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Preliminary Assessment of Geologic Repository Options for Disposal of Intermediate Level Waste from Small Modular Nuclear Reactors in Saskatchewan, Canada

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Summary

The Government of Saskatchewan is investigating in potential deployment of small modular nuclear reactors (SMNRs) to provide the province a base-load electrical power and to replace coal-fired plants. Like in all nuclear energy applications, SMNRs will generate low, intermediate and high-level nuclear waste that needs to be carefully managed based on the type of nuclear waste and properly disposed of.

The prevalent view among the international scientific community is that deep geologic repositories (DGRs) are the safest option for long-term disposal of nuclear waste. In DGRs the waste would be contained in specially designed canisters that can minimize harm to the humans and to the environment, then emplaced within a rock formation. Certain characteristics of host rock environments, such as low seismic hazard, low permeability and low porosity, are essential for selecting an appropriate DGR site. Currently, disposal in mined (shaft and tunnel) repositories is the only method of nuclear waste disposal for high-level waste (HLW) and intermediate-level waste (ILW), while deep borehole repository designs using horizontal or vertical drilling are in the testing phase. In Canada, the Nuclear Waste Management Organization (NWMO), which is responsible for nuclear waste management, has indicated a preference for a mined repository for disposal of ILW based on internationally recognized best practices (NWMO, 2024).

Saskatchewan has a low seismic hazard rating and several rock types that have low permeability and low porosity that could potentially be suitable for DGR. Three strong candidates of interest are the crystalline rocks which underlie the Western Canada Sedimentary Basin (WCSB) in southern Saskatchewan and which outcrop in the north, the bedded halite (rock salt) deposits within the Prairie Evaporite Formation, and thick Cretaceous-age shales. The main goal of this research is to develop an understanding of the distribution (e.g., depth, thickness) and properties of rock formations in Saskatchewan that could be suitable for disposal of ILW, and to identify key knowledge and data gaps that should be addressed if more detailed analyses of a potential ILW DGR options are to be considered in the future.

Objectives

The purpose of this research is to investigate the suitability of low-permeability crystalline, evaporitic or clay-rich rocks in Saskatchewan to host a geological repository for ILW. The proposed research will assess the potential for geological repositories at a range of depths and a

variety of designs (shaft-and-tunnel excavations, vertical and horizontal boreholes) for ILW disposal. The following research objectives will be pursued to achieve the overall purpose.

1. To develop an understanding of the current state of thinking and preferred practices for DGRs in nuclear waste management.
2. To develop site selection criteria for DGRs in crystalline, evaporite and clay rocks.
3. To develop an understanding of the depth, thickness and engineering (thermo-hydro-mechanical) properties of potential host rocks in Saskatchewan.
4. To identify regions within Saskatchewan that could be prospective for a DGR in crystalline rock, evaporites and/or shales.
5. To identify key gaps to be filled in future research pertaining to the engineering properties of rocks in areas deemed prospective for disposal of ILW in DGRs.

Preliminary Results & Next Steps

From a preliminary assessment of the geology of Saskatchewan it is clear that the distribution of the three strong candidate rock types is well known. Three prospective options are identified in Figure 1.

The northern part of the province is comprised of Precambrian-age rocks. These include crystalline rocks of the Canadian Shield, and sedimentary rocks in the Athabasca Basin. Younger (Phanerozoic-age) sedimentary rocks overly Precambrian-age crystalline rocks in the southern part of the province (Government of Saskatchewan, 2008). The total thickness of the sedimentary succession ranges from zero in the north (at the boundary with the Canadian Shield) to more than 3500 m in the south (at the Canada – USA border). As shown in Figure 2, the structure (top surface topography) of Precambrian-age rocks is well established in Saskatchewan. As such, when considering options for mined DGRs at depths of the order of 100's of meters, the starting point will be to delineate the suitable area using Figure 2. Similarly, this figure will be used to delineate areas where deep borehole repositories might be considered (after updating the map based on more recent, deep boreholes in the southern part of the province), as proposed by Brunskill (2006).

