

Unlocking the Potential of Predictive Geoscience Through the Adoption of GeoData Science

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The mineral value chain is an evolutionary and complex system that is currently subject to changing internal or external drivers or evolutionary pressure. One major driver is the increasing demand in quantity and velocity of critical raw materials (CRMs). The mineral value chain is evolving to adapt to the evolutionary pressure through several axes of integration. Two key axes are emerging—across (e.g., predictive geometallurgy and material fingerprinting) and transdisciplinary (e.g., GeoData Science) techniques within the mineral value chain.

Innovation and integration along these axes can exhibit an evolutionary characteristic, which gradually adapts primarily traditional processes, or a transformative characteristic, which creates entirely new processes that expand the niche or scope of traditional domains. We demonstrate transformative integrations of transdisciplinary methods using geochemical exploration, geologic modeling, and mine/metallurgical waste valorization. We provide examples of challenges and rewards in our journey and identify potential solutions.

A major challenge in GeoData Science is the hidden bifurcation of traditional notions of data quality and modern purposes. This challenge encompasses data engineering and specification, scientific philosophies, and the distinction between evolutionary versus transformative integration of transdisciplinary techniques. However, we demonstrate that these challenges can be overcome with the aid of legacy data and discipline knowledge, scientific philosophies, and creative thinking. We share examples of the deployment of predictive geosciences from geochemical exploration (Trans-Hudson orogen and Churchill province, Canada), mineral resources estimation, and predictive geometallurgy (Witwatersrand Basin and Bushveld Igneous Complex, South Africa). Using predictive geoscience, those working in the field can make significant improvements in the sustainable management of CRMs, leading to an efficient and sustainable future.