



**GEOLOGICAL SURVEY OF CANADA  
OPEN FILE 7006**

**Geochemical, Mineralogical and Kimberlite Indicator Mineral  
Data for Silts, Heavy Mineral Concentrates and Waters from a  
Geochemical Survey on Victoria Island, Northwest Territories  
(NTS 87G, 87H, 88A and 88B)**

**M.W. McCurdy, S.J.A. Day, and R.J. McNeil**

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# **Geochemical, Mineralogical and Kimberlite Indicator Mineral Data for Silts, Heavy Mineral Concentrates and Waters from a Geochemical Survey on Victoria Island, Northwest Territories (NTS 87G, 87H, 88A and 88B)**

## **Introduction**

A regional stream sediment, heavy mineral and water geochemical survey was carried out in the northwestern regions of Victoria Island, Northwest Territories in 2010 (Fig. 1). This report consists of field observations and analytical data for 53 elements in stream silts by a partial method of analysis (aqua regia digestion), 35 elements in stream silts by a total method (Instrumental Neutron Activation) and 62 elements in waters from 63 sites. Mineralogical data derived from 15 heavy mineral concentrate samples are included with this report.

Funds for the collection and analysis of stream sediments, heavy minerals and waters were made available under the Geo-Mapping for Energy and Minerals (GEM) Program at NRCan.

The GEM Program is a 5-year investment by the Government of Canada in geoscience information leading to the discovery of new energy and mineral resources in Canada. GEM is delivered at the federal level by Natural Resources Canada (NRCan) and the Polar Continental Shelf Project (PCSP). The major focus is on large areas of Canada's North where insufficient public geoscience information exists to attract and guide effective private sector investment.

The GEM Minerals component (MGM) of the GEM Program is designed to raise the level of geoscience knowledge of Canada's North, with emphasis on the acquisition and rapid release of data for mineral exploration and land-use planning. Supported by geochemical and geophysical information, multidisciplinary teams (federal, territorial/provincial, university-based collaborators and students) are targeting areas with high potential for base and precious metals, diamonds and rare metals.

The Victoria Island Project is a partnership of NRCan, Northwest Territories Geoscience Office (NTGO) and universities that focuses mainly on improving the understanding of the Neoproterozoic Shaler SuperGroup hosting the Franklin/Coronation Sills (base and precious metals, alabaster) in central Victoria Island. Additional work was carried out in Paleozoic strata with potential for Mississippi Valley-type Pb-Zn mineralization in 2011.

Analytical results and field observations form part of a national geochemical database used for resource assessment, mineral exploration, geological mapping, and environmental studies. Sample collection, preparation procedures and analytical methods are strictly specified and carefully monitored to ensure consistent and reliable results regardless of the area, the year of collection or the analytical laboratory undertaking the analyses.

