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Rock physical properties related to mineral systems: linking mineralogy and lithology with petrophysics

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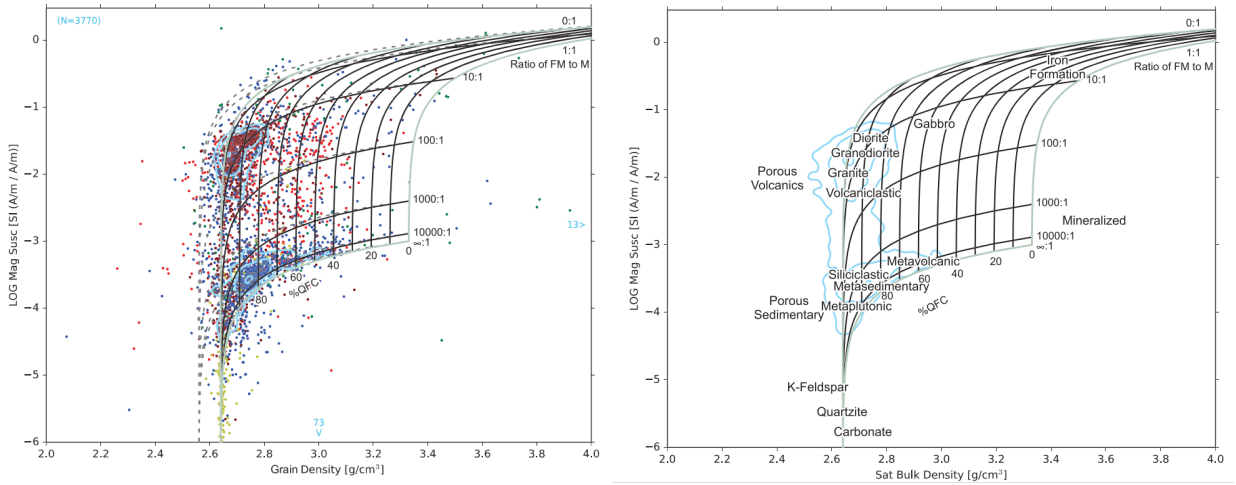
Summary

Effective geophysical mineral exploration requires an integrated approach to understanding the geochemistry, mineralogy, lithology, and geological processes that form the deposit system. We move beyond simple categorization of rock types according to their physical properties, to developing mineral models and interpreting geological processes in terms of physical properties that can be measured in the laboratory and determined from geophysical surveys. In this paper, we focus on density and magnetic susceptibility. These properties are dominantly controlled by the concentration and oxidation state of iron, which directly related to the rock's geological environment and history (Enkin et al., 2020).

Observations and Theory

The Henkel (1976) plot, i.e. the cross-plot of the logarithm of magnetic susceptibility against density for rock samples, reveals contributions from the constituent minerals and the imprint imposed by a variety of geological settings and processes. Enkin (2018) compiled many Henkel plots from around the world, as well as several based on various aspects of the Canadian Rock Physical Property Database (CRPPD). The remarkable property all these plots have in common is that most of the measurements fall on two relatively well-constrained bands, which Henkel (1991) recognized and named the "paramagnetic trend" and the "magnetite trend".

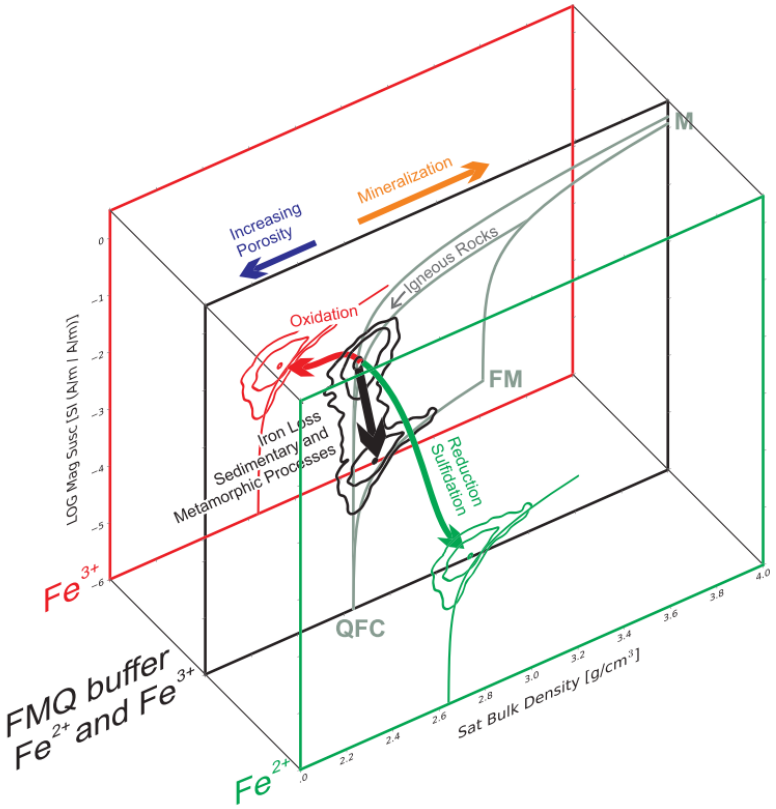


Trends on the Henkel plot can be quantitatively analysed in terms of mixing models for the groups of minerals which control their physical properties. Most common non-porous and non-mineralized rocks are described as combinations of three end-member groups of minerals (QFC-Quartz-Feldspar-Calcite, FM-Ferromagnesian silicates, M-Magnetite). The magnetite trend

approximates the FM:M = 10:1 mixing model. The paramagnetic trend lies along the FM:M = 10000:1 mixing model.

Igneous rocks usually form in the crust under the Quartz-Fayalite-Magnetite oxygen buffer. Given the typical 1-15% iron concentration, igneous rocks usually form with magnetite concentrations between 0.1 to 1% (by volume) and FM:M ratios between 3 and 30. Most geological processes, be they sedimentary, metamorphic, alteration or mineralization, are magnetite destructive.

Applications



We discuss the analysis of gravity and magnetic field surveys using our mineral mixing models in mineral deposit settings, including the Highland Valley Copper porphyry copper deposit, and the Great Bear Magmatic Zone – host to several Iron Oxide Copper Gold and related deposits.

References

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