

Shallow to Deep Crustal Controls on Localization of Mesoproterozoic Iron Oxide Copper-Gold-Rare Earth Element Deposits in Southeast Missouri (USA): Evidence from Gravity and Magnetic Data

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Insights into mantle and crustal architecture and composition that may have influenced emplacement of iron oxide-copper-cobalt gold, iron oxide apatite (IOA), and IOA-rare earth element (IOA-REE) deposits in southeast Missouri are provided by regional aeromagnetic and ground gravity data and high-resolution airborne gravity gradiometry and magnetic data. The deposits are hosted in Mesoproterozoic granite-rhyolite rocks of the St. Francois Mountains terrane. Among the dozen known deposits and prospects, the largest and potentially most economic are concealed beneath 250 to 400 m of Paleozoic sedimentary strata.

Regional gravity and aeromagnetic data for the conterminous United States have been filtered to create two depth slices: a mid-crust layer and a deep crust-mantle (DCM) layer. Pseudo-geologic maps produced from the gravity and magnetic slices are used to map physical property domains separated by boundaries similar to geologic contacts. The boundaries surround the density or magnetization domains with average gravity and magnetic anomaly values within. The average values are relative to apparent densities and magnetizations.

The deep crust/mantle layer shows two major density/magnetization domains separated along a generally N-S trending boundary. The DCM west side is characterized by low-density, high-magnetization rock juxtaposed to higher-density, lower-magnetization material on the east. All of the iron oxide, IOA-REE, and IOCG deposits are located over the low-density, high-magnetization west domain. The N-S boundary is close to and parallels an Nd isotope demarcation that suggests a major crustal boundary between older source rocks that separated from the depleted mantle (TDM) at $TDM \geq 1.55$ Ga on the west, from younger rocks ($TDM \leq 1.55$ Ga) on the east.

Orientation of major crustal features shifts from an N-S direction in the deep crust to a northwest trend in the mid crust. A major NW-trending contact, which separates higher-density and magnetic material on the northeast from lower-density and nonmagnetic material on the southwest, is present in both the mid-crust gravity and magnetic slices. All of the iron oxide deposits occur over or very near the mid-crust higher-density and high-magnetization domain.

Three-dimensional models produced from high-resolution airborne magnetic and gravity gradiometry (AGG) data define the geometry and depth extent of the uppermost parts of the iron oxide deposits. Data come from two high-resolution surveys that were flown in 2014 over four known deposits, all of which have no surface expression. Combining the data allowed us to relate magnetic and gravity patterns and their intensity to magnetite and hematite alteration in two and three dimensions. Prospectivity maps are developed that identify the four known deposits but also delineate new targets for iron oxide deposits. The high-resolution data also allow for testing of various models to determine how “rooted” the deposits are with respect to the physical property domains mapped in the middle and deeper crustal layers.

Our results provide regional- to deposit-scale geophysical frameworks for evaluating the exploration potential of hidden iron oxide deposits in Mesoproterozoic rocks of southeast Missouri. This approach may be useful to other terranes where regional geophysical data are available.