INVESTIGATION OF A NATURAL ACID ROCK DRAINAGE AND AN ANOMALOUS MERCURY-BEARING STREAM, NORTHERN VANCOUVER ISLAND (92L/12, 102I/9)

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INTRODUCTION

As part of the exploration geochemistry component of an integrated northern Vancouver Island project (Panteleyev *et al.*, 1994), detailed studies were undertaken in two areas with unusual geochemical features. These included a strongly acidic stream draining acid-sulphate altered rocks which has not been disturbed by human activity (South McIntosh) and a stream having the highest reported mercury concentration in stream sediments from the Regional Geochemical Survey (RGS) database (Macjack River) (Figure 1). The goals of this study are to determine the relationship of these anomalous concentrations to their bedrock sources, to document natural occurrences of potentially deleterious metal concentrations, and to develop geochemical models which describe the occurrence and behavior of these metals.

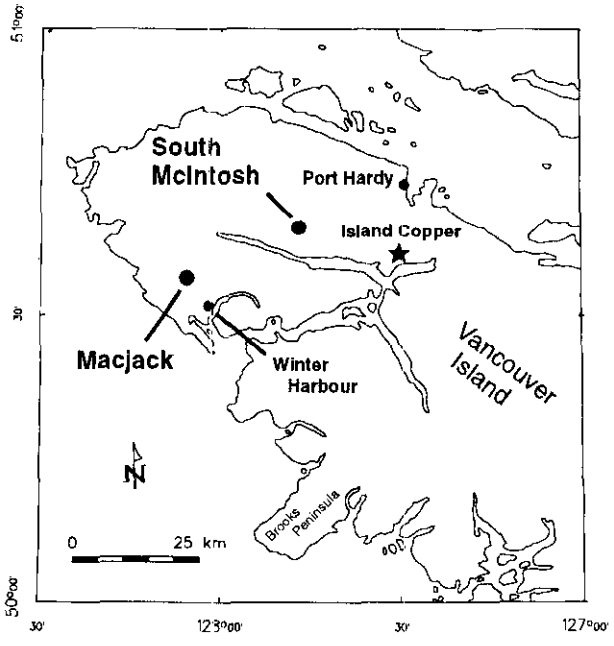

Figure 1. Location of South McIntosh and Macjack study areas, northern Vancouver Island.

NATURALLY ACIDIC STREAM - SOUTH McINTOSH AREA

Koyanagi and Panteleyev (1993, 1994) discovered numerous strongly acidic (pH< 4.0) stream waters that drain areas of acid-sulphate altered bedrock in the Red Dog - Hushamu - Pemberton Hills area. This same area also has potential for porphyry, transitional and epithermal base and precious metal mineralization (Panteleyev, 1992; Panteleyev and Koyanagi 1993, 1994). Regional Geochemical Survey data from this area report some of the lowest pH values measured in stream waters in the province (Hushamu Creek pH 3.9; Youghpan Creek pH 4.2). To further document the controls on natural acid generation and its behavior within a stream environment, a tributary of Hushamu Creek draining the South McIntosh area was selected for detailed investigation (Figure 1). Draining the eastern flank of a ridge known locally as the South McIntosh for a distance of about 1 kilometre, the creek drains an unlogged watershed mainly underlain by pyritic, propylitically altered andesites of the Bonanza Group. A zone of advanced argillic acid-sulphate alteration, containing significant quantities of sulphide (pyrite and marcasite), is exposed in the upper 200 metres of the watershed. An initial survey of this stream (sample EC91AP-19) reported a pH of 3.8 and a sulphate concentration of 39 ppm (Koyanagi and Panteleyev, 1993). Subsequent resampling of this stream has produced similar results (Koyanagi and Panteleyev, 1994).

