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Stream Sediment and Water Geochemistry of the Ecstall Greenstone Belt

NTS 103H/103I

Wayne Jackaman

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INTRODUCTION

Open File 2001-13 presents new field and analytical data from a reconnaissance-scale stream sediment and water geochemical survey (Figure 1) conducted by the British Columbia Geological Survey Branch in the Ecstall Greenstone Belt during 2000. Results for over 48 different metals in stream sediments and pH, uranium, fluoride and sulphate in stream waters are included in this report. The survey covers parts of eight 1:50,000 NTS map sheets in the Douglas Channel (NTS 103H) and the Terrace (NTS 103I) areas. A total of 228 sites were sampled over a combined area of approximately 1800 square kilometres at an average density of 1 site per 7 square kilometres. Details on the geology and mineral potential of the Ecstall Greenstone Belt are described by Alldrick (2001).

Sample collection, preparation and analytical procedures conform to standards established by the National Geochemical Reconnaissance (NGR) as described by Ballantyne (1991). 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. Funded under the government's Corporate Resource Inventory Initiative (CRII), this survey is part of the Ministry of Energy and Mines' contribution to the North Coast Land Resource Planning process.

REPORT FORMAT

This report is divided into the following sections:

- Introduction and survey methodology.
- Listings of field observations and analytical data (Appendix A).
- Summary statistics (Appendix B).
- Sample location, geology and element maps (Appendix C).
- Analytical and field data are included on diskette in comma-delimited format.

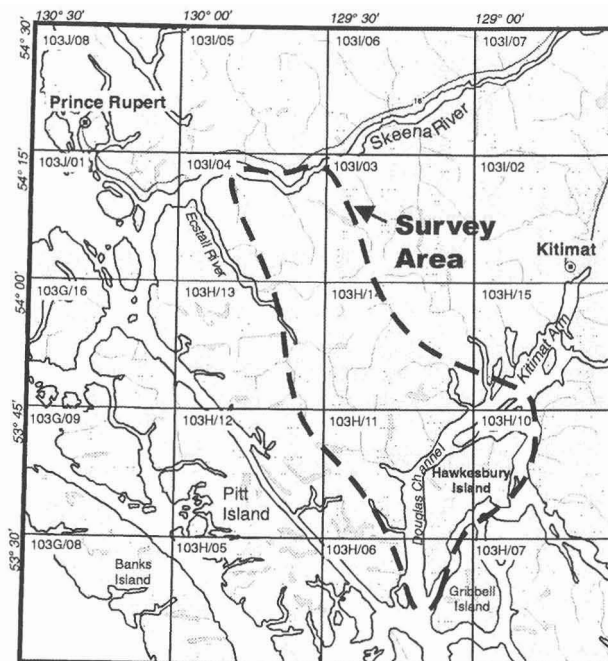


Figure 1. Location map of the Ecstall Greenstone Belt survey area

SURVEY METHODOLOGY

SAMPLE COLLECTION

Helicopter and boat supported sample collection was carried out during the period August 20 to August 26, 2000. A total of 242 drainage sediment and 241 stream water samples were systematically collected from 228 sites. Average sample site density was 1 site per 7 square kilometres over the 1,800 square kilometre survey area. Field duplicate samples (14 total pairs) were routinely collected in each analytical block of twenty samples.

Stream sediment samples weighing 1 to 2 kilograms were obtained from the active (subject to annual flooding) stream channel and placed in kraft paper bags. Samples were primarily composed of fine-grained sediment mixed with

varying amounts of coarse sand, gravel and organic material. Contaminated or poor-quality sample sites were avoided by choosing an alternate stream or by sampling a minimum of 60 metres upstream from the source of contamination. Surface water samples were collected in 250 millilitre bottles. Precautions were taken to exclude suspended solids. Standard field observations regarding sample media, sample site and local terrain were recorded. To assist follow-up, aluminum tags inscribed with the sample site identification number were fixed to permanent objects at each sample site.

