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Geochemical, Mineralogical and Kimberlite Indicator Mineral Electron Microprobe Data from Silts, Heavy Mineral Concentrates and Waters from a National Geochemical Reconnaissance Stream Sediment and Water Survey

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Geochemical, Mineralogical and Kimberlite Indicator Mineral Electron Microprobe Data from Silts, Heavy Mineral Concentrates and Waters from a National Geochemical Reconnaissance Stream Sediment and Water Survey in the Northern and Southwestern Buffalo Head Hills, Northern Alberta (Parts of NTS 84B, 84C, 84F and 84G)

Introduction

A regional stream sediment and water geochemical survey was undertaken in the northern and southwestern part of the Buffalo Head Hills in 2004. The 2004 data are part of an ongoing survey of the Buffalo Head Hills area initiated in 2001 (Friske et al., 2003; McCurdy et al., 2004). This National Geochemical Reconnaissance (NGR) project contributes to Alberta's plan for a multi-year, multi-disciplinary study in the northern part of the province.

Analytical data accompany this document for 49 elements in stream sediments, 50 elements in heavy mineral concentrates, and 60 variables in waters from 122 sites sampled in 2004. Selected results from the 2004 NGR survey were released in Prior et al. (2005a; 2005b). The Geological Survey of Canada, under the Targeted Geoscience Initiative II (TGI II) and Northern Resources Development Program, and the Alberta Energy and Utilities Board/Alberta Geological Survey (EUB/AGS), funded the 2004 survey.

Analytical results and field observations contribute to building a national geochemical database 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 (Friske and Hornbrook, 1991).

The northern Buffalo Head Hills survey area lies south and southeast of La Crete, a community located 550 km north-northwest of Edmonton (Fig. 1). Access to sample sites was mainly by helicopter. Seismic cut lines and pipeline right-of-ways provide some access for all-terrain vehicles. Services available in La Crete include lodging, gas stations, grocery and hardware stores, and restaurants. There is a small airport with no services.

Samples were collected in the southwestern part of the survey area by helicopter based at Red Earth Creek, Alberta, a community located 350 km north-northwest of Edmonton (Fig. 1). Services available in Red Earth Creek include lodging, gas stations, grocery and hardware stores, and restaurants. There is a small airport with several companies providing helicopter and charter services.

