Geochemical anomalies in soil and sandstone overlying the Phoenix uranium deposit, Athabasca Basin

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Introduction

The Wheeler River Property, host of Denison Mine's Phoenix uranium deposit, is situated near the southeastern rim of the Athabasca Basin in Northern Saskatchewan (Figure 1). The mineral resources drilled to date are estimated to contain 35 to 39.5 million pounds U_3O_8, with the deposit formed in 4 distinct ore bodies which are open along strike at both ends. This deposit was originally thought to have no surficial expression, and occurs near the unconformity between the early Paleoproterozoic crystalline basement rocks and the overlying Athabasca Group sandstones approximately 400 meters below the surface.

In September 2011, we initiated a study to evaluate i) whether geochemical anomalies related to such a deeply seated deposit exist in surface media and the uppermost sandstones over the deposit, ii) in which type of surface media (soil, gas, water, till) displays anomalies, and iii) what is the most efficient analytical method to detect these anomalies.

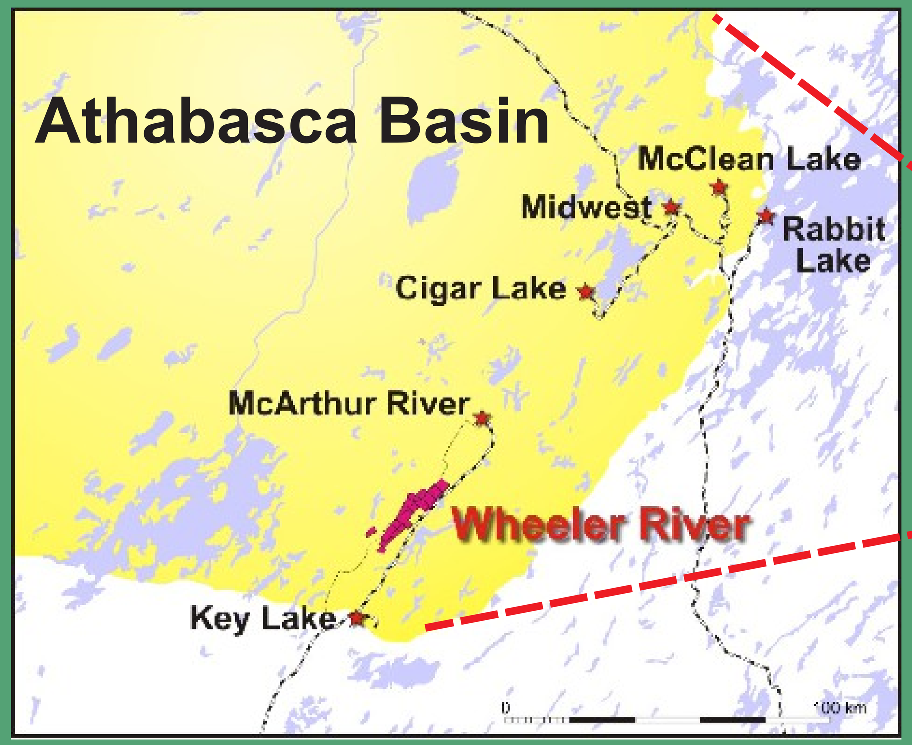


Figure 1: Denison Mine's Wheeler River property, hosting the Phoenix Deposit, in the Athabasca Basin.