Similarly, the depths and thicknesses of most sedimentary formation in the southern part of the province have been mapped extensively and this information can be used to delineate areas that could be prospective in specific formations, upon establishing criteria based on lithology, depth and thickness. For example, a study by Saskatchewan Geological Survey has mapped the depth and thickness of the Prairie Evaporite Formation throughout the province varies in detail. Depths of this formation range from 805 to 2756 m below ground level, with total thickness ranging from 0 to over 220 m, as shown in Figure 3 (Yang et al., 2009). Assuming the thick halite units of this formation are of greater interest for a DGR, additional maps generated by Yang et al. (2009) – which show depths and thicknesses for specific halite and potash members – can be analyzed to assess best options for a DGR.

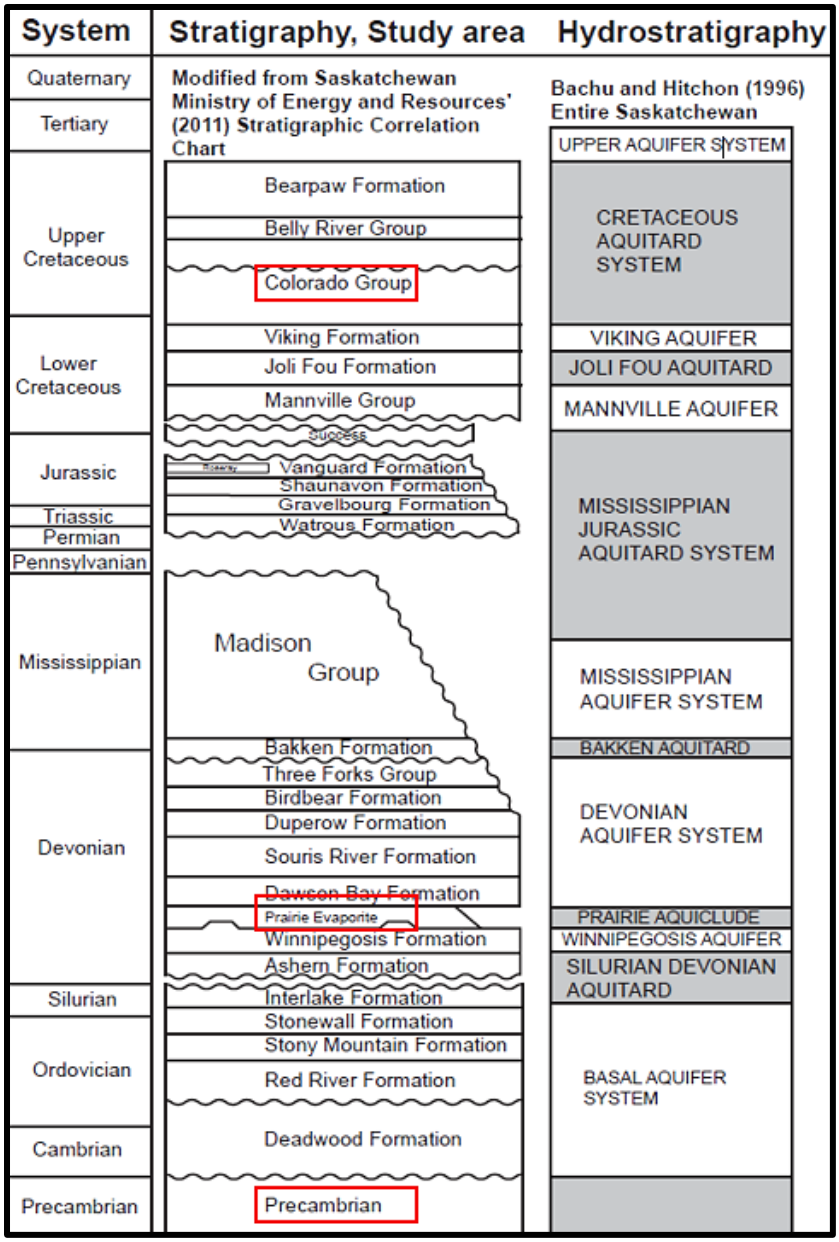

Figure 1: Stratigraphy and hydrostratigraphy of Saskatchewan (After Melnik et al., 2010). Red boxes denote stratigraphic units of interest for potential DGRs.

