Introduction

The Millennium and Phoenix deposits are located in the southeastern corner of the Athabasca Basin, Northern Saskatchewan. Both unconformity-related deposits produced geologic 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.

The Denison Mines Corporation’s Phoenix deposits occur along the unconformity between the Athabasca sandstone and the underlying Wollaston Supergroup metasedimentary rocks at 400 m depth (Gamelin et al., 2012). Shear zones in the basement host mineralization, with currently defined resources of 52.2 Mt (indicated) and 7.6 Mt (inferred) U3O8. 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 cememt drilled diamond holes.

Located just west of the Phoenix deposit, Cameco Corporation’s Millennium deposit has resources of 68.2 Mt (indicated) and 22.3 Mt (inferred) U3O8, 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. Unconsolidated boulder and unconsolidated glacial sediments characterize the topography. 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 (Fig. 2).

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Soil horizon thickness varies depending on topographic relief and vegetation. Samples were collected approximately 20 m apart in undisturbed soil (Fig. 3). Samples were analyzed with ICP-MS after aqua regia digestion (humus) or ammonium acetate leaches (B-horizon) at a regional laboratory in Vancouver.

Reproducibility of soil geochemical anomalies at the Phoenix Deposit

Dense sampling at one site along the Transect C continued a three-year reproducibility of anomalies from 2011 through 2013 (Fig. A). Elevated uranium contents are found in humus and B-horizon soil at Bhorizon soil along Transect 3 at Millennium.

Millennium-helium gas data

Since U is produced by the decay of uranium, elevated 4He/36Ar values relative to that in equilibrium with the atmosphere indicate release of 4He from the deposit into the atmosphere. In 2012 and 2013 anomalous 4He/36Ar ratios were measured in drill holes near the deposit. All drill holes have metal casings through the glacial overburden (ca. 20 m) and are cemented at depth in pre-glacial permafrost. Three of these drill holes have cements 40 m below the surface. The depth to the water table is meters from the groundwater levels.

Gas diffusion samples (Fig. 3) were analyzed for elevated helium content. Samples were analyzed for elevated helium content.

Techniques

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Fig. 3 (left) Gas diffusion samples.

Fig. 3 (right) Millenium-Phoenix helium gas data Since U is produced by the decay of uranium, elevated 4He/36Ar values relative to that in equilibrium with the atmosphere indicate release of 4He from the deposit into the atmosphere. In 2012 and 2013 anomalous 4He/36Ar ratios were measured in drill holes near the deposit. All drill holes have metal casings through the glacial overburden (ca. 20 m) and are cemented at depth in pre-glacial permafrost. Three of these drill holes have cements 40 m below the surface. The depth to the water table is meters from the groundwater levels. Fig. 3 (right) Millenium-Phoenix helium gas data Since U is produced by the decay of uranium, elevated 4He/36Ar values relative to that in equilibrium with the atmosphere indicate release of 4He from the deposit into the atmosphere. In 2012 and 2013 anomalous 4He/36Ar ratios were measured in drill holes near the deposit. All drill holes have metal casings through the glacial overburden (ca. 20 m) and are cemented at depth in pre-glacial permafrost. Three of these drill holes have cements 40 m below the surface. The depth to the water table is meters from the groundwater levels.

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Summary

At Millennium, 2013 results reproduced elevated Cu, U and Pb contents in both humus- and B-horizon soil 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 measured 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 methods.