Indicator Mineral Content and Geochemistry of Stream and Glacial Sediments from the Etsho Plateau Region (NTS 094I, P) as an Aid to Kimberlite and Base Metal Exploration, Northeast British Columbia[1]

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INTRODUCTION

A two-year reconnaissance-scale stream and glacial sediment sampling project, funded by Geoscience BC and the Geological Survey of Canada, was implemented by the Geological Survey of Canada in 2005 with the objective of evaluating the potential for diamond-bearing kimberlite, gold, base metal and other economic commodities in northeast BC (Plouffe *et al*., 2006b). The intended benefit of the project is to promote future investments for mineral exploration and to reduce the risk associated with such activity. This project was created following the announcement of the occurrence of kimberlite indicator minerals (KIM) in glacial sediments from northeast BC (Levson *et al*., 2004; Simandl, 2005), which sparked interest in the exploration of kimberlites in northeast BC. This project includes participants from the Geological Survey of Canada (GSC) and the BC Ministry of Energy, Mines and Petroleum Resources (MEMPR). The GSC, under the Northern Resources Development Program, and the Alberta Energy and Utilities Board/Alberta Geological Survey (EUB/AGS) are funding a project with similar objectives in northwest Alberta. A more detailed overview of the BC project was presented by Plouffe *et al*. (2006b).

The first year of the project (2005) involved reconnaissance-scale sampling of stream and glacial sediments (Plouffe *et al*., 2006b). Samples were processed for heavy minerals during the winter of 2006. In the second and last year of the project, additional stream sediment sampling was completed during the fall along three east-west transects located between Fort St. John and Fort Nelson. The objective of this paper is to present the preliminary results of the 2005 sampling program and the progress made during 2006. Final results will be released in a future publication (GSC Open File Report), which will include an integrated interpretation of the 2005 and 2006 stream and glacial sediment mineralogy and geochemistry. All data produced from this project will be provided in a format that allows it to be integrated into the MEMPR MapPlace website (BC Geological Survey, 2006).

PHYSIOGRAPHY

A description of the physiography, bedrock and surficial geology of the area was provided by Plouffe *et al*. (2006b) and is only briefly summarized here. The study area is generally flat to gently rolling with an average elevation below 600 m asl with the exception of the Etsho Plateau, which stands at an average elevation of 900 m asl. Streams are generally poorly developed because of the flat terrain, except around the Etsho Plateau where they are incised into glacial sediment and bedrock.

GEOLOGY OF THE STUDY AREA

Archean and Proterozoic basement rocks overlain by a succession of nearly horizontal Paleozoic and Mesozoic sedimentary rocks underlie northeast BC. Rocks of the Cretaceous Shaftesbury (dominantly shale) and Dunvegan (dominantly sandstone) formations outcrop in a limited number of places within the region. Given the age of the youngest sedimentary rocks in the region, any kimberlites older than the Cretaceous would not be exposed to glacial or fluvial erosion and would not contribute indicator minerals directly to the surficial sediments. Therefore, the methodology applied in this project limits any discoveries to kimberlites younger than or contemporaneous with the Cretaceous host rocks.

The Laurentide ice sheet advanced over northeast BC during the Late Wisconsinan glaciation leaving behind a thick cover of glacial sediments including sand and gravel-rich glaciofluvial sediments, clay-rich till and glaciolacustrine sediments. Exposures in borrow pits and well-log records indicate great thicknesses of till and other glacial sediments (>20 m) in many parts of the low-lying areas surrounding the Etsho Plateau. Around the periphery of the plateau, till thicknesses are much less, in some places forming only a veneer (<1 m thick) overlying shale bedrock. On

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top of the plateau, till thicknesses are in the order of 5 to 10 m. Several surficial geology maps which depict ice-flow direction and surficial sediment distribution have been published (Bednarski, 2005a, b; Smith, in press a–d). At glacial maximum, ice generally flowed west to southwest as indicated by the orientation of drumlins, flutings, crag-and-tails and till clast fabrics. Deglaciation of the region occurred around 11 500 to 11 000 radiocarbon years before present with the highest point, Etsho Plateau, being deglaciated first (Dyke *et al*., 2003; Dyke, 2004). In his reconstruction of the ice front configuration during ice retreat, Mathews (1980) depicted the ice-free Etsho Plateau surrounded by lobes of ice to the north and south; the southern one was referred to as the Fort Nelson lobe. Meltwater flowing from the retreating ice eroded significant meltwater channels and deposited glaciofluvial sand and gravel, which have been a focus of the glacial sediment sampling program. Glaciofluvial sediments provide a broader regional sampling of the bedrock mineralogy, as compared to till. Such deposits are, however, rare and geographically restricted in the field area, thus the glacial sediment sampling program also includes bulk till samples, and samples from discrete sand and gravel units observed within thicker till sections. These sand and gravel units are associated with glacial deformation processes, including the thrusting and stacking of till sheets. They form as a result of winnowing of finer material by water flow either at the base of a glacier, or along shear planes within the till, and are thus analogous to glaciofluvial deposits. A large proportion of the area is overlain by organic deposits (fens and bogs), which greatly impeded any systematic and spatially integrated sampling of glacial sediments.

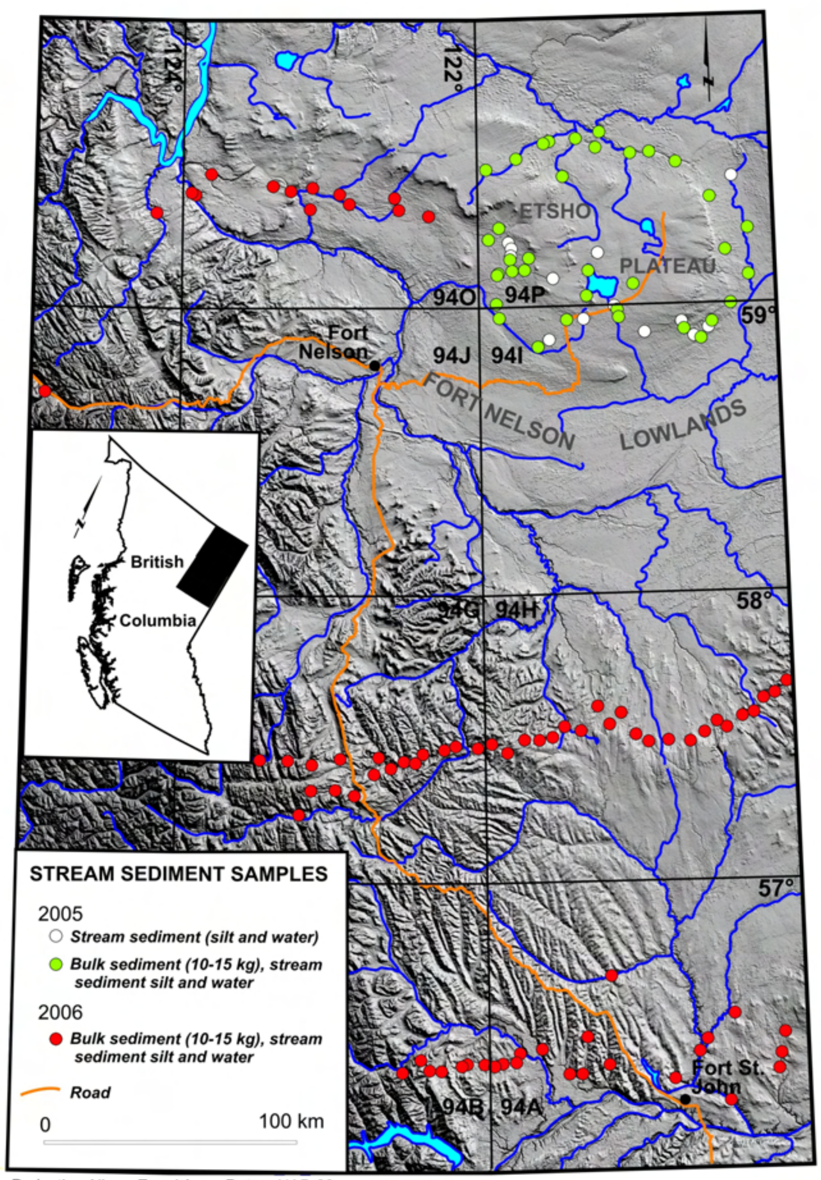
New Potential for Base Metal Exploration