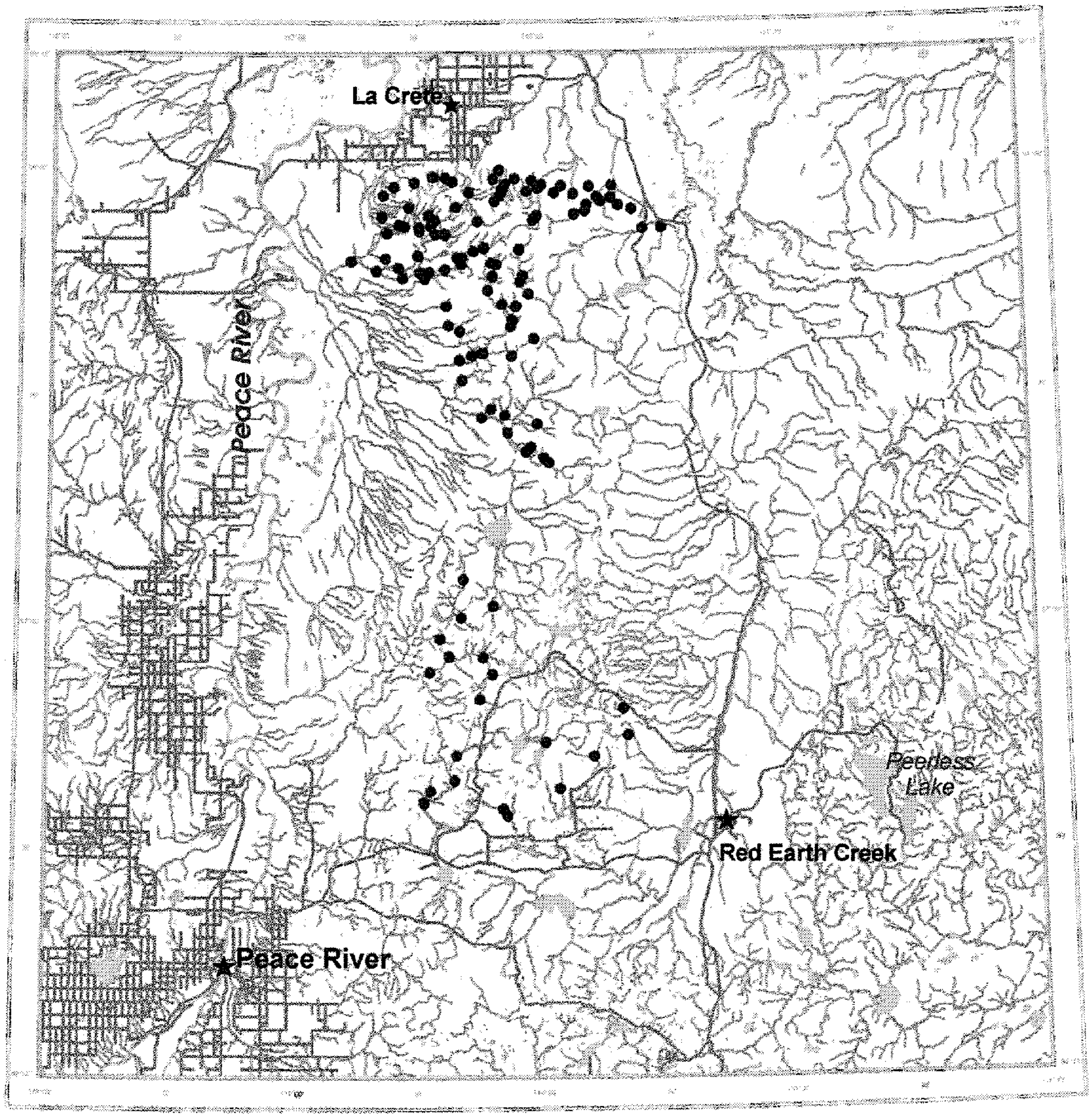

Figure 1. Location map shows area of survey south and southeast of the village of La Crete, and west of Red Earth Creek. Black circles indicate the location of sample sites.

Sample Collection

Stream Sediments (Silts)

At each site a pre-labelled Kraft paper bag (12.5 cm x 28 cm with side gusset) (Fig. 2) was two-thirds filled with silt or fine sand collected from the active stream channel. In practice, the silt sample was collected after water samples were collected but before a bulk sediment sample. Commonly, the sampler collected handfuls of silt from various points in the active stream channel while moving gradually upstream, normally over a distance of 5 to 15 m. If the stream channel consists 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 be added to the sample. A field duplicate pair of silt samples, assigned sequential sample numbers, is collected within each block of 20 samples. The first sample of the pair is assigned a replicate status value of 10 and the second is assigned a replicate status value of 20. Routine (non-duplicate) field samples are 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. Flagging tape with a sample site number is used to mark sample sites. Field observations are noted on pre-printed water-resistant paper (see Appendix).

Stream Waters

Waters were sampled in mid-channel, from flowing water where possible. At each site two water samples were collected in 125-ml Nalgene HDPE bottles (Fig. 2). Samples were collected after first rinsing bottles at least two times in flowing water before a final fill. Field duplicate pairs of water samples, assigned sequential sample numbers, are collected within each block of 20 samples. The first sample of each pair is assigned a replicate status value of 10 and t he second is assigned a replicate status value of 20. Routine (non-duplicate) field samples are 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 points of mid-channel bars. Material was collected from a single location where possible, or within close proximity otherwise. A 5-gallon (22.7 litre) plastic pail was lined with a heavy-duty polyethylene bag (18x24 inches, 4 Mil). Material was wet-sieved through a 12-mesh (1.68 mm) stainless steel sieve, placed on top of the pail, until a sample weight of 10-15 kg was attained. The bag lining the pail was taped shut with black plastic (electrical) tape and placed into a second bag with a 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 a commercial lab, where they were air-dried at temperatures below 40°C and sieved through a minus 80-mesh (177 µm) screen. Control reference and duplicate samples were inserted into each block of twenty sample numbers.

Waters

One set of water samples remained unaltered and was packed and shipped to a laboratory for analysis. The second set of water samples was 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 from the second set of samples was filtered into new 60-ml bottles, the remainder was used for the determination of pH and conductivity before being discarded. Using an Eppendorf pipettor with disposable plastic tips, 0.5 ml 8M HNO_3 was added to filtered water samples. Syringes were re-used after rinsing with distilled, de-ionized water, but 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 the lab. Control reference samples were inserted into each block of 20 water samples. No duplicate water samples were introduced.

