## *Eye-Dashwa Lakes Pluton (Canada)*

***Description:*** The Eye-Dashwa Lakes pluton, Atikokan, Ontario, Canada, is Precambrian in age and consists primarily of coarse-grained porphyritic, hornblende-biotite granite, intruded by aplite and hornblende dykes (Kamineni and Brown, 1981).

This study formed part of the Canadian Nuclear Fuel Waste Programme. The major objective was to sample and analyse weathered surface/near-surface outcrops (Latham and Schwarz, 1987) and to compare these data with existing data from deep drillcore samples (Gascoyne, 1982: Gascoyne and Schwarz, 1986), i.e. essentially comparing surface areas of high U and Ra removal rates under oxidising conditions with those at depth where reducing conditions are prevalent and where emplacement of U and Ra are dominant .

***Relevance:*** The study is of most relevance to the understanding of far-field radionuclide mobility and retardation processes where a crystalline host rock is envisaged.

***Position(s) in the matrix tables:*** This study lies in the long term radionuclide retardation mechanism box in the far-field matrix table.

***Limitations:*** This study is a reasonably good analogy to the mobility and retardation processes expected to occur in the far-field vicinity of a leaking radionuclide source at depth under ambient temperatures. However, some of the more important boundary conditions (e.g. oxidation potential; groundwater saturation) at or near the surface deviate significantly from those expected at depth around a repository. Whilst the deep core samples (down to approx. 1000 m) clearly reflect repository conditions, some of the boundary conditions (e.g. hydrogeology and hydrochemistry) are largely unknown.

***Quantitative information:*** Rock samples, some weathered and associated with leaching processes, were collected from surface and near-surface localities and included fracture infillings (haematite, epidote). Both whole rock samples and separated mineral fractions were analysed for U-decay series radionuclides, in particular to determine the implications of U, Ra and $^{228}$Th in weathered granitic rocks. The sources of $^{228}$Ra and $^{226}$Ra are mainly the resistant minerals such as zircon, sphene and Fe-magnesian minerals (Latham and Schwarz, 1987).

Comparison of the whole-rock and mineral separation data indicated a rapid loss and gain of $^{228}$Ra occurring between grains but a much lower net loss of Ra as observed from the whole rock samples. In the weathered zone of the granite (sampled to a maximum depth of 3m) the mobility of $^{228}$Ra and $^{226}$Ra can be very high, in terms of years. The main sinks, and therefore the most sensitive indicators for Ra mobility, are the altered feldspars (altered to kaolinite and clay).

General conclusions are:

- in exposed weathered zones of granite, Ra is more mobile than U
- inter-mineral mobility of Ra may be high in sub-surface rocks
- feldspars can readily absorb Ra during alteration

Data from deep drill core material at the same site (e.g. Gascoyne, 1982) recorded radioactive equilibrium in most samples indicating negligible radionuclide migration over the last 10 000-350 000 years. Furthermore, there is little indication of variation in isotope activity ratios with depth, as might be expected from the concept of a weathering profile. However, some of the deep fracture material and fracture-filling minerals did show disequilibrium, although this has been interpreted as due to alpha recoil mechanisms and not active bulk leaching processes.

***Uncertainties:*** On a scale of low-medium-high, the uncertainties associated with this semi-quantitative study are assessed as medium to high. Since some of the samples represent surface and near-surface localities, i.e. from an oxidising 'unsaturated' hydraulic environment, the analogy to a deep, reducing, saturated repository environment is limited to a qualitative understanding of

radionuclide mobility and retardation. Greater confidence can be derived from the deeper core samples which better represent repository depths.

***Time-scale:*** The time-scale addressed by the study is geological, both Quaternary to recent (<2 Ma) and beyond (>2Ma).

***PA/safety case applications:*** There are no known examples of its direct use in published PAs but it may have been indirectly used in the AECL EIS *(Environmental Impact Study), 1994* (Canada).

***Communication applications:*** There are no examples of its use in communication and dialogue material.

***References:***

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***Added value comments:*** The analogue could be better used if more sample localities could be included, with each accompanied by quantitative hydraulic and hydrochemical data. This would improve the conceptualisation and also model development. As it is, the data are most useful in confidence building (with respect to certain FEPs) and also in scenario development.

***Potential follow-up work:*** More field measurements and sampling could be undertaken, in particular systematically with depth (e.g. along a well-defined fracture zone(s)) and closely integrated with hydraulic and hydrochemical studies.

***Keywords:*** Radionuclides, mobility, retardation, U-decay series.

***Reviewers and dates:*** John Smellie (December, 2004).