REGIONAL LAKE SEDIMENT AND WATER GEOCHEMISTRY SURVEYS IN THE NORTHERN INTERIOR PLATEAU, B.C. (93F/2,3,6,11,12,13,14)

By Stephen J. Cook and Wayne Jackaman

KEYWORDS: Applied geochemistry, lake sediments, lake waters, Nechako Plateau.

INTRODUCTION

The Interior Plateau Project is a multidisciplinary investigation of bedrock geology, glacial history, and till and lake sediment geochemistry of parts of the Nechako and Fraser plateaus in the Northern Interior. Matysek and van der Heyden (1994, this volume) provide an overview of the project. Mineral exploration of this area has been limited by extensive drift cover, poor exposure and a young volcanic cover. As well, geological information is either nonexistent or obsolete.

Two regional lake sediment and water geochemistry surveys (Figure 1) were carried out by the Geological Survey Branch in the Nechako Plateau area during 1993, as a component of the Interior Plateau Project. The Fawnie survey covers 1:50000 NTS map areas 93F/2 (Tsacha Lake) and 93F/3 (Fawnie Creek), where exploration has been centred on precious metal prospects such as the Wolf (MINFILE 093F 045) and Blackwater-Davidson (MINFILE 093F 037) occurrences. The second, or Ootsa survey is centred on the Eocene volcanic basin south of Burns Lake and covers parts of NTS map areas 93F/6 (Natalkuz Lake), 93F/11 (Cheslatta Lake), 93F/12 (Marilla), 93F/13 (Takysie Lake) and 93F/14 (Knapp Lake). A total of 460 sites were sampled over a combined area of approximately 3530 square kilometres at an average density of 1 site per 7.7 square kilometres (Table 1). The survey areas were selected on the basis of their mineral potential. Concurrent bedrock and surficial geology mapping (Diakow and Webster, 1994; Giles and Levson, 1994) and mineral deposit studies (Schroeter and Lane, 1994, all this volume) were conducted in the western part of the Fawnie survey area. The Eocene volcanic basin offers a favourable but relatively unexplored environment for epithermal precious metal deposits.

The subdued topography, poor drainage and abundance of lakes in the Nechako Plateau make lake sediments an ideal geochemical exploration medium, and Earle (1993) has demonstrated the usefulness of lake sediment geochemistry in the area. Many regional surveys have been conducted, including those of mineral exploration companies, Spilsbury and Fletcher (1974), Hoffman (1976) and Gintautas (1984). They are an effective tool to delineate both regional geochemical patterns and anomalous metal concentrations related to mineral occurrences. For example, sediment geochemistry reflects the presence of a bulk silver prospect near Capoose Lake (Hoffman, 1976; Hoffman and Fletcher, 1981) and and porphyry copper-molybdenum mineralization near Chutanli Lake (Mehrtens, 1975; Mehrtens *et al.*, 1973), and has been successful in locating gold-silver mineralization at the Wolf occurrence (Andrew, 1988). Orientation studies conducted by the senior author in 1992 (Cook, 1993a,b) near the Wolf, Clisbako and Holy Cross epithermal precious metal occurrences have shown that elevated concentrations of gold (max: 56 ppb, 16 ppb and 9 ppb, respectively), arsenic and other elements occur in adjacent lake sediments (Cook, 1994).

This report provides only a general overview of the regional lake sediment surveys, the first such publicly funded surveys to be undertaken in British Columbia since the 1986 surveys of NTS map areas 93E (Whitesail Lake) and 93L (Smithers) (Johnson *et al.* 1987a,b) Results and interpretation, including data booklet, maps and floppy diskette, will be released in 1994.

DESCRIPTION OF THE STUDY AREAS

LOCATION AND ACCESS

The Fawnie survey area covers about 1880 square kilometres and is located approximately 90 kilometres south of Highway 16 and the town of Fraser Lake. There is only limited road access into the field area. The Kluskus-Ootsa and Kluskus-Malaput Forest Service roads provide access to much of the northern part of 93F/3 from Vanderhoof and Fraser Lake, while the Blue Road extends into the easternmost part of the survey area in 93F/2. Two of the major mineral occurrences, the Wolf and Blackwater-Davidson prospects, are road accessible. The Alexander Mackenzie trail crosses the southeast part of the survey area along the Blackwater River.

