Geothermal potential of positive temperature anomalies above salt structures in Nova Scotia

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Summary

To meet our 2030 and 2050 targets, low carbon renewable energy is necessary to support the transition away from hydrocarbons while meeting rising global energy demands. Access to reliable sustainable energy from diverse sources including solar, wind, and geothermal will need to be exponentially increased. Geothermal energy has proven successful for both production of electricity and direct heat in high temperature regions, but until recently was not considered achievable in moderate to low temperature regions. Technological advances have improved the opportunities for geothermal energy in previously eliminated regions, lowering the potential temperature range. Salt is an evaporite with unique characteristics in the subsurface, able to mobilize and flow under suitable conditions, and form structures (e.g., diapirs, canopies) (Jackson and Hudec 2017). The thermal conductivity of salt is two to four times higher than other lithologies, so the geothermal gradient is expected to be higher in sediments above salt structures and are termed positive temperature anomalies (Zentilli 2006; Daniilidis and Herber 2017). Research on potential geothermal development of positive temperature anomalies has primarily focused on theoretical models that have not been evaluated against observed temperature data.

This research focusses on assessing the geothermal potential associated with positive temperature anomalies above salt structures in selected areas of the Scotian and Maritime basins. These basins were selected because they both contain significant salt deposits that have been mobilized since formation, as well as the required seismic and well data (including temperature) for analysis. This study aims to provide new insights on geothermal gradients in low temperature basins, the impact of salt structure configuration and composition, with the novel application of petroleum systems modelling to geothermal energy evaluations.

Methods

This research begins with proof of concept on the existence of positive temperature anomalies with above average geothermal gradients in the study areas within the Scotian and Maritimes basins. This will be completed using simplified 3D geocellular models of interpreted salt structures and overburden in the study areas, generated in Petrel™, that are then imported into PetroMod™ for 3D temperature modelling (2D example provided in Figure 1). Models will be based on integrated 2D and 3D seismic, well logs, and temperature data; all data has been donated or is available from public databases. Once the location and magnitude of the positive temperature anomalies are proven, the model parameters will then be varied to examine impact to geothermal gradient; parameters include structure type, salt structure composition, overburden composition, and heat flow model. Five heat flow models will be tested: McKenzie standard heat flow (1978), Nova Scotia Play Fairway Analysis heat flow (OERA 2011), Bowman heat flow (2012), Negulic and Louden (2016), and Wong heat flow (2018).

Petrel™ and PetroMod™ are well established industry software programs associated for Petroleum Systems Modelling (PSM) but have not been proven for geothermal (energy) assessments. They are excellent at constructing and processing complex 3D models, which is why they have been selected for their novel application in this research. There are already a significant number of scientists skilled in both programs, so the ability to pivot and redeploy their knowledge from using these for hydrocarbon research to energy transition research would be beneficial to science and society.

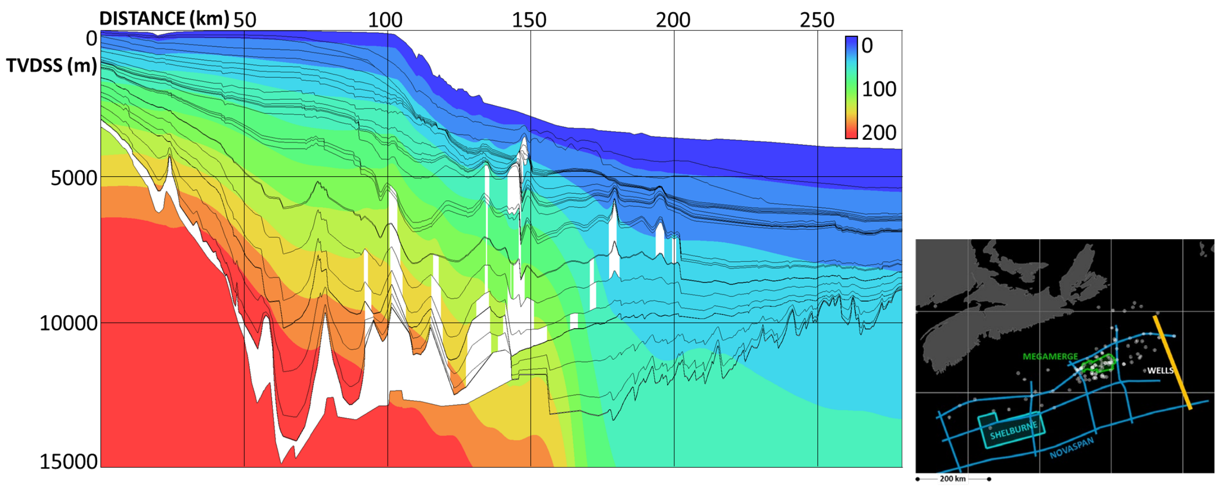

Figure 1: (L) *Example of 2D temperature model output from PetroMod™ of NovaSPAN line 2000.* ***(R)*** *Location map with position of NovaSPAN line 2000 indicated in yellow (Wong 2018).*

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