



## **Investigation of potential upward fluid migration pathways in two study areas hosting unconventional hydrocarbon reservoirs in Eastern Canada**

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In eastern Canada, all provincial jurisdictions have had a moratorium on hydraulic fracturing due to the concerns voiced about its potential environmental impacts, especially on shallow groundwater resources. The Geological Survey of Canada has carried out two projects to assess the potential for fluid migration from deep (~2 km) hydrocarbon-rich shale or tight sandstone units to shallow aquifers: one in southern Quebec (Saint-Édouard area, Ordovician St. Lawrence Platform) and the other in southern New Brunswick (Sussex area, Carboniferous Moncton Sub-basin). In these two areas, regional faults are present and dissolved hydrocarbons, mostly methane, have been found in shallow groundwater, especially in the Saint-Édouard area where they are ubiquitous and locally abundant. The geological and hydrogeological contexts of these study areas are, however, very different. One of the main differences is the aquifer types, which are mainly composed of fractured organic-rich black shale in the Saint-Édouard area and dominated by fractured and porous sandstone in the Sussex area. Also, while no shale gas well is in production in the St. Lawrence Lowlands, the McCully tight sandstone gas field in the Sussex area has been in production since 2001. Geologically, very little is known about the intermediate zone located between shallow aquifers and deep hydrocarbon reservoirs. Because this intermediate domain controls the vulnerability of shallow aquifers to deep industrial activities, these projects had to rely on multi-source direct and indirect data for its characterization.

In both projects, the presence of potential upward migration pathways was studied through the investigation of the intermediate zone integrity using geomechanical and geophysical data, while natural fracturing, groundwater flow and quality, and hydrocarbon composition in shallow bedrock and groundwater were investigated using geology, hydrogeology, and organic and inorganic geochemistry. Data collected and their interpretation do not provide any evidence that large-scale hydraulic connections are present in these study areas. In Saint-Édouard, microbial and thermogenic gas present in groundwater appear to come from the shallow bedrock itself. Nonetheless, some old brines were found in some of the shallow (~50 m) observation wells, but were not accompanied by large concentrations of thermogenic methane; they are thus inferred to come from a few hundred meters below the surface and were associated to regional groundwater discharge in the vicinity of a regional normal fault zone. In the ongoing southern New Brunswick project, the intermediate zone does not seem to be affected by major brittle structures in the hydrocarbon field and adjacent area, but a fault zone located outside the producing field, at the basin margin, was found to bring hydrocarbons at or close to the surface. This specific region is currently being studied to understand the significance of brittle faults at basin-margin as potential natural escape pathways for hydrocarbons and its potential hydraulic connection with the gas field.