

Sr and Nd isotope data from the fluorspar district of Asturias, northern Spain

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Abstract

The origin and age of the hydrothermal fluids related to the precipitation of fluorite, barite and calcite in the Villabona, La Collada and Berbes localities (Asturias fluorspar district, N Spain) have been evaluated from Sr and Nd radiogenic isotopes. Sr isotope data ($^{87}\text{Sr}/^{86}\text{Sr}=0.7081$ to 0.7096) are compatible with mixing between seawater and a more evolved groundwater that interacted with the basement. From Nd isotopes in fluorite, an isochron age of 185 ± 29 Ma (Lower Jurassic) was obtained, consistent with other hydrothermal events in the Iberian Peninsula and Europe. These constraints are essential to proceed with a quantitative model for the genesis of the mineralization that includes fluid and heat flow together with reactive transport of solutes.

Keywords: Fluorite; Sr isotopes; Sm–Nd isochron; Hydrothermal fluids

1. Introduction

The Asturian fluorspar district (N Spain) is one of the most important in Europe. Some of the deposits in the Villabona, La Collada, and Berbes-Caravia subdistricts are currently in operation. They appear as veins cross-cutting the Paleozoic basement, and ‘mantos’ along the Paleozoic–Triassic unconformity, replacing a tectonic breccia. The paragenetic sequence is composed by quartz, fluorite (one generation; from yellow, uncolored to deep purple), barite, calcite, and late sulfides. Fluorite is more abundant towards the centre and west of the district, while barite predominates towards the

east. Coincidentally, there is a decrease in the homogenization temperatures of fluid inclusions in fluorite and quartz from the east and central areas, that is the Caravia-Berbes and La Collada subdistricts, to the west or Villabona subdistrict (García Iglesias and Loredó, 1994; Sánchez et al., 2005). Up to now, no data about the age of the deposits was available although geological constraints suggested they could form at any time from Permian to Lower Jurassic.

Similar mineralization is found in the northeast of the Iberian Peninsula (Pyrenees and Catalan Coastal Ranges); it had presumably formed from Upper Triassic to Middle Jurassic (Canals and Cardellach, 1993). Hydrothermal events of Permian age have also been identified in the central part of Spain (Central System) by Tornos et al. (2000) and Martín-Crespo et al. (2004). Therefore, the time period from Permo-Triassic to

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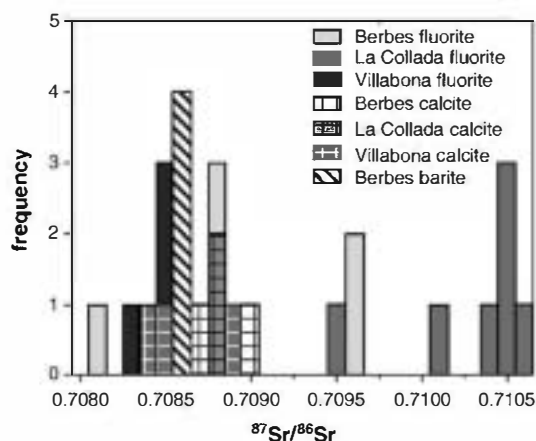


Fig. 1. $^{87}\text{Sr}/^{86}\text{Sr}$ ratios from fluorite, calcite and barite from Berbes-Caravia (eastern subdistrict of Asturias), La Collada (central subdistrict) and Villabona (western subdistrict).

Middle Jurassic seems to have been significant in the mobilization of hydrothermal fluids and generation of FBa–Zn–Pb deposits in the Iberian Peninsula.

The present work focuses on the isotopic characterization of the mineralizing fluids, as a means to constrain the paleofluid flow regime during deposition and to define the age of the deposits.

