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**Till Geochemistry of the
St. George (NTS 21 G/02)
Map Area, Charlotte County,
New Brunswick: Site, Textural
and Geochemical Data With
Contour Plots for As, Sb, Cu
and Pb**

A.G. Pronk, S. Allard, and G.R. Boldon

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ABSTRACT

Regional till sampling in the St. George (NTS 21 G/02) area took place on a 2 km grid and samples were analyzed for a wide range of elements. Field and laboratory methodology are described and contour plots for As, Sb, Cu and Pb are presented. A full field and analytical data listing is included in the report.

RÉSUMÉ

On a effectué un échantillonnage régional de tills suivant une grille de 2 km sur 2 km dans le secteur de St. George (SNRC 21 G/02) et on a analysé la teneur en un vaste éventail d'éléments des échantillons. Le rapport pertinent décrit les méthodes de prélèvement des échantillons et d'analyse en laboratoire, et il présente des tracés de contours de l'As, du Sb, du Cu et du Pb. Le rapport comprend une liste complète des données de terrain et des données d'analyse.

TABLE OF CONTENTS

Introduction	1
Methodology	1
Field Methods	1
Laboratory Methods	2
Sample Preparation	2
Till Lithology Analysis	2
Grain Size Analysis	2
Statistical Methods	2
Analytical Procedures	3
Instrumental Neutron Activation Analysis (INAA)	3
Inductively Coupled Plasma Emission – Mass Spectrometry (ICP-MS)	4
Comparison of Data Produced by Two Methods	4
Contouring	4
Presentation and Interpretation of Gold Data	5
References	6
 Appendix I – Location Maps and Contour Plots	 7
Appendix II – Site Data	14
Appendix III – Textural Data	18
Appendix IV – Statistics (INAA)	26
Appendix V – Statistics (ICP-MS)	34
Appendix VII – Till Geochemistry by INAA	45
Appendix VIII – Till Geochemistry by ICP-MS	54
 Table 1. Elements in till determined by Instrumental Neutron Activation Analysis	 3
Table 2. Elements in till determined by Inductively Coupled Plasma Emission – Mass Spectrometry	3

CD-ROM

Contains Open File 2004-5: text and Appendices I to VII (PDF format),
Appendices 6 and 7 (EXCEL and ASCII formats)

Till Geochemistry of the St. George (NTS 21G/02) Map Area, Charlotte County, New Brunswick: Site, Textural and Geochemical Data With Contour Plots for As, Sb, Cu and Pb

INTRODUCTION

This Open File consists of a brief description of sampling methodology and analytical procedures; a full listing of field data; textural data (including the results from till lithology and grain size analysis); geochemistry data; and contour plots for selected elements (As, Sb, Cu, and Pb). Also included here is a discussion outlining some important points to consider when interpreting gold data. The digital version of this Open File is distributed on compact disc and contains: (1) an introductory text file; (2) all field data (including the results from grain size and lithological analysis) in Microsoft (MS) Excel format; (3) geochemistry listings and statistics in MS Excel format; and (4) select geochemistry plots in Adobe Acrobat PDF format.

METHODOLOGY

Field Methods

The New Brunswick Department of Natural Resources undertook sample collection of glacial sediments in the St. George (21 G/02) map area (Appendix I) during the field season of 2003. Samplers included Toon Pronk, Serge Allard, Rex Boldon, and Will Gillmore. Site locations were based on a flexible 2 km grid (one sample/4 km²). A field duplicate sample was taken for each block of 20 samples. Field methodology and site spacing (Appendix I) in the St. George area were influenced by the presence of abundant glacio-fluvial and outwash deposits as well as by subsequent marine activity. This emphasizes the importance of recognizing surficial deposits of different genesis. Where possible, basal till was the material collected, but ablation till was also collected in areas where no basal till could be found.

