Research Progress Report – April 2014

University of Waterloo & Wilfrid Laurier University Researchers

Project Title: ***Sediment Core Sampling to Assess Contaminant Deposition to the Slave River Delta Over Time***

Background: This project is part of the Slave River & Delta Partnership's (SRDP) activity funded by the NWT Cumulative Impact Monitoring Program (CIMP) 2011-2012

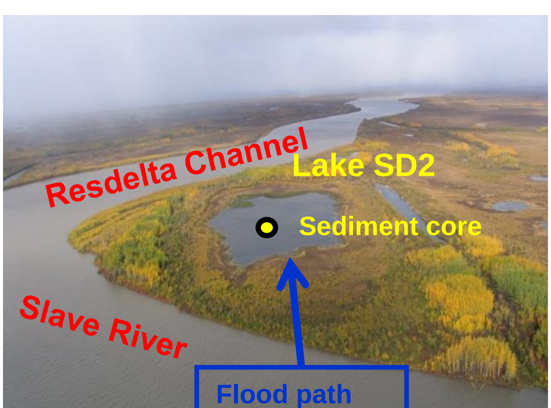
Project Goals: This project, identified as a priority by the SRDP, addresses community concerns that contaminants may be increasing in the Slave River. We analyzed contaminants in a sediment core from frequently-flooded Lake SD2 in the Slave Delta to: **1)** Determine baseline concentrations of metals before oil sands development began; **2)** Assess if the levels of the metals have changed since development of Alberta's oil sands.

When long-term records of measurements of river water are not available, sediments deposited by floods into lakes of the Slave Delta provide one of the best and only sources of information to track changes in water quality of the Slave River over time.

This Report: Provides an update of our activities, results & conclusions so far.

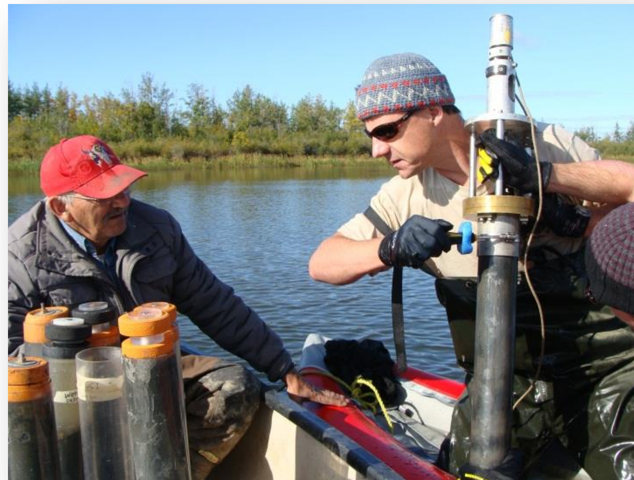
Progress to Date: Sediment cores were collected on September 14, 2011.

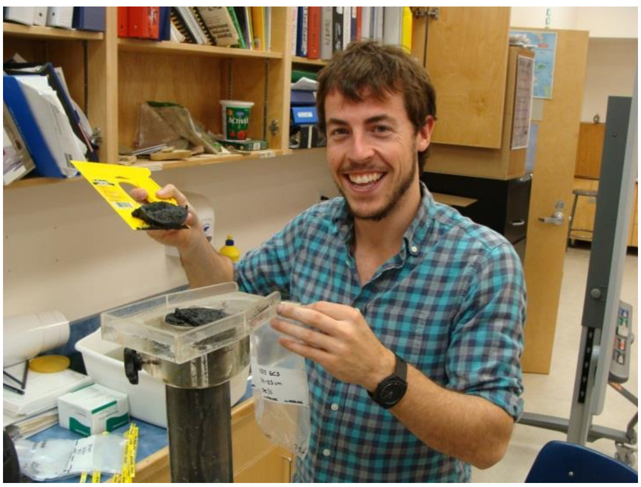
- All samples have been analyzed for organic contaminants (PAHs) and metals.
- Data have been analyzed for PAHs and results & conclusions about PAHs were highlighted in a prior Progress Report (November 2012).
- Here, we report our results and conclusions based on analyses of metals. Metals are contaminants of concern because they can potentially be transported long distances through the air and water and can have adverse effects on wildlife and human health.



Lake SD2 was chosen for the study because 1) it is frequently flooded from the Slave River, and 2) previous research developed knowledge of the lake's flood history during the past century.

- Knowing this makes it possible to assess changes in contaminants carried by the Slave River to the Slave Delta.