SAMPLE PREPARATION

Sediment samples were air dried at a temperature range of 30°C to less than 50°C. Material finer than 1 millimetre was recovered by sieving each sample through a -18 mesh ASTM screen. The -80 mesh (<177 µm) fraction was obtained by dry sieving and was used for all subsequent analytical determinations. Control reference material and analytical duplicate samples were inserted into each analytical block of twenty sediment samples. Any remaining -80 mesh sediment and a representative sample of +80 to -18 mesh fraction was archived for future analyses. Quality control reference standards and analytical blanks were inserted into each analytical block of twenty water samples.

SAMPLE ANALYSIS

Analysis of stream 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. Quality analytical results are ensured by monitoring analytical variation with sample duplicates and control reference standards. A complete list of elements and their stated instrumental detection limits are given in Table 1.

The main analytical methods used to determine elements in stream sediments are aqua regia digestion-inductively coupled plasma emission/mass spectroscopy (ICP), and thermal instrumental neutron activation analysis (INA). INA is non-destructive to the sample and estimates the 'total' element

TABLE 1. ANALYTICAL SUITE OF ELEMENTS

Element		Reported Detection	Units	Analytical Method
Aluminum	Al	0.01	%	ICP
Antimony	Sb	0.02/0.1	ppm	ICP / INA
Arsenic	As	0.1/0.5	ppm	ICP / INA
Barium	Ba	0.5/50	ppm	ICP / INA
Bismuth	Bi	0.02	ppm	ICP
Boron	B	1	ppm	ICP
Bromine	Br	0.5	ppm	INA
Cadmium	Cd	0.01	ppm	ICP
Calcium	Ca	0.01/1	%	ICP / INA
Cerium	Ce	3	ppm	INA
Cesium	Cs	1	ppm	INA
Chromium	Cr	0.5/5	ppm	ICP / INA
Cobalt	Co	0.1/1	ppm	ICP / INA
Copper	Cu	0.01	ppm	ICP
Europium	Eu	0.2	ppm	INA
Gallium	Ga	0.2	ppm	ICP
Gold	Au	0.2/2	ppb	ICP / INA
Hafnium	Hf	1	ppm	INA
Iron	Fe	0.01/0.01	%	ICP / INA
Lanthanum	La	0.5/0.5	ppm	ICP / INA
Lead	Pb	0.01	ppm	ICP
Lutetium	Lu	0.05	ppm	INA
Magnesium	Mg	0.01	%	ICP
Manganese	Mn	1	ppm	ICP
Mercury	Hg	5	ppb	ICP
Molybdenum	Mo	0.01	ppm	ICP
Neodymium	Nd	5	ppm	INA
Nickel	Ni	0.1	ppm	ICP
Phosphorus	P	0.001	%	ICP
Potassium	K	0.01	%	ICP
Rubidium	Rb	15	ppm	INA
Samarium	Sm	0.1	ppm	INA
Scandium	Sc	0.1/0.1	ppm	ICP / INA
Selenium	Se	0.1/3	ppm	ICP / INA
Silver	Ag	2	ppb	ICP
Sodium	Na	0.001/0.01	%	ICP / INA
Strontium	Sr	0.5/0.05	%	ICP / INA
Sulphur	S	0.02	%	ICP
Tantalum	Ta	0.5	ppm	INA
Tellurium	Te	0.02	ppm	ICP
Terbium	Tb	0.5	ppm	INA
Thallium	Tl	0.02	ppm	ICP
Thorium	Th	0.1/0.2	ppm	ICP / INA
Titanium	Ti	0.001	%	ICP
Tungsten	W	0.2/1	ppm	ICP / INA
Uranium	U	0.1/0.5	ppm	ICP / INA
Vanadium	V	2	ppm	ICP
Ytterbium	Yb	0.2	ppm	INA
Zinc	Zn	0.1/50	ppm	ICP / INA
Fluorine	F	10	ppm	ION
Loss on Ignition	LOI	0.1	%	GRAV
Fluoride (waters)	FW	20	ppb	ION
Sulphate (waters)	SO4	1	ppm	TURB
Uranium (waters)	UW	0.05	ppb	LIF
pH (waters)	PH	0.1		GCE

