

EXPRESS LETTER

Helium isotopic ratios in fluid inclusions from fluorite-rich Mississippi Valley-Type district of Asturias, northern Spain

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Helium isotopes have been measured in fluorite and sulphides from fluorite-rich Mississippi Valley-type (MVT) deposits from Asturias, Spain, in order to assess the involvement of mantle and crust-derived volatiles in the genesis of the deposits. The $^3\text{He}/^4\text{He}$ of the ore fluids are $\leq 0.1 R_a$ ruling out a contribution of mantle-derived magmatic helium in the inclusion fluids. Data support a crustal source for the volatiles and is consistent with the existing basinal model for the genesis of the Asturias MVT mineralization by mixing of sedimentary brines with infiltrating superficial fluids.

Keywords: fluorite, noble gases, helium isotopes, fluid inclusions, Asturias, MVT deposits

INTRODUCTION

The F–Ba (Zn–Pb) district of Asturias, northern Spain, has produced more than 15 Mt of ore since the 1970s. The deposits share the mineralogical and geochemical characteristics of Mississippi Valley-type (MVT) ores and they have many similarities with other Mesozoic F–Ba (Zn–Pb) mineral deposits in Europe, such as the Massif Central, the North Pennine Orefield and the Southwest England (Sánchez *et al.*, 2009).

The origin of fluorine in the mineralizing fluids remains an unresolved question. According to García Iglesias and Loredo (1994) the local Permian volcanic rocks are enriched in fluorine and could have been a source of fluorine in the mineralizing fluids. The age of the Villabona deposit (185 ± 28 Ma; Sánchez *et al.*, 2009) is consistent with a regional Early Jurassic hydrothermal event that appears to be coincident with the opening of the North Atlantic Ocean. Ore fluids that penetrated to mid-crust depths during extension and acquired fluorine from the contemporaneous alkaline volcanic and plutonic rocks would be expected to have an elevated $^3\text{He}/^4\text{He}$ ra-

tio. A primary aim of this study is to evaluate evidence for mantle-derived related to alkaline igneous activity within the fluorite-rich Mississippi Valley-type deposit in Asturias.

The $^3\text{He}/^4\text{He}$ of crustal helium is typically 0.01–0.05 R_a (where R_a is the atmosphere value of 1.386×10^{-6}). This is lower by several orders of magnitude than mantle-derived helium, which ranges from 5 R_a up to 50 R_a (Stuart *et al.*, 2003). Thus the helium isotope composition of hydrothermal fluids trapped in minerals, allows the contribution of mantle and crust-derived volatiles in the mineralizing fluids to be quantified (e.g., Stuart and Turner, 1992; Burnard and Polyá, 2004; Yamamoto *et al.*, 2001). Furthermore, helium isotopes are intimately linked to heat; both ^4He and heat are produced by decay of U and Th and their daughter isotopes in crustal rocks. Consequently, the flux of mantle-derived ^3He is coupled to mantle heat flow and is elevated in crustal fluids from regions undergoing extensional tectonics (O’Nions and Oxburgh, 1983). Thus, helium isotopes in fluids have the potential to acts a tracer of past tectonic setting, and can be used to quantify the heat source in hydrothermal systems (e.g., Burnard and Polyá, 2004). Here we present the helium isotopic composition of hydrothermal fluids trapped in fluorite and sulphides from the Asturias F–Ba (Zn–Pb) mineralization. The scope of this study was to evaluate the source of the volatiles, and heat, in the mineralizing fluids.

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