Drainage Sediment and Water Geochemical Surveys in the Anahim Lake and Nechako River Map Areas (NTS 093C and F), Central British Columbia[1]

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KEYWORDS: Nechako Plateau, Fraser Plateau, mineral exploration, geochemistry, multielement, lake sediment, lake water, epithermal, gold, molybdenum, copper, porphyry deposit

INTRODUCTION

During the 2005 field season, Geoscience BC funded two reconnaissance-scale drainage sediment and water surveys that were successfully completed in previously unsurveyed regions of central British Columbia (Fig. 1). These surveys are part of an ongoing effort to complete first-level geochemical coverage of the province and provide the mining and exploration community with new, high-quality geochemical information. The program will help to,

- outline regional geochemical trends,
- identify new exploration targets, and
- profile previously explored mineral properties.

Each component of the work is being conducted according to National Geochemical Reconnaissance (NGR) and BC Regional Geochemical Survey (RGS) program standards and specifications. Resulting digital data will fit seamlessly into current NGR and RGS databases, as well as complement other geoscience information available for the region.

Regional geochemical surveys have been carried out in BC since 1976. A total of 45 1:250 000-scale NTS map sheets and numerous detailed studies have been published to date, covering approximately 500 000 km^2 of the province. Analytical results and field observations contribute to the building of 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 laboratory undertaking the analyses.

SURVEY AREA DESCRIPTION

The Anahim Lake (NTS 093C) and Nechako River (NTS 093F) map sheets are situated in the Nechako Basin

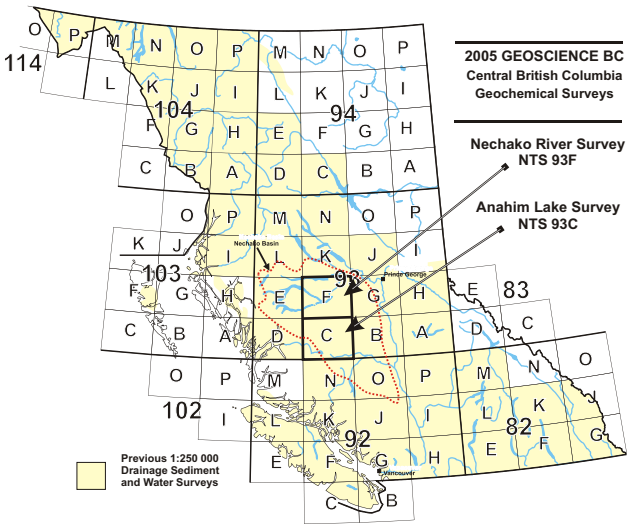

Figure 1. Location of Anahim Lake and Nechako River drainage sediment and water geochemical survey areas, central BC.

of central BC, in a region of low relief characterized by large expanses of flat and gently rolling landscape (Holland, 1976). The surface of the Nechako and Fraser plateaus is generally between 1200 and 1500 m in elevation and comprises a wide variety of physiographic environments, ranging from rocky subalpine peaks to boggy lowlands. To the north, the Fawnie and Nechako ranges break up the plateau landscape, and the Ilgachuz and Itcha ranges interrupt the Fraser Plateau. In the southwest corner, the rugged Coast Mountain Range extends into the study area. The plateaus are mostly forested with subboreal spruce and pine, and are generously dotted with small to medium-sized lakes, as well as extensive wetland systems. Throughout the region, the northern pine beetle kill has significantly impacted extensive areas of forest cover.

The Nechako Basin is a postaccretionary basin bounded to the north by the Skeena arch, to the west and south by the Cost Plutonic Complex and to the east by the Cache Creek Group (Fig. 2). The area is covered by extensive mafic to felsic volcanic flows of Tertiary to recent age, and much of the region is covered with thick glacial drift that has left very little exposed bedrock. Underlying these deposits are Middle Jurassic to Tertiary marine and nonmarine sedimentary rocks and lesser volcanic rocks.