Heavy Mineral Concentrates

Bulk sediment samples were progressively reduced by different laboratory procedures to concentrate heavy minerals. Initially a 500-g character sample was taken and stored

* 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.

before a low-grade table concentrate was prepared from the remainder. Gold grains were observed at this stage and 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 forsterite 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 to separate it into several size fractions, (<0.25 mm, 0.25 to <0.5 mm, 0.5 mm to <1.0 mm, ≥ 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 Carpco® drum magnetic separator into strongly, moderately, weakly and non-paramagnetic fractions.

Analytical Procedures

Stream Sediment (Silt) 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 Elements in stream sediments and the <0.25 mm fraction of heavy mineral concentrates determined by Instrumental Neutron Activation analysis.

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*	500	ppm
U	Uranium	0.2	ppm
W	Tungsten	1	ppm
Yb	Ytterbium	2	ppm
* HMC samples only			

INAA data for silver, cadmium, iridium, selenium, tin, tellurium, zinc, and zirconium are not published because of inadequate detection limits and/or precision.

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

For determination of the 38 elements listed in Table 2, a one-gram sample was leached with 6 ml of a mixture of HCl, HNO_3, and distilled, deionized water (2:2:2 v/v) at 95° C for one hour. The sample solution was diluted with de-ionized water 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.

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

Tin in heavy mineral concentrates was prepared for analysis by heating a 0.2 g sample mixed with 1.5 g of $LiBO_2$ flux in a muffle furnace for 15 minutes at 1050°C in a graphite crucible. The molten mixture was removed and immediately poured into 100 mL of 5% HNO_3. The solution was shaken for two hours and then an aliquot was poured into a test tube. Analytical values were determined using a Perkin-Elmer Elan 6000 ICP-MS (Gravel, 2003).

Table 2 Variables in stream silts and the <0.25 mm fraction of heavy mineral concentrates determined by Inductively Coupled Plasma - Mass Spectrometry and other analytical methods

VARIABLE		DETECTION LEVEL	
Ag	Silver	2	ppb
Al	Aluminum	0.01	pct
As	Arsenic	0.1	ppm
B†	Boron	1	ppm
Ba	Barium	0.5	ppm
Bi	Bismuth	0.02	ppm
Ca	Calcium	0.01	pct
Cd	Cadmium	0.01	ppm
Co	Cobalt	0.1	ppm
Cr	Chromium	0.5	ppm
Cu	Copper	0.01	ppm
F	Fluorine	10	ppm
Fe	Iron	0.01	pct
Ga	Gallium	0.2	ppm
Hg	Mercury	5	ppb
K	Potassium	0.01	pct

La	Lanthanum	0.5	ppm
LOI*	Loss-on-ignition	1	pct
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
Sn	Tin ($LiBO_2$ Fusion)	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	0.1	ppm
Zn	Zinc	0.1	ppm
*Silt samples only			

Fluorine was determined using 0.25-gram sample splits weighed into Ni crucibles. One gram of sodium hydroxide was added and the mixture was fused at 600°C in a muffle furnace. The fusion product was dissolved into a mixture of 7 ml of de-ionized water and 5 ml of 30% sulphuric acid. The solutions were transferred to plastic beakers and 5 ml of 30% ammonium acetate added. The volume was made up to 90 ml with de-ionized water. The pH was tested and adjusted to 7.8 with either sodium hydroxide or sulphuric acid. Fluorine content was determined using a fluorine selective ion electrode.

Water Analyses

The pH of stream waters was determined at the field base location using a Hanna Instruments Combo® waterproof tester with automatic temperature compensation, a range of 0.00 to +14.00 pH, 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.

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

Chloride (Cl^-), fluoride (F^-), nitrate (NO_3^-) and sulphate (SO_4^{2-}) in untreated waters (water samples not filtered or acidified in the field) were determined by ion chromatography (IC) at Geological Survey of Canada laboratories in Ottawa. Untreated water is identified as UU-Water (unfiltered, unacidified) in the data table.

Uranium in untreated waters was determined by inductively coupled plasma-mass spectrometry (ICP-MS) at Geological Survey of Canada laboratories in Ottawa.

