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Ostracods and $\delta^{18}O$ analysis in the Late Triassic of the Northern Calcareous Alps – implications for palaeotemperature and sea level fluctuations

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Oxygen isotope analysis and ostracod assemblages in the upper Kössen Formation at Eiberg section

The global mass extinction, which started in the Late Triassic and culminated at the Triassic/Jurassic boundary, has been attributed to various environmental perturbations such as rapid sea level fall, intensive volcanism, strong increase in atmospheric CO_2 concentration and marine carbonate dissolution. Recent analysis of stomatal frequency of leaf cuticles is suggestive of a strongly rising CO_2 level already during the early and middle Rhaetian (BONIS et al. 2010), which is in accordance with previous carbon-isotope studies on pedogenic carbonate nodules (TANNER et al. 2001). It seems very likely that such a strong increase of atmosphaeric CO_2 had some effect on the water temperature, particularly in shallow marine basins. The present study was intended to detect palaeotemperature changes in intraplatform basin deposits (Kössen Formation) of the Northern Calcareous Alps (Eiberg Basin) and their significance for environmental and climatical conditions in the Rhaetian by means of oxygen isotopes of brachiopod shells and microfossil assemblages. Anorganic carbon isotopes of the brachiopod shells and rock samples were also measured in order to identify other important environmental changes. This research was conducted at the Eiberg section, which is located about 3 km south of Kufstein (North Tyrol).

The Kössen Formation at Eiberg section yielded 34 ostracod assemblages. The ostracod range is very similar to the range at Ampelsbach section, which was recorded by URLICHS (1972). A comparison with the lithofacies and biofacies development in the Kössen Formation (GOLEBIOWSKI 1989, 1991) shows that the stratigraphical distribution of ostracods species is strongly controlled by bathymetric changes and that this fossil group is particularly very useful for ecostratigraphic correlations in the Kössen Formation. The lower and middle part of the Hochalm Member (unit 2) is characterized by low diverse assemblages of *Timiriaseevia ofentalensis* and *Lutkevichinella keupera*, which are indicative of a shallow lagoonal environment with salinity variations.

Relative shallow conditions are also recorded in the upper Hochalm Member (unit 3) by the occurrence of Cytheracea with distinct eye nodes (*Kerocythere hartmanni*, *Judahella andrusovi*). A distinct deepening of the environment is indicated in the lower Eiberg Member (unit 2) by the disappearance of sculptured Bairdiidae (*Lobobairdia triassica*, *Nodobairdia alpina*) and Cytheracea (*J. andrusovi*), which are adapted to shallow subtidal conditions (Mette 1999). Another environmental change is reflected by the occurrence of Healdiidae with delicate spines (*Pseudohealdia* ? spp.) which are suggestive of very calm conditions.

In the upper Kössen Formation 8 horizons with a sufficient number of well-preserved brachiopods for $\delta^{18}O$ analysis have been detected. Most of the brachiopod horizons are represented by a single species. Only the data of two horizons in the upper Eiberg Member (unit 3) were obtained from two different species and the uppermost horizon includes undeterminable fragments of different brachiopods. All material for the isotope analysis was extracted from the inner part of the secondary layer of the valves. The results of the REM analysis and Sr/Mn measurements show that all shells used for the isotope measurements were not altered by diagenesis.

The oxygen isotope ratios show a general long-term trend towards higher $\delta^{18}O$ values (+ 0.64 per mille) from the top of the Hochalm Member (unit 4) to the upper Eiberg Member (unit 3) (Elsler 2010). This $\delta^{18}O$ gradient points to a long-term decrease in water temperature in the middle-late Rhaetian of ± 3 °C. The lithofacies and biofacies development and the ostracod assemblages suggest that this temperature gradient was controlled by the bathymetric development, and there are no indications of climatically induced temperature changes. Considering a deepening of 100–150 m during the middle-late Rhaetian (Golebiowski 1989; Krystyn et al. 2005) the temperature decrease of 3 °C is rather low, which suggests that there was no deep-water circulation between the Eiberg Basin and the Tethys ocean.

Ostracods of the uppermost Kössen Formation – evidence for a sea level drop in the latest Triassic

A global sea level drop is regarded as one of the causes for the global biotic crisis at the Triassic/Jurassic boundary. The palaeobathymetric development of the North Alpine Carbonate Platform during the T/J boundary interval is, however, contrary discussed. Krystyn et al. (2005) argued for a rapid sea level drop of 150 m at the end of the Triassic which resulted in "carstification" and sedimentary break. But this "carstification" of uppermost Triassic carbonates is not recorded by meteoric diagenesis (vadose cements) and could also be a result of marine subsolution due to high CO_2 concentration (Brandner, pers. comm.).

The Triassic/Jurassic boundary is exposed in a number of sections in the western part of Northern Calcareous Alps (Hillebrandt et al. 2007; Hillebrandt & Kment 2009). One of these sections is the Schloßgraben section near Hinterriß (North Tyrol) where the uppermost 3 m of the Kössen Formation and the lowermost 2 m of the Kendlbach Formation (lower Tiefengraben Member) are exposed.

This section yielded 8 ostracod assemblages which are particularly significant for the bathymetric development in the latest Triassic. The microfaunas from marls intercalated in the uppermost limestones of the Kössen Formation are all characterized by high abundance of smooth-shelled Healdiidae (*Ogmoconcha hagenowi*) and few representatives of sculptured Bairdiidae (*Lobobairdia triassica*, *Nodobairdia alpina*). The preservation and composition of these assemblages suggest a deeper subtidal environment (below storm wave base), which is in accordance with the carbonate lithofacies. A rapid and significant shallowing is recorded by the ostracods from the top of the Kössen Formation. Fragmented shells of heavily sculptured Bairdiidae ("*Triebelina*" *bicornuta*, *Nodobairdia dentata*) are here indicative of very shallow and turbulent environments (above wave base). This interpretation is supported by high abundance of Healdiidae with very strong hinge structures (*Ogmoconcha* n.sp.1). Very shallow marine conditions in the uppermost Triassic are also recorded by the foraminifera assemblages (Hillebrandt & Kment 2009).

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