High spatial resolution SHRIMP and LA-ICPMS U-Pb geochronology of Pea Ridge Fe-REE-Au deposit, USA

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Precise and accurate determination of the timing and duration of ore-forming processes is crucial for understanding the origin of deposits and placing them in a regional geologic context. The Pea Ridge iron oxide - apatite deposit in the ~1.47-1.44 Ga St. Francois Mountains terrane, southeast Missouri, USA is an endmember type in the global spectrum of iron oxide – copper - gold deposits. Abundant monazite and xenotime occur in REE-rich breccia pipes that cut the host rhyolite, magnetite ore, and alteration zones associated with the iron ore system. As revealed by CL and BSE imagery, most dateable minerals from this deposit are intergrown in a fine-grained matrix, or have numerous inclusions and/or overgrowths, thereby requiring high spatial resolution geochronology to obtain accurate age constraints on ore formation.

SHRIMP U-Pb zircon ages of 1473.6 ± 8.0 (2σ) and 1472.7 ± 5.6 Ma were obtained for the host rhyolite. Two dissolved bulk apatite samples from magnetite ore yielded TIMS upper intercept ages of 1461.3±8.3 and 1466.2±4.0 Ma and showed normal age discordance due to minor Pb loss. Micron-sized equant monazite inclusions in the apatite yielded a LA-ICPMS age of 1442±12 Ma. LA-ICPMS analysis of inclusion-free portions of pyrite (with U/Pb~0) from magnetite ore yield high radiogenic Pb isotopic values ($^{206}Pb/^{204}Pb$ up to 60), indicating redistribution of Pb during a process that was likely much younger than 1.4 Ga. Monazite and xenotime in the REE-rich breccia pipes have variable morphologies, but yielded nearly identical SHRIMP ages of 1462.5 ± 1.5 and 1462.7 ± 9.3 Ma, respectively.

Although textural evidence suggests the possibility of multiple hydrothermal events, better analytical precision than is currently achieved by LA-ICPMS and SHRIMP is required to resolve potential age variability at a finer time scale. However, our high spatial resolution dating results indicate that the hydrothermal activity responsible for mineralization at the Pea Ridge deposit post-dated volcanism by up to 10 Ma and lasted for tens of millions of years.