Less than one hundred mineral occurrences (Fig. 2) are currently listed in the provincial mineral inventory database (MINFILE, 2005). Several of the more important deposits include epithermal Au-Ag occurrences. These include Wolf (093F 045) and Oboy (093C 015), hosted by Ootsa Lake Group felsic volcanic rocks, and the 3Ts devel-

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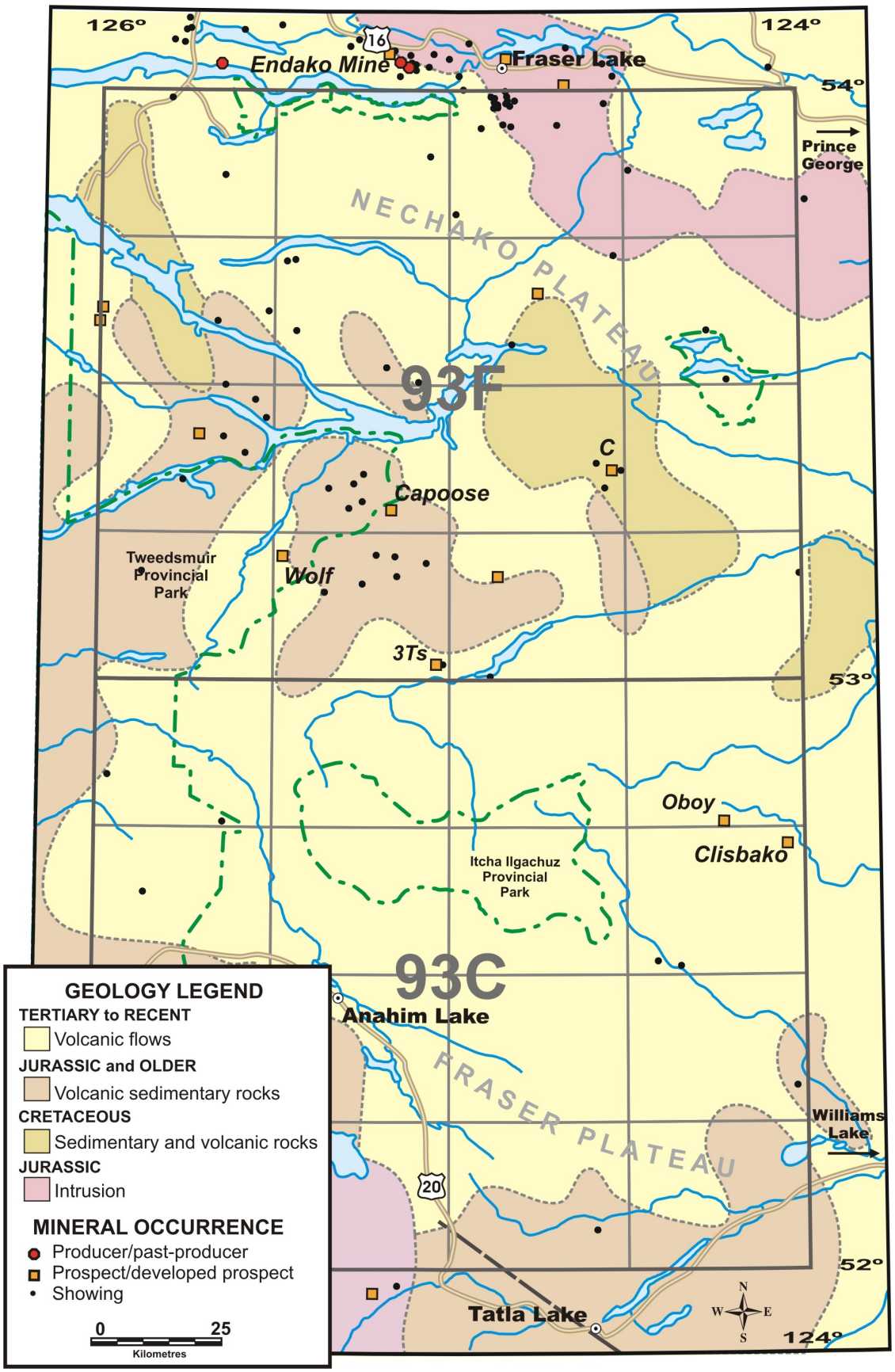

