

Hydrology of marginal evaporitic basins during the Messinian Salinity Crisis: isotopic investigation of gypsum deposits

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The deposition of gypsum in Messinian Mediterranean marginal basins is controlled by basin restriction and the local hydrological cycle (evaporation/precipitation rates and relative importance of continental vs marine water inputs). We are using the stable isotopic composition of gypsum as a proxy of the hydrological cycle that dominated at the moment of gypsum precipitation. We studied the Messinian Caltanissetta (Sicily) and Tertiary Piedmont (north western Italy) basins where we carried out a high-resolution isotopic study of gypsum layers composing gypsum-marl cycles. These cycles are thought to be the sedimentary expression of astronomical precession cycles, lasting approximately 20 kyr, during which the marginal basins experienced a succession of arid and a wet conditions. We determined the isotopic composition of gypsum hydration water ($[U+F064]18O$ and $[U+F064]D$), of the sulphate ion ($[U+F064]34S$, $[U+F064]18O$) and of Strontium (87/86Sr), all of which are potentially affected by the hydrological cycle. In our samples, the mother water from which gypsum precipitated is considerably lighter ($-4.0 < [U+F064]18OH_2O \text{ ‰ vs SMOW} < 3.1$; $-34.8 < [U+F064]DH_2O \text{ ‰ vs SMOW} < 25.3$) than evaporated marine waters from which gypsum precipitates ($[U+F064]18OH_2O [U+F07E] 6-7 \text{ ‰ vs SMOW}$; $[U+F064]DH_2O [U+F07E] 30-40 \text{ ‰ vs SMOW}$), suggesting that the marginal basins were receiving an input of continental water during gypsum precipitation. Moreover, the degree of 18O and D-depletion is basin-specific, which is consistent with the geographical distance between the two basins and their independent local climates and watersheds. Continental water inputs are consistent also with most of the Sr data ($0.70861 < 87/86Sr < 0.70897$), and with previously published low-salinity fluid inclusion data from the same gypsum layers in the Tertiary Piedmont basin (suggesting a salinity lower than 35 ‰ in many cases). However, in the samples from the Caltanissetta basin, the sulphate ion suggests a marine water source ($20.7 < \delta 34S \text{ ‰ vs CTD} < 22.9$). Two interpretations are possible: (1) the continental waters feeding marginal basins were carrying dissolved sulphate ions originating from the dissolution of pre-existing marine gypsum deposits; or (2) gypsum deposits have undergone meteoric water diagenesis that has affected the isotopic signature of the gypsum hydration water while keeping that of the SO_4 ion unchanged. We are planning a detailed petrographic investigation of gypsum crystals to look for evidence of dissolution/precipitation processes at the micro-scale. This is an essential step in interpreting the isotopic signals of gypsum because we can expect the $[U+F064]18O$ and $[U+F064]D$ composition of Messinian continental input to be not too dissimilar from that of modern meteoric waters involved in diagenetic processes.