A LATE MIOCENE CLIMATE HISTORY – INSIGHTS BASED ON NEW PROXIES

Karsten F. Kroeger[1], Thomas C. Brachert[2], and Markus Reuter[3]

1 GeoForschungZentrum Potsdam, Telegrafenberg, 14473 Potsdam; kkroeger@gfz-potsdam.de
2 Johannes Gutenberg Universität Mainz, Becherweg 21, 55099 Mainz
3 Karl-Franzens-Universität Graz, Institut für Erdwissenschaften, Bereich Geologie und Paläontologie, Heinrichstr. 26, A-8010 Graz

Major events and trends in Cenozoic climate are well known from deep sea stable isotope records. Knowledge of surface conditions has been continuously increased in the past years but in many cases remains ambiguous due to the susceptibility of planktonic organisms to diagenesis on one hand and limited age resolution in shallow water sediments on the other. The present study introduces an approach which is independent from stable isotope data, integrating a refined chronostratigraphic method using high resolution Sr Isotope stratigraphy and coralline red algae as climate (water depth and temperature) indicators.

A well preserved and for shallow water deposits relatively continuous succession of Tortonian limestones rich in coralline red algae allowed us to apply both methods and to reconstruct a detailed climate history. Up to 100 m thick Tortonian deposits crop out in a 50 km^2 wide area around the city of Matala. The exceptional outcrop condition allowed reconstructing the stratal architecture. Vertical changes in lithology and biotic elements are very similar in the entire area and are interpreted to reflect change in climate and sea level.

The stratigraphy of Tortonian sediments was established using $^{87}Sr/^{86}Sr$ of pectinid shells which were screened carefully for possible diagenetic alteration during analysis. In contrast to the common approach to infer ages by plotting Sr isotope ratios on a smoothed reference curve we employed unsmoothed Sr isotope curves for reference. In contrast to the common method, which due to the short term fluctuation in seawater Sr isotope ratios has a large uncertainty in resulting ages, this approach uses the fluctuation in seawater Sr isotope that are found both in the reference curve and in the measured dataset as an additional information as outlined in Kroeger *et al.* (2007). Sr isotope curves show remarkable similarities to Atlantic $\delta^{18}O$. It thus becomes apparent that fluctuations in Sr isotope ratios also relate to glaciation-deglaciation processes as has been hypothesized by various authors (e.g. Zachos *et al.* 1999) and therefore to eustasy. Such a relationship is supported by the detection of 400 kyr cyclicities in Tortonian $^{87}Sr/^{86}Sr$ records (Sprovieri *et al.*, 2004). Therefore we propose that Sr isotope stratigraphy can also be used as an additional proxy for climate change.

Paleoenvironmental studies on Tortonian limestones were carried out by analyzing coralline red algal assemblages. Coralline red algae are susceptible to both, temperature and light intensity and therefore to water depth. By establishing relative abundances of coralline red algal associations it is possible to define ranges of temperature and water depth. Results for the studied limestone succession on Crete indicate fluctuation between warm temperate and tropical climatic conditions. As indicated by growth band measurements on *Porites* corals, mean winter seawater surface temperatures (MWSSTs) during tropical intervals are between 20 and 21°C. Minimum temperatures inferred from coralline red algae are around 14–16°C. This indicates a temperature variation of 4–7°C during the Tortonian. A conspicuous temperature minimum occurs around 9,4 Ma which coincides with a discontinuity surface with a wide regional extent, interpreted as an eustatic lowstand (Kroeger *et al.* 2007). This interval is also characterized by a minimum in $^{87}Sr/^{86}Sr$ and a maximum in $\delta^{18}O$. Between 8 and 9 Ma, on the other hand the integrated data suggest stable tropical conditions and little northern hemisphere glaciation.

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