GEOLOGICAL SURVEY OF CANADA
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Publications in this series have not been edited; they are released as submitted by the author.

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Geochemical Data from Stream Silts and Surface Waters in the Pine Point Mining District Northwest Territories (NTS 85-B)

INTRODUCTION

Stream sediments and surface water samples in and around the Pine Point Pb-Zn mining district in the Northwest Territories were collected to identify indicator minerals and trace element signatures indicative of Mississippi Valley-Type (MVT) deposits (Fig. 1). This report consists of field observations and analytical data from 12 sites for 65 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. Isotope ratios of Pb in water from 5 sites are included with this report as well as additional variables measured in the field in waters from 12 sites. Mineralogical data derived from 8 stream sediment samples collected for heavy mineral concentrate samples were released in an earlier report (McClenaghan et al., 2012)

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 specific objectives of the GEM indicator mineral research project are**:** 1) to determine the indicator minerals and their trace element signatures that are indicative of MVT deposits; and 2) to establish practical methods for their recovery from glacial sediments and their identification that can be routinely applied in MVT exploration in glaciated terrain. The purpose of this open file is to report the trace element concentrations in stream sediment and water samples collected in 2010 and 2011 for this case study in the Pine Point mining district.

The Pine Point deposits were chosen as MVT indicator mineral test sites because: (1) the deposits and district geology are well known and bedrock samples were available from drill core; (2) the deposits subcrop and thus were exposed to direct glacial erosion; (3) the deposits were till-covered; and (4) the deposits areas are easily accessible by road.

REGIONAL SETTING

Location and Physiography

The study area straddles the Hay River Lowland and Slave River Lowland ecoregions, extending across low relief, flat-lying Palaeozoic shale and carbonate. The mean annual temperature is approximately -2.5°C with a summer mean of 13°C and a winter mean of -19°C. The mean annual precipitation ranges 300-450 mm. This ecoregion is classified as having a sub-humid mid-boreal ecoclimate. The characteristic vegetation is closed mixed stands of trembling aspen, balsam poplar, white spruce, balsam fir, jack pine and black spruce. Poorly drained sites are dominated by tamarack and black spruce. Surface deposits are predominantly peat-covered clayey lacustrine and glacial till in the nearly level Hay River Lowland and sandy plain with some Aeolian features in the gently undulating Slave River Lowland. Sporadic discontinuous permafrost with low ice content is confined to organic deposits. Moose, black bear, wolf, beaver, and snowshoe hare are common, and woodland caribou are found in some areas. Wood Buffalo Park is home to the world's largest bison herd. Major communities include Hay River, Fort Smith and Fort Providence (Ecoregions Working Group, 1989).

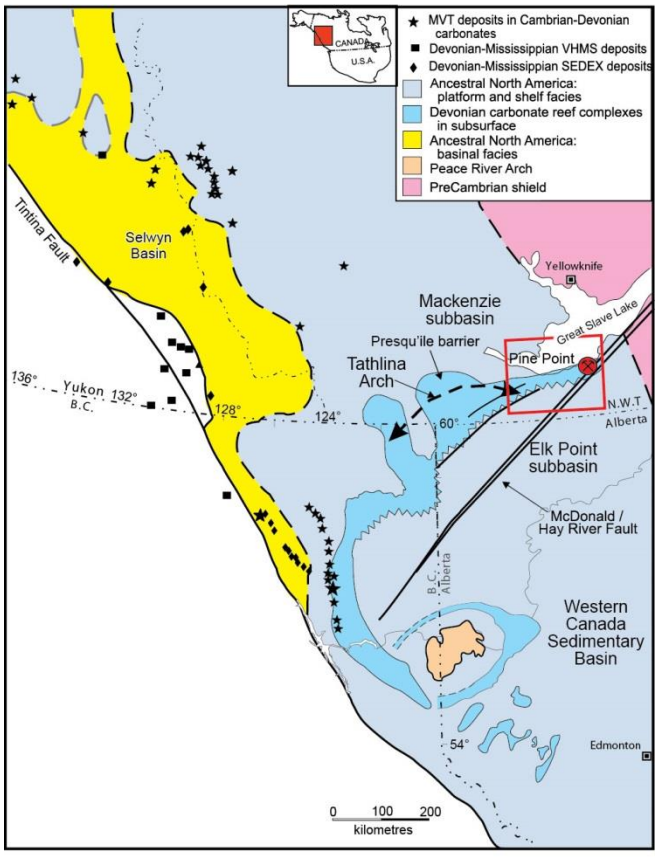

Figure 1. Location of the Pine Mining District in northern Canada (modified from Hannigan, 2007).

