BRITISH COLUMBIA
Ministry of Employment and Investment
Energy and Minerals Division
Geological Survey Branch

REGIONAL LAKE SEDIMENT AND WATER GEOCHEMISTRY OF THE NORTHERN KECHIKA TROUGH, BRITISH COLUMBIA (NTS 94M/2, 3, 4, 5, 6, 12; 104P/8, 9, 10, 15, 16)

By Stephen J. Cook, Wayne Jackaman,
Peter W. Friske, Stephen J. Day, Anna M. Coneys
and Filippo Ferri

GSC OPEN FILE 3499

OPEN FILE 1997-15

Canadian Cataloguing in Publication Data
Main entry under title:
Regional lake sediment and water geochemistry of the northern Kechika Trough, British Columbia (NTS 94M/2, 3, 4, 5, 6, 12; 104P/8, 9, 10, 15, 16)

(BCMEI open file, 0835-3530 ; 1997-15) (GSC open file ; 3499)

Issued by Geological Survey Branch and Geological Survey of Canada.
Includes bibliographical references: p.
ISBN 0-7726-3296-0

1. Water - Composition - British Columbia - Kechika River Region. 2. Sediments (Geology) - British Columbia - Kechika River Region. 3. Geochemistry - British Columbia - Kechika River Region. 4. Geology, Economic - British Columbia - Kechika River Region. I. Cook, S. J. (Stephen John). II. British Columbia. Ministry of Employment and Investment. III. British Columbia. Geological Survey Branch. IV. Geological Survey of Canada. V. Series: Open file (British Columbia. Geological Survey Branch) ; 1997-15. VI. Series: Open file (Geological Survey of Canada) ; 3499.

QE515.R43 1997 551.9'09711'85 C97-960189-4

VICTORIA
BRITISH COLUMBIA
CANADA
AUGUST 1997

ABSTRACT

Results of a regional lake sediment and water geochemistry survey conducted in the northern Kechika Trough in 1996 highlight several new exploration targets in northern British Columbia. The North Gataga survey (NTS 94M/2, 3, 4, 5, 6, 12; 104P/8, 9, 10, 15, 16) covers a frontier area of perceived high mineral potential where exploration has previously been limited by extensive drift cover, poor exposure and an insufficient geological database.

Lake sediments and waters were collected from 445 sites in the survey area at an average density of approximately one site per 11.2 square kilometres. On the basis of results from prior orientation studies in other parts of central B.C., sediment samples were collected from every lake and every sub-basin. These were analyzed for 16 elements by atomic absorption spectroscopy (AAS), and for 29 elements by instrumental neutron activation analysis (INAA). Standard Regional Geochemical Survey (RGS) sampling, analytical and quality control procedures were used. Preliminary discussion of results for several elements including zinc, lead and barium indicate that the survey confirms the locations of currently known prospects and outlines new areas for prospective Sedex-style zinc-lead-barium deposits.

TABLE OF CONTENTS

INTRODUCTION

Open File 1997-15 presents new analytical data for 44 different elements from a regional lake sediment and water geochemistry survey (Figure 1) conducted by the British Columbia Geological Survey Branch and the Geological Survey of Canada in the northern Kechika Trough during 1996. The North Gataga Survey covers all or part of eleven 1:50,000 NTS map areas in the Rabbit River (NTS 94M) and McDame (NTS 104P) areas of northern B.C.: 94M/2 (*unnamed*), 94M/3 (Scoop Lake), 94M/4 (Turnagain River), 94M/5 (Aeroplane Lake), 94M/6 (Gemini Lakes), 94M/12 (Tatisno Mountain), 104P/8 (Badwood River), 104P/9 (Mustela Creek), 104P/10 (*unnamed*), 104P/15 (Lutz Creek) and 104P/16 (Lower Post). Past exploration in this region has centred primarily on sedimentary exhalative lead-zinc-barium targets, and on skarn porphyry targets such as the Boya prospect (MINFILE 94M 016/021). A total of 445 sites were sampled over an area of approximately 5000 square kilometres at an average density of 1 site per 11.2 square kilometres (Table 1). Data for base metals, gold, precious metal pathfinders and rare earth elements are provided here, and several new exploration targets are highlighted. Data for seventeen stream sediment samples collected by bedrock mappers during the course of field work are also included. This report updates and supersedes Open File 1997-14 'Preliminary Regional Lake Sediment Geochemistry of the Northern Kechika Trough' (Cook *et al.*, 1997a), released at the Cordilleran Round-Up in Vancouver in January, 1997.

The subdued topography, poor drainage and abundance of lakes in the northern Kechika Trough make lake sediments an ideal geochemical exploration sample medium. Lake sediment surveys are an effective tool to delineate regional geochemical patterns and anomalous metal concentrations related to mineral occurrences. Most examples of the successful application of lake sediment geochemistry to Cordilleran mineral exploration come from the Nechako Plateau in central B.C. For example, epithermal precious metal prospects such as the Tsacha (Cook *et al.*, 1995) and Wolf prospects in the Nechako Plateau (Dawson, 1988) and, further to the north, porphyry molybdenum mineralization at the Mac deposit (Cope and Spence, 1995) were discovered following up lake sediment geochemical surveys.

The North Gataga Project is a multidisciplinary investigation of bedrock geology, glacial history, and lake sediment geochemistry of the northern Kechika Trough. Mineral exploration of this area has been limited by extensive drift cover, poor exposure and, until the recent detailed bedrock mapping of Ferri *et al.* (1995a,b; 1996a,b; 1997a,b), a low-resolution geological database of a regional nature. The North Gataga survey area follows the northward extension of Devonian-Mississippian Earn Group rocks exposed within the southern Kechika Trough. The Earn Group contains the greatest potential in this belt for hosting sedimentary-exhalative (sedex) zinc-lead-barite deposits, the primary exploration target in the area. New baseline geochemical data should prove useful in stimulating new exploration for these and other mineral deposit types.

Open File 1997-15 is the first release of British Columbia regional lake sediment survey data outside of the Nechako Plateau area of central B.C. Sample collection, preparation and analytical procedures conform to established standards of the National Geochemical Reconnaissance (NGR) and Regional Geochemical Survey (RGS) programs. Details are given here, and in previous lake sediment geochemical reports such as Cook and Jackaman (1994) and Cook *et al.* (1997b). Results will be incorporated at a later date into ongoing regional lake sediment surveys as part of the RGS program. Analytical results and field observations compiled by the RGS program in British Columbia are used in the development of a high-quality geochemical database suitable for mineral exploration, resource assessment, geological mapping and environmental studies.

OPEN FILE FORMAT

Open File 1997-15 is divided into the following sections:

- Introduction, survey methodology and quality control
- Preliminary data interpretation and discussion
- Listings of field variables and analytical data (Appendix A)
- Listings of analytical duplicate data (Appendix B)
- Summary statistics (Appendix C)
- Element distribution, geology and sample location maps (Appendix D)
- Stream sediment analytical data (Appendix E)

Analytical and field data are included as an ASCII file on a 3.5-inch high density diskette. Data for each sample are listed in comma-delimited fields over one data record. Document files detailing format specifications and survey details are also included. The diskette is located in the back pocket, together with a 1:100,000-scale sample location map.

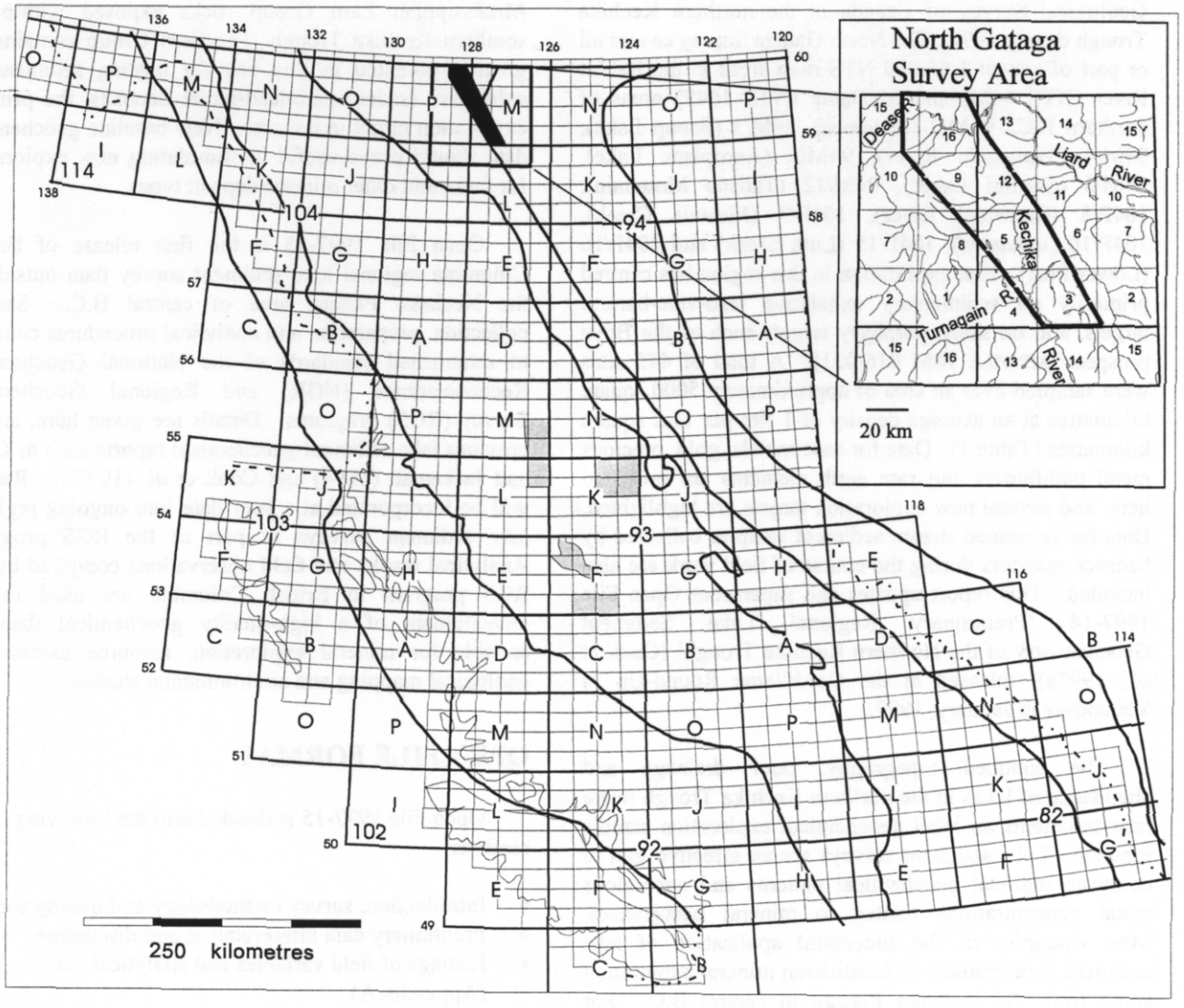


Figure 1. Location of the North Gataga lake sediment survey area in the Rabbit River (NTS 94M) and McDame (NTS 104P) map areas of the northern Kechika Trough, British Columbia. Areas of prior lake sediment surveys (1993-1996) in the Nechako Plateau area are also shown (shaded areas). More detailed location maps of the North Gataga survey area showing bedrock geology, physiographic features and MINFILE occurrences are given in Appendix D.

DESCRIPTION OF THE SURVEY AREA

LOCATION AND ACCESS

The North Gataga survey area (parts of NTS map areas 94M/2, 3, 4, 5, 6, 12; 104P/8, 9, 10, 15, 16) covers an area of about 5000 square kilometres. It comprises an northwest-southeast trending strip, approximately 150 km long and 30 km wide, between 59° and 60° north latitude located immediately south of the B.C. - Yukon border in north-central British Columbia. The town of Watson Lake, YT is located just north of the survey area. The Alaska Highway crosses the northern part of the survey area near the northern B.C. community of Lower Post, but most of the survey area is accessible only by air.

PHYSIOGRAPHY AND SURFICIAL GEOLOGY

The North Gataga survey area is located at the northern terminus of the Rocky Mountains, where the rugged Muskwa Ranges descend in elevation to the low-lying Liard Plain of the northern Plateau. The survey area is bounded in the north by the British Columbia-Yukon border, and in the southwest by the Rocky Mountain Trench and the Cassiar Mountains (Kechika Ranges). The Trench disappears into the Liard Plain in the northern part of the map area. Scoop Lake, Horneline Creek and the Rabbit River mark the approximate south and southeastern boundaries. Refer to Appendix D-4 for further physiographic information for the survey area.

The southern third of the survey area lies within the bounds of the Rabbit Plateau, the hilly northernmost subdivision of the Muskwa Ranges, but much of the northwestern part of the area is within the Liard Plain (Holland, 1976). This relatively low-lying area of minimal relief generally lies between about 2000 to 2500 feet (610 to 762 m) elevation within the survey area. In the north, topography is dominated by Tatisno Mountain (max. elevation: 4192 feet), situated along the northeastern border of the survey area. Topography in the more rugged Rabbit Plateau area to the south ranges from about 2500 to 5000 feet (762 to 1524 m) elevation. Most of the exposed bedrock in the survey area occurs in this region (Ferri *et al.*, 1997a,b), which is transitional between the Liard Plain and the higher peaks of the Muskwa Ranges. Chee Mountain (max. elevation: 1380 m) is a prominent ridge in this area, but unnamed peaks and ridges in the southernmost part of the survey area reach elevations of 5448 feet (1660 m) and 5020 feet (1530 m) in the vicinity of Horneline Lake.

The Liard River flows easterly through the northern part of the survey area. The Kechika River, a tributary of the Liard, meanders through much of the southern part of the survey area. A notable feature of the North Gataga survey area relative to prior surveys in the Nechako Plateau is the absence of very large lakes (>5 km^2). The area is heavily wooded, with dense second-growth forest predominant in old burns east of the Kechika River.

The surficial geology and glacial history of the survey area have been described by Gabrielse (1962, 1963), Mathews *et al.* (1975) and Thurber Consultants (1981). The area is extensively drift-covered, and bedrock exposures are scarce; Ferri *et al.* (1997a) estimated rock exposures to be limited to about 1 per cent of the project area. Till is the most widespread Quaternary deposit. Glacial movement was dominantly in an east to northeasterly direction through the northern part of the survey area, and drumlinized till plains are a common surficial feature. Deglaciation features such as eskers and kettles are common in the northern part of the survey area. Terraces are present in major valleys, many of which are deeply incised into the drift cover and underlying bedrock.

BEDROCK GEOLOGY

Bedrock geology of this part of the Rabbit River and McDame map areas was first mapped at 1:250,000 scale by Gabrielse (1962, 1963). The recent bedrock mapping area of Ferri *et al.* (1997b) coincides with the lake sediment survey area. It is the northernmost of the three bedrock mapping areas in the Gataga region recently mapped at a 1:50,000 scale by Ferri *et al.* (1997a,b; 1996a,b; 1995a,b), and is used as the geological base for this report (Appendix D-3).

The North Gataga lake sediment survey is a directed survey following a belt of rocks of perceived high mineral potential. The survey follows the northward extension of Devonian-Mississippian Earn Group rocks seen within the southern Kechika Trough. The Earn Group is the most significant unit in this belt for hosting sedimentary-exhalative (sedex) zinc-lead-barite deposits, the primary exploration target in the area. The following account of the regional geology of the Kechika Trough was taken from Ferri *et al.* (1997a).

The Kechika Trough is a long-lived early to middle Paleozoic sedimentary off-shelf basin (Figure 2)

containing numerous sedimentary exhalative barium-lead-zinc deposits of different ages. It is linked with the Selwyn Basin to the north, with which it shares a similar stratigraphy and tectonic history. The Trough is characterized by deep-water successions of dark fine-grained siliciclastics and chert. These, together with periodic extensional tectonism, were conducive to the periodic formation of sedimentary exhalative deposits.