Trace and Major Elements

Acidified and filtered stream water samples were analyzed for trace metal and major elements at Geological Survey of Canada 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^{-1}), 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^{-1}, Auxiliary 0.85 l min^{-1}, and Nebulizer 0.9 l min^{-1}. The RF power is 1350 watts. Isotopes measured and corrections for spectral interferences are detailed in Hall et al. (1995) and Hall et al. (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	0.2	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	0.5	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
S	Sulphur	0.05	ppm	ICP-ES
Si	Silicon	0.02	ppm	ICP-ES
Waters –Unfiltered, not Acidified (UU-Water)				
Cl^-	Chloride	100	ppb	IC
F^-	Fluoride	50	ppb	IC
NO_3^-	Nitrate	50	ppb	IC
SO_4^-	Sulphate	50	ppb	IC
Cond.	Conductivity	1	µS/cm	EC (electrolytic conductivity)
pH	-	0.1	-	GCE (glass-calomel electrode)
U	Uranium	0.05	ppb	ICP-MS

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^{-1}), 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^{-1}, Auxiliary 0.5 l min^{-1}, and Nebulizer 0.7 l min^{-1}. The RF power is 1350 watts. All elements were analyzed in axial mode except for sodium and potassium. These elements 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.

Heavy Mineral Concentrate Analyses

Kimberlite indicator minerals (KIMs) were picked and identified 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. The <0.25 mm fraction of the heavy mineral concentrate was sent to a commercial lab where it was ground in a ceramic mill and analyzed by a combination of ICP-MS, INAA and specific methods. Kimberlite indicator mineral grains underwent electron microprobe analysis for chemical characterization. A mineralogical consultant evaluated results of electron microprobe data.

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Appendix - Field Car ds and Descr iptive Notes

NATIONAL GEOCHEMICAL RECONNAISSANCE
(Silt Sediment, Bulk Sediment and Water Field Card - 2005)

NTS SHEET	YEAR	SAMPLE NUMBER	REP STAT	WIDTH	DEPTH	DATE DAY MO	TIME	COLLECTORS

GENERAL PHYSIOGRAPHY
- ☐ Mountainous
- ☐ Hilly
- ☐ Plateau
- ☐ Plain
- ☐ Swamp

SURFACE EXPRESSION
- ☐ Hummocky
- ☐ Inclined
- ☐ Level

DRAINAGE PATTERN
- ☐ Dendritic
- ☐ Herringbone
- ☐ Rectilinear
- ☐ Trellis
- ☐ Poor
- ☐ Discontinuous
- ☐ Closed

SITE DRAINAGE
- ☐ Well
- ☐ Moderate
- ☐ Poor

STREAM SOURCE(S)
- ☐ Ground
- ☐ SpringMelt
- ☐ Glacier
- ☐ Recent Rain
- ☐ Unknown

STREAM CLASS
- ☐ Primary
- ☐ Secondary
- ☐ Tertiary
- ☐ Quaternary
- ☐ Undefined

STREAM TYPE
- ☐ Permanent
- ☐ Intermittent
- ☐ Re-emergent
- ☐ Undefined

STREAM FLOW
- ☐ Stagnant
- ☐ Slow
- ☐ Moderate
- ☐ Fast
- ☐ Torrential

WATER COLOUR

______

WATER CLARITY
- ☐ Transparent
- ☐ Partially Cloudy
- ☐ Cloudy

VEGETATION
- ☐ Coniferous
- ☐ Deciduous
- ☐ Mixed
- ☐ Grass
- ☐ Bog
- ☐ Other

BANK TYPE(S)
- ☐ Alluvium
- ☐ Colluvium
- ☐ Till
- ☐ Outwash
- ☐ Bare Rock
- ☐ Talus/Scree
- ☐ Organic
- ☐ Other

CONTAMINATION(S)
- ☐ None
- ☐ Possible
- ☐ Probable
- ☐ Definite
- ☐ Mining
- ☐ Industry
- ☐ Agriculture
- ☐ Domestic
- ☐ Forestry
- ☐ Burn
- ☐ Other

BANK PRECIPITATE
☐ No Yes ☐

______ Colour(s)

BOTTOM PRECIPITATE
☐ No Yes ☐

______ Colour(s)

STREAM SEDIMENT SAMPLE COLOUR(S)

