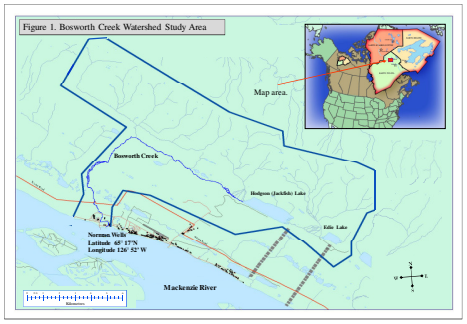
Bosworth Creek ice study - implications for northern ecosystems

Mackenzie Mountain School, Norman Wells and Chief Albert Wright School, Tulita,

Sahtu Settlement Area, Northwest Territories



Introduction

This study looks at the chemistry of creek water and two kinds of ice that occur during the winter throughout northern Canada. The Bosworth Creek Ice Study was created under the Bosworth Creek Monitoring Project (BCMP). The BCMP is a multi-disciplinary, high-resolution, long-term investigation of a local watershed at Norman Wells, Northwest Territories (Figure 1). This project is co-founded and facilitated by the Sahtu Renewable Resources Board (SRRB) and the Department of Fisheries and Oceans Canada (DFO) and provides original research opportunities for local high school students who work closely with government scientists and academic professionals. The BCMP was created in 2006 in answer to concerns raised by local community members about the health of a local fisheries habitat. Since ice is a formidable presence throughout most of our year, we decided to look at the chemistry of various kinds of ice and compare these results to spring-fed creek water that flows year round. Basically, there are three kinds of ice: (1) creek, river and lake water that freezes down from the surface and are composed of their host's water; (2) blue-green overflow ice (Figure 2) that is well known by northerners and results from groundwater forcing its way through a frozen surface layer and causing local flooding events that lead to successional layers of ice on top of the original surface. This type of overflow is the same kind of water that normally flows in creeks during the summer, and for many creeks like Bosworth, throughout the winter under the ice; and (3) yellow-brown overflow ice (Figure 3) that exhibits elevated levels of many heavy metals (Table 1 and accompanying pie charts) and other properties. Local elders and others do not recall seeing this type of ice in the past; while recently, reports have accumulated about first time appearances at places where it has never occurred before. This kind of overflow must originate from a different source than the blue-green overflow. We believe that permafrost provides the most probable source for this anomaly, and explains its new and increasing occurrence, as permafrost degradation throughout Canada's north is accelerating due to climate change.
Since this ice is increasing in both prevalence and abundance, local Aboriginal leaders and community members are becoming concerned about the possible impacts to the health of their people, and the wildlife that are essential for Dene and Métis subsistence and identity.
It was decided that a more thorough investigation was required. We applied to the Canadian Light Source Inc. (CLSI) Students on the Beamline Program to perform synchrotron x-ray experiments on samples of soil and both types of overflow ice using the Spherical Grating Monochromometer (SGM). We are the first people from Northern Canada to use this world class facility and represent schools from two communities; Mackenzie Mountain School (MMS), Norman Wells and Chief Albert Wright School (CAWS), Tulita, Northwest Territories.

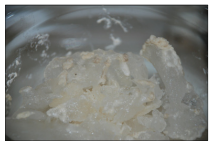
Figure 2. Blue-green overflow ice

Figure 3. Yellow-brown overflow ice

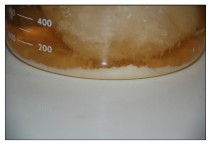
Collecting ice samples: Siobhan Quigg and Nigel Gregory (MMS),

Glen Guthrie (SRRB),

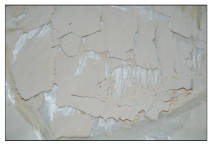
Kit Dennis-Walker and Chantal Bavard (CAWS).



Preparing samples: Ice is placed in beakers and allowed to evaporate in a clean environment. Precipitates form on top of the ice as it melts.

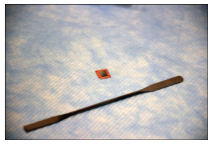


Precipitates also rain out onto the bottom of the beaker.



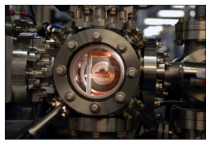
Once the solution has nearly evaporated, the mixture is poured onto wax paper covered trays and allowed to dry and ground into powder.

Preparing samples: Left to right: Tracy Walker (CLS) Chantal Bavard (CAWS), Siobhan Quigg (MMS) and Jamie Mackenzie (CLS).



