Agenda

Student Presentation - Exploration

Willet Green Miller Centre - Auditorium
933 Ramsey Lake Rd, Sudbury, Ontario
November 30, 2011
8:30am-12:00pm

CEMI invites you to join us in providing an opportunity for CEMI sponsored/supported students to share their Exploration & Geophysics related research projects.

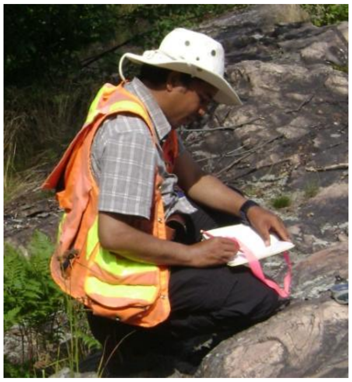
Damien Duff		CEMI Introduction
Dr. Tsilavo Raharimahefa	PDF	Structural, Metamorphic, and U-P Geochronological Evolution of the Southern Province, Sudbury, Canada
Taus Joergensen	PhD	Identification of Pyroxene Hornfels Facies Mafic Rocks within the Metamorphic Aureole of the South Range of the Sudbury Igneous Complex, On, Canada
Fabio Cafagna	PhD	Experimental Study of the Role of Semi-Metals on the Mobility of PGE
Oladele Olaniyan	PhD	Qualitative and quantitative integrated geophysical investigation of the Sudbury structure
		Coffee Break
Josh Lymburner	MSc	A Deep Electromagnetic Tool
Michal Kolaj	PhD	Mapping Laterally Varying Conductance Using Electromagnetic Gradients
Devon Parry	MSc	Borehole Geophysics: Downhole Logging and Comparison with Handheld Physical Property Measurements

Keynote Speaker: R. Mohan Srivastava

“Fracture modeling: New ideas for mineral deposit development and production planning”

A recording of these lectures will be available to watch at your own convince in the following week at: http://www.miningexcellence.ca/events/lectures/

CEMI is proud to work with the next generation of up and coming researchers.



Dr. Tsilavo Raharimahefa
Post Doctoral Fellow (PDF)
Laurentian University
Supervisors: Drs. Douglas K. Tinkham, Bruno Lafrance
On behalf of Dr. Tsilavo Raharimahefa, Dr. Bruno Lafrance will present.

Structural, Metamorphic, and U-P Geochronological Evolution of the Southern Province, Sudbury, Canada

The South Range of the Sudbury impact structure has been affected by several orogenic events that have displaced and folded Huronian footwall rocks and Ni-Cu massive sulphide deposits at the base of the Sudbury Igneous. New and novel exploration approaches are needed to increase exploration success. Development of a 4-D interpretation of the tectonic evolution of the South Range before and after the Sudbury impact event. This integrates structural geology, metamorphic petrology, geochronology, and geochemistry and provides further clarity and understanding of the geology of the Sudbury Igneous Complex. A new interpretation of the tectonic evolution of the South Range has been developed and multiple deformational phases postulated: Pre-impact D1; Post-Impact D2; D3 and D4.

Taus Joergensen
PhD Candidate
Laurentian University
Supervisor: Dr. Michael Lesher

Identification of Pyroxene Hornfels Facies Mafic Rocks within the Metamorphic Aureole of the South Range of the Sudbury Igneous Complex, Canada

