Preliminary results of a geochemical investigation of halogen and other volatile compounds related to mineralization: Lara volcanogenic massive-sulphide deposit (NTS 092B/13) and Mount Washington epithermal gold prospect (NTS 092F/14), Vancouver Island, BC.

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Introduction

The halogens (F, Cl, Br and I) are common rock constituents and are particularly enriched in differentiated magmas; the hydrothermal fluids and volatile compounds derived from them play an important role in the mobilization and transport of metals in ore-forming systems. They are hosted by high-salinity liquid phases and fluid inclusions. In the hydrothermal environment, halogens can be concentrated in alteration minerals such as micas, clays and topaz, and the gangue mineral fluorite. On exposure to surface conditions, these minerals weather and release their halogens as volatile gases (Br and I), more stable compounds, or water soluble ions (F and Cl) that disperse to form detectable anomalies in the surficial environment.

Project Objectives

The main thrust of the study is to analyze for halogen elements (F, Cl, Br and I) and other volatile compounds (e.g. ammonium, sulphate) in common plant tissues and Ah horizon soils as well as selected aqueous phases (snow and plant exudates) over contrasting styles of mineralization and cover, and emanating gaseous phases.

An important component of this work is the development of suitable analytical methods for halogens in organic-rich sample media at sufficiently low detection limits to be able to resolve subtle mineralization signals. Such methods are not currently commercially available.

Selected study sites are:

1) Mount Washington - Epithermal Ag-Au-Cu Prospect.

2) Lara Coronation Zone - Cu-Zn VMS

Sampling

Mount Washington

Sample medium	No. Samples	No. Duplicates	No. Controls	Comment
Mountain hemlock foliage (MHF)	73	5	2 (V14)	Collected June (22) and October (51), 2016
Ion collectors (IC)	19	2		Put in place, June 2016. Recovered October, 2016
Transpired fluids (TFMH)	18	2		Collected August, 2016
Ah soils	39	4	4 (LIM-2011)	Collected October, 2016
Snow	18	2		To be collected March, 2017
Archived yellow cedar bark ash (YCB)	17			Collected August 1990

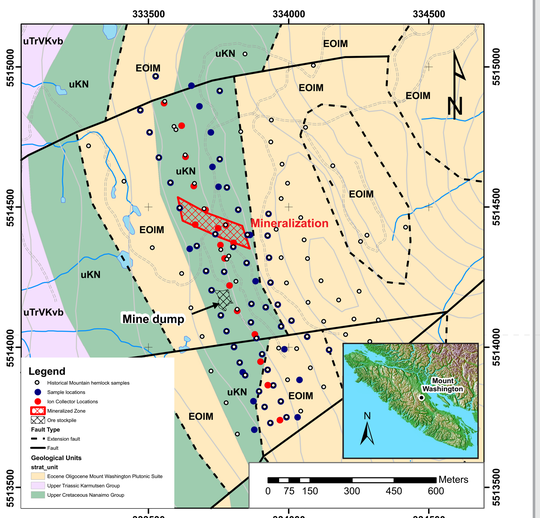
Lara - Coronation Zone

Sample medium	No. Samples	No. Duplicates	No. Controls	Comment
Western hemlock foliage (WHF)	89	8	10 (V14)	Collected May 4-5th, 2017
Douglas-fir bark (DFB)	79	8	7 (V14)	
Western redcedar foliage (RCF)	89	8	7 (V14)	
Western hemlock bark (WHB)	68	8	7 (V14)	
Salal foliage (SALF)	17	2	1 (V14)	
Swordfern foliage (SF)	8	0	1 (V14)	
Oregon grape foliage (OGF)	8	0	1 (V14)	
Ah horizon soil	88	8	10 (LIM-2011)	