Approximately 180 km east-southeast of the Etsho Plateau in the Zama Lake, Alberta region, a new potential for base metal exploration was revealed by the identification of a sphalerite dispersal train in till (Plouffe *et al*., 2006a). The sphalerite was identified in the sand-sized fraction of a number of till samples, which contain up to 1000 grains of sphalerite and trace amounts of galena. The anomaly overlies bedrock of the Shaftesbury Formation and is in close proximity to the Great Slave Lake Shear Zone (GSLSZ), a major structural break trending southwest and extending from Great Slave Lake to northeast BC (Gehrels and Ross, 1998). The Pine Point Mississippi Valley-type deposit, on the south shore of Great Slave Lake, occurs along the GSLSZ approximately 330 km northeast of the anomaly. Plouffe *et al*. (2006a) suggest that the till anomaly is derived from an undiscovered bedrock source as opposed to representing long distance glacial transport from the Pine Point region. The potential for zinc mineralization in northeast BC might also exist given that the bedrock geology of northwest Alberta is similar.

METHODOLOGY

Stream Sediment and Water Sample Collection

Trucks and a helicopter were used to collect stream sediment and water for geochemical and KIM analyses. Stream sediment sampling was focused on the best-developed streams. At 49 sites (Fig 1), a 125 ml water sample and approximately 2 kg of silt and clay were collected



Projection Albers Equal Area, Datum NAD 83
Background image: USGS, SRTM, 2006

Figure 1. Location of stream sediment and water samples collected in northeast BC in 2005 and 2006.

from the active part of the stream channel. At 36 of these sites (Fig 1), coarse sediment (ideally from the upstream end of midchannel bars) was wet-sieved through a 12-mesh (1.68 mm) screen to obtain a sample weighing between 10 and 15 kg for additional geochemical and mineralogical, including KIM, analysis. Site locations were recorded with a global positioning system (GPS) receiver, field observations were noted and sites were flagged. For a more detailed description of sample collection, *see* McCurdy *et al*. (2006). Preliminary results of these analyses are presented below.

To extend the coverage of stream sediment baseline data for northeast BC, three east-west stream sediment sample transects were completed with truck and helicopter support across the zone where the Laurentide ice sheet, Cordilleran ice and Rocky Mountain montane glaciers were thought to be in contact during the late Wisconsinan (Mathews, 1980). Completed in the fall of 2006, silt, water, pebbles and bulk sediment samples were collected from a total of 79 sites (Fig 1). Geochemical data from sediments, water and heavy mineral concentrates in addition to mineralogical information from heavy mineral concentrates and pebbles will be published in 2007.

Glacial Sediment Sample Collection

Trucks, all-terrain vehicles and helicopters were used to collect glacial sediment for geochemical analysis. At 140 sites approximately 4 kg of till were collected below the depth of the oxidized soil horizon from roadcuts, hand-dug pits, borrow pits and auger holes. At 17 of these sites, bulk samples weighing approximately 25 kg were collected for KIM analysis. An additional 26 bulk samples of primarily glaciofluvial sediment were collected for KIM analysis. One sample of crushed bedrock (Dunvegan Formation sandstone) was collected for KIM analysis. Site locations were recorded with a global positioning system (GPS) receiver, field observations were noted and sites were flagged. For a more detailed description of sample collection, *see* Plouffe *et al*. (2006b).

Sample Processing and Analysis

Bulk glacial and stream sediment samples were shipped to Overburden Drilling Management Limited (ODM), Ottawa, Ontario, for heavy mineral separation using a combination of a shaking table and heavy liquids (specific gravity 3.2) to separate the nonferromagnetic heavy mineral fraction. The heavy mineral concentrate (HMC) was picked for KIM and other indicators such as gold in the same laboratory. Gold grains, KIM and other heavy minerals were identified in the 0.25 to 2 mm fraction under binocular microscopes by staff mineralogists at ODM. Based on the total volume of visible gold grains identified in each sample and the total weight, an estimate of the gold concentration of the HMC, in parts per billion, was calculated by ODM. Visual identification of mineral grains was made mainly on the basis of colour, crystal habit, lustre and alteration. A scanning electron microscope was used to confirm the identity of some grains. One sample of bulk till spiked with a known number of KIM was included in the samples sent to the laboratory to monitor the quality of the visual identification.

Microprobe analyses of KIM grains derived from glacial sediments were conducted using the CAMECA Camebax electron microprobe at Carleton University, Ottawa, Ontario. Kimberlite indicator grains derived from the heavy mineral fraction of stream sediments were analyzed at the GSC using a CAMECA SX-50 electron microprobe. Selected results are presented and discussed herein; a complete analytical report will be published in 2007 as a GSC Open File Report.

Stream and glacial sediment samples (2 and 4 kg) were shipped to Acme Analytical Laboratories Ltd., Vancouver, BC, for preparation and geochemical analysis. Inductively coupled plasma mass spectrometry (ICP-MS) and instrumental neutron activation analysis (INAA) were conducted on the silt and clay-sized fraction (–250 mesh or <0.063 mm) of the till samples only. The –80 mesh (<177 µm) fraction of the stream sediments and the <0.25 mm fraction of the heavy mineral concentrates were analyzed by ICP-MS at Acme Analytical Laboratories Ltd. Instrumental neutron activation analysis was carried out at Becquerel Laboratories Inc., Toronto, Ontario. Analytical quality was monitored with additional standard and duplicate samples inserted into the sample suite following sample preparation.

Water samples collected at stream sediment sites were filtered and acidified with nitric acid within 24 hours of collection. An unacidified, unfiltered subsample was used to determine pH and conductivity at this time. Samples were shipped to the GSC for analysis by ICP-MS and inductively coupled plasma emission spectroscopy (ICP-ES).

RESULTS AND DISCUSSION

KIM in Glacial and Stream Sediments

Of the 44 glacial sediment samples submitted for analysis, 23 samples yielded between one and three KIM in the 0.25 to 0.5 mm fraction (Table 1; Fig 2). Most of the KIM were recovered from glaciofluvial sand and gravel deposits and only 2 out of 15 till samples contained a single KIM grain (one Mg-ilmenite and one peridotitic garnet). Concentrations of KIM were low in all samples (a total of 36 individual KIM were identified in the entire sample set), as was mineralogical diversity – only four samples had more than one type of KIM. Peridotitic (Cr-pyrope) garnet (20) was the most common KIM, followed by chromite (8) and lesser amounts of Cr-diopside (4) and Mg-ilmenite (4). With the exception of one ilmenite grain retrieved from the 0.5 to 1.0 mm fraction of sample SUV05329, all of the KIM identified were found in the smallest sand-size fraction, 0.25 to 0.5 mm. No KIM were recovered from the bedrock sample (TFE05-6).