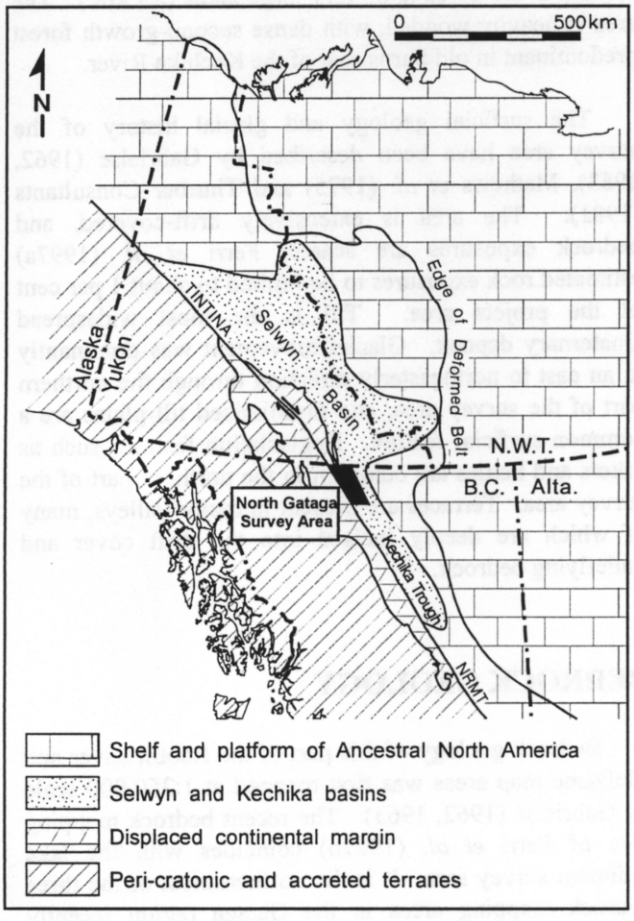


Figure 2. Simplified geological map of the northern Canadian Cordillera showing the shelf to off-shelf boundary during Ordovician to Silurian time, and location of the North Gataga survey area within the Kechika Trough (from Ferri *et al.*, 1997a; modified from Cecile and Norford, 1991). NRMT - Northern Rocky Mountain Trench.

Layered rocks of the survey area range in age from Proterozoic rocks of the Hyland Group to Tertiary-Quaternary basalts of the Tuya Formation. Some intrusive rocks are also present; the most noteworthy being several gabbroic bodies in the Gemini Lakes region. Most of the area, however, consists of a variety of Cambrian to Devonian-Mississippian siliciclastic and carbonate sedimentary units, such as the Upper Cambrian-Lower Ordovician Kechika Group, the Upper Ordovician-Middle Devonian Road River Group, and the Upper Devonian-Mississippian Earn Group. Ferri *et al.* (1997a) provide detailed descriptions of all sedimentary units within the survey area; pertinent points regarding a few units with potential to host sedex mineralization are summarized below:

- The Upper Ordovician-Middle Devonian *Road River Group* is widely exposed in the southern part of the survey area south of Chee Mountain. It comprises a lower sequence of black shale, siliceous shale, chert and minor limestone, and an upper sequence of dolomitic siltstone. Ferri *et al.* (1997a) state that the lower Road River Group closely resembles the Earn Group in lithology. Regionally, this lower sequence has the potential to host significant sedex mineralization.

- The Upper Devonian-Mississippian *Earn Group*, the most important sedex-hosting unit in the Kechika Trough, is exposed in the southern part of the survey area. The Earn Group comprises blue grey to dark grey or black argillite, cherty argillite, siltstone and slate. Exposures here are not as extensive as those mapped to the immediate south by Ferri *et al.* (1996a,b).

- The Lower or Middle Paleozoic *Kitza Creek facies* are characterized by dark grey to black carbonaceous siltstone to silty argillite and shaly slate. These rocks primarily occur in the Kitza Creek area together with dolomitic siltstone of the Road River Group, but contact and age relationships are uncertain. Lithologically, Kitza Creek facies rocks resemble parts of both the Road River and Earn Groups (Ferri *et al.*, 1997a).

MINERAL DEPOSITS

There are only a few known mineral deposits within the bounds of the North Gataga survey area (Appendices D-3 and D-4). They include: (i) sedimentary exhalative barite and lead-zinc-barite deposits, (ii) porphyry molybdenum/copper-tungsten skarn deposits and (iii) sulphide vein mineralization. Only a short commentary on these mineral localities is given here; more detailed descriptions are provided by Ferri *et al.* (1997a), MINFILE listings and relevant assessment reports.

Sedimentary exhalative (sedex) lead-zinc-barite deposits have long been the main focus of mineral exploration in the Kechika Trough and adjacent Selwyn Basin. Numerous such deposits of various ages have been discovered. These include the Driftpile Creek and Cirque (Stronsay) deposits of the Gataga District to the south, and the Tom and Jason deposits of the Macmillan

Pass district to the north, all of which are hosted by Devonian-Mississippian Earn Group strata. Sedex deposits of Cambro-Ordovician (Anvil District) and Silurian (Howard's Pass) ages are also found. MacIntyre (1992, 1991) provides overviews of the regional setting of these deposits. The main sedex mineral prospect within the bounds of the survey area is the Kechika River barite showing (no MINFILE), discovered during the 1996 bedrock mapping program. This stratiform barite-pyrite deposit, at least 4 m thick, is located within Earn Group rocks about 9 km northwest of the Gemini Lakes (Ferri *et al.*, 1997a).

The twin showings of the Boya prospect are located on Boya Hill, about 10 km southwest of Graveyard Lake. Tungsten-molybdenum skarn and porphyry mineralization occurs at the Main Face showing (MINFILE 94M 021), where quartz stockworks and veins within late Early Cretaceous quartz-biotite-feldspar porphyries and adjoining metasedimentary rocks host molybdenite and minor scheelite. Chalcopyrite, scheelite and molybdenite-bearing skarn occurs at the West Hill showing (MINFILE 94M 016).

Sulphide vein mineralization occurs in the Red River (Red-MINFILE 94M 020) and Kitza Creek (Kitza-MINFILE 94M 018) areas, and along the Liard River near Lower Post (Roman-MINFILE 104P 072). Both the Red and Kitza Creek showings, which were discovered in the early 1980's, are hosted at least in part by Kitza Creek facies rocks. Mineralization at the Red showing consists of sphalerite, galena, chalcopyrite and pyrite within quartz breccia zones and veins. At the Kitza occurrence, several dozen quartz-calcite veins contain tetrahedrite, sphalerite, barite and galena. The Kitza occurrence coincides with an extensive zone of anomalous zinc, cadmium, nickel and other elements in lake sediments, and is discussed further in a later section of this report. The Roman showing, comprising both vein and possible stratiform sulphide mineralization, is hosted by Earn Group rocks. The veins may represent a link to potential sedex mineralization. Rainsford (1984) suggested that the Roman veins may be part of a sedimentary exhalative feeder system, while Miller and Harrison (1981) suggested that the Kitza veins may be related to dewatering of the host rocks.

PREVIOUS GOVERNMENT GEOCHEMICAL SURVEYS IN THE REGION

The North Gataga survey area bridges the gap between two prior publicly-available regional geochemical surveys located to the north and south (Appendix D-4). To the south, the survey area is bounded by a Geological Survey Branch stream sediment and water geochemistry survey conducted in 1995 in the more rugged terrain of the Gataga Mountain area (Jackaman *et al.*, 1996). To the north, it is bounded in the Yukon by the Geological Survey of Canada regional lake sediment survey of the Watson Lake map area (NTS 105A; Friske *et al.*, 1994). Regional Geochemical Survey (RGS) stream sediment data for the McDame map area (NTS 104P) is also available for the northern portion of the survey area (NGR, 1979). Mineral exploration companies have also conducted lake sediment surveys in the area.

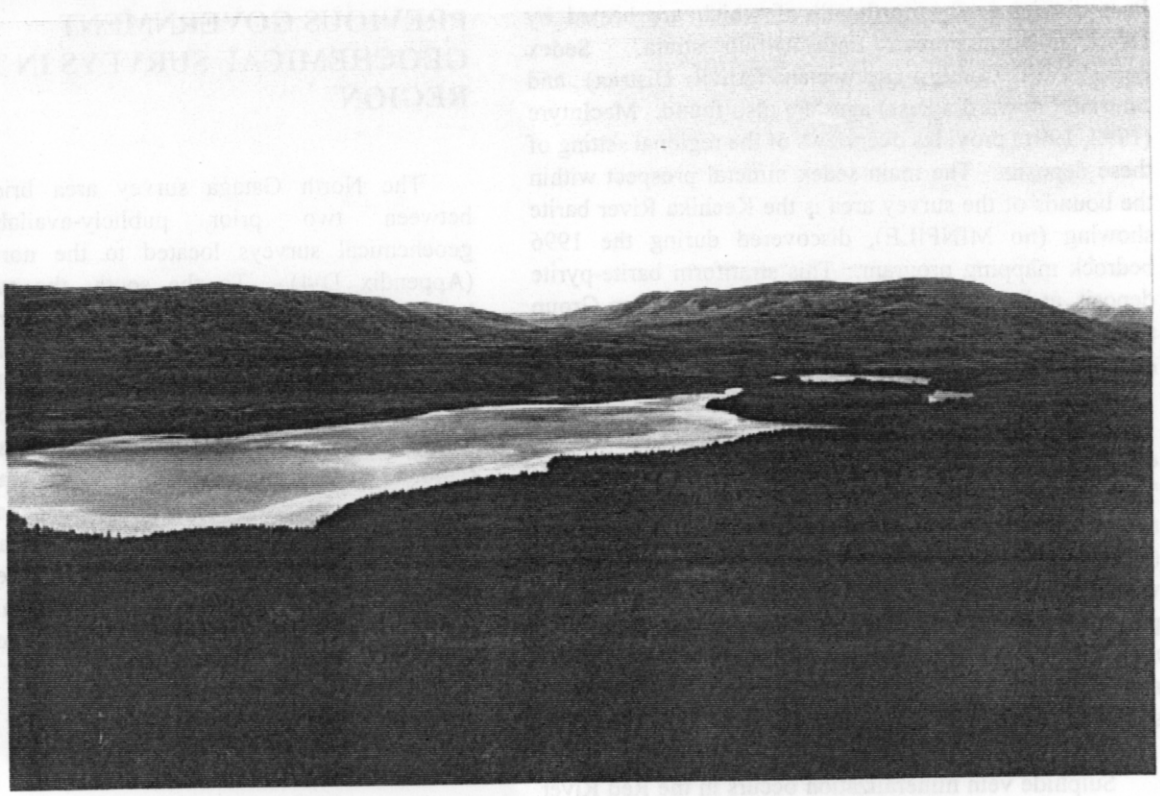


Photo 1. Graveyard Lake, looking south-southwest toward Chee Mountain (July, 1996).

Photo 2. Typical landscape in the more rugged southern portion of the North Gataga survey area: looking northeast toward Horneline Lake and Horneline Creek (July, 1996).

SURVEY METHODOLOGY

SAMPLE COLLECTION

Helicopter-supported sample collection in the North Gataga survey area was conducted by the authors during July 1996. A sediment sample and a water sample were systematically collected at each site using a float-equipped Bell 206 helicopter. A total of 471 sediment and water samples were collected from 445 sites (Table 1), at an average site density of approximately 1 per 11.2 square kilometres.

Survey	NTS	Area (square km)	Sampling Density	Sites	Samples
Fawnie	93F/2,3	1862.6	7.9	237	251
Ootsa	93F/6,11,12,13,14 (parts thereof)	1650	7.4	224	238
Pinchi Lake	93K/9,10,15,16	3584.2	8.7	413	438
Babine	93L/9,16; M/1,2,7,8	3406	10.3	332	352
North Gataga	parts of 94M, 104P	5000	11.2	445	471
Totals:		15502.8	9.4	1651	1750

Table 1. Summary of lake sediment geochemistry surveys conducted in the Kechika Trough and the Interior Plateau area of central British Columbia during the period 1993-1996. Sampling density is in sites per square kilometre.

SEDIMENTS

Sediments were collected using a Hornbrook-type torpedo sampler and samples placed in large (5" x 6") Kraft paper bags. On the basis of results of prior orientation studies (Cook, 1993a,b), regional surveys in British Columbia incorporate some departures from standard lake sediment sampling strategies used elsewhere in Canada for the National Geochemical Reconnaissance (NGR) program (Friske, 1991), particularly pertaining to overall site density and the number of sites sampled in each lake.

First, every lake in the survey area was sampled, rather than sampling only a selection of lakes at a fixed density (*ie.* one site per 13 km^2). Sediment in even small lakes and ponds may contain anomalous metal concentrations revealing the presence of nearby mineralization such as that at the Wolf and Tsacha prospects in the Nechako Plateau (Cook, 1995; Cook *et al.*, 1997b). In practice, some small ponds were not sampled due to unfavourable landing conditions. Samples are not generally collected from the centres of very large and deep lakes (> 10 km^2; > 40 m deep), although there are few such lakes in the North Gataga area. Organic soils from shallow swamps and bogs were also avoided.

Secondly, centre-lake sediment samples were collected following 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. Consequently, several sites were sampled in some of the larger lakes such as Moose Lake or Graveyard Lake. Lake bathymetry maps in unpublished reports of the Fisheries Branch, Ministry of Environment, Lands and Parks (Balkwill, 1991) are routinely consulted prior to sampling larger lakes in order to aid in site selection.

WATERS

Lake water samples were collected at each site in 250-millilitre high-density polyethylene (HDPE) Nalgene 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. These waters were collected for determination of the standard RGS analytical suite (pH, uranium, fluoride, sulphate). An additional 250-millilitre lake water sample was also collected at every second site for more extensive multi-element ICP-MS analysis of trace and major elements. This supplementary water data will be released at a later date.

FIELD OBSERVATIONS

A variety of field variables and observations pertaining to sample media, site and local terrain were

recorded at each site using Geological Survey of Canada lake sediment cards (Garrett, 1974). These included sample depth, colour and composition, as well as the general relief and potential sources of contamination. The absence or presence of suspended solids in water samples was also noted. Lake depth was measured with a depth sounder mounted to one of the helicopter floats.

Site locations were marked on 1:50,000 scale NTS topographic maps in the field, transferred to master basemaps, and later digitized at the British Columbia Geological Survey Branch to obtain Universal Transverse Mercator (UTM) site coordinates (NAD27). Variables such as site geology, which reflects the dominant geological unit of the lake catchment, and lake area were coded after sample collection. Site geology was taken from Ferri *et al.* (1997), and manually verified to ensure that lake watersheds corresponded to the coded geological unit. Common lake names used on NTS topographic maps were included where applicable. Element maps in Appendix D incorporate a NAD27 topographic base, but both NAD27 and NAD83 UTM site coordinates are included in the data listings in Appendix A.

SAMPLE PREPARATION

SEDIMENTS

Sediment samples were field dried and, when sufficiently dry to transport, shipped to Bondar-Clegg and Company, Ottawa, for final drying (max: 25-30°C) and sample preparation. Preparation was conducted under Geological Survey of Canada supervision. The entire sample, to a maximum of about 250 grams, was pulverized in a ceramic ring mill and screened to minus 80 mesh (< 177 microns). Two analytical splits (20-30 grams each) were taken from the pulverized material for subsequent analysis. Sample pulps were later archived.

WATERS

All lake water samples were kept cool following collection, and shipped to the Analytical Sciences Laboratory, Victoria, for insertion of control reference standards and distilled water blanks into the sample suite. No further preparation procedures were performed on routine raw lake water samples prior to analysis.