concentration, but this technique is inadequate for measuring ore-indicator elements such as lead and copper. Ore-indicator elements are determined on a separate sample by aqua regia-ICP. Aqua regia digestion, while very effective for dissolving gold, carbonates and sulphides in a sample, cannot completely break down alumino-silicate, oxide and other refractory minerals such as barite. As a result, element concentrations determined by aqua regia-ICP are considered to be 'partial'.

SEDIMENTS

A split of the recovered -80 mesh material was analyzed for 37 elements (aluminum, antimony, arsenic, barium, bismuth, boron, cadmium, calcium, chromium, cobalt, copper, gallium, gold, iron, lanthanum, lead, magnesium, manganese, mercury, molybdenum, nickel, phosphorus, potassium, scandium, selenium, silver, sodium, strontium, sulphur, tellurium, thallium, thorium, titanium, tungsten, uranium, vanadium and zinc) by Acme Analytical Laboratories Ltd., Vancouver, B.C., ICP. The digestion involved leaching a 1 gram sample with 6 millilitres of hydrochloric acid, nitric acid and distilled, deionized water (2:2:2 v/v) at 95°C for one hour. The solution was diluted to 20 millilitres and analysed by inductively coupled plasma emission spectroscopy on a Jarell Ash instrument and inductively coupled plasma mass spectroscopy on a Perkin Elmer Elan 6000 instrument.

An additional split of each sample, which ranged from 12 to 42 grams (average 31 g), was analyzed for 35 elements (antimony, arsenic, barium, bromine, calcium, cerium, cesium, chromium, cobalt, europium, gold, hafnium, iridium, iron, lanthanum, lutetium, mercury, molybdenum, neodymium, nickel, rubidium, samarium, scandium, selenium, silver, sodium, strontium, tantalum, terbium, thorium, tin, tungsten, uranium, ytterbium and zinc) by Activation Laboratories Ltd., Ancaster, Ontario, using INA. This technique involves irradiating the sample for 30 minutes in a neutron flux of 7×10^{11} neutrons/cm²/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. Data for silver, mercury, nickel, molybdenum, iridium and

tin were not published because of inadequate detection limits and/or poor precision.

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).

WATERS

Unfiltered stream water samples were analyzed for pH, uranium, fluoride and sulphate at CanTech Laboratories, Inc., Calgary. Stated detection limits are given in Table 1.

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.

PRELIMINARY DATA INTERPRETATION

The following data interpretation is of a preliminary nature only and should not be considered exhaustive. Discussions on the distribution and abundance of copper, lead, zinc, silver and gold are intended to highlight geochemical anomalies that may be of interest to mineral explorationists targeting VMS mineralization as described by Höy (1995). The geology and mineral deposits of the Ecstall Greenstone Belt mentioned in this open file are described in detail by Alldrick (2001).

The Ecstall Belt currently hosts a total of 36 sulphide mineral occurrences (Map 2). Developed prospects Scotia (MINFILE 103I 007), Ecstall (MINFILE 103H 011) and Packsack (MINFILE 103H 013) are the main sulphide deposits located in the belt and have combined reserves of 10,818,539 tonnes grading 0.5% Cu, 0.05% Pb, 2.1% Zn, 20.8 g/T Ag and 0.4 g/T Au.

Table 2. Geochemical signature for sediment samples collected downstream of known mineral occurrences.

