Integration of geophysical and remote sensing data with AI for targeting mineral exploration in Northern Ireland

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Project Highlights:

- Integrate the wealth of geophysics, remote sensing and other geoscience data available in Northern Ireland to focus prospective areas for more detailed mineral exploration
- Develop models using a range of techniques guided by supervisors with a wide range of expertise
- Apply cutting-edge AI approaches and develop novel and informed exploration strategies

Overview:

A range of materials, including metals, are needed to support the energy transition and a substantial amount of that is predicted to come from new mineral deposits. The exploration and production of these resources in a sustainable manner is critical to this process. This project addresses this requirement by developing approaches to highlight prospective areas based on pre-existing or remote sensing data prior to more local investigations.

Gravity, magnetic, electromagnetic, radiometric and remote sensing data have long been mainstays of geophysical mineral exploration. Whereas some mineral deposits can be identified directly from these data sets, most depend on building a structural and geological model based on magnetic, gravity and other data together with ground truthing.

A wide range of techniques have been developed to extract geological features and signatures (including structures and depths) from each of these techniques. The data sets are commonly recognised as being complementary and they are often used together in GIS settings, but extracting optimum results from multiple techniques can be cumbersome.

The approach to be used in this study is to make use of existing knowledge of the geology, mineralogy and ore prospectivity of Northern Ireland to guide development of approaches which can be applied more widely.

The extensive and detailed Tellus database for Northern Ireland includes magnetic, electromagnetic, radiometric and geochemical data sets and provides an ideal resource for this approach. Additional associated data sets (e.g. gravity) and generally available multispectral remote sensing data (e.g. Sentinel-2) provide wide-ranging opportunities.

The investigations can include enhancement products to highlight mineral potential using combinations of existing techniques, but also the application of AI algorithms. In this regard, Convolutional Neural Networks with attention mechanisms have been successful in identifying geology and will be applied here to focus on mineral prospectivity.

If regional analysis indicates prospective locations, limited field investigation (e.g. geophysical survey or geological mapping) could be used to assess the results.