Samples collected for the expanded ICP-MS lake water geochemistry survey were filtered to 0.45 microns by the authors using Millipore type HA filters (47 mm) and a Nalgene filtration apparatus with hand pump. Filtered waters were transferred to 250-millilitre I-Chem Certified high-density polyethylene (HDPE) acid-washed bottles, and acidified to approximately pH=2 with 8M nitric acid as per standard methods for analysis of metals (APHA/AWWA/WEF, 1992). Water colour was also recorded at this time. Samples were transported from the field to the Geological Survey of Canada, Ottawa, for analysis.

SAMPLE ANALYSIS

Analysis of routine lake sediment and water samples was conducted by contract laboratories in accordance with established National Geochemical Reconnaissance (NGR) analytical methods. Analytical methods are strictly specified and carefully monitored to ensure consistent and reliable results regardless of the region, year or analytical laboratory. Element suites, detection limits and details of analytical procedures may differ slightly, however, from those reported by Cook and Jackaman (1994) or Cook *et al.* (1997b) for lake sediment surveys of the Nechako River and Fort Fraser map areas, respectively. For example, iron, arsenic, antimony and zinc data for both analytical methods are reported here. INAA nickel and molybdenum were reported in some prior surveys, but INAA determinations of these elements for the Gataga survey are hampered by inadequate detection limits (nickel) or poor precision (molybdenum), and are not included here. Selenium AAS data are also not given here, although reported by Cook *et al.* (1997b) for the Fort Fraser area. Conversely, INAA zinc and selenium data are reported here for the first time.

SEDIMENTS - AAS

A split of each prepared sediment sample was analyzed by CanTech Laboratories Inc., Calgary, Alberta for 16 elements: zinc, copper, lead, silver, molybdenum, cobalt, mercury, iron, manganese, nickel, fluorine, cadmium, vanadium, bismuth, antimony and arsenic. Loss on ignition (LOI) was also determined. Stated analytical detection limits for each element are listed in Table 2. Those concentrations below the stated detection limits are presented in data listings as a value equivalent to the detection limit.

- For the determination of cadmium, cobalt, copper, iron, lead, manganese, nickel, silver and zinc, a 1 gram sample was reacted with 3 millilitres of concentrated HNO_3 for 30 minutes at 90°C. Concentrated HCl (1 millilitre) was added and the digestion was continued at 90°C for an additional 90 minutes. The sample solution was then diluted to 20 millilitres with metal-free water and mixed. Element concentrations were determined by atomic absorption spectroscopy (AAS) using an air-

acetylene flame. Background corrections were made for lead, nickel, cobalt and silver.

- Mercury was determined by the Hatch and Ott procedure with some modifications. A 0.5 gram sample was reacted with 20 millilitres concentrated HNO_3 and 1 millilitre concentrated HCl in a test tube for 10 minutes at room temperature and then for 2 hours in a 90°C hot water bath. After digestion, the sample was cooled and diluted to 100 millilitres with metal-free water. The mercury present was reduced to the elemental state by the addition of 10 millilitres of 10% weight-to-volume $SnSO_4$ in H_2SO_4. The mercury vapour was then flushed by a stream of air into an absorption cell mounted in the light path of an atomic absorption spectrometer (CV-AAS). Measurements were made at 253.7 nanometres. This method is described by Jonasson *et al.* (1973).

- Molybdenum and vanadium were determined by aqua regia digestion - atomic absorption spectroscopy (AAS) using a nitrous oxide acetylene flame. A 0.5 gram sample was reacted with 1.5 millilitres concentrated HNO_3 at 90°C for 30 minutes. At this point 0.5 millilitres of concentrated HCl was added and the digestion continued for an additional 90 minutes. After cooling, 8 millilitres of 1250 ppm Al solution was added and the sample solution diluted to 10 millilitres before determination by AAS.

- Arsenic and bismuth were determined by aqua regia digestion - hydride generation atomic absorption spectroscopy. A 1 gram sample was reacted with 3 ml of concentrated HNO_3 for 30 minutes at 90°C. Concentrated HCl (1 ml) was added and the digestion was continued at 90°C for an additional 90 minutes. A 1 ml aliquot was diluted to 10 ml with 1.5M HCl in a clean test tube. The diluted sample solution was added to a sodium borohydride solution and the hydride vapour aspirated through a heated quartz tube in the light path of an atomic absorption spectrometer (AAS-H).

- Antimony was determined as described by Aslin (1976). A 0.5 gram sample was placed in a test tube with 3 ml concentrated HNO_3 and 9 ml HCl. The mixture was allowed to stand overnight at room temperature prior to being heated to 90°C and maintained at this temperature for 90 minutes. The mixture was cooled and a 1 ml aliquot was diluted to 10 ml with 1.8M HCl. This dilute solution was determined by hydride evolution-atomic absorption spectroscopy (AAS).

- Fluorine was determined by specific ion electrode as described by Ficklin (1970). A 250 milligram sample was sintered with a 1-gram flux consisting of two parts by weight sodium carbonate and 1 part by weight potassium nitrate. The residue was leached with water. The sodium carbonate was neutralized with 10 millilitres 10% weight-by-volume citric acid, and the resulting solution diluted with water to 100 millilitres. Fluoride was then measured with a fluoride ion electrode (ION) and a reference electrode.

- Loss on ignition was determined using a 0.5 gram sample. The sample was weighed into a 30 millilitre beaker, placed in a cold muffle furnace and heated to 500°C over a period of 2 to 3 hours. The sample was maintained at this temperature for 4 hours, then allowed to cool to room temperature before weighing (GRAV).

SEDIMENTS - INAA

An approximately 30 gram split of each sample was analyzed for 29 elements (gold, antimony, arsenic, barium, bromine, calcium, cerium, cesium, chromium, cobalt, europium, hafnium, iron, lanthanum, lutetium, neodymium, rubidium, samarium, scandium, selenium, sodium, strontium, tantalum, terbium, thorium, tungsten, uranium, ytterbium and zinc) by Activation Laboratories, Ancaster, Ontario, using thermal instrumental neutron activation analysis (INAA). This technique involves irradiating the sample for 30 minutes in a neutron flux of $7x10^{11}$ neutrons/cm^2/ second. After a decay period of approximately 1 week, gamma-ray emissions for the elements were measured using a gamma-ray spectrometer with a high-resolution, coaxial germanium detector. Counting time was approximately 15 minutes per sample and the results were compiled on a computer and converted to concentrations. A complete list of elements and their stated instrumental detection limits are given in Table 2. Additional data for the six elements molybdenum, silver, mercury, irridium, nickel and tin were not published because of inadequate detection limits and/or poor precision. Gold and barium concentrations below the stated detection limits are presented in data listings as a value equivalent to one-half the detection limit. Analytical sample weights are also reported.

WATERS

Routine unfiltered lake waters were analyzed for the standard RGS water analytical suite of pH, uranium, fluoride and sulphate at CanTech Laboratories, Inc., Calgary. Stated detection limits are given in Table 2.

- Hydrogen ion activity (pH) was measured, on a separate sample aliquot, with a Fisher Accumet pH meter with glass-calomel combination electrode (GCE).

- Uranium was determined by laser-induced fluorescence (LIF) using a Scintrex UA-3 uranium analyzer. A

complexing agent, known commercially as Fluran and composed of sodium pyrophosphate and sodium monophosphate (Hall, 1979), is added to produce a uranyl pyrophosphate species which fluoresces when exposed to the laser. As organic matter in the sample can cause unpredictable behaviour, a standard addition method is used. A total of 500 microlitres of Fluran solution was added to a 5 millilitre sample and allowed to stand for 24 hours, as the reaction of uranium with the complexing agent may be delayed or sluggish. At the end of this period fluorescence readings were made with the addition of 0.0, 0.2 and 0.4 ppb uranium. For high-concentration samples, the additions were 0.0, 2.0 and 4.0 ppb uranium. All readings are taken against a sample blank.

- Fluoride was determined by ion selective electrode (ION). A 20 millilitre aliquot of the sample was mixed with 20 millilitres of TISAB II (total ionic strength adjustment buffer) buffer solution. Fluoride was determined with an Orion fluoride electrode in conjunction with a Corning ion meter.

- Sulphate was determined by a turbidimetric method (TURB). A 50 millilitre aliquot was mixed with barium chloride and an isopropyl alcohol-HCl-NaCl reagent, and turbidity of the resulting barium sulphate solution measured with a spectrophotometer at 420 nanometres.

TABLE 2. ANALYTICAL METHODS AND STATED DETECTION LIMITS: LAKE SEDIMENTS AND WATERS

Element		Detection Limit	Method	Element		Detection Limit	Method
Antimony	Sb	0.2 ppm	AAS	Gold	Au	2 ppb	INAA
Arsenic	As	0.2 ppm	AAS-H	Antimony	Sb	0.1 ppm	INAA
Bismuth	Bi	0.1 ppm	AAS-H	Arsenic	As	0.5 ppm	INAA
Cadmium	Cd	0.2 ppm	AAS	Barium	Ba	50 ppm	INAA
Cobalt	Co	2 ppm	AAS	Bromine	Br	0.5 ppm	INAA
Copper	Cu	2 ppm	AAS	Calcium	Ca	1%	INAA
Fluorine	F	40 ppm	ION	Cerium	Ce	3 ppm	INAA
Iron	Fe	0.05%	AAS	Cesium	Cs	1 ppm	INAA
Lead	Pb	2 ppm	AAS	Chromium	Cr	5 ppm	INAA
Manganese	Mn	5 ppm	AAS	Cobalt	Co	1 ppm	INAA
Mercury	Hg	10 ppb	CV-AAS	Europium	Eu	0.2 ppm	INAA
Molybdenum	Mo	2 ppm	AAS	Hafnium	Hf	1 ppm	INAA
Nickel	Ni	2 ppm	AAS	Iron	Fe	0.01%	INAA
Silver	Ag	0.2 ppm	AAS	Lanthanum	La	0.5 ppm	INAA
Vanadium	V	5 ppm	AAS	Lutetium	Lu	0.05 ppm	INAA
Zinc	Zn	2 ppm	AAS	Neodymium	Nd	5 ppm	INAA
Loss On Ignition	LOI	0.1%	GRAV	Rubidium	Rb	15 ppm	INAA
				Samarium	Sm	0.1 ppm	INAA
				Scandium	Sc	0.1 ppm	INAA
pH-water	pH	0.1	GCE	Selenium	Se	3 ppm	INAA
Sulphate-water	SO4	1 ppm	TURB	Sodium	Na	0.01%	INAA
Fluoride-water	FW	20 ppb	ION	Strontium	Sr	0.05%	INAA
Uranium-water	UW	0.05 ppb	LIF	Tantalum	Ta	0.5 ppm	INAA
				Terbium	Tb	0.5 ppm	INAA
				Thorium	Th	0.2 ppm	INAA
				Tungsten	W	1 ppm	INAA
				Uranium	U	0.5 ppm	INAA
				Ytterbium	Yb	0.2 ppm	INAA
				Zinc	Zn	50 ppm	INAA

AAS: atomic absorption spectrometry
CV-AAS: cold vapour-atomic absorption spectrometry
GCE: glass-calomel combination electrode
GRAV: gravimetry
INAA: instrumental neutron activation analysis
ION: ion selective electrode
LIF: laser-induced fluorescence
IC: ion chromatography
TURB: turbidimetry

QUALITY CONTROL PROCEDURES AND RESULTS

METHODOLOGY

The ability to discriminate real geological and geochemical trends from those resulting from sampling and analytical variation is of considerable importance in the interpretation of geochemical data. Control reference standards and analytical duplicates are routinely inserted into sample suites to monitor and assess accuracy and precision of analytical results. Control reference standards are used to assess analytical accuracy. Sampling and analytical variation can be quantified using estimates of precision within and between sample sites determined by utilizing field and analytical duplicate data. In accordance with standard National Geochemical Reconnaissance (NGR) and Regional Geochemical Survey (RGS) quality control procedures, each block of 20 lake sediment samples contains (Figure 3):

- Seventeen routine samples,
- One field duplicate sample collected adjacent to one of the routine samples,
- One blind duplicate sample split from one of the 17 routine samples prior to analysis,
- One control reference standard containing sediment of known element concentrations.

The locations of blind duplicate and control reference samples are selected prior to sampling, whereas field duplicate sites are chosen randomly during fieldwork. At these sites, two samples are taken by successive drops of the torpedo sampler. These samples are used to monitor combined sampling and analytical precision, and are a measure of within-site variation. Blind, or analytical, duplicate samples are usually taken from the first sample of each field duplicate pair following sample preparation, and reinserted into the suite to monitor analytical precision. In practice, dry lake sediment samples are sometimes too small (as little as 50 grams) for a blind duplicate split. Here, 50 per cent of the blind duplicates are taken from the corresponding field duplicate sample; the remainder are taken from another routine sample within the block. Blind duplicates are not used in the water suite; a distilled water blank is instead inserted to monitor analytical contamination.

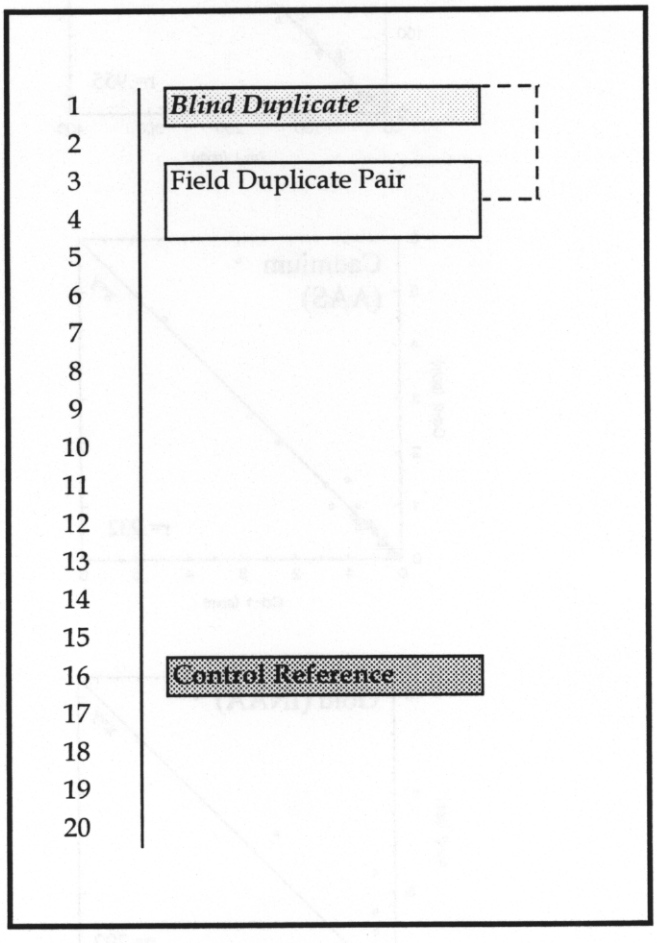


Figure 3. Typical Regional Geochemical Survey sample collection scheme used during the lake sediment survey. The 20-sample collection block incorporates 17 routine samples, a field duplicate sample, a blind duplicate sample and a control reference standard. Blind duplicates are routinely taken from the first sample of each field duplicate pair.

