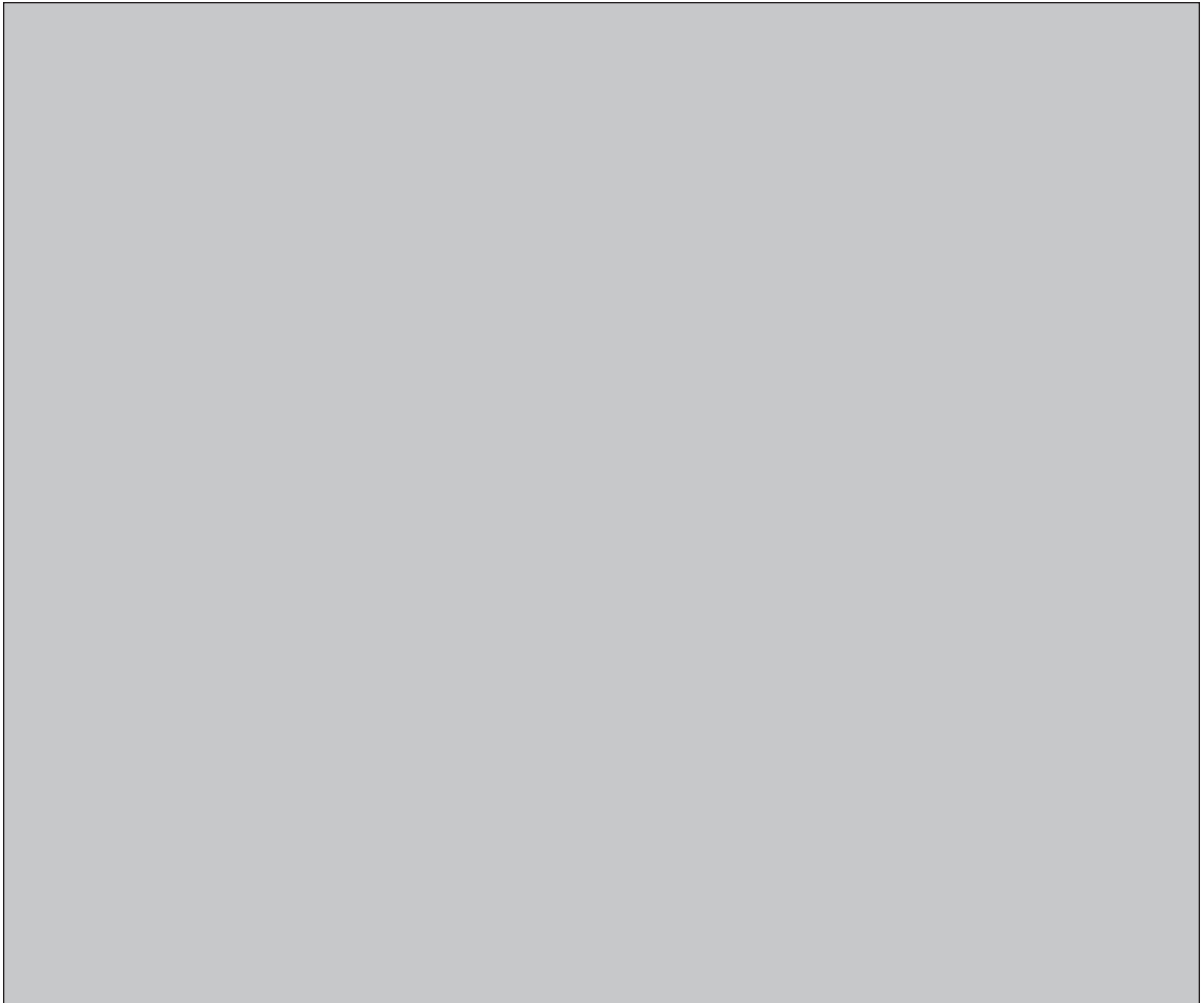


NWMO BACKGROUND PAPERS
4. SCIENCE AND ENVIRONMENT

**4-2 CHARACTERIZING THE GEOSPHERE IN HIGH-LEVEL RADIOACTIVE
WASTE MANAGEMENT**

EXECUTIVE SUMMARY

J.F. Sykes
University of Waterloo



EXECUTIVE SUMMARY

The Nuclear Waste Management Act, Bill C-27, specifies that three approaches must be considered for the management of high-level radioactive wastes. The three approaches are: deep geological disposal in the Canadian Shield, storage at reactor sites and centralized storage either above or below ground. The rock surrounding a disposal vault, any sediments overlying the rock and the groundwater in the rock and sediments is defined as the "Geosphere". For subsurface disposal or storage systems for high-level radioactive waste, the geosphere can provide a buffer between the spent fuel and the biosphere. The importance of the geosphere and geospheric research is dependent on the approach, being least important for above ground storage, and most important for a below ground management system. The degree to which the geosphere will be relied upon to minimize the impact on the biosphere of potential releases of radionuclides from a waste repository or vault determines the relative importance of the geosphere within the overall waste management system. For above ground short-term storage approaches, the waste repository or vault is in close proximity to the biosphere; the geosphere does not contribute to the isolation of the accessible repository from the human environment. Long-term disposal systems, located deep within the geosphere, are designed to be passive. The geosphere is an integral and important part of the high-level radioactive waste management system. It acts to isolate the repository from the human environment. Even if the waste canisters in the repository are breached, the slow rate of the groundwater flow and the range of geochemical immobilization and retardation processes help to ensure that radionuclides continue to be confined within the engineered barrier system and the immediately surrounding rock, so that further radioactive decay takes place. Therefore, a required attribute of the geosphere for a deep disposal system is that groundwater flow at repository depths be either stagnant or sluggish. The plutonic rock of the Canadian Shield has this attribute. Other geosphere formations that also have this property are bedded salts and shales. Within Ontario, there are significantly more potential disposal sites in plutonic rock than either salt or shale.

Plutonic rock is widespread throughout the Canadian Shield. The characteristics of plutonic rock have been studied at the Whiteshell Research Area (WRA) near Lac du Bonnet Manitoba. The fracture, hydraulic, thermal, mechanical and hydrogeochemical properties of the crystalline rock have been extensively studied at the Underground Research Laboratory at the WRA. The hydrogeochemical data indicate that below 500 m at the URL, groundwaters are very saline, reducing, and old. The groundwater can be considered as essentially stagnant over the period of concern for a waste facility (1,000,000 years). The very low permeability of the rock supports this conclusion.

