Geothermal potential of Anticosti sedimentary basin, Canada

Violaine GASCUEL[a], Karine BÉDARD[b], Félix-Antoine COMEAU[c], Jasmin RAYMOND[d], Michel MALO[e]

INRS (Institut National de la Recherche Scientifique), Centre Eau-Terre-Environnement, Canada

Keywords : geothermal exploration, geothermal potential assessment, 3D geothermal modelling

Abstract:

The Anticosti Island, like most remote regions of Canada, relies entirely on fossil fuels for energy consumption. As an effort to diversify energy sources and reduce greenhouse gas emissions, a first estimate of the geothermal potential of the Anticosti sedimentary basin was done, considering both electricity production and direct heat use. Geothermal resource quantification was achieved through a numerical heat transfer model based on a 3D geological model, simulating heat conduction in the Earth's crust (Bédard, Comeau et al. 2014).

The Anticosti sedimentary basin consists of an upper Ordovician to lower Silurian carbonate platform, which unconformably overlies the Precambrian basement. A 3D geological model of the basin, integrating data from 24 oil and gas exploration wells and public seismic lines, was initially built with eight distinct geological units: Romaine, lower Mingan, upper Mingan, Macasty, lower Vauréal, Upper Vauréal-Ellis Bay-Becscie , Merrimack and Gun River-Jupiter-Chicotte. Theses units are manly composed of limestone and shale, with dololstone at the base of the sequence, and sandstone in the eastern part.

Thermal conductivity of the geological units as well as internal heat generation rate were derived from geological and well logs, with a theoretical value for each weighted lithology composing the units.

The undisturbed ground temperature near surface, used as a first type boundary condition for the 3D numerical model, was calculated from meteorological data using (Ouzzane, Eslami-Nejad et al. 2015) global correlation. A constant heat flow of 15mW/m2 was established at the base of the model at 40.5km (Moho depth) as a second type boundary condition. Available bottom-hole temperature data were corrected for drilling disturbances, considering time since circulation stopped according to the method of Waples and Ramly (2001), and for paleoclimatic effects. Terrestrial heat flow and a heat generation of the Precambrian basement were calculated analytically at the location of the 24 wells, according to 1D temperature modeling and assuming the same heat flow at Moho depth. Basement heat generation values were interpolated in 2D and included in the model for the corresponding layers. Vertical side boundaries were considered adiabatic and heat convection was neglected due to a lack of reliable data to constrain flow properties and boundary conditions.

The 3D heat conduction model was solved in steady state with the finite element method using Feflow.

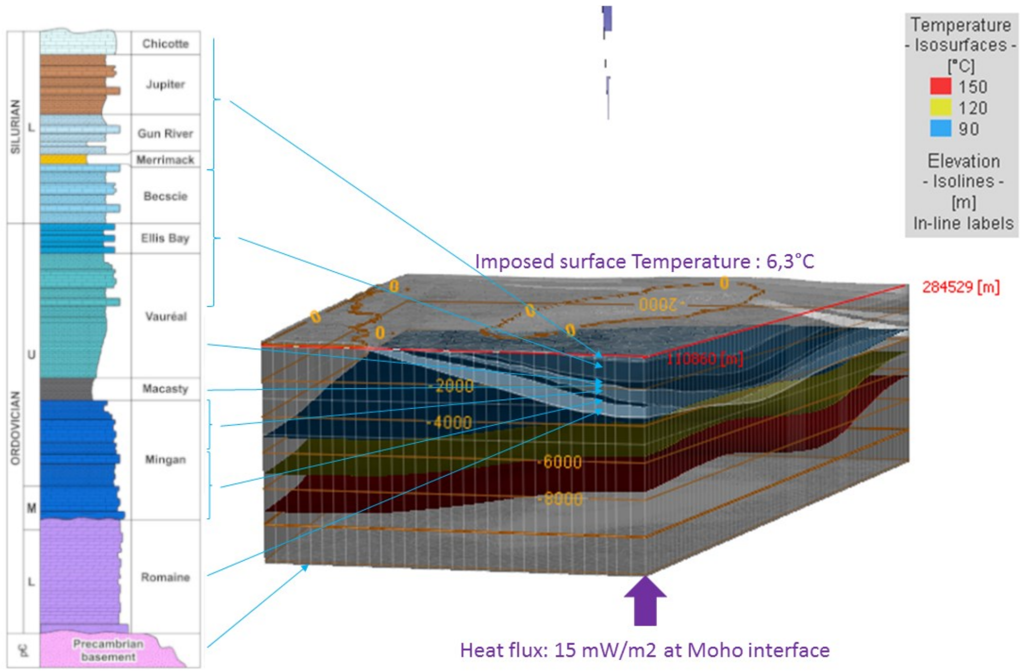

Illustration 1: Thermal model for Anticosti basin (Feflow) based on a geological model (Gocad)

Results show that a temperature of 120 °C, which is considered the lower value needed for an efficient binary geothermal power plant, can be reached between 4 to 5.4 km depth in the Precambrian basement. The most promising temperature anomaly is located in the southeastern part of the island, reaching 120 °C at 4 km depth. However, it is a barely populated area, so the potential for the development of a geothermal plant in the near future is inexistent. The most populated area of the island is the locality of Port-Menier in the northwestern part of Anticosti. A temperature of 120°C is reached at a depth of about 5 km below this locality. Direct geothermal energy use to heat building appears more feasible, with a temperature of 57°C reached at a depth of 2.1 km at the base of the sedimentary basin, which corresponds to the dolostone of the Romaine Formation having a relatively high permeability, reaching more than 10 mD according to Glover (2003).

Future work perspectives include laboratory analysis to measure thermal and hydraulic properties of rock samples from all lithologies. These values could be up-scaled using knowledge of the stratigraphy to improve the numerical model defining geothermal resources.

References

Bédard, K., F.-A. Comeau and M. Malo (2014). Lithostratigraphie standardisée et modélisation géologique 3D du bassin d'Anticosti, INRS**:** 83.

Glover, P. (2003). Evaluation of the porosity and fluid saturations of Well Chaloupe at Anticosti, Petro Advance.

Ouzzane, M., P. Eslami-Nejad, M. Badache and Z. Aidoun (2015). "New correlations for the prediction of the undisturbed ground temperature." Geothermics **53**: 379-384.

Waples, D. W. and M. Ramly (2001). "A statistical method for correcting log-derived temperatures." Petroleum Geoscience **7**(3): 231-240.