The 1.85 Ga. Sudbury Igneous Complex (SIC) is surrounded by a well-developed contact metamorphic aureole along its northern margin, but a corresponding aureole along the southern margin (South Range) has been more difficult to define, and is commonly reported to have been destroyed by younger lowgrade regional metamorphism or by deformation. Although an anatexis isograd locally exists in granitoid rocks of the South Range, metamorphic isograds and facies boundaries have not been reported in the voluminous mafic rocks within the Elsie Mountain Formation, interpreted as a succession of pillowed and massive basalts, mafic and intermediate pyroclastic rocks, and associated quartz-rich metasediments. Recent mapping in the Little Stobie area indicates the local existence of relatively well preserved pyroxene hornfels facies assemblages that could allow mapping of the aureole over large distances within the voluminous mafic rocks of the South Range. The dominant mafic lithology within the study area is a pyroxene hornfels with 0.2-0.5 cm poikiloblastic hornblende porphyroblasts. The matrix is dominated by plagioclase, granoblastic polygonal clino- and orthopyroxene, and minor amounts of magnetite. This mafic lithology can be mapped at least 800 m along strike parallel to the margin of the SIC, and the pyroxene-bearing hornfels assemblage is locally observed up to 400 m away from the SIC contact. Although initial petrographic analysis indicates the observed pyroxenes exhibits thermal metamorphic textures, it is uncertain at this stage if pyroxene formed by thermal recrystallization of pre-existing pyroxene or if it formed during hornblende-consuming dehydration reactions. These observations suggest the South Range metamorphic aureole surrounding the SIC can be resolved despite complications due to post-metamorphic events, heterogeneities in the original footwall lithologies and the geometry of the SIC contact. Furthermore, the high temperature part of the aureole containing pyroxene hornfels facies assemblages in the South Range is thicker than in the North Range, consistent with the SIC Main Mass being thicker in the South Range. Defining the aureole geometry can provide constraints on the thermal evolution of the country rocks below the SIC and the degree of thermomechanical erosion.

Fabio Cafagna
PhD Candidate
Laurentian University
Supervisor: Dr. Pedro Jugo

Experimental Study of the Role of Semi-Metals on the Mobility of PGE

Platinum-group elements (PGE) are economically relevant metals and can be found in Cu-Ni deposits, because they strongly partition into sulfide liquids rather than in silicate melts. Particularly, Ir, Os, Ru, and Rh preferentially fractionate into MSS (monosulfide solid solution), whereas Pd and Pt gather into the Cu-rich residual liquid. Platinum and palladium have a strong tendency to form discrete phases (Platinum-group minerals, PGM), but Pd also partitions into pentlandite. The Pt-Pd-bearing discrete minerals are usually formed with elements such as As, Sb, Te, Bi. An experimental approach has been undertaken to shed light on the mechanisms of formation of these PGM and on the transportation properties of the semi-metals. Experiments were run in two piston-cylinders. A mixture of FeS, NiS and CuS_2 (66.4, 19.7, and 13.8 wt.% respectively) was used as sulfide base; this was doped with a mixture containing each PGE in the proportion of 10:1 (by mass). Experimental charges were placed in graphite capsules and sealed in $Au_{80}Pd_{20}$ capsules. Two sets of experiments were conducted: in the first set, Te was added to the experimental charge in the proportion of 5:1 (by mass) to the PGE mixture; the second set was Te-free. Experiments ran for a minimum of 3 hours to a maximum of 15 days, at temperatures ranging from 500 °C up to 1150 °C, at a pressure of 0.5 GPa. The run products were analyzed with SEM using Energy Dispersive Spectrometry. Results show that in Te-free experiments, all the run products were contained within the graphite capsule. For all Te-bearing experiments above 600 °C, Pd-tellurides were found inside the walls of the graphite capsule, forming a dispersion halo. The halo sometimes migrated all the way to the AuPd capsule and interacted with it, as the capsule was partially corroded and Au tellurides were also found (Au was not in the starting materials). Gold and palladium tellurides in the graphite indicate that Te forms a gas phase able to sequester and transport Au and Pd away from the main sulfide mass.

Oladele Olaniyan
PhD Candidate
Laurentian University
Supervisor: Dr. Richard Smith, Dr. Bill Morris, Dr. Darrel long

Qualitative and quantitative integrated geophysical investigation of the Sudbury structure

Extensive geological work have defined the Sudbury structure on the surface and limited geophysical studies have been used to propose different configurations for the shape of the deeper part of the structure. Currently, exploration activities have been limited to the depth of about 1 km (primarily close to the sub-layer contact) and there is a current interest to develop more effective geophysical techniques to locate new deposits to depths of at least 2.5 km. Having a good understanding of the basin configuration could guide this exploration.

