Shallow lacustrine carbonate microfacies document orbitally paced lake-level history in the Miocene Teruel Basin (NE Spain)

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A cyclostratigraphic study previously showed that the 34 metre-scale mudstone - limestone cycles in the Cascante section are related to precession forcing. Petrographic analysis of successive carbonate beds now shows *ca* 100-kyr and 405-kyr eccentricity related cycling, in which deep lake conditions occur during eccentricity maxima. A modelling study corroborates geological data that lake level high-stands occur during precession minima. This phase relation is used to construct a robust astronomical tuning of the Cascante section to orbital target curves. Subtraction of the identified astronomically related (lake-level) variations from the palaeoenvironmental record at Cascante indicates a shift to deeper and more permanent lacustrine environments in the upper half of the section.

Figure 1. Photo of the siliciclastic Cascante section, capped by a thick lacustrine limestone unit. Indicated are the 34 mudstone-limestone basic cycles in the section (see Figure 3).

The Cascante section

The section is characterised by *basic cyles* that consist of red to green mudstones and lacustrine to palustrine limestones. The mudstones are deposited on a distal alluvial dry mudflat area while petrographic analysis of the limestones indicate that carbonate deposition took place in a very shallow transient to permanent lake environment (Fig. 2).

Intermediate cycling at scales of five and around twenty times a basic cycle is revealed by petrographic analysis of succesive limestone beds (Fig. 3). Precession control of the basic cycles has been proven (Abdul Aziz et al., 2004). The magnetostratigraphic control reveals that the two intermediate-scale cycles are related to the *ca* 100-kyr and 405-kyr eccentricity cycles, with lake level high-stands during maxima. Modelling results from a global climate model (Fig. 4) indicate that high lake levels might be related to excess net winter precipitation during precession minima, as indicated by Mediterranean geological data (Sierro et al 2000; Magri and Tzedakis 2000).

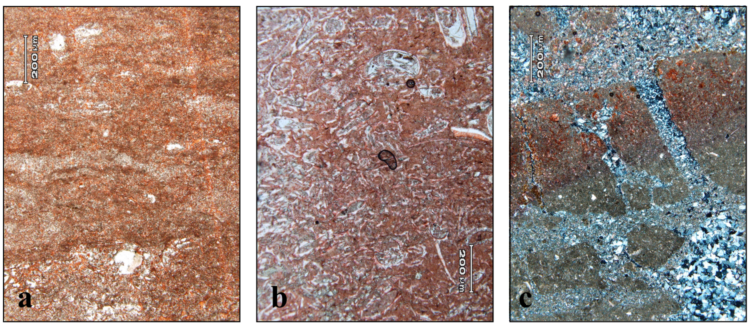

Figure 2 Examples of microfacies sub-groups (see Fig. 3) R (**a**) showing lamination of micrite and broken remains of charophyte stems and gyrogonites that are transported to (slight) deeper lake environments, B (**b**) showing abundant charophyte stem remains of which most are complete indicating low energy conditions, slight preferred orientation of micrite or bioclasts, and E (**c**) showing microbreccia with host rock and filling of cracks with micrite and gypsum, palustrine limestone, upper half red stained, XP light.

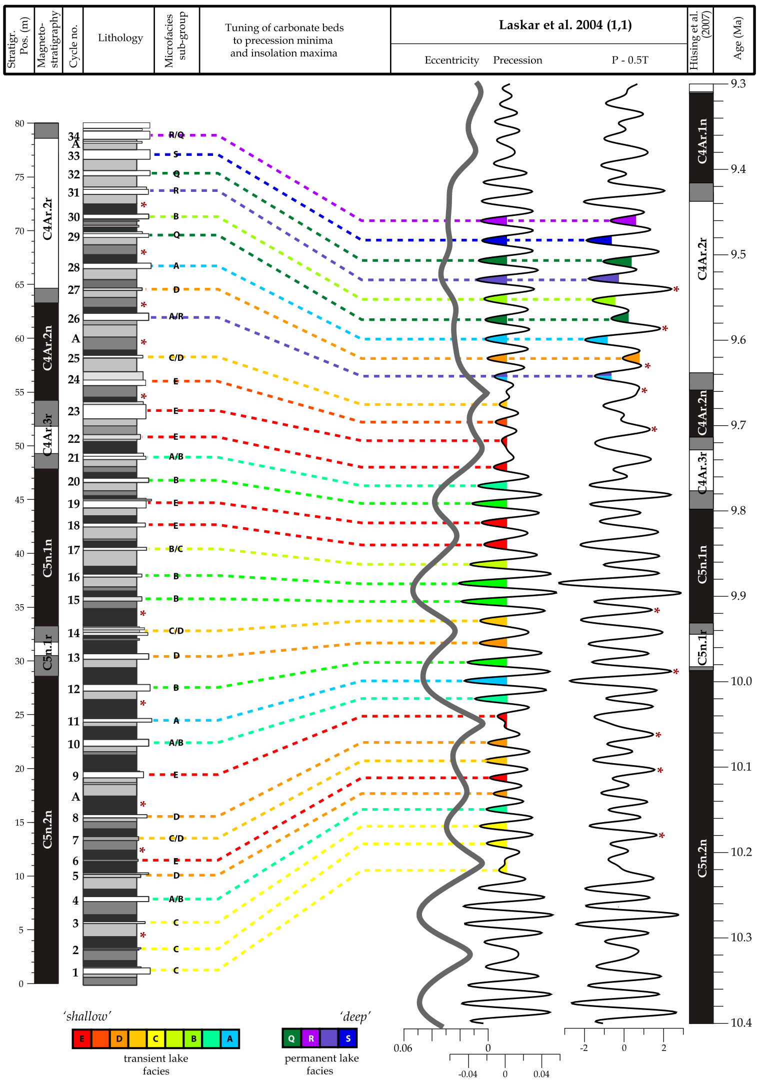

Figure 3. Magnetostratigraphy, basic cycles, lithological column of the Cascante section, petrographic interpretation in terms of microfacies sub-groups (see legend), astronomical tuning to precession target curve, and the astronomically tuned magnetostratigraphy of the Monte dei Corvi section (Hüsing et al. 2007).

Astronomical Tuning

The individual basic cycles are correlated to the precession target curve (Fig. 3). The eccentricity-related lake level variations fit perfectly with the eccentricity curve. All small- and intermediate-scale lithological variations in the Cascante section can thus be related to Milankovitch cycling. After cycle 25 limestone deposition took place in deeper and more permanent lake environments, culminating with a thick lacustrine limestone unit (Fig. 1). This shift occurs during a minimum of the 2.4-Myr eccentricity cycle, but other forcing mechanisms cannot at all be excluded at this stage.

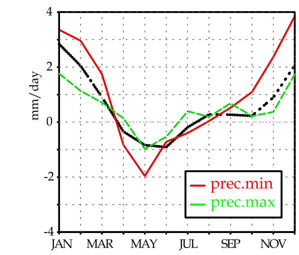

Figure 4. Simulated precipitation minus evaporation averaged for Spain using a atmospheric global climate model (SPEEDY; Hazeleger et al. 2003) of intermediate complexity coupled to a slab ocean for precession minimum (red) and maximum (green). Control run in black.

References

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