National Geochemical Reconnaissance Surveys in the BC Cordillera Identify New Mineral Exploration Targets

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KEYWORDS: Geochemistry, mineral exploration, multi-element, stream sediment, stream water, National Geochemical Reconnaissance Program, Regional Geochemical Survey, RGS, Fort Fraser, Bella Coola.

INTRODUCTION

Since 1976 the British Columbia Ministry of Energy and Mines (MEM) has been involved in reconnaissance-scale stream sediment and stream water surveys under Canada's National Geochemical Reconnaissance (NGR) program. British Columbia continues to independently manage the Regional Geochemical Survey (RGS) in the Province and maintains the sample collection and preparation and analytical standards established by the Geological Survey of Canada. Currently, the RGS database covers close to 65 percent of British Columbia and contains field and analytical information for over 46 000 sample sites. Multi-element data, generated by regional surveys, are used by the mining industry to identify areas of higher mineral potential and to focus on exploration targets.

Program highlights this year were the publication of results from a 1:250 000 scale stream sediment and water survey covering parts of the Bella Coola (NTS 93D) and Laredo Sound (NTS 103A) map sheets (Lett *et al.*, 2002) and completion of a new survey covering parts of the Fort Fraser (NTS 93K) map sheet. The Geological Survey of Canada Targeted Geoscience Initiative (TGI) and the B.C. Ministry of Energy and Mines funded both surveys. Results of a detailed survey covering the Triumph Bay area (parts of NTS 103H) and funded by the Corporate Resource Inventory Initiative (CRII), were published in April (Jackaman, 2002). Instrumental neutron activation (INAA) data, produced by reanalysis of archived samples from previous RGS surveys covering the Prince George (NTS 93G) and McBride (NTS 93H) maps sheets, were also released. These surveys (Figure 1) are described in this paper.

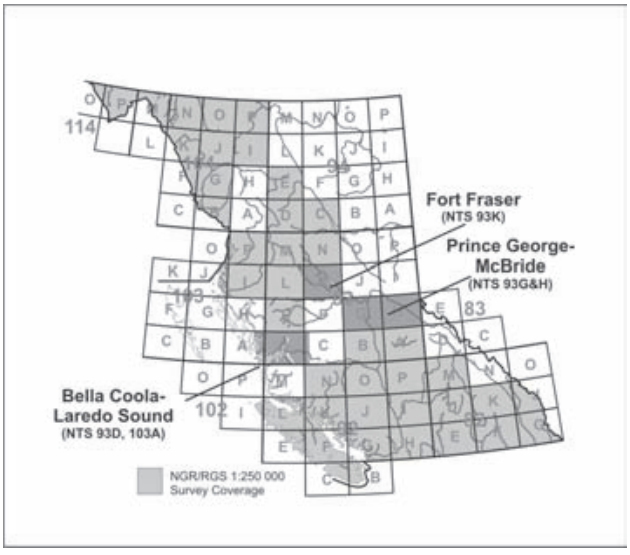

Figure 1. Location map of surveys.

BELLA COOLA-LAREDO SOUND DATA RELEASE

New field and analytical results for 1180 sediment and water samples, collected in the Bella Coola-Laredo Sound area, were published in August 2002 (Lett *et al.*, 2002). Stream sediment samples were analysed for more than 40 parameters (Table 1), including base and precious metals. Water samples were analyzed for pH, uranium and fluoride. In addition 232 filtered and acidified stream water samples were analysed for over 40 trace and major elements.

The western part of the Bella Coola survey area is underlain by Paleozoic to Jurassic metavolcanic and metasedimentary rocks and Eocene intrusive rocks which together form the Coast Complex. This assemblage is separated from Middle Jurassic Hazelton Group volcanic and sedimentary rocks to the east by the Coast Shear zone. Hazelton Group submarine silica-bimodal volcanic rocks and sedimentary rocks, interpreted by Diakow *et al.,* 2002 as a Stikinia magmatic arc, have the potential for hosting porphyry Cu-Au deposits associated with subvolcanic plutons, epithermal Au-Ag deposits in sub aerial volcanic rocks and stratiform massive sulphide deposits. One example of volcanic-associated stratiform sulphide mineralization is the Nifty Pb-Zn-barite prospect (MINFILE 93D007) in the eastern part of the survey area. The Coast Complex has the potential to host gold-quartz veins associated with major faults such as the Surf Inlet occurrence (MINFILE 103H 027) and volcanogenic massive sulphide (VMS) mineralization in metavolcanic rocks such as the Ecstall deposit (MINFILE 103H 011).

