canadamining innovationcouncil

Secondary Dispersion through Cover: Processes, Solutions and Protocols for Exploration Geochemistry

Vision - 7.5 million km^2 (78%) of Canada's land surface is concealed by Quaternary material comprising glacial, alluvial, minor aeolian, and peat deposits. These surficial deposits conceal a significant proportion of the potential mineral wealth of Canada. However, the surficial deposits also provide the pathways and trapping sites for elements migrating from mineral deposits at depth. Additionally, these surficial deposits ultimately provide the environment for the sequestration and storage of mining waste. The CMIC Exploration Innovation Council is developing a new project focused on building innovative mineral exploration technologies and strategies based on processes of formation of anomalous geochemical, hydrogeochemical and biogeochemical responses from concealed mineral deposits at depth, with the focus on the processes and consequences of element migration in the near-surface environment and the resultant surface geochemical expressions. Because of the perceived complexities of the mechanisms by which commodity and associated pathfinder elements migrate to the near-surface environment, improving our ability to effectively use surface responses to detect concealed deposits and to be able to capitalize positively on the migration of elements requires a cumulative effort that must involve multidisciplinary field and laboratory investigations in collaboration with industry end-users. Focused at the regional, district and target evaluation levels, this project aims to both reduce the cost and improve the success rate of mineral exploration, resulting in significant economic benefit to Canada, and also to formulate better mining efficiencies and waste disposal strategies. Enhanced understanding of the processes involved in element mobilization from ore deposits at depth will interface with geometallurgy to improve extraction of primary commodities and by-products from ores and to minimize the impact of waste from mining. Successful delivery of the objectives will provide the Canadian mining and exploration community with a world-class toolbox to facilitate cost-effective and successful exploration, target identification and delineation at a scale unprecedented in comparison with current knowledge and practices.

Proposal - A plethora of studies on surface materials indicate causative links between bedrock mineralization under transported cover and geochemical and biological responses in the surface environment. The challenge, however, is not to prove the causative links, as was the focus of numerous studies to date, but rather the challenge is to understand the processes involved so that:

1. predictive models of element mobility from different styles of mineralization in varying geological environments and ecozones can be employed to guide exploration strategies;
2. true bedrock-related anomalies representing buried mineralization are identified resulting in discovery and false positives eliminated; and
3. the behavior of elements in complex near surface environments are better understood from an exploration, mining, remediation and environmental perspective.

Moreover, understanding these processes will enhance the effective integration of geochemistry with geophysics, as the physical properties measured by geophysics are directly impacted by the mineralogical and hence chemical composition of the material being surveyed.

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Previous Work - Over the past two decades there have been several efforts to document the extent to which surface geochemical anomalies form over deeply buried mineralization and to understand the processes that produce these geochemical anomalies, with variable success. Mobilization processes generally involve: 1) complexation and transport of metals and metalloids (hereafter, metals) by diffusion, as gas phases and solutions as the deposit interacts with its local environment over time; 2) microbial mobilization of metals via gas and aqueous phases; 3) advective, barometric and seismically induced flow of these complexes; 4) biological mobilisation by plants or animals; and 5) redox-driven (electrochemical) migration. Which combination of these five processes dominates the mobilization of components from a deposit depends on the existence, and the relative rates, of the processes as products of the environment.

To form a geochemical anomaly at the surface, fixation and trapping of the mobilized components generally involves: 1) absorption and adsorption of metal complexes on reactive surfaces such as Mn-Fe oxides, clay minerals and organic matter; 2) fixation of microbial-mediated metals in surface communities; 3) uptake by vegetation; and 4) bioturbation. Although theoretically sound and fairly well documented, the relative impact and efficiency of most of these processes are not well understood, thereby inhibiting quantitative interpretation of geochemical data and reducing effectiveness when integrated with geophysics and geology. More importantly, there is still a large knowledge gap regarding how these processes interact to augment, modify, or suppress geochemical responses and the rate at which these processes operate.

Research Strategy - The research project will invert the classic research strategy in exploration geochemistry by first developing geochemical models through experimental work followed by field evaluation and testing of the experimentally derived concepts. Within the time frames of the project, it is not feasible to evaluate all environmental variables, hence the research will focus on two or more selected styles of mineralisation in specific geological and environmental settings. This will require the identification of potential research sites at an early stage of the project so that the environmental conditions can be replicated within the laboratory environment. Final selection of sites and environmental conditions will be developed in conjunction with industry partners to enable appropriate and beneficial research to be conducted. Most likely these will comprise gold focused and base metal focused mineralisation styles.