Figure 2. Simplified geological setting of the Anahim Lake and Nechako River survey areas, with MINFILE locations.

oped prospect (Tsacha [093F055], Taken [093F055] and Tam claims), occurring in Hazelton Group intermediate volcanic rocks. Also important are Mo and Cu porphyry occurrences associated with Tertiary intrusions (*e.g.*, C, 093F 004) and porphyry-related precious and base metal mineralization (*e.g.*, Capoose, 093F 040), hosted by Hazelton Group intermediate volcanic rocks associated with cross-cutting rhyolitic dikes of Cretaceous age.

PREVIOUS GEOCHEMICAL WORK

Although the region offers a favourable environment for new mineral discoveries, extensive glacial drift, poor bedrock exposure and an unproductive volcanic cover have previously hampered much of the exploration activity. In addition, a collection of comprehensive geochemical information for the Nechako and Fraser plateaus has only been developed relatively recently, starting in 1993 as part of the Interior Plateau Project (Diakow, 1997) and, more recently, the Nechako NATMAP Project (Struik *et al*., 2001). Included in these activities were a number of orientation and case studies, summarized by Cook (1997), that outline the importance of lake sediments as an effective exploration tool in the Interior Plateau region. Levson and Giles (1997) and Dunn (1997) highlighted the use of till geochemistry and biogeochemistry within the Interior Plateau. In addition, Cook and Dunn (2006) are conducting further studies dealing with property-scale surficial geochemistry.

In the Nechako Plateau, two lake sediment and water geochemistry surveys (Cook and Jackaman, 1994) were completed in the Fawnie Range and Ootsa Lake areas (Fig. 3), and several till geochemistry surveys were conducted in parts of the southern Nechako Plateau (Levson *et al*., 1994; Weary *et al*., 1997; Levson *et al*., 2001). Biogeochemical surveys have been completed in parts of the Nechako Plateau (Dunn and Hastings, 1998a, b, c, d; Dunn and Hastings, 2000a, b, c, d) and in the Clisbako area of the Fraser Plateau (Dunn, 1997). The 2005 survey areas are also completely surrounded by previous NGR and RGS reconnaissance-scale stream sediment and water geochemistry programs. A list of publicly available geochemistry data for the region has been provided in Table 1.

SURVEY METHODS AND SPECIFICATIONS

Methods and specifications are based on standard lake sediment geochemical survey strategies used elsewhere in Canada for the NGR program (Friske, 1991), as well as prior orientation studies and regional lake sediment surveys completed in BC (Cook, 1997).

Sample Collection

Helicopter-supported sample collection was carried out from July to September 2005, during which 2070 drainage sediment and water samples were systematically collected from 1957 sites (Fig. 4). Within the low-lying areas, lake sediment and water were collected from 1855 sites. In the Anahim Lake map sheet, stream sediment material was collected from 102 sites in areas of greater relief near Mount Dent and Charlotte Lake. The surveys covered a total area of 19 500 km^2 and the average sample site density was 1 site per 9.9 km^2. Field duplicate sediment and water samples were routinely collected in each analytical block of twenty samples.

Lake sites were accessed using a float-equipped Bell Jet Ranger helicopter. The sampling crews collected sediment material with a torpedo style sampler, and water samples were saved in 250 mL bottles. Samples were successfully collected from most of the lakes located in the survey area. However, some of the smaller ponds were not sampled due to poor landing conditions, and samples were not collected from several very large and deep lakes. Lake bottom material typically consisted of organic gels with varying amounts of organic matter. Field observations and site locations were manually and digitally recorded for each site.

Sample Analysis

After drying, each sample was pulverized to approximately –150 mesh (100 μm) in a ceramic ring mill, and two analytical splits (5 g and 30 g) were extracted from the material. To monitor and assess accuracy and precision of analytical results, control reference material and analytical duplicate samples were routinely inserted into each block of twenty sediment samples. The sediment samples were analyzed for base and precious metals, pathfinder elements and rare earths by instrumental neutron activation analysis (INAA) and inductively coupled plasma – mass spectrometry (ICP-MS). Loss-on-ignition and fluorine were also determined for sediment material, and fluoride, conductivity and pH were determined for the water samples. A complete list of elements and analytical detection limits is provided in Tables 2 and 3.