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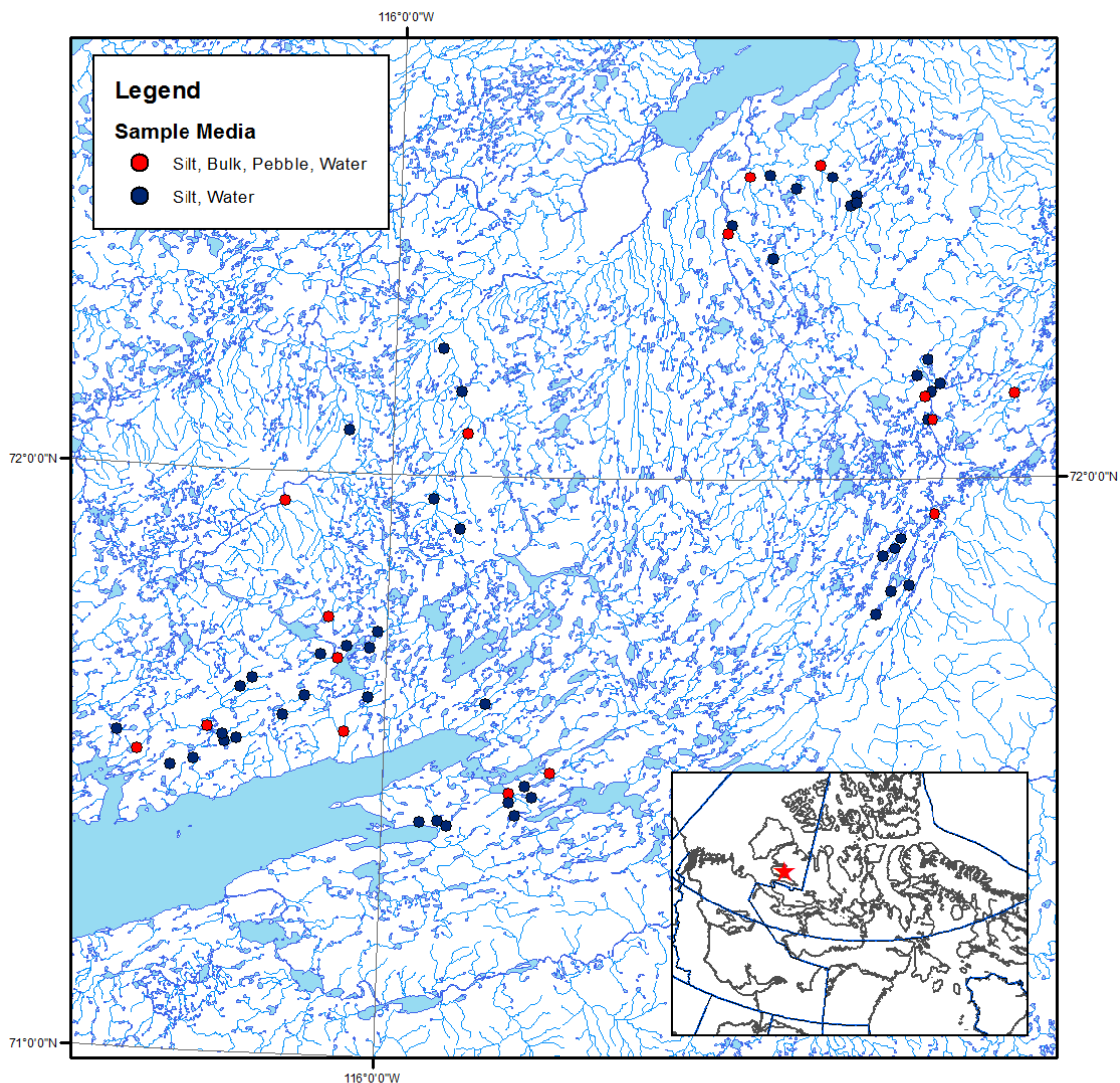
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**Fig. 1 Map showing stream sediment, heavy mineral concentrates and water sampling sites on Victoria Island, Northwest Territories.**

## **SAMPLE COLLECTION**

### *Stream Sediments (Silts)*

At each site, a pre-labelled Kraft paper bag (12.5 cm x 28 cm with side gusset) was two-thirds filled with silt or fine sand collected from the active stream channel (Fig. 2). The silt sample was collected after the water sample(s) and before the bulk sediment sample. Commonly, the sampler collected silt by hand from various points in the active channel while moving upstream, over a distance of 5 to 15 m. If the stream channel was found to consist mainly of clay, coarse material or organic sediment from which suitable sample



material is scarce or absent, moss mat from the stream channel, which commonly contains trapped silt, may have been added to the sample. A field duplicate pair of silt samples, assigned sequential sample numbers, was collected within each block of 20 samples. The first sample of the pair was assigned a replicate status value of 10 and the second was assigned a replicate status value of 20. Routine (non-duplicate) field samples were assigned replicate status values of 0.



**Figure 2:** Pre-labelled Kraft paper bags and plastic bottles are used to collect samples of stream silts and stream waters. A bulk sample, for heavy mineral processing, is collected by wet-sieving coarse-grained stream sediment using a US Sieve Series 12-mesh (1.68 mm) sieve and collecting <12 mesh grains in a plastic pail lined with a polyethylene sample bag. The gold pan is used for adding water for wet sieving, not for heavy mineral concentrate panning. A sample composed of granules and pebbles, for archive, is collected at bulk sample sites by sieving >12 mesh material through a US Sieve Series 2-mesh (10 mm) sieve and collecting the <10 mm material in a labelled Kraft paper bag (not shown). Field observations are noted on pre-printed water-resistant paper (see Appendix 1).