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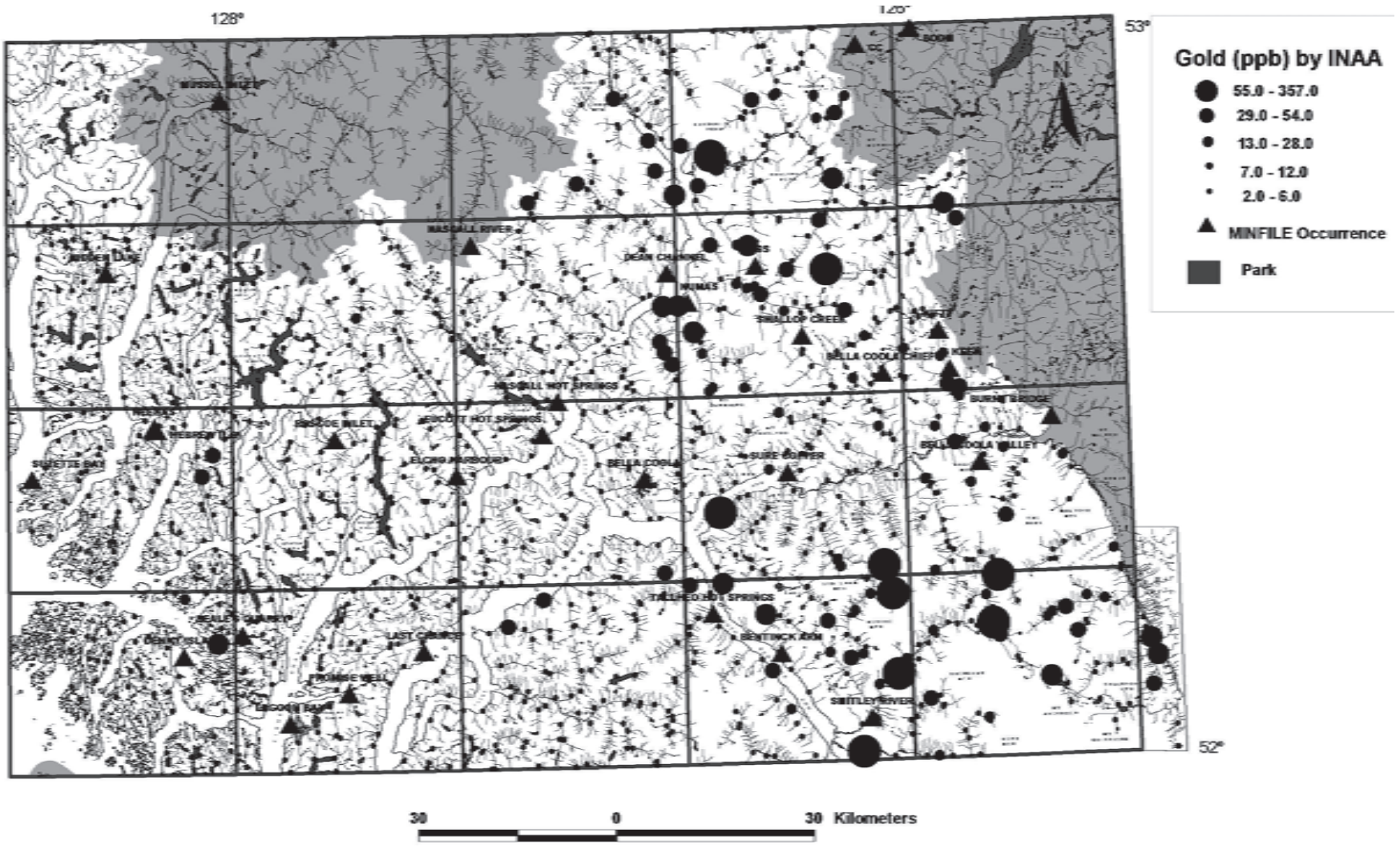

Figure 2. Distribution of gold in stream sediments by INAA in the Bella Coola-Lardo Sound survey area.

TABLE 1
ANALYTICAL SUITE OF ELEMENTS

Element	Detection	Units	Method
Aluminum	0.01	%	ICPMS
Antimony	0.02/0.1	ppm	ICPMS / INAA
Arsenic	0.1/0.5	ppm	ICPMS / INAA
Barium	0.5/50	ppm	ICPMS / INAA
Bismuth	0.02	ppm	ICPMS
Bromine	0.5	ppm	INAA
Cadmium	0.01	ppm	ICPMS
Calcium	0.01/1	%	ICPMS / INAA
Cerium	5	ppm	INAA
Cesium	0.5	ppm	INAA
Chromium	0.5/2	ppm	ICPMS / INAA
Cobalt	0.1/5	ppm	ICPMS / INAA
Copper	0.01	ppm	ICPMS
Europium	1	ppm	INAA
Gallium	0.2	ppm	ICPMS
Gold	0.2/2	ppb	ICPMS / INAA
Hafnium	1	ppm	INAA
Iron	0.01/0.2	%	ICPMS / INAA
Lanthanum	0.5/2	ppm	ICPMS / INAA
Lead	0.01	ppm	ICPMS
Lutetium	0.2	ppm	INAA
Magnesium	0.01	%	ICPMS
Manganese	1	ppm	ICPMS
Mercury	5	ppb	ICPMS
Molybdenum	0.01	ppm	ICPMS
Nickel	0.1	ppm	ICPMS
Phosphorus	0.001	%	ICPMS
Potassium	0.01	%	ICPMS
Rubidium	5	ppm	INAA
Samarium	0.1	ppm	INAA
Scandium	0.1/0.2	ppm	ICPMS / INAA
Selenium	0.1	ppm	ICPMS
Silver	2	ppb	ICPMS
Sodium	0.001/0.02	%	ICPMS / INAA
Strontium	0.5	ppm	ICPMS
Sulphur	0.02	%	ICPMS
Tantalum	0.5	ppm	INAA
Tellurium	0.02	ppm	ICPMS
Terbium	0.5	ppm	INAA
Thallium	0.02	ppm	ICPMS
Thorium	0.1/0.2	ppm	ICPMS / INAA
Titanium	0.001	%	ICPMS
Tungsten	0.2/1	ppm	ICPMS / INAA
Uranium	0.1/0.2	ppm	ICPMS / INAA
Vanadium	2	ppm	ICPMS
Ytterbium	2	ppm	INAA
Zinc	0.1/50	ppm	ICPMS / INAA
Fluorine	10	ppm	ION
Loss on Ignition	0.1	%	GRAV
Fluoride (waters)	20	ppb	ION
Uranium (waters)	0.05	ppb	LIF
pH (waters)	0.1		GCE

