



Ministry of Employment and Investment
Hon. Dan Miller, Minister

ENERGY AND MINERALS DIVISION
Geological Survey Branch

**SPRING WATER AND SPRING
SEDIMENT GEOCHEMISTRY OF
THE GATAGA MOUNTAIN AREA
(PARTS OF 94L/7, 8, 9, 10, 11, 14, 15)**

By Ray Lett, P.Geo., Wayne Jackaman and
Steve Sibbick, P.Geo.

OPEN FILE 1996-30

Canadian Cataloguing in Publication Data

Lett, Raymond Ernest Wingrove, 1945-

Spring water and spring sediment geochemistry of the
Gataga Mountain area (parts of 94L/7, 8, 9, 10, 11, 14, 15)

Open File, ISSN 0835-3530 ; 1996-30

Issued by Geological Survey Branch.
Includes bibliographical references : p.
ISBN 0-7726-2935-8

1. Water - Composition - British Columbia - Gataga
Mountain Region. 2. Sediments (Geology) - British Columbia
- Gataga Mountain Region. 3. Geochemistry - British
Columbia - Gataga Mountain Region. 4. Geology, Economic
- British Columbia - Gataga Mountain Region. I. Jackaman,
W. (Wayne) II. Sibbick, Steven John Norman, 1963- III.
British Columbia. Ministry of Employment and Investment.
IV. British Columbia. Geological Survey Branch. V. Series:
Open file (British Columbia. Geological Survey Branch) ;
1996-30.

QE515.L47 1996 551.9'09711'85 C96-960200-6



VICTORIA
BRITISH COLUMBIA
CANADA

June 1996

TABLE OF CONTENTS

EXECUTIVE SUMMARY	2
INTRODUCTION	2
OPEN FILE FORMAT	2
REGIONAL SETTING	2
SAMPLE COLLECTION	3
SAMPLE PREPARATION	3
SPRING WATER ANALYSIS.....	3
SPRING SEDIMENT ANALYSIS.....	4
ANALYTICAL QUALITY CONTROL	6
GUIDES TO INTERPRETATION	7
REFERENCES	7

APPENDIX A SAMPLE LOCATION MAP AND ANOMALY SUMMARY

APPENDIX B GEOLOGY AND MINERAL OCCURRENCES

APPENDIX C FIELD OBSERVATIONS, ANALYTICAL AND DUPLICATE SAMPLE DATA

APPENDIX D SUMMARY STATISTICS

NOTE: DATA INCLUDED IN THE APPENDICES ARE AVAILABLE FROM THE AUTHOR AS COMMA DELINEATED FILES ON 3.5" DISKETTE IN DOS FORMAT.

EXECUTIVE SUMMARY

Spring water and spring sediment samples were collected over part of the Kechika Trough to complement geological mapping and a regional stream sediment - stream water geochemical survey. Spring water samples were analyzed for aluminum, antimony, arsenic, barium, cadmium, calcium, cobalt, copper, iron, lead, lithium, manganese, magnesium, molybdenum, nickel, potassium, rubidium, selenium, silicon, sodium, strontium, thorium, thallium, uranium, vanadium and zinc by inductively coupled plasma mass spectroscopy. The water samples were also analyzed for pH, conductivity, fluoride and sulphate. Sediment samples were analyzed for antimony, arsenic, barium, bromine, cerium, cesium, chromium, cobalt, gold, hafnium, iron, lanthanum, lutetium, molybdenum, nickel, rubidium, samarium, scandium, sodium, tantalum, terbium, thorium, tungsten, uranium, ytterbium and zinc by neutron activation; for antimony, arsenic, bismuth, cadmium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, silver, and zinc by aqua regia digestion-atomic absorption spectrometry; for fluoride by ion selective electrode and for loss on ignition. Iron oxide precipitates surrounding springs near Bluff Creek and the headwaters of Through Creek have high levels of arsenic, cobalt, molybdenum, nickel and zinc. The spring waters have high conductivity, sulphate and typically have high arsenic, cobalt, thallium and zinc contents. Two other springs in the survey area have anomalous elements including lead, silver and mercury in sediment and water. No secondary iron oxides were observed at either of the sites.

INTRODUCTION

Ground water springs in the Kechika Trough are commonly associated with iron oxide precipitate and other secondary mineral deposits. Previous studies in the area surrounding the Driftpile and Bear deposits (NTS 94K4) have revealed significant differences between the chemistry of ground-water draining sedimentary exhalative barite-lead-zinc mineralization and that from pyrite-bearing Paleozoic shale (Lett and Jackaman, 1995). Spring water and spring sediment samples were collected during the Gataga Mountain stream sediment and water survey (Jackaman, Lett and Sibbick, 1996) to test the exploration potential of ground water chemistry for base metal deposits similar to the Stronsay (Cirque), Bear and Driftpile Creek.

Ministry personnel carried out the spring water and sediment sampling in July, 1995. A total of 38 stream sediment and water samples were collected from 34 sites in an area covering approximately 500 square kilometres extending from Through Creek to Matulka Creek (Figure 1). The low sample density reflects the distribution of active springs within the area underlain predominantly by the Silurian Upper Road River and the Devonian Earn groups

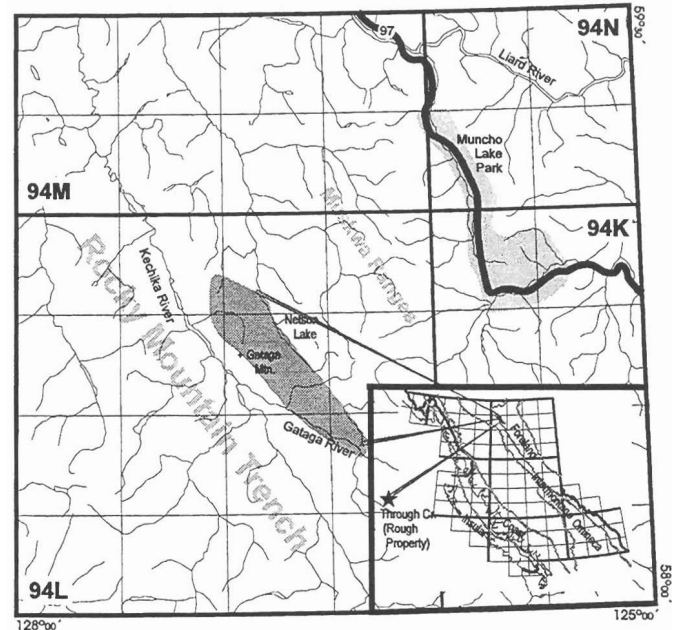


Figure 1. Survey Location Map

REGIONAL SETTING

The survey area lies along the western margin of the Rocky Mountain sub-province of the Canadian Cordilleran Foreland Belt. The main depositional element in the area is the northwest-trending, Paleozoic Kechika Trough which connects to the northwest with the Selwyn Basin in Yukon Territory. Strata within the map area range in age from Late Proterozoic to early Mississippian and belong to the Hyland, Gog, Kechika, Road River and Earn groups. Sedimentary exhalative barite \pm sulphide mineralization is important economically within the Kechika Basin. Late Devonian sedimentary exhalative mineralization is the most significant and is hosted by black shale, siliceous shale, chert and mudstone of the lower Earn Group. Most important occurrences are the Cirque (Stronsay), Driftpile Creek, Akie, Bear and Mount Alcock deposits. The bedrock geology base map (Appendix B) used in this Open File is from MacIntyre *et al.*, 1995.

The spring water survey area covers several valleys within in the western Muskwa Ranges extending roughly 100 km from the Gataga River near Split Top Mountain to north of Matulka Creek. Samples were also collected near the headwaters of Through Creek located 35 km south of Split Top Mountain. The Muskwa Ranges are a region of moderate to high relief with ridge elevations exceeding 2000 metres. Above tree line (1500 metres), surface vegetation consists of scattered alpine fir, willow and heather. Below tree line are alpine fir, black spruce and alder. Mixed woodland, grassland and swamp are typical of the valley bottoms. Drift and colluvium deposits of varying thickness cover

valley floors and lower hill slopes. Ridge crest are covered with rock talus and felsenmeer.

Within the survey area, the British Columbia mineral deposits database lists the Black Wednesday (MINFILE 094L 006), Solo (MINFILE 094L 015), Smoke (MINFILE 094L 016), Bluff Creek (MINFILE 094L 018), Mat (MINFILE 094L 019) and Rough (MINFILE 094L 011) mineral showings. Ferri *et al.* (1995b, 1996b) has also identified new barite-sulphide mineralization (Appendix C) in the lower part of the Earn Group, in Ordovician shales of the Road River Group and basal rocks of the Kechika Group.