### *Stream Waters*

Waters were sampled in mid-channel, from flowing water where possible. One water sample was collected at each site. The samples were collected in 125-ml Nalgene HDPE bottles (Fig. 2). Samples were collected after rinsing each bottle two times in flowing water before a final fill. Field duplicate pairs of water samples, assigned sequential sample numbers, were collected within each block of 20 samples. The first sample of each pair was assigned a replicate status value of 10 and the second was assigned a

replicate status value of 20. Routine (non-duplicate) field samples were assigned replicate status values of 0.

### *Heavy Mineral Concentrates*

Ideal sites for the collection of sediments for the heavy mineral concentrate fraction are located at the upstream ends of mid-channel boulder bars and behind mid-stream boulders (Prior et al., 2007). Material was collected by shovel from one (preferred) or more holes dug in the stream bed (commonly to depths of a few 10's of centimetres. A 22.7 litre (5-gallon) plastic pail was lined with a heavy-duty polyethylene bag measuring 46x61 cm (18x24 inches, 4 Mil). Material was wet-sieved into the pail through a 12-mesh (1.68 mm) stainless steel sieve until a sample weight of 10-15 kg was attained. The bag lining the pail, labelled with the sample number, was taped shut with black plastic (electrical) tape and placed into a second bag, also labelled with the sample number, and taped. Samples were shipped directly to a commercial lab for preparation and analysis.

## **SAMPLE PREPARATION**

### *Stream Sediments (Silts)*

The Kraft paper bags containing the silt samples were placed into plastic bags, taped with electrical tape and shipped directly to the GSC laboratories in Ottawa, where they were unpacked and air-dried at temperatures below 40°C. After drying, samples were disaggregated and sieved through a minus 80-mesh (177 µm) screen. Control reference and duplicate samples were inserted into each block of twenty samples.

### *Waters*

Water samples for acidification were filtered within 24 hours of collection through single-use Millipore Sterivex-HV 0.45-µm filter units attached to 50-ml sterile plastic syringes. After 50-ml of water was filtered into new 60-ml bottles, the remainder was used for the determination of pH and conductivity before being discarded. Eppendorf pipettors with disposable plastic tips were used to add 0.5 ml 8M HNO<sub>3</sub> to filtered water samples. Syringes were re-used after rinsing with distilled, de-ionized water (syringes were replaced daily). Control reference samples (filter, acid and travel blanks\*) were added to each batch of samples. Filtered and acidified waters were kept in a cool dark place until shipment to GSC laboratories. Control reference samples were inserted into each block of 20 water samples. Field duplicate water samples were included in the sample suite.

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\* Filter (sample) blanks are 60-ml bottles filled with deionized water used in the field that has been filtered and acidified at the same time as routine samples; acid blanks are samples of the deionized water used in the field and acidified (but not filtered) at the same time as routine samples; travel blanks are bottles of deionized water pre-filled at the GSC lab in advance of field sampling and acidified in the field with the survey samples.

### *Heavy Mineral Concentrates*

Before processing, a 500-g character sample was collected from each sample and archived. The bulk sediment samples were then progressively reduced by a range of laboratory procedures to concentrate heavy minerals. Initially a low-grade table concentrate was prepared from each of the samples. Gold grains were observed at this stage and were counted, measured and classified as to degree of wear (reflecting distance of transport). The table reject was re-tabled to scavenge possible unrecovered kimberlite indicator minerals and magmatic massive sulphide indicator minerals. The concentrate from both tabling runs was separated in methylene iodide diluted with acetone to S.G. 3.20 to recover heavy minerals including Cr-diopside and olivine. Magnetite was removed after the heavy liquid separation and the remaining concentrate cleaned with oxalic acid to remove limonite stains. The dried concentrate was sieved into several size fractions, (<0.25 mm, 0.25 to <0.5 mm, 0.5 mm to <1.0 mm,  $\geq 1.0$  mm to 2.0 mm). The <0.25 mm fraction was kept for chemical analysis and the 0.25 to 0.50 mm fraction was sorted with a Carpc® drum magnetic separator into strongly, moderately, weakly and non-paramagnetic fractions.