There are numerous base and precious-metal stream sediment geochemical anomalies in the Bella Coola-Laredo Sound survey area. For example, Au values exceed 55 ppb in sediment at nine sites in the eastern part of the survey area (Figure 2). Sample sites where there are different, multi-element anomalies are shown in Figure 3. The element associations were chosen to reflect VMS-type mineralization (Ag-Ba-Cd-Pb-Se-Zn), porphyry-type mineralization (Cu-Mo) and epithermal vein-type mineralization (As-Sb-Hg-Au). Lefebure *et al.*, 2002, used a similar procedure for interpreting stream sediment multi-element anomalies west of Dease Lake, B.C. There are clusters of samples with a VMS-type signature in the area between Dean and Burke Inlets (93D/04 and 93D/08), north of Cascade Inlet (93D/12) and in the northern half of NTS 93D/15. Two sites with a VMS-type signature occur in NTS 103A/08 along a northwest trending belt of Paleozoic age sedimentary-volcanic rocks in the Coast Complex. Another site with a VMS-type signature is a stream draining the area of the Nifty prospect. Samples sites with anomalous Cu-Mo values are located predominantly in the eastern part of the survey area. Those sites showing an As-Sb-Hg-Au geochemical signature are grouped in NTS 93D/15 and 93D/11. In NTS 103A/08 one As-Sb-Hg-Au site has a spatial association with a VMS-type anomaly on a northwest trend. Samples with elevated Ag-Ba-Cd-Pb-Se-Zn, Cu-Mo and As-Sb-Hg-Au values are listed in Tables 2, 3 and 4.

Sample sites with a Ag-Ba-Cd-Pb-Se-Zn signature have been ranked by calculating Ag, Ba, Cd, Pb, Se, Zn normalized values from raw element data and plotting the sum of normalized values as symbols (Figure 4). The largest cluster of sites with high normal values is in the area between Dean and Burke Inlets.

PRINCE GEORGE AND MCBRIDE ARCHIVE DATA RELEASES

Since 1991 over 21 000 archived stream sediment samples have been analysed by instrumental neutron activation analysis (INAA) for Au and 25 other metals. These sediment samples were saved from reconnaissance-scale stream sediment and water surveys conducted from 1976 to 1985. The original RGS publications contained analytical data for a small number of key ore-indicator metals (*e.g.* Ag, Cu, Co, Hg, Fe, Mn, Pb, Ni, Mo, U). New INAA data for twenty-one 1:250 000 NTS map sheet areas have been published to date.

This year, archive data were released for the Prince George (NTS 93G) and McBride (NTS 93H) map sheets. Conducted in 1986, the Prince George and McBride RGS programs comprised a total of 2344 sediment samples and 2213 water samples collected from 2214 sites over a 30 000 square kilometre area. The distribution of Au by INAA in the stream sediments (Figure 5) clearly shows a cluster of anomalies in the southwest part of the McBride sheet corresponding to the Wells-Barkerville area. However, the highest Au values (up to 1650 ppb) are in southeast part of the Prince George sheet. Samples with Au values above 170 ppb are listed in Table 5.

