

Genesis of Mg-Fe Carbonates from the Sierra Menera Magnesite-Siderite Deposits, Northeast Spain: Evidence from Fluid Inclusions, Trace Elements, Rare Earth Elements, and Stable Isotope Data

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Abstract

The Mg-Fe carbonate deposits of Sierra Menera, underneath exploited goethite gossan, are located in the Iberian Range of northeastern Spain within the Late Ordovician dolomitic formation of the Sierra Menera unit. MgO and FeO contents of the carbonates range between 13.74 and 44.02 and 5.52 and 41.73 wt percent, respectively, corresponding to the breunnerite and pistomesite members. The morphology, petrographic, mineralogical, and geochemical characteristics of the Mg-Fe carbonates are consistent with a metasomatic hydrothermal origin by replacement of a dolomitic protolith as the result of the influx of hot Fe-Mg-rich fluids under acid and reducing conditions. These deposits have similarities to Alpine-type magnesite deposits (Austria, Slovakia, western Carpathian Mountains, Pyrenees) and Mississippi Valley-type Fe deposits (Basque-Cantabrian basin, northern Spain).

The Mg-Fe carbonates have normalized rare earth element (REE) patterns characterized by low light REE/heavy REE ratios and positive Eu anomalies. Dolomite rocks that host Mg-Fe occurrences have been recrystallized to saddle dolomite crystals and have less fractionated normalized REE patterns but are also characterized by positive Eu anomalies. These patterns are distinct from the pristine host dolomite, which has REE distribution typical of marine carbonates. Based on REE, fluid inclusion, and stable isotope data, the Mg-Fe carbonates are interpreted to have been formed by interaction between hot (100°–150°C), ¹⁸O-enriched, and saline (20 wt % NaCl equiv) iron-rich hydrothermal fluids and marine carbonates. Recrystallization of the host dolomite resulted from moderate to low fluid/rock ratios (<5), whereas the Mg-Fe carbonates formed at high fluid/rock ratios (>>10).

The Mg-Fe carbonates were partially replaced by late dolomite (redolomitization) due to the action of more dilute solutions. Although this event resulted in ¹⁸O depletion, REE patterns and ¹³C values of the precursors were preserved.

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