Halogens and Multi-Element Signatures in Soils and Vegetation:
Investigating their use to explore for concealed mineral deposits

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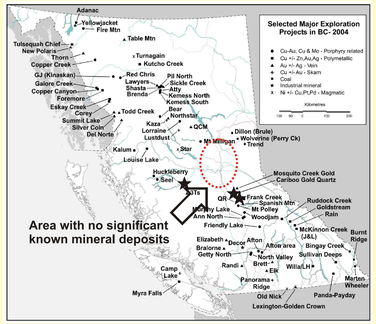
OBJECTIVES

- Develop geochemical methods for detecting mineralization concealed by glacial overburden or volcanic cover, *by*
- investigating the distribution of *readily-leachable* halogens (F, Cl, Br, I) in soils and vegetation
- Identify analytical problems and transfer new protocols to commercial labs



METHODS

LABORATORY TESTS

Using soils and vegetation of known composition, **compare and contrast low-cost commercially-available analytical techniques for determining F, Cl, Br and I.**

FIELD PROGRAM

Collect samples over prospective areas containing deposits representing different styles of mineralization at:

Mt. Polley - Cu-Au-Ag porphyry (volcanics and/or Quaternary cover).
QR (Au skarn), and the nearby **Cariboo** (andesite overlying minor gabbro containing Au in shear zones)
3Ts Epithermal Au/Ag veins (Quaternary cover)

ANALYSIS OF TEST SAMPLES

35 test samples were selected for sending to several laboratories for multi-element analysis by a variety of methods (Table 1). According to the method employed for the *halogens*, considerable differences in results were obtained - notably for ***FLUORINE*** (Table 2)

Table 1: List of analytical methods evaluated on test samples

Analytical Methods - Test samples of soils and vegetation
INAA - epithermal neutron activation for Cl, Br and I
ICP-MS Water leach (approximately 50 elements)
ICP-MS Ammonium acetate pH7 leach (approximately 50 elements)
ICP-ES Water leach (10 elements)
ICP-ES Ammonium acetate pH7 (10 elements)
Ion Chromatography - Water Leach (all availble anions)
Ion Chromatography - Ammonium acetate pH7 leach (all available anions)
F_Water leach - Ion selective electrode
Cl_Water leach - Ion selective electrode
F_Fusion (Teflon Bomb) - Ion selective electrode
Enzyme Leach - full suite of elements including I, Br and semi-quantitative Cl
XRF (high resolution) - halogens

Table 2: Fluorine analyses of vegetation samples by 4 labs and several methods

Sample Sample #	F-Lab A1 *Dionex (IC)* Water Leach ppm	F-Lab C Dionex (IC) Water leach ppm	F-Lab B Dionex (IC) Water leach ppm	F-Lab D *XRF Total* ppm	F-Lab A3 *NaOH fusion Total* ppm	F-Lab A2 *Sel. Ion Electrode* Water leach ppm
Needles_04	1241	1380	27	75	<10	0.36
Needles_08	1529	1776	35		20	0.34
Needles_14	1324	1476	27	78	<10	0.2
Needles_22	839	1168	24	86	<10	0.24
Needles_33	1383	1613	16	63	<10	0.15
Needles_45	1429	1623	45	72	<10	0.23
Needles_60	1121	1255	26	72	<10	0.21
Needles_65	1253	1393	33	68	<10	0.15
Needles_70	1616	2028	18	65	<10	0.19
Needles_74	1170	1318	20	83	<10	0.2
Pine Bark_09	74	124	15		<10	0.14
Pine Bark_11	64	109	18		<10	0.11
Pine Bark_28	99	128			<10	0.14
Pine Bark_68	63	102	24		<10	0.09
Pine Bark_73	88	115	24		<10	0.22
Controls						
V6	*70*	*83*	*0.75*	*96*	*<10*	*1.17*
V6	*77*	*83*	*0.92*	*81*	*<10*	*0.6*

SAMPLE MEDIA - 3 Field Areas

Table 3: Summary of soil and vegetation samples collected at each location. Principal vegetation samples sent for analysis are shown in bold italics

Location	Areas Sampled	Soil Sites n*	Horizon	Vegetation Sites Species	n*
Mt. Polley	Boundary Zone	45	B	***Western redcedar foliage***	***46***
	Boundary Zone			Engelmann spruce outer bark	41
	Pond Zone	60	B	***Subalpine fir foliage***	***54***
	Pond Zone			Western redcedar foliage	58
	Pond Zone			Engelmann spruce outer bark	21
QR	Main and West Zones**	0		***Douglas-fir needles (crowns)****	***100***
	Northern extension	0		Douglas-fir needles (low branches)	10
	Northern extension			Lodgepole pine outer bark	21
	Eastern IP* transect	32	B	***Engelmann spruce foliage***	***32***
	Eastern IP* transect			***Lodgepole pine outer bark***	***31***
	Cariboo Zone	24	B	***Engelmann spruce foliage***	***23***
	Cariboo			Lodgepole pine outer bark	13
3Ts	Tommy vein transect	20	B***	***White spruce foliage***	***43***
	Tommy vein transect			***Lodgepole pine outer bark***	***40***
	Ted vein transect	15	B***	***White spruce foliage***	***24***
	Ted vein transect			***Lodgepole pine outer bark***	***24***