The Cr-pyrope garnets contain between 2.66 and 11.61 wt.% Cr_2O_3. Most are classified as G9 garnets from lherzolite xenoliths, except for four G12 garnets high in CaO, which are from wehrlite, and one moderately Ti-rich (0.40 wt.% TiO_2) G11 garnet, which could be classified as a garnet from sheared and/or metasomatized lherzolite (Table 1). One pyrope from sample SUV05311 falls on the Gurney's (1984) 85% line separating subcalcic harzburgitic garnets from fertile peridotitic garnets – all other garnets fall above the 85% line. No subcalcic harzburgitic garnets were found.

Microprobe analysis of the Cr-diopside grains yielded Cr_2O_3 concentrations between 0.65 and 1.17 wt.%, which are fairly moderate compared to other mantle Cr-diopsides.

TABLE 1. GLACIAL SEDIMENT SAMPLE LOCATIONS AND KIMBERLITE INDICATOR MINERAL (KIM) DATA, NORTHEAST BC. ALL KIM GRAINS WERE RETRIEVED FROM THE 0.25 TO 0.5 MM FRACTION EXCEPT FOR ONE MAGNESIUM-ILMENITE GRAIN IN THE 0.5 TO 1.0 MM FRACTION OF SAMPLE SUV05329.

						Kimberlite indicator minerals (confirmed by probe analysis)						
Sample no.	Sample type	Easting (NAD83)	Northing (NAD83)	Sample weight (g)	Material	Peridotitic garnet	Eclogitic garnet (G3)	Cr-diopside	Olivine	Chromite	Mg-ilmenite	Total
AH05082208	glaciofluvial	495542	6345782	16.8	sand, gravel							0
AH05090315	glaciofluvial	526846	6285837	16.2	sand, gravel							0
AH05090801	glaciofluvial	673984	6114298	17.7	sand, gravel							0
05BJB003	glaciofluvial	642388	6582953	27.8	sand, gravel							0
05BJB008	glaciofluvial	657605	6606064	22.4	sand, gravel							0
05BJB015	glaciofluvial	558510	6631336	29.1	sand	3						3
05BJB018	glaciofluvial	571458	6577012	25.6	sand	1		1			1	3
05BJB019	glaciofluvial	558408	6576514	26.8	sand	1						1
05BJB023	glaciofluvial	542323	6611531	15.9	sand, gravel	1 (G12)						1
05BJB026	glaciofluvial	566397	6647091	19.5	sand, gravel	2 (G9,G12)						2
05BJB028	glaciofluvial	620082	6649890	18.4	sand, gravel	1						1
TDE05-5	glaciofluvial	575001	6559192	28.0	sand	2 (G9,G12)						2
TDE05-18	till	568431	6570801	25.1	till							0
TDE05-25	glaciofluvial	570268	6554421	25.1	sand, gravel	2 (G9,G11)						2
TDE05-29	glaciofluvial	570642	6576584	19.3	sand, gravel							0
TDE05-34	glaciofluvial	569289	6541614	21.7	sand, gravel			1				1
TDE-05w-03	glaciofluvial	577988	6557173	25.4	sand, gravel			1				1
TFE05-3	glaciofluvial	568376	6570926	17.3	sand, gravel					1	1	2
TFE05-5	till	567670	6580969	25.3	till							0
TFE05-6	bedrock	567986	6566251	12.5	crushed rock							0
TFE05-7	glaciofluvial	579115	6554073	17.4	sand, gravel	1		1		1		3
TFE05-8	glaciofluvial	618526	6601001	21.5	sand, gravel					1	1	2
TFE05-9	till	609589	6541386	21.0	till							0
TPCE-05-26	glaciofluvial	569294	6553872	19.4	sand, gravel	2 (G9,G12)						2
SUV05311	till	623127	6493387	30.6	sand	1						1
SUV05314	fluvial, Tertiary	654056	6539077	16.8	sand, gravel					2		2
SUV05317	till	537106	6516768	23.2	sand, gravel	1						1
SUV05318	till	548627	6513265	25.8	sand, gravel	1						1
SUV05319	till	579208	6516097	23.6	till							0
SUV05320	till	571489	6529518	24.1	sand, gravel					1		1
SUV05321	glaciofluvial	579560	6538956	25.1	sand, gravel					1		1
SUV05322	till	564840	6487053	19.0	sand, gravel							0
SUV05323	till	561225	6483879	24.1	sand, gravel					1		1
SUV05324	till	559889	6478976	24.6	till	1						1
SUV05325	till	595816	6514514	24.4	till							0
SUV05326	till	600606	6538407	21.8	till							0
SUV05328	till	604594	6517488	25.7	till							0
SUV05329	till	597854	6516988	14.7	till						1	1
03SUV2338	till	565925	6507214	32.5	till							0
03SUV2339	till	575154	6533261	27.9	till							0
03SUV2341	till	595709	6504607	26.7	till							0
03SUV2343	till	605130	6517808	22.6	till							0
03SUV2344	till	599821	6538389	25.8	till							0
VLE-05-01	fluvial, modern	554596	6443457	23.4	till							0