A sample ready for the endstation.

Final inspection of the samples.



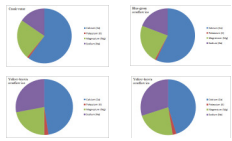
Samples in the SGM endstation.

Robert Blyth (CLS), Nigel Gregory and Siobhan Quigg (MMS).

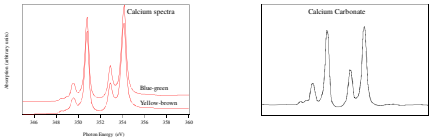
First look at the results on the computer monitor.

mg/L	Creek Water	Blue-Green	Yellow-Brown	Yellow-Brown
Calcium (Ca)	120	164	1540	1600
Potassium (K)	1.83	2.47	74.4	78.4
Magnesium (Mg)	47.3	66.6	773	738
Sodium (Na)	31	55.2	1020	941
Iron (Fe)	0.054	0.0606	0.986	0.56
Manganese (Mn)	0.0056	0.0116	0.734	0.48
Aluminium (Al)	0.01	0.023	0.326	0.31
Boron (B)	<0.050	0.057	0.609	0.534
Barium (Ba)	0.0861	0.112	1.32	1.33
Cobalt (Co)	<0.0020	<0.0020	0.0036	0.0041
Copper (Cu)	<0.0010	0.0017	0.0226	0.0246
Lithium (Li)	0.013	0.016	0.237	0.215
Molybdenum (Mo)	<0.0050	<0.0050	0.018	0.021
Nickel (Ni)	0.0034	0.0041	0.0398	0.0432
Lead (Pb)	<0.00010	0.00086	0.00669	0.00837
Antimony (Sb)	<0.00040	<0.00040	0.00116	0.00108
Titanium (Ti)	0.0012	<0.0010	0.0133	0.0111
Uranium (U)	0.00178	0.00362	0.0203	0.0222
Vanadium (V)	<0.0010	<0.0010	0.0035	0.0047
Zinc (Zn)	<0.0040	0.0108	0.187	0.0753

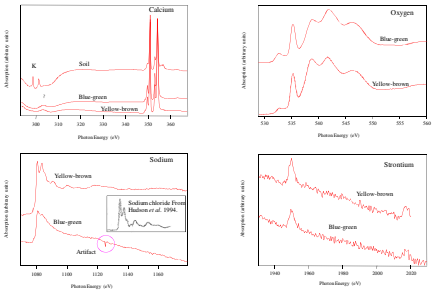
Table 1. Elemental analyses of creek water and both types of overflow ice.



Pie charts showing the relative abundance of Ca, K, Mg and Na in creek water and both types of overflow ice. Note similarities between creek water and blue-green ice, compared to yellow-brown ice.



Identifying elemental compounds with the Spherical Grating Monochromometer. We found very specific signatures for Calcium. Our samples (left) match the spectrum for calcium carbonate ($CaCO_3$) as illustrated on the right from Naftel *et al.* 2001.



Examples of elemental spectra imaged by the Spherical Grating Monochromometer. The signature for Ca has been identified as calcium carbonate. However, our results for O and Na have not yet been identified. The Sr spectrum is the first imaged by this beamline at CLS.

Conclusions

Further elemental analyses and synchrotron experiments are required to answer a number of questions raised by this study. First, we still don't know why the discoloured ice is yellow–brown. Sulphurous compounds or tannins (plant polythenols) may be responsible for this colour. Second, the oxygen spectra from both ice samples resemble each other except for the difference between the third peaks. These phenomena occur in both types of ice, but were not observed in the soil sample and their chemical signatures have not yet been identified. Third, the sodium signature in yellow-brown ice resembles sodium chloride more than the blue-green ice sample. However, the morphology of the second peaks and subsequent profiles preclude sodium chloride as the compound found in either ice sample.

Project Sponsors

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Hudson, E., Moler, E., Zheng, Y., Kellar, S., Heimann, P., Hussain, Z., and D.A. Shirley 1994. Near-edge sodium and fluorine *K*-shell photoabsorption of alkali halides. Physical Review B (49), 3701-3708.

The Team

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March 2-4, 2010. From left to right: Nigel Gregory (MMS), David Chevrier (CLS), Chantal Bavard (CAWS), Kit Dennis-Walker (CAWS), Jamie Mackenzie (CLS), Siobhan Quigg (MMS), Tracy Walker (CLS), Glen Guthrie (SRRB), and Robert Blythe (CLS).