Geological Setting

The Pine Point mining district is underlain by rocks of the eastern margin of the Western Canada Sedimentary Basin (Fig. 1). Archaean and Proterozoic crystalline basement rocks are overlain by 350 to 600 m thick Ordovician to Devonian strata. All the MVT deposits are hosted within and adjacent to Middle Devonian carbonate rocks of the Presqu'ile barrier reef complex (Fig. 1), outcropping south of Great Slave Lake and extending west into the subsurface of the Western Canada Sedimentary Basin in northeastern British Columbia (Locock et al, 2006; Kent, 1994). The Sulphur Point Formation overlies the Upper Keg River Formation (Fig. 2) and consists of bioherms, bioclastic limestone and carbonate sandstone (Rhodes et al, 1984); Hannigan, 2007) that has undergone alteration into a coarse crystalline, vuggy dolomite, known as Presqu'ile dolomite and is the host of the majority of the ore bodies (Skall, 1975; Hannigan, 2007). Sulphide mineralization occurs as open-space cavity fills of breccia, fractures, and vugs, as well as local replacements of carbonate and disseminations (Oviatt et al, 2013). Sulphide minerals consist of galena and sphalerite (Hannigan, 2007). Minor minerals include smithsonite, cerussite, chalcopyrite, marcasite, pyrite, sulphur, pyrrhotite, celestite, barite, gypsum, anhydrite and fluorite (Hannigan, 2007).