## **ANALYTICAL PROCEDURES**

### *Stream Sediment (Silt) Geochemical Analyses*

#### *Instrumental Neutron Activation Analysis (INAA)*

Weighed and encapsulated samples, normally 30 g, were packaged for irradiation along with internal standards and international reference materials. Samples and standards were irradiated together with neutron flux monitors in a two-megawatt pool type reactor. After a seven-day decay period, samples were measured with a high-resolution germanium detector. Typical counting times were 500 seconds. Elements determined by INAA are listed in Table 1.

Table 1. Variables determined by INAA reanalysis of stream silt samples

Variable	Detection Limit	Units of Measurement	Variable	Detection Limit	Units of Measurement
Ag	2	ppm <sup>1</sup>	Ni	10	ppm
As	0.5	ppm	Rb	5	ppm
Au	2	ppb <sup>2</sup>	Sb	0.1	ppm
Ba	40	ppm	Sc	0.2	ppm
Br	0.5	ppm	Se	5	ppm
Cd	5	ppm	Sm	0.1	ppm
Ce	5	ppm	Sn	100	ppm
Co	5	ppm	Ta	0.5	ppm
Cr	20	ppm	Tb	0.5	ppm
Cs	0.5	ppm	Te	10	ppm
Eu	1	ppm	Th	0.2	ppm

Variable	Detection Limit	Units of Measurement	Variable	Detection Limit	Units of Measurement
Fe	0.2	pct <sup>3</sup>	Ti	500	ppm
Hf	1	ppm	U	0.2	ppm
Ir	50	ppb	W	1	ppm
La	2	ppm	Wt	0.1	g <sup>4</sup>
Lu	0.2	ppm	Yb	2	ppm
Mo	1	ppm	Zn	100	ppm
Na	0.02	pct	Zr	200	ppm

- <sup>1</sup> parts per million, mg/kg  
<sup>2</sup> parts per billion, µg/kg  
<sup>3</sup> percent  
<sup>4</sup> grams

### *Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and Other Analyses*

For the determination of 53 elements listed in Table 2, a 15-gram sample was leached with 6mL/g of concentrated HCl, HNO<sub>3</sub> and demineralised water (2:2:2 v/v) at 95° C in a beaker for one hour. After cooling the solution was made up to a final volume with 5% HCl. The ratio of sample weight to solution volume was 0.5 g per 10 ml. The sample solution was analysed by inductively coupled plasma emission spectroscopy and inductively coupled plasma mass spectroscopy.

Organic and inorganic carbon data listed in **Appendix 2 GSC OF 7006 FIELD & ANALYTICAL DATA.xls, Worksheet ‘Carbon Data’** were determined in stream sediment samples using a Leco CR-412 Carbon Analyser®. “Total” carbon content was first determined on a split, and the inorganic carbon determined on another split after removing organic carbon by ashing at <500° C. Organic carbon was determined by subtracting the inorganic carbon from the total (Girard et al., 2004).

Loss-on-ignition was determined using a one-gram sample. Each sample, in a Leco® crucible, was placed into a 100°C muffle furnace and brought up to 500° C for one hour. The oven was then cooled to 100°C and the crucibles transferred to a desiccator followed by cooling to room temperature. The crucibles were re-weighed to determine the loss-on-ignition.