SPRINGS AND SPRING DEPOSITS

Ground water springs, often surrounded by secondary mineral deposits, are a common feature of the Ketchika Trough. Previous ground-water geochemical studies (Lett and Jackaman, 1995) around the Bear Pb-Zn-Ag occurrence (Fig 1) determined that the acid (pH <5.0) spring water typically has elevated aluminum, barium, lead and thallium levels. Corresponding secondary iron oxide spring deposits are enriched in bromine, lead, silver and thallium. However, in areas where springs drain pyritic shales rather than Pb-Zn-Ag sulphides, the ground water is more alkaline and commonly has high levels cadmium, calcium, cobalt, fluorine, magnesium, nickel, zinc and uranium. The secondary iron oxide spring deposits associated with these alkaline springs have abundant arsenic, cadmium, cobalt, molybdenum, nickel, cadmium and zinc. Thick, laminated red to dark brown iron oxide terracettes and recent iron hydroxide precipitates, similar to those seen at the Bear property, surround springs on the Rough Claims close to the headwaters on Through Creek and on the Bluff Creek property (Figure 1). Granular calcium carbonate and calcrete spring deposits are more common in the Ketchika Trough north of Through Creek. A water temperature of 22.5°C and strong hydrogen sulphide odor detected at one calcium carbonate spring on the south side of the Gataga River suggests that the water may have a thermal source. Several of the springs north of Bluff creek had no associated precipitates or sediment.

SAMPLE COLLECTION

Helicopter supported sample collection was carried out during the summer of 1995. A total of 36 spring sediment and 38 spring water samples (including field duplicates) were collected from 34 sites (Appendix A). Spring water samples were collected in 250 millilitre bottles at each site. Precautions were taken to exclude suspended solids from the water sample. Mineral precipitate (iron oxide or calcium carbonate) or fine grained stream sediment (<1 mm) weighing 1-2 kilograms was collected from as close as possible to the spring water discharge point and stored in kraft paper bags. Observations on sample medium, sample site and local terrain were recorded at each site.

SAMPLE PREPARATION

Field-dried sediment samples were shipped to the Geological Survey Branch, Victoria for final sample preparation. The samples were air-dried, crushed in a mortar and the -230 mesh (<63 µm) fraction was obtained by dry sieving. Quality control reference standards and analytical duplicate samples were inserted into analytical blocks of twenty sediment samples. Any -230 mesh sediment remaining after analyses was archived for future analyses.

In the field camp, a 250 millilitre portion of each spring water sample was filtered through a 0.45 micron cellulose nitrate filter paper and acidified to pH 2-3 with 50% ultrapure nitric acid. Filtered and unfiltered distilled, deionized water blanks were prepared and acidified at the same time as the samples. A second unfiltered 250 millilitre portion of the water and unfiltered distilled, deionized water blanks were stored in a cool room (5-8°C) for later pH, uranium, fluoride and sulphate analysis. Dissolved solids (conductivity) was measured with a Hanna Model DiST 3ATC meter. The pH and temperature were measured with a combination glass-reference electrode and a Corning Checkmate meter. At the Ministry's laboratory, quality control reference standards and were inserted into analytical blocks of twenty water samples.

SPRING WATER ANALYSIS

Water samples were analyzed for trace and major elements by ICP-MS in addition to pH, sulphate, fluoride and uranium. Detection limits for each element are listed in Table 1.

pH by Glass-reference Electrode

Unfiltered water pH was measured by CanTech Laboratories (Calgary, Alberta) on an aliquot of the sample in a clean dry beaker with a Fisher Accumet pH Meter and a combination glass-reference electrode.

Sulphate by Turbidimetry

Sulphate in unfiltered water samples was determined by CanTech Laboratories (Calgary, Alberta) using a turbidimetric method. A 20 millilitre aliquot was mixed with barium chloride and an isopropyl alcohol-hydrochloric acid-sodium chloride reagent. The turbidity of the resulting barium sulphate suspension was measured with a Milton Roy colorimeter at a wavelength of 420 nanometers.

Fluoride by Specific Ion Electrode

Fluoride in unfiltered water samples was determined by CanTech Laboratories (Calgary, Alberta) using an ion specific electrode method. An aliquot of the sample was mixed with an equal volume of total ionic strength adjustment buffer (TISAB II solution) and the fluoride measured using a Corning 101 Electrometer with Orion Fluoride and reference electrodes.

Uranium by Laser-Induced Fluorescence

Uranium in unfiltered water samples was determined by CanTech Laboratories (Calgary, Alberta) using laser-induced fluorescence analysis. A 5 millilitre sample was spiked with 0.5 millilitre of fluran solution for 24 hours and activated by laser energy to cause fluorescence. Uranium was determined with a Scintrex UA-3 uranium analyzer.

Trace and Major Elements by Inductively Coupled Plasma Mass Spectroscopy (ICP-MS)

Activation Laboratories (Ancaster, Ontario) analyzed filtered and acidified water samples for aluminum, antimony, arsenic, barium, cadmium, calcium, cobalt, copper, iron, lead, lithium, manganese, magnesium, molybdenum, nickel, potassium, rubidium, selenium, silicon, sodium, strontium, thorium, thallium, uranium, vanadium and zinc by inductively coupled plasma mass spectroscopy (ICP-MS) using a Perkin Elmer Elan 6000 mass spectrometer and an AS91 Perkin Elmer autosampler.

An advantage of ICP-MS for water analysis compared to inductively coupled plasma emission spectrometry (ICP-ES) and atomic absorption spectrometry (AAS) is that this method can determine elements to lower concentrations and is less susceptible to inter-element interference.

The spring water sampling and the associated regional stream water survey (Jackaman, Lett and Sibbick, 1996) represent the first regional geochemical surveys in British Columbia where ICP-MS has been used routinely for water sample analysis. This method is therefore described here in more detail. A 10 millilitre aliquot of the water sample is spiked with an internal standard of known element concentrations. The spiked sample is introduced through a nebulizer into a plasma (partially ionized gas) where elements are ionized at a temperature approaching 7500 K. Part of the plasma is transferred to a low-pressure region (1 Torr) through a water cooled sampler. An in-line skimmer allows the gas jet to pass into a high-vacuum chamber (10^{-5} Torr) where electrostatic lenses collect ions from the supersonic gas jet and focus the ion beam into a mass analyzer. In the quadrupole mass analyzer ions are deflected into a detector depending on their mass to charge ratio. A channel electron multiplier for counts the ions for a particular element and provides an estimate of element concentration.

At Activation Laboratories the spring and stream water samples were analyzed using external calibration with internal standards. Water samples were spiked with an internal standard of known element concentrations. Two in-house reference standards were also prepared using fully certified and traceable standards which contained all elements of interest. These standards are used to prepare calibration curves. Each group of samples analyzed contained a certified reference standard

(SLRS-3) and a reagent blank (18.2 m Ω hm deionized water). The data were calculated from the in-house standard calibration curves and results for the SLRS-3 certified values.

Interferences found in ICP-MS are spectral and sample matrix induced (Hall, 1992). Two mass spectral interferences are caused by species formed in the plasma gas (e.g. Ar⁺) and in the acids used for water sample preservation (e.g. ArCl⁺). The second interference can be minimized by using nitric acid as a preservative. Commonly associated matrix elements (e.g. TiO⁺ on ⁶²Ni⁺, ⁶³Cu⁺, ⁶⁵Cu⁺) are also a potential source of spectral interference. This can be minimized by selecting an element isotope which is free from spectral overlap or by mathematically correcting for its presence. Examples of interfering species are the formation of rare earth element, tungsten and molybdenum oxides (MO⁺), the interference of cadmium by molybdenum oxide and the interference by ArCl⁺ on arsenic and selenium isotopes. These spectral interference can be reduced by various measures such as adding an organic solvent to the sample which suppresses the influence of ArCl⁺ on arsenic and selenium isotopes. Non spectral interference is caused by differences in transport efficiency of heavy and light ions in the ion beam. Because of this effect, suppression of lithium could be expected in a solution containing high uranium. Non-spectral interference can be reduced by appropriate instrument tuning to enhance the analyte signal and maintaining the total salt solution below 0.1%.

Several elements (e.g. Au) which reported a significant number of values (over 95%) below instrument detection limit have not been included in this report. The ICP-MS instrument detection limits and method detection limits are shown in Table 1. The instrument detection limits are those stated by Activation Laboratories. The method detection limits (mean + 3 standard deviation level) were calculated from element data for the acidified (ultrapure nitric acid) filtered, distilled, deionized water blanks inserted into sample batches before routine analysis. The method detection limit is a guide to the expected levels of element introduction during field filtration.

SPRING SEDIMENT ANALYSIS

CanTech Laboratories (Calgary, Alberta) analyzed the sediment samples for antimony, arsenic, bismuth, cadmium, cobalt, copper, fluorine, iron, lead, manganese, mercury, molybdenum, nickel, silver, vanadium, and zinc. Detection limits for each element are listed in Table 2.