In the South McIntosh study, sample sites were established at intervals along the stream and above the confluence of tributaries draining into it. Filtered and unfiltered waters and, where available, stream sediment, moss-mat, bank and bedrock samples were collected at each site. In-field water measurements were made for pH, conductivity and total dissolved solids (TDS) using a portable Corning CheckMate™ 90 microprocessor-based meter. Additional field measurements were made for sulphate, free and total acidity, carbon dioxide, total hardness and dissolved oxygen. Acid-washed 250-millilitre plastic bottles were used to collect water samples, in triplicate, at each site. Water samples were refrigerated after collection. One of each sample trio was filtered and acidified with nitric acid in the laboratory. Water samples, together with measurements of pH, conductivity and TDS were repeatedly taken from a

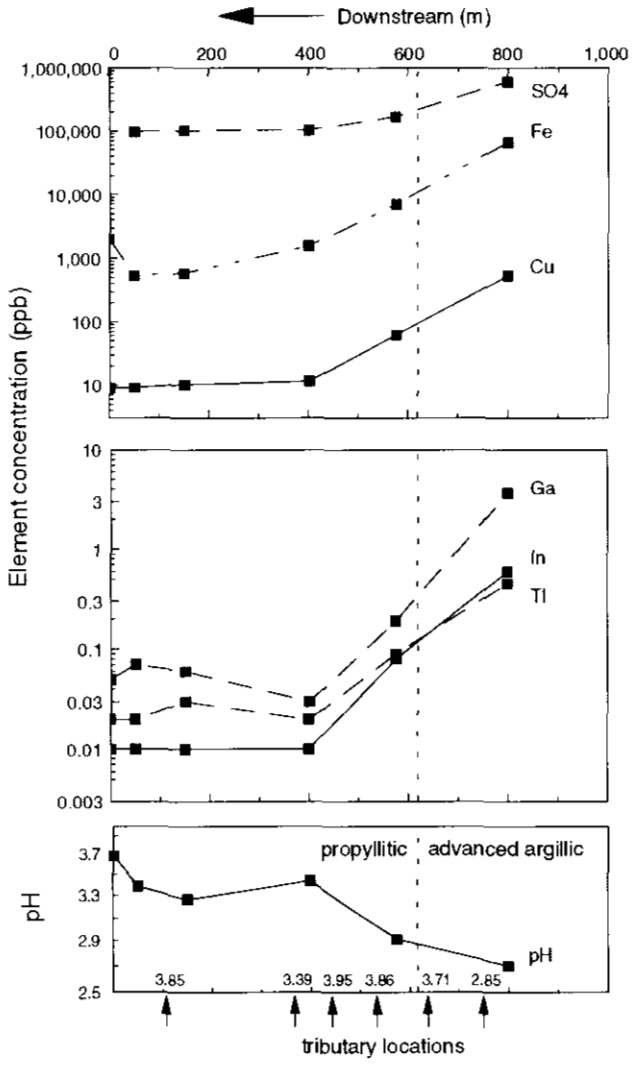

Figure 2. Downstream dispersion patterns of selected elements. Tributary confluences marked with arrows.

single site during the month of July, to study temporal variation.

Sediment samples were dried at room temperature and dry sieved to -177+62.5 microns and -62.5 microns. Rock samples were pulverized and ground in a tungsten carbide ring mill. Filtered and unfiltered water samples were analyzed for minor and major elements by ICP-MS and ICP-AES, respectively. Sulphate analyses were performed on unfiltered water samples. Stream sediment, moss-mat sediment, bank and rock samples were analyzed by INAA and by a four-acid digestion (HNO_3, HCl, $HClO_4$ and HF) plus ICP-AES analysis. Major element oxides were determined by a lithium boride fusion, nitric acid (LiBO-HNO_3) digestion and ICP-AES analysis. Analytical duplicates and standards were inserted at the laboratory before analysis.

Preliminary results suggest that stream acidity and dissolved metal content are strongly related to the style of bedrock alteration. Median pH of the stream and its tributaries is 3.4. Rapid increases in pH and decreases in conductivity, TDS and sulphate were observed in waters flowing from advanced argillic altered bedrock to propylitically altered bedrock (Figure 2). pH values of 2.7 to 2.8 measured in stream water flowing from and over advanced argillic altered bedrock rose to a pH of 3.4 within 200 metres downstream from the contact.