**Table 2** Variables in stream silts determined by Inductively Coupled Plasma – Emission Spectroscopy (ICP-ES)/Mass Spectroscopy (ICP-MS)

Element	Detection Limit	Units of Measurement	Analytical Method	Element	Detection Limit	Units of Measurement	Analytical Method
Ag	2	ppb <sup>1</sup>	ICP-MS	Na	0.001	pct	ICP-MS
Al	0.01	pct <sup>2</sup>	ICP-MS	Nb	0.02	ppm	ICP-MS
As	0.1	ppm <sup>3</sup>	ICP-MS	Ni	0.1	ppm	ICP-MS
Au	0.2	ppb	ICP-MS	P	0.001	pct	ICP-MS
B	20	ppm	ICP-MS	Pb	0.01	ppm	ICP-MS



Element	Detection Limit	Units of Measurement	Analytical Method	Element	Detection Limit	Units of Measurement	Analytical Method
Ba	0.5	ppm	ICP-MS	Pd	10	ppb	ICP-MS
Be	0.1	ppm	ICP-MS	Pt	2	ppb	ICP-MS
Bi	0.02	ppm	ICP-MS	Rb	0.1	ppm	ICP-MS
Ca	0.01	pct	ICP-ES	Re	1	ppb	ICP-MS
Cd	0.01	ppm	ICP-MS	S	0.01	pct	ICP-MS
Ce	0.1	ppm	ICP-MS	Sb	0.02	ppm	ICP-MS
Co	0.1	ppm	ICP-MS	Sc	0.1	ppm	ICP-MS
Cr	0.5	ppm	ICP-MS	Se	0.1	ppm	ICP-MS
Cs	0.02	ppm	ICP-MS	Sn	0.1	ppm	ICP-MS
Cu	0.01	ppm	ICP-MS	Sr	0.5	ppm	ICP-MS
Fe	0.01	pct	ICP-ES	Ta	0.05	ppm	ICP-MS
Ga	0.2	ppm	ICP-MS	Te	0.02	ppm	ICP-MS
Ge	0.1	ppm	ICP-MS	Th	0.1	ppm	ICP-MS
Hf	0.02	ppm	ICP-MS	Ti	0.001	pct	ICP-MS
Hg	5	ppb	ICP-MS	Tl	0.02	ppm	ICP-MS
In	0.02	ppm	ICP-MS	U	0.1	ppm	ICP-MS
K	0.01	pct	ICP-ES	V	2	ppm	ICP-MS
La	0.5	ppm	ICP-MS	W	0.1	ppm	ICP-MS
Li	0.1	ppm	ICP-MS	Y	0.01	ppm	ICP-MS
Mg	0.01	pct	ICP-ES	Zn	0.1	ppm	ICP-MS
Mn	1	ppm	ICP-ES	Zr	0.1	ppm	ICP-MS
Mo	0.01	ppm	ICP-MS				

- <sup>1</sup> parts per billion, µg/kg
- <sup>2</sup> percent
- <sup>3</sup> parts per million, mg/kg

### ***Water Analyses***

The pH of stream waters was determined at the field base using Hanna Instruments Combo® waterproof testers with automatic temperature compensation, a range of 0.00 to +14.00 pH, a resolution of 0.01 pH and an accuracy of ±0.05 pH. Meters were calibrated using commercial buffer solutions with pH values of 4.0, 7.0 and 10.0.

The conductivity of stream waters was determined at the field base using a Hanna Instruments Combo® waterproof tester with a range of 0 to 3999 µS/cm, a resolution of 1 µS/cm and an accuracy of ±2%. Meters were calibrated using commercial conductivity standards with values of 1413 µS/cm and 84µS/cm.

### ***Trace and Major Elements***

Acidified and filtered stream water samples were analyzed for trace metal and major elements at GSC laboratories in Ottawa. A complete list of elements and stated detection limits are given in Table 3.

Trace metal analysis was performed using a VG PQII ICP-MS with a Meinhard concentric glass nebulizer, Type K (solution uptake rate 1 ml min<sup>-1</sup>), a quartz Scott-type double-pass chilled spray chamber (2°C) and a 27 MHz standard quartz torch. The argon flow-rates are: Cool 12.5 l min<sup>-1</sup>, Auxiliary 0.85 l min<sup>-1</sup>, and Nebulizer 0.9 l min<sup>-1</sup>. The RF power is 1350 watts. Isotopes measured and corrections for spectral interferences are detailed in Hall et al. (1995, 1996). Data for hafnium and zirconium are not published because these elements are not sufficiently stabilized in waters by the addition of nitric acid. Data for indium, selenium, silver, tantalum and thulium are not published because of inadequate detection limits and/or precision.