Recent advancements in data acquisition systems in combination with advanced data processing and modelling techniques provide opportunities to generate a better understanding of the configuration of the Sudbury structure. This project involves three phases: a qualitative interpretation phase and two quantitative phases involving 2D and then 3D modelling. The qualitative phase of this project has employed vertical and horizontal derivatives and normalised grids as well as edge enhancement and contact-mapper techniques to extract surface and near-surface structures, lithology boundaries, faults and contacts from airborne geophysical data. The extracted information will be used to update the current geological and bedrock map of Sudbury structure.

Although not all geophysical contacts correspond to the lithological contacts, geophysical contacts provide key information in structural regimes, deformation styles and trends, and magnetic textures. The new geological information already gathered from the interpreted geophysical data have showed that some of the mapped dykes and structures such as faults and fractures are more extensive than they appear on the existing geological map. Also, some existing lithological boundaries are more continuous in the airborne data than they appear on the surface geological mapping, while other geophysical contrasts appear to correspond to physical property contrasts that have not been mapped geologically.

Josh Lymburner
M.Sc. student
Laurentian University
Supervisor: Dr. Richard Smith

A Deep Electromagnetic Tool

Many ground electromagnetic (EM) systems have been deployed in the Sudbury basin, such as Geonic's EM37, Crone's PEM, and Lamontagne Geophysics' UTEM system. Under ideal conditions these systems are capable of detecting large conductors to depths of approximately 800m, while common detection limits are in the order of a couple hundred meters (<400m). Although these systems have had great success in Sudbury, they may experience poor coupling and small signal to noise ratios, decreasing the quality and interpretability of the data. To detect deeper conductors these issues must be addressed. Increasing the signal-to-noise ratio is often addressed through larger loops (increase currents in the subsurface) or, though longer receiver acquisition times. Coupling still remains a large issue, unless properties of the subsurface feature (orientation, geometry, depth) are roughly known. If unknown, multiple transmitter locations, (over the target site) can be utilized to ensure good coupling (and response) with the subsurface feature. A recent time-domain electromagnetic survey was conducted to test a new methodology, combining the two concepts over a known conductor. Coupling was addressed through multiple transmitter locations and spatial stacking of receiver measurements (from the various transmitter-receiver combinations) amplified the conductor response and reduced noise. Results indicate, utilizing multiple transmitter locations can improve coupling and the response of a subsurface conductor. Preliminary results indicate, spatially stacking receiver measurements, (from different transmitter combinations) can improve the response of a subsurface conductor above the noise threshold. Creating a methodology to detect deeper conductive features is an important step towards discovering deeper mineral deposits.

Michal Kolaj
PhD Candidate
Laurentian University
Supervisor: Dr. Richard Smith

Mapping Laterally Varying Conductance Using Electromagnetic Gradients

Mine waste and the saprolite associated with nickel laterites have a conductivity thickness (conductance) that varies laterally. The differential equation which needs to be inverted in order to solve for laterally varying conductance over thin sheet like bodies requires the measurement of a spatial electromagnetic (EM) gradient (dH_z/dz). While gradient measurements have not seen much research in electromagnetic prospecting methods due to the large signal-to-noise ratio required, they have been extensively used in gravity and magnetics due to their increased resolution and potential for unwanted signal reduction (i.e. noise). Two inversions to map a conductance which varies laterally have been developed and tested on synthetic data. The first is based on the equation which describes the electromagnetic induction in an infinite thin sheet whereas the second method assumes a uniform thin sheet conductance and inverts for an "apparent conductance" in models with laterally varying conductance. The simplified method, which requires two measured components, generates accurate results in symmetric models where the horizontal magnetic field components are not as significant (in-loop survey) and when the conductance contrasts are low. The full inversion does not have the above limitations but requires the measurement of two additional components and a more complicated inversion. An EM gradient time domain survey was performed over an area of dry mine tailings in Sudbury, Ontario but it was unable to detect the rapid EM decay. A Geonics EM34-3 survey suggested that a high frequency system is required due to the tailings' low interpreted conductance. A subsequent survey is planned in the upcoming months which should address the frequency issue and allow for the inversion to be tested on field data. Mapping conductance as a function of lateral position in a thin sheet model is an important step towards assessing if there are contaminants and/or leftover economic metal concentrations in mine waste and where lateritic nickel might be found.