High concentrations of dissolved copper and iron decrease downstream from acid-sulphate altered bedrock (Figure 2). Dilution by tributary streams and a decrease in the amount of metal dissolved from bedrock probably account for the observed changes. Interestingly, concentrations of gallium (Ga), indium (In) and thallium (Tl) were observed to increase by an order of magnitude in waters flowing from the area of advanced argillic alteration (Figure 2). These elements may serve as potential pathfinders for acid sulphate alteration and its associated mineralization. Comparison of these data with the paired unfiltered samples suggests that almost all of the metal in these waters exists in the dissolved form as cations.

ANOMALOUS MERCURY CONCENTRATIONS - MACJACK RIVER AREA

A belt of anomalous (>250 ppb) mercury concentrations, 20 kilometres wide, extends up the west coast of Vancouver Island from the Brooks Peninsula region northwestwards towards Cape Scott. These anomalous concentrations appear to be spatially associated with a series of northwest-trending faults interpreted to be Tertiary age. Mercury is a known pathfinder for epithermal precious metal mineralization as well as a common product of fault-related venting of crustal volatiles. Northwest of Winter Harbour, RGS site (883007, NTS 102I/9), a tributary of the Macjack River, reports the highest mercury concentration in the province (20 000 ppb). Apart from prior logging activity on the lower western half of the watershed, no other human activity was observed. This catchment was investigated in order to determine the potential source of the mercury anomaly and to determine if any other media (soils, waters and vegetation) are similarly anomalous.

Moss-mat samples were collected from RGS site 883007, upstream from the site, and all streams in the vicinity (Figure 3). Stream sediment, moss-mat, humus (decomposed organic soil material) and rock samples were collected at regular intervals upstream from site MM04. Bank samples were also taken where available. Stream water samples and in-field water measurements were taken at the original RGS site and at sites MM03 and MM04. Moss-mat and water samples were also taken at two sites along the Macjack River. One soil profile was sampled within the drainage, near site MM02.

Sample preparation was carried out at the B.C. Geological Survey Branch laboratory. Sediment samples were air dried and dry sieved into five size fractions: -1000+500, -500+250, -250+125, -125+62.5 and -62.5 microns. Moss-mat vegetation remaining from the

sieving process was thoroughly washed to remove any adhering mineral grains. Rock samples were pulverized and ground in a tungsten carbide ring mill. Analytical duplicates and standards were inserted at the laboratory before analysis. Filtered and unfiltered stream waters were analyzed for 22 elements by ICP-AES and for mercury by cold vapour AAS. Unfiltered waters were also analyzed for sulphate. Stream sediment, moss-mat sediment, moss-mat vegetation and rock samples were analyzed for 35 elements by INAA, 32 elements by ICP-AES and mercury by aqua regia cold vapour AAS. Humus samples were analyzed for mercury by aqua regia cold vapour AAS.

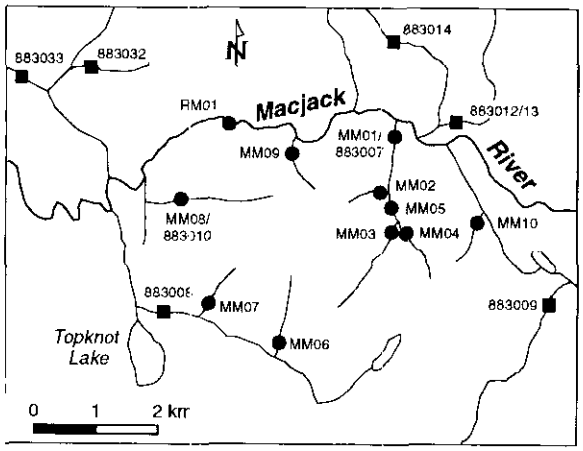

Figure 3. Location of original RGS sample sites and new sample sites, Macjack River area.