Antimony by Hydride Vapour-Atomic Absorption Spectrometry

Antimony was determined as described in Aslin (1976). A 0.5 gram sample was mixed in a test tube with 3

millilitre of concentrated nitric acid and 9 millilitre of concentrated hydrochloric acid. The mixture was allowed to stand overnight at room temperature and then heated to 90°C for 90 minutes. The mixture was cooled and a 1 millilitre aliquot was diluted to 10 millilitre with 1.8M hydrochloric acid. This dilute solution was analyzed for antimony by hydride generation-atomic absorption spectroscopy.

Arsenic and Bismuth by Hydride Vapour-Atomic Absorption Spectrometry

A 1 gram sample was digested with 3 millilitre of concentrated nitric acid for 30 minutes at 90°C. Concentrated hydrochloric acid (1millilitre) was added and the digestion continued at 90°C for an additional 90 minutes. A 1 millilitre aliquot of the solution was diluted to 10 millilitre with 1.5M hydrochloric acid in a clean test tube. The diluted sample solution was added to a sodium borohydride solution and the element hydride evolved passed through a heated quartz tube positioned in the light path of an atomic absorption spectrometer.

Cadmium, Cobalt, Copper, Iron, Lead, Manganese, Nickel, Silver and Zinc by Flame-Atomic Absorption Spectrometry

A 1 gram sample was digested with 3 millilitre of concentrated nitric acid for 30 minutes at 90°C. Concentrated hydrochloric acid (1millilitre) was added and the digestion was continued at 90°C for an additional 90 minutes. The sample solution was then diluted to 20 millilitre with distilled-deionized water and mixed. Concentrations of cadmium, cobalt, copper, iron, lead, manganese, nickel, silver, and zinc were determined by atomic absorption spectrometry using an air-acetylene flame. Background corrections were applied for cobalt, nickel, lead and silver.

Fluorine by Ion Selective Electrode

Fluorine was determined as described in Ficklin (1970). A 0.25 gram sample was sintered with a 1 gram flux consisting of 2 parts by weight of sodium carbonate and 1 part by weight of nitric acid. The residue was then leached with water and the residual sodium carbonate was neutralized with 10 millilitre of 10% citric acid. The resulting solution was diluted to 100 millilitre with water to a pH of 5.5. to 6.5 and fluoride ion measured with an ion selective electrode and a Corning 101 Electrometer.

Molybdenum and vanadium by Flame Atomic Absorption Spectrometry

Molybdenum and vanadium were determined by atomic absorption spectrometry using nitrous oxide acetylene flame. A 0.5 gram sample was digested with 1.5 millilitre of concentrated nitric acid at 90°C for 30 minutes. 0.5 millilitre of concentrated hydrochloric acid was added and the digestion continued for an additional 90 minutes. After cooling, 8 millilitre of 1250 ppm

aluminum solution was added and the sample solution diluted to 10 millilitre. The solution was analyzed for molybdenum and vanadium by flame atomic absorption spectrometry.

Mercury by Cold Vapour Atomic Absorption Spectrometry

A 0.5 gram sample was digested with 20 millilitre of

Table 1. Instrument and method detection limits for elements determined by ICP-MS, Ion Selective Electrode (F), Turbidimetry (SO₄) and Laser-Induced Fluorescence (U)

Element	Instrument Detection Limit (ppb)	Method Detection Limit (ppb)
Al	0.2	7.5
Ag	0.002	0.002
As	0.02	0.07
Ba	0.002	1.62
Ca	1	882
Cd	0.002	0.07
Co	0.002	0.013
Cr	0.1	2.69
Cu	0.002	2.24
Fe	0.2	19.36
K	1	145
Li	0.1	0.44
Mg	0.5	185
Mn	0.02	2.72
Mo	0.02	0.66
Na	0.8	454
Ni	0.002	4.29
Pb	0.02	0.2
Rb	0.002	0.14
Sb	0.02	0.02
Se	0.02	2.71
Si	1	120
Sr	0.002	8
Th	0.002	0.05
Tl	0.002	0.01
U	0.002	0.15
V	0.02	0.33
Zn	0.002	13
F (ppb)	20	20
SO ₄ (ppm)	1	1
U (ppb)	0.05	0.05

concentrated nitric acid and 1 millilitre concentrated hydrochloric acid in a test tube for 10 minutes at room temperature and then heated for 2 hours in a 90°C water bath. After digestion the sample was cooled and diluted to 100 millilitre with distilled, deionized water. The mercury present in the sample was reduced to elemental form by the addition of 10 millilitre of 10% weight per

253.7 nanometres. The method is described in detail by Jonasson, *et al.* (1973).

Loss on Ignition

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 left to cool at room temperature for 4 hours before weighing.

Elements by Instrumental Neutron Activation

A 15 gram split of each spring sediment sample was analyzed for antimony, arsenic, barium, bromine, cerium, cesium, chromium, cobalt, gold, hafnium, iron, lanthanum, lutetium, molybdenum, nickel, rubidium, samarium, scandium, sodium, tantalum, terbium, thorium, tungsten, uranium, ytterbium and zinc by Activation Laboratories (Ancaster, Ontario) using instrumental thermal neutron activation analysis. This method involves irradiating the sediment samples, which range from 5 to 20 grams (average 15 grams), for 30 minutes in a reactor with a neutron flux of 7×10^{11} neutrons/cm²/second. After a decay period of approximately 1 week, gamma-ray emissions from secondary isotopes of elements were measured using a gamma-ray spectrometer with a high resolution, coaxial germanium detector. Counting time was approximately 15 minutes per sample and counts were converted to concentrations using data for internal standards. Table 2 lists the instrumental detection limits for elements determined by neutron activation.

ANALYTICAL QUALITY CONTROL

Meaningful interpretations of geochemical data require that real variations, related to geological and geochemical factors, are distinguished from sampling and analytical error. Control reference standards, analytical duplicates and field duplicates are routinely used to monitor and analytical accuracy and precision. Each analytical block of twenty sediment samples typically comprises 17 routine samples, a field duplicate sample, an analytical duplicate sample and a control reference standard sample. Analytical blocks of corresponding water samples contain a control reference standard sample and a blank (filtered or unfiltered), but no analytical duplicate samples. Four field duplicates and two analytical replicates analytical replicate samples were included with the spring water and sediment samples analyzed. Results of the field replicate analyses are listed in Appendix. Results of the two analytical replicate sample analyses are listed in Table C-1.

Analytical precision for pH, uranium, fluoride, sulphate and for elements by ICP-MS was calculated from data produced by multiple analyses of two Geological Survey Branch Water Standards GSB-A (8 analyses) and GSB-B (4 analyses). These standards were analyzed

Table 2. Instrument detection limits for elements determined by neutron activation, atomic absorption, ion selective electrode (F) and loss on ignition (LOI)

Element	Detection Limit (INA)	Detection Limit (AAS)
Au	2 ppb	
Ag	5 ppm	0.2 ppm
As	0.5 ppm	0.2 ppm
Ba	50 ppm	
Br	0.5 ppm	
Ca	1%	-
Cd		0.2 ppm
Ce	3 ppm	-
Co	1 ppm	2 ppm
Cr	5 ppm	-
Cs	1 ppm	-
Cu		2 ppm
Eu	0.2 ppm	-
Fe	0.01%	0.02%
Hf	1 ppm	-
Hg	1 ppm	10 ppb
Ir	5 ppb	
La	0.5 ppm	
Mn		5 ppm
Mo	1 ppm	2 ppm
Na	0.01%	
Nd	5 ppm	
Ni	20 ppm	2 ppm
Pb		2 ppm
Rb	15 ppm	
Sb	0.1 ppm	0.2 ppm
Sc	0.1 ppm	
Se	3 ppm	
Sm	0.1 ppm	
Sn	100 ppm	
Sr	500 ppm	
Ta	0.5 ppm	
Th	0.2 ppm	
Tb	0.5 ppm	
U	0.5 ppm	
W	1 ppm	
V		5 ppm
Yb	0.2 ppm	-
Zn	50 ppm	2 ppm
F	40 ppb	
LOI	0.1%	

volume stannous sulphate in sulphuric acid. The mercury vapor was flushed by a stream of air into an absorption cell mounted in the light path of an atomic absorption spectrometer. Measurements were made at

in a single batch comprising the spring water samples and the RGS stream water samples reported in Open

Table: 3 Analytical precision for elements determined in water samples from Standards GSB-A. and B Mean values are in ppb. SO₄ is in ppm

Element	Mean	%RSD	Mean	%RSD
	<u>GSB-A</u>	<u>GSB-A</u>	<u>GSB-B</u>	<u>GSB-B</u>
Al	1.9	60	11	31
Ag	-0.002	<1	2.48	35
As	0.08	69	0.03	248
Ba	359.5	10	1.24	37
Ca	4215	21	403	152
Cd	0.015	46	14.74	5
Co	0.2	7	20.47	6
Cr	1.6	71	1.58	200
Cu	2.1	20	42.11	2
Fe	34	8	31.55	16
K	507	10	23	101
Li	309	7	0.02	600
Mg	8226	4	4.4	42
Mn	3.75	10	0.33	38
Mo	0.11	34	0.02	0
Na	105622	4	102.5	7
Ni	0.02	100	53.04	13
Pb	0.128	16	11.92	17
Rb	0.5	6	0.01	100
Sb	0.015	94	0	0
Se	0.4	180	0.6	200
Si	2436	20	124	90
Sr	875.9	3	0.61	63
Th	0.022	250	0	0
Tl	0.103	8	0.1	30
U	0.67	19	0.01	-180
V	0.23	70	0.22	209
Zn	0.52	44	20.19	5
SO ₄	13	12		
F	0.66	11		
pH	3.7	1		
U	0.28	7		

File 96-18. Mean concentrations and percent relative standard deviations (RSD) for elements are shown in Table 3. Precision for the elements typically present in the spring water (e.g. Cd, Co, Cu, Fe, Ni, Pb, Zn) is better than 20% RSD.