- A 48-cm long sediment core was collected from Lake SD2 using a corer fitted with a plexiglass tube. We worked with Gaby Lafferty out in the delta to complete this project.
- The sediment core was cut into 1-cm thick slices (~2 years each). We did this work at the Deninu School, which provided opportunity to engage with the students.
- The core spans the past 87 years (back to about the year 1925).

Preliminary Conclusions

1. We measured the concentration of metals in a sediment core from flood-prone Lake SD2 in the Slave Delta, which spans the past 87 years, and compared values in sediments before (pre-1967) and after (post-1967) development of Alberta's oil sands.

2. This comparison shows that post-1967 concentrations of metals of concern (e.g., Vanadium, Arsenic) are within ranges of expected natural variations.

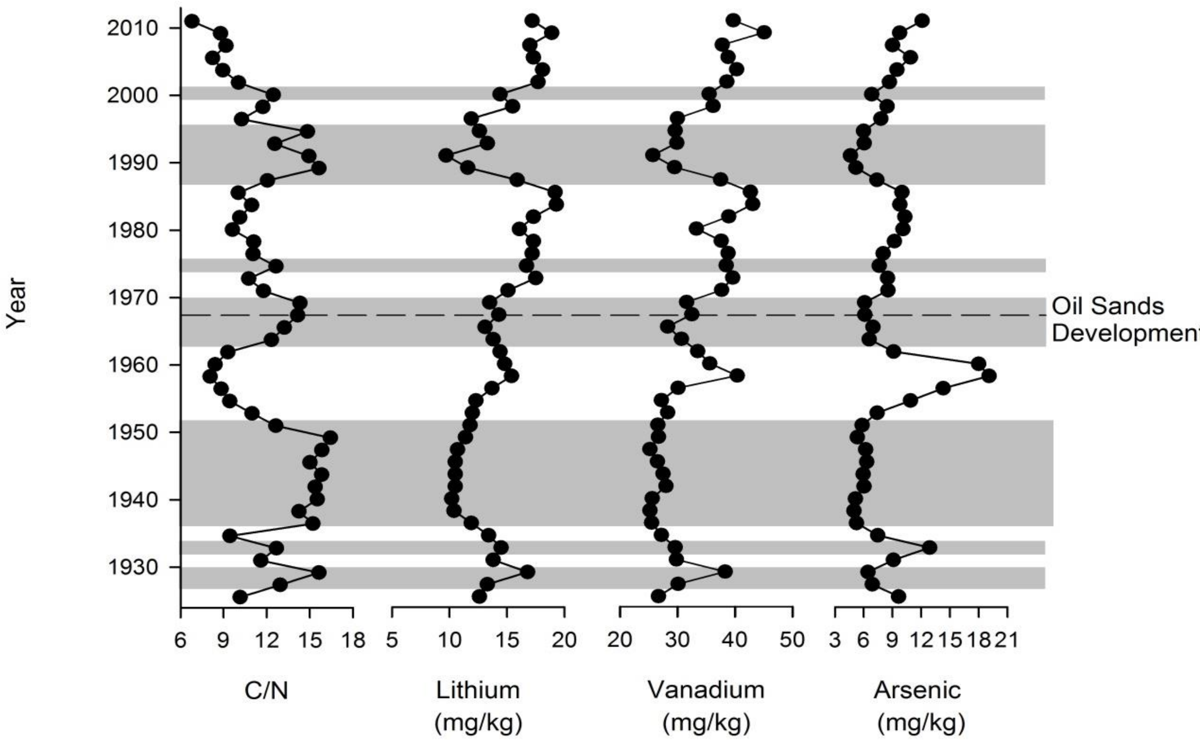
3. These findings agree with research on bitumen-associated PAHs in Lake SD2, which show no increase since onset of oil sands development. (See our previous research report from November 2012)

4. However, we did find concentrations of some metals (Arsenic, Strontium and Calcium) that exceeded background levels (1956, 1958, 1960), which may be associated with Giant Mine production because they coincide with peak emissions from gold smelting.

Oil sands operations and tailings pond along the Athabasca River.

Exposed bitumen along the Athabasca River.