MINFILE	Name	Map	ID	Rep	Cu (ppm)		Pb (ppm)		Zn (ppm)		Ag (ppb)		Au (ppb)	
					ICP	ICP	ICP	ICP	ICP	ICP	ICP	ICP	ICP	ICP
	Ecstall	103H13	9106	10	125.99	14.07	139.8	304	10					
	Ecstall	103H13	9107	20	125.00	11.30	158.1	240	7					
	Strike	103H11	9145	00	74.96	11.88	88.7	99	5					
	Horsefly	103H14	9150	00	70.88	6.61	69.0	102	92					
	Ravine	103H14	9174	00	54.31	6.00	104.4	141	2					
	Steelhead	103H11	9179	00	90.71	3.98	117.2	167	22					
	Scotia	103I04	9038	00	21.33	9.57	80.1	48	2					

The geochemical signature for sediment samples collected downstream from a selection of known mineral occurrences are listed in Table 2. For comparison, summary statistics for the total Ecstall Belt data set and the total RGS data set for copper, lead, zinc, silver and gold in stream sediments are provided in Table 3.

Results show that the samples collected downstream of known occurrences are anomalous in one or more of the listed metals relative to the Ecstall data set and in some cases the total RGS database. Samples 9106/07 collected downstream of the Ecstall deposit are characterized by enhanced concentrations (greater than the 98th percentile) for copper, lead, zinc and silver. Downstream from the Strike occurrence, sample 9145 lists a lead value greater than the 98th percentile and copper and zinc values above the 90th percentile. Sample 9150, collected below the Horsefly (MINFILE 103H 014) showing produced the survey's highest gold value of 92 ppb.

Table 3. Summary statistics for total Ecstall Belt stream sediment data set and the total provincial RGS data set.

	Ecstall Data Set					RGS Data Set				
	Cu ppm ICP	Pb ppm ICP	Zn ppm ICP	Ag ppb ICP	Au ppb INA	Cu ppm AAS	Pb ppm AAS	Zn ppm AAS	Ag ppm AAS	Au ppb INA
N	228	228	228	228	228	41845	41842	41845	41840	27821
Mean	33.93	3.66	51.85	73.0	5.1	36.1	9.3	80.1	0.16	9.4
Med	27.49	2.94	45.70	48.0	2.0	25.0	5.0	61.0	0.10	2.0
SD	28.52	3.19	27.84	117.13	11.04	63.92	105.82	451.58	0.36	46.85
Min	2.12	0.76	12.4	10	2	1	1	1	0.1	2
90 th %	71.01	6.15	83.8	132	7	68	16	126	0.2	14
95 th %	85.13	8.68	103.2	218	26	95	23	165	0.3	26
98 th %	104.92	11.88	139.8	287	37	138	39	250	0.6	64
Max	226.26	27.18	187.9	1563	92	7100	20000	88000	39.0	3530

Table 4 provides the mean and median concentrations calculated for samples underlain by the various stratified and igneous rocks found in the Ecstall Belt (Alldrick, 2001). As expected, element concentrations for samples underlain by the Ecstall Batholith (KEG), Big Falls Tonalite (DBO) and the Johnston Lake-Foch Lake Tonalite (JFO) are generally lower for the listed metals. Samples underlain by metavolcanic rocks of the Big Falls Igneous Complex (PV), layered gneiss (PN) and metasedimentary rocks of the Big Falls Igneous Complex (PQ) tend to have higher concentrations.

Table 4. Mean and median concentrations of samples subset on underlying geology.

		PV	PN	PQ	PS	KEG	TQT	DBO	JFO
	N	65	30	17	16	48	27	15	10
Cu (ICP)	Mean	38.46	46.54	48.07	41.42	15.24	26.03	43.48	27.46
	Median	31.59	34.26	41.33	23.99	9.76	24.75	43.82	14.42
Pb (ICP)	Mean	4.19	3.68	3.17	3.03	3.95	2.65	3.64	3.40
	Median	3.32	2.92	2.28	1.78	3.18	2.35	2.80	2.95
Zn (ICP)	Mean	56.17	58.68	60.84	55.53	39.02	53.43	45.73	48.72
	Median	53.40	47.00	52.00	49.80	31.60	47.60	46.10	44.40
Ag (ICP)	Mean	73.2	83.2	193.6	83.9	39.8	59.1	54.9	43.6
	Median	54.0	58.0	86.0	51.0	33.0	58.0	38.0	28.0
Au (INA)	Mean	7.0	5.9	8.1	3.0	3.8	2.4	4.4	3.3
	Median	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