GUIDES TO DATA INTERPRETATION AND ANOMALY SUMMARY

Among the factors responsible for the distribution and concentration of elements in the spring sediment and water are:-

- **Surface Absorption of Elements to Iron Oxide Spring Deposits.** This process can produce large concentrations of arsenic, cadmium, cobalt, copper, lead, mercury, molybdenum, nickel, selenium, silver, uranium, vanadium and zinc. The chemistry of spring deposits reflects the distribution of different elements in the spring water. Oxides formed from spring water draining metal-enriched shales typically have high levels of cobalt, nickel, molybdenum, uranium and zinc. Higher levels of bromine, lead, silver and thallium in iron oxides could indicate ground water flowing from buried base-metal sulphides.
- **Water pH.** Water pH is one of the main factors controlling the solubility of dissolved minerals and the accumulation of elements by secondary iron oxides. Metals are more strongly absorbed by iron oxides and hydroxides at higher pH. This factor may be responsible for the high arsenic, cobalt, molybdenum, nickel and zinc found in spring samples from Bluff and Through Creek. More alkaline waters can have enhanced uranium levels through formation of bicarbonate, but non-detectable concentrations of the least soluble elements (e.g. Pb). For this reason, the lead detected in water sample 952020 could be significant.

A summary of spring and sediment samples with anomalous elements (values above mean + 2 standard deviations) are shown in Appendix B. Two of the anomalous sites are at Red Bluff Creek and Through Creek (Rough Property). In both cases the enhancement of arsenic, cobalt, molybdenum, nickel and zinc reflects accumulation of metals in secondary iron oxides. Other anomalies (952020 and 952027) have no apparent source of metal enrichment in sediment and water.

REFERENCES

- 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.
- Ferri, F., Rees, C. and Nelson, J.L. (1996a): Geology and Mineralization of the Gataga Mountain Area, Northern Rocky Mountains; *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.L. (1996b): Geology and Mineralization of the Gataga Mountain Area, Northern Rocky Mountains; *In Geological Fieldwork 1995*, Grant, B. and Newell, J.M., Editors, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Open File 1996-3.

- Ferri, F., Nelson, J.L. 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.L. 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*, Open File 1994-4.
- Hall, G.E.M. (1992): Inductively Coupled Mass Spectrometry in Geoanalysis; *Journal of Geochemical Exploration*, Volume 44, pages 201-250.
- Jackaman, W., Lett, R.E. and Sibbick, S.J. (1996): Geochemistry of the Gataga Mountain Area, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Open File 96-18.
- 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.
- Lett, R.E. and Jackaman, W. (1994): Application of Spring-Water Chemistry to Exploration in the Driftpile Creek Area, Northeastern B.C. (94K/4, 94L/1): in Geological Fieldwork 1994, Grant, B. and Newell, J.M., Editors, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1995-1, pages 269- 275.
- MacIntyre, D.G., Legun, A., Bellefontaine, K.S. and Massey, N.W.D. (1995): Mineral Potential Project - Digital Geological Compilation NEBC North 1/2; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Open File 1995-6.
- MINFILE 094L, Rees, C. (1995): Kechika Mineral Occurrence Map; *B.C. Ministry of Energy, Mines and Petroleum Resources*, MINFILE, released March 1995

Energy and Minerals Division
Geological Survey Branch

Open File 1996-30

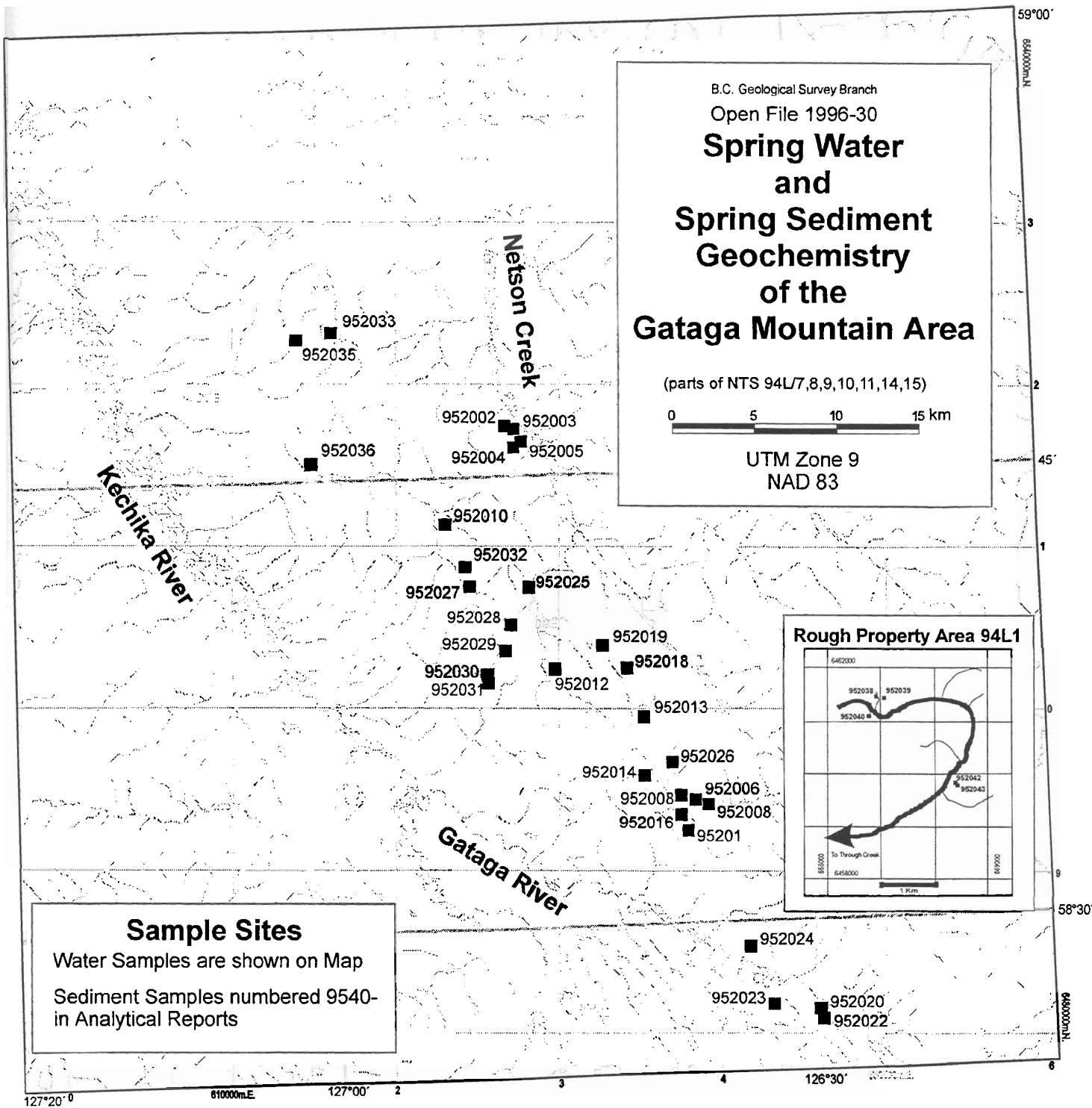
SPRING WATER AND SPRING SEDIMENT GEOCHEMISTRY of the GATAGA MOUNTAIN AREA

(parts of 94L/7, 8, 9, 10, 11, 14, 15)

Appendix A

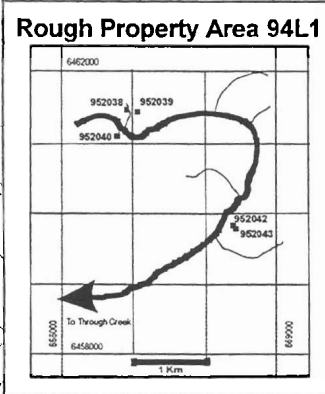
Page A-2 Sample Location Map

Page A-3 Anomaly Summary



B.C. Geological Survey Branch
 Open File 1996-30
**Spring Water
 and
 Spring Sediment
 Geochemistry
 of the
 Gataga Mountain Area**
 (parts of NTS 94L/7,8,9,10,11,14,15)
 0 5 10 15 km
 UTM Zone 9
 NAD 83

