Precession-paced climate oscillations in Messinian sulphate evaporites recorded by carbon stable isotopes of leaf wax derived n-alkanes

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During the Messinian salinity crisis (MSC), the Mediterranean Sea was gradually isolated from the Atlantic Ocean due to tectonics, ultimately resulting in the deposition of enormous volumes of evaporites on the Mediterranean seafloor. In marginal Mediterranean sub-basins, the first phase of the MSC is represented by a cyclic succession of gypsum and shales (Primary Lower Gypsum unit; PLG), changing laterally into an alternation of shales, marls and carbonates towards the deeper parts of the basins. The current consensus is that the lithological cyclicity is the expression of precession-paced climate oscillations, with shales deposited during insolation maxima (precession minima) and gypsum deposited during insolation minima (precession maxima). However, this hypothesis has yet to be validated, because this assumption is primarily based on the continuation of sedimentary cyclicity from the open marine pre-MSC sediments into the Primary Lower Gypsum unit. To assess the possible role of orbitally-driven paleoclimate change on the deposition of the PLG unit, we have analysed molecular fossils (lipid biomarkers) preserved in shales and gypsum of the Pollenzo section (Piedmont basin, NW Italy).

Long-chain n-alkanes are reliable biomarkers that are used to track the input of terrestrial organic matter and allow to reconstruct paleovegetation. By using the distribution of higher plant-derived long chain n-alkanes and their compound specific carbon isotope signature (δ¹³C), we show that the sedimentary cyclicity in the PLG unit is indeed controlled by precession. Our high-resolution paleoclimatic proxy records cover approximately 300 Ka (6.003 Ma – 5.721 Ma) and comprise the onset of the MSC (5.971 Ma) and the first 12 cycles of the PLG unit. Cyclic fluctuation of δ¹³C values is observed, with higher δ¹³C values typifying long-chain n-alkanes extracted for gypsum, while lower values correspond to shales.

Our results, which represent the first paleoclimatic proxy data derived from Messinian gypsum, show that riverine flux of organic matter to the basin varied significantly during the first phase of the MSC. In agreement with a precessional control on paleoclimate, lower n-alkane abundance in gypsum reflects drier conditions, while higher n-alkane abundance in shales indicates more humid climate and increased input of terrestrial organic matter to the basin.