The Ootsa survey area lies north of the Fawnie area and covers about 1650 square kilometres south of Burns Lake. The irregular shaped area is bounded by Ootsa and Natalkuz lakes of the Nechako Reservoir in the south, and extends northwest to the Uncha Lake area. The northern boundary is about 25 kilometres south of Burns

Lake. There is considerably more logging activity in the Ootsa area than in the more remote Fawnie area, and hence better road access. The Kluskus-Natalkuz ('500' road), Marilla and Holy Cross-Binta Forest Service roads cross the survey area and provide access from Vanderhoof, Fraser Lake and Burns Lake.

BEDROCK GEOLOGY AND MINERAL DEPOSITS

The survey areas lie within the Stikinia Terrane. Bedrock geology of the Fawnie survey area has been mapped by Tipper (1963) and, in part, by Diakow and Webster (1994, this volume). Most of the area is underlain by volcanic and sedimentary rocks of the Lower to Middle Jurassic Hazelton Group. These are intruded by Cretaceous granitic rocks of the Capoose batholith and overlain by Eocene volcanics of the Ootsa Lake Group, Oligocene and Miocene volcanics of the Endako Group and Miocene-Pliocene basalt flows. In contrast, the Ootsa survey area covers most of the northwest-trending belt of Ootsa Lake Group felsic volcanic rocks mapped by Tipper (1963) on the north side of the Nechako Reservoir. This unit, comprising a differentiated succession of Eocene andesitic to rhyolitic flows and pyroclastic rocks, underlies about 65 to 70% of the area. Other rock units, particularly Endako Group volcanics, are less extensively exposed.

The metallogeny and mineral deposits of the Fawnie area are outlined by Schroeter and Lane (1994, this volume). Epithermal precious metal deposits in Ootsa Lake volcanics and transitional precious metal deposits associated with the Capoose batholith are the most promising exploration targets. Interest in the potential for epithermal and related deposits has increased in recent years, and both the Wolf and Blackwater-Davidson prospects occur within the Fawnie survey area. The Wolf prospect is a low sulphidation adularia-sericite epithermal gold-silver occurrence (Schroeter and Lane, 1994, this volume), currently under exploration by Metall Mining Corporation, and is hosted by felsic flows, tuffs and subvolcanic porphyries. Mineralization occurs as