TABLE 1. PREVIOUS GEOCHEMICAL SURVEYS CONDUCTED IN THE ANAHIM LAKE AND NECHAKO RIVER AREAS

Survey Type	Survey Date	NTS Map Sheets	Survey Name	Reference
Till geochemistry	1994	93F/03	Fawnie Creek	Levson *et al*., 1994
Till geochemistry	1997	93F/07	Chedakuz Creek	Weary *et al*., 1997
Till geochemistry	2001	93F/05, 12	Tetachuk Creek and Marilla	Levson *et al*., 2001
Lake sediment and water geochemistry	1994	93F/02, 03	Fawnie Range	Cook and Jackaman, 1994
Lake sediment and water geochemistry	1994	93F/06, 11, 12, 13, 14	Ootsa Lake	Cook and Jackaman, 1994
Biogeochemistry	1996	93C/09	Clisbako	Dunn, 1997
Biogeochemistry	1998	93F/03, 05, 07, 12	Ootsa-Francois Lakes	Dunn and Hastings, 1998
Biogeochemistry	2000	93F/12, 13, 14	Nechako River	Dunn and Hastings, 2000

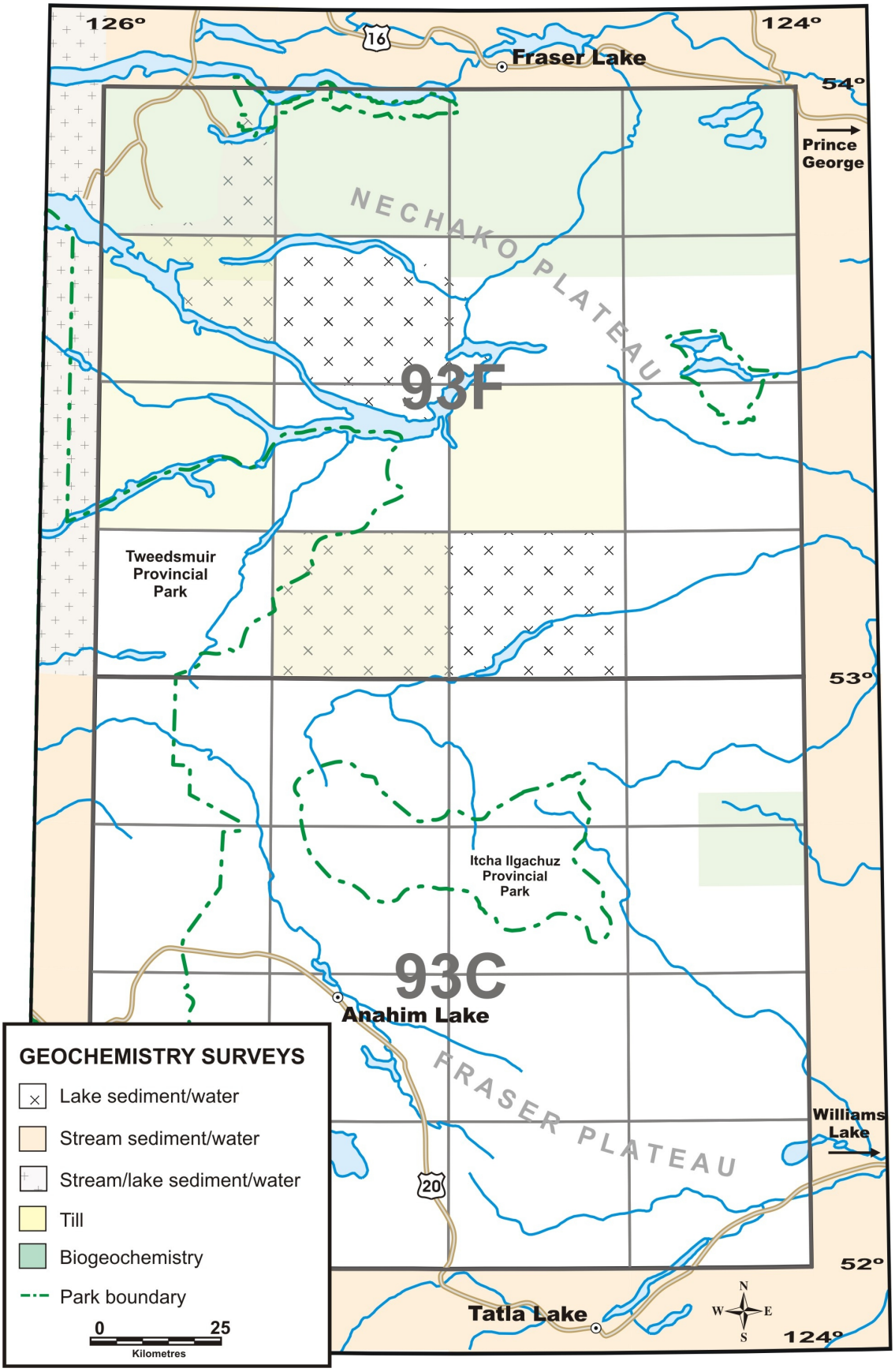

Figure 3. Location of previous geochemical surveys in the Anahim Lake and Nechako River areas.

