

Lithogeochemical Vectors and Mineral Paragenesis of Hydrothermal REE-F-Bearing Veins and Breccias in the Gallinas Mountains, New Mexico

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The Gallinas Mountains district in New Mexico showcase hydrothermal rare earth element (REE)-bearing fluorite veins and breccias hosted in Permian sedimentary rocks that formed during the emplacement of trachyte/syenite sills, dikes and breccias ~30 Ma ago. This district occurs within the Lincoln County Porphyry Belt and is part of the North American Cordilleran alkaline-igneous belt, which has produced significant amounts of gold and silver, as well as lesser fluorite and REE. The Gallinas Mountains district has recorded production of base and precious metals in the early 1900s, with later fluorite and REE production in the 1950s. The Gallinas Mountains district is a prime location to study hydrothermal REE mobilization in an alkaline system because of the well exposed geology. Rare earth elements are primarily found in the fluorocarbonate mineral bastnäsite-(Ce), which is also the primary ore mineral of several world-class carbonatite REE deposits such as Mountain Pass in California and Bayan Obo in China. In this study, a mineral and vein paragenesis was documented using petrographic observations, scanning electron microscopy (SEM)-based automated mineralogy, cathodoluminescence (CL) microscopy, and backscattered electron (BSE) imaging. Trace element chemistry of fluorite was obtained using laser ablation inductively coupled mass spectrometry (LA-ICP-MS) to characterize different types of fluorite found within crosscutting veins and track the occurrence and distribution of REE in the district. Previously collected whole-rock geochemical data allow the authors to link petrographic observations to deposit- and district-scale features, creating lithogeochemical vectors for REE and related alteration styles that may aid exploration for REE in this and other districts.

Three REE-bearing fluorite vein types have been characterized using optical microscopy, BSE imaging, SEM-based automated mineralogy, and CL microscopy. These are: Type 1 barite-fluorite, Type 2 bastnäsite-fluorite, and Type 3 calcite-fluorite veins. Three distinct fluorite generations (fluorite I-III) with unique CL signatures were distinguished in these veins.

Of these, fluorite II, found in Type 2 veins, appears to be most significant for the REE endowment as it forms fine intergrowths with bastnäsite-(Ce) overprinting fluorite I in Type 1 veins. Preliminary LA-ICP-MS analysis on fluorite indicates distinct REE chondrite-normalized profiles for each fluorite type. Fluorite I exhibits a LREE-enriched profile, fluorite II a flat LREE profile depleted in HREE, and fluorite III a LREE-depleted and HREE-enriched profile. Whole rock F and REE concentrations in fluorite veins and breccias display a positive correlation with Ba, which indicates an increase in REE mineralization associated with elevated barite concentration. This relationship corroborates the common, district-wide observation of Type 2 bastnäsite-fluorite veins overprinting earlier Type 1 barite-fluorite veins. These results indicate that F-metasomatism plays a key role in the hydrothermal mobilization and deposition of REE, which needs to be further investigated to develop additional geochemical vectors in this type of REE mineral deposit.