* Excluding field duplicates
** Archived samples from collection made in 1988, prior to site development
*** Multi-horizon samples collected

1. Mt. Polley

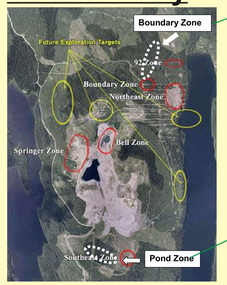


Fig. 1 Mt. Polley Locations of sample sites - Boundary and Pond Zones

Boundary Zone

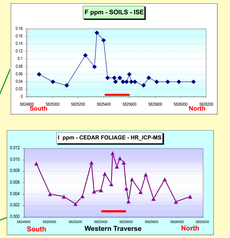


Fig. 2 F (soils) and I (cedar foliage). Soil anomaly is displaced to S (downhill); cedar anomaly is directly over mineralization

Pond Zone

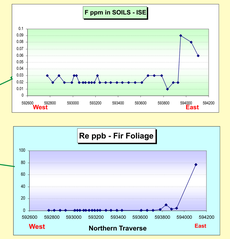


Fig. 3: F in soil and Re in vegetation. Anomaly suggests possible concealed Mo porphyry.

Table 4 Average concentrations of the halogens in the *water soluble fraction* of different sample media. The analytical methods need to achieve these low levels.

			QR		Mt. Polley		3Ts
			Cariboo	QR	Boundary	Pond	
F	ppm	*Soil*	<0.02	<0.02	0.05	0.03	0.05
Cl	ppm	*Soil*	10.0	10.9	8.5	8.2	8.5
Br	ppm	*Soil*	0.22	0.21	0.24	0.16	0.09
I	ppm	*Soil*	0.075	0.049	0.078	0.046	0.019
			Spruce	*Spruce*	*Cedar*	*Fir*	*Spruce*
F	ppm	*Foliage*	0.027	0.075	0.023	0.025	0.030
Cl	ppm	*Foliage*	425	431	390	305	337
Br	ppm	*Foliage*	1.4	2.0	2.4	1.7	1.7
I	ppm	*Foliage*	0.006	0.006	0.006	0.009	0.006
				Pine			*Pine*
F	ppm	*Bark*		0.298			0.042
Cl	ppm	*Bark*		23			30
Br	ppm	*Bark*		<0.1			0.659
I	ppm	*Bark*					0.080

CURRENTLY THE BEST METHODS ARE:

Warm water leach, then:

Fluorine
Ion Selective Electrode (ISE)

***Chlorine, Bromine and Iodine* -**
High Resolution ICP-MS

2. 3Ts

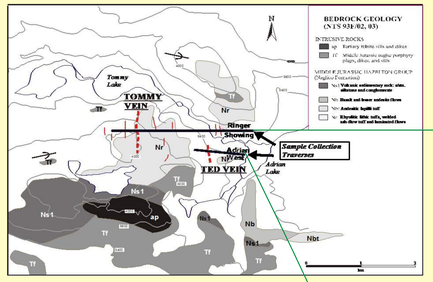


Fig. 4: 3Ts 'Tommy' traverse. Ag, F and I in pine bark. Positive response to known epithermal Au veins.

3. QR (Cariboo)

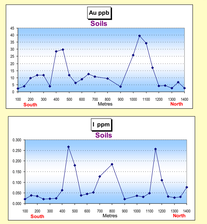


Fig. 6: Plots of Au and iodine in soils. Poor exposure of andesites and 1 known Au prospect (ddh in gabbro). Iodine suggests other prospective zones

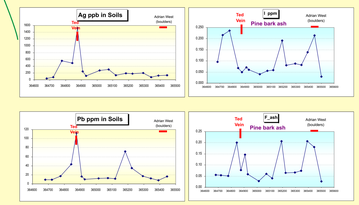


Fig. 5: 'Ted' traverse. Ag and Pb in soils; F and I in bark *ash.*

DATA RELEASE

The data and a summary report are scheduled for release by March 31, 2006.

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CONCLUSIONS

1. Low detection levels for F, Cl, Br, I are required
2. At this time, the preferred methods are F by ISE; Cl, Br, I by HR-ICP-MS after warm water leach (to extract labile fraction)
3. Soils and vegetation have substantially different halogen concentrations:
   a). Highest **iodine and fluorine** in bark
   ...b). Highest **chlorine and bromine** in foliage.
4. Each survey area has a positive response of halogens to mineralization
5. Patterns are not consistent - one deposit may have high F, whereas another may have high I. Is this a 'fingerprint'?