The geochemical riddle of Mediterranean low-salinity gypsum deposits

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Large deposits of gypsum accumulated in the marginal basins of the Mediterranean Sea during the Messinian Salinity Crisis. These form the marginal portions of the Mediterranean Salt Giant (MSG) that also occupies the deep, central Mediterranean basins. Although the marine, evaporitic origin of the MSG is undisputed, the analysis of gypsum fluid inclusions and of gypsum-bound water (δ¹⁸O_H₂O and δD_H₂O) suggest that marginal basin gypsum formed from low- to moderate-salinity water masses (5 - 60 ‰), rather than from high-salinity brines (130 - 320 ‰), as expected during the evaporation of seawater. The formation of low-salinity gypsum poses a fundamental geochemical problem: how can gypsum saturation conditions be met in marginal basins if evaporation does not concentrate marine water to high salinity? In other words, can gypsum saturation be attained by adding Ca²⁺ and/or SO₄²⁻ ions rather than by extracting water? We are exploring two geochemical scenarios to explain this phenomenon: (1) the addition of Ca²⁺ and SO₄²⁻ to marginal basins by continental runoff, and (2) the non-steady state addition of SO₄²⁻ to marginal basins via the biogeochemical oxidation of reduced sulfur. Both scenarios may lead - at least theoretically - to the decoupling of saturation state from salinity that is suggested by gypsum geochemical signatures.