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Athabasca Regional Geophysical Study - Implications for Geothermal Development in Northeastern Alberta, Canada

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SUMMARY

Athabasca region in northeastern Alberta hosts many producing oil sand projects. These projects require large amounts of thermal energy to produce most of which is currently provided by burning natural gas; and this increases the greenhouse gas footprint to producing such hydrocarbons. One possible solution is to instead use geothermal heat directly with hot fluids produced using Engineered Geothermal Systems (EGS). Geothermal exploration always starts with broad geological structure reconnaissance of the area. Seismic reflection profiles, High Resolution Aeromagnetic (HRAM) data, and a large amount of available well-logs are used in an integrated approach to outlining sedimentary basin, mapping geological formation tops, locating fault zones and other structural lineaments, finding true depth of metamorphic basement, and finally building a detailed geological model of the region. The 3D geological model is constructed using these available data that reveals some detail about the gross structure of the region. This model shows that the Precambrian basement surface is a smoothly undulating surface that could be consistent with minor faulting. The topography of this surface affects the structure of overlying sedimentary formations.

Introduction

Currently, the GFZ-Potsdam and the University of Alberta in Edmonton are carrying out exploratory research for the potential development of low-enthalpy geothermal energy. This work is motivated by the need to find sustainable and lower greenhouse gas emission solutions for production of bitumen from Alberta's oil sands. The generally low heat fluxes observed in Alberta, however, make exploration and development of such resources challenging. However, the ability to heat water to even modest temperatures could supplement the current thermal energy requirements that are satisfied primarily from the burning of natural gas.

The focus of this study is on the regional scale characterization of Athabasca region in NE Alberta extending across 56.25° to 57.12°N and 111.92° to 113.52°W from which new in situ projects for extraction of bitumen from sands and carbonates are now just beginning. In order to evaluate the potential for developing geothermal systems in this area, the main object is having an insight to the regional geothermic and structural geology. According to the available industrial thermal data, depths in excess of 4 km may have to be attained in order to reach 100°C in NE Alberta. The average gradient in this part of Alberta is 22 mK/m (Grey et al. 2012). This heat would be enough for water pre-heating to get used for in situ oilsand production through the EGS. Our study is focused on reconnaissance of the regional structural geology.

Geophysical datasets available and methodology

In the way of achieving the goal of construction of a regional geological/geophysical model for the study area, we employ three complementary classes of data: seismic reflection, geophysical well-logs, and High Resolution Aeromagnetic (HRAM). Nearly 600 line km of legacy 2D seismic data obtained through purchases and donations from a number of petroleum exploration companies (Fig.1a). An industry data base to which we have access shows that 2,917 boreholes exist in the study area. Only 1066 boreholes have digital or raster logs and among these wells just 255 of them possess Digital Sonic (DT) and Density (RHOB) logs. Among these 255 boreholes only 21 of them are deeper than 500 meters. The HRAM data covers the whole study area of 22,508 km² (Fig.1b).

Figure 1 a) The 2D profiles (solid lines) and borehole (circles) locations in the study region. Darker colored circles are the boreholes drilled deeper than 500m and contain DT and RHOB in their log datasets. b) Map of final total magnetic field after applying diurnal, leveling and cultural corrections.

Seismic images have the potential to detect geological features that could influence the regional structure such as major faulting, collapses, channels and reefs. Magnetic data is used for mapping structure lineaments as a reference for seismic interpretation (Peirce 2010). Borehole data usually is used for seismic interpretation. Here, the 3D geological model seeds are large amount of geological tops determined by well-logs and seismic horizons. Seismic horizons are used to make up for the lack of information between boreholes. Figure 2a shows the constructed geological model for the study area. Broadly, this model displays the gross structure of the region with the gentle dips to the west of the structure from the Precambrian unconformity up through the Paleozoic sediments. The geological groups that are modeled from top to base are Colorado, Mannville, Woodbend, Beaverhill, Upper and Lower Elk Point and Precambrian basement. The Precambrian basement surface may suggest a smoothly undulating surface that could be consistent with minor faulting below seismic resolution limits but resolvable on HRAM. Figure 2b illustrates the seismic-corrected Precambrian unconformity surface extracted from the model. This surface displays surface topography in elevation depth domain.

Figure 2 a) 3D geological model in the study region in elevation depth domain. The axes units are in UTM-NAD83-Zone12 projection system. b) The seismic-corrected Precambrian unconformity surface in the study area in elevation depth domain.

Conclusions

The presented paper is an update on progress of an integrated research to evaluate the regional geology of the Athabasca area for geothermal energy development. Since the Canadian sedimentary basin is shallow in this area, the EGS is known as the best solution for green energy production. We developed the first geological model of the area that integrates seismic and HRAM and well logs.

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References

- Grey, A., Majorowicz, J. and Unsworth, M. [2012] Oil industry thermal data in exploring of geothermal state of the basin— biases and corrections - northern Alberta case study. *Geophysics and Engineering*, **9**, 534–548.
- Peirce, J.W. [2010] Constraining seismic interpretation with aeromagnetic data. *Search and Discovery Article #40606*, 4.