Surficial Geochemistry associated with the deeply buried Millennium and Phoenix Uranium Deposits, Athabasca Basin, Northern Saskatchewan

Austin Krahenbil[1], Keiko Hattori[1], Michael Power[1], Tom Kotzer[2]

[1]Department of Earth Sciences, University of Ottawa, Ottawa, Ontario
[2]Cameco Corporation, Saskatoon, Saskatchewan

akrah036@uottawa.ca

Introduction

The Millennium and Phoenix deposits are located in the southeastern corner of the Athabasca Basin, Northern Saskatchewan. Both unconformity-related deposits produced geochemical anomalies that were detected in soils and ground water during surveying in 2011 and 2012 (Power et al., 2013). This 2013 study aimed to: i) evaluate the reproducibility of geochemical anomalies, ii) increase the sample population and iii) determine which surface media (soil or gas) produces the most robust signatures.

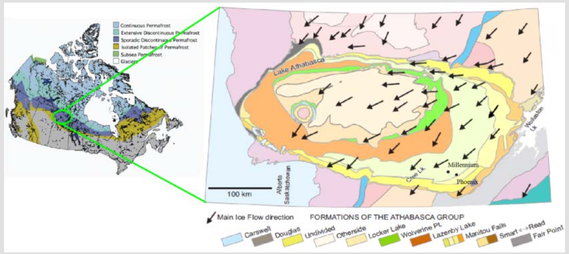


Fig. 1: Permafrost map of Canada shows that the Athabasca Basin is within the region of sporadic discontinuous permafrost (dark blue colored region; Burgess et al., 1999). Inset shows regional ice flow directions of the last glaciation (Campbell, 2007, and geology from Jefferson et al., 2007).

The Denison Mines Corporation's Phoenix deposits occur along the unconformity between Athabasca sandstones and the underlying Wollaston Supergroup metasedimentary rocks at 400 m depth (Gamelin et al., 2012). Shear zones rooted in the basement host mineralization, with currently defined resources of 52.3 M lbs (indicated) and 7.6 M lbs (inferred) U_3O_8. At Phoenix, soil samples were collected from the site that yielded high uranium concentrations in 2011 and 2012 (Fig. 5) and 4 dissolved gas samples from cemented diamond drill holes.

Located just west of the Phoenix deposit, Cameco Corporation's Millennium deposit has resources of 68.2 M lbs (indicated) and 22.3 M lbs (inferred) of U_3O_8 hosted within basement rocks along the Marker fault at 750 m depth. In 2013, 27 sites were sampled for humus and B-horizon soils along a new transect (Transect 3), and dense sampling of selected sites along Transect 2 (Fig. 13). Dissolved gas samples from groundwater were collected from 15 cemented diamond drill holes.

Field Area

The area has a sub-arctic climate with cold, dry winters and warm, wet summers. Undisturbed boreal forest and unconsolidated glacial sediments characterize the property. Glacial sediments are 20–25 m thick above the Phoenix and Millennium sites. The dominant land forms are lakes, eskers and drumlins oriented to the southwest.

Techniques

Soil horizon thickness varies depending on topographic relief and vegetation. Samples were collected approximately 20 m apart in undisturbed forest (Fig. 2).

Samples were analyzed with ICP-MS after aqua regia digestion (humus) or ammonia acetate leaches (B-horizon) at Acme Labs in Vancouver.

Fig. 2: Dutch auger with representative soil profile.

Gas diffusion samplers (Fig. 3) were lowered in cemented exploration drill holes below the water table at various depths for a minimum of 72 hours.
Noble gas abundances in the samplers were determined by quadruple mass spectrometry at GEOTOP in Montreal.

Fig. 3 (left): Gas diffusion sampler.

Reproducibility of soil geochemical anomalies at the Phoenix Deposit

Dense sampling at one site along the Transect C confirmed a three year reproducibility of anomalies from 2011 through 2013 (Fig. 4a). Elevated uranium contents are found in humus overlying deposit B and are located on the surface projection of the WS Hanging Wall shear zone (Fig. 4).