ANALYTICAL PRECISION AND ACCURACY

Variations in element concentrations in lake sediments may be due to regional geological and geochemical variations (different bedrock lithologies and surficial materials, absence or presence of mineralization, limnological variations), within-site variations (combined sampling, preparation and analytical variations), or analytical variation alone. As noted by Fletcher (1981), a high degree of analytical precision is of limited

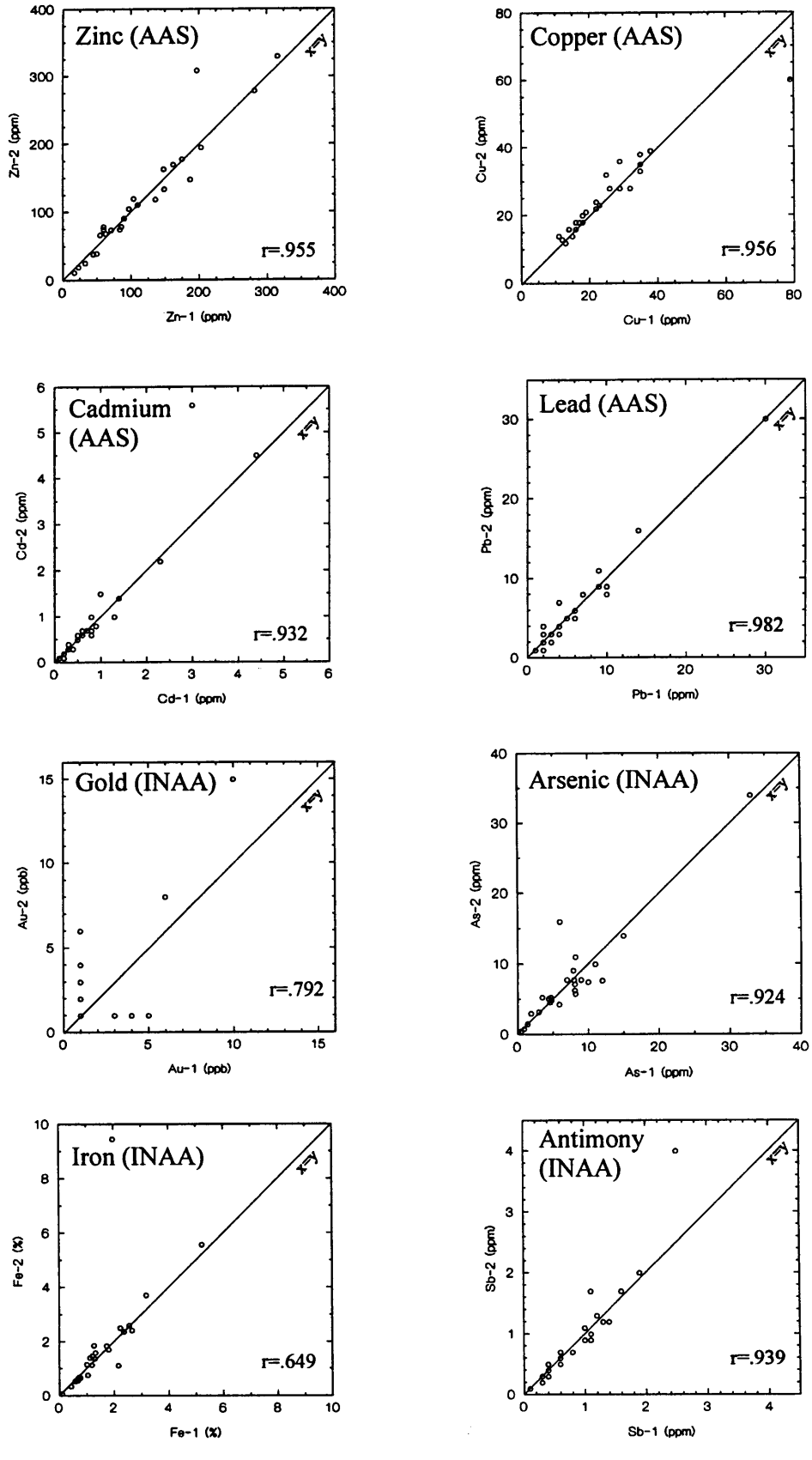


Figure 4. Scatterplots of field duplicate pairs (N=26) for zinc, copper, cadmium and lead (AAS) and for gold, arsenic, iron and antimony (INAA).

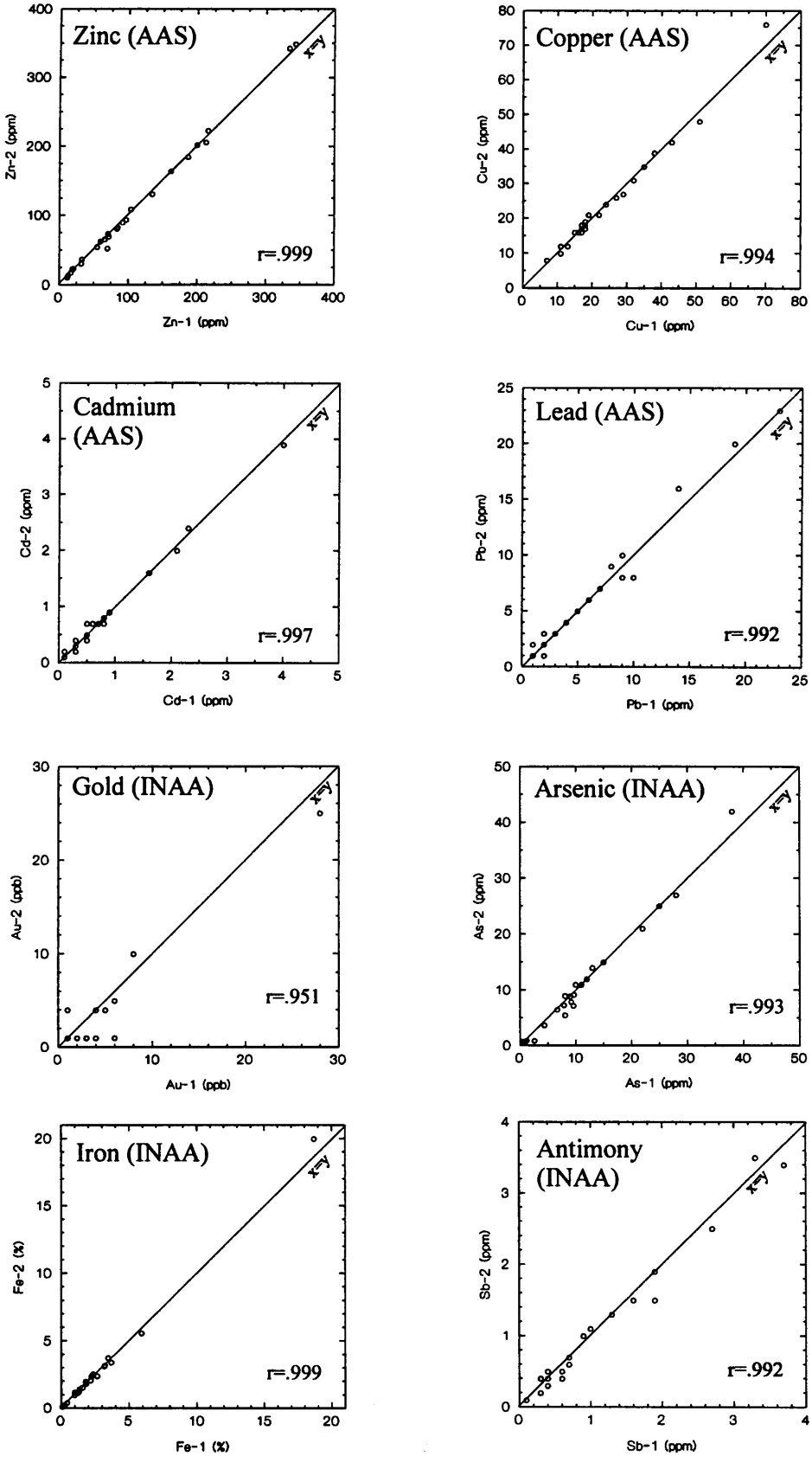


Figure 5. Scatterplots of blind duplicate pairs (N=27) for zinc, copper, cadmium and lead (AAS) and for gold, arsenic, iron and antimony (INAA).

importance if the sample collection and preparation error is so great as to be indistinguishable from the regional geochemical variation.

Scatterplots of analytical results for 26 field duplicate pairs (Figure 4) and 27 blind duplicate pairs (Figure 5) are shown for zinc, copper, cadmium and lead (AAS) and for gold, arsenic, antimony and iron (INAA). Good reproducibility, particularly for those elements with concentrations well above analytical detection limits, imparts a high degree of confidence in the quality of both the sampling and analytical procedures. Estimates of analytical precision at different concentration levels are not given for the 27 blind duplicate pairs, as this is fewer than the minimum of 50 pairs recommended by Thompson and Howarth (1978). However, mean relative standard deviation (RSD) values were calculated for both field and blind duplicate pairs of gold determinations by averaging the per cent RSD between each pair. Mean RSD for blind duplicate gold values (n=27 pairs) is 22.1%, similar to that reported for the Pinchi survey in the Nechako Plateau (Cook *et al.*, 1997b). Mean RSD for field duplicate gold values (n=26 pairs) is only marginally greater at 23.2%. Greater precision is generally expected with the analysis of blind duplicate pairs, as it is a measure of subsampling and analytical variability only. Analysis of field duplicate sample pairs, on the other hand, measures field sampling, preparation, subsampling and analytical variability. Field duplicate data for all elements are included within the data listings in Appendix A, and analytical duplicate data are listed in Appendix B.

Three internal lake sediment standards of the Geological Survey of Canada were used as routine control standards (n=27) for the North Gataga survey. Analytical data for the control standards compare favourably with informal accepted values, indicating a high degree of analytical accuracy. For example, AAS analyses of the three standards returned mean zinc concentrations of 58.7 ± 2.8 ppm (n = 10), 67.4 ± 3.4 ppm (n = 8) and 152.8 ± 4.5 ppm (n = 9) zinc relative to informal accepted values of 57.6 ppm, 66.7 ppm and 148.1 ppm zinc, respectively. Similarly, AAS analyses of the same standards returned mean copper concentrations of 18.5 ± 1.3 ppm, 25.4 ± 0.9 ppm and 83.4 ± 2.8 ppm copper relative to informal accepted values of 17.1 ppm, 24.1 ppm and 82.0 ppm, respectively. In the case of lead, AAS analyses of the three standards returned concentrations of 4.5 ± 0.5 ppm, 4.9 ± 0.8 ppm and 24.3 ± 0.5 ppm relative to informal accepted values of 6.4 ppm, 6.8 ppm and 26.7 ppm lead, respectively.

In addition to the foregoing, three insertions of CANMET certified reference material LKSD-1 yielded mean concentrations of 351.3 ± 6.7 ppm zinc (*accepted value: 337 ± 11 ppm*), 85.0 ± 2.7 ppm lead (*accepted value: 84 ± 10 ppm*), 47 ± 1 ppm copper (*accepted value: 44 ± 5 ppm*), and 420 ± 60 ppm barium (*INAA; accepted value: 430 ± 40 ppm*). Accepted values of LKSD-1 are from Lynch (1990).

As a measure of analytical precision of control standards results, relative standard deviation (% RSD) values determined from replicate analyses are given in Table 3 for several elements from the AAS suite. Data for two to three insertions of CANMET certified reference standards LKSD-1 (lake sediment) and SO-3 (calcareous till) are also included.

TABLE 3. SEDIMENT CONTROL STANDARDS RESULTS - AAS SUITE: PER CENT RSD VALUES

	Zn (% RSD)	Pb (% RSD)	Cu (% RSD)	Mo (% RSD)	As (% RSD)	Hg (% RSD)
Standard 1	4.8	11.7	6.9	20.2	15.6	9.3
Standard 2	5.0	17.1	3.6	10.9	8.7	13.8
Standard 3	3.0	2.1	3.4	12.4	4.2	3.6
LKSD-1	1.9	3.1	2.1	0.0	3.4	12.4
SO-3	1.7	8.3	3.6	15.7	26.2	47.1

The RGS water analytical suite included distilled water blanks and various control standards. Median results of 0.02 ppb uranium, 10 ppb fluoride and 1 ppm sulphate obtained for distilled water blanks (N=27 insertions) are all at or below stated analytical detection limits (Table 2). Five different water standards (N=27 insertions) were used in the North Gataga analytical suite. Most were internal standards prepared in 1996 from bulk natural waters obtained from central British Columbia lakes, including one from the survey area (Graveyard Lake). Regarding analytical precision of the water standards results, five to seven replicate analyses of each of the five standards returned relative standard deviation (% RSD) values of 5.3 - 51.4% for uranium, 3.8 - 25.7% for fluoride and 5.6 - 29.4% for sulphate.

Repeat INAA analyses are routinely conducted on sediment samples reporting gold concentrations greater than the 90th percentile (Au2 in the data listings). Here, repeat analyses were conducted on samples from 48 sites with gold concentrations of at least 6 ppb (10.8% of total sites). All reanalyses were conducted on separate splits, of varying sizes, of the original pulverized sample

material, providing a measure of both subsampling and analytical variability rather than simply analytical variability from one batch to another. Scatterplot results are shown in Figure 6. Gold reproducibility here is relatively poor compared to that achieved in prior B.C. lake sediment surveys (Cook *et al.,* 1997b; Cook and Jackaman, 1994). Only 13 of 48 reanalyses yielded gold concentrations greater than the stated analytical detection limit of 2 ppb, and only 8 of 48 returned gold concentrations of at least 6 ppb. A mean relative standard deviation (RSD) of 87.8% was calculated for repeat gold analyses by averaging the per cent RSD between each of the 48 analytical pairs. This RSD is substantially greater than that reported for the Pinchi survey (19.6%; Cook *et al.*, 1997b) in the Nechako Plateau, although this may be at least partly attributed to the re-analysis here of new sample material rather than the original INAA sample capsules. It is also considerably higher, however, than that determined for gold in field and blind duplicate pairs in this area, suggesting that the often low and erratic weights of some of the subsamples used in the repeat analyses may be the source of at least part of this variability. Subsample weights of paired field duplicate (Appendix A) and blind duplicate (Appendix B) splits are substantially similar and generally in the range of 20-25 grams, but the very small amount of sediment material available for subsequent repeat analyses has resulted in many samples of considerably less weight (Appendix A). For example, 20 of the 48 repeat samples are of less than 10 grams weight, and 15 weigh less than 5 grams.

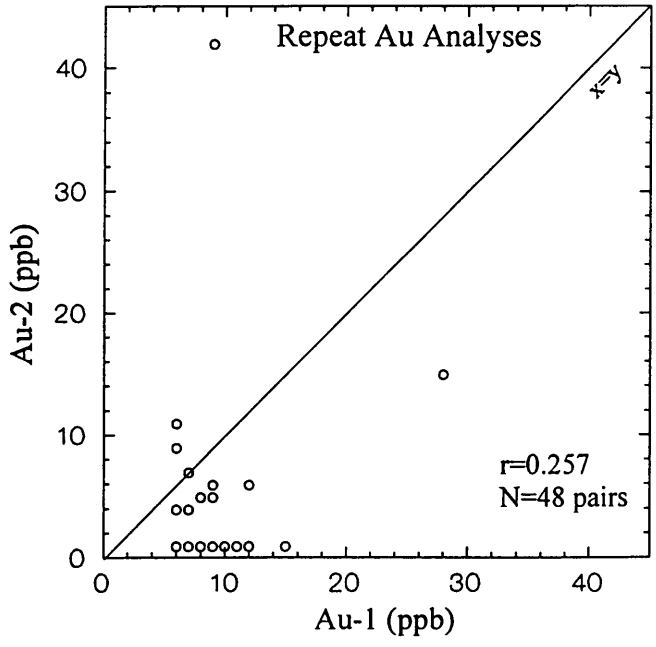


Figure 6. Scatterplot of results for 48 pairs of repeat gold analyses (ppb). Au-1 represents the original gold result; Au-2 represents the value obtained on reanalysis. Both values are reported in the data listings (Appendix A) together with corresponding sample weight data.