______

STREAM SEDIMENT COMPOSITION
- Sand ______ %
- Silt & Clay ______ %
- Organics ______ %

SAMPLE TYPE(S)
- ☐ Silt Sediment (SS)
- ☐ Bulk Sediment (BS)
- ☐ Pebble (PB)
- ☐ Water (SW)
- ☐ ______ other

IN-SITU WATER

pH	COND

BULK SITE
- ☐ Longitudinal Bar
- ☐ Transverse Bar
- ☐ Point Bar
- ☐ Diagonal Bar
- ☐ Boulder Trap
- ☐ Log Trap
- ☐ Vegetation Trap
- ☐ Bedrock Step
- ☐ Pool
- ☐ Gravel Veneer
- ☐ Stream Bed
- ☐ Beaver Dam

SITE RATING
- ☐ Good
- ☐ Good to Moderate
- ☐ Moderate
- ☐ Moderate to Poor
- ☐ Poor

CLAST SHAPE
- Rounded ______ %
- Sub-Angular/ Sub-Rounded ______ %
- Angular ______ %
- Platy/Flat ______ %

BULK SITE COMPOSITION
- Cobbles ______ %
- Pebbles ______ %
- Sand ______ %
- Silt ______ %
- Clay ______ %
- Organics ______ %

PEBBLE LITHOLOGY(IES)
- ______ ______ %
- ______ ______ %
- ______ ______ %
- ______ ______ %

BEDROCK EXPOSED
☐ No Yes ☐

______ Type(s)

BOULDERS PRESENT
☐ No Yes ☐

______ Type(s)

N	A	D			Longitude (DD) Decimal Degrees	Latitude (DD) Decimal Degrees

COMMENTS:

NTS SHEET	YEAR	SAMPLE NUMBER	REP STAT	WIDTH	DEPTH	DATE DAY MO	TIME	COLLECTORS

GENERAL PHYSIOGRAPHY
- ☐ Mountainous
- ☐ Hilly
- ☐ Plateau
- ☐ Plain
- ☐ Swamp

SURFACE EXPRESSION
- ☐ Hummocky
- ☐ Inclined
- ☐ Level

DRAINAGE PATTERN
- ☐ Dendritic
- ☐ Herringbone
- ☐ Rectilinear
- ☐ Trellis
- ☐ Poor
- ☐ Discontinuous
- ☐ Closed

SITE DRAINAGE
- ☐ Well
- ☐ Moderate
- ☐ Poor

STREAM SOURCE(S)
- ☐ Ground
- ☐ SpringMelt
- ☐ Glacier
- ☐ Recent Rain
- ☐ Unknown

STREAM CLASS
- ☐ Primary
- ☐ Secondary
- ☐ Tertiary
- ☐ Quaternary
- ☐ Undefined

STREAM TYPE
- ☐ Permanent
- ☐ Intermittent
- ☐ Re-emergent
- ☐ Undefined

STREAM FLOW
- ☐ Stagnant
- ☐ Slow
- ☐ Moderate
- ☐ Fast
- ☐ Torrential

WATER COLOUR

______

WATER CLARITY
- ☐ Transparent
- ☐ Partially Cloudy
- ☐ Cloudy

VEGETATION
- ☐ Coniferous
- ☐ Deciduous
- ☐ Mixed
- ☐ Grass
- ☐ Bog
- ☐ Other

BANK TYPE(S)
- ☐ Alluvium
- ☐ Colluvium
- ☐ Till
- ☐ Outwash
- ☐ Bare Rock
- ☐ Talus/Scree
- ☐ Organic
- ☐ Other

CONTAMINATION(S)
- ☐ None
- ☐ Possible
- ☐ Probable
- ☐ Definite
- ☐ Mining
- ☐ Industry
- ☐ Agriculture
- ☐ Domestic
- ☐ Forestry
- ☐ Burn
- ☐ Other

BANK PRECIPITATE
☐ No Yes ☐

______ Colour(s)

BOTTOM PRECIPITATE
☐ No Yes ☐

______ Colour(s)

STREAM SEDIMENT SAMPLE COLOUR(S)

______

STREAM SEDIMENT COMPOSITION
- Sand ______ %
- Silt & Clay ______ %
- Organics ______ %