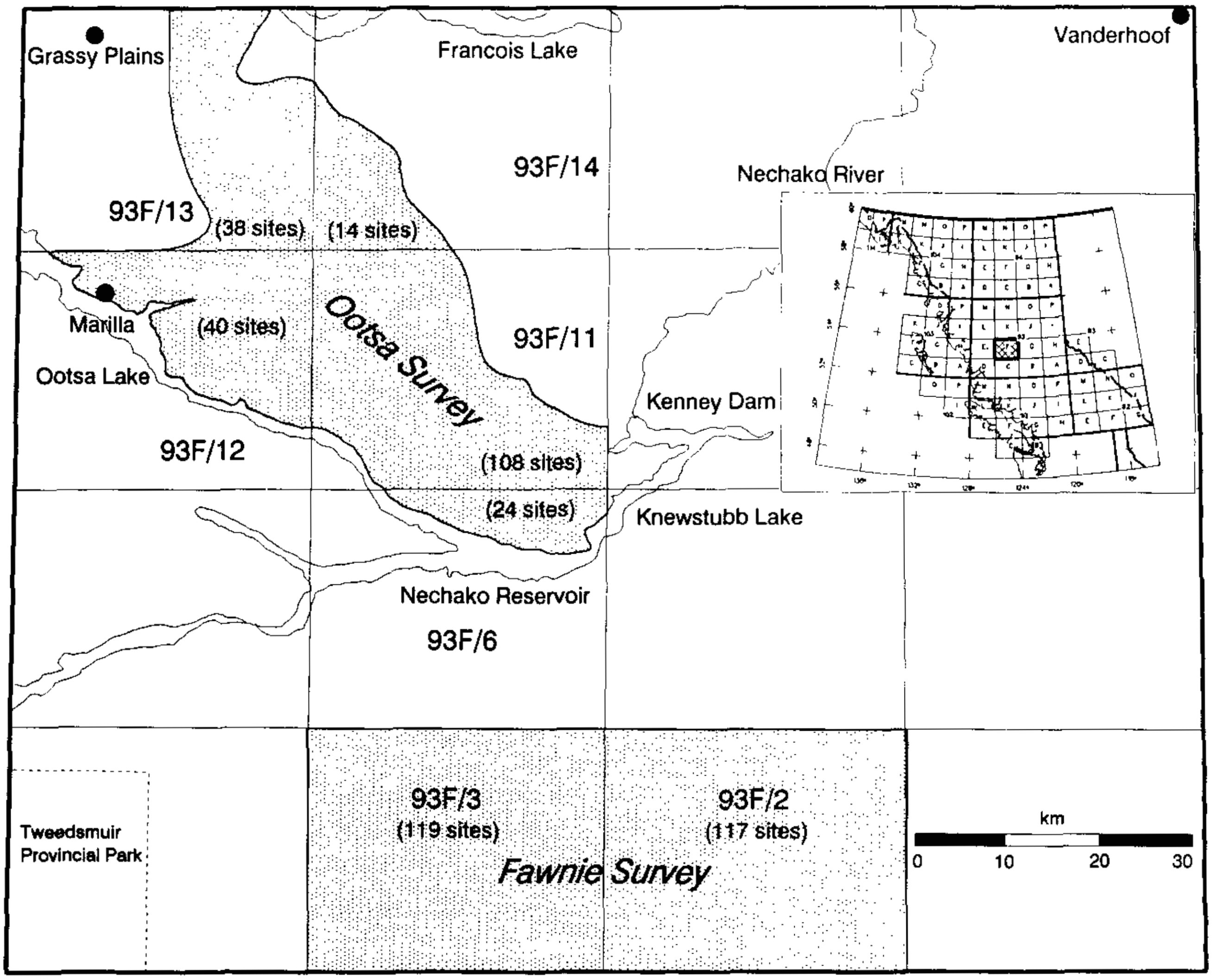

Figure 1. Locations of 1993 Interior Plateau lake sediment surveys in NTS map area 93F (Nechako River), showing the number of sites in each 1:50,000 NTS map area.

quartz-carbonate veins, silicified stockworks and hydrothermal breccia zones. Anomalous silver, zinc, arsenic and molybdenum concentrations in sediment of a nearby lake led to the discovery of the prospect (Dawson, 1988). The Blackwater-Davidson prospect is a structurally controlled transitional gold-silver-zinc-lead-copper occurrence (Schroeter and Lane, 1994, this volume). There is little information available on the metallogeny of the Ootsa survey area, and there are no precious metal occurrences within this area currently recorded in MINFILE. However, exploration for epithermal deposits is in progress in the region (Cogema Ltd.).

PHYSIOGRAPHY AND SURFICIAL GEOLOGY

The surficial geology and glacial history of the Fawnie area have been documented by Giles and Levson (1994, this volume). Much of the region is drift covered although some areas, particularly the Naglico Hills in 93F/3, have considerable outcrop. Most of the survey area lies within the Nechako Plateau, although a small area southeast of Tsacha Lake and the Blackwater River falls within the Fraser Plateau (Holland, 1976). Topography is dominated by the subparallel ridges of the Fawnie and Nechako ranges, with Mount Davidson (elev: 1852 m) and Kuyakuz Mountain (elev: 1781 m) forming maximum elevations, respectively. The Entiako Spur and Naglico Hills are also prominent topographic highs. A wide variety of physiographic regimes, ranging from rocky subalpine peaks to boggy lowlands along the Blackwater River and Fawnie Creek, occur throughout the area. Active first-order streams are relatively uncommon. Lakes are not uniformly distributed; they are numerous in parts of the Naglico Hills, but absent in large expanses of the Fawnie Range and Entiako Spur. The area within the Fraser Plateau is predominatly flat lying and characterized by abundant bogs but few lakes.

The Ootsa survey area lies wholly within the Nechako Plateau and, like the Fawnie area, has extensive drift cover. It is less mountainous than the Fawnie area, with most of the plateau surface at an elevation of 900 to 1100 metres. The Devils Thumb (elev: 1287 m) forms a prominent topographic high. The Ootsa area has a more rugged and hummocky topography; lakes are more evenly distributed across the landscape, and there are fewer small ponds and lowlands.