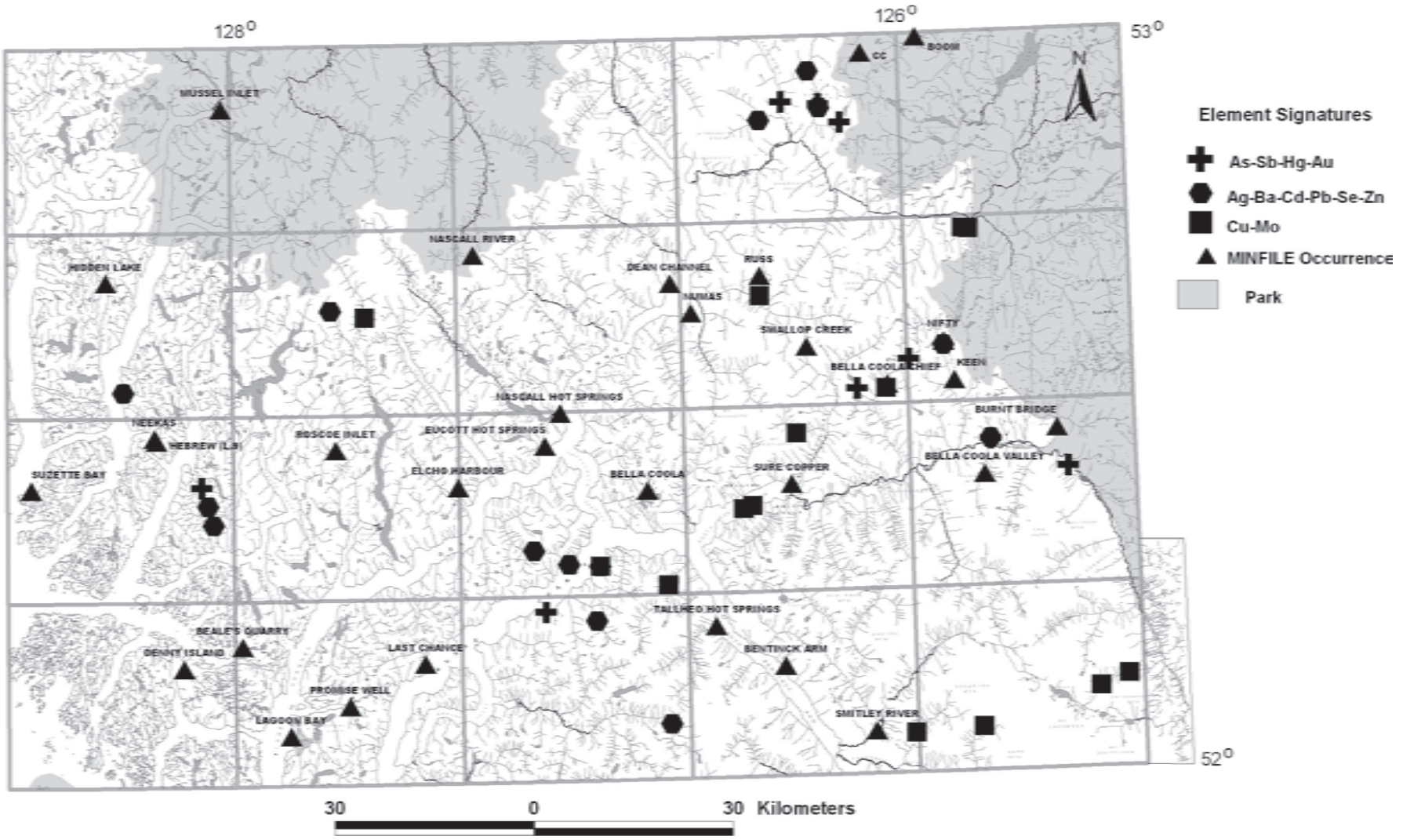

Figure 3. Multi-element geochemical associations in stream sediments in the Bella Coola-Lardo Sound survey area.

TABLE 2
RGS SITES WITH ANOMALOUS (> 80 PERCENTILE) AG-BA-CD-PB-SE-ZN VALUES

NTS MAP	Sample ID Number	UTM Zone	UTM East 83	UTM North 83	Ag ppb	Ba ppm	Cd ppm	Pb ppm	Se ppm	Zn ppm
93D09	093D 1186	9	674965	5828257	319	840	0.89	32.67	1.50	163.2
93D08	093D 1242	9	682160	5814236	216	730	0.76	29.92	1.10	139.8
93D15	093D 1251	9	656084	5863800	224	820	0.58	13.55	0.50	63.4
93D15	093D 1257	9	647056	5861850	149	930	0.25	6.41	0.50	87.0
93D06	093D 1313	9	613378	5796981	313	2200	1.25	6.88	3.40	260.6
93D03	093D 1346	9	622848	5786555	98	870	0.27	14.49	0.60	72.2
93D15	093D 1439	9	654349	5869307	131	900	0.09	12.01	5.20	88.7
93D03	093D 1487	9	634151	5771079	141	800	0.99	6.16	1.70	132.6
93D06	093D 3115	9	623329	5794738	781	2800	5.00	5.88	9.40	406.9
93D06	093D 3124	9	618613	5794967	395	1900	4.98	5.88	4.80	452.8
93D12	093D 3342	9	582588	5833091	76	740	0.18	6.16	0.70	75.1
103A09	103A 1019	9	551413	5820696	136	1200	0.51	6.61	1.10	148.2
103A08	103A 1248	9	565053	5800790	87	1500	0.33	8.38	1.00	62.4
103A08	103A 1250	9	564206	5803673	100	1200	0.57	6.22	1.50	144.4

Ba by INAA; Ag, Cd, Pb, Se and Zn by Aqua Regia-ICPMS

TABLE 3
RGS SITES WITH ANOMALOUS
(> 95 PERCENTILE) CU-MO VALUES

MAP	Number	Zone	East 83	North 83	ppm	ppm
93D01	093D 1013	9	698784	5777049	93.13	9.73
93D01	093D 1025	9	703018	5778891	105.98	5.97
93D01	093D 1053	9	681166	5770785	83.45	3.90
93D02	093D 1072	9	670933	5769805	263.13	72.15
93D06	093D 1112	9	633536	5791923	79.63	5.00
93D09	093D 1114	9	677643	5845834	101.50	6.52
93D09	093D 1132	9	678551	5845716	305.61	26.41
93D10	093D 1166	9	647206	5835459	158.46	20.12
93D10	093D 1199	9	666313	5821683	147.97	12.96
93D06	093D 3115	9	623329	5794738	81.26	5.64
93D12	093D 3177	9	587662	5832092	92.34	4.07
93D07	093D 3370	9	652814	5814839	187.84	10.18
93D07	994100	9	644867	5803396	80.94	6.08
93D07	994111	9	646193	5803850	89.63	9.01

Cu and Mo by Aqua Regia-ICPMS

TABLE 4
RGS SITES WITH ANOMALOUS
(> 90 PERCENTILE) AU-AS-HG-SB VALUES

NTS MAP	Sample ID Number	UTM Zone	UTM East 83	UTM North 83	As ppm	Au ppb	Hg ppb	Sb ppm
93D10	093D 1197	9	662057	5821644	18	6	115	0.4
93D09	093D 1202	9	669768	5826127	23	12	63	1.8
93D08	093D 1242	9	682160	5814236	10	10	62	0.8
93D08	093D 1249	9	693873	5810165	15	6	220	1.1
93D15	093D 1443	9	656069	5864482	45	6	55	1.3
93D15	093D 1445	9	659285	5861747	13	13	128	6.7
93D15	093D 1448	9	650406	5864739	10	9	71	1.5
93D03	093D 3127	9	615187	5787888	14	13	86	2.4
103A08	103A 1251	9	563325	5806524	10	24	109	1.1