SAMPLE TYPE(S)
- ☐ Silt Sediment (SS)
- ☐ Bulk Sediment (BS)
- ☐ Pebble (PB)
- ☐ Water (SW)
- ☐ ______ other

IN-SITU WATER

pH	COND

BULK SITE
- ☐ Longitudinal Bar
- ☐ Transverse Bar
- ☐ Point Bar
- ☐ Diagonal Bar
- ☐ Boulder Trap
- ☐ Log Trap
- ☐ Vegetation Trap
- ☐ Bedrock Step
- ☐ Pool
- ☐ Gravel Veneer
- ☐ Stream Bed
- ☐ Beaver Dam

SITE RATING
- ☐ Good
- ☐ Good to Moderate
- ☐ Moderate
- ☐ Moderate to Poor
- ☐ Poor

CLAST SHAPE
- Rounded ______ %
- Sub-Angular/ Sub-Rounded ______ %
- Angular ______ %
- Platy/Flat ______ %

BULK SITE COMPOSITION
- Cobbles ______ %
- Pebbles ______ %
- Sand ______ %
- Silt ______ %
- Clay ______ %
- Organics ______ %

PEBBLE LITHOLOGY(IES)
- ______ ______ %
- ______ ______ %
- ______ ______ %
- ______ ______ %

BEDROCK EXPOSED
☐ No Yes ☐

______ Type(s)

BOULDERS PRESENT
☐ No Yes ☐

______ Type(s)

N	A	D			Longitude (DD) Decimal Degrees	Latitude (DD) Decimal Degrees

COMMENTS:

| | N | T | S | S | H | E | E | T | | → e.g. | 0 | 8 | 4 | F | 1 | 3 |

NTS Sheet: National Topographic System 1:250,000 index reference, consisting of three numbers and one letter e.g. 085E and occupy the first four boxes. The final two boxes are used for the 1:50,000 sheet identification e.g. 13, if applicable.

YEAR e.g. 2 0 0 5

Year: The four-digit year, e.g. 2005.

SAMPLE NUMBER e.g. 1 0 0 2

Sample Number: A four-digit sample number e.g. 1002. The first digit refers to the collection party crew number, while the other three digits are a sequential series from 001 to 999, for example:

Crew 1 samples range from 1002 to 1999,
Crew 2 samples range from 2002 to 2999,
Crew 3 samples range from 3002 to 3999, …

REP STAT e.g. 0 0

Rep Stat (Replicate Status): A two digit number e.g. 00, defining the relationship of the current sample to others in the survey

00 routine sample
10 first sample of a field duplicate pair
20 second sample of a field duplicate pair
80 blind duplicate number (empty bag) for a blind duplicate cut of one of previous 18 field samples
90 control reference number (empty bag) for cut of a control reference sample

WIDTH e.g. 1.1

Stream Width: width of the stream estimated in metres to the closest 1/10th of a metre e.g. 1.1metres wide.

DEPTH e.g. 0.1

Stream Depth: depth of the stream estimated in metres to the closest 1/10th of a metre e.g. 0.1 metres deep.

DATE (DAY MO) e.g. 1 1 0 7

Date: date of collection, DD MM format, e.g. July 11 = 11 07

TIME e.g. 1 4 2 6

Time: time of day (24 hour clock), e.g. 2:26pm = 14:26

COLLECTORS e.g. A B C D E F

Collectors: initials of the collection crew, first three boxes for the navigator (A.B.C.), and the last three for the second sampler (D.E.F.), e.g. ABC DEF

GENERAL PHYSIOGRAPHY

- [ ] Mountainous - rugged area of uplift having at least 300m gain from base to peak
- [ ] Hilly - natural elevation change, of less than 300m, while having a well defined outline
- [ ] Plateau - an elevated area of fairly level ground
- [ ] Plain - any area of level or near-level open land
- [ ] Swamp - low waterlogged area having shrubs and/or trees

SURFACE EXPRESSION

- [ ] Hummocky - series of rounded knobs and kettles
- [ ] Inclined - constant sloping surface
- [ ] Level - flat or gently sloping

DRAINAGE PATTERN

- [ ] Dendritic - "tree-like" network of streams
- [ ] Herringbone - V-shaped pattern of streams
- [ ] Rectilinear/Trellis - series of parallel streams with near right-angle turns and perpendicular intersections
- [ ] Parallel - streams flowing parallel before joining at small angles
- [ ] Poor/Deranged - no clear geometry in the drainage and no true stream valley pattern
- [ ] Discontinuous - stream disappears for a short distance then re-appears down slope
- [ ] Closed