SURVEY METHODOLOGY

SAMPLE COLLECTION

Helicopter-supported sample collection in the Fawnie survey area was carried out during the period June 15-18, 1993, while collection in the Ootsa area was carried out in the period September 17-19. A sediment sample and a water sample were systematically collected at each site. A total of 251 sediment and water samples were collected from 236 sites in the Fawnie area, and 238 sediment and water samples were collected from 224 sites in the Ootsa area (Table 1). Average site density was approximately 1 per 8.0 square kilometres in the Fawnie area *versus* 7.4 square kilometres in the Ootsa area. Helicopter sampling rates averaged 10.5 sites per hour in the Fawnie survey and 12 sites per hour in the Ootsa survey.

TABLE 1. SUMMARY OF 1993 INTERIOR PLATEAU LAKE SEDIMENT SURVEYS. SAMPLING DENSITY IS IN SITES PER SQUARE KILOMETRE.

Survey	*NTS*	*Area* (square km)	*Sampling Density*	*Sites*	*Samples*
Fawnie	93F/2,3	1880	8	236	251
Ootsa	93F/6,11,12,13,14 (parts thereof)	1650	7.4	224	238
Totals		3530	7.7	460	489

SEDIMENTS

Sediments were sampled from a float-equipped Bell 206 helicopter using a Hornbrook-type torpedo sampler, and placed in Kraft paper bags. Standard National Geochemical Reconnaissance (NGR) sampling procedures, as discussed by Friske (1991) were used. On the basis of results of 1992 orientation studies in the region (Cook, 1993a,b), the surveys incorporate some departures from standard lake sediment sampling strategies used elsewhere in Canada for the NGR program, particularly pertaining to overall site density and the number of sites sampled per lake

First, every lake and pond in the survey area was sampled, rather than sampling only a selection of lakes at a fixed density (*ie.* 1 site per 13 km^2). Sediment in even small ponds may contain anomalous metal concentrations revealing the presence of nearby mineralization such as that at the Wolf prospect (Cook, 1994). In practice, some small ponds were not sampled due to unfavourable landing conditions. Samples were also not collected from the centres of very large and deep lakes (*ie.* > 10 km^2, or more than 40 m deep) such as Tsacha, Uncha, Binta and Lucas lakes, nor from reservoir areas such as Ootsa or Cheslatta lakes which have been altered by the creation of the Nechako Reservoir. Organic soils from swamps and bogs were also avoided.

Secondly, centre-lake sediment samples were collected as per standard NGR procedure, but sediment from the centres of all major known or inferred sub-basins was also collected to investigate the considerable trace element variations which may exist among sub-basins of the same lake. The extent of these variations is illustrated by the molybdenum distribution in sediments of Tatin Lake (Figure 2), a large (4-5 km long) lake situated about 6 kilometres north of Endako, adjacent to the Ken porphyry molybdenum-copper occurrence (MINFILE 093K 002). This lake was sampled during 1992 orientation studies (Cook, 1993a). Molybdenum concentrations in centre-basin sediments vary from 7 ppm in the centre of the lake, to 12 ppm and 23 ppm in the western and eastern sub-basins, respectively. These variations may be controlled at least partly by limnological differences among the sub-basins. Consequently, up to five sites were sampled from some of the larger lakes in the Fawnie and Ootsa surveys. Lake bathymetry maps in unpublished reports of the Fisheries Branch, Ministry of Environment, Lands and Parks, were consulted prior to sampling several of the larger lakes such as Kuyakuz, Moose and Johnny lakes to aid in site location and to avoid wasting helicopter time over extremely deep basins.

WATERS

Water samples were collected in 250-millilitre polyethylene bottles using a custom-designed sampling apparatus. Waters were sampled from approximately 15 centimetres below the lake surface to avoid collection of surface scum, and precautions were taken to minimize suspended solids. The purpose of the water sampling differed between the two survey areas. Waters from the Ootsa area were collected for standard RGS analysis (pH, U, F, SO_4), but those from the Fawnie area were collected as a pilot study of regional trace element concentrations in lake waters. Consequently, all Fawnie survey water bottles were rinsed three times with distilled water at the Analytical Sciences Laboratory, Victoria, prior to use, and transported to the field in sealed plastic bags to ensure a high level of cleanliness. Analytical tests conducted on acidified and unacidified distilled water blanks, prior to field work, showed no measurable contamination of the waters by the containing bottles.