Initial results indicate that the highest mercury concentrations are found in moss-mat sediments (Table 1). Resampling of RGS site 883007 (sample MM01) produced a comparable but lower mercury concentration (16 900 ppb). Higher values were reported for samples upstream from this site. Moss-mat vegetation contains significant but lower mercury values (110 to 450 ppb). Smith (1986) found comparable levels of mercury in stream mosses in Alaska. Based on a poor correlation with the percentage of non organic material (ash) within the sample these levels were attributed to uptake of mercury by inter- and extra-cellular biochemical reactions. However, the present lack of data on the ash content of the mosses in this study does not preclude the presence of fine-grained mercury-bearing particles adhering to the vegetation as a possible explanation. Stream waters contain significant levels of mercury (0.8 to 1.6 ppb). These values are near or above the approved level (1 ppb) for drinking water (Pommen, 1989). Of note is sample RM01, taken from the Macjack River, which contains 1.6 ppb mercury. Analysis of wet-sieved size fractions from one moss-mat sediment sample (MM04) shows a distinct partitioning of mercury and suggests that mercury within the sediment exists in a discrete particulate form (Figure 4). High concentrations in samples MM04, MM05 and MM01 which increase systematically upstream suggest that the source of the mercury lies upstream from site MM04 (Figure 3). Geochemical analyses of samples from this area are pending.

TABLE 1
MERCURY CONCENTRATIONS IN VARIOUS MEDIA FROM THE MACJACK RIVER AREA

	Mercury (ppb)		
Sample	Moss-mat Sediment	Moss-mat Vegetation	Water (Filtered)
MM01	16900	210	1.0
MM02	7050	110	
MM03	170	150	0.8
MM04	34600	450	1.2
MM05	25300	190	
MM06	1100	140	
MM07	210	150	
MM08	1200	230	
MM09	3950	280	
MM10	3350	190	
RM01	200		1.6

RGS Data	(moss-mat sediment)		
Sample	Hg (ppb)	Sample	Hg (ppb)
883007	20000	883013	10
883008	2100	883014	90
883009	3200	883032	700
883010	700	883033	200
883012	120		

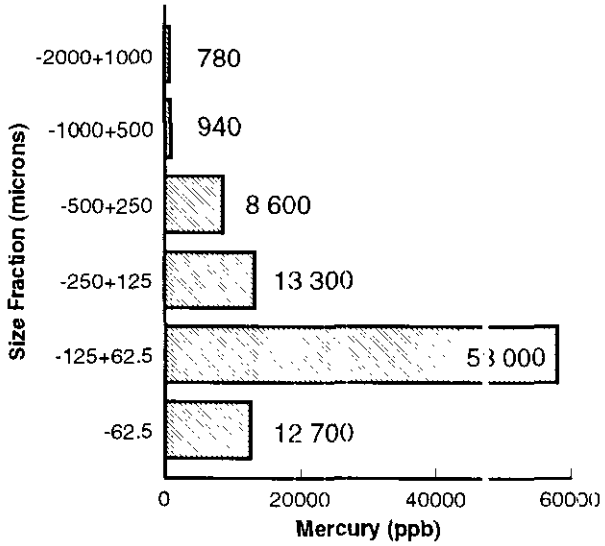

Figure 4. Partitioning of mercury between size fractions, sample MM04.

CONCLUSIONS

Rapid changes in pH and dissolved metal concentrations of natural waters emanating from a natural acid rock drainage source are apparently strongly controlled by the composition of the underlying bedrock and the presence of diluting water from tributaries. Anomalous mercury concentrations at RGS Site 883007 in the Macjack River area appear to have a discrete natural source upstream from sample site MM04. Future work on both sites will focus on analysing new and existing data to develop models of metal dispersion for application to mineral exploration and environmental assessment.

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