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Multiphase Flow and Underpressured Shale at the Bruce nuclear site, Ontario, Canada

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A deep geologic repository (DGR) for low- and intermediate-level radioactive waste has been proposed at the Bruce nuclear complex on the eastern flank of the Michigan Basin in southeastern Ontario, Canada. The proposed location for the repository is at a depth of ~680 m, in the middle of a ~450 m-thick sequence of Ordovician-aged shale and limestone with extremely low porosity and permeability, which makes fluid flow and mass transport processes very slow. Significant underpressure exists in these rocks, and questions have been raised about whether gas phase methane is present and how it relates to the generation and persistence of the underpressure here, as well as those in numerous other shale- and gas-rich sedimentary basins around the world. Multiphase flow simulations have suggested that water can become underpressured in the presence of gas phase due to transient glacial loading cycles, and a previous modeling study of the Bruce site, in which the presence of gas phase was approximated using ad hoc adjustments to single-phase flow parameters, showed that underpressures can persist for geologically significant periods of time. However, while multiphase interaction and migration processes have been studied extensively for conventional petroleum and environmental engineering applications, they are relatively poorly understood in low-permeability argillaceous rocks such as those at the DGR. The goals of this study are to: (1) determine which rock and fluid parameters are most critical for understanding the multiphase flow processes that may have occurred in the low-permeability formations at the Bruce site through geologic time, (2) assess uncertainty in our understanding of those parameters, and (3) investigate, using the multiphase flow simulator iTOUGH2-EOS7C, whether the presence of gas phase methane could have generated or contributed to the underpressure. Results suggest that the presence of gas phase methane does not by itself fully explain the underpressure.

References

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