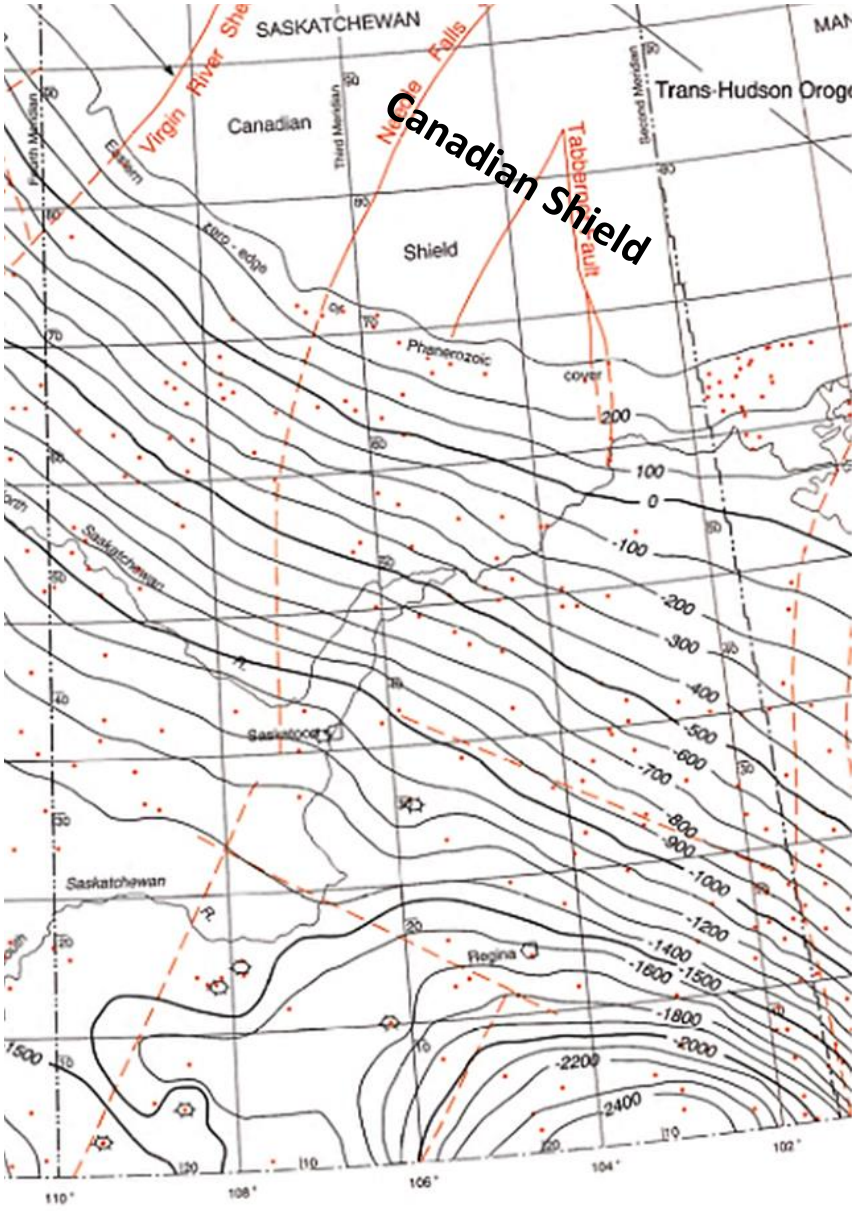

Figure 2: Structure map for Precambrian rocks in Saskatchewan. Contours represent elevation of the top of the Precambrian in meters relative to sea level. Orange dots represent borehole locations used to generate this map (Burwash et al., 1994).