Sample Sites
 Water Samples are shown on Map
 Sediment Samples numbered 9540-
 in Analytical Reports



Energy and Minerals Division
Geological Survey Branch

Open File 1996-30

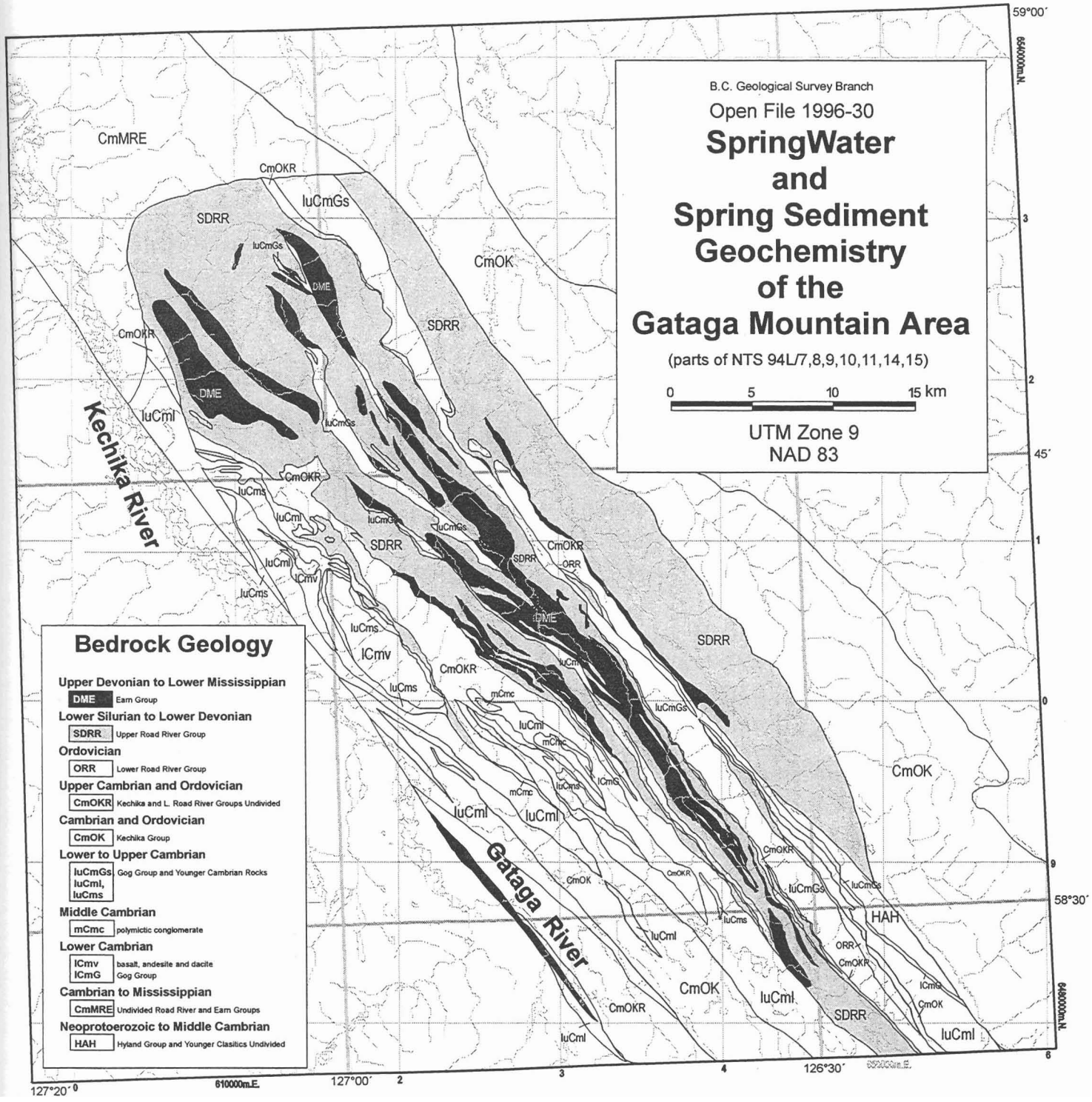
SPRING WATER AND SPRING SEDIMENT GEOCHEMISTRY of the GATAGA MOUNTAIN AREA

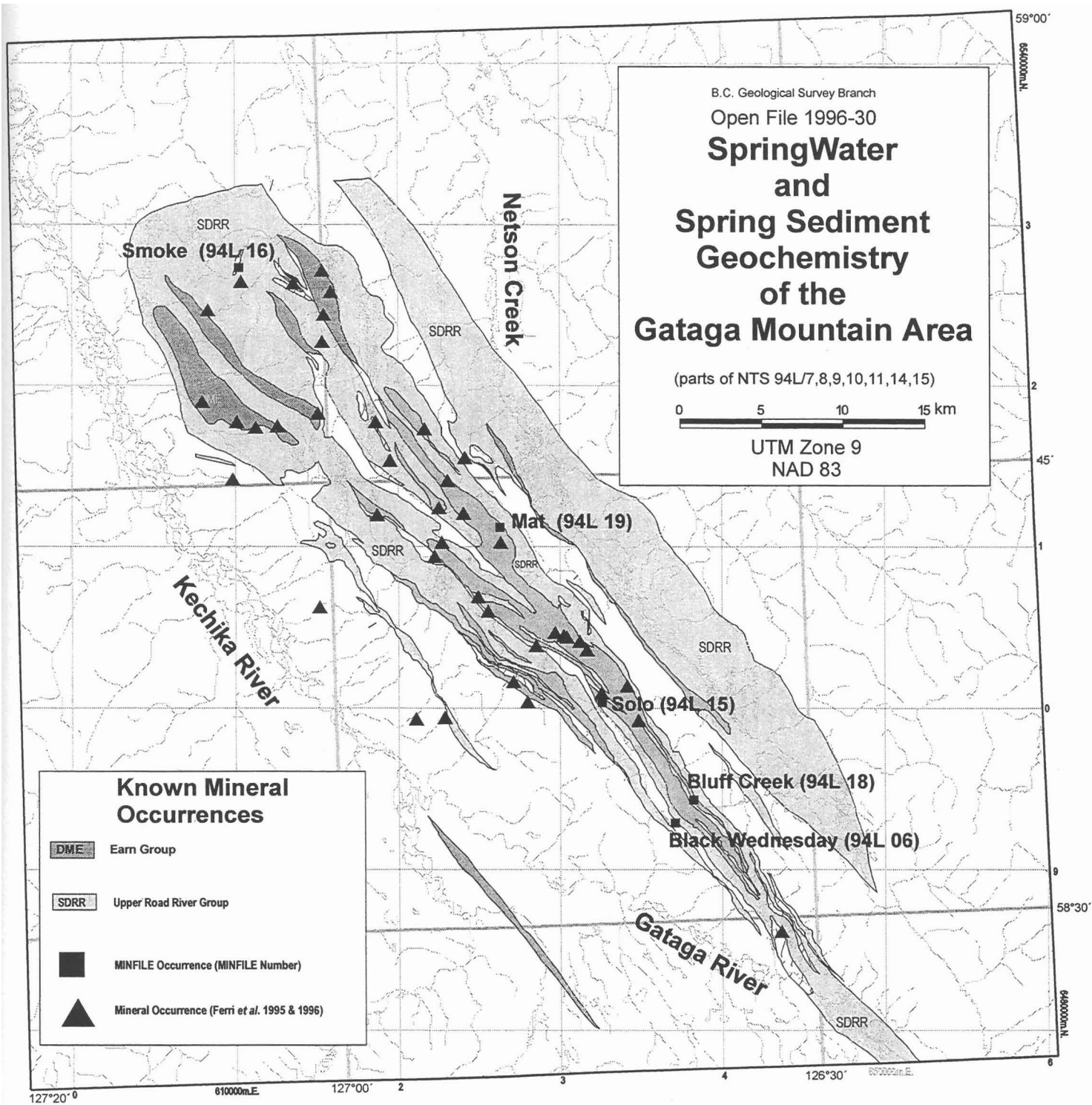
(parts of 94L/7, 8, 9, 10, 11, 14, 15)

Appendix B

Page B-2. Bedrock Geology

Page B-3. Known Mineral Occurrences





Open File 1996-30

SPRING WATER AND SPRING SEDIMENT GEOCHEMISTRY of the GATAGA MOUNTAIN AREA

(parts of 94L/7, 8, 9, 10, 11, 14, 15)

Appendix C

- Page C- 2. Field Observations
- Page C- 3. Reference Guide to Field Observations
- Page C- 4. Spring Water ICPMS Data
- Page C- 5. Atomic Absorption Data
- Page C- 6. Neutron Activation Data
- Page C- 7. Duplicate Sample Analytical Data.

