

Hydrothermal Rare Earth Elements (REE) Partitioning into Fluorite: A Fluid Inclusion Study from the Gallinas Mountains REE-bearing Fluorite Deposit, NM

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Rare earth elements (REE) are becoming increasingly important in modern society due to their numerous uses in manufacturing of components for green and high-tech energy industries. Studying the mechanisms of REE mineral formation in geologic systems is vital for understanding where and how these mineral deposits form. Previous studies of REE mineral deposits have shown that hydrothermal fluids can play a key role in the mobilization and enrichment of REE (Williams-Jones et al., 2000; Gysi et al., 2016; Vasyukova and Williams-Jones, 2018). Fluorite is ideal to study the behavior of REE because of their compatibility in its structure and it is a ubiquitous hydrothermal vein mineral found together with REE fluorocarbonates (i.e., bastnäsite and parisite). However, the controls on hydrothermal fluid-mineral REE partitioning in these deposits are not yet fully understood.

In this study, we present petrographic observations of fluorite veins and fluid inclusions from the Gallinas Mountains REE-bearing fluorite veins/breccia deposit in New Mexico (McLemore, 2010; Williams-Jones et al. 2000). The Gallinas Mountains deposit notably contains hydrothermal fluorite and bastnäsite, and is associated with ~30 Ma alkaline igneous rocks intruded into Permian sedimentary rocks (McLemore, 2010). The goal of this study is to better understand the cause of REE variations in fluorite as a function of temperature and salinity of the fluids, and to determine how the REE concentrations change in barren and mineralized veins. Optical microscopy and cold-cathode cathodoluminescence (CL) is used to distinguish different fluorite generations and fluid inclusion types. Scanning electron microscopy (SEM) is used to identify REE minerals, zonation in fluorite, and acquire elemental compositions of different vein minerals.

Fluorite samples collected in this study include sandstone-hosted (i-iv) and trachyte-hosted (v) veins/breccias that are classified into: i) bastnäsite-quartz-fluorite veins (GAL3015B); ii) barite-calcite veins crosscut by barren calcite-fluorite veins (GAL3018B); iii) barite-calcite veins crosscut by mineralized bastnäsite-(calcite)-fluorite veins (GAL3046); iv) barite-fluorite and bastnäsite-fluorite breccia and vein infills containing base metal sulfides (GAL3041A); v) bastnäsite-(calcite)-fluorite breccia (GAL3044A). Three different fluorite generations are distinguished based on CL with distinct fluid inclusion types. Fluorite 1 is euhedral and zoned, with generally bright blue to purple CL colors, and is found in bastnäsite-(calcite)-fluorite veins and breccias (samples GAL3046 and GAL3044A) as brecciated fluorite clasts and cubes with bastnäsite rimming or replacement textures in a calcite matrix. In samples GAL3015B and GAL3041A, fluorite 1 is present in bastnäsite-quartz-fluorite and barite-fluorite veins/breccias with later crosscutting finer grained fluorite ± bastnäsite infills. The later fluorite is classified as fluorite 2, which shows a green to dark blue/purple CL color. Fluorite 3 displays a bright green to lavender luminescence and forms euhedral cubes with complex growth zoning and occurs in sample GAL3018B. Another very fine-grained fluorite was distinguished in the matrix of some veins and breccias found in GAL3015B and GAL3041A, being pronounced in the vicinity of sandstone and possibly being a replacement of some of the quartz clasts, similarly observed by Williams-Jones et al. (2000).

Several types of fluorite-hosted fluid inclusions (FI) were identified including vapor (V) rich inclusions, liquid (L)+V inclusions, and L+V+solid inclusions. The L+V can be classified into two populations: high temperature inclusions with high vapor proportions between ~30-40 vol% and low temperature inclusions with smaller vapor proportions ranging between ~5-15 vol%. The next step in this study is to relate the FI petrography to the different fluorite generations, and to conduct microthermometry heating/freezing experiments to determine their salinities and homogenization temperatures.

In conclusion, the studied fluorite can be classified into different vein types depending on the presence or absence of barite, bastnäsite, calcite, and quartz. Three main different fluorite generations were distinguished but more CL work is needed to identify some of the more complex fluorite intergrowth textures and relationships. The FI petrography indicates a potential to link the fluorite types with different FI types based on their varying L+V ratios. The latter are indicative of entrapment temperatures, with inclusions with larger vapor proportions reflecting a higher fluid entrapment temperature.

References:

- Gysi, A. P., Williams-Jones, A. E., and Collins, P. (2016) Lithogeochemical vectors for hydrothermal processes in the Strange Lake peralkaline granitic REE-Zr-Nb deposit. *Economic Geology* 111, 1241–1276. <https://doi.org/10.2113/econgeo.111.5.1241>
- McLemore, V. T. (2010) Geology and mineral deposits of the Gallinas Mountains, Lincoln and Torrance counties, New Mexico: Preliminary report. New Mexico Bureau of Geology and Mineral Resources, Open-file Report OF-532, 92 p. <https://doi.org/10.58799/OFR-532>
- Vasyukova, O. V., Williams-Jones, A. E. (2018) Direct measurement of metal concentrations in fluid inclusions, a tale of hydrothermal alteration and REE ore formation from Strange Lake, Canada. *Chemical Geology* 483, 385–396. <https://doi.org/10.1016/j.chemgeo.2018.03.003>
- Williams-Jones, A. E., Samson, I. M., and Olivo, G. R. (2000) The genesis of hydrothermal fluorite-REE deposits in the Gallinas Mountains, New Mexico. *Economic Geology* 95, 327–341. <https://doi.org/10.2113/gsecongeo.95.2.327>

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