Influence of Mineralogy, Texture, and Grain Size on Density and Magnetic Susceptibility Within the Kiruna Mining District, Sweden

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The shift to fossil-free energy systems will lead to increased demand for minerals used in clean-energy technologies. In addition, the decelerating rate of new shallow ore deposit discoveries further amplifies the challenging circumstances for mineral exploration that must focus on deeper exploration targets. As improving our understanding of the deeper underground becomes more important, reliance on geophysical exploration techniques increases. In greenfield exploration or areas without dense drill hole coverage, the geological understanding of the subsurface is limited and the interpretation of geophysical responses requires a good understanding of the physical and chemical properties of the rocks. Petrophysical characterization of the lithological units serves as a link in integrating geophysical models and understanding their geological implications.

The Kiruna mining district is situated in northern Sweden and is recognized as the type locality of the Kiruna-type iron oxide-apatite (IOA) deposits, hosting the Kiirunavaara orebody. The stratigraphic sequence constitutes well-preserved Rhyacian greenstones followed by Orosirian volcanic, volcanoclastic, and sedimentary rocks, affected by low-grade metamorphosis. Based on 32 outcrop samples, we investigated the signatures of density and anisotropic magnetic susceptibility in accordance with lithology, secondary geological processes, location, and porosity within the Kiruna mining district. The bulk (modal mineralogy), grain, and texture control of the samples were studied using whole-rock lithogeochemistry, micro-X-ray fluorescence, and X-ray computed tomography. Crossplots of density and magnetic susceptibility values result in clusters corresponding to specific lithological units, while alteration zones can be effectively recognized if the spatial location of the samples is considered. The resulting characterization of the local lithologies supports the analysis of geophysical measurements in combination with geological information and facilitates the integration of the local geological framework with geophysical surveys. Furthermore, integrated characterization of an active mining district serves as a base for further development of exploration campaigns in similar geological settings.