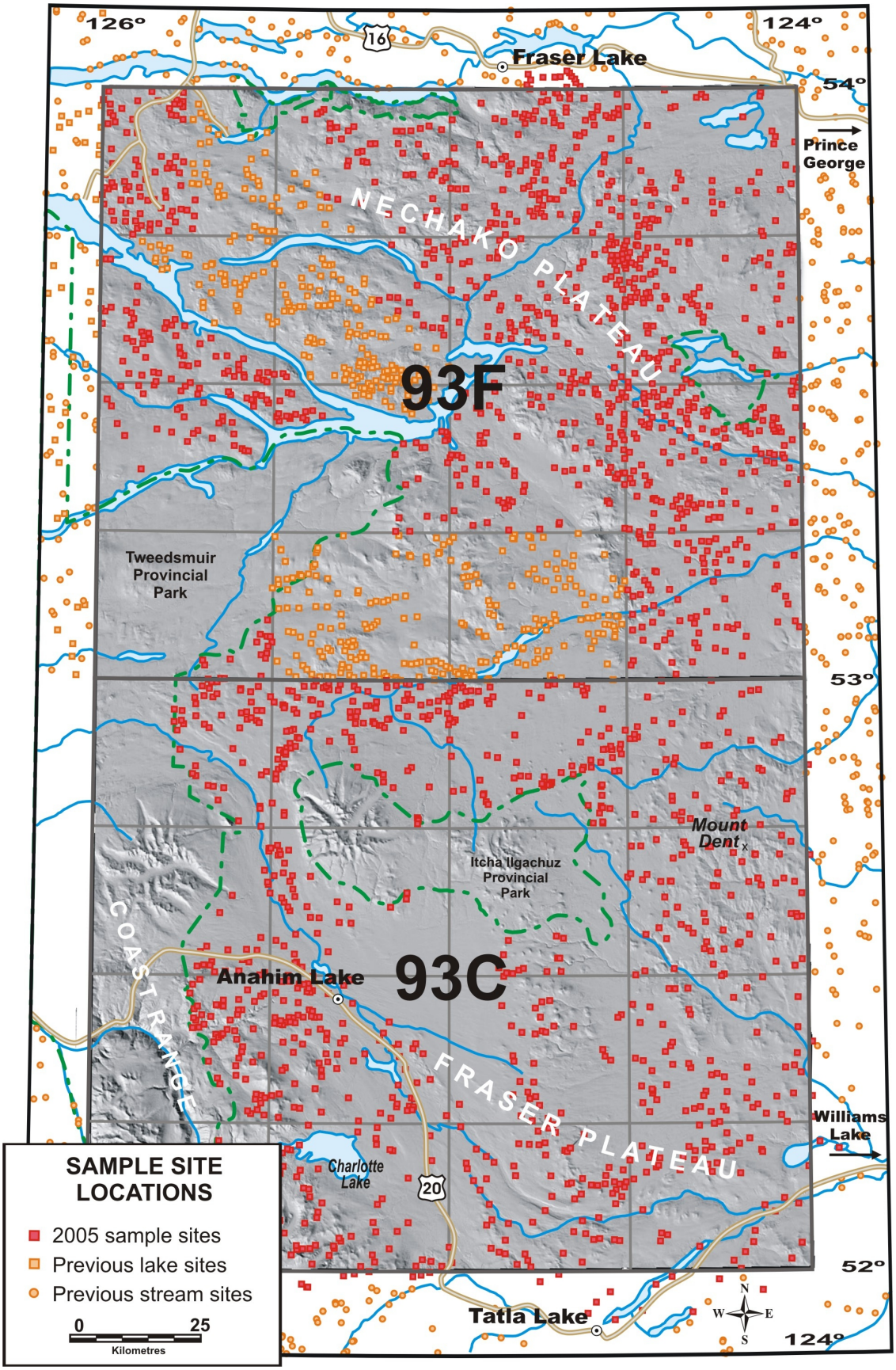

Figure 4. Location of sample sites, Anahim Lake and Nechako River survey areas.

TABLE 2. DETECTION LIMITS FOR SEDIMENT SAMPLES ANALYZED BY INDUCTIVELY COUPLED PLASMA – MASS SPECTROMETRY (ICP-MS)

Element		Detection Limit	Units
Aluminum	Al	0.01	%
Antimony	Sb	0.02	ppm
Arsenic	As	0.1	ppm
Barium	Ba	0.5	ppm
Bismuth	Bi	0.02	ppm
Cadmium	Cd	0.01	ppm
Calcium	Ca	0.01	%
Chromium	Cr	0.5	ppm
Cobalt	Co	0.1	ppm
Copper	Cu	0.01	ppm
Gallium	Ga	0.2	ppm
Iron	Fe	0.01	%
Lanthanum	La	0.5	ppm
Lead	Pb	0.01	ppm
Magnesium	Mg	0.01	%
Manganese	Mn	1	ppm
Mercury	Hg	5	ppb
Molybdenum	Mo	0.01	ppm
Nickel	Ni	0.1	ppm
Phosphorus	P	0.001	%
Potassium	K	0.01	%
Scandium	Sc	0.1	ppm
Selenium	Se	0.1	ppm
Silver	Ag	2	ppb
Sodium	Na	0.001	%
Strontium	Sr	0.5	ppm
Sulphur	S	0.02	%
Tellurium	Te	0.02	ppm
Thallium	Tl	0.02	ppm
Thorium	Th	0.1	ppm
Titanium	Ti	0.001	%