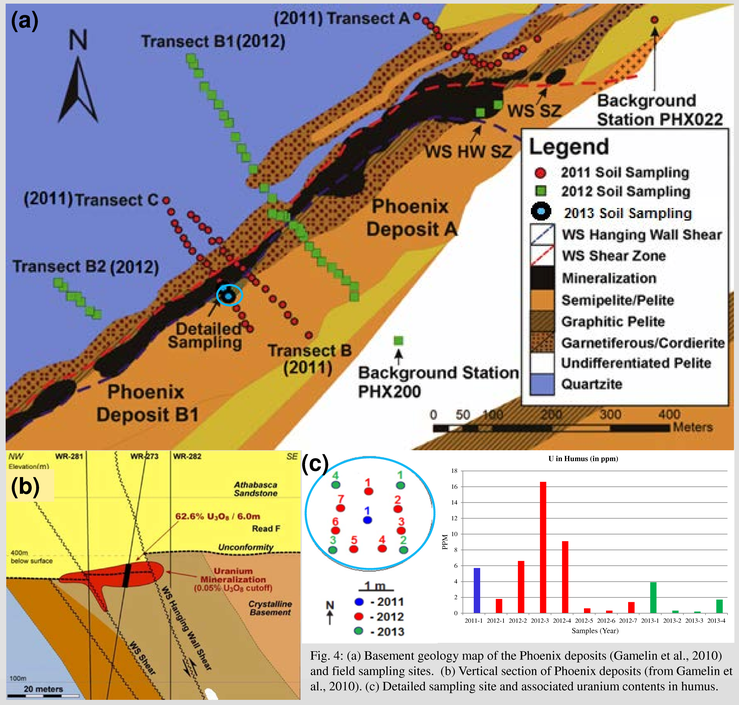
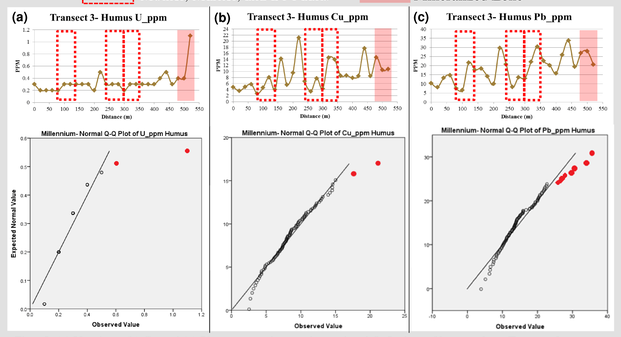


Fig. 4: (a) Basement geology map of the Phoenix deposits (Gamelin et al., 2010) and field sampling sites. (b) Vertical section of Phoenix deposits (from Gamelin et al., 2010). (c) Detailed sampling site and associated uranium contents in humus.

Millennium-Transect 3 soil analysis

Anomalous concentrations of Cu, U and Pb occur in humus and B-horizon samples from Millennium. The anomalies are located on the surface projections of the Mother, Marker and B1 faults and the area over the mineralized zones (Figs. 5 & 6). Surface traces of the faults illustrated on the map are based on reflection seismic data provided by Cameco Exploration.

The Q-Q plots represent all samples taken from Millennium during the 2012 and 2013 field seasons (total of 99 samples).



Figs. 5: (a) Uranium, (b) Cu and (c) Pb concentrations and associated Q-Q plots of humus along Transect 3.

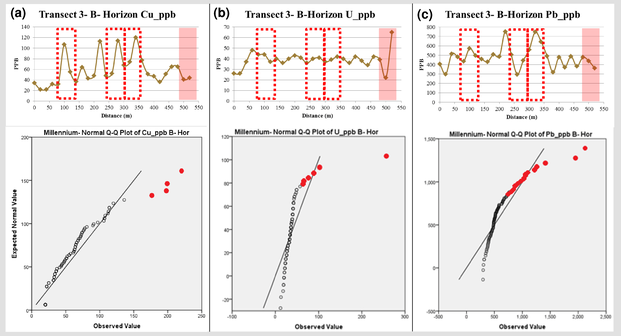


Fig. 6: (a) Copper, (b) U and (c) Pb concentrations and associated Q-Q plots for in ammonia acetate leach data of B-horizon soil along Transect 3 at Millennium.

Millennium- helium gas data

Since ^4He is produced by the decay of uranium, elevated $^4He/^{36}Ar$ values relative to that in equilibrium with the atmosphere indicate release of ^4He from the deposit into the groundwater.
In 2012 and 2013 anomalous $^4He/^{36}Ar$ ratios were recorded in drill holes near the deposit. All drill holes have steel casing through the glacial overburden (ca. 20 m) and are cemented at depth to prevent groundwater discharge. The ground water levels were approximately 10 m below the surface. The depth in the table is meters from the groundwater levels.

DDH	Year	Depth (m)	$^4He/^{36}Ar$ (sample) / $^4He/^{36}Ar$ (air)
CX-40	2012	10	108
CX-40	2013	21	77
CX-43	2013	16	45
CX-52	2012	50	715
CX-52	2013	10	18
CX-52	2013	30	259
CX-52	2013	47	120
CX-58	2013	10	1.2
CX-63	2013	20	0.8
CX-86	2012	11	240
CX-86	2013	30	216
CX-98	2013	23	0.6

Reproducibility of soil geochemical anomalies at Millennium

Repeat sampling around the site that yielded high U in 2011 (Power et al., 2013) yielded anomalous concentrations of uranium in B-horizons soils.