Field Observations

MAP ID	SAMPLE ZONE	UTM EAST	UTM NORTH	ELEV STA	MED FORM	WAT COL	FLW COL	SED TYP	PPT CON	STRM WPTH	STRM DPTH	BANK	CHL PPT	CHL BED	PHY M	DRN M	TYPE D	ODR P	SRC	DATE						
94L15	952002	9	626916	6517342	880	6	DME	0	2	W	C	N	310	0.1	0.1	C	N	S	M	M	D	P	1	G	607	
94L15	952003	9	627111	6516874	880	6	DME	0	2	W	C	N	122	0.1	0.1	C	N	S	M	M	D	P	1	G	607	
94L15	952004	9	627169	6516711	880	6	DME	0	2	W	C	N	310	0.1	0.1	C	N	S	M	M	D	P	1	G	607	
94L15	952005	9	627233	6516640	880	6	DME	0	2	W	C	N	310	0.1	0.1	C	N	S	M	M	D	P	1	G	607	
94L10	952006	9	637905	6493903	900	10	6	DME	0	2	R	F	N	130	0.1	0.1	A	N	F	M	M	D	P	1	G	707
94L10	952007	9	637904	6493899	900	20	6	DME	0	2	R	F	N	130	0.1	0.1	A	N	F	M	M	D	P	1	G	707
94L10	952008	9	637798	6493937	900	6	DME	0	3	R	F	N	130	0.1	0.1	A	N	F	M	M	D	P	1	G	707	
94L10	952010	9	623477	6511296	1220	6	SDRR	0	1	W	C	N	310	0.1	0.1	C	N	S	M	M	D	P	1	G	1007	
94L10	952011	9	629273	6502963	1180	6	SDRR	0	2	T		N	133	0.1	0.1	A	N	F	M	M	D	P	1	G	1007	
94L10	952012	9	633355	6499000	1060	6	SDRR	0	1	T		N	220	0.1	0.1	A	N	F	M	M	D	P	1	G	1007	
94L10	952013	9	634952	6499444	1280	6	DME	0	2	R	F	N	131	0.1	0.1	A	N	F	M	M	D	P	1	G	1007	
94L10	952014	9	635633	6495664	1040	6	LuGs	0	2	T		N	221	0.1	0.1	A	N	F	M	M	D	P	1	G	1007	
94L10	952015	9	637606	6492988	1200	6	DME	0	1	W	C/F	N	220	0.1	0.1	A	N		M	M	D	P	1	G	1007	
94L10	952016	9	637359	6493677	880	6	DME	0	1	T		N	310	0.5	0.1	A	N	S	M	M	D	P	1	G	1007	
94L10	952017	9	638000	6493891	880	6	DME	0	1	W	C	N	300	0.1	0.1	A	N	S	M	M	D	P	1	G	1007	
94L10	952018	9	633057	6502991	880	7	DME	0	1			N		0.1	0.1	A	N	O	M	M	D	P	1	G	1007	
94L10	952019	9	632407	6503584	1320	7	DME	0	1			N		0.1	0.1	A	N	O	M	M	D	P	1	G	1007	
94L08	952020	9	650862	6477519	780	6	SDRR	0	2	W	C	N	300	0.2	0.2	A	N	S	M	M	D	P	1	G	1007	
94L08	952022	9	651153	6477147	780	6	SDRR	0	2	W	C	N	300	0.2	0.2	A	N	S	M	M	D	P	1	G	1007	
94L08	952023	9	650653	6477752	780	6	SDRR	0	2	W	C	N	301	0.5	0.2	A	N	S	M	M	D	P	1	G	1007	
94L07	952024	9	641014	6485167	740	6	LuL	0	1	W	C	N	300	0.1	0.1	A	N	S	M	M	D	P	1	G	1007	
94L10	952025	9	628264	6507566	1180	6	DME	0	1	T		N	301	0.1	0.1	G	N	F	M	M	D	P	1	G	1107	
94L10	952026	9	636675	6496542	1260	6	DME	0	1	T	C	N	310	0.1	0.1	A	N	S	M	M	D	P	1	G	1107	
94L10	952027	9	624261	6507565	1280	6	DME	0	1	T		N	221	0.1	0.1	A	N	S	M	M	D	P	1	G	1107	
94L10	952028	9	627380	6505501	1220	6	DME/SDRR	0	1	W		N	221	0.1	0.1	A	N	F	M	M	D	P	1	G	1107	
94L10	952029	9	626476	6503748	1320	6	DME/SDRR	0	1	R	F	N	31	0.1	0.1	G	N	F	M	M	D	P	1	G	1107	
94L10	952030	9	625950	6502222	1360	10	6	DME/SDRR	0	2	G		N	130	0.2	0.1	C	N	F	M	M	D	P	1	G	1107
94L10	952031	9	626007	6502030	1360	20	6	DME/SDRR	0	2	G		N	130	0.2	0.1	C	N	F	M	M	D	P	1	G	1107
94L10	952032	9	623932	6507994	1260	6	DME	0	1	T	C	N	210	0.2	0.1	A	N	F	M	M	D	P	1	G	1107	
94L15	952033	9	616385	6523789	1120	6	DME	0	2	T		N	221	0.1	0.1	A	N	F	M	M	D	P	1	G	1107	
94L14	952035	9	613990	6523266	1300	6	DME	0	2	G	C	N	130	0.2	0.1	A	N	F	M	M	D	P	1	G	1107	
94L14	952036	9	615027	6514893	1020	6	SDRR/DME	0	2	G	C	N	130	0.1	0.1	A	N	F	M	M	D	P	1	G	1107	
94L08	952037	9	666913	6461394	1760	10	6	SDRR	0	2	R	F	N	130	0.1	0.1	C	N	F	M	M	D	P	1	G	1507
94L08	952038	9	666913	6461394	1760	20	6	SDRR	0	2	R	F	N	130	0.1	0.1	C	N	F	S	M	D	P	1	G	1507
94L08	952039	9	666850	6461350	1760	6	SDRR	0	2	G		N	310	0.5	0.2	C	N	S	S	M	D	P	1	G	1507	
94L08	952040	9	666658	6461133	1760	6	SDRR	0	3	G		N	310	1	0.2	C	N	S	S	M	D	P	1	G	1507	
94L01	952042	9	668250	6459600	1500	10	6	SDRR	0	2	R	F	N	120	0.1	0.1	C	N	S	S	M	D	P	1	G	1507
94L01	952043	9	668255	6459600	1500	20	6	SDRR	0	2	R	F	N	120	0.1	0.1	C	N	S	S	M	D	P	1	G	1507

Table C - 1. Reference Guide for Field Observations

MAP	1:50 000 NTS Map Sheet Number	SED COMP	Sediment Composition, Estimate of Sand - Fines - Organic Content : 0 Absent 1 Minor (<1/3 of total) 2 Moderate (1/3 to 2/3 of total) 3 Major (>2/3 of total)
SAMPLE ID	Sample Site Number	STRM WDTH	Stream Width 1 m from Spring (metres)
UTM ZONE	Site UTM Zone	STRM DPTH	Stream Depth 1 m from Spring (centimetres)
UTM EAST	Site UTM East Coordinate (NAD 83)	BANK	Bank Composition : U Unknown G Glacial Outwash A Alluvium R Rock C Colluvium S Scree-Talus O Organic
UTM NORTH	Site UTM North Coordinate (NAD 83)	BNK PPT	Bank Precipitate : N None (otherwise, same as SED COL)
ELEV	Elevation at Sample Site (metres)	CHL BED	Channel Bed : B Boulders F Clay-Sand S Sand-Gravel O Organic
STA	Replicate Sample Status : 10 1st Field Duplicate 20 2nd Field Duplicate	CHL PTN	Channel Pattern : S Shoots-Pools M Meandering
MED	Sample Media Collected : 6 Spring Water and Sediment 7 Spring Water only	PHY	Physiography : M Mature Mts P Plateau
FORM	Geological Unit	DRN	Drainage Pattern : D Dendritic
WAT COL	Water Colour : 0 Colourless 2 White Cloudy 1 Brown Clear 3 Brown Cloudy	TYP	Stream Type : P Permanent S Seasonal
FLW	Water Flow Rate : 0 Stagnant 1 Slow 2 Moderate 3 Fast 4 Torrent	ODR	Stream Order : 1 Primary 2 Secondary 3 Tertiary
SED COL	Sediment Colour : R Red W White-Buff G Grey-Blue B Black T Tan-Brown	SRC	Stream Source : G Groundwater
PPT TYPE	Sediment Precipitate : N None (otherwise, same as SED COL)	DATE	Sample Collection Date (day/month)
CON	Site Contamination : N None		

