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IMPACT OF A GLACIAL URANIUM DEPOSIT ON THE GROUNDWATER QUALITY AT KEY LAKE, SASKATCHEWAN (CANADA)

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ABSTRACT

Concentrations of radionuclides derived from uraniferous material embedded in a pervious unconsolidated aquifer have been determined at Key Lake. It is concluded that dispersion and retardation can provide safe storage of radioactive waste in shallow aquifers over a long term period.

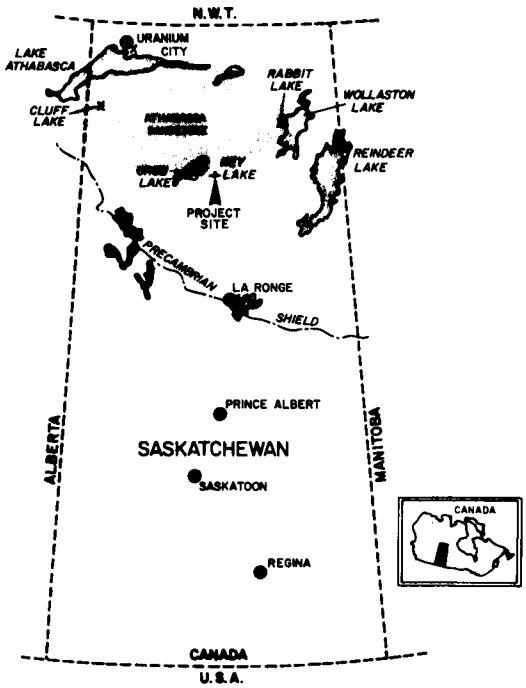
INTRODUCTION

At Key Lake, Saskatchewan (Fig. 1), economic uranium deposits have been discovered and are presently in the process of development. Major parts of the deposits are found in bedrock formations however, some parts were eroded during the quaternary glaciation and incorporated in glacial sediments. The gradation of the eroded ore ranges from boulder size to silt size. In vicinity of one of the future open pits, about 840,000 tonnes of uranium ore at an average grade of about 0.6% U_3O_8 have been delineated.

Drilling and pump testing of a series of wells designated to dewater the glacial sediments above the main orebody opened up the opportunity to assess the impact of the glacial uranium deposit on the groundwater quality.

GROUNDWATER REGIME

The glacial sediments, predominantly silica sand, form the main aquifer at Key Lake. They are embedded in a trough shaped bedrock depression and have a water saturated thickness varying between 20 m and 70 m in the area under consideration. The glacial uranium ore is found within the relatively coarse grained lower portion of the aquifer. The average hydraulic conductivity is about 4×10^{-4} m/s. The average hydraulic conductivity of the bedrock formation was found to be several order of magnitudes lower to the effect that a major contribution to the total groundwater flow cannot be expected (UNLAND & HOLL, 1980).



The groundwater flow in the glacial aquifer is mainly directed from SW to NE and traverses the glacial ore deposit over a maximum width of 500 m and over a maximum length of about 1,100 m. The actual groundwater regime is assumed to have been established about 8,000 years ago when the Wisconsin ice masses retreated and gave way to the present surface drainage pattern.

RESULTS OF GROUNDWATER QUALITY ANALYSES

Water quality samples were taken at the end of constant rate pump tests which lasted for a minimum of 17 hours. A total of 34 wells were tested in the vicinity of the glacial ore deposit with an average discharge rate of 3.5 m^3/min. The total ion content of the groundwater is fairly low and results in an average specific conductivity of 25 µmhos/cm. The average pH value is 6.4. Eh values have been measured at a few well sites and were found to average between +200 mV and +50mV, decreasing with depth.

The average iron concentration was found to be about 0.6 mg/ℓ. All water quality variables show some local variations, however most evident differences were found in the radionuclides analysed. Concentrations of natural uranium peak at more than 700 µg/ℓ within the glacial ore deposit to decline to about 60 µg/ℓ approximately 400 m groundwater downstream and to assume background values of <0.5 µg/ℓ at a distance of 1500 m groundwater downstream.

Levels of total Ra-226 above approximately 0.4 Bq/ℓ (10 pCi/ℓ) were encountered only within a limited area of the aquifer hosting the glacial ore deposit. Concentrations below the detection limit (<0.1 pCi/ℓ) were consistently found about 600 m groundwater downstream the glacial ore deposit.

The coefficient for direct linear correlation between Ra-226 and U is very low at 0.3, whereas significantly better correlations were found between Ra-226 and Pb-210 and Ra-226 and Po-210 in the groundwater (UNLAND, 1981).

INTERPRETATION

Although the samples taken during well pump tests average over a larger section of the aquifer, they indicate clearly a considerable decrease of the radionuclide concentrations groundwater downstream of the glacial ore deposit.

The concept of dispersion and retardation yields the formal description for the observed distribution although the mechanism for the attenuation of U and Ra-226 is not yet fully understood. However, the more efficient retardation of Ra-226 in comparison with U under oxidizing conditions has been observed elsewhere (JOHNSTON & GILLHAM, 1980). Since the leaching of U and other radionuclides persisted over the last 8,000 years under practically the same conditions as present, the retardation capacity of the aquifer seemed to be very significant. Dynamic processes such as adsorption to ionized silica surfaces or ferric hydroxides (GRISAK & JACKSON , 1978) are considered to be the most active mechanisms.

CONCLUSION

Long term aspects of disposal of low radioactive waste derived from mining or certain parts of the nuclear fuel cycle are of considerable concern due to lack of experience and limitations of laboratory - scale testing.

The situation observed at Key Lake clearly indicates that storage of radioactive material in shallow unconsolidated aquifers must not necessarily result in a wide spread contamination of groundwater resources. The retardation and dispersion capacity of aquifers composed mainly of silica sand can be significant enough to make well planned storage of radioactive waste in unconsolidated aquifers a viable alternative to other options. On the other hand, U and Ra-226 dissolved by groundwater appear to be of limited value for the exploration on U orebodies.

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