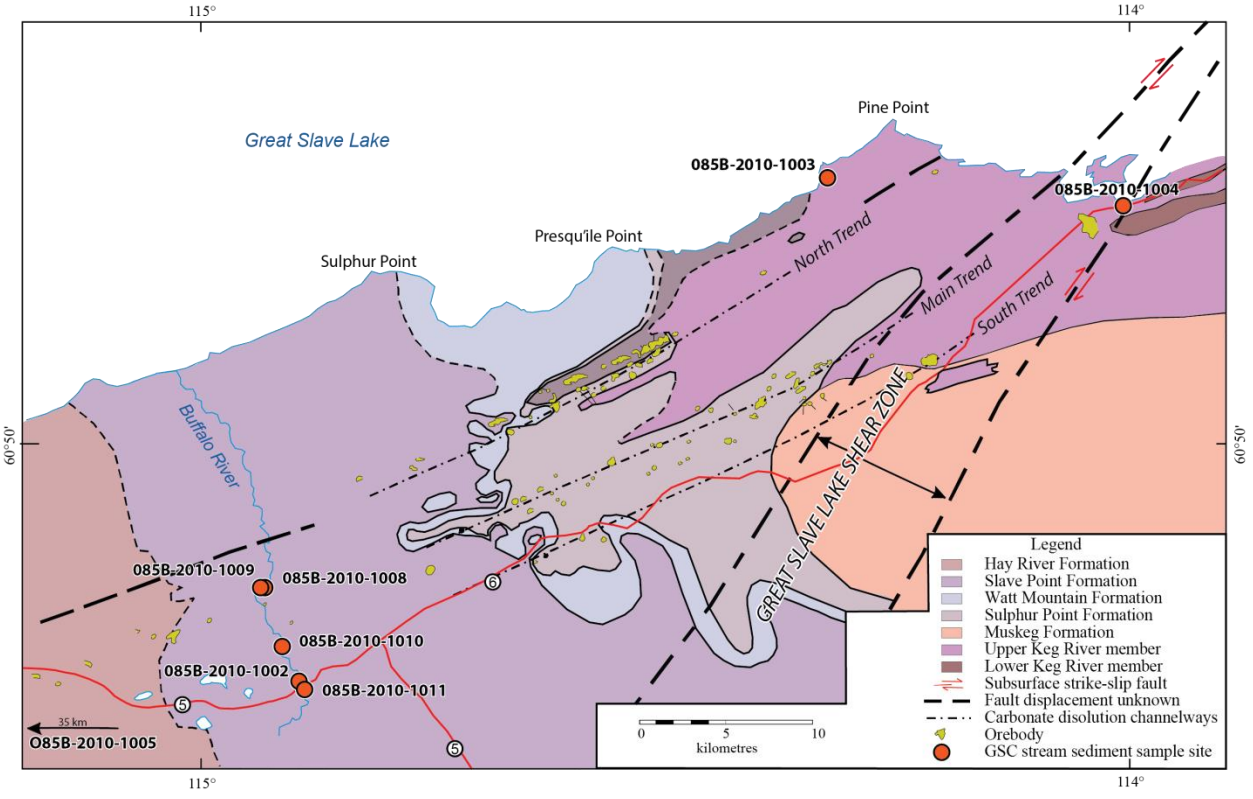

Figure 2. Regional bedrock geology of the Pine Point Mining District showing the three trends (North, Main, and South) and the location of the Pb-Zn orebodies (modified from Hannigan, 2007). Stream sediment and water samples were collected from sites indicated by orange dots (modified from Oviatt et al., 2013).

Surficial Geology

Glacial sediments formed and deposited by the Keewatin sector of the Laurentide Ice Sheet overlie relatively flat bedrock topography of the Pine Point district. Till cover occurs as a continuous blanket that generally increases in thickness from east to west (Lemmen, 1990). Till deposits at the eastern margin of the district range from <1 m to 3 m thick, and gradually thicken westward to >25 m at the western Pine Point open pits (Oviatt et al, 2013). Commonly, till in the area has a silt to fine sand matrix with very little clay (Lemmen, 1998a, b). Deglaciation took place between 10.0 and 9.6 ka BP (14C; Dyke, 2004) followed by inundation by glacial Lake McConnell (Smith, 1994).

SAMPLE COLLECTION

Stream Sediments (Silts)

At each of the ten sites from which silt samples were collected, a Kraft paper bag (12.5 cm x 28.5 cm) was two-thirds filled with silt and/or fine sand collected from the active stream channel (Fig. 3). The silt sample was taken after the water sample(s) and before a bulk sediment sample was collected. 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. Field observations were noted on pre-printed water-resistant paper forms.

Figure 3: Birch Creek: Kraft paper bags and plastic bottles were used to collect samples of stream silts and stream waters above the stream HMC site (stream is flowing towards reader). A bulk sample for heavy mineral processing (HMC) was collected at the point indicated by the arrow by wet-sieving coarse-grained stream sediment.

Surface Waters

Surface waters were collected from a number of different sources, including flowing streams (Figs. 3), rivers, drill holes (Fig. 4), mineral seeps and flooded open pit mines. At each site the first 8 variables listed in Table 1 were measured in waters using a YSI ('Yellow Springs Instrument Company') Professional Plus handheld multi-parameter meter. Colour and Turbidity were determined using a LaMotte TC-3000i meter. Field instruments were calibrated daily with known standards.

One water sample was collected at each site for trace element analysis. After flushing a 50 mL plastic syringe in the waters to be sampled, water was drawn into the syringe and filtered into a 60 ml HDPE bottle through a 0.45 µm disposable filter unit for later acidification.

At five sites 500 ml of near-surface water for Pb-isotope analysis were filtered through a 0.45 µm disposable filter and acidified within 12 hours with 5 ml 8M HNO_3. Samples were refrigerated and kept out of direct light until analysis.

	Range	Accuracy	Resolution	Units
Dissolved Oxygen (%)	0-500%	0 to 200% (±2% of reading or 2% air saturation, whichever is greater)	1% or 0.1% air saturation	%
Dissolved Oxygen (ppm)	0 to 50 ppm	0 to 20 mg/L (±2% of reading or 0.2 mg/L, whichever is greater)	0.1 or 0.01 mg/L	mg/L, ppm
Temperature	-5 to 70°C	±0.2°C	0.1°C	°C, °F, K
Conductivity	0 to 200 mS/cm	±0.5% of reading or 0.001 mS/cm, whichever is greater	0 to 500 µS/cm=0.001; 501 to 5000 µS/cm=0.01	µS, mS
Salinity	0 to 70 ppt	±1.0% of reading or 0.1 ppt, whichever is greater	0.01 ppt	ppt, PSU
pH	0 to 14 units	±0.2 units	0.01 units	mV, pH units
ORP	-1999 to +1999 mV	±20 mV in redox standards	0.1 mV	mV
Total Dissolved Solids	0 to 100 g/L TDS		0.001 g/L	kg/L, g/L
Turbidity	0 to 2000 NTU	±0.05 or ±2% of reading, whichever is greater below 100 NTU	0.05 NTU	(Nephelometric Turbidity Units (NTU)
Colour	0.0 to 50.0 cu	±0.5 cu or ±2%, whichever is greater	0.2 NTU	Platinum Cobalt Colour Units (cu)

Table 1. Specifications for YSI Professional Plus hand-held multiparameter meter (grey highlight) and LaMotte TC-3000i portable nephelometer and colorimeter (blue highlight).

