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

Evan J. Owen¹, Alexander P. Gysi², Virginia T. McLemore² and Nicole Hurtig¹

¹New Mexico Tech, E&ES Department, 801 Leroy Place, Socorro, NM, 87801, evan.owen@student.nmt.edu
²New Mexico Bureau of Geology and Mineral Resources, 801 Leroy Place, Socorro, NM, 87801

The Gallinas Mountains district located in Lincoln and Torrance Counties, New Mexico, is host to hydrothermal REE-bearing fluorite veins and breccias. Rare earth elements (REE) are found in bastnäsite-(Ce) ([Ce,La]CO₃F), which is also the primary ore mineral mined in several important carbonatite deposits (e.g. Mountain Pass in California; Bayan Obo in China). Minor production of REE, fluorite, Cu, Pb, Zn, Ag, and Fe has been recorded in the Gallinas Mountains district between the early 1900s and the 1950s. The REE-bearing fluorite veins and breccias are hosted in Permian sedimentary rocks as well as genetically related trachyte/syenite sills and dikes emplaced between 28-30 Ma. Previous studies have described the REE occurrences in the Gallinas Mountains, but the controls of hydrothermal processes on the transport and deposition of REE in the district remain unclear. In this study, we combine microtextural observations with mineral and whole rock chemistry of hydrothermal REE-bearing fluorite veins and breccias to determine the vein types, alteration styles, and establish a detailed mineral paragenesis. The goal of this study is to determine lithogeochemical vectors towards REE enriched zones in the district by linking thin section and deposit scale observations with mineral and whole rock geochemistry. This district is an exceptional natural laboratory for studying the role of hydrothermal processes for transport/deposition of REE in an alkaline F-rich magmatic-hydrothermal system because very few deposits worldwide have such well-preserved and exposed geology.

Hand samples of hydrothermal veins and breccias containing fluorite ± calcite ± barite ± bastnäsite-(Ce) were collected from outcrops, prospect pits, and mine dumps. Optical microscopy was used to identify minerals and determine the textural features and crosscutting relationships of the different fluorite veins. Multiple vein generations have been observed: i) early K-feldspar veins; ii) barite-fluorite ± hematite ± quartz veins; iii) bastnäsite-fluorite veins; iv) late quartz and calcite veins. Bastnäsite-(Ce) is commonly found in veins overprinting earlier barite-fluorite veins and contain barite that display dissolution textures (skeletonized crystals). Cathodoluminescence (CL) microscopy reveals at least three distinct fluorite generations with complex overprinting, including a generation intergrown with bastnäsite-(Ce). These textural observations suggest a key control of REE mineralization in the Gallinas Mountains district is by coupled dissolution of barite-fluorite veins and precipitation of later bastnäsite-fluorite veins. LA-ICP-MS analysis was performed on multiple fluorite generations to link fluorite chemistry with textural relationships. At least three distinct chondrite-normalized REE patterns are revealed, including: i) enriched LREE; ii) flat LREE with depleted HREE; iii) depleted LREE with enriched HREE. One fluorite generation seen replacing euhedra contains over 1% total REE. Geochemical whole rock data within the New Mexico Bureau of Geology and Mineral Resources database were analyzed using the IMDEX ioGAS™ program to define geochemical signatures of rock types, alteration styles, and vein types. Preliminary data analysis indicates a positive correlation between Ba, F, and total rare earth oxides (TREO). These trends corroborate with the observed vein microtextures, suggesting that the interaction of a hydrothermal fluid with the barite-fluorite veins represents a key process for defining geochemical vectors in the district.

Keywords:
critical minerals, alkaline system, rare earth elements, fluorite, hydrothermal, carbonatite, vectoring, bastnasite, barite

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