Results (1)



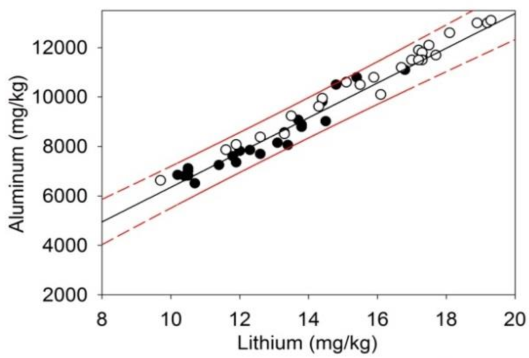
- The majority of metals carried by the Slave River tend to be bound to sediment that is fine-grained like clays. These fine-grained materials dominate sediments that are deposited in Lake SD2 during periods of little to no flooding. We suspect these fine-grained sediments are washed in from the catchment during the spring snowmelt and substantial rain events. These intervals are recorded by low C/N ratios in the above graph and marked as white zones in the graph.

- In contrast, during high energy flood events, larger particles (i.e., sand and silt) are deposited in Lake SD2 which have a much lower concentration of most metals. These intervals are recorded by high C/N ratios in the above graph and marked as grey zones. As a result, periods of intense flooding lower the concentration of metals deposited in Lake SD2.

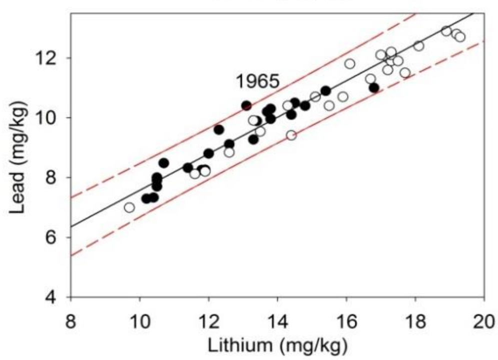
- In the above graph we show changes in time of three metals in the sediment core from Lake SD2. Lithium is a common metal in natural rocks, is associated with clay-sized minerals and is not influenced by human activities. Vanadium is a naturally occurring metal, but can also serve as an indicator of oil contamination. Notably, the Lithium and Vanadium profiles co-vary (i.e., show the same pattern) suggesting the Vanadium is largely natural. While we generally see a similar trend with Arsenic, notably high concentrations occurred during the 1950s.

Results (2)

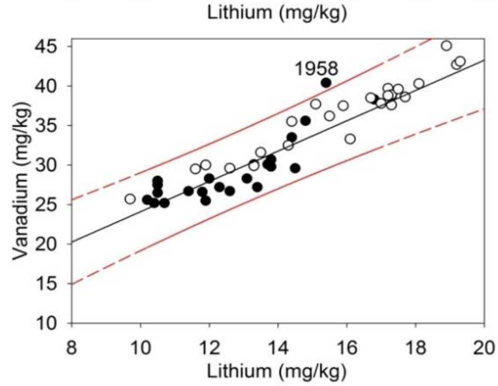
The graphs on this page allow us to assess if there is evidence of metal contamination since the onset of oil sands development in 1967. To account for changes due to variations in natural supply and energy conditions (i.e., changes in grain-size from flooding and erosion), metal concentrations are compared to Lithium concentration. Lithium is a common metal in natural rocks, is associated with clay-sized minerals and is not influenced by human activities so it gives us a good idea of natural changes. The red lines represent 95% prediction intervals based on patterns from pre-1967 data. The prediction intervals tell us with a 95% probability where we would expect data from post-1967 should fall if there are no effects from oil sands development. Values that fall within the red lines represent samples within the range of natural variation. Values that plot above the upper red line represent samples with metal concentrations above expected natural abundance (i.e., contamination). The solid circles represent sediments deposited before 1967 and open circles represent sediments deposited after 1967.



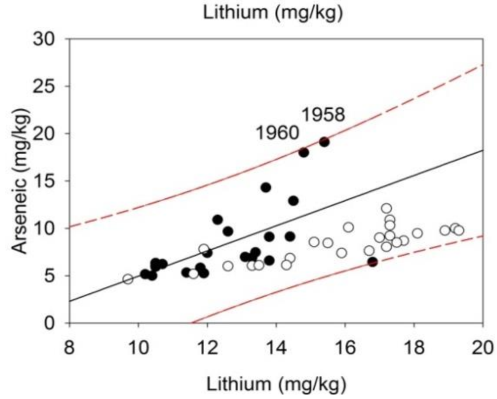
- **Lithium** and **Aluminum** are naturally occurring metals that are not easily influenced by human activities. The tight clustering of points within the red lines shows that their concentrations co-vary (i.e., have the same pattern).
- This strong relation is driven by similar responses to changes in natural supply and energy conditions.



- **Lead** concentrations in sediments of Lake SD2 show a strong relation with Lithium content. This reflects that changes in natural supply and energy conditions are dominant controls on lead concentration.
- Only one sample is near the edge of the upper prediction interval. It represents 1965, which closely corresponds with peak atmospheric lead deposition in North America from leaded gasoline emissions before oil sands development.