Using stainless steel equipment, a total of 110 till samples (excluding field duplicates) were collected from natural exposures, road-cuts, and hand-dug excavations. Seven duplicates were collected to ensure quality control and consistency in sampling procedures. Sample material was obtained from the C-horizon at a mean depth of 0.75 m and consisted of approximately 5 lbs of matrix material and 60 to 100 clasts, ranging in size from 2 cm to 10 cm in diameter. Also, a detailed site card was completed at each site that involved systematically tabulating information regarding the texture, consistency and colour of the sample material, soil profile characteristics, as well as information concerning local drainage and vegetation (Appendix II).

Laboratory Methods

Sample Preparation

Sample preparation was done in-house by the Geological Survey Branch (Fredericton). Samples were first dried in low temperature ovens to remove moisture and then dry sieved to the clay plus silt fraction (<0.063 mm) for geochemical analysis, and to the sand plus silt plus clay fraction (<2 mm) for grain size analysis. Fifty grams of the <2 mm material were weighed out for each sample as required for grain size analysis.

Lab duplicate and standard samples were added, and the suite of samples submitted for geochemical analysis by Instrumental Neutron Activation Analysis (INAA) — Becquerel Labs, Mississauga, ON and Inductively Coupled Plasma Emission-Mass Spectrometry (ICP-MS) — ACME Labs, Vancouver, BC.

Till Lithology Analysis

Lithological analysis of the till samples was conducted on the clast component only, therefore no significant sample preparation was required, as clasts sized between 2 and 10 cm in diameter were hand-separated from till samples in the field. After a thorough cleaning by water under high-pressure, these clasts were examined and then categorized on the basis of lithology. When necessary, clasts were cut or split to expose a fresh surface. Results of the clast identifications are presented as percent concentrations of specific lithologies relative to the total clast count. For example, if for a particular site there are 20 grey sandstone clasts, and the total clast count is 80 then the grey sandstone concentration for that site is 25 percent. Results of lithological analysis are presented as part of the site data (Appendix III – Textural Data).

Grain Size Analysis

Using a sedimentation technique modified after the hydrometer method of Bouyoucos (1962), granulometric analysis was conducted on the <2 mm fraction to quantify the relative amount of sand, silt, and clay in each of the 110 till samples. Results are presented in Appendix III.

Statistical Methods

The mean value, minimum value, maximum value, standard deviation, and percentiles (25^{th} , 50^{th} , 75^{th} , 80^{th} , 90^{th} , 95^{th} , 98^{th} , 99^{th}) are presented for each element (Appendix IV — INAA; Appendix V — ICP-MS). Data analysis was conducted on all sites as a whole, but for comparative purposes, it was also carried out on the basal till and ablation till data populations separately.

ANALYTICAL PROCEDURES

(adapted from NGR open files text - e.g. Friske et al., 2002)

Instrumental Neutron Activation Analysis (INAA)

Weighed and encapsulated samples are packaged for irradiation along with internal standards and international reference materials. Samples and standards are irradiated together with neutron flux monitors in a two-megawatt pool type reactor. After a seven-day decay period, samples are measured with a high-resolution germanium detector. Typical counting times are 500 seconds.

ELEMENT		DETECTION LEVEL	
As	Arsenic	0.5	ppm
Au	Gold	2	ppb
Ba	Barium	50	ppm
Br	Bromine	0.5	ppm
Ce	Cerium	5	ppm
Co	Cobalt	5	ppm
Cr	Chromium	20	ppm
Cs	Cesium	0.5	ppm
Eu	Europium	1	ppm
Fe	Iron	0.2	pct
Hf	Hafnium	1	ppm
La	Lanthanum	2	ppm
Lu	Lutetium	0.2	ppm
Mo	Molybdenum	1	ppm
Na	Sodium	0.02	pct
Ni	Nickel	10	ppm
Rb	Rubidium	5	ppm
Sb	Antimony	0.1	ppm
Sc	Scandium	0.2	ppm
Sm	Samarium	0.1	ppm
Ta	Tantalum	0.5	ppm
Tb	Terbium	0.5	ppm
Th	Thorium	0.2	ppm
Ti	Titanium	100	ppm
U	Uranium	0.2	ppm
W	Tungsten	1	ppm
Yb	Ytterbium	2	ppm
Zn	Zinc	100	ppm

Table 1. Elements in till determined by Instrumental Neutron Activation Analysis. Minimum detection limits are also shown (above).