Experimental Research - Laboratory experiments will comprise active and passive simulations to emulate what occurs in natural systems to mobilize and attenuate elements. Active experiments will be conducted via large columns filled with geological or engineered materials configured to simulate real systems. These columns can have several unique features that will permit tracing of element migration and the processes by which they move and are trapped. They will have fluid and gas inputs at the base and sample sites at discrete levels in the columns from which the fluids flowing through the columns can be collected via manifolds and characterized. Columns will have ports to collect headspace gases and gaseous complexes that are released and accumulate in the head-space at the top of the columns, thus linking the geo-, bio, hydro- and atmospheres. If these gaseous complexes are sampled at the surface in real situations in the field, they can reflect element mobility from depth, which diffuse much faster than aqueous species, and for which a specific detector can be engineered for use in the field. Fill materials characterized in detail before, after, and during the column experiments will reveal the effects of fluid-rock interactions on the solids and vice versa.

Simultaneous with column experiments, large tank experiments will allow for the evaluation of anomaly development in static conditions, likewise monitoring chemical and physicochemical changes, however on a larger scale to include a greater 3-dimensional component, allowing the monitoring of electrical changes within the environment and potential lateral element chromatography as responses develop.

Analytical work will include the complete mineralogical, organic, inorganic, isotopic and microbiological characterization of the ore and "cover" materials in the experiments before and during the experiments to document changes over time and space, hence allowing the understanding of both processes and time constraints on element migration.

Field Research - Following the development of experimental derived models of anomaly formation and retention, research will re-focus to the industry-sponsored field sites where the surface environment comprises a variety of materials (various soil horizons, biological materials, till, gasses). At these sites materials will be collected and chemically characterized, as appropriate, to ascertain the correlations and validity of field and experimental derived concepts under natural conditions. Depending on the knowledge of the field sites, field work may also include trenching to fully understand the overburden structure in addition to passive seismic mapping of the till-bedrock interface and the within-till structures. Given the expense and opportunity for this field sampling will include comprehensive oversampling allowing the opportunity to archive and resample into the future as new methods are developed to optimise sampling strategies.

Analytical work will focus on full characterisation of the field site surface materials, again from a mineralogical, organic, inorganic, isotopic, biological and microbiological characterization of the surface materials.

Deliverables - The long-term deliverable of this research will be to provide robust guidelines as to what surface media should be targeted in an exploration program and the significance of anomaly recognition within different media. At the project scale the research will identify the processes responsible for the generation of geochemical, biological and physicochemical responses at the research sites based on experimental and field-based research. Specific deliverables include:

- White paper on the experimental research, experimental design and execution
- Report on the experimental results
- White paper with respect to the undertaking of Orientation surveys
- Report on Field activities at the individual sites
- Final report and workshop on the experimental and field results of the research
- Proposal for Phase II

In addition, it is proposed that regular meetings would be held with industry sponsors (for example at 6-month intervals or after key activities) to coordinate and critically assess the work being undertaken, while providing opportunities for industry involvement at key research milestones.

A field-based workshop based on the results is also envisaged with respect to identifying the different materials and undertaking appropriate high-quality sampling and physicochemical measurements.

Other Outputs -

- Best practices manual including landscape mapping and sample collection protocols, sample treatment procedures, analytical protocols, and data treatments;
- Transfer of analytical methodologies from the research to the commercial laboratories;
- Training the next generation of geologists to take the results to the exploration industry;
- Network of Excellence in mineral exploration and analysis (geometallurgy, geoenvironmental);
- Strategic methods for the integration of geology, geochemistry and geophysics;
- Reactivity hierarchy of minerals within till-dominated landscape, with implications for geometallurgy and tailings management;
- Development of predictive and genetic models to assess and interpret observed field geochemical anomalies in different superficial materials.

Schedule - A detailed schedule is attached, the project is formulated over 3 years with the experimental component initiated and undertaken in year 1, though with the experiments running on as appropriate and a field-based component in year 2. Integration of the results and final documentation with proposals for phase 2 would be completed in year 3.

The project as it currently stands, includes a year 0 – pre-project phase, in which, in addition to compiling the proposal to NSERC, initial identification of potential research field sites would be undertaken in collaboration with the identified industry sponsors in which the initial materials for the experimental research would be sourced and prepared.

Project Costs - A detailed project budget is in preparation with respect to the NSERC application, however initial estimates suggest the budget will be in the order of $1.25M to $1.5M with the greater part of the costs being directed at the experimental research and the analytical work related to both lab and field experiments.

The budget does assume in-kind support from industry, in particular with respect to field support, information and data, and provision of materials.

Research Staff - The combined field and experimental research seeks to deliver novel well-constrained, field-based strategies, techniques and technologies for the effective surface detection of mineralization below overburden cover in a variety of environments. A high level multi-disciplinary approach drawing on expertise from a wide variety of scientific fields is required for success, including geology, chemistry, physics, genomics biology and microbiology, soil science, mineralogy, analytical chemistry, hydrology, and remote sensing.