Photo 3. Regional lake sediment sampling in the Northern Kechika Trough

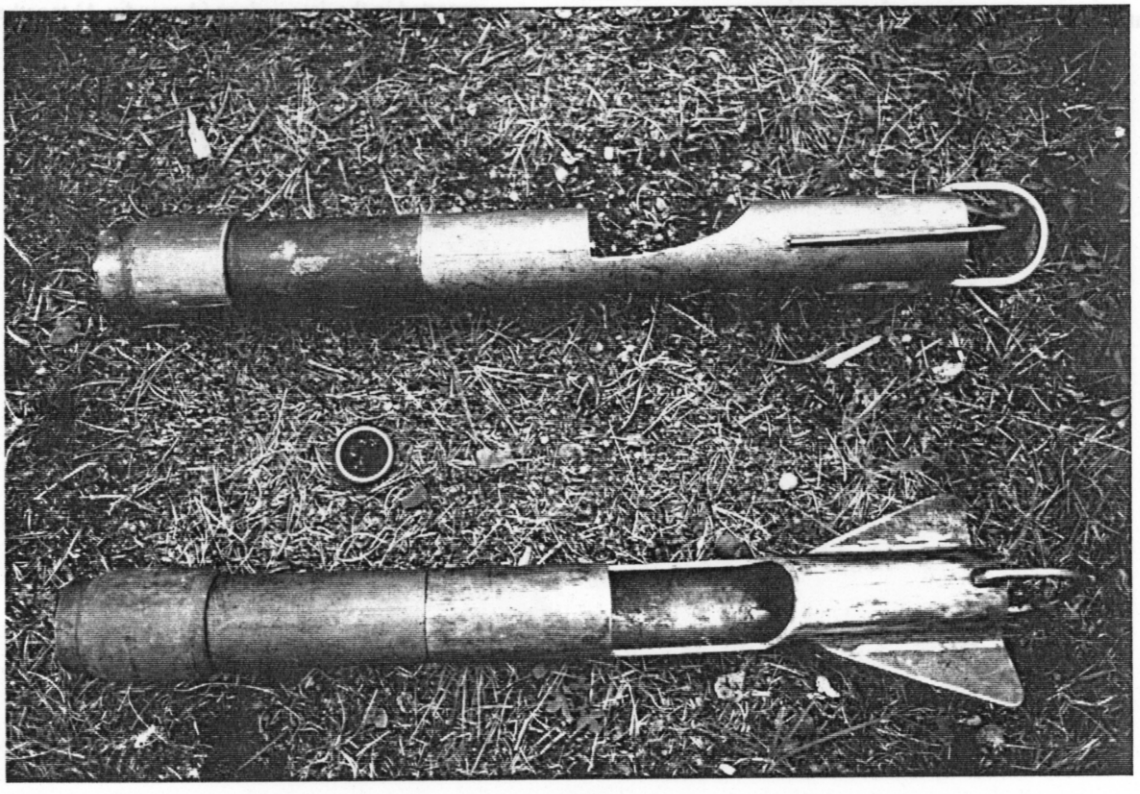


Photo 4. Hornbrook-type lake sediment sampler used in regional geochemical surveys

PRELIMINARY DATA INTERPRETATION

FIELD VARIABLES

Distribution of lake sediment sites by geological unit in the North Gataga survey area is shown in Appendix D-3 and, schematically, in Figure 7. Unit designations are those of Ferri *et al.* (1997b). Although the watersheds of most sites are within Paleozoic sedimentary rocks of the Kechika Trough, there was insufficient geological information available to code 212 of the sites (48%). Most of these sites (*Q: alluvium, glacial deposits*) are located in the poorly-exposed northern part of the survey area. Of Paleozoic sedimentary units, the Road River Group contains the greatest number of sample sites (48; 10.8%). Only two sites drain areas of gabbroic intrusive rocks. A further 38 sites (8.5 %) drain Proterozoic rocks of the Hyland Group, while 12 sites (2.7%) drain rocks of the adjacent Cassiar terrane to the west.

The majority of sites in the North Gataga survey area (78%) are in lakes of pond size or smaller (*e.g.* < 0.25 km^2). This is somewhat greater than the proportion of pond-sized sites recorded to the south in surveys of the Nechako Plateau area (Cook and Jackaman, 1994; Cook *et al.*, 1997b). Approximately 12% of the sites are in lakes in the range 0.25 to 1 km^2, but only 3 sites (0.7%) are in large lakes (*e.g.* > 5 km^2), which are not common in the survey area. Median lake depth is 4 metres. Shallow lakes are very common, and more than one-third (38%) of all sites have depths of 2 metres or less (Figure 8). A majority of the sites (84%) have depths of 10 metres or less. The deepest site recorded was 36 metres, but only 24 sites in the entire survey area (5.4%) have depths of more than 20 metres. It should be noted that lake depth, measured here with a float-mounted depth sounder, is not synonymous with sample depth, which is the distance from the water surface to the sample location within the sediment column. This is because the sampler typically penetrates up to a few metres into the sediment before stopping. Depth of penetration may be negligible in small ponds, but may reach up to 3 or 4 metres in large, deep lakes.

More than two-thirds (68%) of sites were classed as being in areas of low relief, with a further 26% classed as areas of medium relief. Less than 6% of sediment sites were categorized as being in areas of high relief, mostly in the southern part of the survey area. Field observations indicate that potential sources of anthropogenic contamination within the survey area are minimal. Road building and logging activity is largely absent, and camp sites were recorded on the shores of only eight (1.8%) sites.

SEDIMENTS

The following data interpretation is of a preliminary nature. Discussions on the distribution and abundance of zinc, cadmium, lead, barium, silver, arsenic, antimony, nickel, copper, molybdenum, gold and mercury in sediments, and sulphate and pH in water, are intended to highlight geochemical patterns that may be of interest to explorationists, and are not exhaustive. Please refer to the appropriate topographic maps for lake and place names.

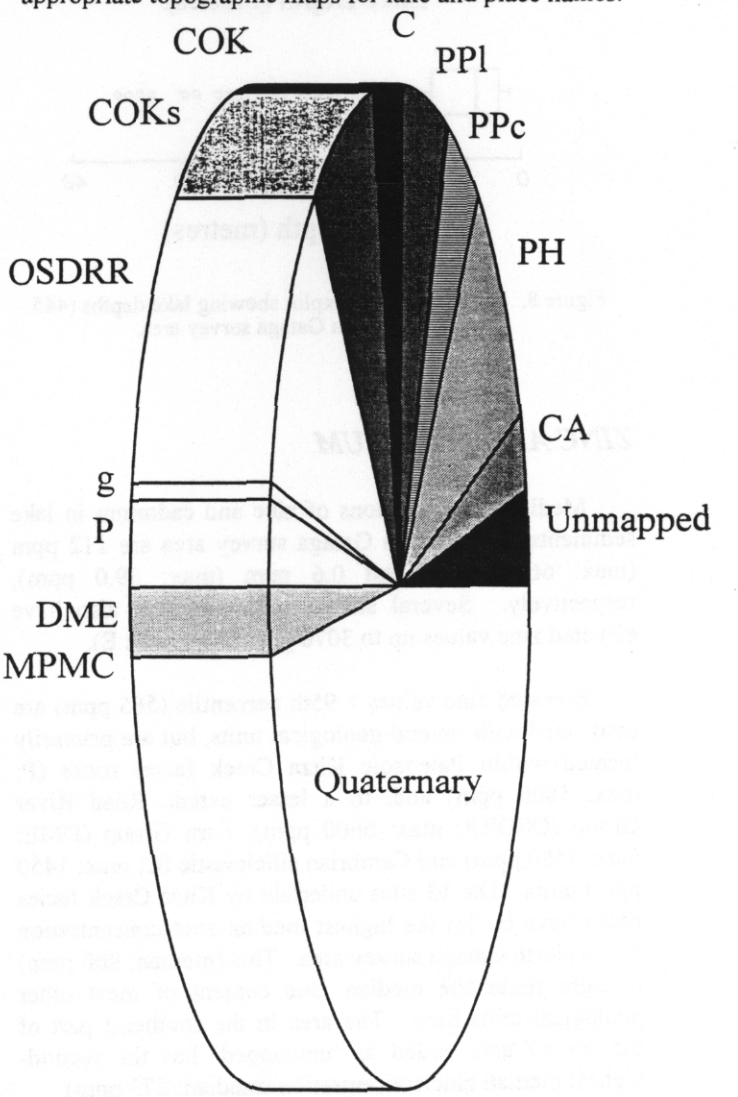


Figure 7. Distribution of lake sediment sample sites by geological units in the North Gataga survey area. Refer to Appendices A and D-3 for descriptions of units, which here are shown counter-clockwise from oldest (CA) to youngest (Quat).

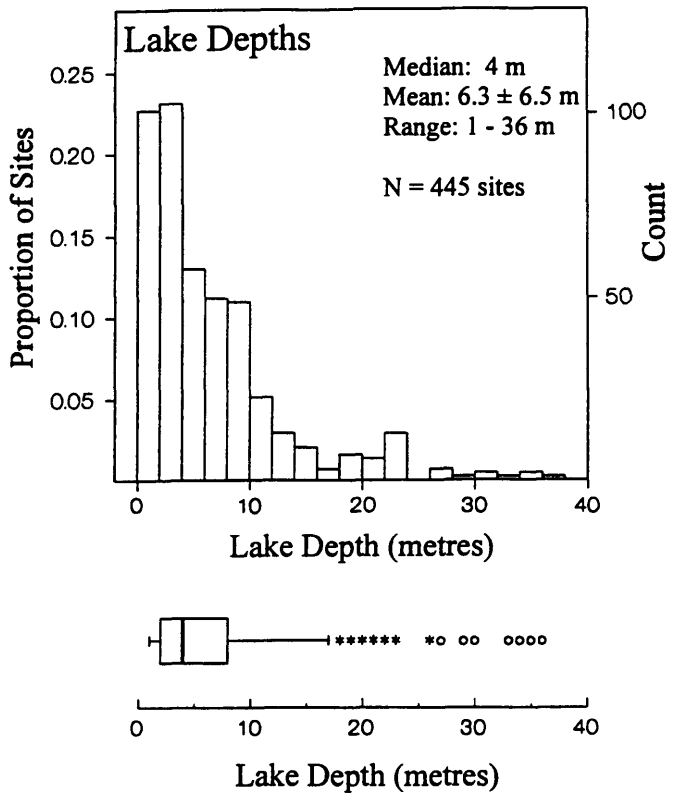


Figure 8. Histogram and boxplot showing lake depths (445 sites) in the North Gataga survey area.

ZINC AND CADMIUM

Median concentrations of zinc and cadmium in lake sediments of the North Gataga survey area are 112 ppm (max: 6600 ppm) and 0.6 ppm (max: 39.0 ppm), respectively. Several stream sediment sites also have elevated zinc values up to 3070 ppm (Appendix E).

Elevated zinc values > 95th percentile (565 ppm) are associated with several geological units, but are primarily located within Paleozoic Kitza Creek facies rocks (P; max: 5800 ppm) and, to a lesser extent, Road River Group (OSDRR; max: 6600 ppm), Earn Group (DME; max: 3550 ppm) and Cambrian siliciclastic (C; max: 1450 ppm) units. The 13 sites underlain by Kitza Creek facies rocks have by far the highest median zinc concentration in the North Gataga survey area. This (median: 900 ppm) is eight times the median zinc content of most other geological units here. The area in the southeast part of the survey area coded as 'unmapped' has the second-highest median zinc concentration (median: 273 ppm).

The distribution of elevated cadmium values > 95th percentile (3.9 ppm) generally parallels that of zinc. The maximum cadmium concentration (39 ppm) and the maximum median concentration (median: 3.4 ppm) are both associated with Kitza Creek facies rocks; the second-highest median cadmium concentration is associated with the 'unmapped' area (median: 1.6 ppm).

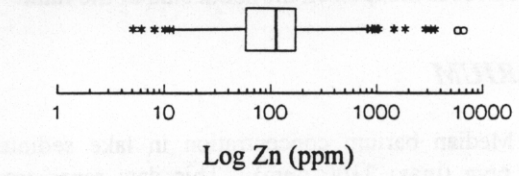
Zones of elevated zinc and cadmium concentrations occur in two principal areas:

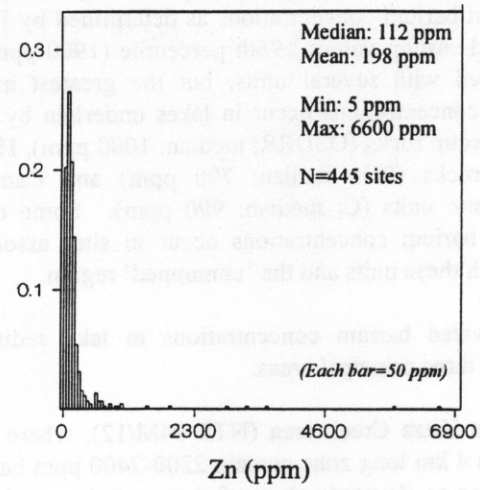
- The Kitza Creek area (NTS 94M/12), a zone of hummocky hills and incised creek valleys, approximately 12 km x 7 km, which is located just northwest of the Kechika River. The distributions of elevated zinc and cadmium concentrations here are substantially similar. Nine sites in this area, located between Kitza and Wadin Creeks, contain sediment zinc concentrations (range: 595 - 5800 ppm) in the upper 5 percentiles of the North Gataga data set; seven of the sites contain cadmium concentrations in the upper 5 percentiles. Elevated concentrations of numerous other elements including silver, barium, antimony, nickel, molybdenum, selenium, copper, vanadium and mercury, among other elements, also occur in sediments of this group of lakes, although the distributions of zinc and cadmium are the most widespread.

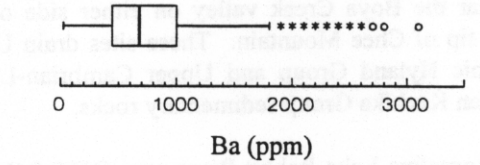
Most of these, and the other sites in this area with elevated zinc and cadmium concentrations, are underlain by Kitza Creek facies sedimentary rocks. The remaining sites in the Kitza Creek area drain rocks of the Road River Group. The black slates and argillites of the Kitza Creek facies are largely restricted to this area, which was mapped as a fault-bounded area of approximately 15 km x 15 km dimensions by Ferri *et al.* (1997b). It is one of the most northwesterly areas of mappable bedrock in the North Gataga survey area before the bedrock surface is obscured by the vast Liard Plain. No data is available on the background metal content of rocks of this unit.

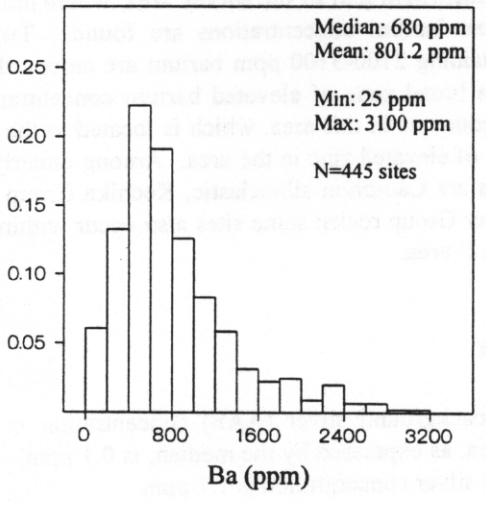
The highest zinc and cadmium concentrations occur in the northeastern part of this area. Four sites which form an approximately 11 km-long zone contain zinc concentrations in the range 1850 - 5800 ppm, and coincident cadmium concentrations in the range 11 - 39 ppm. Four of the five highest sediment cadmium values in the survey area occur within this small northwest trending zone.

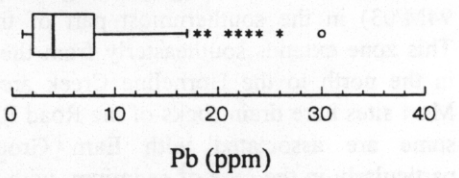
The Kitza Creek area is in the area of the Kitza copper-zinc-barium-lead occurrence (MINFILE 94M 018), an approximately 8 km x 3 km area of many small tetrahedrite-sphalerite-barite vein showings. These have been interpreted to have formed from sediment dewatering (Miller and Harrison, 1981) and no sedex-style mineralization has been previously reported.