As, Au by INAA, As, Hg, Sb by Aqua Regia-ICPMS

TABLE 5
STREAM SEDIMENT AU ANOMALIES IN THE PRINCE GEORGE-MC BRIDE MAP SHEETS
AS, AU, BA, CR, FE, MO AND SB BY INAA, AG, CU, HG, MN, PB AND ZN BY AQUA REGIA-ATOMIC ABSORPTION SPECTROMETRY

Map	Sample	UTM	UTM83 Easting	UTM83 Northing	Ag ppm	As ppm	Au ppb	Ba ppm	Cr ppm	Cu ppm	Fe %	Hg ppb	Mn ppm	Mo ppm	Pb ppm	Sb ppm	Zn ppm
93G01	841107	10	543256	5881828	0.6	4.6	1650	550	490	43	3.70	50	300	1	3	1.2	63
93H02	841484	10	637451	5896910	0.1	9.2	1500	390	70	27	3.03	61	760	7	15	0.4	72
93G16	841483	10	547265	5961167	0.1	4.5	1120	600	120	28	3.26	36	550	1	3	0.7	68
93G11	855423	10	491911	5932083	0.1	4.0	1040	460	49	31	2.61	70	940	1	7	1.0	59
93G16	841475	10	535403	5959159	0.1	5.9	840	760	85	16	3.36	33	8200	1	1	0.5	87
93G08	841426	10	552852	5926006	0.1	0.8	680	890	58	4	1.83	35	360	1	1	0.2	20
93G08	841248	10	537556	5903429	0.1	7.9	620	910	290	20	4.43	32	1390	1	1	1.4	51
93H04	841187	10	588830	5876473	0.1	8.6	560	570	43	19	2.15	18	750	1	16	0.7	68
93H12	841476	10	576825	5934477	0.1	4.9	530	290	220	54	6.37	48	740	1	1	0.8	60
93H04	841279	10	584745	5891980	0.1	14	350	1000	99	34	4.19	27	480	1	22	1.1	78
93G02	841224	10	533018	5896605	0.1	6.5	344	650	180	28	4.24	26	910	1	3	1.0	70
93H03	841416	10	594123	5886763	0.1	16	330	1300	120	43	5.31	74	1470	1	23	1.1	100
93G14	855562	10	474709	5963256	0.1	3.8	294	410	80	18	3.26	90	550	1	1	0.7	45
93G08	841340	10	543364	5908501	0.1	2.9	287	620	120	114	2.27	47	190	1	4	0.8	41
93G16	841488	10	543552	5981942	0.1	5.6	260	470	200	18	5.35	18	510	1	4	0.6	55
93H11	841123	10	606264	5957132	0.2	1.6	260	380	170	30	1.2	152	180	1	7	0.7	63
93H11	841227	10	604148	5948970	0.1	8.3	260	830	110	19	3.77	46	390	1	7	0.9	53
93G16	841484	10	547732	5961571	0.1	2.1	257	710	140	26	3.09	40	220	1	2	0.7	57
93H04	841245	10	597048	5881409	0.2	34	252	1500	79	43	4.19	21	710	1	21	1.4	73
93G02	841065	10	502746	5900523	0.1	8.0	235	1300	320	25	5.89	48	680	1	1	1.9	53
93G02	841015	10	511305	5872377	0.1	3.1	232	800	220	24	3.32	46	1200	1	1	0.7	42
93G02	841062	10	504784	5898052	0.1	3.1	221	710	230	25	3.02	62	360	1	1	0.7	47
93G07	841376	10	506991	5912151	0.1	4.9	209	970	150	33	3.81	69	360	1	5	1.0	65
93G15	841532	10	517500	5970094	0.1	8.3	204	710	160	23	3.59	30	1240	1	7	1.2	69
93H15	855053	10	658346	5963096	0.2	4.9	190	710	39	17	3.22	20	580	1	17	0.3	62
93G15	841410	10	530056	5962259	0.1	5.4	176	720	180	20	5.45	35	590	1	1	1.1	47
93G06	855004	10	496380	5926816	0.1	3.9	175	690	380	12	3.52	60	1400	1	3	0.9	45
93H05	841006	10	571771	5900594	0.1	4.8	172	930	110	24	3.69	77	1980	1	4	0.5	76

As, Au, Ba, Cr, Fe, Mo and Sb By INAA, Ag, Cu, Hg, Mn, Pb and Zn by Aqua Regia-Atomic

