Mineral and Melt Inclusion Constraints on the Petrogenesis of Regional Magmas and Magnetite Ore from the Pea Ridge (IOA-REE) and Boss Bixby (IOCG) Deposits, USA

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The St. Francois Mountains in Missouri, USA, preserve remnants of an eroded Mesoproterozoic caldera-complex that hosts diverse types of iron mineralization, including the Pea Ridge iron oxide apatite-REE (IOA-REE) and Boss Bixby iron oxide copper-gold (IOCG) deposits. The role of regional rhyolitic and trachytic magmatism in the genesis of these deposits remains controversial. High spatial resolution textural and geochemical analyses are essential for unraveling the complex magmatic and hydrothermal histories in the districts, before petrogenetic models may be evaluated effectively.

Our approach is twofold: (1) combine high-resolution major and trace element analyses of magnetite, feldspar, biotite, amphibole, and apatite with crystal-scale oxygen isotope data to distinguish magmatic versus hydrothermal generations of mineralization in ore and related regional igneous rocks; and (2) examine major and trace element abundances of zircon and zircon-hosted silicate melt inclusions in igneous rocks to constrain the petrogenesis, temperature, redox, halogen content, and REE endowment of magmas coincident with ore deposition. For these analyses, we selected samples representative of the magnetite ore zones from Pea Ridge and Boss Bixby, host rhyolite porphyries, and regional rhyolitic tuffs and trachytes.

Preliminary petrographic, SEM, and electron microprobe (EMP) data reveal at least three distinct generations of magnetite in samples from the ore bodies, porphyries, and trachytes:
(1) High-Ti (2–6 wt% TiO_2) magnetite that has undergone variable oxy-exsolution, forming ilmenite lamellae; (2) Moderate-Ti (1–2 wt% TiO_2) magnetite; and (3) Low-Ti (<0.8 wt% TiO_2) magnetite that contains zones of abundant, tiny (10–20 µm) mineral inclusions. No saline-silicate melt inclusions have been identified in magnetite, as reported at the Los Colorados, Chile, IOA deposit. Porphyry and trachyte samples contain original (magmatic) phenocrysts (100–500 µm) of type 1 magnetite that are typically resorbed and overgrown by a rim of type 2 magnetite, which are in turn resorbed and overgrown by type 3 (hydrothermal) magnetite. Fine-grained (10–20 µm) type 3 magnetite is also scattered throughout the matrix. Ore magnetite samples are dominated by type 3 magnetite (10–500 µm), but contain sparse relict grains (100–500 µm) of type 1 magnetite that is overprinted by type 3 magnetite. Porphyries and trachytes preserve original (magmatic) anorthitic plagioclase ($Or_1Ab_{50-29}An_{49-70}$) phenocrysts that are overprinted by secondary alkalic plagioclase ($Or_{10}Ab_{87}An_3$) and orthoclase ($Or_{94}Ab_6An_0$). Magnetite ore samples show sparse, relict trachytic feldspar phenocryst textures but contain only alkalic feldspar.

Zircon phenocrysts from regional rhyolites contain crystallized silicate melt inclusions. We performed experiments at ~1.4 kbar and ~1000°C on a subset of zircons using rapid-quench cold-seal apparatuses and have successfully homogenized melt inclusions in preparation for FTIR, EMP, LA-ICP-MS, and SHRIMP analyses, which will be presented.