Top rated sample sites that exhibit multi-element analytical results characteristic of VMS deposits are identified in Table 5. The sites listed are not associated with any known mineral occurrences and the ground upstream from the anomalies is currently not staked (as of March, 2001). Some of the more interesting results include sites 9154 and 9100, located in the headwaters of Sparkling Creek (Figure 2), which show the most notable multi-element signature for VMS associated metals, and situated on Hawkesbury Island, site 9230 exhibits anomalous data for copper, lead, zinc and silver. The list identifies several other interesting results that may suggest the presence of VMS mineralization.

Table 5. Sample sites that exhibit survey results characteristic of VMS mineralization.

Map	ID	Cu ppm ICP	Pb ppm ICP	Zn ppm ICP	Ag ppb ICP	Au ppb INA	Cd ppm ICP	S % ICP	Se ppm ICP
103H13	9154	106.63	20.99	187.9	1563	70	2.00	0.33	18.3
103H13	9100	55.18	16.92	82.9	319	2	1.18	0.15	6.0
103H10	9230	79.37	20.64	151.2	229	8	0.33	0.04	1.0
103H14	9117	84.25	4.14	92.8	189	26	0.38	0.02	1.2
103H14	9130	71.01	4.84	94.8	218	2	0.31	0.02	2.1
103H14	9104	176.44	3.42	55.8	422	2	0.18	0.03	1.5
103H11	9158	38.92	6.22	72.1	241	64	0.17	0.12	2.8
103H11	9189	95.15	8.22	67.3	203	17	0.24	0.06	1.1
103H10	9410	32.12	3.90	150.5	258	2	1.05	0.18	3.2
103I04	9015	36.46	6.98	83.8	127	2	0.19	0.07	0.7
103I04	9022	226.26	2.63	41.4	50	2	0.04	0.03	0.3
103H14	9177	105.36	3.29	77.4	160	2	0.24	0.02	0.6
103H10	9234	40.22	11.02	52.8	92	2	0.13	0.03	0.5
103H14	9103	74.51	1.57	49.8	259	2	0.37	0.05	1.6
103H14	9165	41.33	1.33	107.1	177	2	0.17	0.02	1.5

Overall, survey results clearly highlight the mineral potential of this belt. It can be shown that geochemical data for copper, lead, zinc, silver and gold detect known mineral occurrences, enlarge target areas for currently known prospects and outline new areas for prospective VMS deposits.

