Evaluating the use of radon for exploring deeply buried uranium deposits: Case study in the Denison Mine's Phoenix deposits, northern Saskatchewan

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The Phoenix Deposits, 70.2 M lb U_3O_8, are located along the unconformity between the Athabasca sandstones and the crystalize basement at a depth of 400 m on the south-eastern margin of the Athabasca basin. Groundwater collected from drill holes had high Rn concentrations, specifically near the top of the water column. Five sources of Rn are considered. Simple modelling indicates that Rn requires >4000 years to diffuse the 400 meters from the deposits to the surface. Rn has a half-life of 3.82 days, thus diffusion of Rn from the deposit is rejected, but He can diffuse for a long distance without decay. Radon concentrations in holes that intersected mineralization does not vary from holes that did not intersect mineralization, thus possible contamination by drilling can be rejected. No bubbling was observed from groundwater or samples and thus gas transportation of Rn is rejected. Helium/Ar and He/Ne ratios are in near equilibrium with the atmosphere, indicating that groundwater is not ascending from the deposits, and thus cannot be transporting Rn from deposit to surface. Water in holes WR-314 and WR-380 recorded high Rn (105 and 20 Bq/L respectively), but pore fluids in soil around these holes show Rn below the detection limit (3 Bq/L). The data indicates that soil is not the major source of Rn in groundwater. Under secular equilibrium, only 0.036-6.6 ppm of U is required to produce observed Rn concentrations. The sandstones above the Phoenix deposits have been shown to contain anomalously high U and other metals. Rn concentrations in drill holes are correlated with U in partial leach of RD, MFb, and MFc sandstones. By process of elimination, sandstones are the major source of observed Rn, although transport of Rn from such depths as RD seems implausible. High Rn values in groundwater in the property likely reflect high U in the sandstones over the deposit. Abnormally high concentrations of metals above many U deposits suggest that Rn measurements may be an easy and useful tool in detecting concealed U deposits.