[1]Total sample weight of the <2 mm fraction processed

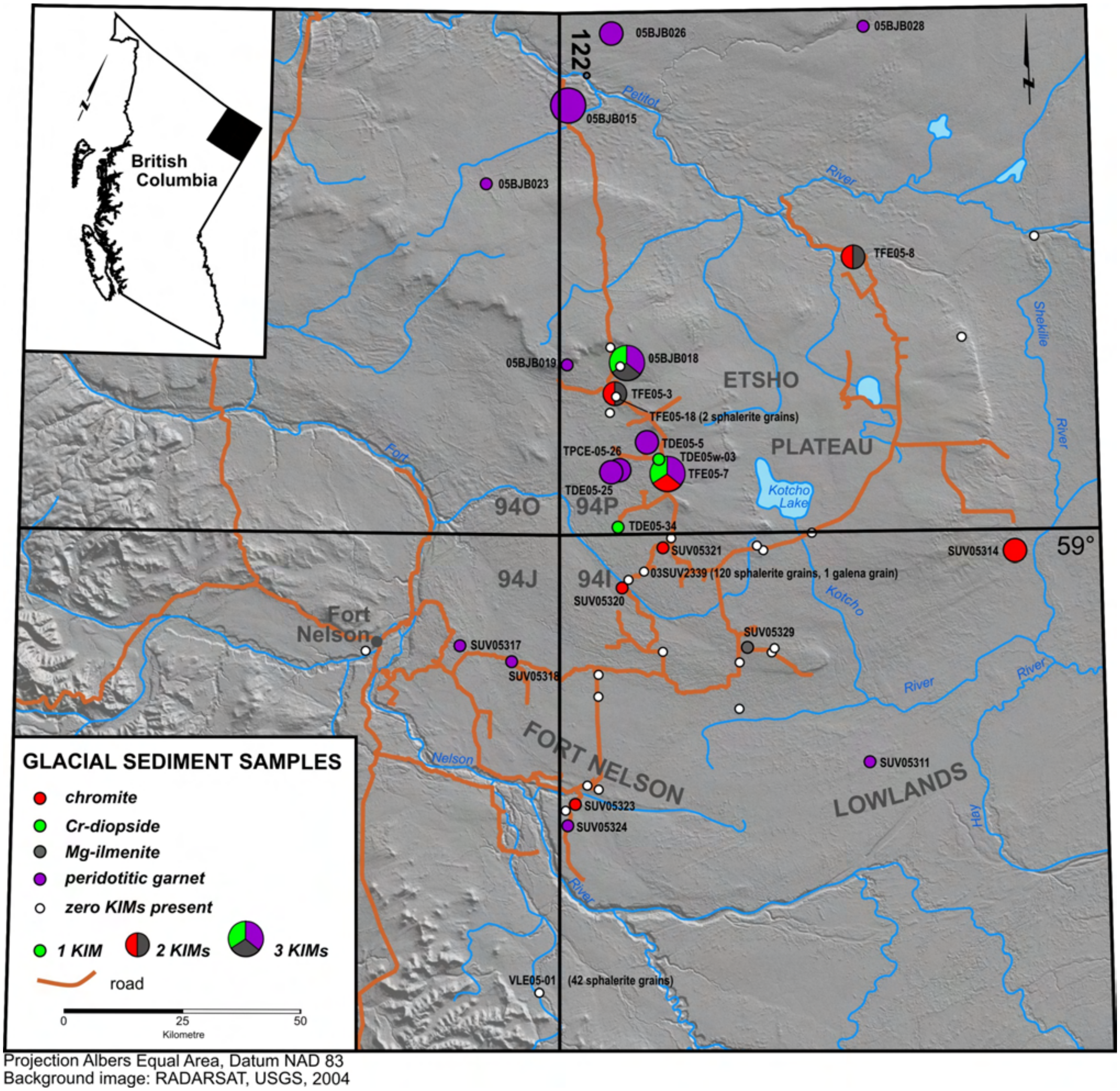


Figure 2. Kimberlite indicator mineral (KIM), confirmed by electron microprobe, and sphalerite and galena concentrations from heavy mineral separates of bulk (approximately 26 kg) glacial sediment samples, northeast BC. All peridotitic garnets are classified as G9 garnets, unless otherwise indicated.

When plotted using Nimis (1998) criteria, three of the Cr-diopside grains are discriminated as being from garnet peridotite (samples TDE05-34, TDE05w-03, TFE05-7), while the fourth (sample O5BJB018) is from spinel-peridotite assemblages.

Most of the oxide grains were chromites with one Cr-spinel in sample SUV05314, and one hercynite ($(Fe,Mg)Al_2O_4$) in sample TFE05-3. Interestingly, sample SUV05314 chromite is interpreted to represent a Tertiary fluvial outlier, largely composed of quartzite erratics of montane provenance. None of the oxide grains identified fall within the diamond intergrowth or inclusion fields of Fipke *et al*. (1995).

Of four ilmenite grains identified, only three were Mg-ilmenites (samples SUV05329, TFE05-3, TFE05-8), containing between 5.84 to 12.08 wt.% MgO and between 0.78 to 2.22 wt.% Cr_2O_3. These grains plot within the compositional range of kimberlitic megacryst ilmenite.

No fresh olivine grains were found in any of the samples. Olivine easily succumbs to alteration when it is exposed to chemical weathering for a long period of time, and thus does not travel well in glacial or fluvial sediments (Ehlers and Blatt, 1982). Garnet, Cr-diopside and spinel compositions indicate that garnet and spinel-peridotite, specifically lherzolite and wehrlite, xenoliths were sampled by the kimberlite(s) that have been eroded and depos-

TABLE 2. BULK STREAM SEDIMENT SAMPLE LOCATIONS AND KIMBERLITE INDICATOR MINERAL DATA. PERIDOTITIC GARNET IS LHERZOLITIC (G9), UNLESS OTHERWISE INDICATED. NUMBERS IN BRACKETS INDICATE GRAINS IN THE 0.5 TO 1.0 MM FRACTION. ONE GRAIN, AN OLIVINE AT SITE 094P051034, IS IN THE 1.0 TO 2.0 MM FRACTION. ALL OTHER GRAINS ARE IN THE 0.25 TO 0.5 MM FRACTION.

Sample no.	Easting (NAD83)	Northing (NAD83)	Sample weight (kg)	<2.0 mm table concentrate (g)	Kimberlite indicator minerals (confirmed by probe analysis): Peridotitic garnet	Eclogitic garnet (G3)	Cr-diopside	Olivine	Chromite	Mg-ilmenite	Total
094I051003	647349	6536003	10.6	806.1	0	1	0	0	3 (3)	0	4
094I051005	643192	6529531	11.1	927.4	1	0	0	0	1	0	2
094I051006	636540	6533138	14.5	1575	2 (G9,G12)	0	1	1 (1)	5	2 (1)	11
094I051009	610799	6540231	9.8	906.9	1 (G11)	0	1	0	0	0	2
094I051011	611309	6537325	1.7	931.1	0	0	0	0	2	0	2
094I051013	591243	6536148	7.9	863.9	0	0	2	0	1	0	3
094I051015	580239	6525552	10.9	1514.9	4 (1)	0	0	0	1	0	5
094I051016	565271	6536580	9.3	1093.2	0	0	0	0	1	0	1
094I051017	654556	6543119	9.1	892.6	1	0	1	0	0	0	2
094P051006	569388	6559214	11.2	826.6	0	0	0	0	0	0	0
094P051007	564922	6553818	6.9	606.3	0	0	1	0	1	1	3
094P051008	564431	6553144	10.5	1199.8	2	0	1	0	2	1 (1)	6
094P051009	570215	6554817	11.0	1024.8	1	0	0	0	0	0	1
094P051010	576618	6559853	8.0	1143.2	0	0	0	0	0	0	0
094P051011	575049	6555203	10.9	1367.9	1	0	1	0	2	1	5
094P051012	564125	6542029	8.7	1174.3	0	0	0	0	1 (1)	1 (1)	2
094P051013	561033	6566895	13.1	1361.2	0	0	0	0	0	0	0
094P051014	565041	6571435	11.9	1780.2	1 (1)	0	0	0	1	0	2
094P051015	560027	6593946	15.0	1713	1	0	0	0	2	0	3
094P051016	571624	6598150	8.5	1251.4	2	0	1	0	1	1	5
094P051020	599561	6555248	10.1	1049.7	0	0	0	0	0	1 (1)	1
094P051022	598889	6545501	11.9	1361.7	1	1	0	1 (1)	0	0	3
094P051023	589594	6591531	11.4	1496.2	1 (G11)	0	2	0	1	0	4
094P051024	584389	6605039	8.9	1232.2	0	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	5
094P051025	594628	6606255	14.7	1578.6	0	0	2	0	3 (2)	2	7
094P051026	602210	6602842	9.1	1028.2	0	0	2	0	0	1 (1)	3
094P051027	603688	6608825	15.4	1221.5	0	0	1	0	0	0	1
094P051028	615566	6600765	13.7	1703.7	1	0	1	0	0	0	2
094P051030	582156	6604214	10.4	895.4	1 (G11)	0	0	0	0	0	1
094P051031	622976	6601386	9.1	1239	0	0	0	0	3 (1)	0	3
094P051032	633158	6597549	8.7	1163	0	0	0	0	5 (2)	4 (3)	9
094P051034	646292	6584199	12.6	1667.8	0	0	0	**1**	0	0	1
094P051035	661007	6572141	10.3	1199.7	0	0	1	0	0	0	1
094P051037	652374	6563796	8.4	620.9	0	0	0	0	0	0	0
094P051038	661394	6554199	9.4	1176.9	0	0	2	0	4 (2)	1 (1)	7
094P051039	616867	6550299	10.9	1161.7	2	0	0	0	0	0	2

ited in association with the regional glacial sediment samples. However, no grains from diamond-bearing assemblages such as eclogite or subcalcic harzburgite were found.