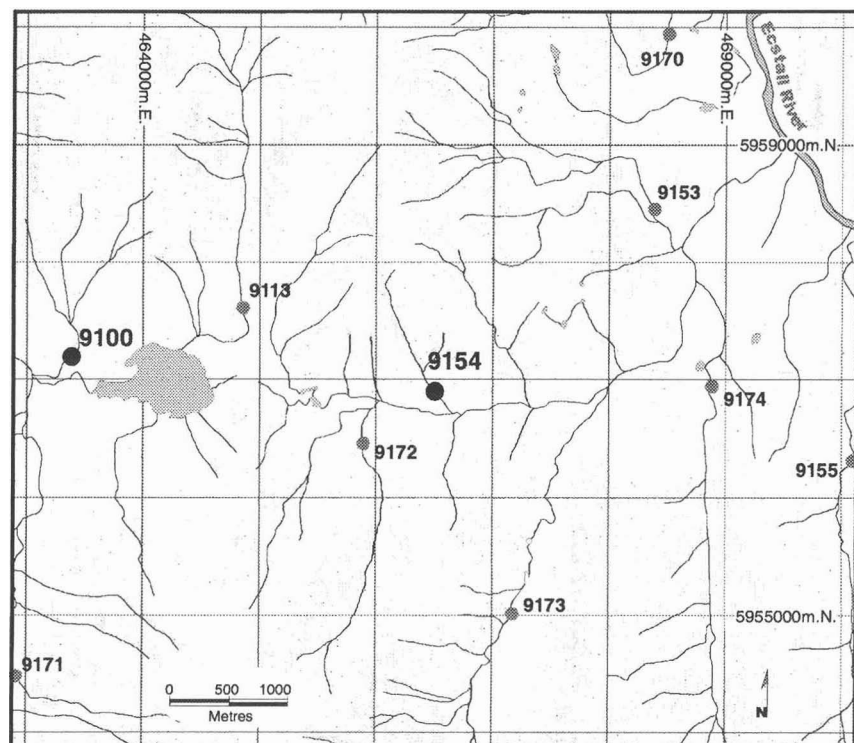


Figure 2. Location map of sample sites 9154 and 9100.

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Collection:

McElhanney Consulting Ltd., Vancouver, B.C.

Preparation:

Bondar Clegg Ltd., North Vancouver, B.C.

Sediment Analysis:

ACME Analytical Laboratories Ltd., Vancouver, B.C. (ICP)
Activation Laboratories Ltd., Ancaster, Ontario (INAA)

Water Analysis:

CanTech Laboratories Inc., Calgary, Alberta

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Ecstall Greenstone Belt (103H/103I) GSB OF 2001-13

A total of 242 sediment samples and 241 water samples were collected from 228 sites covering over 1, 800 square kilometers at a density of one sample per 7 km². Sediment samples analysed by INAA and aqua regia-ICPMS for base and precious metals, pathfinder and rare earth elements. Water samples analysed for pH, uranium, sulphate and fluoride.

Element	Units	INAA	ICP/ICPMS	OTHER
Aluminum	%		ICP	
Antimony	ppm	INAA	ICPMS	
Arsenic	ppm	INAA	ICPMS	
Barium	ppm	INAA	ICPMS	
Bismuth	ppm		ICPMS	
Bromine	ppm	INAA		
Cadmium	ppm		ICPMS	
Calcium	%	INAA	ICPMS	
Cerium	ppm	INAA		
Cesium	ppm	INAA		
Chromium	ppm	INAA	ICPMS	
Cobalt	ppm	INAA	ICPMS	
Copper	ppm		ICPMS	
Europium	ppm	INAA		
Gallium	ppm		ICPMS	
Gold	ppb	INAA	ICPMS	
Hafnium	ppm	INAA		
Iron	%	INAA	ICPMS	
Lanthanum	ppm	INAA	ICPMS	
Lead	ppm		ICPMS	
Lutetium	ppm	INAA		
Magnesium	%		ICPMS	
Manganese	ppm		ICPMS	
Mercury	ppb		ICPMS	
Molybdenum	ppm		ICPMS	
Nickel	ppm		ICPMS	
Phosphorus	%		ICPMS	
Potassium	%		ICPMS	
Rubidium	ppm	INAA		
Samarium	ppm	INAA		
Scandium	ppm	INAA	ICPMS	
Selenium	ppm		ICPMS	
Silver	ppb/ppm		ICPMS	
Sodium	%	INAA	ICPMS	
Strontium	ppm		ICPMS	
Sulphur	%		ICPMS	
Tantalum	ppm	INAA		
Tellurium	ppm		ICPMS	
Terbium	ppm	INAA		
Thallium	ppm		ICPMS	
Thorium	ppm	INAA	ICPMS	
Titanium	%		ICPMS	
Tungsten	ppm	INAA	ICPMS	
Uranium	ppm	INAA	ICPMS	
Vanadium	ppm		ICPMS	
Ytterbium	ppm	INAA		
Zinc	ppm	INAA	ICPMS	
Fluorine	ppm			ION
Loss on Ignition	%			FUSION
Fluoride (waters)	ppb			ION
Sulphate (water)	ppm			TURB
Uranium (waters)	ppb			FLUOR
pH (waters)				ELECTRODE