SITE DRAINAGE

- [ ] Well - stream channel well developed and well drained
- [ ] Moderate
- [ ] Poor - stream channel poorly developed and poorly drained

STREAM SOURCE

- [ ] Ground - stream flow originates from natural springs or seeps
- [ ] SpringMelt - stream flow greater due to melting of winter's snow
- [ ] Glacier - stream originates from melting glacier
- [ ] Recent Rain - stream flow greater due to recent rain
- [ ] Unknown

STREAM CLASS *(determined from 1:250,000 NTS)*

- [ ] Primary - smallest stream, originates from springs and seeps
- [ ] Secondary - stream below confluence of two primary streams
- [ ] Tertiary - stream below confluence of two secondary streams
- [ ] Quaternary - stream below confluence of two tertiary streams
- [ ] Undefined

STREAM TYPE

- [ ] Permanent - year-round flow
- [ ] Intermittent - seasonal flow during wet season or spring runoff
- [ ] Re-emergent - discontinuous stream course
- [ ] Undefined -

STREAM FLOW

- [ ] Stagnant - little or no flow
- [ ] Slow - speed of a slow walker
- [ ] Moderate - speed of someone briskly walking
- [ ] Fast - speed of a jogger
- [ ] Torrential - speed of a quick jogger

WATER COLOUR

________________ ⇩ dominant colour (if any) of the stream **water**

WATER CLARITY

- [ ] Transparent - clear (any colour)
- [ ] Partially Cloudy - semi opaque (any colour)
- [ ] Cloudy - opaque or nearly opaque (any colour)

VEGETATION

- [ ] Coniferous - having needle-like leaves, e.g. spruce, pine, incl. tamarack.
- [ ] Deciduous - trees that shed their leaves annually, e.g. maple, poplar ...
- [ ] Mixed - roughly equal mixture of coniferous and deciduous trees
- [ ] Grass - grasslands surrounding site
- [ ] Bog - waterlogged spongy ground, sphagnum moss dominate
- [ ] Other ________________

BANK TYPE

- [ ] Alluvium - clay, silt, sand or gravel recently deposited by stream action
- [ ] Colluvium - accumulation of material through the action of gravity
- [ ] Till - glacial till (unsorted)
- [ ] Outwash - stratified sand or gravel deposited by glaciofluvial melt water
- [ ] Bare Rock - bedrock
- [ ] Talus/Scree - loose rock fragments derived from an adjacent steep rocky slope
- [ ] Organic - peaty organic soil or sediment
- [ ] Other ________________

CONTAMINATION

- ☐ None - no sign of any human activity
- ☐ Possible - some human activity in area, no obvious sign of contamination
- ☐ Probable - site, area disturbed by human activity
- ☐ Definite - obvious contamination due to human activity

(Specify)

- ☐ Mining
- ☐ Industry
- ☐ Agriculture
- ☐ Domestic
- ☐ Forestry
- ☐ Burn
- ☐ Other

BANK PRECIPITATE

☐ No Yes ☐

____

Colour(s)

Syntax
single colour
dominant-subordinant
multiple distinct colours
dominant ; subordinate

BOTTOM PRECIPITATE

☐ No Yes ☐

____

Colour(s)

Syntax
single colour
dominant-subordinant
multiple distinct colours
dominant ; subordinate

STREAM SEDIMENT SAMPLE COLOUR(S)

____

Syntax
single colour
dominant-subordinant
multiple distinct colours
dominant ; subordinate

STREAM SEDIMENT COMPOSITION

Sand ______ % - particles between 0.0625 and 2 mm in size
- will fall apart when squeezed into a ball

Silt & Clay ______ % - particles smaller than 0.0625 mm
- holds together when squeezed, silt is fine grained with gritty feel, clay is very fine grained and has slippery feel

Organics ______ % - muck-like light weight sediment composed of organic materials

SAMPLE TYPE(S)

Check ***ALL*** applicable boxes

- ☐ Silt Sediment (SS)
- ☐ Bulk Sediment (BS)
- ☐ Pebble (PB)
- ☐ Water (FA)
- ☐ ______________