**Table 3:** Major and trace elements determined in stream waters

ELEMENT		DETECTION LEVEL		LABORATORY METHOD
Waters –Filtered, Acidified (FA-Water)				
Al	Aluminum	2	ppb	ICP-MS
As	Arsenic	0.1	ppb	ICP-MS
B	Boron	0.5	ppb	ICP-MS
Ba	Barium	0.2	ppb	ICP-MS
Be	Beryllium	0.005	ppb	ICP-MS
Cd	Cadmium	0.02	ppb	ICP-MS
Ce	Cerium	0.01	ppb	ICP-MS
Cs	Cesium	0.01	ppb	ICP-MS
Co	Cobalt	0.05	ppb	ICP-MS
Cr	Chromium	0.1	ppb	ICP-MS
Cu	Copper	0.1	ppb	ICP-MS
Dy	Dysprosium	0.005	ppb	ICP-MS
Er	Erbium	0.005	ppb	ICP-MS
Eu	Europium	0.005	ppb	ICP-MS
Ga	Gallium	0.01	ppb	ICP-MS
Gd	Gadolinium	0.005	ppb	ICP-MS
Ge	Germanium	0.02	ppb	ICP-MS
Ho	Holmium	0.005	ppb	ICP-MS
La	Lanthanum	0.01	ppb	ICP-MS
Li	Lithium	0.02	ppb	ICP-MS
Lu	Lutetium	0.005	ppb	ICP-MS
Mn	Manganese	0.1	ppb	ICP-MS
Mo	Molybdenum	0.05	ppb	ICP-MS
Nb	Niobium	0.01	ppb	ICP-MS
Nd	Neodymium	0.005	ppb	ICP-MS
Ni	Nickel	ppb		ICP-MS
Pb	Lead	0.01	ppb	ICP-MS
Pr	Praseodymium	0.005	ppb	ICP-MS
Rb	Rubidium	0.05	ppb	ICP-MS
Re	Rhenium	0.005	ppb	ICP-MS
Sb	Antimony	0.01	ppb	ICP-MS
Sm	Samarium	0.005	ppb	ICP-MS
Sn	Tin	0.01	ppb	ICP-MS
Sr	Strontium	0.5	ppb	ICP-MS
Tb	Terbium	0.005	ppb	ICP-MS
Te	Tellurium	0.02	ppb	ICP-MS
Ti	Titanium	0.5	ppb	ICP-MS
Tl	Thallium	0.005	ppb	ICP-MS
U	Uranium	0.005	ppb	ICP-MS
V	Vanadium	0.1	ppb	ICP-MS
W	Tungsten	0.02	ppb	ICP-MS
Y	Yttrium	0.01	ppb	ICP-MS
Yb	Ytterbium	0.005	ppb	ICP-MS
Zn	Zinc	ppb		ICP-MS
Ca	Calcium	0.02	ppm	ICP-ES
Fe	Iron	0.005	ppm	ICP-ES
K	Potassium	0.05	ppm	ICP-ES
Mg	Magnesium	0.005	ppm	ICP-ES
Na	Sodium	0.05	ppm	ICP-ES
P	Phosphorus	0.05	ppm	ICP-ES

ELEMENT		DETECTION LEVEL		LABORATORY METHOD
S	Sulphur	0.05	ppm	ICP-ES
Si	Silicon	0.02	ppm	ICP-ES

Major element analysis was performed using a Perkin-Elmer 3000DV Inductively Coupled Plasma – Emission Spectrometer (ICP-ES) with a cross-flow nebulizer (solution uptake rate 1 ml min<sup>-1</sup>), a Ryton Scott-type double-pass spray chamber and a custom demountable quartz ICP-ES torch. The argon flow-rates are: Plasma 15.0 l min<sup>-1</sup>, Auxiliary 0.5 l min<sup>-1</sup>, and Nebulizer 0.7 l min<sup>-1</sup>. The RF power is 1350 watts. All elements were analyzed in axial mode except for sodium and potassium, which were run in radial mode. Inter-element correction factors were applied as required to correct for various spectral interferences. Data for scandium are not published because of inadequate detection limits and/or precision.