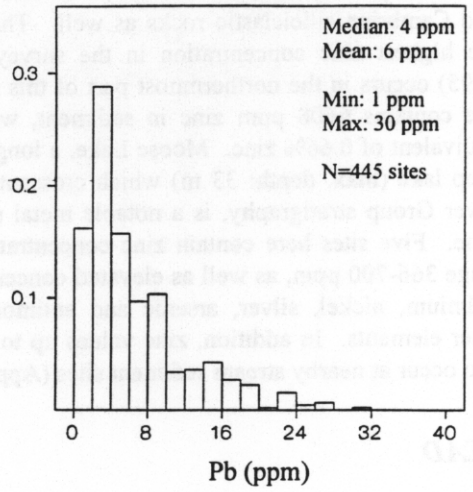


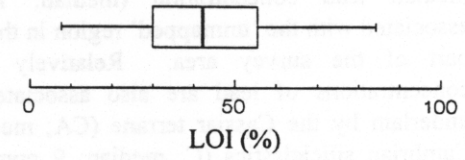












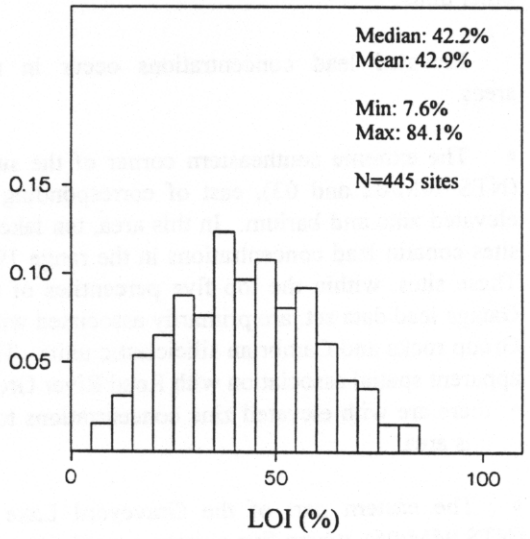


Figure 9. Boxplots and histograms showing distribution of zinc (AAS), lead (AAS), barium (INAA) and Loss on Ignition in lake sediments of the North Gataga survey area. Fifty per cent of the data lies within the box; the lower and upper bounds of each box define the first quartile and third quartile of data, respectively.

- The second zone of elevated zinc and cadmium values occurs in a roughly wedge-shaped area (NTS 94M/03) in the southernmost part of the survey area. This zone extends southeasterly from the Pup Lake area in the north to the Horneline Creek area in the south. Most sites here drain rocks of the Road River Group, but some are associated with Earn Group rocks and, particularly in the case of cadmium, with Kechika Group and Cambrian siliciclastic rocks as well. The lake with the highest zinc concentration in the survey area (site 4095) occurs in the northernmost part of this zone. This site contains 6600 ppm zinc in sediment, which is the equivalent of 0.66% zinc. Moose Lake, a long, relatively deep lake (max. depth: 33 m) which crosscuts the Road River Group stratigraphy, is a notable metal sink in this zone. Five sites here contain zinc concentrations in the range 366-700 ppm, as well as elevated concentrations of cadmium, nickel, silver, arsenic and antimony, among other elements. In addition, zinc values up to 3070 ppm also occur at nearby stream sediment sites (Appendix E).

LEAD

The median lake sediment lead (AAS) concentration in the North Gataga survey area is 4 ppm (max: 30 ppm). Elevated values >95th percentile (18 ppm) are associated with a half-dozen different geological units, but both the maximum lead concentration (30 ppm) and the greatest median lead concentration (median: 16 ppm) are associated with the 'unmapped' region in the southeastern part of the survey area. Relatively high median concentrations of lead are also associated with lakes underlain by the Cassiar terrane (CA; median: 8 ppm), Cambrian siliciclastics (C; median: 9 ppm), and a few other units.

Elevated lead concentrations occur in two main areas:

- The extreme southeastern corner of the survey area (NTS 94M/02 and 03), east of corresponding zones of elevated zinc and barium. In this area, ten lake sediment sites contain lead concentrations in the range 19-30 ppm. These sites, within the top five percentiles of the North Gataga lead data set, are primarily associated with Hyland Group rocks and Cambrian siliciclastic units. There is no apparent spatial association with Road River Group rocks, as there are with elevated zinc concentrations to the west of this area.

- The eastern part of the Graveyard Lake drainage (NTS 94M/06), where five closely-spaced sites containing 19-26 ppm lead occur within three interconnected lakes and ponds. These sites drain Cambrian siliciclastic rocks, mapped by Ferri *et al.* (1997b) on the north side of the Graveyard Lake fault and, to a lesser extent, Road River Group rocks mapped on the south side of the fault.

BARIUM

Median barium concentration in lake sediments is 680 ppm (max: 3100 ppm). This data represents total sediment barium concentrations as determined by INAA. Elevated barium values >95th percentile (1900 ppm) are associated with several units, but the greatest median barium concentrations occur in lakes underlain by Road River Group rocks (OSDRR; median: 1000 ppm), Hyland Group rocks (PH: median: 790 ppm) and Cambrian siliciclastic units (C; median: 990 ppm). Some of the highest barium concentrations occur in sites associated with both these units and the 'unmapped' region.

Elevated barium concentrations in lake sediments occur in three principal areas:

- The Kitza Creek area (NTS 94M/12), where three sites in a 4 km long zone contain 2200-2400 ppm barium, in addition to elevated values of zinc, cadmium and other elements. Underlying rock units here are those of the Kitza Creek facies and Road River Group.

- The northern Chee Mountain area (NTS 94M/03), where three sites containing 2200-2800 ppm barium occur near the Boya Creek valley on either side of the northern tip of Chee Mountain. These sites drain Upper Proterozoic Hyland Group and Upper Cambrian-Lower Ordovician Kechika Group sedimentary rocks.

- The Horneline Lake-Rabbit River area (NTS 94M/03) in the southeastern part of the survey area, where most of the highest barium concentrations are found. Twelve sites containing 2100-3100 ppm barium are among those forming a broad zone of elevated barium concentrations in lake sediments in this area, which is located to the east of a zone of elevated zinc in the area. Among underlying rock units are Cambrian siliciclastic, Kechika Group and Road River Group rocks; some sites also occur within the 'unmapped' area.

SILVER

The background silver (AAS) concentration in the survey area, as expressed by the median, is 0.1 ppm. The maximum silver concentration is 1.7 ppm.

Median silver concentrations do not appreciably differ from background values, and are in the range 0.1 - 0.2 ppm for all underlying geological units. There are numerous sites in the survey area with elevated silver

concentrations well in excess of background levels. For example, sixteen sites report silver concentrations >95th percentile, in the range 0.6 - 1.7 ppm. Elevated silver values of this magnitude are associated with six different units, but the greatest number of these sites (max: 1.7 ppm) are within lakes draining Road River Group rocks. Among other units, the 'unmapped' region and that area overlain by Quaternary sediments each also contain 2-3 sites in the top five percentiles of the silver data for the North Gataga survey area.

Elevated silver values >95th percentile are present in three main groups of two to seven sites each:

- The Moose Lake area (NTS 94M/03) in the southern part of the survey area, where seven sites containing elevated silver concentrations of at least 0.6 ppm occur within an approximately 7 km x 5 km area. They are largely coincident with, but more areally restricted than, the aforementioned zone of elevated zinc concentrations in the same area, and are all underlain by Road River Group sedimentary rocks. Of the seven sites, five are within Moose Lake itself (range: 0.8-1.7 ppm), including those with the three highest individual silver concentrations in the survey area.

- The Kitza Creek area (NTS 94M/12), where two sites with largely coincident zinc-cadmium-barium-nickel-molybdenum-copper-antimony-mercury values contain 0.9-1.0 ppm silver in sediment. These sites drain Kitza Creek facies and Road River Group rocks.

The Kaska Creek area (NTS 104P/09 and 16) in the northern part of the survey area, where two adjacent ponds about 2.5 km apart contain 0.6-0.7 ppm silver. These sites are located within a few kilometres to the east of this Liard River tributary.

ARSENIC AND ANTIMONY

Median arsenic and antimony concentrations (AAS) in the North Gataga survey area are 2.5 ppm and 0.5 ppm, respectively. Maximum concentrations are 360 ppm for arsenic and 6.5 ppm for antimony. Median INAA arsenic and antimony determinations are 5.4 ppm (max: 270 ppm) and 0.7 ppm (max: 9.0 ppm), respectively. Arsenic and antimony distributions in the North Gataga survey area are only locally coincident. The following discussion is based on AAS results unless otherwise noted.

Highest median arsenic concentrations (8.5 ppm) occur in lake sediments draining rocks of the Cassiar terrane (CA). However, the highest individual sediment arsenic concentrations occur in lakes above siliceous facies rocks of the Kechika Group (COKs; max: 360 ppm), Quaternary sediments (Q; max: 260 ppm) and, to a lesser extent, rocks of the Road River Group (OSDRR; max: 60 ppm). Those concentrations >95th percentile (29 ppm) occur in four distinct areas:

- The Moose Lake-Horneline Creek area (NTS 94M/03), where eight sites contain up to 60 ppm arsenic in sediment. The maximum value here (site 4090) is found in a small pond in the southern part of the survey area. The distribution of anomalous sites in this area, which is underlain by Road River Group rocks, is similar to that of silver and covers a smaller area than those sites with, for example, elevated zinc, cadmium and nickel.

- Graveyard Lake (NTS 94M/06), where the highest (site 4253; 360 ppm) and third-highest (site 4252; 190 ppm) arsenic concentrations in the survey area occur in two basins at the northeastern end of the lake. Sediment at these sites, which drain siliceous facies units of the Kechika Group (COKs), also contain elevated concentrations of molybdenum (20-36 ppm) and iron (4.30-7.90%). A third site in this area (site 4258), located further northeast up the Graveyard Lake drainage, also contains an elevated lead concentration of 26 ppm in addition to 33 ppm arsenic.

- Twin Island Lake (NTS 94M/04 and 05), where three sites draining rocks of the Cassiar terrane contain 31-43 ppm arsenic in addition to elevated levels of antimony, lead, nickel and/or mercury at least one of the sites.

- An extensive area of moderately-elevated arsenic values, approximately 30 km x 10 km, extending from the Sunshine Lake area near Kitza Creek, to Black Anus Creek near its confluence with the Liard River (NTS 94M/12; 104P/09 and 16). This northwest-southeast trending zone is underlain by Quaternary sediments in an area of little topographic relief or bedrock exposure. A large number of sites here fall within the 70-95th percentile ranges (4.6-29 ppm) for the North Gataga survey area. Only five sites, in the range 30-260 ppm arsenic, are within the top five percentiles of data (at least 29.1 ppm). These are most common near Sunshine Lake, where three sites contain 51-90 ppm arsenic in sediment in the vicinity of lakes with some of the lowest water pH values in the survey area. Iron and manganese concentrations in sediment are similarly high in this zone, suggesting that scavenging of arsenic by hydrous iron and manganese oxides may at least partly account for the elevated arsenic concentrations here.

Regarding antimony, highest median concentrations occur in sediments draining Kitza Creek facies rocks (P; median: 1.2 ppm) and Road River Group rocks (OSDRR; median: 0.9 ppm). Relatively high median concentrations

also occur in sediments associated with the 'unmapped' area (median: 0.7 ppm) and Cambrian siliciclastic rocks (C; median: 0.7 ppm).

Elevated antimony concentrations >95th percentile (2.1 ppm) occur in lakes over several units, but are most common in two main areas:

- The Pup Lake-Moose Lake area (NTS 94M/03) in the southern part of the survey area, where elevated sediment antimony concentrations of up to 6.5 ppm occur in several lakes and ponds to the north, east and southeast of Chee Mountain. Many of these lakes, which primarily drain rocks of the Road River and Kechika Groups, also contain elevated concentrations of zinc, cadmium, silver, nickel and mercury. Three of the four highest antimony concentrations in the survey area, including the maximum (6.5 ppm), occur here in sediments of Moose Lake. Two sites near the northern tip of Chee Mountain (2.5-3.5 ppm), just south of the Boya Main Face skarn prospect (MINFILE 94M 021) are also included in this group.

- The Kitza Creek area (NTS 94M/12), where five sites exceeding the 95th percentile are among several sites above predominantly Kitza Creek facies rocks which have elevated concentrations of zinc, cadmium, nickel and other elements, in addition to antimony. The site with the third-highest antimony concentration (site 4176; 5.6 ppm) in the survey area occurs here.

Among other sites, elevated antimony in sediment is present in Twin Island Lake (2.4 ppm) on the west side of the Rocky Mountain Trench, and in the 'unmapped' area east of the Rabbit River (2.4-3.4 ppm). Elevated antimony concentrations are only coincident with upper five percentile gold concentrations at a few sites, but one of those is site 4362 (28 ppb gold, 2.5 ppm antimony) above Kechika Group rocks. This site, located north of the Gemini lakes, has the highest gold concentration in the survey area.

NICKEL

Median nickel (AAS) concentrations in lake sediments of the survey area is 16 ppm; the maximum concentration is 500 ppm. Note that no INAA nickel data is presented in this report.

Elevated nickel concentrations > 95th percentile (62 ppm) are associated with six geological units. Of these, the greatest nickel values are associated with Kitza Creek facies rocks (P; max: 500 ppm), the Road River Group (OSDRR; 400 ppm), the Earn Group (DME; max: 270 ppm) and the Hyland Group (PH; max: 185 ppm). Of these, the Kitza Creek facies contains both the single highest nickel concentration in lake sediment (500 ppm; site 4179) and, by a wide margin, the greatest median nickel concentration (median: 75 ppm) in the survey area. This median nickel value is several times that of most other geological units.

Distribution of elevated nickel values exceeding the 95th percentile is substantially similar to that of zinc, and occurs in two main areas:

- The Kitza Creek area (NTS 94M/12), where several sites with elevated nickel concentrations, up to 500 ppm, are largely coincident with sites containing elevated zinc and cadmium. These sites are underlain by Kitza Creek facies and Road River Group rocks.

- The southernmost part of the survey area, where a roughly wedge-shaped zone extends southeasterly from the Pup Lake area in the north to the Horneline Creek area near the southern border of the survey area (NTS 94M/03). The distribution of elevated nickel concentrations here is substantially similar to the distribution of elevated zinc values in the same area. Two of the four highest sediment nickel concentrations in the survey area are present in this zone, north of Pup Lake (site 4095; 400 ppm) and west of Moose Lake (site 4079; 270 ppm).

COPPER

The median copper concentration (AAS) in the North Gataga survey area is 22 ppm (maximum: 126 ppm), slightly lower than that reported in prior surveys of the Nechako Plateau area to the south (Cook *et al.*, 1997b; Cook and Jackaman, 1994; Johnson *et al.*, 1987a,b).

Elevated lake sediment copper values > 95th percentile (52 ppm) are associated with several geological units, but are most commonly present in the 'unmapped' area in the southeastern portion of the survey area. Lake sediment copper concentrations here are not particularly high; nevertheless, there are three distinct zones of elevated (>95th percentile) copper concentrations in the North Gataga survey area:

- The 'unmapped' area in the southeast corner of the survey area, where five sites with up to 126 ppm copper (site 4018) occur both east and west of the Rabbit River (NTS 94M/02). Elevated lead values are also present at most of these sites. The 'unmapped' area also has the highest median copper concentration (median: 46 ppm) in the survey area, in addition to the maximum single concentration.

- The Moose Lake-Horneline Lake area (NTS 94M/03) in the south-central part of the survey area. Numerous sites with elevated copper concentrations up to 86 ppm (site 4077) occur in and adjacent to these two lakes. Interestingly, this zone of elevated copper values crosscuts the Road River Group, Kechika Group and Cambrian siliciclastic stratigraphy in this area.

