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**Geochemical Data from a National Geochemical Reconnaissance  
Stream Sediment and Water Survey in the Area of the Coal River,  
Southeast Yukon Territory (Part of NTS 95E)**

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P.W.B. Friske, R.J. McNeil, M.W. McCurdy, R.S. Wilson and S.J.A. Day

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# **Geochemical Data from a National Geochemical Reconnaissance Stream Sediment and Water Survey in the Area of the Coal River, Southeast Yukon Territory (Part of NTS Map Sheet 95E)**

## **Introduction**

A stream sediment and water survey was carried out in the Coal River area of southeast Yukon during the summer of 2005 (Fig. 1). This survey was carried out under a Joint Research Agreement between the Yukon Government (Oil & Gas and Mineral Resources Division of the Department of Energy, Mines and Resources) and the Federal Government, acting through the Earth Science Sector's Metals in the Environment Program.

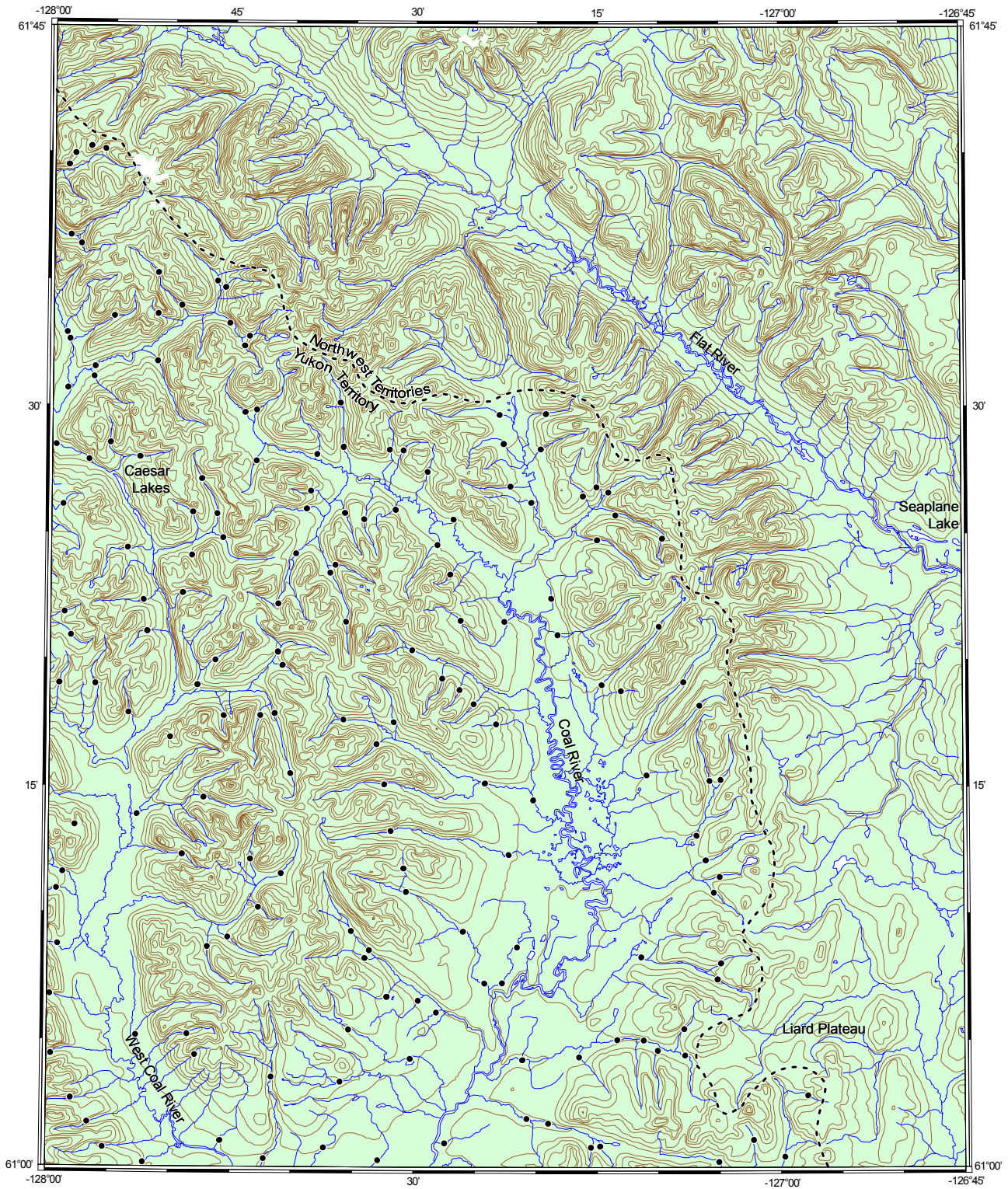
The Geological Survey of Canada provided assistance in the form of geoscientific expertise and project management experience in the conduct of regional geochemical field surveys. Yukon Department of Energy, Mines and Resources funded the project and provided critical technical expertise and insight into the geological framework.