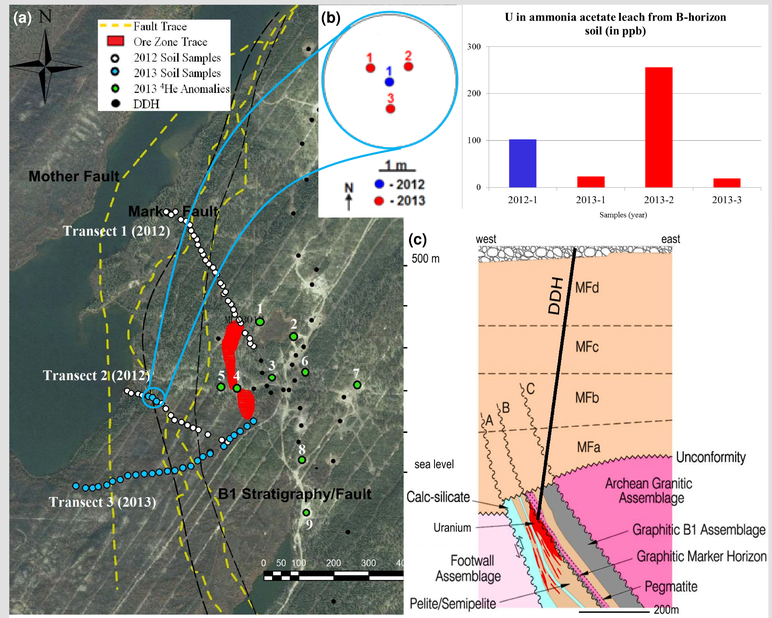


Fig. 7: (a) Aerial photo of the area, overlain with sampling sites and surface projections of the deposits and faults. (b) Uranium contents within the dense sampling area. (c) Vertical section of the Millennium deposit (modified after Wood et al., 2012)

Summary

- At Millennium, 2013 results reproduced elevated Cu, U and Pb contents in both humus and B- horizon oil samples along the new transect.
- At Phoenix, elevated uranium contents were detected in humus samples for a third consecutive year.
- At both Millennium and Phoenix, surficial geochemical anomalies are spatially associated with faulting and shear zones, suggesting upwelling of metal-rich fluids along the faults.
- At Millennium, anomalous concentrations of ^4He are dissolved in groundwater overlying the Millennium deposit. ^4He anomalies are found in cemented drill holes that intersect and do not intersecting the deposit.
- The 2013 results confirm that strategic soil sampling is an efficient and inexpensive exploration technique to detect a deeply buried uranium deposits. Geochemical exploration is effective when combined with other exploration tools such as geophysical data.

Acknowledgments

We would like to thank Cameco and Denison Mines for their technical assistance and logistical support during fieldwork. This worked is supported through a Targeted Geoscience Initiative Four (TGI-4) grant to Keiko Hattori. This presentation benefitted from a critical review by Eric Potter.

References

Burgess, M., Brown, R., Duguay, C., Nixon, M., Smith, S., Wright, F., 1999. Canadian Contributions to GCOS - Permafrost: a background document to assist in the development of a Canadian initial observing system for the Global Climate Observing System, 23p.
Campbell, J.E., 2007. Quaternary geology of the eastern Athabasca Basin, Saskatchewan, in Jefferson, C.W. and Delaney G., 2007. Geology and uranium exploration of the Proterozoic Athabasca Basin, Saskatchewan and Alberta, GSC Bulletin 588, p. 211-228.
Gamelin, C., Sorba, C., Kerr, W. 2010. The Discovery of the Phoenix Deposit: A New High-grade, Athabasca Basin Unconformity-type Uranium Deposit, Saskatchewan, Canada. SGS Open House 2010, Abstract Volume; p. 17.
Jefferson, C.W., Thomas, D.J., Gandhi, S.S., Ramaekers, P., Delaney, G., Brisbin, D., Cutts, C., Quirt, D., Portella, P., and Olson, R.A., 2007. Unconformity- associated uranium deposits of the Athabasca Basin, Saskatchewan and Alberta, Geol. Ass. Canada, Mineral Deposits Div. Sp. Publ. No. 5, p. 273-305.
Power, M.J., Hattori, K., Sorba, C., Kotzer, T., Potter, E.G., 2013. Surface media expressions of buried uranium: the Phoenix and Millennium deposits, Athabasca Basin, Saskatchewan; 12th SGA meeting, Vol. 1, p. 426-429
Wood, G., O'Dowd, C., Cosma, C., and Enescu, N., 2012. An interpretation of surface and borehole seismic surveys for mine planning at the Millennium uranium deposit, northern Saskatchewan, Canada. Geophysics, Vol. 77, p. 203-212

Recommended citation

Krahenbil, A., Hattori, K., Power, M., and Kotzer, T., 2014. Surficial Geochemistry associated with the deeply buried Millennium and Phoenix Uranium Deposits, Athabasca Basin, Northern Saskatchewan; Geological Survey of Canada, Open File 7611, 1 poster. doi:10.495/293928
Poster originally presented at the 2014 SEG-PDAC Student Mineral Colloquium

OPEN FILE DOSSIER PUBLIC
7611
GEOLOGICAL SURVEY OF CANADA COMMISSION GÉOLOGIQUE DU CANADA
2014
Publications in this series have not been edited; they are released as submitted by the author.
Les publications de cette série ne sont pas révisées; elles sont publiées telles que soumises par l'auteur.

doi:10.4095/293928
This publication is available for free download through GEOSCAN (http://geoscan.nrcan.gc.ca/).

Natural Resources Canada | Ressources naturelles Canada