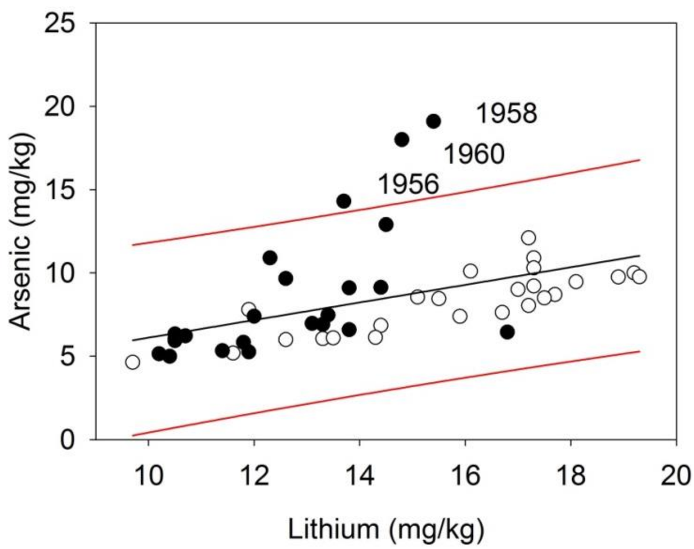
- **Vanadium** concentrations in sediments of Lake SD2 show a strong relation with Lithium content, indicating that changes in natural supply and energy conditions are dominant controls on Vanadium concentration.
- Only the sample from 1958 lies above the upper prediction interval. This pre-dates oil sands development. Vanadium levels are not elevated above background in the post oil-sands period.

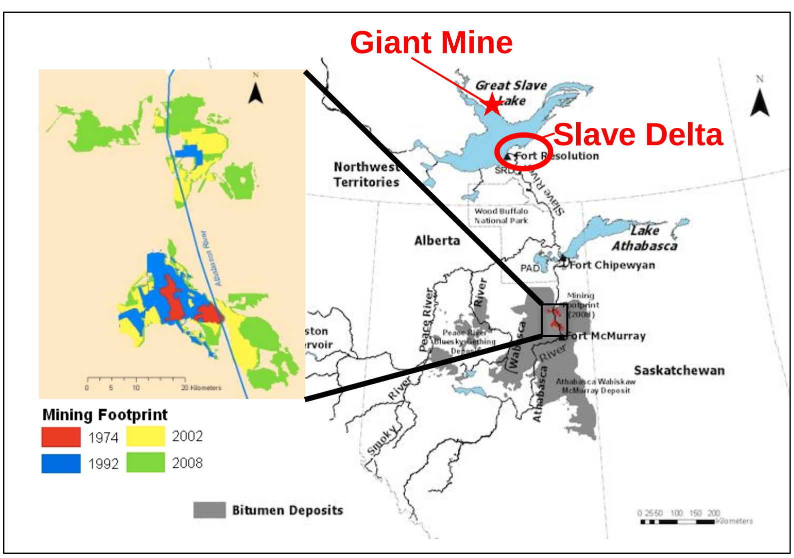


- **Arsenic** concentrations in sediments of Lake SD2 show a strong relation with Lithium content, reflecting that changes in natural supply and energy conditions are dominant controls on Arsenic concentration.
- Two samples (1958 & 1960) approach the upper prediction interval. These pre-date oil sands development. The post-oil sands period is not associated with levels of Arsenic above background.

Results (3)

To explore further the high Arsenic concentrations in two sediment samples deposited before oil sands development (1958, 1960), we plotted prediction intervals based on all of the data (pre- and post-1967). This allowed us to determine that three samples have unusually high Arsenic concentration (1956, 1958, 1960). Similar findings were found for Strontium and Calcium concentrations. This corresponds with a period of high Arsenic emissions from the Giant Mine in Yellowknife, NWT.





These maps show the location of the Slave River Delta, in relation to Giant Mine and Alberta's oil sands development (grey area).

<u>Future Contributions</u>: We plan to present these results and preliminary conclusions at the upcoming joint Quebec-Ontario Graduate Student Paleolimnology Symposium (Quebec City, May 2014).

<u>Contact Information</u>: **Brent Wolfe**, Department of Geography & Environmental Studies, Wilfrid Laurier University, Waterloo, Ontario. Email: ***bwolfe@wlu.ca***;

Roland Hall, Department of Biology, University of Waterloo, Waterloo, Ontario. Email: ***rihall@uwaterloo.ca***