Iron oxide-apatite (IOA) and iron oxide-copper-gold (IOCG) deposits in southeast Missouri occur within ~1.47 Ga subalkaline volcanic rocks of the St. Francois Mountains terrane. Deposits are near the western margin of a regional crustal boundary defined by Nd model ages; basement structural control is suggested by broad spatial association of the deposits with northwest-trending gravity and magnetic anomalies. Several deposits are ~300-500 m beneath Cambrian sedimentary rocks. The IOA group includes the 136-Mt Pea Ridge, 30-Mt Iron Mountain, and 20-Mt lower Pilot Knob deposits, which are massive to brecciated bodies hosted mainly by rhyolite or andesite. Magnetite is the predominant iron oxide mineral, accompanied by minor apatite, albite, calcite, and sparse pyrite and chalcopyrite. Altered wall rocks, best developed at Pea Ridge, have zones rich in hematite, amphibole±pyroxene, K-feldspar, or quartz. At Pea Ridge, margins of the magnetite orebody contain four unmined REE-rich breccia pipes that together constitute 600,000 t @ 12% REO with relatively high HREE/LREE ratios, abundant barite, and locally high Au (to 10.8 oz/t). REE reside in monazite, with lesser xenotime and allanite. The largest known IOCG deposit is Boss-Bixby (40 Mt @ 0.8% Cu with minor Co, Au, and REE).

Detailed geochronological studies of the Pea Ridge deposits provide ages of (1) host rhyolites determined by SHRIMP U-Pb on zircon (1474±8 and 1473±6 Ma); (2) magnetite ore by TIMS on apatite and LA-ICPMS on exsolved monazite (1468±10 Ma and 1442±12 Ma, respectively); and (3) REE-rich breccia pipes by SHRIMP U-Pb on coexisting monazite and xenotime (cores 1463±3; monazite rims 1447±5 Ma), Ar/Ar on muscovite (1454±2 Ma), and Re-Os on molybdenite (1441±9 Ma). These data indicate at least two ages of REE mineralization. Fluid inclusion studies of paragenetically late quartz and barite from the Pea Ridge breccia pipes record dilute, brine, and hypersaline fluids with homogenization temperatures of 85-385°C; ion ratios of Na/Cl (~0.3-3.0) and Cl/Br (~100-4800) obtained for inclusion fluids suggest mineralization from mixtures of magmatic-hydrothermal fluids, basinal brines, and possibly metamorphic fluids. Nd isotope data (εNd1470) for igneous rocks (-3.6 to 3.7) and REE breccia pipes (2.6 to 4.9) indicate mainly depleted
mantle sources for Nd without significant contributions from older Proterozoic or Archean crustal rocks. Oxygen isotope thermometry (quartz-magnetite) gives isotopic equilibration temperatures for the magnetite assemblage of 410-680°C; sulfur isotope thermometry (pyrite-barite) yields temperatures for the breccia pipes of 180-460°C. Both the magnetite- and breccia-forming fluids carried isotopically heavy sulfur (~8 per mil), which implies sulfur derivation partly from a non-magmatic source.

The geological settings and nature of the IOA and IOCG deposits in southeast Missouri are similar to those in the Stuart Shelf region of South Australia and the Norbotten-Kolari region of northern Sweden and adjacent Finland. Significant potential exists for undiscovered REE-rich IOCG deposits in southeast Missouri, hidden under Cambrian sedimentary rocks. A new high-resolution airborne magnetic and gravity gradiometry survey flown over the Pea Ridge, Bourbon, and Kratz Spring deposits provides key geophysical data on basement rocks and mineral deposits, and will greatly improve the exploration framework of the region.