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Presenter: **Michael J. Power**

Surface media expressions of buried unconformity-related uranium: The Phoenix & Millennium deposits, Athabasca Basin

Power, M.J.[1], mpowe102@uottawa.ca, Hattori, K.H.[1], Sorba, C.[2], Kotzer, T.[3], Pinti, D.L.[4] and Potter, E.G.[5], [1]Department of Earth Sciences, University of Ottawa, 140 Louis Pasteur Ottawa, ON K1N 6N5; [2]Denison Mines Corp., 200-230 22nd St East, Saskatoon, SK S7K 0E9; [3]Cameco Corp., 2121-11th St West, Saskatoon, SK S7M 1J3; [4]GEOTOP, Université du Québec à Montréal, CP 8888, succ. Centre-Ville, Montréal, QC H3C 3P8; [5]Geological Survey of Canada, 601 Booth St., Ottawa, ON K1A 0E9

In order to evaluate surficial geochemical anomalies over deeply-buried unconformity-related uranium deposits, we selected two deposits with no apparent surface expression of mineralization: The Phoenix and Millennium deposits. The Phoenix deposit, owned by Denison Mines Corporation, has currently defined indicated resources of 52.3 million lbs U_3O_8 situated ~400 m below the surface, whereas Cameco Corporation's basement-hosted Millennium deposit has indicated resources of 46.8 million lbs U_3O_8, at a depth of ~750 m. Both are located in the southeastern margin of the Athabasca Basin in northern Saskatchewan. The area is covered by 25-100 m thick glacial tills comprised of moraine plains, streamlined moraines and subordinate eskers. Whole rock compositions of till samples from both properties suggest that the glacial sediments were sourced from a mixture of granitic basement rocks and Athabasca sandstones.

2011 field sampling above the Phoenix deposit yielded anomalous concentrations of U, Ni, Cu, Mo, Ag and W in humus, B-horizon soil and C-horizon glacial till in the areas directly above the A and B deposits and the WS Shear zone. 2012 sampling reproduced similar geochemical anomalies in soil samples (2-17 ppm U, 10-27 ppm Cu, 4-7 ppm Ni, 1000-1500 ppb As). Furthermore, leaching of humus samples in H_2O, HBr, HNO_3 and HF-HBr solutions show that these metals are not simply adsorbed on the surface; instead, they are tightly held in organics. Finally, analyses of the uppermost Manitou Falls "D" Formation sandstones with partial HF-HNO_3-HCl digestion above the ore zones contain anomalous U (up to 2 ppm).

Following the successes at Phoenix, soil sampling was carried out along the transects over the Millennium deposit in the summer of 2012, and yielded anomalies in U (0.4-0.6 ppm), Pb (15-35 ppm) and Cu (5-15 ppm) in aqua regia digestion of humus as well as anomalies in ammonium acetate leach of B horizon soils again above the ore zones and surface traces of B1 and Marker faults. Broad surficial geochemical anomalies in the property likely reflect abundant faults and fault-bound mineralization. Gas samples placed in water-filled drill holes at depths of several m yielded anomalously high radiogenic ^4He as indicated by $^4He/^{36}Ar$ ratios up to 700 times the atmospheric one, confirming the upward migration of 4He from the Millennium deposit. The combined results suggest upward migration of both mobile metal ions and uranium decay products from the ore zones to the surface.