Tungsten	W	0.1	ppm
Uranium	U	0.1	ppm
Vanadium	V	2	ppm
Zinc	Zn	0.1	ppm

TABLE 3. DETECTION LIMITS FOR SEDIMENT SAMPLES ANALYZED BY INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS (INAA), LOSS-ON-IGNITION (LOI) AND F, AND FOR FLUORIDE, CONDUCTIVITY AND PH OF WATER SAMPLES

Element		Detection Limit	Units
Antimony	Sb	0.1	ppm
Arsenic	As	0.5	ppm
Barium	Ba	50	ppm
Bromine	Br	0.5	ppm
Cerium	Ce	5	ppm
Cesium	Cs	0.5	ppm
Chromium	Cr	20	ppm
Cobalt	Co	5	ppm
Europium	Eu	1	ppm
Gold	Au	2	ppb
Hafnium	Hf	1	ppm
Iron	Fe	0.2	%
Lanthanum	La	2	ppm
Lutetium	Lu	0.2	ppm
Rubidium	Rb	5	ppm
Samarium	Sm	0.1	ppm
Scandium	Sc	0.2	ppm
Sodium	Na	0.02	%
Tantalum	Ta	0.5	ppm
Terbium	Tb	0.5	ppm
Thorium	Th	0.2	ppm
Tungsten	W	1	ppm
Uranium	U	0.2	ppm
Ytterbium	Yb	2	ppm
Sample weight	Wt	0.01	gm
Fluorine	F	10	ppm
Loss-on-ignition	LOI	0.1	%
pH	pH		
Conductivity	CND	0.01	µS

