REVISITING LAC DE GRAS TILL GEOCHEMISTRY IN PREPARATION FOR THE SLAVE PROVINCE SURFICIAL MATERIALS STUDY, NORTHWEST TERRITORIES, CANADA

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Introduction

The Slave Province Surficial Materials and Permafrost Study (Fig. 1) is a flagship research project of the Northwest Territories Geoscience Office (NTGO) that consists of regional and targeted overburden drilling, glacial dispersal studies, surficial geology mapping and permafrost studies. It aims to provide geoscience data for informed and sustainable decision making in regards to land use planning. This project was developed in partnership with Carleton University, Simon Fraser University and the University of Waterloo in addition to numerous other industry participants including Diavik Diamond Mines Inc., Dominion Diamond Corp., North Arrow Minerals Inc. and the Canadian Mining Industry Research Organization (CAMIRO). The present work is a preliminary analysis of legacy till matrix geochemical data, focused on refining our understanding of the background signal variations, in preparation for the summer 2015 mapping campaign.

Figure 1. Regional study area for the Slave Province Surficial Materials Study.
Multiple geochemical surveys were performed within the study area during the 1990’s, and the data from these surveys were compiled and made publicly available in the early 2000’s. Analyses of till matrix performed by private parties from 1990 to 1999 have been compiled by the NTGO under NWT-NU Open Report 2005-001 (Cairns & Rasmussen 2005). The 1993 and 1994 Geological Survey of Canada (GSC) regional geochemical surveys (OF2867 and OF2868; Dredge et al. 1994; Ward et al. 1994) are summarized within OF5015 (Kerr & Knight 2005). These surveys have been used ‘as is’ and have influenced mineral exploration decision making within the Northwest Territories, however, interpretation of the geochemical regional variations was not part of their deliverables. A single GSC Current Research report used data found in OF5015 to characterize geochemical variations in relation to till thickness (Wilkinson et al. 2001). Background variations were attributed to different bedrock sources and transport distances leading to contrasting original element concentration as well as various degrees of attrition and mixing.

The present preliminary study examines subsets of both GSC and NTGO datasets, along with Dredge et al. (1995) surficial geology map (Map 1867A) and LiDAR data graciously provided by Dominion Diamond Corp. to characterize possible associations between till geochemistry, till thickness and landform. Conventional kimberlite vectoring elements of the Slave Craton (Ni, Cr, Ba, Co, Sr, K, Mg and Mn) as defined by Wilkinson et al. (1999) and reported by McClenaghan and Kjarsgaard (2001) are used.

**Methodology**

Regional surface till geochemical data from 301 samples from GSC OF5015 were used. Original analysis were performed by Chemex Laboratories Ltd, Mississauga on the clay-size fraction (<0.002 mm) of the till matrix and digested through aqua regia before ICP-AES. Complete sampling and analytical protocol description and QA/QC procedures are available in the 2005 data compilation as well as within the original open files. The data were related to the till units from GSC map 1867A based on sample location. Geochemistry from till veneer (less than 2 m thick) and till blankets (from 2 to 10 m thick) were combined into a single category and compared to geochemistry from thicker hummocky till (5 to 30 m thick, with an uneven surface)(Fig. 2), as done by Wilkinson et al. (2001).

Till geochemical data from 77 samples within compilation NWT-NU 2005-001 (Report 83463 in Cairns & Rasmussen 2005) were used in a test area between Lac de Gras and Aylmer Lake to assess local background variability between till units and landforms (Fig. 3 and 4). The area was selected to meet the following criteria: (1) contains a high amount of samples analysed with a uniform protocol; (2) is located within the available Dominion Diamond Corp. LiDAR coverage; (3) lies within an area of uniform underlying bedrock (Archean granitoids: Stubley 2005); (4) and does not contain any known kimberlite pipes. A known kimberlite is present in the southwestern corner of the selected area but no samples are located down-ice
(northwest) of it (Fig 4). The data from Report 83463 (Cairns & Rasmussen 2005) were acquired by Kennecott Canada Inc. and processed at Chemex Laboratories Ltd, Mississauga. Brief descriptions of the sampling and analytical methods are provided in Cairns & Rasmussen (2005). Analyses were performed on the ‘de-slimed’ (approximately silt and clay size, <0.063 mm) portion of indicator mineral samples. The digestion method is unknown and ICP- (AES?) was used.