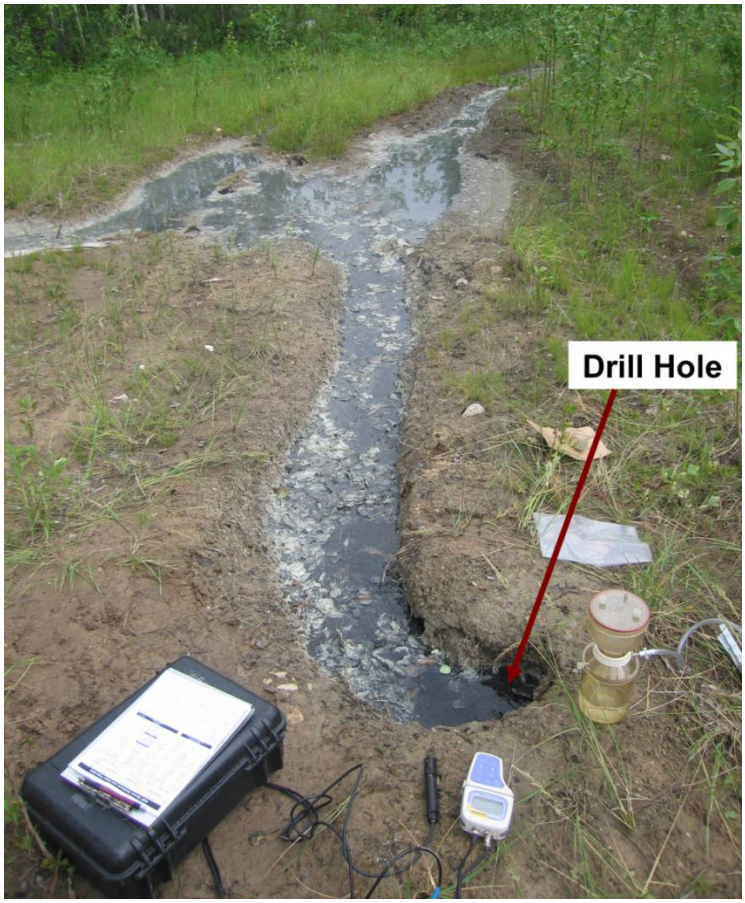

Figure 4. Water flowing from an old drill hole within an area surrounded by large ponds and other seeps was sampled and measured for the variables listed in Table 1. This site was associated with red, white and black precipitates and a sulphurous odour (photo: Rick McNeil, GSC).

SAMPLE PREPARATION

Stream Sediments (Silt)

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 40ºC. After drying, samples were disaggregated and sieved through an 80-mesh (177 μm) screen (Girard et al, 2004). Two internal control reference standard samples and a duplicate analytical sample pair were included with each of the two the sample batches sent out to commercial labs for analysis.

Surface Waters

Filtered waters were kept cool and away from light until shipment to GSC laboratories in Ottawa. Water samples were acidified with 0.5 ml 'ultra-pure' 8M HNO_3. Samples to monitor

quality assurance (filter, acid and travel blanks*) were added in the field to each batch of samples. A certified reference standard was included with the samples analyzed by the lab.

ANALYTICAL PROCEDURES

Stream Sediment (Silts)

Instrumental Neutron Activation Analysis (INAA)

Weighed and encapsulated samples, normally 30 g, were packaged for irradiation along with international reference materials, field and analytical duplicates. Samples and quality control insertions 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 2.

Variable	Detection Limit	Units of Measurement		Variable	Detection Limit	Units of Measurement
Ag	2	ppm[1]		**Ni**	10	ppm
As	0.5	ppm		**Rb**	5	ppm
Au	2	ppb[2]		**Sb**	0.1	ppm
Ba	50	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
Fe	0.2	pct[3]		**Ti**	500	ppm
Hf	1	ppm		**U**	0.2	ppm
Ir	50	ppb		**W**	1	ppm
La	2	ppm		**Weight**	0.1	g[4]
Lu	0.2	ppm		**Yb**	2	ppm
Mo	1	ppm		**Zn**	100	ppm
Na	0.02	pct		**Zr**	200	ppm

[1] parts per million
[2] parts per billion
[3] percent
[4] grams

Table 2. Variables determined by INA analysis of stream silt samples

* 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.