Project Management will be undertaken by:

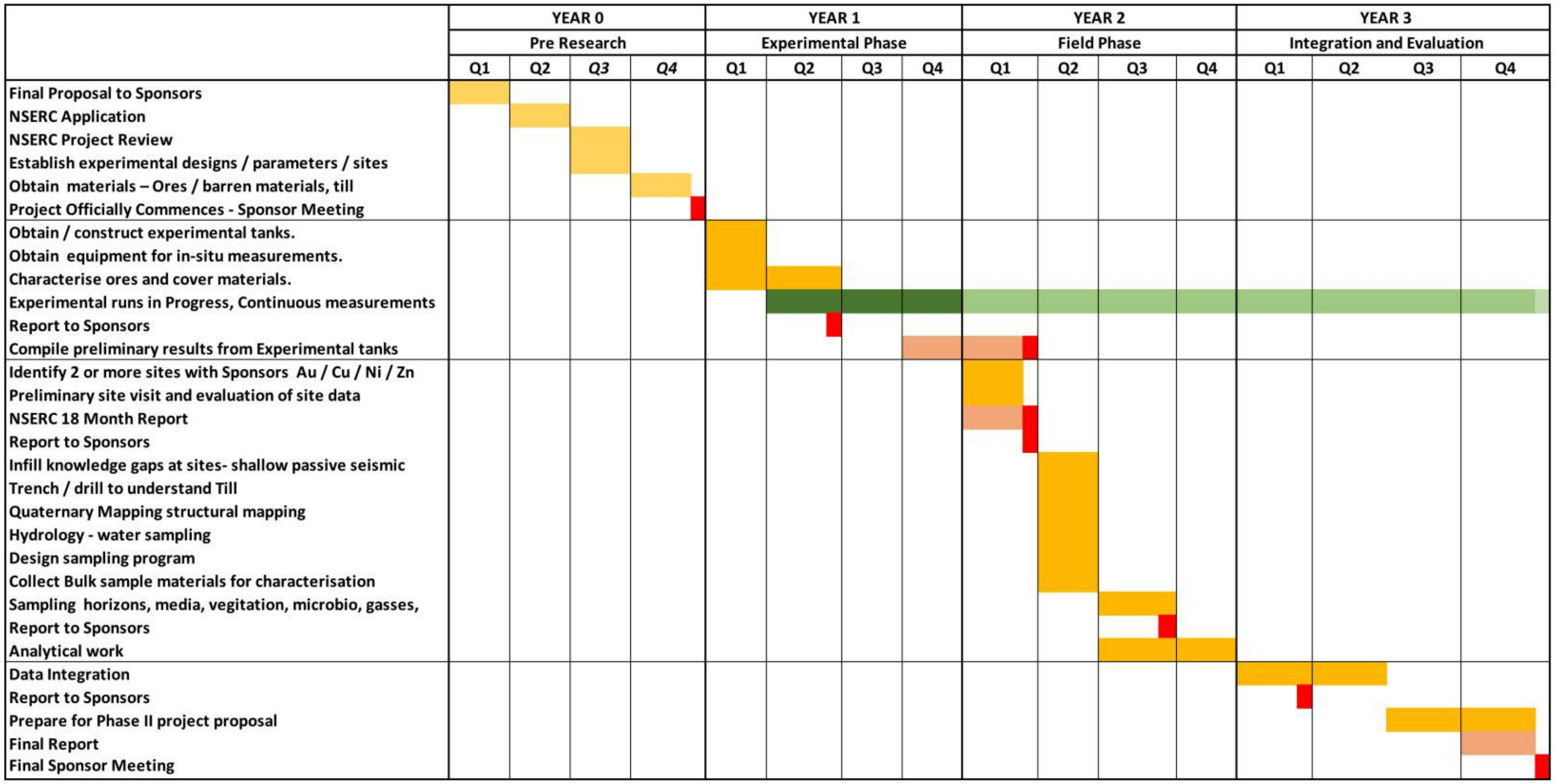
- Dr. Peter Winterburn, Research Chair in Exploration Geochemistry, MDRU, UBC.
- Dr. Matthew Leybourne, Associate Professor, Queen's Facility for Isotope Research.
- Dr. Dan Layton-Matthews, Associate Professor, Queen's Facility for Isotope Research.

Other key researchers identified to date with significant roles include:

- Dr. Dirk Kirste, Professor, SFU, Reaction Modelling and hydrogeology
- Dr. Martin Ross, Professor, UoW, Quaternary Geology
- Dr. Anna Harrison, Assistant Professor, QU, Experimental Geochemist
- Dr. Sean Crowe, Professor, Life Sciences and EOAS, UBC, Geomicrobiology

It is proposed that HQP post docs, graduate and under graduate students would be involved in the research project with different focus on the experimental and field-based research. The final number is to be determined. Given the time frame of the project, Graduate students would likely be constrained at the M.Sc. level.

If you are interested in becoming a part of the process, please contact Dick Tosdal (+1-908-240-5881; rtosdal@gmail.com).



Project Schedule.

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