

AI Approaches for Geological Mapping: From Lithological Prediction to Geophysical Modelling

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Geological mapping relies on the integration of diverse datasets, including remote sensing, geophysical surveys, and field observations. With recent advances in artificial intelligence (AI), there is growing potential to improve how these data are interpreted and translated into geological maps. However, many of these approaches remain at different stages of development and are often explored independently.

Here, we present a set of ongoing and completed research efforts that explore how AI can be applied to geological mapping and modelling.

We introduce a deep learning approach for predictive lithological mapping based on the Spatially Constrained Bayesian Network (SCB-Net) [1], which integrates remote sensing data with field observations to generate spatially consistent lithological maps while quantifying uncertainty. The method has been tested on datasets from northern Quebec and demonstrates improved accuracy compared to conventional architectures, while ensuring consistency with field data.

We also present ongoing work on deep-learning-based inversion of magnetic data [2], aiming to recover three-dimensional subsurface physical properties. This approach incorporates physics-informed constraints to reduce the non-uniqueness of inversion and improve geological interpretability.

Finally, we outline ongoing research in predictive modelling for mineral prospectivity [3], which integrates geological, geochemical, and geophysical datasets to estimate the spatial likelihood of mineralization and associated uncertainty.

These projects are developed as complementary efforts addressing key challenges in geological mapping: prediction of surface geology, reconstruction of subsurface structure, and identification of mineral potential. Together, they highlight both the potential and current limitations of AI in geological mapping, particularly in terms of data integration, uncertainty quantification, and transferability across regions.

[1] dos Santos, V. S., Gloaguen, E., & Tirdad, S. (2025). Lithological mapping using Spatially Constrained Bayesian Network (SCB-Net): A deep learning model for generating field-data-constrained predictions with uncertainty evaluation using remote sensing data. *Computers & Geosciences*, 204, 105964.

[2] Tirdad, S., Bellefleur, G., Yrro, F., Bavand Savadkoohi, M., and Gloaguen, E.: Toward Robust Three-Dimensional Magnetic and Gravity Inversion Using Deep Learning, EGU General Assembly 2026, Vienna, Austria, 3–8 May 2026, EGU26-1760, <https://doi.org/10.5194/egusphere-egu26-1760>, 2026.

[3] Gosselin, E., Gloaguen, E., & Tirdad, S. (2025). HANDLING MISSING GEOCHEMICAL DATA FOR PREDICTIVE MAPPING OF VMS DEPOSITS: A CASE STUDY OF THE BATHURST MINING CAMP (NB, CANADA). *Geoscience Canada*, 52(2).