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Carbonate and lignite cycles in the Ptolemais Basin: Orbital control and suborbital variability (Late Neogene, northern Greece)

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We recently commenced a project to investigate deep drillings as well as outcrops in the Ptolemais Basin, northern Greece, for paleoenvironmental and paleoclimate change. Specific attention is paid to mining sites Achlada, Vevi, Vegora, Amynteon, North Field, South Field, and Lava. The sediment archive comprises Upper Miocene to Quaternary continental lake deposits (up to 800 m thick) with an extended Lower Pliocene section. The Upper Miocene sections are composed of diatomaceous mud and gray marls. Pliocene lake sediments commence with the Kyrio member (lignite/grey marl), followed by the Theodoxus member (beige marl/lignite), and the Notio member (marl with intercalated sand /lignite). The limnic deposits show striking rhythmic bedding of (mostly) carbonates and lignites, reflecting orbital-induced humidity and temperature changes in this small NW-SE elongated continental basin.

First, we retrieved chronometric information by determining magnetic polarity changes on three sites as independent stratigraphic ground-truth in combination with palynological evidence and published data. Then we conducted a number of high-resolution (1 – 6 cm increment), non-destructive measurements to obtain paleoclimate proxies: photospectrometry (colors L, a, b), magnetic susceptibility, and natural gamma. Accordingly, we achieved a multi-proxy insight into paleoclimate and paleoenvironmental evolution at unprecedented temporal resolution (up to a few decades!) over long time series and at a number of key sites.

Using the newly-developed ESALab software, we conducted spectral and evolutionary spectral analysis to evaluate the cyclo-stratigraphic development. As for orbital variability, spectral power is concentrated on precession, hemi-precession, and eccentricity, with only minor impact of orbital tilt. We used this information to increase the temporal resolution of our age models by tuning as many precession (insolation) maxima as possible to carbonate minima (lignite maxima), assuming that the lignite phase is associated with maximum temperature and humidity. The reason to apply the tuning was primarily to obtain a better temporal control on the cyclicity documented in the suborbital frequency band. These higher-frequency variations provide a significant contribution and visually resemble those that have been documented for the Greenland Ice Sheet during the last glacial cycle.

Future goals of our work include the establishment of possible teleconnections to other parts of the global climate system. We would like to evaluate (i) how the aridification of the Messinian salinity crisis affected the Upper Miocene limnic record, (ii) why the lignite production was enhanced during the warm Lower Pliocene and how the link to the warm global climate might have been created, and (iii) whether the massive northern hemisphere glaciation during the Upper Pliocene might have contributed to the termination of lignite formation in the Ptolemais Basin.