Sulfur cycle and geological history of the Carnian evaporites in the Western French Alps as recorded by TSR

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Thermochemical Sulfate Reduction (TSR) is a well known reaction which commonly occurs in oil-gas reservoirs and ore sedimentary deposits. This reaction is strongly controled by the temperature and the physico-chemical conditions prevailing in the host geological environment, but also by sulfur speciation, and organic matter availability. Therefore TSR is a key reaction of the sulfur cycle in deep sedimentary environments and provides geochemical markers helping to constrain the evolution of geological settings.

In this study, we analyzed the Carnian evaporites of the Western French Alps where all the reactants and products of the TSR process are present. This makes it an ideal natural laboratory to track the sulfur cycle and the evolution of the TSR all along the history of the Western Alps orogeny. Indeed, the Carnian evaporites belong to the "Nappe des Gypse" which is a major decollement responsible for Alpine thrust sheets. Based on the analysis of i) all fluid phases present in fluid inclusions ($NaCl$-$CaCl_2$-SO_4^{2-}-S_8-H_2S-CO_2-N_2±CH_4-H_2, trapping temperature and pressure), ii) stable isotopes $\delta^{34}S$ (+15‰ for sulfates, +2‰ for sulfides and -15‰ for elemental sulfur), $\delta^{13}C$ and $\delta^{18}O$ (marines carbonates and negatives values), iii) organic matter, and iv) petrographic and structural data, we reveal that the TSR recorded major steps of the metamorphic history within the Carnian evaporites since maximum burial. Our study reveals a fluid regime reacting in closed system, within the temporal constraints brought by the successive deformation stages of the exhumation. This imposed a crucial temporal constraint on the TSR process and allow the identification of the role of each constituant which influenced the sulfur cycle in this formation.