Regional geochemical surveys support the principles of the Earth Science Sector 'Metals in the Environment' Program by providing additional data to the national survey database. Results are integrated into the NGR database, augment the National Atlas risk assessment maps, and provide geochemical background data for land use planning and resource assessment. The Yukon Territory geoscience database is expanded and provides essential information for evaluating energy and mineral potential.

Analytical data accompany this document for 50 elements in stream sediments and 60 variables in waters from a total of 174 sites sampled in 2005. National Geochemical Reconnaissance protocol (described below) was used for the collection, preparation and analysis of waters and silts.

Samples were collected in the Yukon Territory portion of National Topographic System map sheet 95E, west of the height of land that marks the boundary between Yukon and Northwest Territories and separates the Coal River and Flat River drainage basins (Fig. 1). Elevations range from 2,189 m above mean sea level (Mount Nooshka) in the Logan Mountains (Selwyn Mountains) to about 1,000 m above mean sea level in the valley of the Coal River. The survey area is a moderately rugged and thick vegetation is found at most elevations, particularly in river and stream valleys.

The southeast Yukon Territory survey ran concurrently with a survey carried out adjacent to Nahanni National Park Reserve. Participants in the survey stayed at the Cantung mine site, owned by North American Tungsten. Access to the mine site is along the Nahanni Range Road, off the Campbell Highway running north from Watson Lake, the nearest community. Access to sample sites was entirely by helicopter. Services available in Watson Lake include lodging, fuel, and groceries. There is an airport with scheduled flights.



**Figure 1.** Location map shows locations of sample sites in the Flat River map sheet (NTS 95E). 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. 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 were used to collect samples of stream silts and stream waters. Flagging tape with a sample site number was used to mark sample sites. Field observations were noted on pre-printed water-resistant paper.**

## *Stream Waters*

Waters were sampled in mid-channel, from flowing water where possible. At each site, water was collected in a 125-ml Nalgene HDPE bottle. 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, 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.

## **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*

Water samples 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 from each sample 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<sub>3</sub> 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.

## **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

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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.

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.

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
U	Uranium	0.2	ppm
W	Tungsten	1	ppm
Yb	Ytterbium	2	ppm

**Table 1** Elements in stream sediments determined by Instrumental Neutron Activation analysis.

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 36 elements listed in Table 2, a one-gram sample was leached with 6 ml of a mixture of HCl, HNO<sub>3</sub>, 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 100°C muffle furnace and brought up to 500° C for one hour. The oven was cooled to 100°C 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.

Samples were prepared for analysis for tin by heating a 0.2 g sample mixed with 1.5 g of LiBO<sub>2</sub> 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<sub>3</sub>. 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.

VARIABLE		DETECTION LEVEL	
Ag	Silver	2	ppb
Al	Aluminum	0.01	pct
As	Arsenic	0.1	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 (fusion/ion selective electrode)	10	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
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 <sub>2</sub> 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

**Table 2** Variables in stream silts determined by Inductively Coupled Plasma - Mass Spectrometry and other analytical methods

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.

### 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<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 were: 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 was 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.

ELEMENT		DETECTION LEVEL		LABORATORY METHOD
<i>Waters – Filtered, Acidified (FA-Water)</i>				
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	Europlium	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	0.01	ppm	ICP-ES
S	Sulphur	0.05	ppm	ICP-ES
Si	Silicon	0.02	ppm	ICP-ES
<b>Waters –Unfiltered, not Acidified (UU-Water)</b>				
Cond.	Conductivity	1	µS/cm	EC (electrolytic conductivity)
pH	-	0.1	-	GCE (glass-calomel electrode)

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

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 were: 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 was 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.

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Preparation: Acme Analytical Laboratories  
Vancouver, British Columbia

Analysis: *Silts (Elements by ICP-MS, plus F, Sn, LOI)*

Acme Analytical Laboratories  
Vancouver, British Columbia

*Silts (Elements by INAA)*

Becquerel Laboratories Inc.  
Mississauga, Ontario

*Waters (Elements by ICP-MS and ICP-ES)*

GSC Analytical Method Development Laboratory  
Ottawa, Ontario

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