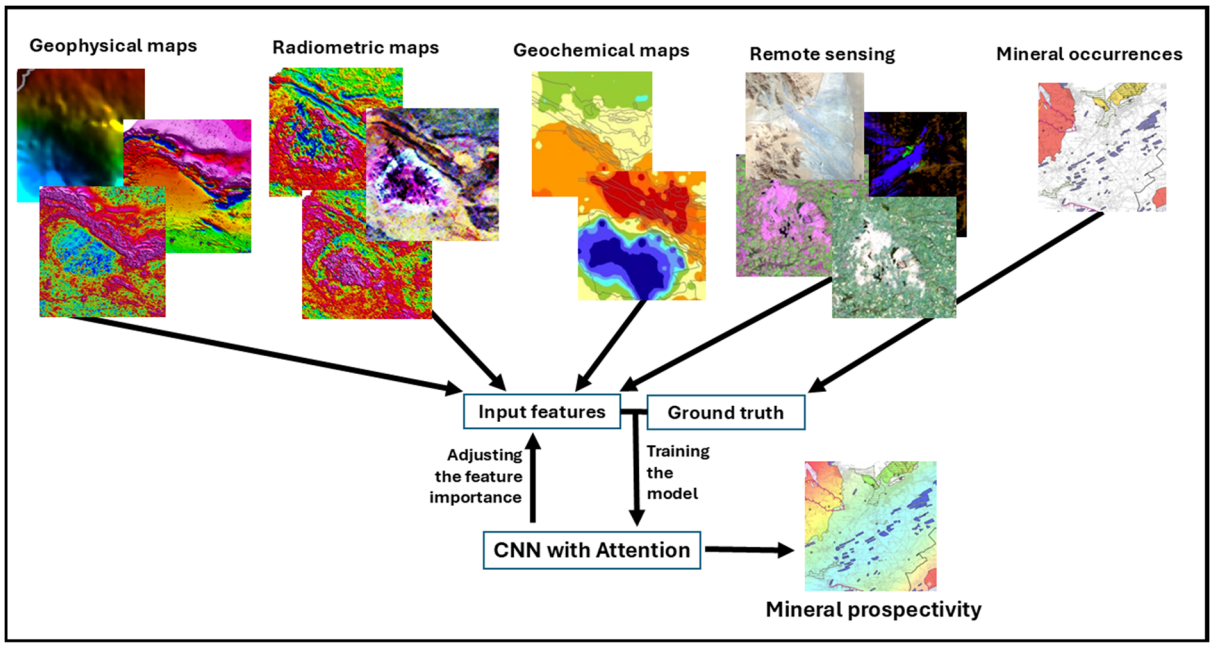

Figure 1: Schematic process: a range of geoscience data (geophysics, radiometrics, geochemistry, remote sensing, known mineral occurrences) are integrated through AI to predict mineral prospectivity.

Methodology:

Initial work will require assembling and developing familiarity with the various data sets and understanding the capability, resolution and limitations of each.

Application of a wide range of processes to these data will identify a variety of structural and geological features; these can be combined with existing knowledge to build geological models and possibly high-grade potential target areas.

In addition to this, AI approaches (particularly CNN with attention mechanisms) will be applied to the various data sets. Some of the enhancements and outputs from the process-oriented approach can also be incorporated at this stage.

Based on these results, small-scale field work (geological or geophysical) could be applied to investigate features of interest.

Possible Timeline

Year 1: Assemble data sets and investigate their properties. Apply enhancement processes to highlight features of interest

Year 2: Integrate original and enhanced data to generate and modify geological models. Apply AI algorithms to multiple data sets

Year 3: Integrate results of both approaches independently and together to build prospectivity models. Test ideas in the field where feasible.

Training and skills:

TARGET researchers will participate in a minimum of 40 days training over the 3.5 years of study composed of:

- an annual one-week workshop dedicated to their year group, and tailored to that cohort's needs in terms of skills development – *for the first three years of their study*;
- an annual all-TARGET workshop with cross-year interactions, advanced training and opportunities to specialise in particular areas – *all years of study*;
- a number of one-day workshops;
- additional online events and in-person workshops attached to relevant conferences.
- access to and support with modules in geoscience and data science at the University of Leeds

Partners and collaboration (including CASE):

Leeds supervisors have a range of expertise, particularly in ore geology, structural geology, geophysics and AI. GSNI supervisors have in-depth understanding of the geological context in Northern Ireland together with a detailed knowledge of the available data sets. The successful applicant will work together with both these groups making use of this broad resource with regular group meetings and visits to Northern Ireland to develop local insights. There should also be the opportunity to work with partners to investigate highlighted features using small scale fieldwork.

Further reading:

- KUMAR, C., CHATTERJEE, S., OOMMEN, T. & GUHA, A. 2020. Automated lithological mapping by integrating spectral enhancement techniques and machine learning algorithms using AVIRIS-NG hyperspectral data in Gold-bearing granite-greenstone rocks in Hutti, India. International Journal of Applied Earth Observation and Geoinformation, 86, 102006.
- SHAW, J.I., TORVELA, T., COOPER, M.R., LESLIE, G. & CHAPMAN, R., 2022. A progressive model for the development of the Cavanacaw Au–Ag–Pb vein deposit, Northern Ireland, and implications for the evolution and metallogeny of the Grampian Terrane. Journal of Structural Geology 161, 104637.
- SHIRMARD, H., FARAHBAKHSH, E., MÜLLER, R. D. & CHANDRA, R. 2022. A review of machine learning in processing remote sensing data for mineral exploration. Remote Sensing of Environment, 268, 112750.
- YENNE, E. Y., GREEN, C. & TORVELA, T. 2024. Implications to basin evolution from the interpretation of superficial and buried geological features from remote sensing and magnetic data sets, Lower and Middle Benue Trough, Nigeria. Results in Earth Sciences, 2, 100029.

Further details:

Please visit https://target.le.ac.uk/ for additional details on how to apply.

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