#### *Format of Analytical Data Files*

Analytical results are presented in an Excel® spreadsheet file included with this report: **Appendix 2 GSC OF 7006 FIELD & ANALYTICAL DATA**. There are four worksheets in this file:

<u>Worksheet</u>	<u>Contents</u>
<b>Field Data</b>	site specific field observations including geographic coordinates
<b>Silt Data</b>	ICP-MS/ES and INA analytical data for silt samples
<b>Carbon Data</b>	Total, Inorganic, Organic C and Loss-on-Ignition in silts
<b>Water Data</b>	ICP-MS/ES and pH and conductivity of water samples

#### *Heavy Mineral Concentrate Analyses*

Kimberlite indicator minerals (KIMs) were visually identified and hand-picked from each of three size fractions (0.25-0.5 mm, 0.5 mm-1.0 mm, 1.0-2.0 mm). Fractions exceeding a 100 g threshold were characterized by a 100 g split and normalized to represent the total sample weight. Following removal of the kimberlite indicator minerals, 100 grains were randomly selected from each 0.25-0.5 mm fraction and identified. After 100 grains were identified they were recombined with the source sample fraction. The 0.25-0.5 mm, 0.5-1.0 mm and 1.0-2.0 mm fractions (minus KIMs) were archived.

#### *Format of Heavy Mineral Concentrate Data Files*

Heavy mineral concentrate data are presented in an Excel® spreadsheet file included with this report: **Appendix 3 GSC OF 7006 HMC DATA**. There are five worksheets in this file:

<u>Worksheet</u>	<u>Contents</u>
<b>Tabling Data</b>	Description of original bulk sample as received at laboratory
<b>Gold Summary</b>	Gold grain data
<b>KIM Data</b>	Kimberlite Indicator Mineral (KIM) data
<b>MMSIM</b>	Magmatic or metamorphosed Massive Sulphide Indicator Mineral (MMSIM) data
<b>Abbreviations</b>	Abbreviations used by Overburden Drilling Management in published reports

## QUALITY CONTROL FOR GEOCHEMICAL RESULTS

Reliability (Trueness, Accuracy and Precision) of analytical data returned from commercial laboratories was determined by incorporating field duplicates (FD pairs) within the sampling protocol, and including analytical ('blind') duplicates (BD), standard reference materials (SRM) in the sample suite submitted to the labs. Table 4 provides information on the number of each quality control sample within each sample suite, based on the year of collection. Analytical data for control reference standards, analytical and field duplicates, and blanks are included with this report in Appendix 2.

	<b>Victoria Island (87G, 87H, 88A, 88B)</b>			
n	63			
	FD Pairs	BD Pairs	SRM (STSD-1)	SRM (STSD-4)
N	7	6	2	2

Table 4. Quality control samples included with 2010 stream sediment samples.

Data quality was evaluated in a three step process using control reference materials to evaluate trueness, and analytical duplicate samples to evaluate analytical precision. Field duplicate data were used to carry out an Analysis of Variance (ANOVA) in order to compare the estimated sampling and analytical variability for mapping purposes.

Tables 1 through 4 in **Appendix 4 GSC OF 7006 QUALITY CONTROL** can be used to estimate the quality of analysis for almost every element listed in Tables 1 and 2 above. Elements are grouped based on their position in the Periodic Table.

### ***'Trueness'***

'Trueness' of analytical data was evaluated by inserting Canadian Certified Reference Materials STSD-1 and STSD-4 at random locations throughout the analytical suite. STSD-1 consists of the -80 mesh (<180 micron) fraction of sediment collected from Lavant Creek, about 75 km southeast of Ottawa, ON (NTS 31F). STSD-4 is a composite

sample made up from stream sediments collected throughout NTS map sheet 31F and 93A and 93B. All -80 mesh material was ball-milled and sieved through a -200 mesh (<74 micron) screen prior to bottling (Lynch, 1990).