FIELD OBSERVATIONS

A variety of field observations were recorded at each site using Geological Survey of Canada lake sediment cards (Garrett, 1974). These included observations pertaining to the sample itself, including depth, colour, composition and odour, as well as those regarding the lake and immediate area, including lake size, general topography and potential sources of contamination. The absence or presence of suspended solids in water samples was also noted. Lake names used on either NTS topographic maps or the Vanderhoof Forest District map were included where applicable.

SAMPLE PREPARATION AND ANALYSIS

SEDIMENTS

Sediment samples were initially field dried and, when sufficiently dry to transport, shipped to Bondar-Clegg and Company, North Vancouver (Fawnie survey),

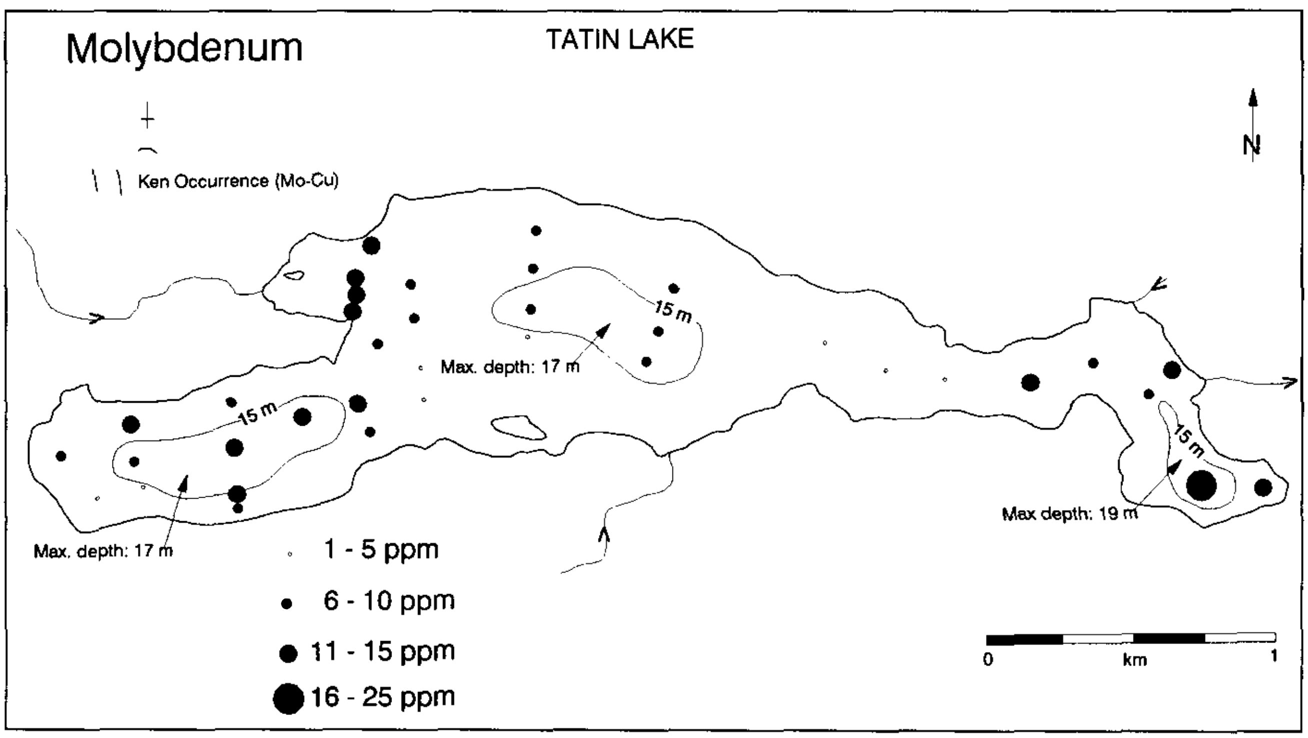

Figure 2. Molybdenum (ppm) distribution in sediments of Tatin Lake (93K/03), north of the village of Endako, showing variations in metal content between various sub-basins (15 metre contour). Bathymetry modified after Walsh (1977).

and Rossbacher Laboratory Ltd., Burnaby (Ootsa survey) for final drying at 40°C. The sample preparation procedure will comprise two steps. First, the sample will be disaggregated inside a plastic bag with a rubber mallet. The entire sample, to a maximum of 250 grams, will then be pulverized to approximately -150 mesh (~100 microns) in a ceramic ring mill, and two analytical splits (10 g and 30 g) taken from the pulverized material.