RELEASE DETAILS

Reconnaissance-scale drainage sediment and water surveys are widely recognized as one of the most important reconnaissance exploration tools in the Canadian Cordillera. To date, more than 70% of BC has been surveyed. These high-quality grassroots data are directly responsible for follow-up mineral exploration that is valued in the millions of dollars and has been credited with the discovery of numerous mineral prospects. Survey results from the 2005 programs will provide the exploration community access to new geochemical information for underexplored areas of high mineral potential and will help stimulate mineral exploration.

Final survey results will be compiled into an NGR-RGS – style data package that will include survey descriptions and details regarding methods; analytical and field-data listings; summary statistics; and sample location maps and maps for individual elements. In addition, existing lake sediment results from previous surveys conducted in the study area will be incorporated into the final data package. The publications will be released on a CD as PDF files and will include all raw digital data files used in the production process. The data package is scheduled for release by March 31, 2006.

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REFERENCES

Cook, S.J. (1997): Regional and property-scale application of lake sediment geochemistry in the search for buried mineral deposits in the southern Nechako Plateau area, British Columbia; *in* Interior Plateau Geoscience Project: Summary of

Geological, Geochemical and Geophysical Studies, Diakow, L.J. and Newell, J.M., Editors, *Geological Survey of Canada*, Open File 3448 and *BC Ministry of Energy, Mines and Petroleum Resources*, Paper 1997-2, pages 175–203.

Cook, S.J. and Dunn, C.E. (2006): Preliminary results of the Cordilleran Geochemistry Project: a comparative assessment of soil geochemical methods for detecting buried mineral deposits, 3Ts Au-Ag prospect (NTS 093F/03), central British Columbia; *in* Geological Fieldwork 2005, *BC Ministry of Energy, Mines and Petroleum Resources*, Paper 2006-1 and *Geoscience BC*, Report 2006-1.

Cook, S.J. and Jackaman, W. (1994): Regional lake sediment and water geochemistry of part of the Nechako River map area (93F/2,3; parts of 93F/6, 11, 12, 13, 14); *BC Ministry of Energy, Mines and Petroleum Resources*, Open File 1994-19.

Diakow, L.J. (1997): Introduction; *in* Interior Plateau Geoscience Project: summary of geological, geochemical and geophysical studies, Diakow, L.J. and Newell, J.M., Editors, *Geological Survey of Canada*, Open File 3448 and *BC Ministry of Energy, Mines and Petroleum Resources*, Paper 1997-2, pages 1–3.

Dunn, C.E. (1997): Biogeochemical surveys in the Interior Plateau of British Columbia; in Interior Plateau Geoscience Project: Summary of Geological, Geochemical and Geophysical Studies, Diakow, L.J. and Newell, J.M., Editors, *Geological Survey of Canada*, Open File 3448 and *BC Ministry of Energy, Mines and Petroleum Resources*, Paper 1997-2, pages 205–218.

Dunn, C.E. and Hastings, N.L. (1998a): Biogeochemical survey of the Ootsa-Francois Lakes area using outer bark of lodgepole pine (NTS 93F 13/14 and part of 12, north-central British Columbia): base metals and pathfinder elements; *Geological Survey of Canada*, Open File 3587a (1 sheet of coloured maps).

Dunn, C.E. and Hastings, N.L. (1998b): Biogeochemical survey of the Ootsa-Francois Lakes area using outer bark of lodgepole pine (NTS 93F 13/14 and part of 12, north-central British Columbia): mafic suite of elements with thorium and lanthanum; *Geological Survey of Canada*, Open File 3587b (1 sheet of coloured maps).