In Tables 1 and 2, Worksheet 'Trueness', Appendix 4, means and standard deviations (MEAN  $\pm$  SD) for control reference standards STSD-1 and STSD-4 for which provisional values have been published by Lynch (1990, 1999) are compared with the Mean of these elements determined by total and partial methods in Victoria Island samples. Accepted values in square brackets are derived from unpublished data ( $n \geq 40$ ) collected from recent projects at the GSC. The Lower Detection Limit (LDL) used by the commercial laboratories that analysed the Victoria Island samples is also listed.

For STSD-1 and STSD-4, for elements for which an accepted mean exists, almost all elements are within one or two Standard Deviations of an accepted mean. Elements with possible analytical problems are shown in bold type. However, means falling outside  $\pm 2$  SD, suggesting poor repeatability, may also be an indication that analytical results are close to the detection limit for the element.

### ***Precision***

Precision is considered in terms of the closeness of agreement between analytical duplicate samples analyzed by the same method, i.e. independent test results obtained using the same equipment within short intervals of time on duplicate project samples. In order to provide an estimate of precision for each element or analyte, the squared difference between two analytical duplicates was calculated for  $N = 7$  duplicate pairs. The sum of these values was divided by the number of samples ( $(2*N) = 14$ ) to estimate a measure of variability (variance). A Standard Deviation was then obtained by calculating the square root of this variance. The resulting numerical estimates of precision are shown in Table 3 in Appendix 2 represented by the Relative Standard Deviation, where the Standard Deviation is divided by the overall mean of the samples and multiplied by 100 to obtain a percentage (Reimann et al., 2009). Elements are grouped based on their position in the Periodic Table. Included with the element or and method of analysis are the Lower Detection Limit (LDL), the percentage of data below the Lower Detection Limit (% Below LDL), the Range and the Mean. This information provides context for the estimate of Precision in the last column of Table 3.

Elements with precisions poorer than 15% in Table 3, Worksheet 'BD Precision, Appendix 4 tend towards generally low concentrations in samples, as indicated by the Range, the Mean and the percentage of data below the detection limit. Such is the case for elements such as Pt, Pd, Re, In, Cd, Be, In, Ge, Sb, Se and Te by partial methods, and Zr, Ta and Lu by INA analysis. Results for Au by a partial method are affected by the particulate nature of gold ('nugget effect') and should be considered accordingly.

### ***Analysis of Variance (ANOVA)***

Precision and accuracy are ‘external’ criteria against which geochemical survey data are evaluated. In order to establish that these data are ‘fit for purpose,’ an Analysis of Variance (ANOVA) is required. Appendix 4, Table 4 shows results from an ANOVA undertaken on field duplicate pairs collected throughout the Victoria Island survey.

### ***Field Duplicates***

A one-way random effects model ANOVA was undertaken on each element in a set of 7 field duplicate pairs, representing one field duplicate within each block of 20 sequential sample numbers, to estimate, as a percentage, how much of the total variability is due to sampling and analysis (‘within’) of a stream and how much can be attributed to regional variability across the survey area (‘between’). Results are shown in Table 4, Worksheet ‘ANOVA’, Appendix 2. Data were not log-transformed because the range of observations did not exceed 1.5 orders of magnitude. The sampling variability was estimated from field duplicates using the ‘anova2’ function in the ‘rgr’ package running under the R system, a random effects ANOVA model estimating whether the combined sampling and analytical variability between duplicate pairs is significantly smaller than the variability between lakes (Garrett, 2011a).

<b><u>Worksheet</u></b>	<b><u>Contents</u></b>
<b>Trueness</b>	Compares accepted values for two international reference standards with results from analysis of Victoria Island samples
<b>BD Precision</b>	Provides an estimate of precision using analytical duplicate pairs
<b>ANOVA</b>	Simple pair ANOVA estimates proportion of total variability due to each of sampling and analysis
<b>Control Reference Data</b>	Analytical data used to estimate ‘trueness’ and accuracy
<b>Analytical Duplicate Data</b>	Analytical data used to estimate precision
<b>Field Duplicate Data</b>	Field duplicate data used for ANOVA

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