Devon Parry
M.Sc. student
Laurentian University
Supervisor: Dr. Richard Smith

Borehole Geophysics: Downhole Logging and Comparison with Handheld Physical Property Measurements

Throughout the Sudbury Basin, physical property measurements have been taken in boreholes in order to extract information about the geology and minerals close to the borehole. Conductivity is one of the physical properties that are often measured. Aside from measuring the in-hole response, conductivity measurements can also be taken on core samples that have been removed from the boreholes. The latter measurements often differ from those taken in the hole due to the expansion and drying that occurs after a core sample is removed. Further differences between the two types of measurement are expected as the in-hole measurements are responding to a much larger volume of rock than the core samples extracted from the hole. Downhole logging involves the use of either inductive or passive geophysical instruments to measure the physical properties of the nearby rock units. Due to the large number of different geophysical instruments that are currently in use across the basin (DGI, IFG, Auslog, RIM), it is difficult to determine which measurements are the most accurate as each system uses different physical principles, measurement frequencies and calibration procedures. Conductivity and Total Gamma measurements were taken using the Geonics EM39 induction tool and compared with previously collected data and handheld conductivity measurements. Preliminary analysis shows similar trends, however; differences can be identified in anomalous regions. By measuring responses from different instruments in similar boreholes and on the core from those holes, a comparison can be made to indicate the advantages and disadvantages of each probe. After measurements are complete, it will be possible to identify whether or not each instrument is calibrated correctly. By determining a way to calibrate each instrument, similar physical property measurements can be obtained. The data collected by these instruments can then be identified as being accurate enough to utilize as constraints for geophysical inversion models.

Craig Stewart
PhD Candidate
Laurentian University
Supervisor: Dr. Dan Kontak

Assessment and characterization of alteration in the granophyre of the Sudbury Igneous Complex

The granophyre accounts for ~60 volume % of the Sudbury Igneous Complex (SIC) and is thought to represent the end product of fractionation or unmixing of the SIC melt sheet. The unit is a massive, fine to medium-grained, quartz and two-feldspar rock with variable amounts (0-30%) of mafic minerals (biotite and hornblende) with some zones containing late stage miaroles, which reflect fluid saturation at the terminal stage of crystallization the unit also contains a highly variable amount of granophyre. The granophyre indicates the system was not in equilibrium and reflects sudden crystallization of the melt due to rapid heat loss or possibly dehydration of the melt. Previous petrographic study of the granophyre indicates extensive subsolidus exchange and equilibration with a fluid of unknown origin. The granophyre also contains features (e.g., quartz-feldspar intergrowths, secondary amphibole, dissolution textures, etc.) which suggest chilling of the SIC occurred at or below 700°C, which is close to the temperature of pentlandite exsolution from MSS, but below the temperature of ISS formation. The presence of pervasive alteration within the granophyre may potentially be sued to identify areas of high fluid flow, which can be correlated to the cooling of the SIC. Fluids have been implicated in alteration peripheral to ore zones and may be relevant in this context.

To date, a comprehensive suite of granophyre samples has been collected from both other studies (n=138) and two traverses; one through the south range (n=80) and one through the north range (n=40). These new samples will be integrated with previous material to generate a 3D spatial distribution of the granophyre texture, the distribution and intensity of alteration and origin of the altering fluids. Preliminary data indicates the volume percent of granophyric texture varies both laterally and vertically, ranging from 0 to 60 vol. %. This and newer data will be used to further understand the thermal evolution of the SIC. Detailed petrographic study of archived suites integrated with SEM-EDS study supports earlier observations regarding alteration, but also suggests a dissolution-precipitation mechanism accompanied re-equilibration, as preserved by micropores in most mineral phases except quartz, the most robust phase in the graonphyre. In order to address the nature and origin of the altering fluid an integrated study of fluid inclusions (microthermometry, SEM-EDS of evaporite mounds, LA IC P-MS) and stable isotopes (O, D) is planned. Petrography indicates an abundance of fluid inclusions of L-V and L-V-solid types are locally abundant in quartz and also feldspars, thus there is preservation of the fluid implicated in the alteration and future work will address the PTX properties of this fluid.