Dunn, C.E., and Hastings, N.L. (1998c): Biogeochemical survey of the Ootsa-Francois Lakes area using outer bark of lodgepole pine (NTS 93F 13/14 and part of 12, north-central British Columbia): alkali metals, alkaline earths, manganese and aluminum; *Geological Survey of Canada*, Open File 3587c (1 sheet of coloured maps).

Dunn, C.E. and Hastings, N.L. (1998d): Biogeochemical survey of the Ootsa-Francois Lakes area using outer bark of lodgepole pine (NTS 93F 13/14 and part of 12, north-central British Columbia): digital data listings and summary notes; *Geological Survey of Canada*, Open File 3587d.

Dunn, C.E. and Hastings, N.L. (2000a): Biogeochemical survey of the Nechako River area using outer bark of lodgepole pine (NTS 93F/15, 16 and parts of 9 and 10): base metals, silver and pathfinder elements; *Geological Survey of Canada*, Open File 3594a (1 sheet of coloured maps).

Dunn, C.E. and Hastings, N.L. (2000b): Biogeochemical survey of the Nechako River area using outer bark of lodgepole pine (NTS 93F/15, 16 and parts of 9 and 10): mafic suite of elements with thorium and lanthanum; *Geological Survey of Canada*, Open File 3594b (1 sheet of coloured maps).

Dunn, C.E. and Hastings, N.L. (2000c): Biogeochemical survey of the Nechako River area using outer bark of lodgepole pine (NTS 93F/15, 16 and parts of 9 and 10): alkali metals, alkaline earths, manganese and aluminum; *Geological Survey of Canada*, Open File 3594c (1 sheet of coloured maps).

Dunn, C.E. and Hastings, N.L. (2000d): Biogeochemical survey of the Nechako River area using outer bark of lodgepole pine (NTS 93F/15, 16 and parts of 9 and 10): digital data listings and summary notes; *Geological Survey of Canada*, Open File 3594d.

Friske, P.W.B. (1991): The application of lake sediment geochemistry in mineral exploration; *in* Exploration Geochemistry Workshop; *Geological Survey of Canada*, Open File 2390, pages 4.1–4.20.

Holland, S.S. (1976): Landforms of British Columbia — a physiographic outline; *BC Ministry of Energy, Mines and Petroleum Resources*, Bulletin 48.

Levson, V.M. and Giles, T.R. (1997): Quaternary geology and till geochemistry studies in the Nechako and Fraser Plateaus, central British Columbia (NTS 93C/1, 8, 9, 10; F/2, 3, 7; L/16; M/1); *in* Interior Plateau Geoscience Project: Summary Of Geological, Geochemical And Geophysical Studies, Diakow, L.J. and Newell, J.M., Editors, *Geological Survey of Canada*, Open File 3448 and *BC Ministry of Energy, Mines and Petroleum Resources*, Paper 1997-2, pages 121–147.

Levson, V.M., Giles, T.R., Cook, S.J. and Jackaman, W. (1994): Till geochemistry of the Fawnie Creek area (93F/03); *BC Ministry of Energy, Mines and Petroleum Resources*, Open File 1994-18.

Levson, V.M., Mate, D., Stumpf, A.J. and Stewart, A. (2001): Till geochemistry of the Tetachuck Lake and Marilla map areas (NTS 93 F/5 and F/12); *BC Ministry of Energy, Mines and Petroleum Resources*, Open File 2001-15.

MINFILE (2005): MINFILE BC mineral deposits database; *BC Ministry of Energy, Mines and Petroleum Resources*, URL <http://www.em.gov.bc.ca/Mining/Geolsurv/Minfile/> [Nov 2005].

Struik, L.C., MacIntyre, D. and Hastings, N.L. (2001): Nechako NATMAP Project, geochemistry data CD-ROM; *Geological Survey of Canada*, Open File 4356 and *BC Ministry of Energy, Mines and Petroleum Resources*, Paper 2001-9.

Weary G.F., Levson, V.M. and Broster, B.E. (1997): Till geochemistry of the Chedakuz Creek map area (93F/7), British Columbia; *BC Ministry of Energy, Mines and Petroleum Resources*, Open File 1997-11.