2. Analysis and results

2.1. Sr isotopes

25 samples of fluorite, calcite and barite from the Villabona, La Collada and Caravia-Berbes areas have been analyzed (Fig. 1). $^{87}\text{Sr}/^{86}\text{Sr}$ ratios show a wide range especially in Caravia-Berbes (0.7081 to 0.7096) and La Collada (0.7088 to 0.7106). Contrarily, in the Villabona area, Sr isotope values are more homogeneous (0.7083 to 0.7089). It is interesting to point out that $^{87}\text{Sr}/^{86}\text{Sr}$ ratios are higher and more variable in the easternmost deposits (La Collada and Berbes-Caravia) than those from the western deposit (Villabona) of the district (Fig. 1).

2.2. Nd isotopes

Yellow, violet and uncolored fluorites from the three subdistricts were selected for the analysis of Nd isotopes. However, only the fluorites from Villabona contained high enough Sm (1.68–3.71 ppm) and Nd (4.70–8.90 ppm) concentrations to obtain a reliable isochron. The $^{143}\text{Nd}/^{144}\text{Nd}$ vs. $^{147}\text{Sm}/^{144}\text{Nd}$ plot (Fig. 2) shows that fluorite of the Villabona area describes an isochron corresponding to an age of 185 ± 29 Ma (Early Jurassic) with an initial $^{143}\text{Nd}/^{144}\text{Nd}$ of 0.511911 ± 0.000055 .

3. Discussion and conclusions

The Sr isotopic signature of fluorite, calcite and barite from La Collada and Berbes-Caravia areas can be explained by a mixture of Sr from distinct sources with different $^{87}\text{Sr}/^{86}\text{Sr}$ ratios. The small variation of $^{87}\text{Sr}/^{86}\text{Sr}$ ratios in the Villabona deposit could also be the result of such a mixing, when the mixture was overwhelmingly dominated by a fluid of low $^{87}\text{Sr}/^{86}\text{Sr}$ ratio. This fluid source is compatible with the Sr isotope composition of seawater during the Lower Jurassic (Koepnick et al., 1990), whereas a more radiogenic source could be related to a brine that had interacted with the Paleozoic basement and/or Permo-Triassic volcanic rocks.

The higher $^{87}\text{Sr}/^{86}\text{Sr}$ ratios in minerals from the central and eastern subdistricts (La Collada and Berbes-Caravia) compared to the westernmost subdistrict (Villabona) could be due to two different reasons. The first one would involve different paths for the evolved groundwater, related to a more fractured zone of the basement in the eastern-central area that allowed deeper circulation of fluids, thus becoming ^{87}Sr -enriched. Alternatively, different mixing ratios between the fluids implicated in both areas (probably Jurassic seawater and evolved groundwater) could also account for the variable $^{87}\text{Sr}/^{86}\text{Sr}$ ratios.

The Lower Jurassic age for fluorite is consistent with one of the contributing fluids being seawater. In fact, the stratigraphic record in Asturias indicates that sedimentation in Jurassic times took place in a marine environment. On the other hand, the calculated Jurassic age for the Asturian fluorite deposits is also compatible with similar hydrothermal events in the Iberian Peninsula and Europe (e.g. Sizaret et al., 2004).

The geochemical characterization and age calculation are the first steps for building not only a conceptual

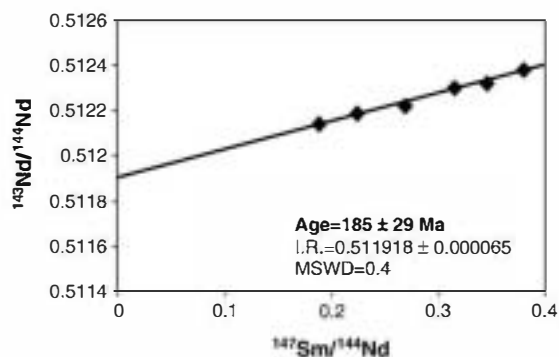


Fig. 2. Sm–Nd isochron from fluorites of Villabona subdistrict, western Asturias, northern Spain.

model for the genesis of the fluor spar district, but also for constructing a quantitative model that combines fluid and heat flow with solute transport and reaction.

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