KIM in stream sediments were visually identified from the heavy mineral concentrates of 34 out of 36 samples collected around the margins of the Etsho Plateau. Identified KIM include peridotitic garnet, eclogitic garnet, Cr-diopside, olivine, chromite and Mg-ilmenite (Table 2). Note that results are not normalized to a standard heavy mineral concentrate weight. Total abundance of confirmed KIM varies from one grain (seven sites) to eleven grains.

The distribution of KIM, identified as such by electron microprobe, are shown in Figure 3. Using the classification scheme of Grütter *et al.* (2004), three garnets were classified as eclogitic (G3) garnets. Eclogitic garnets are extremely important pathfinder minerals in diamond exploration (Grütter, 2004). A further 19 were classified as Cr-pyrope garnets derived from lherzolite (G9 garnets).

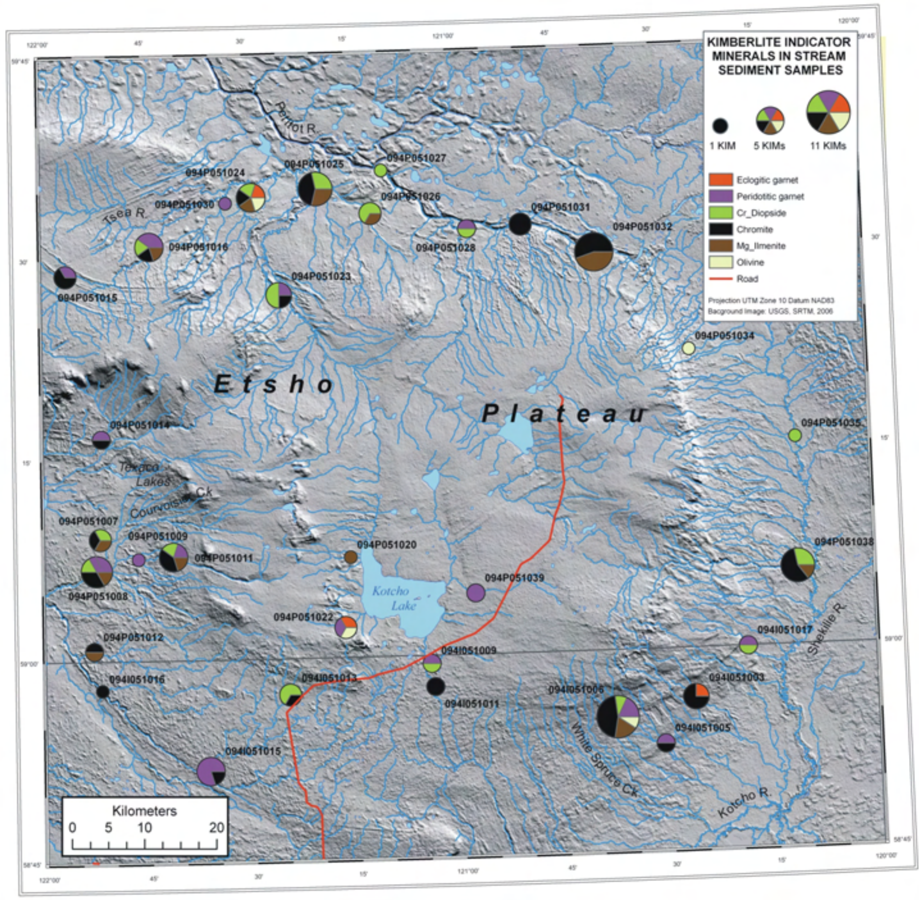


Figure 3. Kimberlite indicator mineral results, confirmed by electron microprobe, from bulk (10–15 kg) stream sediment samples, northeast BC. All peridotitic garnets are classified as G9 garnets, unless otherwise indicated.

BASE METAL POTENTIAL: GEOCHEMISTRY AND INDICATOR MINERALS FROM GLACIAL SEDIMENTS

A summary of the geochemical results for selected elements in the <0.063 mm fraction of glacial sediments is presented in Table 3. No localized anomalous distribution or concentration of any one, or combined suite of elements was detected in a preliminary examination of the results. However, the Zn and Pb geochemical maps suggest relatively moderate elevated concentrations over the Etsho Plateau, falling off to the west in the direction of ice flow (Fig 4). In the region of the aforementioned sphalerite dispersal train in Alberta, 180 km east of the Etsho Plateau, Zn con-

TABLE 3. SUMMARY OF GEOCHEMICAL DATA FOR SELECTED PRECIOUS AND BASE METALS, IN THE SILT AND CLAY-SIZED FRACTION (–250 MESH, <0.063 MM) OF GLACIAL SEDIMENT SAMPLES, NORTHEAST BC. MEASURED BY INDUCTIVELY COUPLED PLASMA MASS SPECTROMETRY AND EMISSION SPECTROSCOPY (ICP-MS AND ES) WITH AQUA REGIA DIGESTION. DISTRIBUTION OF SAMPLES IS SHOWN IN FIGURE 2.

	ICP-ES and MS with aqua regia digestion								INAA						
	Ag (ppb)	Cu (ppm)	Mo (ppm)	Ni (ppm)	Pb (ppm)	S (%)	U (ppm)	Zn (ppm)	As (ppm)	Au (ppb)	Ba (ppm)	Co (ppm)	Fe (%)	Sb (ppm)	U (ppm)
No. of samples	142	142	142	142	142	142	142	142	139	139	139	139	139	139	139
Minimum	26.0	6.1	0.12	9.5	5.5	<0.01	0.3	23.1	2.0	-2	250	3.0	0.8	-0.1	0.9
Maximum	1315.0	170.8	12.30	205.8	197.1	1.42	6.2	355.5	27.8	16	4090	28.0	4.5	2.5	9.2
Median	217.5	29.3	2.49	31.6	14.2	0.03	1.9	112.1	12.9	-2	740	11.0	3.0	1.0	4.1
75 percentile	250.8	31.6	3.53	35.3	15.8	0.15	2.4	120.8	14.7	-2	820	12.0	3.3	1.3	4.7
90 percentile	282.8	34.7	4.91	40.8	18.3	0.66	2.8	132.5	16.4	6	1042	14.2	3.5	1.6	5.1
95 percentile	341.9	37.3	5.65	44.5	19.4	0.76	3.1	145.3	17.5	8	1142	16.1	3.6	1.7	5.8

Abbreviations: ICP-ES and MS, inductively coupled plasma emission spectroscopy and mass spectrometry; INAA, instrumental neutron activation analysis