Inductively Coupled Plasma - Mass Spectrometr and Other Analyses

For the determination of 65 elements listed in Table 3, a 15 gram sample was leached with a modified aqua regia solution of 6mL/g of concentrated HCl, HNO_3 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 (ICP-ES) and inductively coupled plasma - mass spectroscopy (ICP-MS).

Element	Detection Limit	Units of Measurement	Analytical Method		Element	Detection Limit	Units of Measurement	Analytical Method
Ag	2	ppb	ICP-MS		**Mo**	0.01	ppm	ICP-MS
Al	0.01	percent	ICP-MS		**Na**	0.001	percent	ICP-MS
As	0.1	ppm	ICP-MS		**Nb**	0.02	ppm	ICP-MS
Au	0.2	ppb	ICP-MS		**Nd**	0.02	ppm	ICP-MS
B	20	ppm	ICP-MS		**Ni**	0.1	ppm	ICP-MS
Ba	0.5	ppm	ICP-MS		**P**	0.001	percent	ICP-MS
Be	0.1	ppm	ICP-MS		**Pb**	0.01	ppm	ICP-MS
Bi	0.02	ppm	ICP-MS		**Pd**	10	ppb	ICP-MS
Ca	0.01	percent	ICP-ES		**Pt**	2	ppb	ICP-MS
Cd	0.01	ppm	ICP-MS		**Pr**	0.02	ppm	ICP-MS
Ce	0.1	ppm	ICP-MS		**Rb**	0.1	ppm	ICP-MS
Co	0.1	ppm	ICP-MS		**Re**	1	ppb	ICP-MS
Cr	0.5	ppm	ICP-MS		**S**	0.02	percent	ICP-MS
Cs	0.02	ppm	ICP-MS		**Sb**	0.02	ppm	ICP-MS
Cu	0.01	ppm	ICP-MS		**Sc**	0.1	ppm	ICP-MS
Dy	0.02	ppm	ICP-MS		**Se**	0.1	ppm	ICP-MS
Er	0.02	ppm	ICP-MS		**Sm**	0.02	ppm	ICP-MS
Eu	0.02	ppm	ICP-MS		**Sn**	0.1	ppm	ICP-MS
Fe	0.01	percent	ICP-ES		**Sr**	0.5	ppm	ICP-MS
Ga	0.1	ppm	ICP-MS		**Ta**	0.05	ppm	ICP-MS
Gd	0.02	ppm	ICP-MS		**Tb**	0.02	ppm	ICP-MS
Ge	0.1	ppm	ICP-MS		**Te**	0.02	ppm	ICP-MS
Hf	0.02	ppm	ICP-MS		**Th**	0.1	ppm	ICP-MS
Hg	5	ppb	ICP-MS		**Ti**	0.001	percent	ICP-MS
Ho	0.02	ppm	ICP-MS		**Tl**	0.02	ppm	ICP-MS
In	0.02	ppm	ICP-MS		**Tm**	0.02	ppm	ICP-MS
K	0.01	percent	ICP-ES		**U**	0.1	ppm	ICP-MS
La	0.5	ppm	ICP-MS		**V**	2	ppm	ICP-MS
Li	0.1	ppm	ICP-MS		**W**	0.1	ppm	ICP-MS
LOI	0.1	percent	gravimetric		**Y**	0.01	ppm	ICP-MS
Lu	0.02	ppm	ICP-MS		**Yb**	0.02	ppm	ICP-MS
Mg	0.01	percent	ICP-ES		**Zn**	0.1	ppm	ICP-MS
Mn	1	ppm	ICP-ES		**Zr**	0.1	ppm	ICP-MS

Table 3. Variables in stream silts determined by ICP-ES/ICP-MS

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

Surface Waters

Trace and Major Elements

Filtered and acidified surface 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 4.

Trace metal analysis was performed using a Thermo X Series 2 quadrupole inductively coupled plasma mass spectrometer (ICP-MS) with Xt cones, PlasmaScreen fitted, standard concentric nebulizer and Peltier cooled conical impact bead spray chamber (3°C) using Rh and Ir as internal standards. Most 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.

