

## Regional Geologic Setting of the Mesoproterozoic Iron Oxide Ore Systems of Southeast Missouri, USA

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Mesoproterozoic A-type igneous rocks of the St. Francois Mountains of southeastern Missouri, USA, host several low-titanium iron-oxide deposits that variously contain copper, gold, and rare earth elements (REE). New geologic, isotopic, and geophysical studies by the US Geological Survey and the Missouri Geological Survey provide insights into the regional framework and ore genesis.

The St. Francois Mountains lie along the southeastern margin of Laurentia and are part of the Eastern Granite-Rhyolite Province that formed during two major pulses of igneous activity: an older ~1.48 to 1.45 Ga episode of volcanism and plutonism and a younger ~1.32 to 1.27 Ga episode of bimodal plutonism (gabbro and granite) that is related to the Southern Granite-Rhyolite Province. In Missouri, volcanic rocks are dominantly high-silica rhyolite pyroclastic flows, volcanogenic breccias, and associated volcanogenic sediments, plus minor amounts basalt, basaltic andesite, and high-iron trachyte. The iron ore at the Pea Ridge deposit formed between (1)  $1474 \pm 6$  Ma (age of host rhyolite, which was contemporaneous with the  $1475 \pm 8$  Ma age of host rhyolite at the Boss deposit), and (2)  $1463 \pm 4$  Ma (age of crosscutting REE-bearing breccia pipes). About 70 km south in the Ironton, MO area, the Taum Sauk Rhyolite, Grassy Mountain Ignimbrite, and Royal Gorge Rhyolite erupted at ~1466 to 1459 Ma, coeval with emplacement of the Silver Mines, Butler Hill, Knoblick, and Slabtown Granites. The younger ~1.32 to 1.27 Ga bimodal plutonic suite, previously assumed to be resurgent intrusions in the core of caldera structures (e.g.,  $1313 \pm 10$  Ma Graniteville Granite), was associated with neither the ~1.46 Ga caldera structures responsible for the volcanic rocks nor the ore-forming systems.

Textural and mineralogical evidence support a conceptual framework model in which the iron-oxide hydrothermal systems were emplaced at various crustal depths, including deeper magmatic-hydrothermal iron-oxide-apatite (IOA), shallower mesothermal iron oxide-copper-gold (IOCG), and near-surface epithermal hematite-jasperoid systems that formed in subaqueous environments. The IOA deposits (e.g., Pea Ridge, Kratz Spring, Iron Mountain, lower Pilot Knob) are magnetite-dominant. Brecciation and alteration of the host volcanic rocks was concomitant with emplacement of hydrothermal systems, resulting in textures that range from far-field (hundreds of meters) replacement "pseudobreccia" to autobreccias of the iron-oxide ores. At Pea Ridge, REE-rich breccia pipes were forcefully emplaced as phreatomagmatic post-iron orebodies. The volcanic-hosted IOCG Boss deposit is interpreted to have formed in a shallower mesozonal environment in the root zone of a caldera. The epithermal hematite-dominant jasperoid-bearing iron oxide hydrothermal systems formed in near-surface environments (e.g., Cedar Mountain) and near paleo-hot springs that debouched hydrothermal fluids enriched in Fe, Mn, Si, and trace amounts of Sb and Tl into shallow water environments (e.g., Upper Pilot Knob, Cuthbertson Mountain, Ketcherside Gap, Russell Mountain).

The Mesoproterozoic basement of southeast Missouri exhibits NW- and NE-trending steep regional gravity gradients, many linked to the buried basement architecture. All the known IOA and IOCG deposits are within or adjacent to these features. Ongoing geophysical modeling is exploring the role of these throughgoing crustal features in localizing ore-forming systems within host volcanic systems.