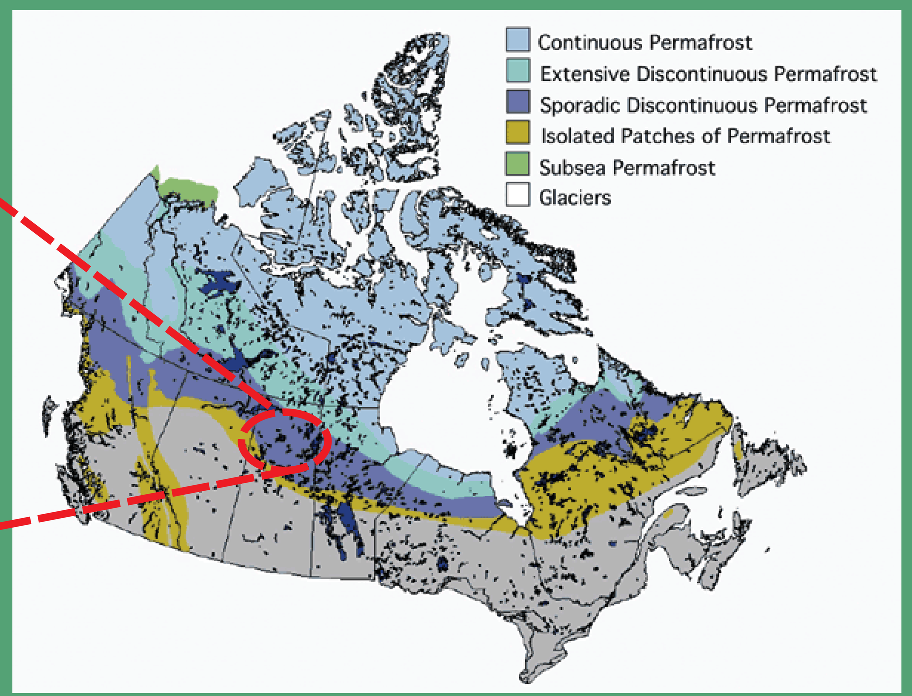


Figure 2: Permafrost Map of Canada. The Athabasca Basin is within the region of mainly sporadic discontinuous permafrost (Burgess, 1999).

Study Area

The Athabasca Basin experiences a sub-arctic climate (Figure 2) with long, dry and cold winters with warm, wet summers. The surface topography on the Wheeler River Property consists mainly of gently rolling hills of glacial moraines and till, and has experienced several ice flow episodes. The area is covered with ~3 m tall young black spruce trees (Figure 5) and caribou moss and minor shrubbery. Average thickness of overburden is approximately 25 to 100 m in places, with the uppermost sandstones below the overburden. The study area receives approximately 475 mm of annual precipitation.

Figure 3: Lease road at the Wheeler River Property. The small hills in the background indicate gentle topographical relief.

Figure 4: View through the forest, with abundant young black spruce and extensive mossy undergrowth.