- The northern tip of Chee Mountain (NTS 94M/03), where two sites with elevated sediment copper values roughly coincide with an earlier-mentioned zone of elevated barium. One of these sites (site 4278; 74 ppm) also contains an anomalous lead concentration (24 ppm); it is located about 3 km downslope of the Boya Main Face tungsten-molybdenum-copper-lead-zinc-bismuth skarn prospect (MINFILE 94M 021).

In addition to the foregoing, single sites with elevated copper concentrations also occur east of Graveyard Lake within a zone of anomalous lead in lake sediments, and in the Kitza Creek area where many lakes contain elevated concentrations of zinc, cadmium, nickel and other elements.

MOLYBDENUM

The median molybdenum concentration (AAS) in North Gataga survey area sediments is 6 ppm (max: 100 ppm). Note that all discussions refer to molybdenum determined by AAS; no INAA molybdenum data is presented here.

Median molybdenum concentrations in lake sediments do not vary appreciably from one geological unit to another. The highest median concentrations (8 ppm each) occur in sediments draining Cassiar terrane (CA), Earn Group (DME) and Kitza Ck. facies (P) rocks. Elevated molybdenum concentrations >95th percentile (17 ppm) are present in lakes within almost every geological unit, but the highest concentrations are associated with the Road River Group (OSDRR; max: 100 ppm), the Kitza Creek facies (P; max: 55 ppm), parts of the Aeroplane Lake panel (PPc; max: 48 ppm), Kechika Group siliceous facies (COKs; max: 36 ppm), the Earn Group (DME; max: 27 ppm) and the extensive region underlain by Quaternary sediments (Q; max: 52 ppm) in the northern part of the survey area.

Elevated molybdenum concentrations >95th percentile occur as a number of small clusters of a few sites each . There are five principal areas, none of which are associated with the known Boya showings:

- The southeastern corner of the survey area (NTS 94M/02 and 03), where three widely-separated sites with up to 39 ppm molybdenum (site 4053) occur within the 'unmapped' area and adjacent rock units.

- The northeast flank of Chee Mountain (NTS 94M/03), where two closely-spaced sites with 18-35 ppm molybdenum in sediment drain Road River Group and Kechika Group rocks mapped on Chee Mountain and adjacent slopes.

- Graveyard Lake (NTS 94M/06), where two sites with 20-36 ppm molybdenum occur in the northeastern basins of this large lake. These sites overlie siliceous facies units of the Kechika Group (COKs).

- The Aeroplane Lake area (NTS 94M/05), where two sites at the base of a ridge mapped as Aeroplane Lake Panel calcareous phyllite and schist (Ferri *et al.*, 1997b) contain 25-48 ppm molybdenum in sediment. One of these sites is within Aeroplane Lake itself, while the second is located immediately to the south.

- The Kitza Creek area (NTS 94M/12), where four sites (19-55 ppm molybdenum) within the top five percentiles of the North Gataga data set are among several elevated molybdenum values in this area. One of these (site 4179; 55 ppm) has the second-highest molybdenum concentration in the survey area, in addition to 500 ppm nickel. Furthermore, a broad zone of moderately-elevated molybdenum concentrations in lake sediments, including two sites with 24-25 ppm, are present within about 15 km west and northwest of the Kitza Creek zone.

Among other sites with elevated sediment molybdenum concentrations is a small pond atop the southern flank of Chee Mountain in the southern part of the survey area. This site (site 4088; 100 ppm), which overlooks Scoop Lake, has the highest molybdenum concentration in the survey area. The third-highest molybdenum concentration (site 4202; 52 ppm) occurs in the northernmost part of the survey area, in an esker field located between the Alaska Highway and the B.C.-Yukon border.

GOLD

Background gold concentration in lake sediments of the North Gataga survey area, as expressed by median values, is 1 ppb. Only nine sites in the survey area contain 10 ppb gold or greater. Interested readers are referred to the discussion on the analytical reproducibility of Gataga gold data in the quality control section of this report, and to the supplementary platinum-palladium-gold

fire assay results for selected samples from the Kitza Creek area.

Elevated values (95th percentile: 7 ppb; max: 28 ppb) are associated with several geological units, but the highest median gold concentration of any unit occurs above the slate and limestone facies (COK) of the Kechika Group. At 4 ppb, the median gold concentration of lake sediments here is considerably greater than the 1 ppb median typical of most other units in the survey area.

Several sites with elevated gold concentrations >95th percentile occur as isolated highs throughout the survey area, but the most interesting single group of lake sediment sites with elevated gold values are found in an approximately 10 km-wide zone in the Hare Lake area. Six sites in this upland area, located north of the Gemini lakes and southeast of the Kechika River, contain 8-28 ppb gold; four of these have at least 10 ppb gold (NTS 94M/05, 06, 12). These anomalous sites are generally associated with siliceous facies units of the Kechika Group (COKs), but a notable feature is their proximity to Early Paleozoic gabbroic rocks mapped in this area by Ferri *et al.* (1997).

Among other areas where sediment gold concentrations exceed background levels is an extensive part of the Liard Plain between Sunshine Lake and Kaska Creek. Numerous lakes in this approximately 25 km x 20 km region contain moderately-elevated to elevated sediment gold concentrations in the range 6-9 ppb. In the southern end of the survey area, one site (4279; 9 ppb gold) located near the northern end of Chee Mountain appears to reflect the presence of the Boya Main Face skarn prospect (MINFILE 94M 021) a few kilometres upslope to the north.

MERCURY

The median mercury concentration of North Gataga survey area lake sediments is 50 ppb, considerably lower than median values reported for either the Nechako area (80-110 ppb; Cook and Jackaman, 1994) or the Pinchi lake area (130 ppb; Cook *et al.*, 1997b). Maximum mercury concentration in the North Gataga area is 560 ppb. The following discussion is based on raw data only and does not consider the role of organic scavenging in controlling lake sediment mercury concentrations.

Relatively higher median mercury concentrations occur in sites draining three of the geological units: Cassiar terrane rocks (CA; median: 90 ppb), Road River Group rocks (OSDRR; median: 90 ppb) and the 'unmapped' area (median: 100 ppb). Individual elevated mercury concentrations >95th percentile (190 ppb) are associated with several units, but the highest concentrations, including the maximum value, most commonly occur in lake sediments draining the Road River Group (OSDRR; max: 560 ppb) and the Hyland Group (PH; max: 330 ppb).

Elevated mercury concentrations >95th percentile occur in four main areas:

- The Moose Lake-Horneline Creek area (NTS 94M/03) in the southern part of the survey area, where several sites containing 250-560 ppb mercury are associated primarily with Road River Group (OSDRR) rocks. The two sites with the highest sediment mercury concentrations (520-560 ppb) are found in Moose Lake. This zone is generally coincident with sites containing elevated values of silver, zinc, cadmium, arsenic, antimony and nickel, in addition to mercury.

- The northern tip of Chee Mountain (NTS 94M/03), where two sites (4276, 4278) contain 210-330 ppb mercury in addition to other elements such as lead and copper. These sites are also located just south of the Boya Main Face skarn prospect (MINFILE 94M 021).

- Twin Island Lake, along the western margin of the survey area, where two sites draining Cassiar terrane rocks to the west contain 250-450 ppb mercury in sediments (NTS 94M/04 and 05). The site with the higher of the two mercury concentrations (site 4123) has the third-highest mercury value in the North Gataga survey area. Elevated concentrations of arsenic, antimony, lead and nickel also occur in these and adjacent sites.

- The Kitza Creek area (NTS 94M/12), where two sites (4175, 4176) overlying Kitza Creek facies sedimentary rocks contain 240-350 ppb mercury in addition to elevated concentrations of zinc, barium, antimony, nickel and other elements.

WATERS

WATER pH

The pH of raw surface lake waters in the North Gataga survey area are in the range 5.2 - 8.6. However, most lake waters here are alkaline, and median pH is 8.1. Only a very small proportion of sites (13 of 445; 2.9%) exhibit a pH of 7.0 or less, and only one site has a pH of less than 6.0. Conversely, a full 90% of the sites exhibit a pH of 7.8 or greater.

Median pH of lake waters draining most units is in the range 8.0 - 8.2. However, the median pH of waters draining Cassiar terrane rocks (CA) is slightly more alkaline (median: 8.4). The lake waters in the 'unmapped' area are the only ones in the North Gataga survey area to exhibit a near-neutral median pH (7.3). Of the few sites which exhibit neutral to acidic pH values of 7.0 or less, nearly all occur within the 'unmapped' area (min: 6.1) or in that part of the survey area overlain by Quaternary sediments (Q; min: 5.2). More specifically, clusters of low-pH sites occur in two areas:

- The southeast corner of the survey area (NTS 94M/02 and 03), particularly that area southeast of Horneline Lake, where pH values as low as 6.1 are among several sites with near-neutral or lower lake water pH values. These sites are underlain by 'unmapped' units, Hyland Group rocks or Cambrian siliciclastic rocks.

- An approximately 14 km-long east-west trending area extending from the Kitza Creek area to Sunshine Lake (NTS 94M/12; 104P/09). Four of the lakes within this region, underlain by Quaternary sediments, have a pH of 7.0 or less. In particular, two ponds located to the south and north of Sunshine Lake have the lowest (site 4440; ph=5.2) and third-lowest (site 4353; pH=6.3) pH levels in the North Gataga survey area, respectively.

Among other clusters of near-neutral pH values in the lower ten percentiles (5.2-7.7) of the data set are sites in the Kitza Creek area, several sites located between Hare Lake and the Gemini lakes which also have elevated sediment gold concentrations, and the area northwest of Graveyard Lake to the Kechika River. A similar cluster of near-neutral pH values in the northwestern part of the survey area occurs in the area between Black Angus Creek and Kloye Creek.

SULPHATE

Median sulphate concentration in North Gataga lake waters is 9 ppm, greater than the median values of 0.6 - 4 ppm sulphate reported for previous surveys of the Nechako Plateau area to the south (Cook *et al.*, 1997b; Cook and Jackaman, 1994). The maximum sulphate concentration here is 730 ppm.

The highest median sulphate concentration occurs in lake waters associated with Devonian Earn Group rocks (DME; median: 280 ppm). Relatively high median sulphate concentrations are also present in lakes draining Kitza Creek facies (P; 170 ppm) and Road River Group rocks (OSDRR; 100 ppm), among other units. By way of contrast, the median sulphate concentration in the large number of lakes underlain by Quaternary sediments (n=212 sites) is only 3 ppm. In fact, there are very few sites with sulphate concentrations above background levels in that relatively flat-lying third of the survey area extending from Kitza and Wadin Creeks to the Yukon border.

In the more rugged southeastern two-thirds of the survey area, elevated sulphate concentrations >95th percentile (280 ppm) occur above several units, most notably rocks of the Road River Group (OSDRR; max: 730 ppm), the Kechika Group (COK; max: 600 ppm), the Kitza Creek facies (P; max: 360 ppm) and the Hyland Group (PH; max: 640 ppm), among others. These and other sites cluster in two distinct areas:

- The eastern and southern flanks of Chee Mountain (NTS 94M/03), where ten sites with elevated sulphate values occur in a zone extending from the Boya Creek-Pup Lake area in the north, to the upland area between Moose and Scoop lakes in the south. These sites are underlain by rocks of the Road River, Kechika and Earn Groups. The highest sulphate value in the survey area (site 4095; 730 ppm) occurs in the northern part of this zone; the third-highest (site 4087; 600 ppm) is in the southern part of the zone near Scoop Lake.

- Three widely-spaced sites (NTS 94M/04 and 05) straddling the Kechika River northwest of the Boya prospects. Three of the top seven sulphate values in the survey area (380-640 ppm) occur here. Of these, two sites are underlain by low-grade metamorphic rocks of the Aeroplane Lake Panel, and the third by Upper Proterozoic rocks of the Hyland Group.

Other areas with elevated sulphate concentrations in lake waters include the Kitza Creek area (up to 360 ppm), where elevated concentrations of several elements occur in sediments, and two oxbow lakes on the eastern side of the Kechika River valley (360-370 ppm). The latter sites are located west of the Gemini lakes and about 2 km south of the Kechika River barite showing.

SUPPLEMENTARY PGE RESULTS: KITZA CREEK AREA

Elevated concentrations of zinc, cadmium, nickel, silver, antimony, molybdenum, barium and selenium, among other elements, are present in lake sediment sites in the Kitza Creek area, most of which are underlain by Ordovician to Mississippian siltstone, argillite and slate of the Kitza Creek facies. In addition to their potential for hosting sedimentary exhalative zinc-lead-silver deposits, these rocks may also have potential for shale-hosted nickel-zinc-molybdenum-PGE deposits, which are known to occur in similar geological environments. Prospects of this type include the Nick nickel-zinc-PGE property, located in the northern part of the Selwyn Basin near Mayo, YT (Hulbert *et al.*, 1992), and the Netson property (Carne, 1991) to the south of the survey area near the Gataga River. In the case of the Netson property, the mineralized sedimentary horizon apparently occurs at the contact between Earn and Road River Group rocks (Carne, 1991).

These sediment-hosted prospects are characterized by elevated concentrations of nickel, molybdenum, barium, zinc, selenium, arsenic, uranium and platinum-group elements (PGE), among other elements, in rocks and stream sediments (Lefebure and Coveney, 1995). The geochemical signature of Kitza Creek area lake sediments is relatively similar to these, but platinum-group element concentrations are not routinely determined as part of RGS-style geochemical surveys such as the North Gataga survey.

Consequently, prepared sediment material from 14 selected sites in the Kitza Creek area were submitted to Acme Analytical Laboratories, Vancouver, for fire assay determination of platinum, palladium and gold. These sites included those with both elevated metal contents and near-background levels. No sediment remained for some Kitza Creek area sites, and consequently no PGE results were obtained in these cases. The fire assay procedure involved fusion of a 20 gram sample with subsequent acid digestion and ICP analysis. In cases where 20 grams of sediment material was not available, a smaller analytical sample was used.

Results (Table 4) indicate that sediment from the Kitza Creek area does not contain more than background concentrations of platinum or palladium. Results are at or below stated detection limits for most sites. Gold results obtained here vary considerably with the standard INAA gold results in Appendix A. Results for some sites (e.g. 4176) are relatively comparable with the INAA determinations, while those for other sites (e.g. 4377, 4378) are not.

TABLE 4. GOLD-PLATINUM-PALLADIUM RESULTS: KITZA CREEK AREA

Sample	Au (ppb)	Pt (ppb)	Pd (ppb)	Sample Size (g)
964173	2	2	1	20.0
964174	<1	<1	<1	20.0
964175	10	<1	<1	20.0
964176	<1	<1	<1	7.3
964177	4	1	1	20.0
964178	1	1	2	20.0
964179	<1	1	2	20.0
*964179**	*1*	*<1*	*<1*	*20.0*
964317	2	1	2	13.5
964373	2	1	<1	16.8
964374	2	<1	<1	20.0
964376	1	<1	<1	20.0
964377	<1	2	3	19.3
964378	22	<1	<1	7.7
964379	<1	<1	<1	20.0
Silica Blank	*<1*	*<1*	*<1*	*20.0*

* Blind duplicate repeat

SUMMARY

A regional lake sediment and water geochemistry survey, the North Gataga survey (445 sites), was conducted during 1996 in the northern Kechika Trough over parts of the Rabbit River (NTS 94M) and McDame (NTS 104P) map areas. The survey is a contribution to the ongoing objective of completing Regional Geochemical Survey lake sediment coverage of selected areas of central B.C. This survey confirms the locations of known mineral prospects and outlines new areas for prospective sedimentary exhalative-style zinc-lead-barium mineralization. Areas of potential gold mineralization are also indicated. Four areas of particular interest to explorationists include:

- Zinc, nickel and several other elements in lake sediments of the Kitza Creek area (NTS 94M/12). These are generally associated with black slates and argillites of the Kitza Creek facies.