Sample Preparation

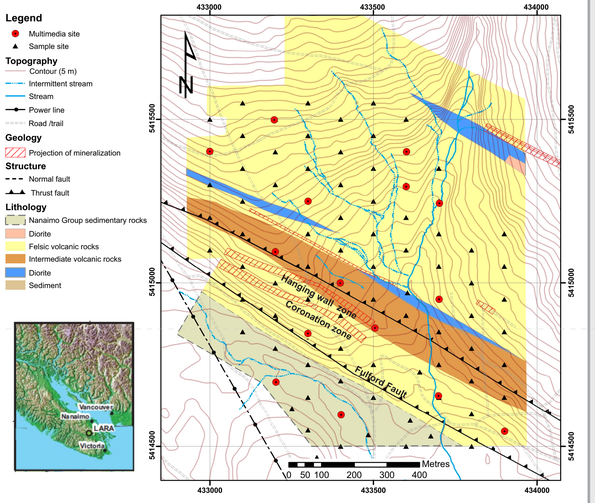
Vegetation and soil samples were oven dried at 80° C for 24 hours to remove all moisture. Ah horizon soil samples were sieved to –80 mesh (177 micron) in preparation for analysis of the finer fraction. Foliage was separated from twigs. All foliage and bark samples were then milled to a fine powder. Each sample medium was split into either two or three subsets for submission to several laboratories for different treatments (Table 2). Transpired fluids were filtered to -0.45 microns in the field.

Mount Washington



Geology of the Mount Washington study area (after Massey et al., 2005), east-central Vancouver Island, showing sample locations.

Lara



Geology of the Lara study area, southeastern Vancouver Island, showing surface projections of the mineralized horizons (red hatching) and sample locations.

Ion Collectors

Ion collectors used at Mount Washington contain two different collection media: activated charcoal for cations and ion-exchange resin for anions. The media were accurately weighed into 10 by 7 cm porous nylon sachets (15 and 20 g, respectively) that were then heat sealed. They were placed on a 2 cm thick bed of pure silica sand housed in an 18 cm diameter by 15 cm deep cardboard tube that was buried to 20 cm in the ground. The silica sand serves to isolate the collectors from the soil, so as to avoid capture of endogenic ions: a filter paper was used to isolate the collectors from the silica sand. A ceramic tile was placed between the collectors in order to avoid the possibility of cross-contamination between the charcoal and resin sachets. The apparatus was capped with an overlapping plastic lid to prevent entry of rain water and surface debris, and shallowly buried.

Ion collection device with ion exchange resin (left) and activated charcoal sachets (right). Sachets are separated by a ceramic tile to prevent cross contamination. Tube diameter:19mm.

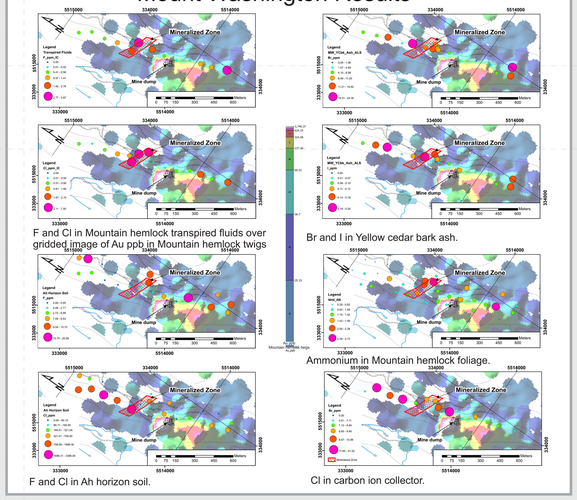
An example of a buried ion collector site.