Transects for Sampling

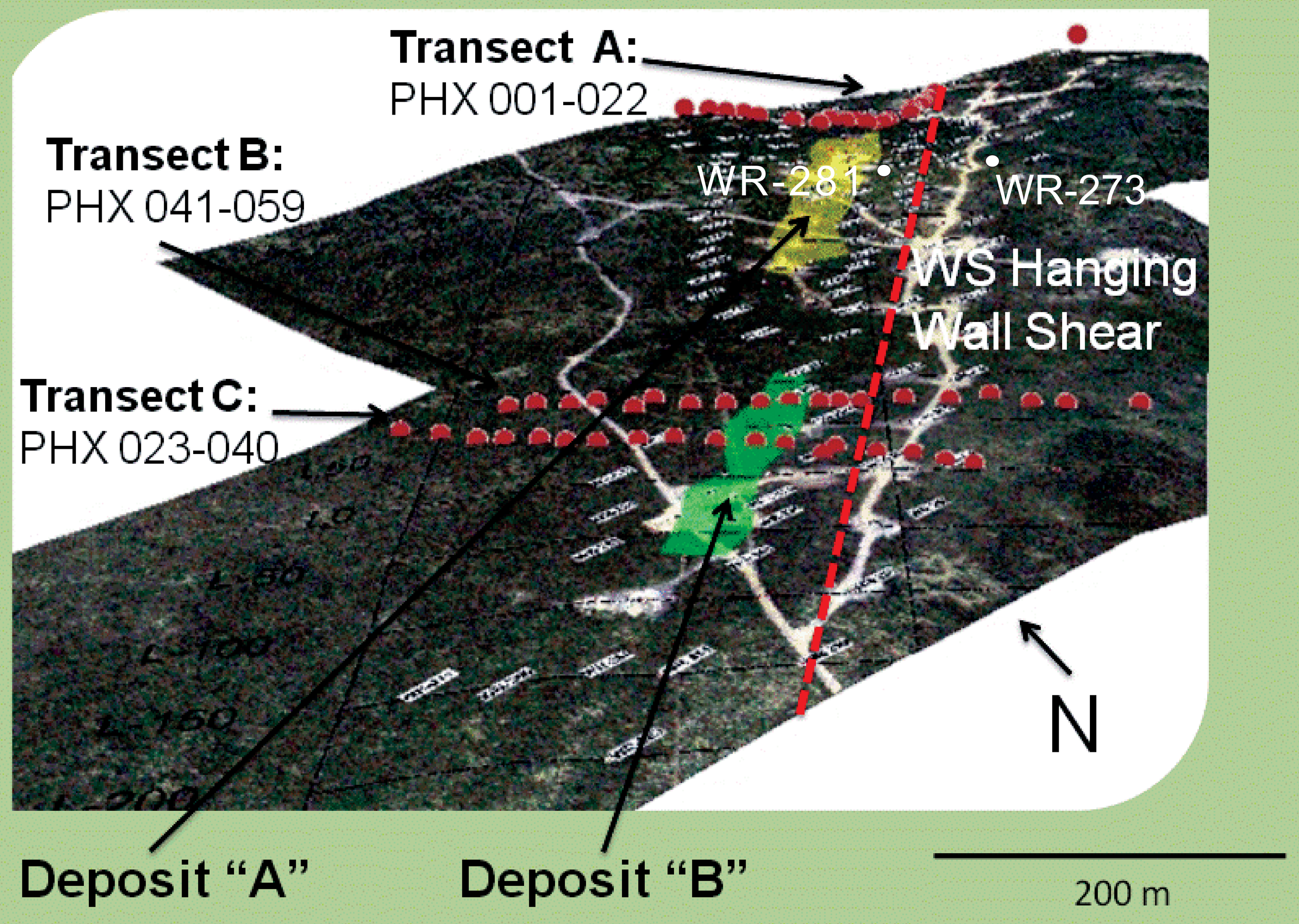


Figure 8: Sampling was conducted along three transects A, B, and C (red dots) that include the areas directly above the ore zones and northeast-trending WS Hanging Wall Shear Zone. The surface projection of two ore zones (yellow and green areas) and the WS Hanging Wall Shear Zone (red dashed line) are shown on the above map.

Ore Zone "A"

Ore Zone "B"

WS Hanging Wall Shear Zone

Sampling & Analysis

In September 2011, a total of 226 soil samples (humus, B, E, and C horizon) from 59 sites along 3 transects over the "A" and "B" ore zones were collected approximately 10 meters apart in undisturbed forest (Figures 5 and 6). Humus samples were subjected to *aqua regia* digestion, whereas B horizon soil samples underwent both an *ammonium acetate* and *hydroxylamine* leach, with all being measured with ICP-MS. Soils were dried at 60°C to minimize loss of volatile elements, and screened at 180 μm (-80 mesh ASTM).

pH and conductivity were measured for soil-water *in-situ* shortly after sampling. The 74 sandstone core samples used in this study were subjected to near total digestion and subsequent analysis with ICP-MS and also ICP-OES.

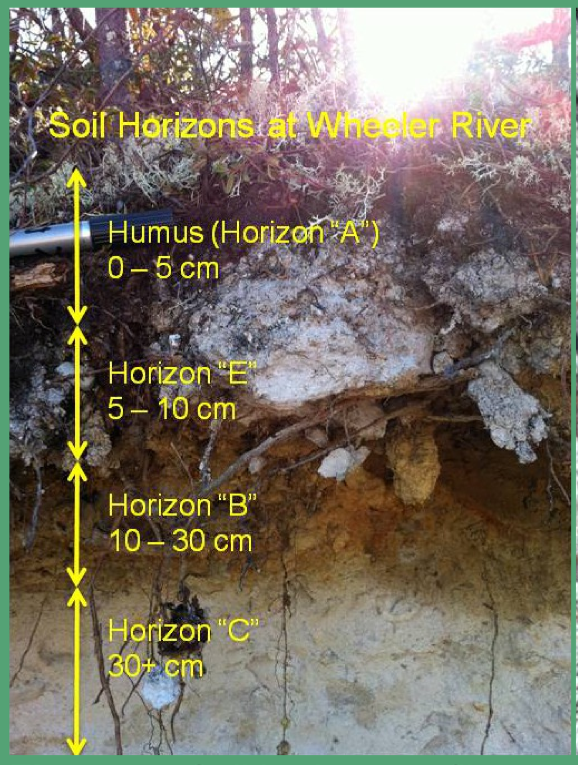


Figure 5: Soil horizon profile at Wheeler River, with a marker in the upper left for scale. It is characterized by a thin humus layer with substantial E and B horizons at most sites.