ELEMENT		DETECTION LEVEL	
Ag	Silver	2	ppb
Al	Aluminum	0.01	pct
As	Arsenic	0.1	ppm
Au	Gold	0.2	ppb
B	Boron	1	ppm
Ba	Barium	0.5	ppm
Bi	Bismuth	0.02	ppm
Cd	Cadmium	0.01	ppm
Ca	Calcium	0.01	pct
Co	Cobalt	0.1	ppm
Cr	Chromium	0.5	ppm
Cu	Copper	0.01	ppm
Fe	Iron	0.01	pct
Ga	Gallium	0.1	ppm
Hg	Mercury	5	ppb
K	Potassium	0.01	pct
La	Lanthanum	0.5	ppm
Mg	Magnesium	0.01	pct
Mn	Manganese	1	ppm
Mo	Molybdenum	0.01	ppm
Na	Sodium	0.001	pct
Ni	Nickel	0.1	ppm
P	Phosphorus	0.001	pct
Pb	Lead	0.01	ppm
S	Sulphur	0.01	pct
Sb	Antimony	0.02	ppm
Sc	Scandium	0.1	ppm
Se	Selenium	0.1	ppm
Sr	Strontium	0.5	ppm
Te	Tellurium	0.02	ppm
Th	Thorium	0.1	ppm
Ti	Titanium	0.001	pct
Tl	Thallium	0.02	ppm
U	Uranium	0.1	ppm
V	Vanadium	2	ppm
W	Tungsten	0.2	ppm
Zn	Zinc	0.1	ppm

Table 2. Elements in till determined by Inductively Coupled Plasma Emission - Mass Spectrometry. Minimum detection limits are also shown (above).

Elements determined by INAA include: Ag, As, Au, Ba, Br, Cd, Ce, Co, Cr, Cs, Eu, Fe, Hf, Ir, La, Lu, Mo, Na, Ni, Rb, Sb, Sc, Se, Sm, Sn, Ta, Tb, Te, Th, Ti, U, W, Yb, Zn, and Zr. Data for Ag, Cd, Ir, Se, Sn, Te, Ti, and Zn are not published because of inadequate detection limits and/or precision. Elements and detection limits are shown in Table 1.

Inductively Coupled Plasma Emission - Mass Spectrometry (ICP-MS)

For the determination of 37 elements listed in Table 2, a one gram sample is leached with 6 ml of a mixture of HCl, HNO₃, and distilled, deionized water (2:2:2 v/v) at 95° C for one hour. The sample solution is diluted to 20 ml and analysed by inductively coupled plasma emission spectroscopy on a Jarell Ash instrument and inductively coupled plasma mass spectroscopy on a Perkin Elmer Elan instrument.

Comparison of Data Produced by Two Methods

Analytical results obtained by the two methods are listed for several elements. Caution should be exercised in comparing data generated by the two methods.

Results for As, Ba, Co, Cr, Fe, La, Na, Sb, Sc, Th, U and W in sediments were obtained by ICP-MS using a partial extraction method with an HNO₃ – HCl digestion. Chemistry data for elements obtained by INAA are 'total' data. Hence, ICP-MS results will likely be lower than those obtained by INAA.

CONTOUR MAPS

The included contour maps show geochemical relief (variation in concentration) across the study area for As, Sb, Cu, and Pb (Appendix I). The presentation of this data in visual format allows for enhanced recognition of anomalous zones, dispersal patterns, or any other trends. They can be used as a quick reference in distinguishing areas that warrant further investigation from those that are less favourable.