IN-SITU WATER

PH		COND	

If applicable

N	A	D		

Datum, either NAD27 or NAD83

Decimal Degrees								

Longitude (decimal degrees to at least five decimal places)

Decimal Degrees							

Latitude (decimal degrees to at least five decimal places)

BULK SEDIMENT SITE

- [ ] Longitudinal Bar - elongated bodies of sediment parallel to stream flow
- [ ] Transverse Bar - lobate bodies of sediment oriented roughly perpendicular to stream flow
- [ ] Point Bar - elongated bodies of sediment that form on the inside of stream bend, often attached to the inside bank
- [ ] Diagonal Bar - elongated bodies of sediment orientated obliquely to the stream flow
- [ ] Boulder Trap - sediment on the down-stream side of a boulder
- [ ] Log Trap - sediment on the down-stream side of a log
- [ ] Vegetation Trap - sediment on the down-stream side of vegation
- [ ] Bedrock Step - sediment collects down-stream of break in bedrock slope
- [ ] Pool - sediment collects down-stream of waterfall or set of rapids
- [ ] Gravel Veneer - thin layer of gravel atop finer sediment
- [ ] Stream Bed - sediment taken from main stream channel
- [ ] Beaver Dam - course sediment exposed by flushing action adjacent or below dam

SITE RATING*

- [ ] Good - Clast supported, tightly packed, poorly sorted gravel in well formed bedrock depression, pothole or crevice. Clast sizes: boulders, cobbles, pebbles, granules. Matrix contains sand and silt. Excavation to bedrock and/or presence of abundant well-rounded clasts enhances site rating. Lack of boulders diminishes rating.
- [ ] Good to Moderate - Clast supported, tightly packed, poorly sorted gravel upstream or downstream of prominent rock bar or large boulder and preferably at a level well below the obstruction. Clast sizes: boulders, cobbles, pebbles, granules. Matrix contains sand and silt. Excavation to bedrock and/or presence of abundant well-rounded clasts enhances site rating.
- [ ] Moderate - Clast supported, poorly sorted gravel amongst boulders. Packing moderate to tight. Clast sizes boulders (mainly small), cobbles, pebbles, granules. Matrix contains sand and silt. Excavation to bedrock and/or presence of many well-rounded clasts and/or association with some kind of obstruction enhances site rating. Lack of boulders diminishes rating.
- [ ] Moderate to Poor - Matrix supported, generally losely packed gravel strewn on river bed and not associated with any prominent obstruction. Sorting is moderate to poor. Boulders are rare or absent. Main clast sizes: cobbles, pebbles, granules. Matrix contains sand and silt.
- [ ] Poor - Matrix supported, very loosely packed, fine gravel. Clasts are relatively rare and often form a thin surface veneer on sand or are confined to isolated lenses within a sand mass. Clast sizes: cobbles (rare), pebbles, granules. Matrix of sand and/or silt. No associated obstruction.

Muggeridge, M.T., 1986. Pathfinder sampling techniques for locating primary sources of diamond: Recovery of indicator minerals, diamonds and geochemical signatures. Journal of Geochemical Exploration 53 183-204.

PEBBLE SHAPE

Rounded ____ % - smooth and rounded clasts
Sub-Angular/ Sub-Rounded ____ % - rough and semi-rounded clasts
Angular ____ % - sharp edged angular clasts
Platy/Flat ____ % - disclike clasts, one dimension much shorter than other two

BULK SEDIMENT SITE COMPOSITION

Cobbles ____ % - particles between 64 and 256 mm in size
Pebbles ____ % - particles between 2 and 64 mm in size
Sand ____ % - particles between 0.0625 and 2 mm in size
- will fall apart when squeezed into a ball
Silt ____ % - particles between 0.02 and 0.0625 mm
- holds together when squeezed, silt is fine grained with gritty feel
Clay ____ % - particles smaller than 0.02 mm
- holds together when squeezed, clay is very fine grained and has slippery feel
Organics ____ % - muck-like light weight sediment composed of organic materials

PEBBLE LITHOLOGY(IES) - Rough estimate of pebble lithology(ies)

____________ ____%
____________ ____%
____________ ____%
____________ ____%

BEDROCK EXPOSED

☐ No Yes ☐

____
Type(s)

BOULDERS* PRESENT

☐ No Yes ☐

____
Type(s)

* > 256 mm