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Possible links between multiphase methane evolution and anomalous subsurface pressures 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 near the Bruce Nuclear Site on the eastern flank of the Michigan Basin in southeastern Ontario, Canada, and extensive characterization studies have produced voluminous data on the physical and chemical characteristics of the subsurface at the site. 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 units that exhibit extremely low permeability and porosity, which cause fluid flow and mass transport processes to occur at very slow rates over geologic timescales. Significant underpressures exist 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 underpressures here, as well as in numerous other shale- and gas-rich sedimentary basins around the world. 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 underpressures. Results suggest that the presence of gas phase methane does not by itself fully explain the underpressures.