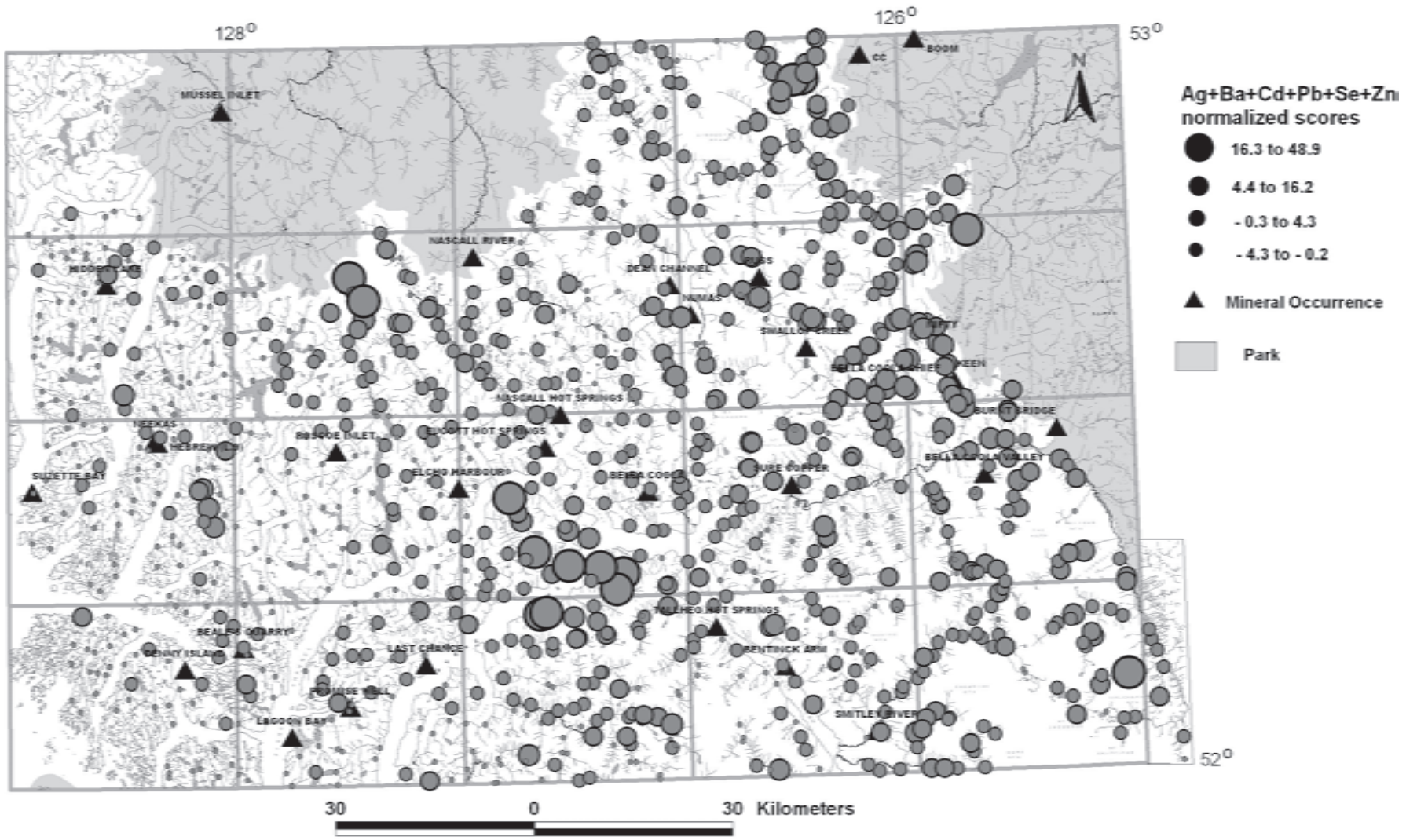

Figure 4. Normalized Ag-Ba-Cd-Pb-Se-Zn values in stream sediments in the Bella Coola-Lardo Sound survey area.

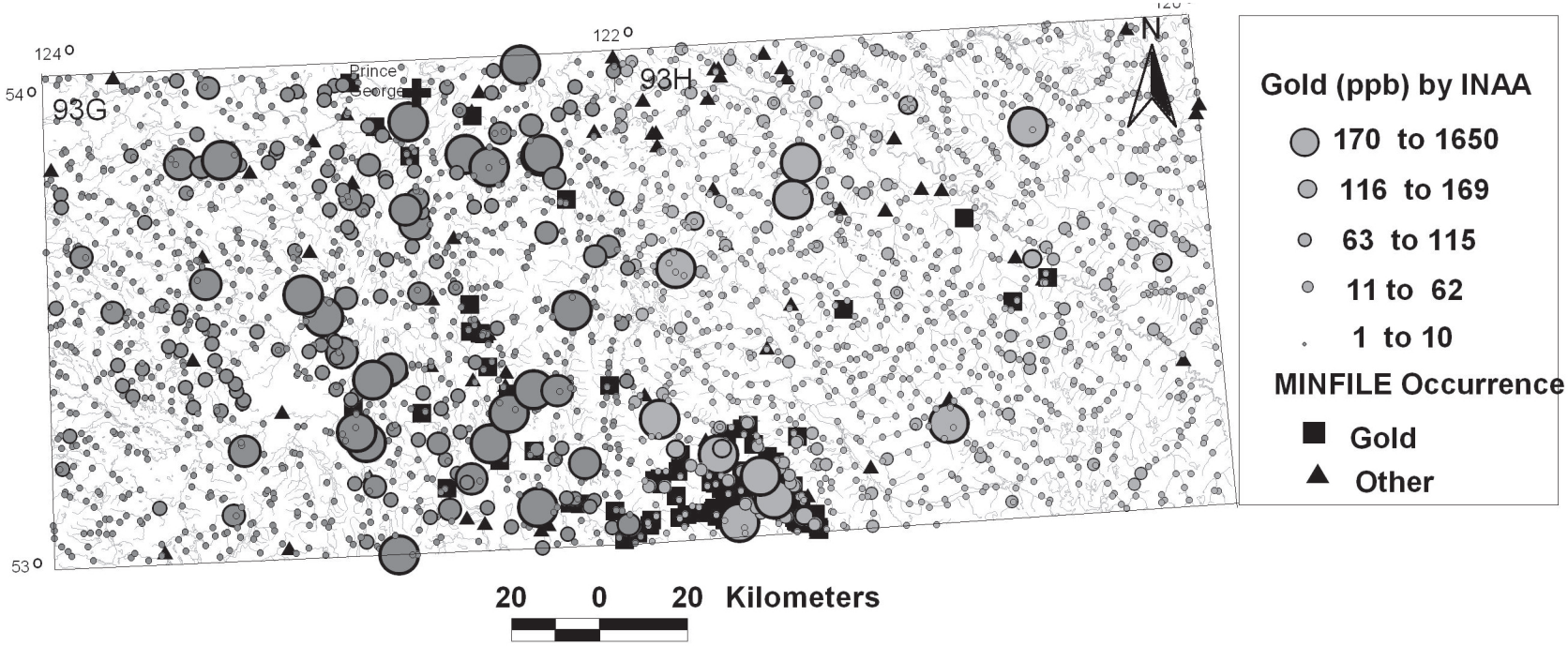

Figure 5. Distribution of gold in stream sediment, Prince George and McBride map sheets.

