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Lead Isotope and Fluid Inclusion Investigations of the Hicks Dome Critical Mineral Resource, Illinois-Kentucky Fluorspar district, USA

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Deep drilling at Hicks Dome has defined an inferred critical mineral resource of 65.8 Mt with average grades of 15.8% fluorite, 4.8% barite, 1.3% TiO_2, 0.3% REY oxide, 0.2% Nb_2O_5, and 0.16% BeO using a fluorite cut-off grade of 10%. Fine-grained purple fluorite mineralization occurs in solution collapse breccias with a rock flour-matrix. Breccias are hosted in Ordovician to Silurian platform carbonate rocks at depths of 700-1000 m. The resource is associated with 271 Ma lamprophyre dikes and diatremes, an upper crustal magnetic anomaly, and a Th radiometric anomaly at the surface. It is hypothesized the origin for the dome and the HREE enrichment is the product of fluid exsolved from a concealed carbonatite intrusion.

SEM-EDS raw x-ray intensity maps and laser Raman spectroscopy were utilized to identify mineral phases in high grade ore. X-ray intensity maps were grouped with Aztec algorithms to form phase maps that identify fluorite, barite, Pb-Zn-Fe-sulfides, Ca-Mg±Sr±Ba carbonates, apatite, Th-REE phosphates, and Nb-Ti oxides. In-situ Pb isotope analyses of ore and gangue minerals by LA-MC-ICP-MS is proceeding to establish an isochron and to constrain the source(s) of Pb in the system.

Quartz and fluorite contain distinct secondary fluid inclusion populations. Two-phase liquid-rich inclusions are irregular to equant in shape, with a small to medium bubble. Three-phase liquid-vapor-solid inclusions are morphologically similar to the liquid-rich inclusions. Sparse vapor-rich inclusions occur with liquid-vapor inclusions in fluorite. Three-phase water-CO_2 inclusions are restricted to quartz, contain varying ratios of vapor- and liquid-CO_2 and liquid water; some assemblages contain a solid daughter mineral. Pyrite mineral inclusions are restricted to late-stage fluorite, while primary liquid-rich inclusions are present in calcite and late-stage fluorite. Microthermometric and laser Raman characterization of these fluid inclusion populations is underway to constrain the temperature, salinity, and gas compositions of hydrothermal fluids in the system.