Results

Within the regional dataset (Fig. 2), the till blanket and veneer and the hummocky till categories have similar ranges in elemental concentrations, with the exception of Ba. Elemental concentrations in both till categories have a strong bimodal distribution which is more pronounced in the hummocky till category. The population with higher Ba values in hummocky till has a noticeably flat distribution. Ni has the most variation between till categories, with a distribution having a constant decline in the till blanket and veneer class.

Bimodality is also present in the data from the higher sampling density test area, specifically for Ni, Cr and Ba (Fig. 3). The bimodality is better defined for the till blanket and veneer category than for the hummocky till class for Cr and Ba. K, Mg and Mn have the most similar distribution between till categories for both regional and local datasets. Sr distribution is similar in both till categories in the regional dataset but not in the local one.

Figure 2. Regional elemental concentrations in hummocky till (n=46) vs. till blanket and veneer (n=255), <0.002 mm, aqua regia, ICP-AES (data from GSC Open File 5015).
Figure 3. Local elemental concentrations in hummocky till (n=47) vs. till blanket and veneer (n=30); ~ <0.063 mm, ICP (data from Report 83463 in Cairns & Rasmussen 2005).

Figure 4a shows that till units are aligned with the dominant ice flow direction in the local test area (northwestward). Hummocky tills are generally associated with higher elevation zones (Fig. 4b) independently of the northwest trending slope of the local test area. Without being a streamlined topography per say, this alignment is not in accordance with the general east to west bedrock lineaments present in this area of the Slave Craton (Stubley 2005).

The Ni distribution reaches its peak density at somewhat lower elemental concentrations for thinner till than thicker till in the data from the higher sampling density test area (Fig. 3). Also, Ni distributions consistently display less bimodality in thinner till than in thicker till (Fig. 2 and 3). Ni was therefore selected to assess spatial distribution and relationship with till units and elevation (Fig. 4). The map shows that the elongated area of till veneer and exposed bedrock immediately northeast of the large area of hummocky till exclusively contains low Ni values (Fig 4a). This area may represent a meltwater corridor. However, the till veneer and exposed bedrock area southwest of the esker contains both high and low Ni values (Fig. 4a). Zones of higher elevation (above 460 m. a.s.l., Fig. 4b) contain both high and low Ni values, while lower areas tend to be low in Ni for all till units.
Figure 4. Ni concentration in till from the high sampling density test area over (a) surficial geology map from Dredge et al. (1995) and (b) DEM from Dominion Diamond Corp. LiDAR data.

Discussion

The bimodality within the regional dataset may be caused by the presence of kimberlite dispersal trains and/or ultramafic bedrock in the region. This explanation is concordant with previous observations (Wilkinson et al. 2001). It is, however, not reconcilable with the test area of higher sampling density. The presence of bimodality for Ni, Cr and Ba and the distribution differences between till thickness categories are unexpected where bedrock composition is considered homogenous and kimberlite dispersal trains thought to be absent. This cannot be explained without involving either: (1) one or multiple modes of deposition and/or successions
of deposition and erosion events; and/or (2) late to postglacial processes modifying the material’s geochemical signal. The till unit contact and topography defining these areas are aligned with the latest and dominant ice flow direction within the test area despite the complex ice flow history of the Lac de Gras and Aylmer Lake region (Dredge et al. 1995; Ward et al. 1997), suggesting a late glacial origin. These observations along with the possible association between the areas of thinner till and erosive corridors alongside eskers and their influence on the geochemical signal will be tested against new ground mapping data following the summer of 2015. In addition, till depth will be better constrained by the borehole data from planned drilling activities.

Conclusions and future work

Geochemical background in a test area of homogenous bedrock varies with till units. This variation is therefore thought to be related to glacial and/or post-glacial processes. The alignment of till units with the dominant ice flow direction suggests a late glacial origin. These processes, along with their possible association with meltwater corridors and their effect on till thickness, texture and geochemical signals will be investigated within the Slave Surficial Material and Permafrost Study. Future research also includes; investigation of till geochemical variation within kimberlite dispersal trains, quantification of till reworking index and assessment of possible heavy indicator mineral enrichments caused by late to post-glacial processes.

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References