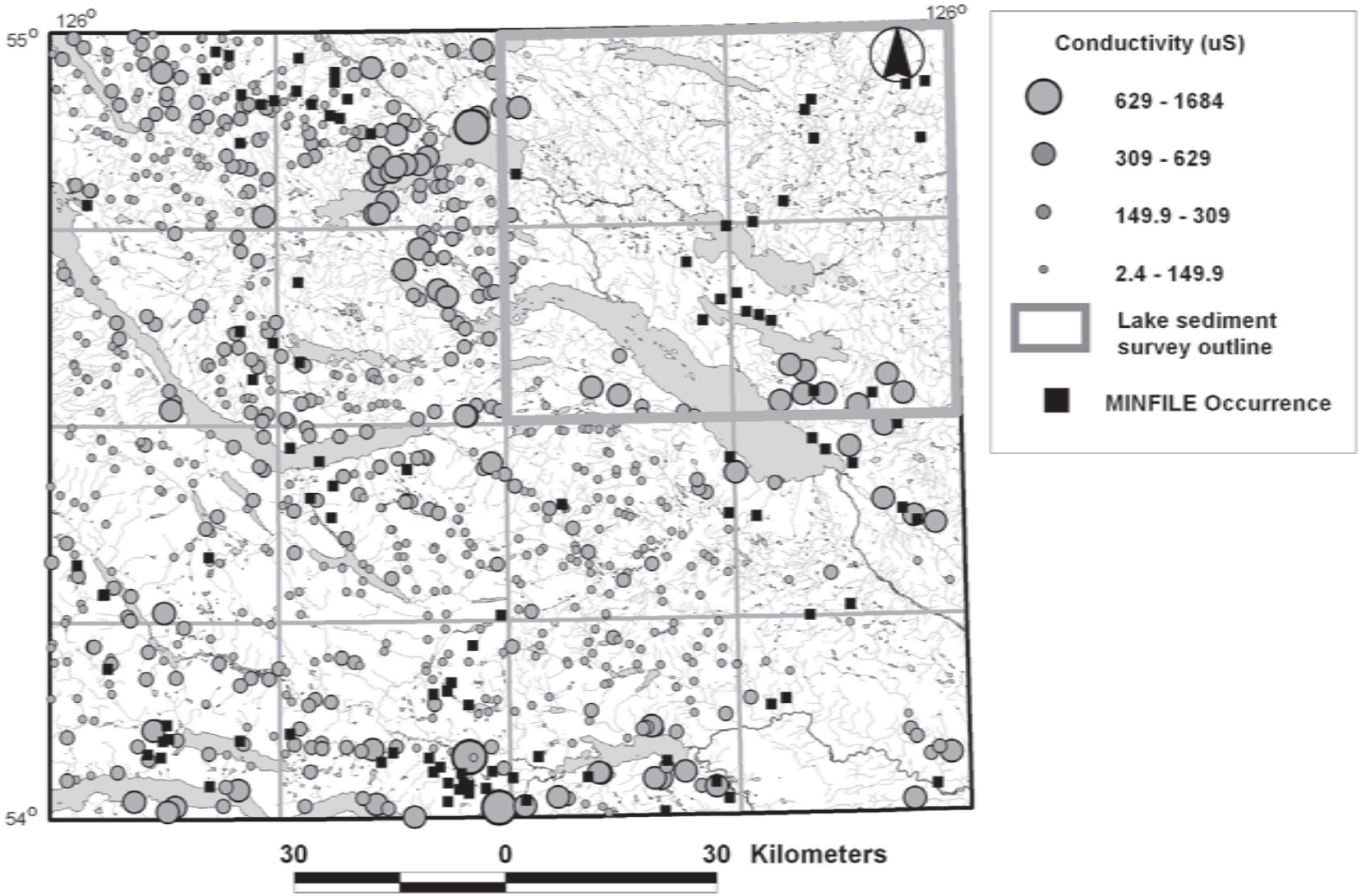

Figure 6. Stream water conductivity in the Fort Fraser Map Sheet.