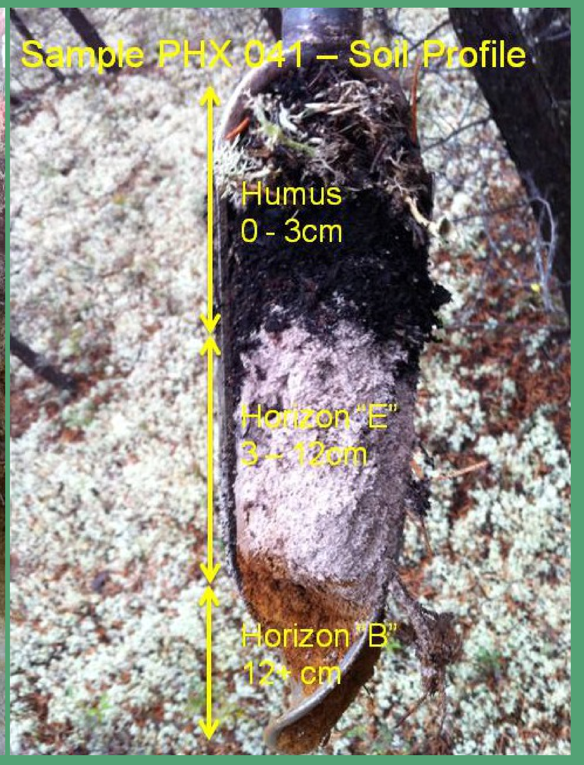


Figure 6: Soil profile at the site PHX 041, with the humus, E and top of "B" horizons clearly visible.

