Tracing the source of anomalous geochemical patterns in carbonate-rich bog soils near the Nazko volcanic cone, BC.

Geoscience BC
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TREK Project

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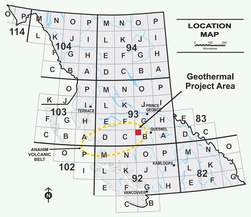
GEOTHERMAL POTENTIAL

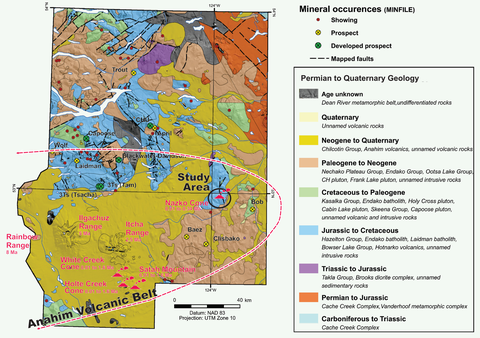
BACKGROUND



Travertine deposits, soil gas seepages and organic soil mixed with calcium carbonate are among surface features observed in two wetlands informally named the North and South bogs near the Nazko volcanic cone, BC (Figure 1). A previous study detected carbon dioxide with traces of methane and helium in the seepage gas (Hickson, pers comm, 2013; Vigouroux, pers comm, 2013) and the isotopic composition (δ^{13} C between – 6.2 to – 6.9 per mil PDB) of the gases suggested a magmatic origin (Williams-Jones, pers comm, 2013).

Although the highest water temperature measured in the bogs is 15˚C, the existence of carbon dioxide seepages, travertine deposits on the bog surface, the nearby Nazko volcanic cone and an interpretation of seismic data (Kim et al. 2014) suggest a magmatic source for the seepage gas. Cool surface waters do not necessarily indicate an absence of geothermal activity beneath the

FIGURE 1. Location of geothermal study area, Interior Plateau, central BC.



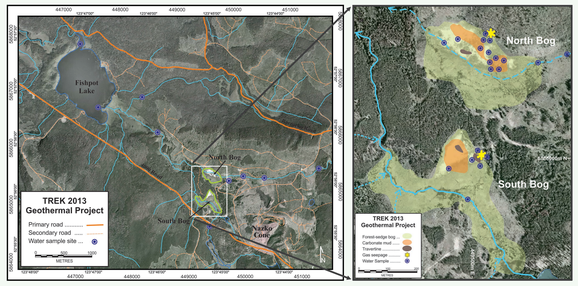
The North and South bogs are in the Anahim volcanic belt (Figure 1), an east-trending belt of Pleistocene-Holocene volcanoes that include the Nazko cone. Much of the surrounding area is underlain by Eocene Ootsa Lake Group, Miocene Endako Group and Pleistocene-Holocene volcanic rocks and by clastic sedimentary rocks of the Cretaceous Taylor Creek formation (Talinga and Calvert, 2014). Glacial deposits covering bedrock are till and glacio-fluvial sediments.

Souther at al. (1987) estimated that the Nazko volcanism began during the Fraser Glaciation. Post glacial deposition of red pyroclastic ash, lapilli and volcanic bombs ejected from vents in the cone created the present-day edifice. Souther et al. (1987) interpreted an ash layer to have been deposited by an eruption from 7100 and 7200 years BP when, in addition to the ash fall, olivine basalt lava flowed from the volcano to the south and west. An earthquake swarm near the Nazko cone in 2007 (Cassidy et al. 2011) and the interpretation of seismic data by Kim et al. (2014) suggest the presence of magma in the lower crust between 22 and 36 km depth.

The soil and water geochemical expression of geothermal indicator elements (e.g. Li, B) in the Nazko wetlands and surrounding area has been described by Lett and Jackaman, 2014. This poster summarizes the results of more detailed ground water, surface water, soil, rock, till and tree bark sampling to around the Nazko North Bog to better understand the geochemical dispersion processes (Lett and Jackaman, 2015). This study, supported by Geoscience BC's TREK Project, is designed to complement earlier investigations and to support local community interest in geothermal resources.

STUDY METHODOLOGY

FIGURE 2. Detailed maps showing the topographic location, general structure and stream water sample sites associated with the North and South bogs targeted during 2013 and 2014 geothermal field explorations, Interior Plateau, central BC.



FIELD STUDIES - Sampling (Figure 2 & 3a, b, c) and field work in 2014 involved:

- Sampling bog ground water, surface water and stream water.
- Sampling soil, till, humus and tree bark at sites in the North Bog around a travertine cone - CO_2 vent.
- Measuring water temperature, pH, conductivity, alkalinity, dissolved CO_2 and salinity.
- Sampling travertine for geochemical, mineralogical and stable isotope analysis in the North and South Bogs.

SAMPLE ANALYSIS - The following laboratory methods were used:

Water samples were analysed at ALS Environmental, Burnaby, BC for dissolved Al, Ag, As, Ba, Be, Bi, B, Cd, Ca, Cs, Cr, Co, Cu, Ga, Hg, Fe, Pb, Li, Mn, Mo, Na, Ni, P, Re, Rb, Sb, Se, Si, Sn, Sr, Te, Tl, Th, Ti, U, V, Y, Zn and Zr by high resolution mass spectrometry (HRMS); for total alkalinity by titration, and for F^-, Cl^-, Br^-, NO_3-, NO_2- and SO_4- by ion chromatography.