Major element analysis was performed using an axial Spectro Arcos, inductively coupled plasma optical emission spectrometer (ICP-ES) using a 1% CsNO3 buffer (1:5 ratio) as a matrix modifier with a Burgener Teflon Mira Mist Nebulizer (uptake rate 1 mL/min) and a cyclonic spray chamber. The argon flow-rates are: Coolant 14.5 L/min^{-1}, Auxiliary 0.9 L/min^{-1}, and Nebulizer 0.8 L/min^{-1}. The RF power is 1500 watts. 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.

Pb-Isotopes

Ion-exchange column chromatography was used to isolate Pb ions from 500 mL of acidified surface waters. Pb-isotope ratios were determined using a thermal ionization mass spectrometer (TIMS) total evaporation method, used for small, low-concentration samples, which collects ions in isotope collectors to make one calculation (e.g. total 208 Pb ions / total 206 Pb ions) at the end (E.A. Spencer, pers.comm.). A standard, NBS 981, at similarly low concentrations of Pb, was run with the samples and results were within range of regular runs. Data were corrected for fractionation.

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

Table 4. Major and trace elements determined in stream waters

Analytical results are presented in an Excel® workbook included with this report: **Appendix 1 GSC OF 7577 FIELD & ANALYTICAL DATA.xlsx**. There are four worksheets in this file:

Worksheet	**Contents**
Field Data	site specific field observations including geographic coordinates
Silt Data (ICP&INA)	ICP-MS/ES and INA analytical data for silt samples
Water Data	ICP-MS/ES and pH and conductivity of surface water samples
Water – Pb Isotope	Pb isotope ratios in filtered and acidified surface water samples
Standards Data	Concentrations of elements in standard materials analyzed with Pine Point silt samples with accepted published and unpublished values

QUALITY CONTROL FOR GEOCHEMICAL RESULTS (SILT SAMPLES)

Accuracy

The accuracy of analytical results received from commercial laboratories, in the sense of the closeness to an accepted, or 'true' value, was monitored by inserting one each of two internal stream sediment standards at the end of the routine sample sequence. Internal reference materials consist of stream sediments from two creeks near Dawson City, YT, collected, dried, sieved and homogenized for use as internal standards at the GSC. Results for each element are shown in Tables 3 and 4 of Appendix 1 ('Standards Data').

Accepted Means, Ranges, Standard Deviations and Relative Standard Deviations for elements determined in Bonanza Creek (n=55) and Burwash Creek (n=40) stream sediment are derived from published (McCurdy et al, 2012) and unpublished data collected from recent projects at the GSC. A Lower Detection Limit (LDL) for each element determined by the commercial laboratories that analysed the Pine Point area samples is also listed. Results from one analysis each of Bonanza and Burwash Creek standards are listed for comparison.

For elements that can be compared with an accepted mean, most are within two Standard Deviations of the accepted value. Ti (aqua regia digestion) is an exception. Other elements with possible analytical problems such as Zr, Nb, Hf, Rb, Cs, Sb and Se (Bonanza; aqua regia digestion), Ba (Bonanza; INAA) and Ag, Sr, Ba and Sb (Burwash; aqua regia digestion) are shown in bold type. However, means falling outside ±2 SD, suggesting poor repeatability, may also represent analytical results close to the detection limit for the element. Results can also be an indication of the mineralogy of a region, that is, an element such as Ti may be present in refractory minerals such as ilmenite or titanite identified in Pine Point area samples (Oviatt et al., 2013) that are relatively unaffected by an aqua regia digestion.

Precision

Precision of analytical results for nine sites, with one analytical duplicate pair, cannot be statistically determined. A simple graphical presentation in the form of an x-y plot of $\log_{10}$ pairs of values for each element determined in silts however (Fig. 5) generating a linear trend line with a slope=1 suggests acceptable precision for most elements. Because precision depends on concentration, with poor precision near the detection limits to high precision in the optimal working range of the analytical technique (Reimann et al, 2008) the appearance of increased variability in the lower left quadrant of Fig. 5 is not unexpected. Three pairs of analyses, for Au (ICP), Lu (INA) and Te (ICP) reflect one analysis above detection and one below. Two elements in the upper right quadrant of the diagram off the line are Ni and Zn by INA analysis, a result of a relatively high detection limit (10 ppm and 100 ppm respectively). In both cases one analysis is above the detection limit and one below. Because values below detection limit are set to one half laboratory detection limits, differences between the data pairs are accentuated and points plot off the trend line.