The characteristics of the URL were used as the basis of a 1994 Environmental Impact Statement on the concept for disposal of Canada's nuclear fuel waste. The EIS was extensively reviewed. The concerns of the Scientific Review Group (SRG) and Seaborn Environmental Assessment Panel have been addressed by a Second Case Study and more recently by the ongoing Third Case Study (TCS). Research on site characterization and safety assessment methods for the deep disposal concept in plutonic rock are an important part of the TCS. Contributions to geospheric research relative to a deep

disposal system include: improved methods for data management and visualization, the development of a new generation of site characterization and safety assessment models that resolve the concerns of the SRG, new methods for assessing the complex network of discrete fracture zones that are found in the Canadian Shield, the study of the temperature regime and deep permafrost that occurs in northern sections of the crystalline rock of the Canadian Shield, the determination of the hydraulic and transport properties of moderately fractured rock and discrete fractures, the continued study of the hydrogeochemistry of crystalline rock, and the study of the impact of glaciation-deglaciation cycles on a deep repository.

From our understanding of the glaciation-deglaciation cycles that have occurred for the last 900,000 years, it is virtually certain that the geosphere above a deep repository will be covered by ice for a significant interval in the next 100,000 years. The impact of the thickness of the ice and remoteness of the biosphere are important factors that must be considered in safety assessment. The presence of the ice cover should significantly reduce the possible impact of a repository on the biosphere.

Current engineering, construction and hazardous waste handling practices are at a standard that ensures safe short-term surface and near surface high-level radioactive waste management; however, the waste remains accessible and is not isolated from the human environment. Geosphere research and knowledge is well developed and there is a broad and diverse base of expertise for such systems. In comparison, research for deep geologic storage or disposal is highly specialized and has been undertaken by a relatively small group of scientists and engineers. The EIS and SCS were largely the work product of AECL. An important outcome of the SRG and Seaborn Environmental Assessment Panel reviews of the EIS is that a wider base of expertise is now being developed to undertake research on the deep geologic disposal of high level radioactive waste. This research base includes scientists and engineers in numerous consulting firms and universities as well as those at AECL, OPG and other power authorities.