Soil (< 0.180 mm size) and travertine samples (< 0.050 mm size) were analysed at Acme Labs, Vancouver, BC, for Al, Ag, As, Au, Ba, Be, Bi, Cd, Ca, Cs, Cr, Co, Cu, Ga, Fe, Pb, Li, Mn, Hg, Mo, Ni, P, K, Re, Rb, Se, Na, Sr, Te, Tl, Th, Sn, U, V,Y, Zn and Zr by aqua regia digestion-inductively coupled mass spectrometry (ICPMS); for major oxides (Al2O3, SiO2, Fe2O3, CaO, MgO, MnO, P2O5) and minor elements (Cu, Ba, Zn, Ni, Co, Sr, Zr, Ce, Y, Nb, Sc), by lithium borate – ICPMS; for loss on ignition at 1100˚C; for C and S by Leco combustion. Selected travertine samples were also analysed for carbonate minerals X-ray diffraction and for carbon and oxygen isotopes.

Milled tree bark and sieved (< 180 mm) humus samples were analysed for Al, Ag, As, Au, Ba, Be, Bi, Cd, Ca, Cs, Cr, Co, Cu, Ga, Fe, Pb, Li, Mn, Hg, Mo, Ni, P, K, Re, Rb, Se, Na, Sr, Te, Tl, Th, Sn, U, V,Y, Zn and Zr by regia digestion-ICPMS.

ACKNOWLEDGMENTS

- Assistance from Francis Bertoia with the sampling and data recording the field was greatly appreciated.
- Glyn Williams-Jones, Simon Fraser University, Catherine Hickson, Alterra Power Corp and Nathalie Vigouroux, Douglas College are thanked for generously provided information about the Nazko wetlands.

RESULTS & CONCLUSIONS

SUMMARY OF RESULTS - WATER

Geochemical indicators of geothermal activity, Li, B, As, Rb and Sr are elevated in ground and surface waters. Analysis of water samples collected in 2013 and 2014 reveals that:

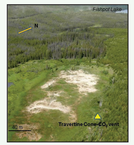
- Nazko bog waters have up to 637 ppb B (ground water), 547 ppb Li (surface water) and 15.9 ppm Sr (surface water).
- Water pH ranges from 5.85 (ground) to 9 (surface) with up to 383 ppm Ca (ground water), 850 ppm dissolved CO_2 (surface water), 15.9 ppm Sr and 18.7 ppm Si.
- Water from a small travertine cone on the edge of the North Bog. (Figure 3b) has 44 ppb Ni, 2.4 ppb, As, over 5 ppm Fe and no detectable Hg. There is a vigorous CO_2 flow from a vent in the cone (Figure 3c). Water temperature (< 6˚C) is lower than ground water and surface water (> 12˚C).
- Several pathfinder elements in water have a strong correlation (e.g. Ca versus Sr correlation coefficient = + 0.89; Li versus Ce correlation coefficient = + 0.88).

SUMMARY OF RESULTS - SOIL & TRAVERTINE

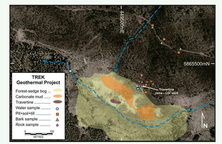
Soil sample analysis in 2013 and 2014 of the North Bog samples revealed that:

- Boron and Li levels in deeper soil (> 50 cm depth) are less than 65 ppm and values vary only slightly from well-drained mineral soils to calcium carbonate-rich organic soil.
- Trace elements (As, Ni, Cu) increase in water-saturated organic soil on the bog margin. Mercury is elevated in well drained soil upslope from the CO_2 vent and with other trace metals (e.g. Cu, Ni) is likely weathered from the glacial deposits.
- X-ray diffraction analysis of the travertine cone wall reveals that the rock is > 80% aragonite.

FIGURE 3a, b and c.



a) North Bog and CO_2 vent.



b) 2014 sampling program.

c) CO_2 bubbling from a 35 cm high cone-shaped travertine deposit enclosing a partly water covered vent. Travertine from the cone wall has 31% Ca, 2.6 ppm Li, 1.18 % Sr, 33 ppm B, 66 ppm Ni and 449 ppb Hg.

CONCLUSIONS

There are subtle geochemical indications of a thermal anomaly beneath the Nazko bogs including:

- The variations in the Nazko ground and surface water chemistry that could be the result of (1) cold ground water flowing into the bogs from the surrounding uplands, (2) thermal water upwelling from bedrock and (3) mixing of hot and cold water.
- Anomalous B, Li and Sr levels in bog waters, but at concentrations lower than in water at geothermal fields (e.g. Pasvanoglu, 2013).
- The correlation between geothermal pathfinders (e.g. Li, Cs) in the water and higher dissolved Li, Cs, Sr and Si. These elements may be the soluble products of reactions between volcanic wall rock and upwelling thermal water.
- Higher dissolved B concentrations that could reflect mixing and dilution of more concentrated, upwelling thermal water with cooler, near surface ground water.
- The travertine is predominantly aragonite suggesting that the carbonate was deposited from warm water.
- The elevated soil Hg near the travertine cone-CO_2 seep that could be an expression of cinnabar grains in the till on uplands surround the bogs rather than vapour Hg from geothermal activity.

REFERENCE

Lett, R.E. and Jackaman (2015): Tracing the source of anomalous geochemical patterns in carbonate-rich bog soils near the Nazko volcanic cone, BC, NTS 93B/13, Geoscience BC Report, 2015-1.