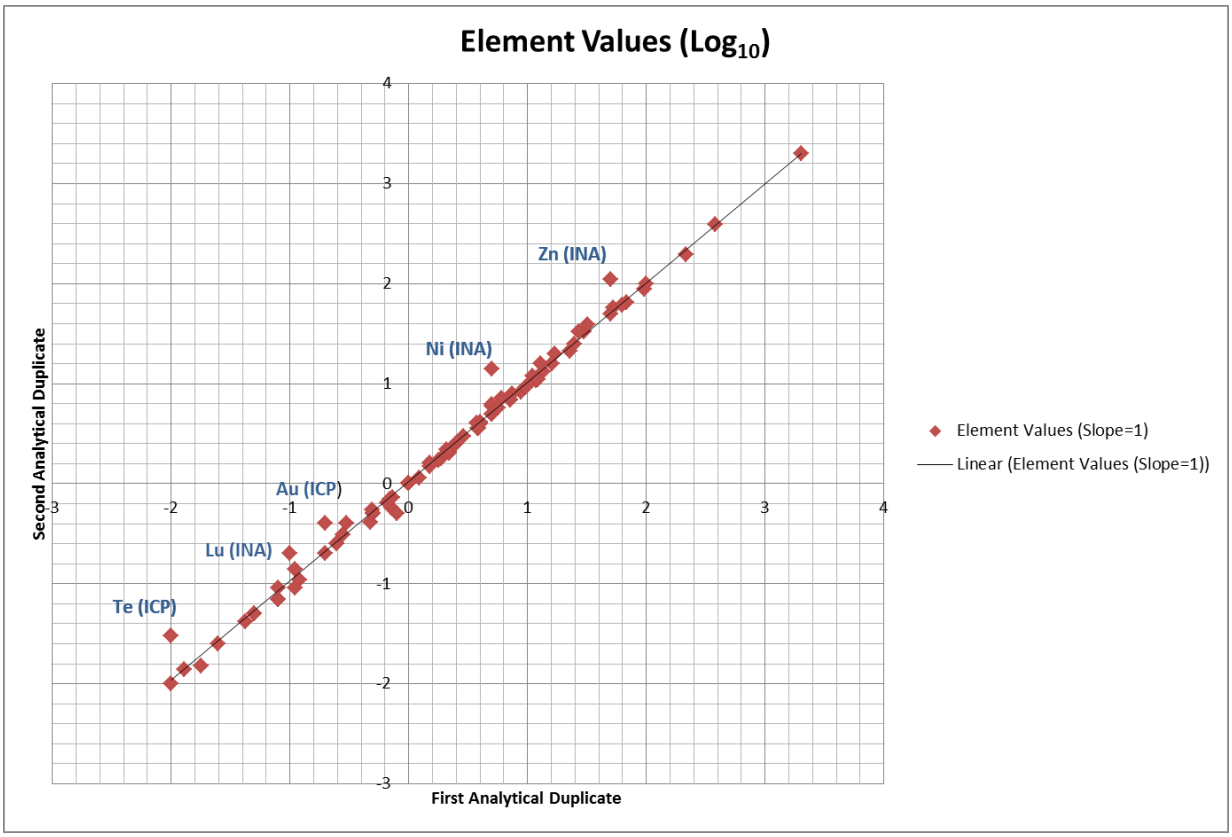

Figure 5. Concentrations of all elements determined in one analytical duplicate pair were converted to $\log_{10}$ values and plotted as x-y coordinates. The slope of the trend line (Slope=1) suggests overall good analytical precision. Labelled points indicate pairs of analyses in which one is above detection and one below.

ACKNOWLEDGEMENTS

The Pine Point mining district geochemical survey of stream sediments, heavy minerals and waters in 2010 was conducted as part of the Geological Survey of Canada's Geo-Mapping for Energy and Minerals (GEM) Program (2008-2013). This case study was a collaborative research effort between the Geological Survey of Canada, University of Alberta, Tamerlane Ventures Incorporated and Teck Resources Limited. Wolf Schliess (Tamerlane Ventures Inc.) provided aerial photographs and borehole information used for site selection. Stephen Day, GSC, carried out a thorough review of this open file and provided many useful comments and suggestions. Beth McClenaghan, Roger Paulen, Natasha Oviatt, Sarah Gleeson and Suzanne Paradis are thanked for providing advice and assistance throughout this activity.

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