Schematic Cross Section

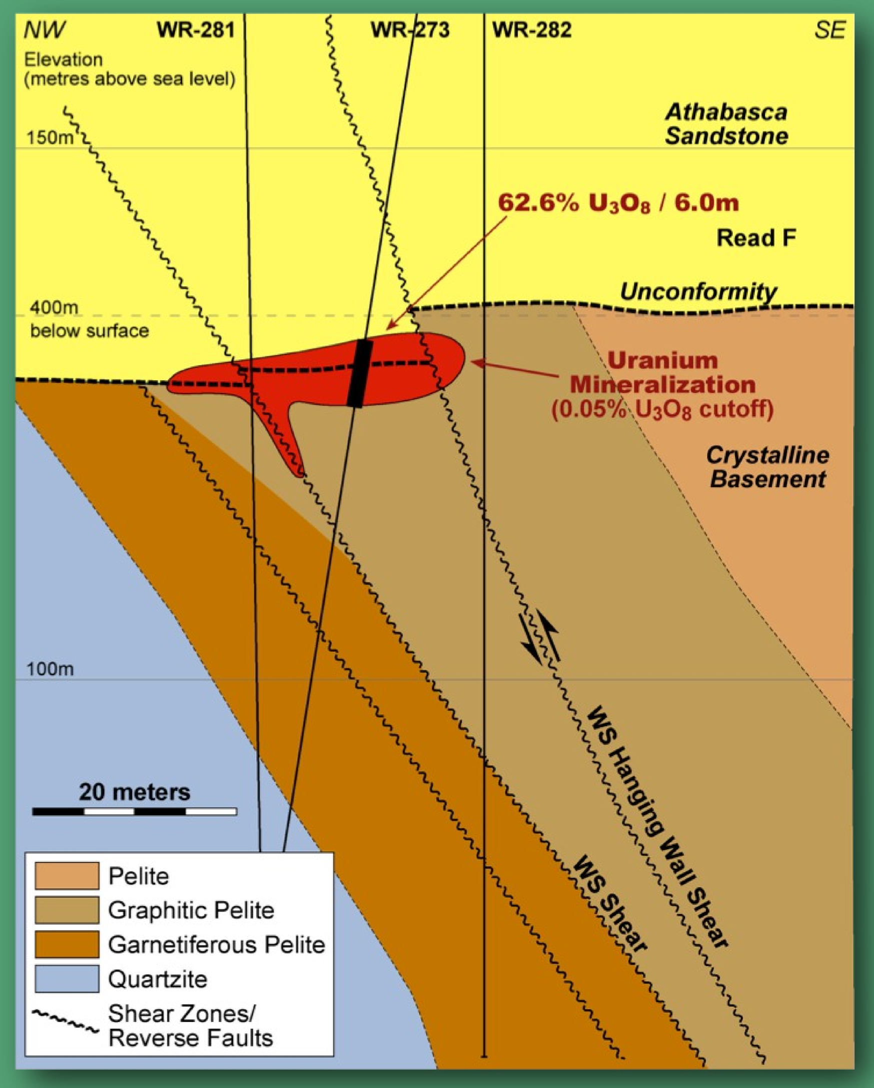
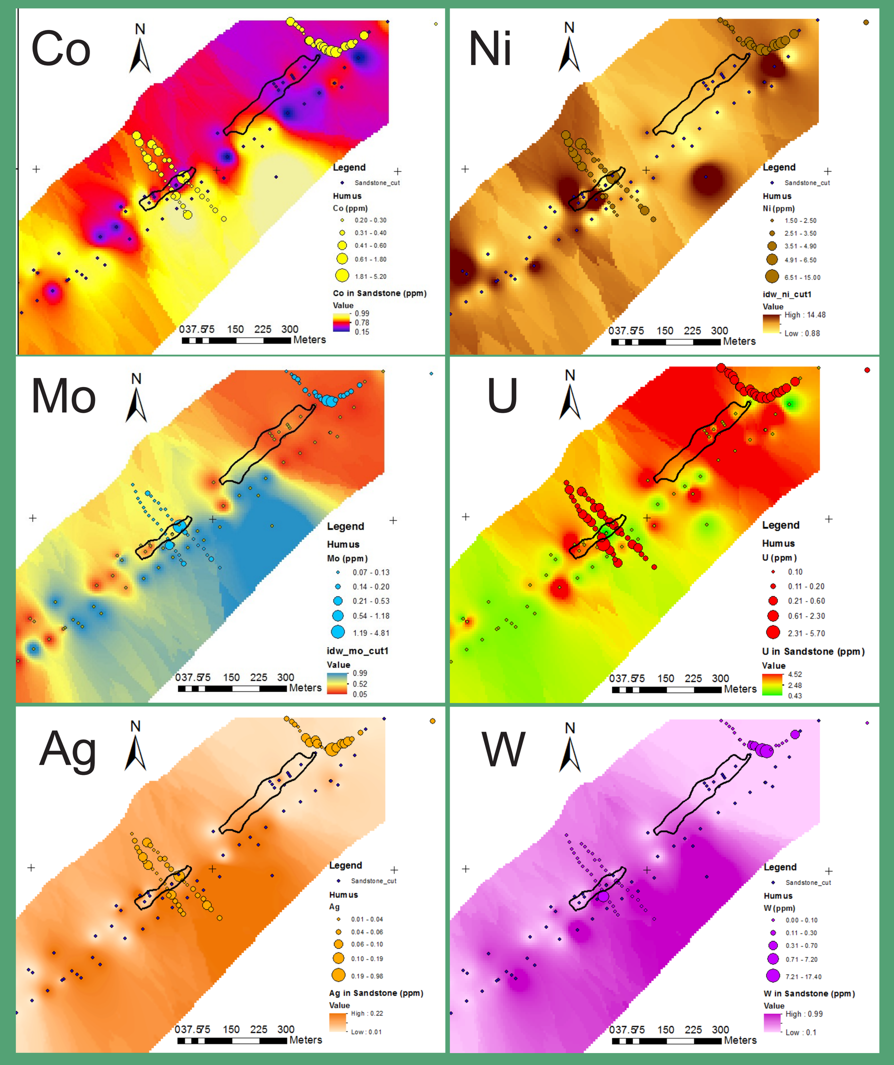


Figure 7: Schematic cross section of the Phoenix deposit by Gamelin et al. (2010). The deposit straddles the unconformity between the crystalline basement and the Athabasca Manitou Falls sandstone units. Note the presence of the WS Hanging Wall Shear zone, which extends to the surface and may have acted as a conduit for fluid movement.

