

# Vein and Karst Barite Deposits in the Western Jebilet of Morocco: Fluid Inclusion and Isotope (S, O, Sr) Evidence for Regional Fluid Mixing Related to Central Atlantic Rifting

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## Abstract

Numerous vein and karst barite deposits are hosted by Hercynian basement and Triassic rocks of the western Jebilet in Morocco. Sulfur, oxygen, and strontium isotope analyses of barite, combined with fluid inclusion microthermometry on barite, quartz, and calcite were used to reveal the nature and source of the ore-forming fluids and constrain the age of mineralization.

The  $\delta^{34}\text{S}$  values of barite between 8.9 and 14.7 per mil are intermediate between the sulfur isotope signatures of Triassic evaporites and Triassic-Jurassic seawater and lighter  $\text{SO}_4^{2-}$ , probably derived from the oxidation of dissolved  $\text{H}_2\text{S}$  and leaching of sulfides in the Hercynian basement. The  $^{87}\text{Sr}/^{86}\text{Sr}$  ratios of barite between 0.7093 and 0.7130 range between the radiogenic strontium isotope compositions of micaceous shale and sandstone and the nonradiogenic isotopic signature of Triassic to Jurassic seawater and Cambrian limestone. The  $\delta^{18}\text{O}$  values of barite between 11 and 15 per mil (SMOW) support mixing between two or more fluids, including Late Triassic to Jurassic seawater or a water dissolving Triassic evaporites along its flow path, hot basinal, or metamorphic fluids with  $\delta^{18}\text{O}$  values higher than 0 per mil and/or meteoric fluids with  $\delta^{18}\text{O}$  values lower than 0 per mil. The general trend of decreasing homogenization temperatures and initial ice melting temperatures with increasing salinities of  $\text{H}_2\text{O}-\text{NaCl} \pm \text{CaCl}_2$  fluid inclusions trapped in barite, quartz, and calcite indicates that a deep and hot basinal fluid with salinities lower than 6 wt percent NaCl equiv might have mixed with a cooler surficial solution with a mean salinity of 20 wt percent NaCl equiv. Calcium was leached from the Cambrian limestone and the clastic and mafic volcanic rocks of the Hercynian basement. Alkali feldspars and micas contained in the Cambrian sandstones provided most of the Ba to the hydrothermal system.

Vein and karst deposits are modeled as a two-component mixing process in which the temperature and the S and Sr isotope composition of the end members changed during the 220 to 155 Ma interval. The hot basinal fluid remained volumetrically dominant during the entire mineralization process. Differences in mean S, O, and Sr isotope compositions among the barite families are interpreted as reflecting differences in mineralization age. Most barite deposits formed before the Kimmeridgian, except for north-south-oriented vein barite, karst barite, and barite cement in the conglomeratic Upper Jurassic, which were deposited later, possibly around 155 Ma.

Similar genetic processes have been described for late Paleozoic to Mesozoic F-Ba vein deposits in western Europe. The vein and karst barite in the western Jebilet of Morocco reveals a wide-scale regional mineralization event related to Central Atlantic rifting.