One split of each prepared sediment sample will be submitted to a commercial laboratory and analyzed for zinc, copper, lead, silver, molybdenum, cobalt, arsenic, antimony, mercury, iron, manganese, nickel, bismuth, cadmium, fluorine and vanadium using atomic absorption spectroscopy (AAS). Loss on ignition will also be determined. A second 30 gram split will be analyzed for gold, arsenic, antimony and 30 additional elements using instrumental neutron activation analysis (INAA) at a second commercial laboratory. Details of digestion and analytical procedures for individual elements will be given in the Open File data releases.

WATERS

Water samples from the Fawnie area were kept cool in a refrigerator and filtered to 0.45 microns at the Analytical Sciences Laboratory, Victoria. Samples will be analyzed at a commercial laboratory for a range of elements, including copper, zinc, molybdenum and arsenic, as well as for pH and SO_4. No special preparation procedures were applied to Ootsa area waters, which will be analyzed for the standard RGS water suite (pH, U, F, SO_4) at a second commercial laboratory.

Acidity was also determined on all samples in the Analytical Sciences Laboratory using a Corning model Checkmate 90 pH meter. A pH frequency distribution for the Ootsa area is shown in Figure 3. Lake waters are predominately of near-neutral pH, with a median value of

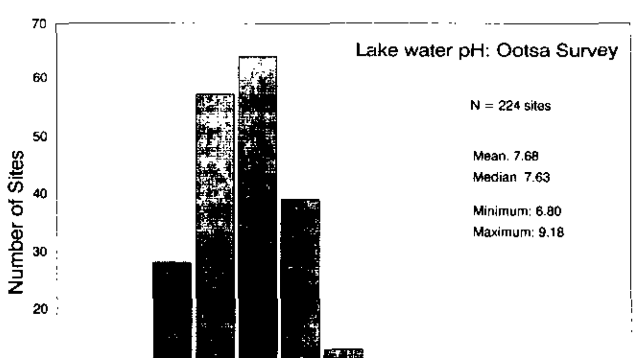

Figure 3. Frequency distribution of pH values in Ootsa survey lake waters.

7.63 (Range: 6.80 to 9.18). Nevertheless slightly alkaline pH values of 8.00 or greater occur at 27 sites, with pH values of 8.40 or greater at 12 of these. The highest pH (9.18) occurs in a small lake east of Yellow Moose Lake (93F/6) in the southernmost part of the survey area, while the largest grouping of slightly alkaline lake waters is near Marilla in the western part of the area (Figure 1).

QUALITY CONTROL PROCEDURES

Each block of twenty sediment samples contains seventeen routine samples, one field duplicate sample, one blind duplicate sample and one control standard in accordance with standard Regional Geochemical Survey (RGS) quality control procedures. Field duplicate sites are chosen randomly during fieldwork. Blind, or analytical, duplicate samples are taken from the field duplicate in each block following sample preparation, and reinserted into the suite to monitor analytical precision. Blind duplicates are not used in the water suite; a distilled water blank is inserted to monitor analytical contamination.

SUMMARY

Two lake sediment surveys (460 sites) were conducted in map area 93F in the northern Interior, with Open File data release scheduled for 1994. Additional surveys of adjoining areas are planned for next year, with the eventual objective of completing Regional Geochemical Survey coverage of NTS map areas 93C (Anahim Lake), 93F (Nechako River) and 93K (Fort Fraser). Regional geochemical surveys are only one component of ongoing applied geochemical research in the northern Interior. The development of new or improved geochemical exploration methods applicable to the region is also an important objective of the Interior Plateau project. Consequently, it is anticipated that previous lake sediment orientation studies (Cook, 1993a; 1994) will be complemented in 1994 by formulation of follow-up guidelines for lake sediment anomalies, and by additional research into the relative effectiveness of other geochemical sampling media in the region.

ACKNOWLEDGMENTS

The authors thank R.E. Lett of the Analytical Sciences Laboratory for his helpful assistance, and P.F. Matysek for his support of the project and comments on the manuscript. Special thanks are extended to M. King of White Saddle Air Services, Takla Lake, and J. Meier, Northern Mountain Helicopters, Vanderhoof, for their skillful flying. P.W. Friske of the Geological Survey of Canada, Ottawa, loaned sampling gear. B. Bhagwanani, Analytical Sciences Laboratory, filtered the lake water samples and did the pH determinations.

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