Results

Results show strong anomalies of Co, Ni, U, Mo, Ag, W in humus and lesser anomalies of U, Pb, Ni and W in B horizon soil not only overlying the A and B deposits, but also immediately southeast of the deposit where a northeast-trending WS Hanging Wall Shear Zone is located. Anomalies are also displayed in the uppermost sandstone map, based on drill hole data (locations shown with small blue dots). The traverse sampling method provided the location of anomalies and background values in these given environments.

Humus & Sandstone



Figures 9 to 14: Element transect maps overlain on uppermost sandstone maps of the same elements. Anomalies of Ni, Cu, and U were up to 20 times the background values, Mo more than 50 times, and Ag and W more than 250 and 70 times, respectively. Sandstone values are similar in magnitude and location to the humus values.

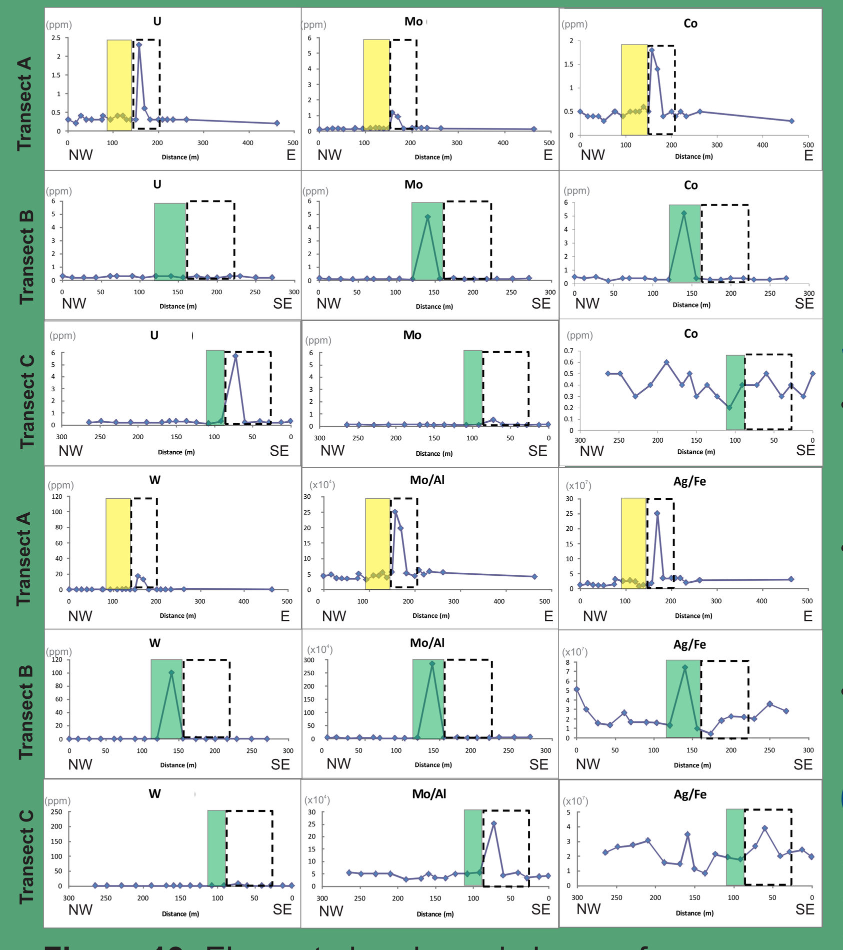
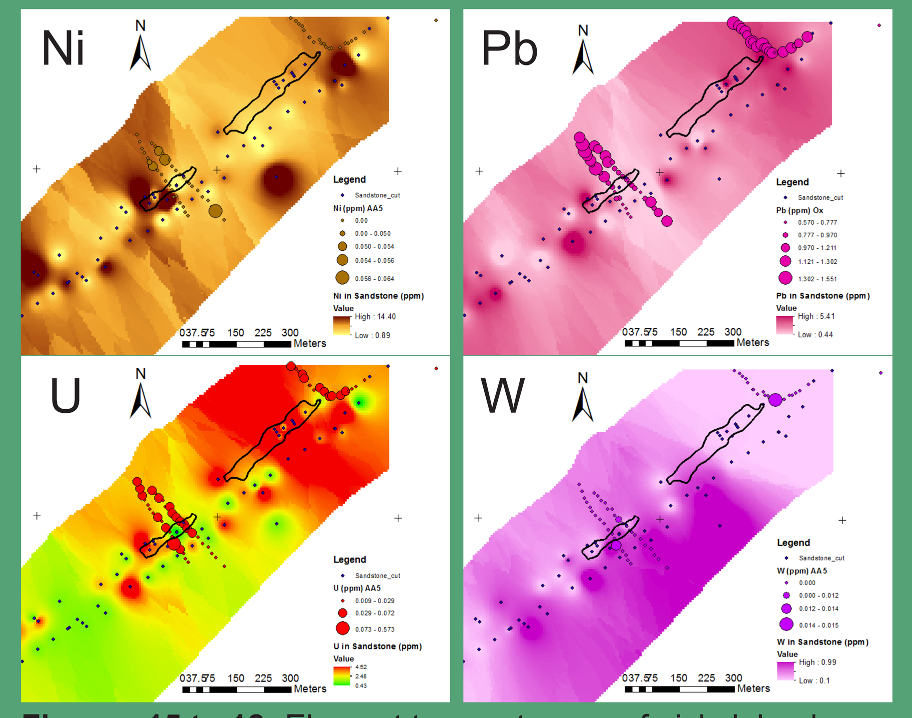


