Tracking critical minerals using ice sheet dynamics

Lead supervisor: Prof. Matteo Spagnolo, University of Aberdeen

Co-supervisors: Dr Lorna Linch, University of Brighton (TARGET Institution); Riley Mulligan Ontario Geological Survey; Prof. Brice Rea, University of Aberdeen; Assoc. Prof. Martin Ross, University of Waterloo, Canada; Assoc. Prof. Chris Yakymchuk, University of Waterloo, Canada

Project Highlights:

- Critical mineral dispersal
- palaeo ice sheet dynamics and glacial sediment prospecting
- 4-month OGS supported field mapping and sampling campaign

Overview:

Critical mineral exploration across metasedimentary rock belts in formerly glaciated settings is both challenging and fascinating, as it requires unravelling the complex interaction of highly variable: (i) bedrock properties (e.g., physical and compositional characteristics), (ii) topography, and (iii) glacial dynamics (sediment transport, mixing and deposition, coupled with multiple ice flow directions). It is this complex interaction that ultimately determines the down-flow glacial sediment composition and dispersal trains derived from outcrops containing critical minerals, and their pathfinder elements and minerals.

This project, which brings together a range of supervisory expertise and the Ontario Geological Survey, will cover a portion of the Grenville Province Central Metasedimentary Belt of the Canadian Shield (southeastern Ontario). This region is selected due to ease of access for field research, an intriguing glacial history, as well as the multiple occurrences of rare earth elements (e.g., Easton 2016), past gold and uranium mines, historic graphite mines and advanced prospects, copper-nickel PGE mineralisation, molybdenum (e.g. Mancini, 2022), barite, bismuth, chromium, fluorspar.

The project will focus on glacial surficial deposits (drift) prospecting, which is a crucial component of mineral exploration in glaciated landscapes. Drift sampling in southeastern Ontario was undertaken in the 1980s (Kettles and Shilts 1983), but this legacy data is insufficient to address current exploration and research needs. Furthermore, the recent release of lidar data provides a new opportunity to reconstruct the evolution of past ice flow (direction, slow vs. fast, etc.) throughout the last glaciation, in order to better constrain previous conflicting reports and overall glacial dynamics (e.g., Ross et al. 2006). This is crucial to understand glacial dispersal patterns and establish links between drift geochemical anomalies and the locations of mineralized source rocks (Paulen and McClenaghan 2017). The work will be conducted with the agreement, following consultation, of indigenous (First Nations) communities and other stakeholders, who are keen to better understand ongoing issues related to geohazards (e.g. flooding), pollution from historic mines, land-use and climate changes.

This project will be relevant to exploration across many glaciated regions in Canada, USA, Scandinavia, UK, etc.