- Zinc, nickel, antimony, silver and other elements in the Chee Mountain-Moose Lake-Horneline Creek area (NTS 94M/03) in the southern part of the survey area.

- Lead in sediments of numerous lakes in the extreme southeastern part of the survey area near the Rabbit River (NTS 94M/02 and 03).

- Gold in sediments of several lakes, associated with Kechika Group siliceous facies rocks, to the north of the Gemini lakes (NTS 94M/05, 06, 12).

ACKNOWLEDGMENTS

Survey design and implementation was by the authors. Sample preparation and geochemical analyses were conducted by the following companies:

PREPARATION:

Bondar-Clegg and Company, Ottawa, Ontario

SEDIMENT ANALYSIS:

CanTech Laboratories Inc., Calgary, Alberta (AAS)
Activation Laboratories Ltd., Ancaster, Ont. (INAA)
Acme Analytical Laboratories, Vancouver (PGE-FA)

WATER ANALYSIS:

CanTech Laboratories Inc., Calgary, Alberta

Survey duties were allocated as follows:

Survey Design: *Cook*
Sample Collection: *Cook, Jackaman, Friske, Day, Coneys*
Quality Control: *Cook*
Data Interpretation: *Cook*
Geology and topographic basemaps: *Ferri*
Geochemical Map Production: *Cook*
Open File Production and Coordination: *Cook, Jackaman*

The authors thank Hilda Reimer, cook at the Graveyard Lake base camp, for the fine meals provided during the field program. Helicopter services were provided by Frontier Helicopters, Watson Lake, YT. Watson Lake Flying Services Ltd. provided transport between Watson Lake and the base camp. The cooperation of the North Gataga bedrock mapping team, particularly F. Ferri, C. Rees, J. Nelson and A. Legun, contributed a great deal to the success of the project. These individuals also collected the stream sediment samples, geochemical data for which is presented in this report. The authors also thank H.F.N. Wong and G.J. Wyatt for office assistance, and P.F. Matysek for reviewing the manuscript.

REFERENCES

APHA/AWWA/WEF (1992): Standard Methods for the Examination of Water and Wastewater. 18th Edition. Greenberg, A.E., Clesceri, L.S. and Eaton, A.D., Editors.

Armstrong, J.E. and Tipper, W.F. (1948): Glaciation in North Central British Columbia; *American Journal of Science*, Volume 246, pages 283-310.

Aslin, G.E.M. (1976): The Determination of Arsenic and Antimony in Geological Materials by Flameless Atomic Absorption Spectrophotometry; *Journal of Geochemical Exploration*, Volume 6, pages 321-330.

Balkwill, J.A. (1991): Limnological and Fisheries Surveys of Lakes and Ponds in British Columbia: 1915-1990; *B.C. Ministry of Environment, Lands and Parks*, Fisheries Technical Circular No.90, 157 pages.

Carne, R.C. (1991): Report on Geochemical Sampling and Geological Mapping on the Netson Property, British Columbia, Liard Mining Division; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 21980.

Cecile, M.P. and Norford, B.S. (1991): Ordovician and Silurian Assemblages, Chapter 7; *in* Geology of the Cordilleran Orogen in Canada, Gabrielse, H. and Yorath, C.J., Editors, *Geological Survey of Canada*, Geology of Canada, No. 4, pages 184-196.

Cook, S.J. (1993): Preliminary Report on Lake Sediment Studies in the Northern Interior Plateau, Central British Columbia (93C, E, F, K, L); *in* Geological Fieldwork 1992, Grant, B. and Newell, J.M., Editors, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1993-1, pages 475-481.

Cook, S.J. (1995): Gold Distribution in Lake Sediments near Epithermal Gold Occurrences in the Northern Interior Plateau, British Columbia; *in* Drift Exploration in the Canadian Cordillera, Bobrowsky, P.T., Sibbick, S.J., Newell, J.M. and Matysek, P.F., Editors, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1995-2, pages 193-213.

Cook, S.J. (1997): Regional and Property-Scale Application of Lake Sediment Geochemistry in the Search for Buried Mineral Deposits in the Northern Interior Plateau, British Columbia; *in* Interior Plateau Geoscience Project: Summary of Geological, Geochemical and Geophysical Studies, Diakow, L.J. and Newell, J.M., Editors, *B.C. Ministry of Employment and Investment*, Paper 1997-2, pages 175-203.

Cook, S.J. and Jackaman, W. (1994): Regional Lake Sediment and Water Geochemistry of part of the Nechako River Map Area (93F/2,3; 93F/6,11,12,13,14); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Open File 1994-19.

Cook, S.J., Levson, V.M., Giles, T.R. and Jackaman, W. (1995): A Comparison of Regional Lake Sediment and Till Geochemistry Surveys: A Case Study from the Fawnie Creek Area, Central British Columbia; *Exploration and Mining Geology*, Volume 4, pages 93-110.

Cook, S.J., Jackaman, W., Friske, P.W., Day, S.J., Coneys, A.M. and Wong, H.F.N. (1997a): Preliminary Regional Lake Sediment Geochemistry of the Northern Kechika Trough, British Columbia; *B.C. Ministry of Employment and Investment*, Open File 1997-14.

Cook, S.J., Jackaman, W., McCurdy, M.W., Day, S.J. and Friske, P.W. (1997b): Regional Lake Sediment and Water Geochemistry of part of the Fort Fraser Map Area, British Columbia (NTS 93K/9, 10, 15 and 16); *B.C. Ministry of Employment and Investment*, Open File 1996-15.

Cope, G.R. and Spence, C.D. (1995): Mac Porphyry Molybdenum Prospect, North-central British Columbia; *in* Porphyry Deposits of the Northwestern Cordillera of North America, Schroeter, T.G., Editor, *Canadian Institute of Mining, Metallurgy and Petroleum*, Special Volume 46, pages 757-763.

Dawson, J.M. (1988): Geological and Geochemical Report on the Wolf Property, Omenica Mining Division, British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 16995.

Ferri, F., Rees, C., Nelson, J. and Legun, A. (1997a): Geology of the Northern Kechika Trough (94L/14,15; 94M/3,4,5,6,12; 104P/8,9,15,16); *in* Geological Fieldwork 1996, *B.C. Ministry of Employment and Investment*, Paper 1997-1, pages 125-144.

Ferri, F., Rees, C., Nelson, J. and Legun, A. (1997b): Geology of the Northern Kechika Trough (94L/14,15; 94M/3,4,5,6,12; 104P/8,9,15,16); *B.C. Ministry of Employment and Investment*, Open File 1997-14.

Ferri, F., Rees, C., Nelson, J., Cook, S.J., Jackaman, W., Lett, R., Sibbick, S., Levson, V. and Paradis, S. (1997c): New Geological Results from the Northern Kechika Trough: a Sedex Frontier; *British Columbia and Yukon Chamber of Mines*, 1997 Abstracts, 14th Annual Cordilleran Geology and Exploration Roundup, pages 17-19.

Ferri, F., Rees, C. and Nelson, J. (1996a): Geology and Mineralization of the Gataga Mountain Area, Northern Rocky Mountains (94L/10, 11, 14, 15); *in* Geological Fieldwork 1995, Grant, B. and Newell, J.M., Editors, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1996-1, pages 137-154.

Ferri, F., Rees, C. and Nelson, J. (1996b): Preliminary Geology of the Gataga Mountain Area (94L/10, 11, 14, 15); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Open File 1996-3.

Ferri, F., Nelson, J. and Rees, C. (1995a): Geology and Mineralization of the Gataga River Area, Northern Rocky Mountains (94L/7, 8, 9, 10); *in* Geological Fieldwork 1994, Grant, B. and Newell, J.M., Editors, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1995-1, pages 277-298.

Ferri, F., Nelson, J. and Rees, C. (1995b): Preliminary Geology of the Gataga River Area (94L/7, 8, 9, 10); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Open File 1995-4.

Ficklin, W.H. (1970): A Rapid Method for the Determination of Fluoride in Rocks and Soils, Using an Ion-Selective Electrode; *United States Geological Survey*, Professional Paper 700C, pages 186-188.

Fletcher, W.K. (1981): Analytical Methods in Geochemical Prospecting; Handbook of Exploration Geochemistry, Volume 1, Govett, G.V.S., Editor, *Elsevier*, 255 pages.

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.

Friske, P.W.B. and Hornbrook, E.H.W. (1991): Canada's National Geochemical Reconnaissance Programme; *Transactions of the Institution of Mining and Metallurgy*, Volume 100, pages B47-B56.

Friske, P.W.B., McCurdy, M.W., Day, S.J., Gross, H., Balma, R.G., Lynch, J.J. and Durham, C.C. (1994): National Geochemical Reconnaissance Lake Sediment and Water Data, Southeastern Yukon (Parts of NTS 105A); *Geological Survey of Canada*, Open File 2860.

Gabrielse, H. (1963): McDame Map-Area, Cassiar District, British Columbia; *Geological Survey of Canada*, Memoir 319 and Map 1110A, 138 pages.

Gabrielse, H. (1962): Geology: Rabbit River, British Columbia (94M); *Geological Survey of Canada*, Map 46-1962.

Garrett, R.G. (1974): Field Data Acquisition Methods for Applied Geochemical Surveys at the Geological Survey of Canada; *Geological Survey of Canada*, Paper 74-52.

Hall, G.E.M. (1979): A Study of the Stability of Uranium in Waters Collected from Various Geological Environments in Canada; *in* Current Research, Part A, *Geological Survey of Canada*, Paper 79-1A, pages 361-365.

Holland, S.S. (1976): Landforms of British Columbia - A Physiographic Outline; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Bulletin 48.

Hulbert, L.J., Gregoire, D.C., Paktunc, D. and Carne, R.C. (1992): Sedimentary Nickel, Zinc and Platinum-Group-Element Mineralization in Devonian Black Shales at the Nick property, Yukon, Canada: A New Deposit Type; *Exploration and Mining Geology*, 1, pages 39-62.

Jackaman, W., Lett, R. and Sibbick, S. (1996): Geochemistry of the Gataga Mountain Area (Parts of 94L/7, 8, 9, 10, 11, 14, 15); *B.C. Ministry of Employment and Investment*, Open File 1996-18.

Johnson, W.M., Hornbrook, E.H.W. and Friske, P.W.B. (1987a): National Geochemical Reconnaissance 1:250 000 Map Series - Whitesail Lake, British Columbia (NTS 93E); *B.C. Ministry of Energy, Mines and Petroleum Resources*, RGS 16.

Johnson, W.M., Hornbrook, E.H.W. and Friske, P.W.B. (1987b): National Geochemical Reconnaissance 1:250 000 Map Series - Smithers, British Columbia (NTS 93L); *B.C. Ministry of Energy, Mines and Petroleum Resources*, RGS 17.

Jonasson, I.R., Lynch, J.J. and Trip, L.J. (1973): Field and Laboratory Methods Used by the Geological Survey of Canada in Geochemical Surveys: No. 12, Mercury in Ores, Rocks, Soils, Sediments and Water; Geological Survey of Canada, Paper 73-21.

Lefebure, D.V. and Coveney, R.M., Jr. (1995): Shale-hosted Ni-Zn-Mo-PGE; *in* Selected British Columbia Mineral Deposit Profiles, Volume 1; Lefebure, D.V. and Ray, G.E., Editors, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Open File 1995-20, 135 pages.

Lynch, J. (1990): Provisional Elemental Values for Eight New Geochemical Lake Sediment and Stream Sediment Reference Materials LKSD-1, LKSD-2, LKSD-3, LKSD-4, STSD-1, STSD-2, STSD-3 and STSD-4; *Geostandards Newsletter*, Volume 14, pages 153-167.

MacIntyre, D.G. (1992): Geological Setting and Genesis of Sedimentary Exhalative Barite and Barite-Sulfide Deposits, Gataga District, Northeastern British Columbia; *Exploration and Mining Geology*, Volume 1, pages 1-20.

MacIntyre, D.G. (1991): Sedex-Sedimentary Exhalative Deposits; *in* Ore Deposits, Tectonics and Metallogeny in the Canadian Cordillera; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1991-4, pages 25-70.

Mathews, W.H., Gabrielse, H. and Rutter, N.W. (1975): Glacial Map, Beatton River Sheet (1,000,000): *Geological Survey of Canada*, Open File 274.

Miller, D.C. and Harrison, J.C. (1981): Geological and Geochemical Report on the Peg-1 to Peg-5, Rous-1 and Rous-2, JW-3 and JW-4 Claims; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 9442.

MINFILE 094M, Rees, C.J. (1995): Rabbit River; *B.C. Ministry of Energy, Mines and Petroleum Resources*, MINFILE, released March 1995.

MINFILE 104P, Bradford, J. and Jakobsen, D.E. (1988): McDame Mineral Occurrence Map; *B.C. Ministry of Energy, Mines and Petroleum Resources*, MINFILE, released December 1988.

NGR (1979): Regional Stream Sediment and Water Geochemical Reconnaissance Data: McDame Map Area (NTS 104P); *Geological Survey of Canada*, Open File 562, NGR 42.

Rainsford, D.R.B. (1984): Geophysical Report on Val, Roman 50, Rom 1, Rom 2, and Vent 19 Claims; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 12731.

Thompson, M. and Howarth, R.J. (1978): A New Approach to the Estimation of Analytical Precision; *Journal of Geochemical Exploration*, Volume 9, pages 23-30.

Thurber Consultants Ltd. (1981): Liard River Hydroelectric Development-Soils, Surficial Geology and Landforms Inventory, Appendix A; Report for British Columbia Hydro and Power Authority; August, 1981.

BRITISH COLUMBIA
Ministry of Employment and Investment
Energy and Minerals Division
Geological Survey Branch

SAMPLE SITE LOCATION MAP

TO ACCOMPANY

Geological Survey Branch
OPEN FILE 1997-15

Geological Survey of Canada
OPEN FILE 3499

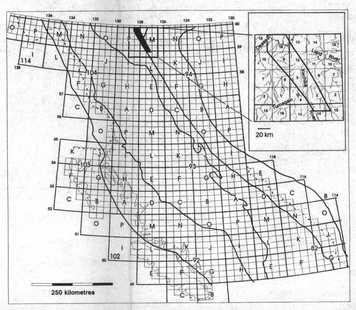
REGIONAL LAKE SEDIMENT AND WATER GEOCHEMISTRY OF THE NORTHERN KECHIKA TROUGH, BRITISH COLUMBIA

NTS 94M/2, 3, 4, 5, 6, 12; 104P/8, 9, 10, 15, 16

by Stephen Cook, Wayne Jackaman, Peter Friske, Stephen Day, Anna Coneys and Filippo Ferri

SCALE 1:100 000

kilometres
1 0 1 2 3 4 5 6 7 8 9 10



BASE MAP INFORMATION

ELEVATIONS IN METRES OR FEET ABOVE SEA LEVEL; CONTOUR INTERVALS VARY

TRANSVERSE MERCATOR PROJECTION

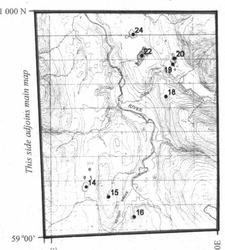
ONE THOUSAND METRE UNIVERSAL TRANSVERSE MERCATOR GRID, ZONE 9

NORTH AMERICAN DATUM 1927

GRID NORTH IS APPROXIMATELY 1° EAST OF TRUE NORTH

BASE MAPS PRODUCED BY SURVEYS AND MAPPING BRANCH, MINISTRY OF NATURAL RESOURCES, OTTAWA

Rabbit River Inset Map



See Rabbit River Inset Map Above

BC Geological Survey Branch Open File 1996-18