To represent the St. George map area geochemical relief in a regional sense, geochemical data from St. George were combined with recent survey data from 21G/03, 06, 07 and G/10 and the resulting dataset converted to percentiles. The St. George percentile data was then extracted from this dataset and contoured using Surfer 8[®]. The method of contouring used was point kriging. Point kriging estimates the values at grid nodes by using a moving-average technique of contouring, thereby compensating for the somewhat irregular spacing of the sample sites. Statistically, kriging is based on the Theory of Regionalized Variables. A variable is considered a 'regionalized variable' if it varies from one place to another with apparent continuity. Such is the case with geochemical data; therefore kriging is viewed as the best suited contouring method.

Due to lack of adequate basal till coverage, contour plots are the amalgamation of basal till and ablation till sites. It is up to the reader to distinguish anomalies inherent to each population by referring to the geochemistry listings (Appendices VI and VII). It should

be noted that contour plots for gold were not included because of the skewed database that results from excessive near/below detection results and the nugget effect (see analytical methods below). Sites with >4.5 ppm (>95th percentile) gold are shown in purple on the Arsenic and Antimony contour plots for easy reference. Gold anomalies can also be viewed in the geochemistry listing and should be compared with the pathfinder elements (As, Sb).

PRESENTATION AND INTERPRETATION OF GOLD DATA

(adapted from NGR open files text - e.g. Friske et al., 2002)

The following discussion reviews the format used to present the gold geochemical data and outlines some important points to consider when interpreting these data. This discussion is included in recognition of the special geochemical behavior and mode of occurrence of gold in nature and the resultant difficulties in obtaining and analyzing samples reflecting the true concentration level at a given site.

An appropriate interpretation of geochemical gold data from regional till surveys requires an appreciation of the unique chemical and physical characteristics of gold and its mobility in the surficial environment. Key properties of gold that distinguish its geochemical behaviour from most other elements include:

1. Gold occurs most commonly in the native form, which is chemically and physically resistant. A significant proportion of the metal is dispersed in a micron-sized particulate form, and the high specific gravity of gold results in a heterogeneous distribution.
2. Gold typically occurs at low concentrations, in the parts per billion (ppb) range. Whereas gold concentrations of only a few parts per million (ppm) may represent economic deposits, background levels in tills seldom exceed 10 ppb, and commonly are near the detection limit of 2 ppb.

These factors result in a particle sparsity effect wherein very low concentrations of gold are heterogeneously enriched or depleted in the surficial environment. Hence, a major problem facing the geochemist is to obtain a representative sample. In general, areas where concentrations of gold in sediments are low, and/or grain sizes of the gold present are relatively high, require proportionally larger samples to reduce the variability between subsample analytical values. Conversely, as actual gold concentrations increase, or grain size decreases, the number of gold particles to be split between random subsamples increases and the variability of results decreases. The limited amount of material collected during the rapid, reconnaissance-style regional surveys and the need to analyze for a broad spectrum of elements, precludes the use of a significantly large sample weight for the gold analyses. Therefore, to obtain representative samples, sieving of the dried sediments is employed to reduce grain size.

The following control methods are currently applied to evaluate and monitor the sampling and analytical variability, which are inherent in the analysis of gold in geochemical media.

For each block of 20 samples:

- a) Random insertion of a standard reference sample to control analytical accuracy and long-term precision;
- (b) Collection of a field duplicate (two samples from one site) to measure sampling and analytical variance;
- (c) Analysis of a second subsample (blind duplicate) from one sample to measure and control short-term precision or analytical variance.

In summary, geochemical follow-up investigations for gold should be based on a careful consideration of all geological and geochemical information, and especially a careful appraisal of gold geochemical data and its variability. In some instances, pathfinder element associations in favourable geology may indirectly identify prospective follow-up areas, even though an anomalous gold response due to natural variability may be lacking.

Once an anomalous area has been identified, field investigations should be designed to include detailed geochemical follow-up surveys and collection of large representative samples. Subsequent repeat subsample analyses will increase the reliability of results and permit a better understanding of natural variability which can then be used to improve sampling methods and interpretation.

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