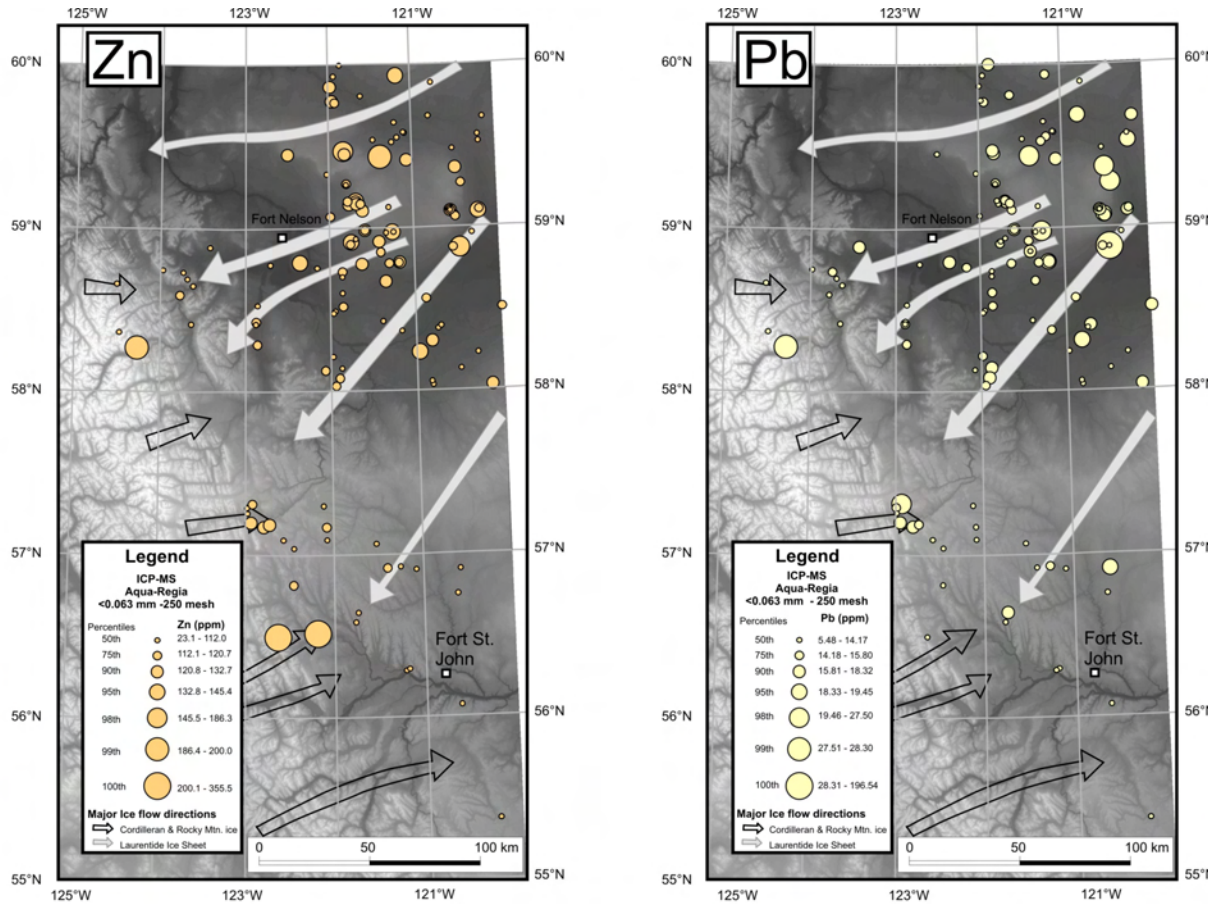


Figure 4. Lead (Pb) and zinc (Zn) concentrations in the silt and clay-sized fraction (–250 mesh, <0.063 mm), as measured by inductively coupled plasma mass spectrometry (ICP-MS) with aqua regia digestion, northeast BC.

centrations in the silt and clay-sized fraction of glacial sediments were also not high, ranging from 169 to 231 ppm (Plouffe *et al*., 2006a). Similarly, even with the presence of trace amounts of galena in the same region, lead concentrations were low, varying from 17 to 25 ppm.

Similar Pb and Zn concentrations were observed in the glacial sediment samples from the Etsho Plateau. Sphalerite grains, however, were found in one fluvial and two till sediment samples (03SUV2339, till, 120 grains; VLE05-01, fluvial, 42 grains; TDE05-18, till, 2 grains) and one till sample yielded a galena grain (03SUV2339). None of these samples have yielded anomalous Zn or Pb concentrations. These results suggest that base metal mineralization might be present in northeast BC and that heavy mineral concentrates recovered from the sand-sized fraction of glacial sediments are more effective than geochemical analysis of the fine fraction (–250 mesh, <0.063 mm) to detect concealed mineralization. The effectiveness of the geochemical analysis of the sand-sized fraction at detecting mineralization remains to be tested.

STREAM SEDIMENT GEOCHEMISTRY

The relative mobility of elements in surface environments is affected by climate and physiography, as well as biological, anthropogenic and geological factors (Plant and Raiswell, 1994). Stream sediment and water surveys were carried out from 2001 to 2004 (Friske *et al*., 2003; McCurdy *et al*., 2006) in an area east of the survey area, in the Buffalo Head Hills of northwest Alberta. A useful comparison can be made between data from the Buffalo Head Hills survey and the present survey around the perimeter of the Etsho Plateau. The two areas are similar in nature, with similar geology, glacial history, physiography, vegetation and surficial geology. Table 4 compares mean and median concentrations in the silt fraction for selected metals from the two datasets. Generally, values are similar. Median and mean values of Ag in Buffalo Head Hills stream sediments are lower than comparable values around the Etsho Plateau and may be affected by slightly more alkaline streamwater in the Buffalo Head Hills. The average pH of streams draining the Buffalo Head Hills is 7.65 (Friske *et al*., 2003; McCurdy *et al*., 2006), whereas the average pH of streams draining the Etsho Plateau is 7.19. The geochemical mobility of Ag is reduced in neutral to alkaline waters (Plant and Raiswell, 1994). Because the main purpose of the stream sediment survey was to establish the potential for diamond-bearing rock in northeast BC, samples were mainly taken from second and third-order streams, from which elemental concentrations of most elements would be expected to be diluted from input from large areas of drainage basins. However, geochemistry of the silt does suggest moderate potential for follow-up work in three areas, west of Shekilie River, Courvoisier Creek and Tsea River. West of the Shekilie River a number of sites contain elevated concentrations of Zn and Pb (Fig 5a, b). In this area, Ag, Cd,

TABLE 4. COMPARISON OF MEAN AND MEDIAN VALUES OF SELECTED ELEMENTS IN STREAM SEDIMENT (SILT) FROM THE ETSHO PLATEAU, NORTHEAST BC AND BUFFALO HEAD HILLS, NORTH-CENTRAL ALBERTA (FRISKE *ET AL.*, 2003; MCCURDY *ET AL.*, 2006). ALL VALUES ARE PPM UNLESS OTHERWISE INDICATED.