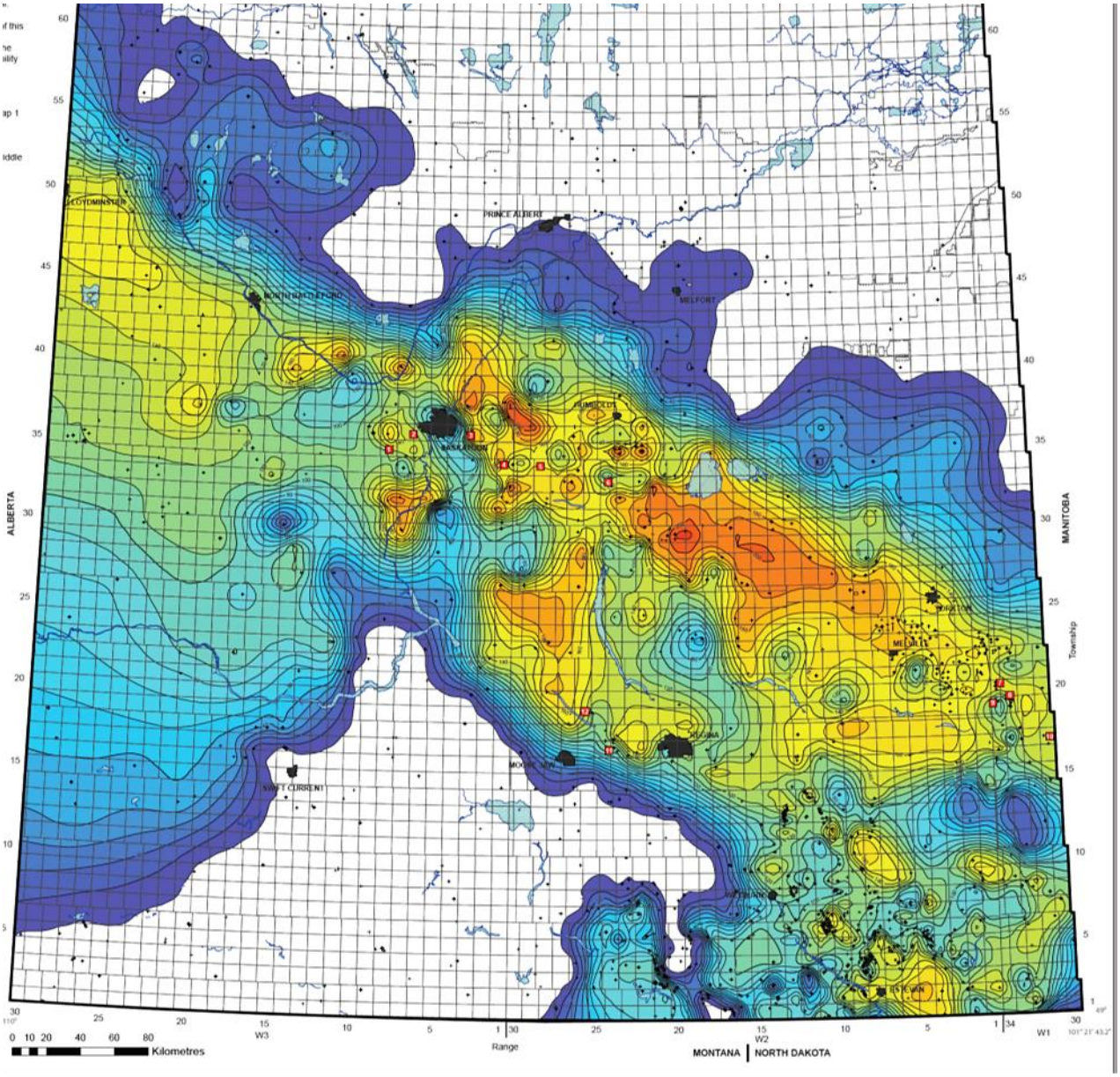

Figure 3: Prairie Evaporite Formation thickness (m) (Yang et al., 2009). The orange squares show the locations of existing potash mines.

The presentation will provide background on nuclear waste categories and disposal needs, and a more detailed update on preliminary results obtained in this project; e.g., repository designs compiled from literature, geological and hydrogeological data compiled from various sources, and selected thermo-hydro-mechanical rock properties.

Acknowledgements

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