Figure 19: Element abundance in humus for aqua regia leach along the 3 transects. They show the areas of the surface projection of ore zones (coloured) and the WS Hanging Wall Shear Zone (dashed line).

B horizon & Sandstone



Figures 15 to 18: Element transect maps of nickel, lead, uranium and tungsten for B horizon samples treated with acetate (AA5) leach (Ni, U, W) and hydroxylamine (Ox) leach (Pb) underlain by uppermost sandstone maps of the same metals. Anomalies were more pronounced with respect to the background in weak leach such as AA5.

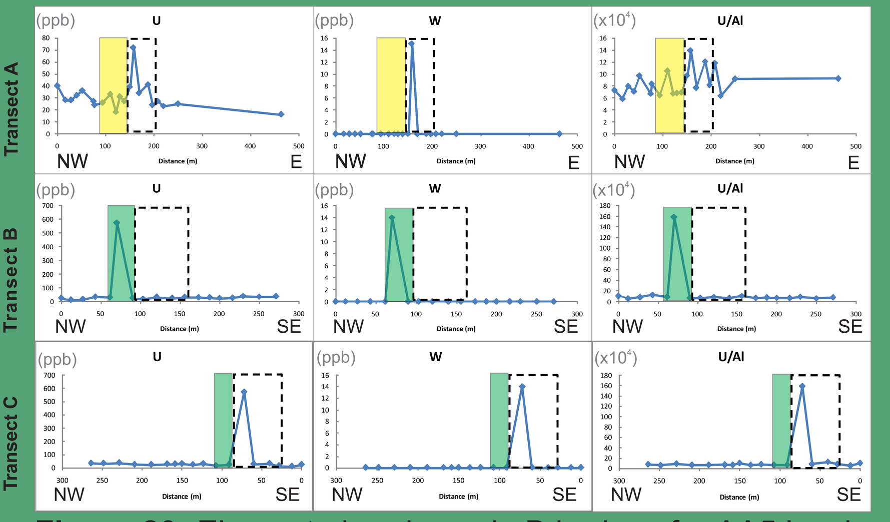


Figure 20: Element abundance in B horizon for AA5 leach. The anomalies above the shear zone suggest upward movement of elements from the ore bodies.

Summary

- Low background values suggest that there is no effect from potential sources of contamination, such as dust particles from the nearly Key Lake uranium milling facility.
- Distribution of geochemical anomalies in surface media is narrow, restricted to less than 10 meters away from either directly above the deposits or above the WS Hanging Wall shear zone.
- Broad anomalies in the uppermost sandstones near shear zones suggest upward movement of metals from the ore bodies through sandstone.

Ongoing Work

- Aqua regia leach & analysis of silt fraction of C horizon soil
- Geochemical analysis of water samples from drill holes
- Noble gas abundance analysis of gas samples collected from selected drill holes
- Lead isotope compositions will be determined with a TIMS
- Compare the results with those in other areas in Athabasca Basin
- Evaluate the migration mechanisms of elements from such deeply buried deposits to the surface & integration into exploration geochemical models

References

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