Element (analysis)	Etsho Plateau (n=49)		Buffalo Head Hills (n=470)	
	Mean	**Median**	**Mean**	**Median**
Ag (ICP-MS)	117 ppb	104 ppb	84 ppb	77 ppb
As (INAA)	8.7	8.7	10.9	10
Ba (INAA)	720	710	878	810
Co (INAA)	10	10	10	9
Cu (ICP-MS)	12.6	11.08	12.18	10.52
Fe (INAA)	2.90%	2.80%	3.00%	2.80%
Hg (ICP-MS)	38 ppb	34 ppb	47 ppb	39 ppb
Mn (ICP-MS)	431	331	718	440
Mo (ICP-MS)	1.51	1.26	0.99	0.67
Ni (ICP-MS)	17.3	15.8	16.7	14.7
Pb (ICP-MS)	8.38	8.23	8.29	7.81
Sb (INAA)	0.6	0.6	0.7	0.6
U (INAA)	4.1	3.6	3.2	3
Zn (ICP-MS)	80	76.6	61.9	57.6

Abbreviations: ICP-MS, inductively coupled plasma mass spectrometry; INAA, instrumental neutron activation analysis

Co±As and Sb are also elevated relative to the whole dataset. Similar patterns of distribution are noted in the drainage basins of Courvoisier Creek and the Tsea River (Fig 5a, b).

In addition to the silt samples, geochemical analyses were conducted on the heavy mineral concentrates of the <0.25 mm fraction. The geochemical results for the heavy mineral concentrates are presented using a descriptive terminology defined as follows: the median value for a given element is considered as background and anomalies are considered weak (2–3 times the median value), moderate (3.1–5 times the median value), strong (5.1–10 times the median value) or very strong (>10 times the median value).

Median values for selected elements are similar in the Buffalo Head Hills and the Etsho Plateau except for Zn and Pb; both exhibit higher median and mean values over the Etsho Plateau compared to the Buffalo Head Hills (Table 5). In addition, the Ag median value is more elevated over the Etsho Plateau in comparison to the Buffalo Head Hills.

Zinc values are elevated generally around the northwest margins of the Etsho Plateau (Fig 6a). Throughout the drainage basin of the Tsea River, Zn values are anomalous, with a strongly anomalous value of 1295 ppm (ap-

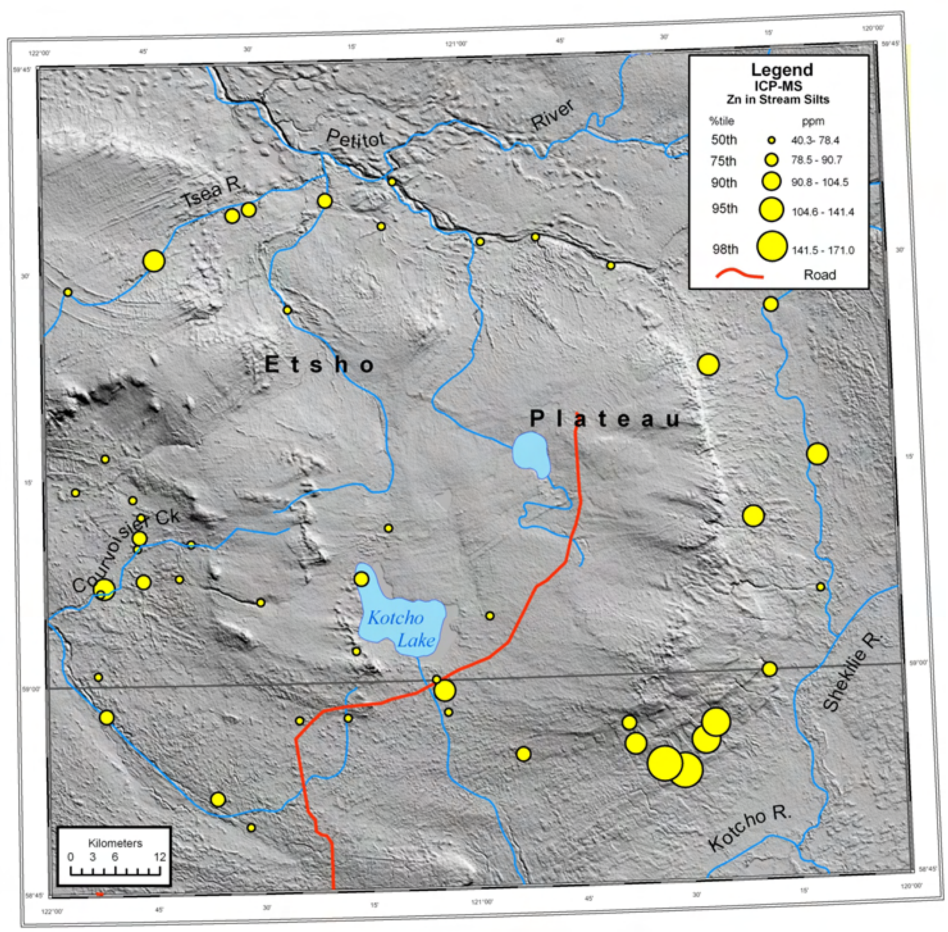


Figure 5a. Zinc concentrations in stream silts (<177 μm), determined by inductively coupled plasma mass spectrometry (ICP-MS) with aqua regia digestion, northeast BC.

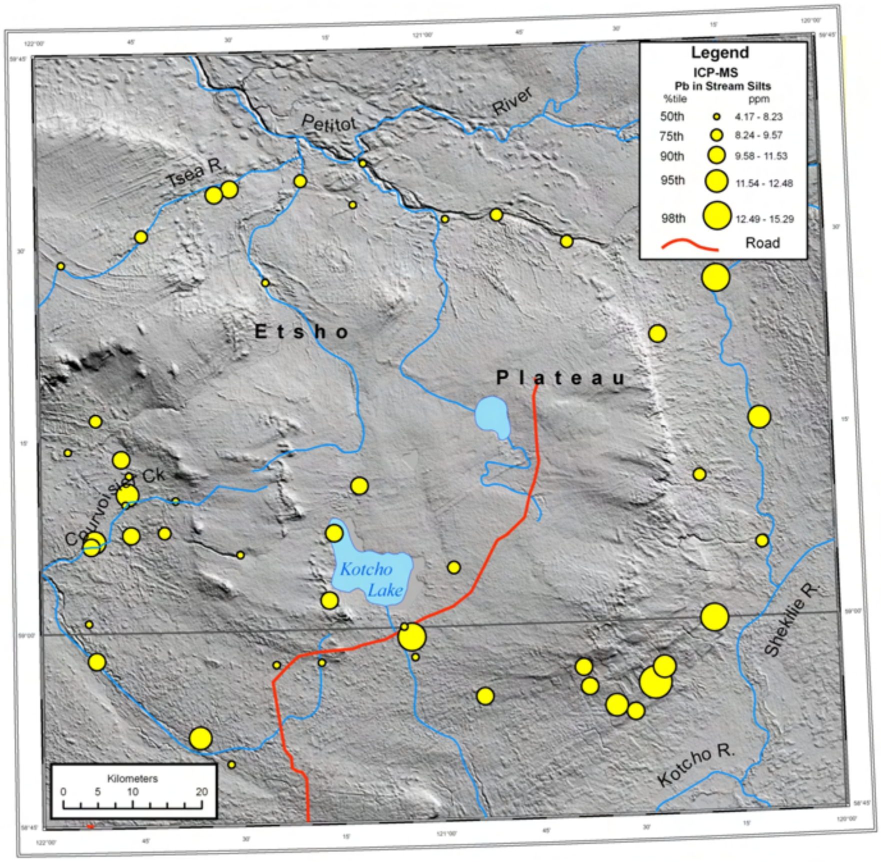


Figure 5b. Lead concentrations in stream silts (<177 µm), determined by inductively coupled plasma mass spectrometry (ICP-MS) with aqua regia digestion, northeast BC.

