CHROMIUM AND ARSENIC
IN THE OIL INDUSTRY

Introduction

A major portion of Alberta's economy is based in the oil and gas sector. Understanding the industry's environmental impact is critical. Last year, we studied the speciation and redox potential of tailings with respect to sulfur. Continuing this investigation of toxic species within tailings ponds, we decided to study arsenic and chromium this year.

The question that we aimed to answer is: *How do the concentrations and oxidation states of chromium and arsenic change as a result of the bitumen extraction process and aging of the tailings from the process?*

We predicted:
- Higher concentrations of arsenic and chromium in Mature Fine Tailings (MFT) compared to Raw Ore (RO)
- Higher concentrations of arsenic (III) than arsenic (V) present in MFT and RO
- Higher concentrations of chromium (III) than chromium (VI) present in MFT and RO

Techniques

XRF/XANES Techniques

XRF and XANES techniques on the IDEAS beamline were used to analyze the samples. XRF (X-ray Fluorescence Spectroscopy) analyzes the relative amounts of different elements within the sample. XANES (X-ray Absorption Near Edge Structure Spectroscopy) shows the oxidation state of the element being studied, thus providing an indication of the species present.

Linear Combination Fitting

Linear combination fitting is a data analysis technique where computer software sums XANES scans of standards in a weighted fashion in an attempt to recreate the XANES scan of a sample of unknown composition. The weighted values used in the sum give insight to the amounts of species (standards) that are present in the sample.

Analysis

Figure 1

Figure 2

MFR AND RO XRF

The peak at 5414eV is representative of chromium. The chromium peak of the RO is smaller than the chromium peak of the MFT. This could suggest that the MFT have a larger concentration of chromium. The graphs are normalized to the scatter peak.

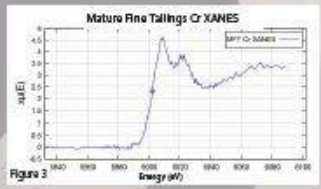

Figure 3

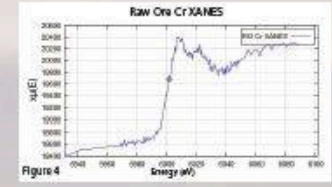

Figure 4

MFT AND RO CHROMIUM XANES

Chromium(VI) has a large pre-edge peak at approximately 5990eV. The fact that the RO and MFT XANES graphs do not have that pre-edge peak, and have a peak at approximately 6007eV, could suggest that chromium(III) is present in the samples.

Figure 5

Figure 6

LINEAR COMBINATION FITTING OF RO/MFT CHROMIUM XANES

Standards of chromium(III) oxide, chromium(III) sulfide and chromium(VI) oxide were used in a linear combination fitting analysis. The analyses for both RO and MFT showed the samples were 100% chromium(III) oxide, however, the graphs do not match. It is reasonable to suggest that the samples may be part chromium(III) oxide, but more standards are needed for a better analysis.

Figure 7

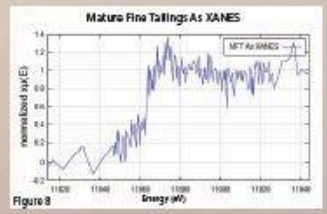

Figure 8

MFT ARSENIC XANES

The arsenic XANES scan has a large noise to signal ratio, however, there is still signal. Our results support that there is arsenic in the MFT. The difference in the peaks in Figure 7 indicates that there is also lead in the sample.

Conclusion

Our data suggests that the environmentally neutral chromium (III) species was present in small amounts in the MFT whereas carcinogenic chromium (VI) was most likely not present in measurable amounts in any of the samples. This could suggest that chromium (VI) is not present in significant or measurable amounts throughout the bitumen extraction process. The consistency in the concentrations of chromium (III) may suggest that the process does little to remove this species from tailings.

Arsenic may have been present in very trace amounts in the RO and MFT samples. The evidence that we were able to collect was not substantial enough to draw any specific or meaningful conclusions in regards to the effectiveness of the bitumen extraction process in removing arsenic.

Future Research

The continued use of linear combination fitting will enable more accurate comparisons between standards and samples in the future. The initial XRF scans of the RO and MFT suggest that the samples contain relatively large amounts of iron, which may be an element of interest to investigate further, as well as titanium, which may be present as the carcinogenic species titanium dioxide. The scan also displayed evidence of the presence of highly toxic lead. For future study, we may review literature to inquire into the possibility of the presence of other heavy metals in the samples.

Acknowledgements

This has been an unforgettable experience for all of us. A very special thank you to Anna-Maria Boechler and Toby Bond who have helped us throughout this project and to Dr. David Muir, our beamline scientist. To Dr. Lois Boxill and Brad Komishke, thank you for providing our samples. Finally, a huge thank you to the CLS for providing us with the chance to participate in the Students on the Beamline program.

Canadian Light Source / Centre canadien de rayonnement synchrotron

Bishop Carroll: Eva Ambrose, Carlos Bagni, Joel Braganza, Brynna Clarke-Leene, Julia Craig, Carter Markic, Kol McArthur, Urban Pistek, Emma Raleigh-Smith, , Talia Santarossa, Everett Yee, Laurie O'Connor, Steve Ambrose,
CLS: Toby Bond, Anna-Maria Boechler, Dr. David Muir