# Long-Term Management of Canada's Used Nuclear Fuel in a Deep Geological Repository – Natural Analogues

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The Nuclear Waste Management Organization (NWMO) is responsible for the implementation of Adaptive Phased Management (APM), the federally-approved plan for safe long-term management of Canada's used nuclear fuel. Under the APM plan, used nuclear fuel will ultimately be placed within a deep geological repository in a suitable rock formation, either crystalline or sedimentary.

Long-term repository performance cannot be verified by experiment over relevant time scales. Natural analogues illustrate long-term behaviour, providing support for key model assumptions and for the identification of processes that need to be represented and those that can be excluded.

Deposits of metallic copper provide a natural analogue for estimating the longevity of copper-coated used fuel containers. The Keweenaw Peninsula of Michigan hosts the largest known deposit of metallic copper, where large pieces were either mined or found in glacial outwash. Archaeological analogues for corrosion are also used to support more quantitative estimates of container longevity: the Swedish Bronze Canon and Inchtuthil Roman Nails provide estimates of long-term corrosion rates for copper and steel.

The Greenland ice sheet is considered an analogue of the surface conditions expected to prevail in Canada and Fennoscandinavia during future glacial cycles. Results from the Greenland Analogue Project help illustrate the potential impact of glacial processes on the long-term performance of a repository: specifically, groundwater flow and water chemistry at the base of a continental ice sheet.

Groundwater salinity has the potential to impact the properties of repository sealing materials: bentonite, concrete, or asphalt (bitumen). Natural analogues of these materials can illustrate their durability under saline conditions. Bentonites studied under the Cyprus Natural Analogue Project remained in a marine environment for nearly 90 million years and show no significant impact on their swelling capacity. Pozzolanic cements developed in Ancient Rome were exposed to marine salinities for about 2000 years; studies suggest remarkably little degradation. Bitumen within the McMurray Formation in Athabasca has remained stable for over 10 million years under brackish groundwater.