TABLE 6
STREAM AND MOSS MAT SEDIMENT DATA FOR SELECTED RGS SITES

Sample		002RL002	002RL003	002RL007	002RL008	002RL017	002RL018
UTM	East	365200	365200	360905	360905	363200	363200
UTM	North	6010250	6010250	6008550	6008550	6031300	6031300
Type		SEDIMENT	MOSS MAT	SEDIMENT	MOSS MAT	SEDIMENT	MOSS MAT
Ag	ppb	398	313	56	48	177	136
Al	%	1.23	1.02	0.9	0.84	1.44	1.2
As	ppm	1.7	1.4	3.4	3.4	4.1	3.3
Au	ppb	-0.2	-0.2	0.2	-0.2	0.2	0.2
B	ppm	1	1	1	1	-1	1
Ba	ppm	247.9	198.3	147.8	132.9	143.5	112
Bi	ppm	0.41	0.32	0.07	0.07	0.22	0.12
Ca	%	0.72	0.69	0.5	0.53	0.84	0.79
Cd	ppm	0.35	0.29	0.12	0.12	0.34	0.32
Co	ppm	6.4	5.7	8.3	8.4	13.6	10.3
Cr	ppm	16.5	19.2	23.8	36.6	43.2	41.5
Cu	ppm	16.3	13.03	13.28	13.42	32.8	26.78
Fe	%	2.37	2.86	2.9	3.95	2.92	2.63
Ga	ppm	4.2	3.7	3.4	3.6	5.4	4.5
Hg	ppb	33	25	11	12	32	31
K	%	0.08	0.07	0.05	0.06	0.06	0.08
La	ppm	28.3	28.9	14	16.3	14.9	13.2
LOI	%	9.9	9.2	4.6	5.4	10.8	10.6
Mg	%	0.4	0.33	0.35	0.32	0.71	0.61
Mn	ppm	590	443	508	432	883	682
Mo	ppm	9.01	6.26	0.45	0.6	1.85	1.34
Na	%	0.011	0.01	0.014	0.014	0.013	0.013
Ni	ppm	9.6	8.1	11.4	12	28.4	23.4
P	%	0.096	0.115	0.079	0.101	0.08	0.082
Pb	ppm	14.24	11.18	6.93	6.13	7.31	6.21
S	%	0.03	0.03	0.01	0.02	0.03	0.04
Sb	ppm	0.13	0.13	0.28	0.32	0.31	0.3
Sc	ppm	2.9	2.4	3	3	4.8	4.1
Se	ppm	0.4	0.2	0.4	0.5	0.8	0.9
Sr	ppm	89	75.7	48.3	47.2	67.6	58.6
Te	ppm	0.02	0.02	-0.02	-0.02	0.03	0.02
Th	ppm	7.1	5.6	2.2	2.6	1.5	1.4
Ti	%	0.049	0.046	0.068	0.078	0.067	0.067
Tl	ppm	0.09	0.07	0.05	0.04	0.06	0.05
U	ppm	6.9	5.3	1.8	1.5	0.9	0.8
V	ppm	57	78	92	134	64	63
W	ppm	-0.1	-0.1	-0.1	-0.1	-0.1	0.3
Zn	ppm	61.7	55.2	43	45.5	93.3	79.9

FORT FRASER

Covering approximately 11 500 square kilometres of the Interior Plateau (Figure 1), the eastern part of the survey area is a rolling plateau with numerous lakes and swamps becoming more mountainous to the west. The area is underlain by Mesozoic to Tertiary volcanic and sedimentary rocks intruded by monzonite to granodiorite plutons. There are over sixty known mineral occurrences including the Endako molybdenum mine and the area has the potential for VMS, epithermal Au-Ag vein and porphyry Cu-Mo deposits. A regional till survey (Plouffe, 1995) and a lake sediment survey (Cook *et al.*, 1995) cover parts of the map sheet. A Geoscape map (Hastings *et al.*, 1999), produced from data compiled by Struik *et al.,* 2001, displays the relationships between bedrock geology, surficial geology and existing geochemistry for the Fort Fraser map sheet.

Truck, boat and helicopter-supported sample collection started in late July 2002 and was completed by early September. A total of 842 stream sediment and 800 water samples were collected from 795 sites (Figure 6). Despite

the low summer rainfall in the area only five percent of the streams were dry. Additional 125 ml water samples, collected from 138 of the sites, were filtered and acidified in the field. All water samples were analysed in the field for pH and conductivity. Stream water conductivity is shown in Figure 6. Stream sediment samples were air dried and sieved to -18 mesh (<1 mm) in a Fraser Lake preparation laboratory. The - 80 mesh (< 0.177 mm) fraction of the sediment samples will be analyzed for metals by aqua regia-ICPMS and by INAA. Water samples are being analyzed for elements including U and F.

ORIENTATION GEOCHEMISTRY

Orientation surveys aim to establish the characteristics of geochemical dispersion from a mineralized source so that optimum sampling density and preferred sample media can be selected for future surveys. Although stream sediments are the preferred sample type for large scale reconnaissance surveys other media such as moss mat sediment, heavy mineral and lake bottom sediments can be used depending on survey area topography (*e.g.* moss mat sediment in mountainous terrain) and commodity sought (*e.g.* heavy mineral for Au). Moss mat and stream sediment pairs were collected from several streams (Figure 7) during the regional survey and the - 80 mesh (< 0.177 mm) fraction analysed by aqua regia digestion and ICPMS to compare the geochemistry of the two media. Results, shown in Table 6, indicate that most ore indicator (*e.g.* Cu, Mo) and pathfinder elements are higher in stream sediment compared to the moss mat sediment.

CONCLUSIONS

In the Bella Coola-Laredo Sound area multi-element stream sediment anomalies suggest the presence of VMS, porphyry Cu-Mo and epithermal Au-vein type mineralization. Many of the multi-element anomalies are not related to known mineral occurrences.

New data from re-analysis of archived sediment samples by instrumental neutron activation reveals numerous Au anomalies in the Prince George and McBride map sheets. The highest Au value, exceeding one part per million, occurs in sediment is from a stream in the southeast part of the Prince George map sheet.

Orientation studies in the Fort Fraser survey area reveal that element values are higher in stream sediment than in moss mat sediment.

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