TABLE 5. COMPARISON OF MEAN AND MEDIAN VALUES OF SELECTED ELEMENTS IN THE <0.25 MM FRACTION OF HEAVY MINERAL CONCENTRATES FROM THE ETSHO PLATEAU, NORTHEAST BC AND BUFFALO HEAD HILLS, NORTH-CENTRAL ALBERTA (FRISKE *ET AL*., 2003; MCCURDY *ET AL*., 2006). ALL VALUES ARE PPM UNLESS OTHERWISE INDICATED.

Element (analysis)	Etsho Plateau (n=36)		Buffalo Head Hills (n=267)	
	Mean	Median	Mean	Median
Ag (ICP-MS)	176 ppb	103 ppb	271 ppb	76 ppb
As (INAA)	18.5	23.8	34.4	17
Ba (INAA)	14293	13750	21601	18250
Co (INAA)	38	38	36	35
Cu (ICP-MS)	19.25	14.83	16.8	9.73
Fe (INAA)	27.30%	27.30%	24.70%	25.00%
Hg (ICP-MS)	57 ppb	36 ppb	155 ppb	42 ppb
Mn (ICP-MS)	989	935	1389	1239
Mo (ICP-MS)	3.22	2.4	3.52	1.71
Ni (ICP-MS)	13.2	10.1	17.6	9.6
Pb (ICP-MS)	36.09	37.35	27.13	26.2
Sb (INAA)	1.9	1.8	1.8	1.2
U (INAA)	24.6	25.8	21	21
Zn (ICP-MS)	351.2	182.4	124.8	63.3

Abbreviations: ICP-MS, inductively coupled plasma mass spectrometry; INAA, instrumental neutron activation analysis

proximately seven times the median value of 182 ppm) on the upper reaches of the Tsea River (092P051016). Zinc values are also elevated south of Kotcho Lake. Both Ag and Pb (Fig 6b) exhibit similar patterns of distribution, suggesting the possibility of proximity to a number of different sedimentary-hosted mineralization types. In addition, sphalerite grains were identified visually and confirmed by scanning electron microscope in samples from the Tsea River drainage basin. Barium values are relatively high throughout the survey area.

CONCLUSIONS

KIM have been recovered from glacial (mostly glaciofluvial sand and gravel) and stream sediments from the Etsho Plateau of northeast BC. The distribution of KIM in both sample media does not suggest a specific source region over the Etsho Plateau. Therefore, it is still unclear if the KIM are locally derived from concealed kimberlite(s) or represent material from the east and northeast that has been glacially transported long distances and reworked by fluvial processes.

The potential for Pb-Zn-Ag mineralization might be present in the Etsho Plateau region given the elevated concentration of these metals in the heavy mineral concentrates of stream sediments and the presence of sphalerite grains in two till samples from this region.

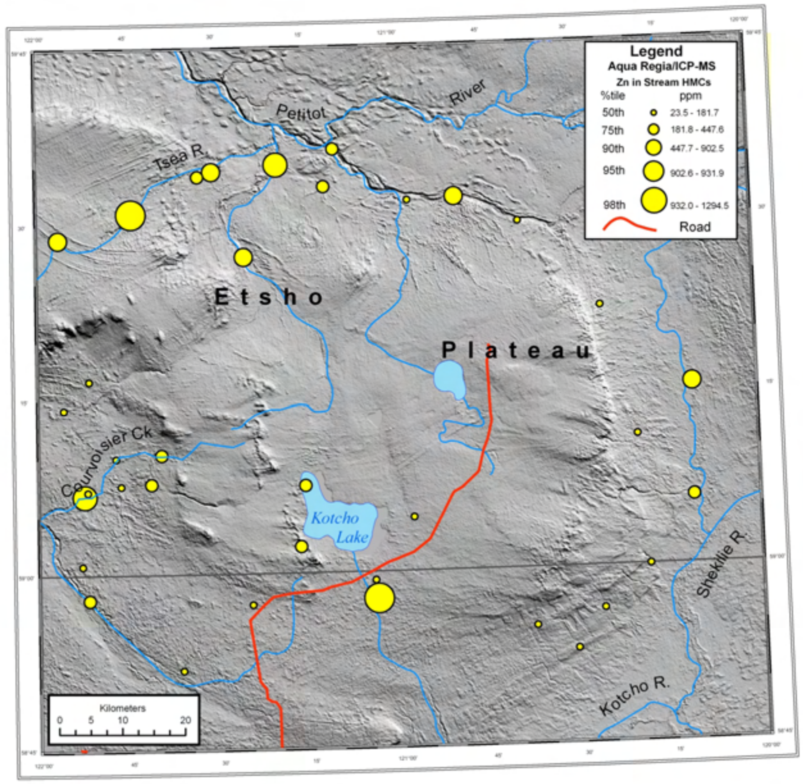


Figure 6a. Zinc (Zn) concentrations in the <0.25 mm fraction of heavy mineral concentrates (HMC), determined by inductively coupled plasma mass spectrometry (ICP-MS) with aqua regia digestion, northeast BC.

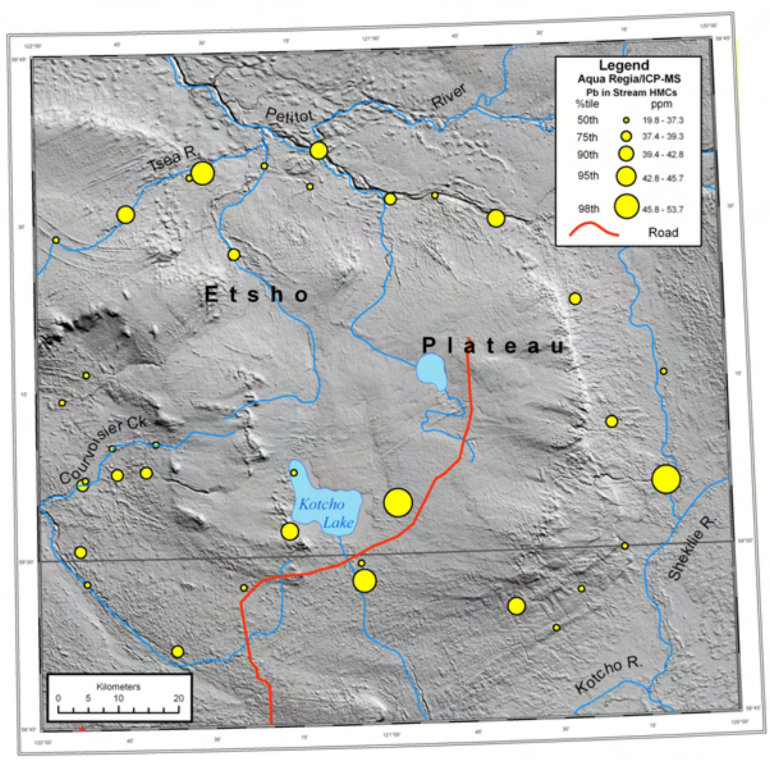


Figure 6b. Lead (Pb) concentrations in the <0.25 mm fraction of heavy mineral concentrates (HMC), determined by inductively coupled plasma mass spectrometry (ICP-MS) with aqua regia digestion, northeast BC.

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