Analytical Methods

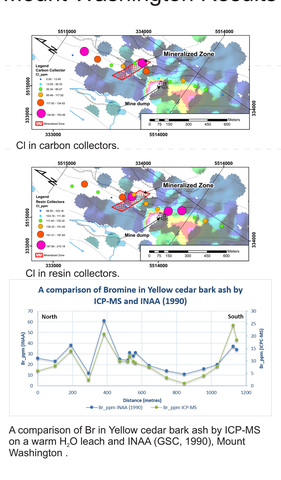
Sample Media	Laboratory	Pretreatment	Digestion	Analytical methods	Lara	Mt. Wash.
Ah horizon – All sites	ALS Minerals, N. Vancouver, BC	Sieving -80#	Aqua regia	ICP-MS	X	X
Ah horizon – All sites	ALS Minerals, N. Vancouver, BC	Ashed	Warm water leach	ICP-MS including Br, Cl, I, F by IC[2]	X	X
Ah horizon – All sites	Actlabs, Ancaster, ON	Sieving -80#	Bioleach	ICP-MS	X	X
Foliage – All sites	Actlabs, Ancaster, ON	Milling	Bioleach	ICP-MS	X	X
Foliage - All sites	BC MOE Laboratory[1], Victoria	Milling	Warm H_2O	IC[2] for Cl, Br, I, NH_4 and SO_4; F by ISE[3]	X	X
Foliage - All sites	BC MOE Laboratory[1], Victoria	Milled	Microwave HNO_3	Analysis at ALS by ICP-MS	X	X
Foliage	ALS Minerals, N. Vancouver, BC	Ashed	Warm H_2O	ICP-MS including Cl, Br, I, F by IC[2]	X	X
Yellow-cedar bark	ALS Minerals, N. Vancouver, BC	Ashed	Aqua regia, Warm H_2O	ICP-MS including Br, I, F by IC[2]		X
Mtn. hemlock foliage	ALS Minerals, N. Vancouver, BC	Ashed	Aqua regia, Warm H_2O	ICP-MS including Br, I, F by IC[2]		X
Mtn. hemlock foliage	ALS Minerals, N. Vancouver, BC	Milled	Warm H_2O	ICP-MS including Br, I, F by IC[2]		X
Ion collectors - Charcoal	ALS Minerals, N. Vancouver, BC		Sodium pyrophosphate	ICP-MS		X
Ion collectors – Resin	ALS Minerals, N. Vancouver, BC		Ammonium acetate	ICP-MS		X
Ion Collectors - Both types	ALS Minerals, N. Vancouver, BC		Warm H2O leach	ICP-MS		X
Transpired fluids	ALS Minerals, N. Vancouver, BC		None	ICP-MS including Br, Cl, I, F by IC[2]		X
Snow	ALS Minerals, N. Vancouver, BC		None	ICP-MS including Br, Cl, I, F by IC[2]		X

[1] - B.C. Ministry of Environment (Environmental Sustainability and Strategic Policy Division, Knowledge Management Branch) in Victoria, BC.
[2] - High Performance Liquid Chromatography/Ion Chromatography (IC).

Mount Washington Results

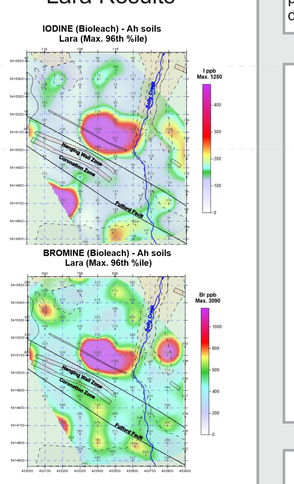


Mount Washington Results



A comparison of Br in Yellow cedar bark ash by ICP-MS on a warm H_2O leach and INAA (GSC, 1990), Mount Washington .

Lara Results



Preliminary Results

Mount Washington

1) Meaningful responses for NH_4, F, Cl, Br and I are detected in different sampling media over known epithermal mineralization.
2) Concentrations vary considerably among media but contrast and patterns are comparable.
3) Results from new analytical methods developed for this project are confirmed by historical INAA analyses.
4) The cleanest signature is from the transpired fluids. In this medium all halogens, especially F, show a strong response over known mineralization, but not over the waste dump or other disturbed areas.
5) It appears that the clarity of the halogen signature improves from Ah horizon soils – hemlock foliage – cedar bark ash – transpired fluids. This we interpret as a progressive purification of the signal through the biogeochemical cycle.

Preliminary Results

6) Both the carbon and resin passive ion collectors yielded a distinct enrichment of Cl, Br and I in the vicinity of the Au mineralization, but with these elements in the C collector also relatively enriched in an area of poor drainage to the north. Responses in ion collectors imply a gaseous or vapour transport of halogens.

Lara

1) Portions of samples from the Lara collection was used for method development and final results on reanalysis are pending.
2) Samples of common vegetation species at Lara were collected to provide a database of halogen concentrations typical of those species. Of particular note are very high levels of F in swordfern.
3) The Bioleach method (ActLabs) shows interesting anomalies in Br and I to the northeast and southwest of the zones of mineralization, suggesting a possible rabbit ears anomaly pattern (see panel above). Data on F and water leach results for Br, Cl and I are pending.

Acknowledgments

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