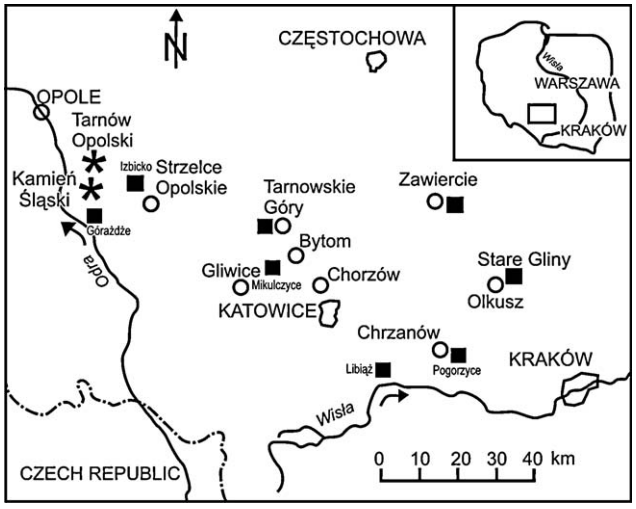

Fig. 1. Upper Silesian region. Location of scleractinian coral-bearing carbonates; limestones with corals shown by black squares; reefal limestones with corals shown by stars.

at the Institute of Geological Sciences, Jagiellonian University.

3. Palaeogeographic setting of the Cracow-Silesian region in the Northern Peri-Tethys

During Middle Triassic, the Cracow-Silesian region was situated in the SE part of the Germanic Basin (=Central European Basin). This basin, on the northern periphery of the western Tethys Ocean, was closed in the north, and open to the south (Senkowiczowa, 1962; Szulc, 2000) by tectonically controlled gates and thresholds. The threshold was dissected by deep grabens providing communication between the Tethys and the Germanic Basin.

The semi-enclosed nature of the basin resulted in distinctive environments. Open marine environments developed within the Silesian part of the basin, which we regard as an integral part of the Tethys Ocean, rather than an epicontinental sea. North and west of the Silesian domain, environments became more restricted. As indicated by faunal diversity, facies variability, and geochemical properties of the sediments during almost all of Anisian time, the eastern part (southern Polish basin) was dominated by open marine sedimentation, whereas the western part (mostly German) displayed restricted circulation, typical of the semi-enclosed, evaporitic basin.

Because the region was situated within the margins of the tropical zone (ca. 22–24° north palaeolatitude; Nawrocki and Szulc, 2000), its climate was hot and arid, favouring extensive carbonate and evaporite sedimentation. The region suffered severe subtropical storm activities, as evidenced by numerous tempestite deposits. After Ladinian time, the climate became more humid and milder, the probable result of vigorous volcanic activities within the Tethys spreading belt (Szulc, 2000).

Evolution of the southern parts of the Germanic Basin (Silesia, Holy Cross Mts., SW Germany) was influenced directly by Tethys rifting. As suggested by the timing between principal tectonic events and palaeontological evidence, the Cracow-Silesian Basin shows similarities to the Southern Alps (Szulc, 2000). Crustal motion was transmitted from the Tethys rifts onto its northern margin by reactivated Hercynian master faults. It seems very likely that the Silesian Gate and the southern Alpine Basin were influenced by the same master fault system.

4. Lithofacies succession and basin evolution of the Cracow-Silesian area in Scythian-Carnian times

The Cracow-Silesian Triassic displays a characteristic tripartition, reflecting the principal transgressive-regressive cycle. This cycle began with the Buntsandstein continental clastics, followed by marine carbonates of the Muschelkalk, and ended with continental Keuper evaporites and clastics. Conodont stratigraphy has enabled a relatively precise correlation of the Muschelkalk sequence with the alpine Middle Triassic (Zawidzka, 1975). Recently, the chronostratigraphic framework of the Silesian Triassic has been corroborated using magnetostratigraphic studies of Nawrocki and Szulc (2000). Based on integrated biostratigraphic dating and magnetostratigraphic data, the lower boundary of the Muschelkalk in the Cracow-Silesian Basin is assumed to be coincidental with the beginning of the Anisian Stage. Szulc (2000) has distinguished several third-order depositional sequences within the Muschelkalk succession, suggesting that the main Triassic transgressive phase took place in the Pelsonian interval. During this time, the Tethys margin reached as far north as Upper Silesia, where a tectonically controlled threshold separated the open ocean from the back ramp basin of the Muschelkalk Sea.

The marginal position of the Silesian threshold provided favourable environmental conditions for sponge-coral reef development. The Silesian reefs of Pelsonian-Illyrian age are the oldest known in situ coral reefs after the Permian/Triassic extinction.

With basin shallowing, the reefs of the Karchowice Beds were replaced by oncolites, dasycladacean grainstones, and finally by oolitic bars of the Diplopora Beds, representing the Middle Muschelkalk. The oolitic carbonates underwent a subsequent ephemeral emersion, giving rise to palaeosol formation, dolomitisation, karstic pavements, as well as playa clastics and evaporites. The Silesian-Moravian Gate became restricted in the uppermost Muschelkalk, while open communication persisted through the East Carpathian Gate. Shallowing trends and clastic sedimentation in the Polish Basin took place by intensive crustal uplift that occurred in the eastern basin by the end of Fassanian (=early Ladinian) (Szulc, 2000) (Fig. 3).

5. Characteristics of Silesian reefs

Anisian scleractinian reef corals were recorded from the Karchowice Beds, mainly from quarries still in operation at Tarnow Opolski (Figs. 1 and 2A and B) and from one of the old, no longer active, quarries in Kamien Slaski (Figs. 1 and 2E). The thickness of these beds in the Opole area reaches several metres (Dzulynski and Kubicz, 1971). The coral reefs occurring in these sediments vary in dimension, morphology and to a small extent in quantity of biotic components. Some of these