Atomic Absorption Data

MAP ID	SAMPLE ID	UTM ZONE	UTM EAST	UTM NORTH	ELEV	STA	MED	FORM	Ag	As	Bi	Cd	Cu	Co	Fe	F	Hg	LOI	Mn	Mo	Ni	Pb	Sb	V	Zn
									ppm	ppm	ppm	ppm	ppm	ppm	%	ppb	ppb	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm
94L15	954002	9	626916	6517342	880			6 DME	0.3	8.3	0.2	0.5	14	7	0.2	170	20	6.2	4	6	4	2	0.2	20	12
94L15	954003	9	627111	6516874	880			6 DME	0.7	21	0.3	32	47	2	0.65	190	160	41.3	75	5	71	2	0.4	24	4760
94L15	954004	9	627169	6516711	880			6 DME	0.3	6.4	0.4	0.6	15	<2.0	0.1	200	20	7.5	6	6	6	<2.0	0.1	19	12
94L15	954005	9	627233	6516640	880			6 DME	0.2	2	0.3	0.3	14	3	0.15	240	10	6	10	2	5	<2.0	0.1	20	14
94L10	954006	9	637905	6493903	900	10		6 DME	0.4	100	1.9	33	5	58	39	480	20	25.7	1600	805	1560	2	4.9	13	20750
94L10	954007	9	637904	6493899	900	20		6 DME	0.5	230	3.1	64	7	64	36	570	30	28.1	2050	882	1660	2	6.5	10	20500
94L10	954008	9	637798	6493937	900			6 DME	0.3	200	3.6	189	9	77	39	960	20	26.2	3600	384	1040	<2.0	18	16	16700
94L10	954010	9	623477	6511296	1220			6 SDRR	0.2	4.1	0.5	40	26	<2.0	0.2	190	40	9.4	20	4	30	2	0.3	24	584
94L10	954011	9	629273	6502963	1180			6 SDRR	0.8	4.3	0.4	13	94	9	1.5	590	240	18.2	2200	5	312	15	0.9	50	1120
94L10	954012	9	633355	6499000	1060			6 SDRR	0.3	7.6	0.3	56	47	2	0.2	440	80	32.9	15	6	136	2	0.5	32	1170
94L10	954013	9	634952	6499444	1280			6 DME	0.3	135	2.4	46	6	61	40	200	10	24	2190	224	170	<2.0	8.8	9	4850
94L10	954014	9	635633	6495664	1040			6 Lu/Gs	0.4	6.4	0.2	2.2	19	3	0.65	320	30	11.3	408	6	22	4	0.6	17	93
94L10	954015	9	637606	6492988	1200			6 DME	0.3	21	0.4	95	295	36	29	820	60	29.1	363	15	545	<2.0	1.4	26	13700
94L10	954016	9	637359	6493677	880			6 DME	0.2	18	0.2	39	41	265	14	500	70	19.7	8200	16	652	6	1.7	30	8800
94L10	954017	9	638000	6493891	880			6 DME	0.6	3.2	0.1	0.2	12	2	0.15	680	10	7.3	<5.0	4	10	<2.0	0.2	15	228
94L08	954020	9	650862	6477519	780			6 SDRR	6.4	0.2	0.2	2.1	43	4	0.3	240	4220	11.8	57	7	21	200	0.4	26	3080
94L08	954022	9	651153	6477147	780			6 SDRR	0.5	3.9	0.3	0.7	14	2	0.7	300	30	15.7	82	4	8	6	0.1	20	96
94L08	954023	9	650653	6477752	780			6 SDRR	3	4.2	0.3	0.4	28	3	0.2	300	130	9.5	24	7	16	12	0.1	22	1420
94L07	954024	9	641014	6485167	740			6 Lu/L	0.4	0.1	0.2	3.9	16	4	1.3	220	30	16.5	1900	9	52	2	0.6	24	140
94L10	954025	9	628264	6507566	1180			6 DME	1	4.3	0.3	3.4	36	5	1.2	280	120	16.3	173	8	31	11	0.4	35	178
94L10	954026	9	636675	6496542	1260			6 DME	0.4	1.3	0.4	0.5	13	3	0.4	460	30	17.9	95	2	56	<2.0	0.2	16	265
94L10	954027	9	624261	6507565	1280			6 DME	1.3	29	0.6	270	82	86	0.55	480	190	24.5	6700	72	3510	2	6.7	80	99000
94L10	954028	9	627380	6505501	1220			6 DME/SDRR	0.2	11	0.2	26	33	<2.0	0.2	340	40	11.7	18	4	17	2	0.5	14	171
94L10	954029	9	626476	6503748	1320			6 DME/SDRR	0.2	52	1	<0.2	9	5	24	220	40	32.9	613	23	18	<2.0	2.4	20	61
94L10	954030	9	625950	6502222	1360	10		6 DME/SDRR	0.2	3.1	0.2	0.7	23	9	2.1	170	40	15.4	174	3	28	13	0.5	28	97
94L10	954031	9	626007	6502030	1360	20		6 DME/SDRR	0.2	8.4	0.4	1	69	7	1.9	500	110	29.2	581	2	23	15	0.2	19	65
94L10	954032	9	623932	6507994	1260			6 DME	0.3	90	0.5	0.2	10	4	3.6	390	10	13.7	220	24	14	2	0.9	12	81
94L15	954033	9	616385	6523789	1120			6 DME	0.4	5	0.3	81	117	2	0.2	270	530	21.9	22	5	91	3	0.6	17	907
94L14	954035	9	613990	6523266	1300			6 DME	0.5	0.1	0.2	3.7	17	2	0.15	600	60	12.1	33	8	27	3	0.4	21	688
94L14	954036	9	615027	6514893	1020			6 SDRR/DME	0.2	0.1	0.4	4.1	15	<2.0	0.2	380	20	16.6	36	7	44	<2.0	0.2	23	327
94L08	954037	9	666913	6461394	1760	10		6 SDRR	0.2	90	1.9	550	7	785	38	130	20	23.5	15200	93	1360	21	9.5	40	31750
94L08	954039	9	666850	6461350	1760			6 SDRR	3.5	90	4	97	162	27	2.3	890	720	9.9	710	144	550	259	19	500	6700
94L08	954040	9	666658	6461133	1760			6 SDRR	1.1	65	1.1	2.4	41	13	2.2	580	100	3.3	175	10	40	25	4.2	53	355
94L01	954042	9	668250	6459600	1500	10		6 SDRR	0.2	70	1.5	10	6	66	42	1450	10	16.5	45	37	104	<2.0	3.3	10	4950
94L01	954043	9	668255	6459600	1500	20		6 SDRR	0.5	87	1	7.6	8	72	45	1210	10	15.5	42	22	103	<2.0	1.4	8	5520

Neutron Activation Data

Table with columns: MAP SAMPLE UTM, UTM EAST, UTM NORTH, ELEV STA, MED FORM, Au, Ag, As, Ba, Br, Ca, Co, Cr, Cs, Fe, Hf, Hg, Ir, Mo, Na, Ni, Rb, Sb, Sc, Se, Sn, Sr, Ta, Th, U, W, Zn, La, Ce, Nd, Sm, Eu, Tb, Yb, Lu, Mass. The table contains a dense grid of numerical data for each element and isometry across various sample locations and forms.

Analytical Repeats - Atomic Absorption Analysis

Element	Ag	As	Bi	Cd	Cu	Co	Fe	F	Hg
Units	PPM	PPM	PPM	PPM	PPM	PPM	%	PPM	PPB
Detection limit	0.260.2	0.2	0.2	0.2	2	2	0.02	40	10
954006	0.4	100	1.9	33	5	58	39	480	20
954006 Rep	0.3	150	1.5	30	5	58	37	490	20
954027	1.3	29	0.6	270	82	86	0.55	480	190
954027 Rep	0.9	44	0.7	260	80	78	0.5	370	200

Element	LOI	Mn	Mo	Ni	Pb	Sb	V	Zn
Units	%	PPM	PPM	PPM	PPM	PPM	PPM	PPM
Detection limit	0.1	5	1	2	2	0.2	5	2
954006	25.7	1600	805	1560	2	4.9	13	20750
954006 Rep	25.1	1530	825	1540	-2.0	4.1	11	19800
954027	24.5	6700	72	3510	2	6.7	80	99000
954027 Rep	27.5	6350	65	3260	2	6.1	79	94000

Analytical Repeats-Neutron Activation Analysis

Element	Au	Ag	As	Ba	Br	Ca	Co	Cr	Cs	Fe
Units	PPB	PPM	PPM	PPM	PPM	%	PPM	PPM	PPM	%
Detection limit	2	5	0.5	50	0.5	1	1	5	1	0.02

954006	2	-5	190	720	6.7	3	92	17	-1	43.5
954006 Rep	2	-5	200	410	8.9	1	93	17	-1	44
954027	2	-5	29	740	31	19	110	21	-1	0.51
954027Rep	2	-5	32	1000	31	19	120	28	-1	0.52

Element	Hf	Hg	Ir	Mo	Na	Ni	Rb	Sb	Sc	Se
Units	PPM	PPM	PPB	PPM	%	PPM	PPM	PPM	PPM	PPM
Detection limit	1	1	5	1	0.01	20	15	0.1	0.1	3