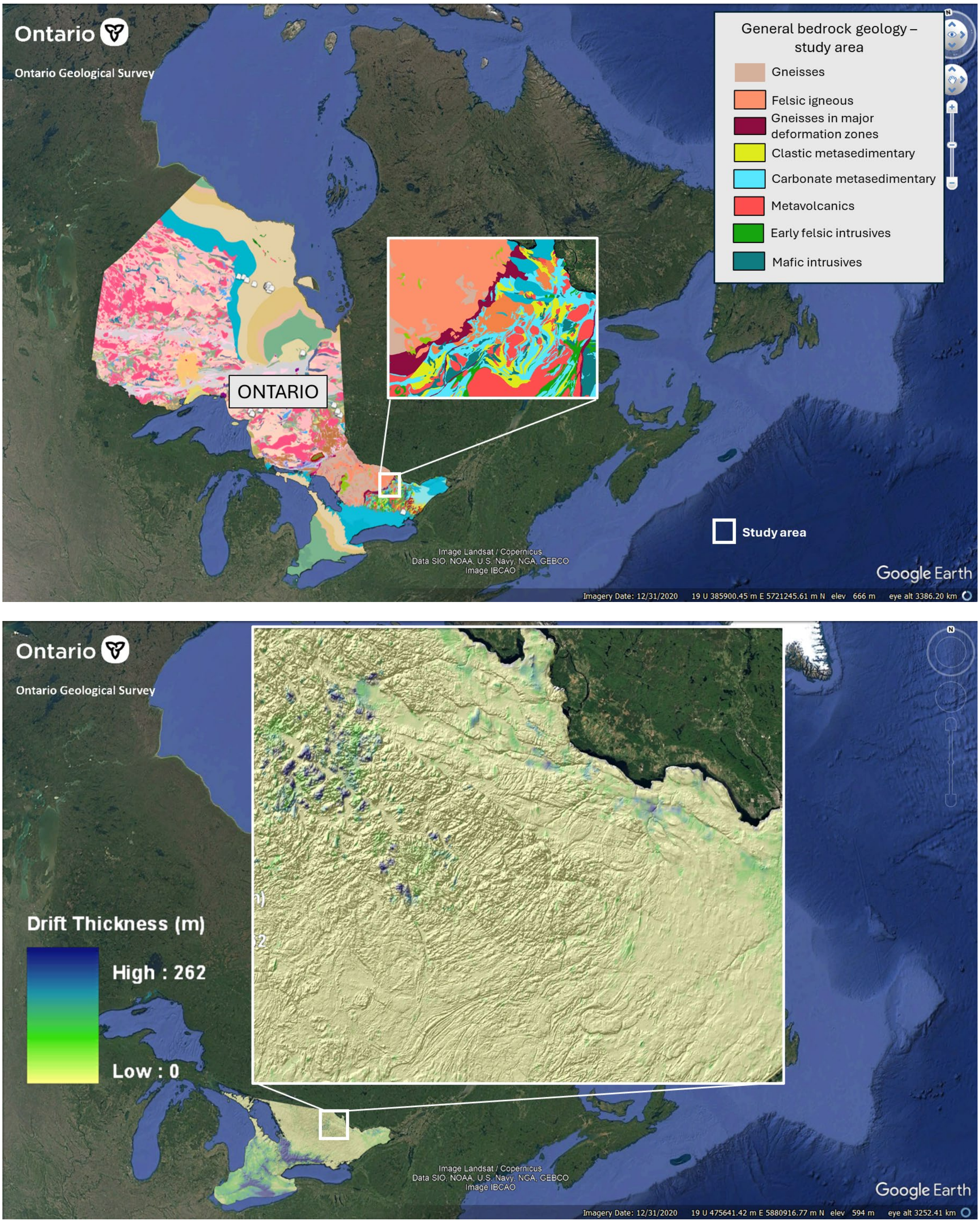

Figure 1: Study area: bedrock geology, general surface topography and glacial drift thickness.

Methodology:

Please note a valid driving licence is required for this project.

1. Year 1: Mining existing data and literature (including bedrock and drift geochemistry, and indicator minerals), bedrock and glacial landform mapping (in GIS) and interpretation, to generate a first order approximation of drift dispersal patterns.
2. Year 1: Extensive field work to log, sample and map surficial sediments and landforms.

3. Year 2: Analytical work on the sediment samples (e.g. [Rice et al., 2024]), including the identification of indicators associated to critical minerals from heavy mineral concentrates obtained from the sand fraction of the drift, as well as major and minor/trace pathfinder element analysis from the silt and clay fraction of the drift.
4. Year 3&4: Statistical and machine learning analysis of collected and assembled data to reduce dimensionality, classify data into meaningful groups, and establish key relationships that can be linked to geological processes. Dissemination of results to indigenous (First Nations) communities and other stakeholders, and the scientific community.

Training and skills:

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

1. TARGET provided training

- 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.

Project specific training

- An extensive programme of training ((First aid, occupational health and safety, bush road driving, ATV, boating, bear safety, logging road procedures, working in gravel pits/steep slopes, field work instruction etc.) linked to the fieldwork will be provided courtesy of the Ontario Geological Survey
- additional training, will be provided by the supervisory team as required.

Partners and collaboration (including CASE):

The supervisors have expertise in all relevant techniques and have a strong track record of successful PhD supervision and paper publication. The Ontario Geological Survey will also provide: student salary for all training and field work ($9,600-16,050 CAD); vehicle and all fuel, accommodation, equipment, and grocery costs in the field and training ($18,000-23,000 CAD); lab expenses ($30,000 – 40,000 CAD). Crucially, they will also provide meaningful consultation with local First Nations Communities, who have previously requested geological data acquisition in the proposed mapping areas, before the commencement of fieldwork. There may be an opportunity to engage with these consultations to gain experience in working with indigenous stakeholder communities.

Further reading:

1- Paulen, R.C. and McClenaghan, B.E. (2017) (eds). New frontiers for exploration in glaciated terrain; Geological Survey of Canada, Open File 7374 (revised), 85p.

2- Rice, J.M., Ross, M., Campbell, H.E., Paulen, R.C., and McClenaghan, M.B. (2024). Net evolution of subglacial sediment transport in the Quebec–Labrador sector of the Laurentide Ice Sheet. Canadian Journal of Earth Sciences. 61(4), 524-542.

3- Ross, M., Parent, M., Benjumea, B., and Hunter, J., (2006). The late Quaternary stratigraphic record northwest of Montreal: Regional ice-sheet dynamics, ice stream activity, and early deglacial events. Canadian Journal of Earth Sciences. 43, 461-485.

Further details:

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

Informal enquiries can be directed to the lead supervisor: Prof. Matteo Spagnolo (m.spagnolo@abdn.ac.uk) or any of the other listed supervisors