954006	-1	-1	-5	890	0.02	1700	43	2.6	0.5	-3
954006 Rep	-1	-1	-5	900	0.03	1800	-15	2.9	0.5	-3
954027	-1	-1	-5	85	0.05	3300	-15	17	2	18
954027Rep	-1	-1	-5	87	0.06	3600	-15	18	2.1	19

Element	Sn	Sr	Ta	Th	U	W	Zn	La	Ce	Nd
Units	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM
Detection limit	100	500	0.5	0.5	0.5	1	50	0.1	3	5

954006	-100	-500	-0.5	-0.5	120	-1	19000	4.1	23	-227
954006 Rep	-100	-500	0.8	-0.5	120	-1	20000	4.3	25	9
954027	-100	-500	-0.5	0.9	24	-1	93000	4.6	9	-5
954027Rep	-100	-500	-0.5	1.7	25	-1	93000	5.1	11	-5

Element	Sm	Eu	Tb	Yb	Lu	Mass
Units	PPM	PPM	PPM	PPM	PPM	g
Detection limit	0.1	0.2	0.5	0.2	0.05	

954006	-227	-0.2	-0.5	-0.2	-0.05	3.305
954006 Rep	-227	-0.2	-0.5	0.3	0.05	3.426
954027	0.4	-0.2	-0.5	0.9	0.21	3.994
954027Rep	-227	0.5	-0.5	0.7	0.19	4.121

Energy and Minerals Division
Geological Survey Branch

Open File 1996-30

SPRING WATER AND SPRING SEDIMENT GEOCHEMISTRY of the GATAGA MOUNTAIN AREA

(parts of 94L/7, 8, 9, 10, 11, 14, 15)

Appendix D

Summary Statistics

Summary Statistics for Spring Waters

Element	U1	F	SO ₄	PH	COND	Al	Ag	As	Ba	Ca	Cd
Units	ppb	ppb	ppm		us	ppb	ppb	ppb	ppb	ppb	ppb
MDL	0.1	20	1		10	0.2	0.002	0.02	0.002	1	0.002
Method	LIF	ION	TURB	GCE	COND	ICPMS	ICPMS	ICPMS	ICPMS	ICPMS	ICPMS

No. Samples	35	35	35	35	35	35	35	35	35	35	35
Minimum	0.1	20	1	5	340	0.2	0.002	0.02	3.409	63025	-0.002
Maximum	23	2440	345	8	1910	141.2	0.13	0.84	213.25	202597	16.45
Range	22.9	2420	344	3	1570	141	0.128	0.82	209.841	139572	16.452
mean	6.871	468.4	138	7.829	737.429	9.043	0.006	0.155	76.616	113703	1.197
Std Deviatio	6.624	647.451	108.654	0.707	326.977	32.546	0.022	0.225	61.83	42483	3.184
Median	3.5	200	120	8	720	0.2	0.002	0.04	64.106	97685	0.051

Element	Co	Cu	Fe	K	Li	Mn	Mg	Mo	Na	Ni	Pb
Units	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
MDL	0.002	0.002	0.1	1	0.1	0.1	0.1	0.02	0.1	0.002	0.02
Method	ICPMS	ICPMS	ICPMS	ICPMS	ICPMS	ICPMS	ICPMS	ICPMS	ICPMS	ICPMS	ICPMS

No. Samples	35	35	35	35	35	35	35	35	35	35	35
Minimum	0.069	0.002	5.3	193	0.9	0.1	7721	1.06	224.1	0.21	0.02
Maximum	57.882	13.444	49745	3388	26	1533	104147	56.4	5089.6	826	0.87
Range	57.813	13.442	49739.7	3195	25.1	1532.9	96426	55.34	4865.5	825.79	0.85
mean	2.848	1.18	1802.83	976.34	7.323	119.431	37161	8.508	2014.554	115.96	0.08
Std Deviatio	9.915	2.184	8437.46	829.27	6.811	300.311	20347	11.615	1243.235	238.45	0.157
Median	0.126	0.957	10.1	700	5.1	0.5	33130	4.24	1676.3	6.95	0.04

Element	Rb	Sb	Se	Si	Sr	Th	Tl	U-ICP	V	Zn
Units	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
MDL	0.002	0.02	0.02	1	0.002	0.002	0.02	0.002	0.02	0.002
Method	ICPMS	ICPMS	ICPMS	ICPMS	ICPMS	ICPMS	ICPMS	ICPMS	ICPMS	ICPMS

No. Samples	35	35	35	35	35	35	35	35	35	35
Minimum	0.08	-0.02	-0.02	1363	180.73	-0.002	0.002	1.345	0.01	2.316
Maximum	3.923	1.81	8.69	6230	1521	0.237	0.234	27.652	3.15	2987.3
Range	3.843	1.83	8.71	4867	1340.27	0.239	0.232	26.307	3.14	2985
mean	0.79	0.255	1.053	2723.1	494.48	0.012	0.027	8.184	0.184	333.15
Std Deviatio	1.015	0.404	1.976	1325.9	339.761	0.044	0.055	7.58	0.577	722.89
Median	0.269	0.11	0.02	2112	347.04	-0.002	0.003	4.344	0.01	9.409

Summary Statistics for Spring Sediments - INA

Element	Au	Ag	As	Ba	Br	Ca	Co	Cr	Cs	Fe	Hf	Hg	Ir	Mo	Na	Ni	Rb
Units	ppb	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	%	ppm	ppm
DL	2	5	0.5	50	0.5	1	1	15	1	0.01	1	1	5	1	0.02	20	15
Method	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA

No. Samples	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
Minimum	-2	-5	-0.7	-50	-0.6	-2	1	-5	-1	0.1	-1	-1	-5	-227	0	-38	-15
Maximum	12	7	330	8200	240	43	860	260	9	50	8	6	-5	890	0.8	3300	110
Range	14	12	330.7	8250	240.6	45	859	265	10	49.9	9	7	0	1117	0.8	3338	125
Mean	1	-4.63	39.58	1161.00	41.13	21.78	60.28	32.09	0.69	10.23	0.875	-0.656	-5	13.875	0.113	304.281	7.75
St. Deviation	4.25	2.12	72.66	1728.73	54.53	15.78	160.38	53.69	2.66	16.51	3.013	1.405	0	212.604	0.183	682.649	42.254
Median	-2	-5	4.35	520	16.5	25.5	6.5	15.5	-1	0.95	-1	-1	-5	5.5	0.1	-20	-15

Element	Sb	Sc	Se	Sr	Ta	Th	U	W	Zn	La	Ce	Nd	Sm	Eu	Tb	Yb	Lu
Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DL	0.1	0.1	3	500	0.5	0.2	0.5	1	50	0.5	3	5	0.1	0.2	0.5	0.2	0.05
Method	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA

No. Samples	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
Minimum	-0.1	0.2	-3	-500	-0.5	-0.5	-0.5	-1	-50	-0.5	-3	-227	-227	-0.2	-0.5	-0.2	-0.1
Maximum	48	16	27	1400	1.8	18	160	33	93000	59	120	52	7.6	3.3	3	13	1.96
Range	48.1	15.8	30	1900	2.3	18.5	160.5	34	93050	59.5	123	279	234.6	3.5	3.5	13.2	2.06
Mean	5.375	3.841	1.594	-306.25	-0.316	2.747	23.441	1.313	6500.156	13.044	24.719	-14.844	-33.669	0.494	-0.088	1.903	0.248
St. Deviation	10.477	4.476	8.473	477.12	0.527	5.176	40.469	6.631	17232.942	17.566	32.722	71.387	84.557	0.976	0.934	3.034	0.48
Median	1.5	2.1	-3	-500	-0.5	0.75	5.8	-1	570	4.4	10	-5	0.45	-0.2	-0.5	0.65	0.09

Summary Statistics for Spring Sediments-Aqua Regia-AAS

Element	Ag	As	Bi	Cd	Cu	Co	Fe	F	Hg	LOI	Mn	Mo	Ni	Pb	Sb	V	Zn
Units	ppm	ppm	ppm	ppm	ppm	ppm	%	ppb	ppb	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DL	0.2	0.2	0.2	0.2	2	2	0.02	40	10	0.1	5	1	2	2	0.2	5	2
Method	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS
No. Samples	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
Minimum	0.2	0.1	0.1	-0.2	5	-2	0.1	130	10	3.3	-5	2	4	-2	0.1	9	12
Maximum	6.4	200	4	550	295	785	42	1450	4220	41.3	15200	805	3510	259	19	500	99000
Range	6.2	199.9	3.9	550.2	290	787	41.9	1320	4210	38	15205	803	3506	261	18.9	491	98988
Mean	0.8	33.0	0.8	50.1	41.1	48.0	8.89	428	223	17.3	1405	61	330	18	3	40	6971
St. Deviation	1.3	48.2	1.0	108.9	58.2	143.7	15.00	287	745	8.9	3163	157	705	56	5	85	18281
Median	0.35	7	0.35	4	18	4	0.675	330	40	16.4	134	7	42	2	0.55	21.5	636