

Geothermal energy potential of active and flooded mines in the Plan Nord territory

Edgardo J. Alvarado¹, Andrea L.F. Morgan¹⁻², Félix-Antoine Comeau¹, Jasmin Raymond¹

¹ Institut national de la recherche scientifique, Centre Eau Terre Environnement, Québec, Canada

² Reykjavik University, Iceland School of Energy, Reykjavik, Iceland

INRS
UNIVERSITÉ DE RECHERCHE



HÁSKÓLINN Í REYKJAVÍK
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Introduction

High energy costs and environmental issues are a major challenge in the present-day world (Figure 1), highlighting the need to utilize low emission, economical, and local energy sources. Low-temperature geothermal energy from mining sites is an interesting heating solution since underground mines maintain an approximately constant temperature throughout the year which is relatively high compared to surface temperatures. Water from the mines can be used in conjunction with heat pump systems to produce energy for nearby communities or infrastructure [1]. In active mines, groundwater heat pumps coupled with existing dewatering systems can be used to regulate temperatures. Furthermore, flooded underground abandoned mines can be exploited similarly [2].

Objectives

The objective of these studies is the characterization of geothermal resources in order to design heat pump systems adapted for active and abandoned flooded mines is the main objective. Two sites are currently under study in Québec: the active Éléonore mine in James Bay and the abandoned Springer and Perry mines near Chapais (Figure 2).

Specific objectives:

- Diversify energy sources;
- Establish local and continuous energy sources;
- Minimize fossil fuel demand and consumption [3];
- Minimize greenhouse gases emissions;
- Minimize costs.

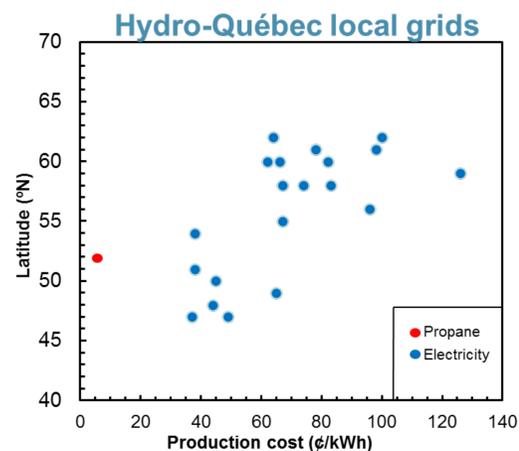


Figure 1. Cost of electricity production depending on the latitude in Northern Québec. Comparison with the price of propane. [4]

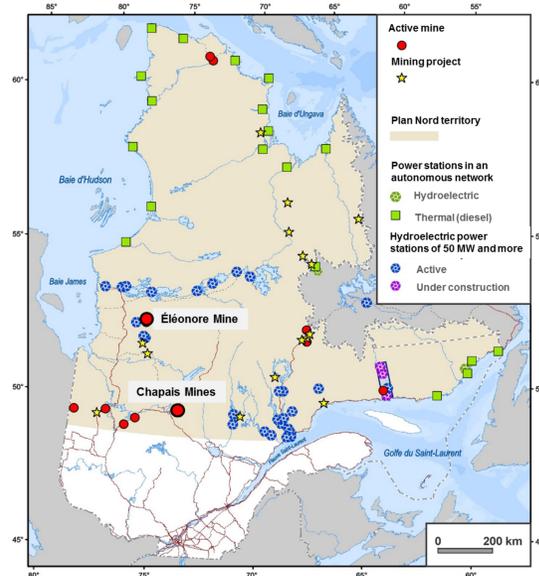


Figure 2. Map of electricity production and mining projects in Northern Québec [5]

Geothermal heat pump systems

A geothermal heat pump system (GSHP) for a mine consists of a heat pump unit linked to a plate heat exchanger connected to the geothermal reservoir. In winter, the GSHP technology allows energy to be extracted from the reservoir for heating. In summer, the system transfers excess heat to the geothermal reservoir [6]. This process employs the vapour-compression refrigeration cycle is schematized in Figure 3.

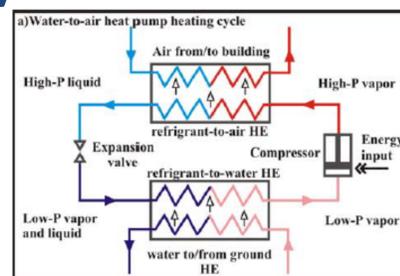


Figure 3. Heat pump cycle schematic [6]

Methodology

Energy balance calculation

$$q = Q_{air} \rho_{air} C_{air} (T_i - T_f)$$

- Calculate the heating requirements



Water sampling campaign

- Measure flow rate and temperature
- Analyze water chemistry to assess the risk of scaling and corrosion

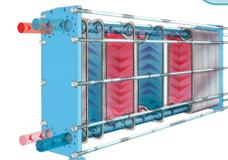
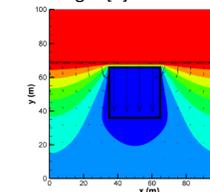


Plate Heat Exchanger [7]



Numerical model [8]

Geothermal heat pump system design

- Determine the amount of energy that can be extracted from mine water

Numerical modelling

- Establish the amount of energy available under varying temperature and flow conditions
- Ensure the sustainability of the geothermal resource

Preliminary Results

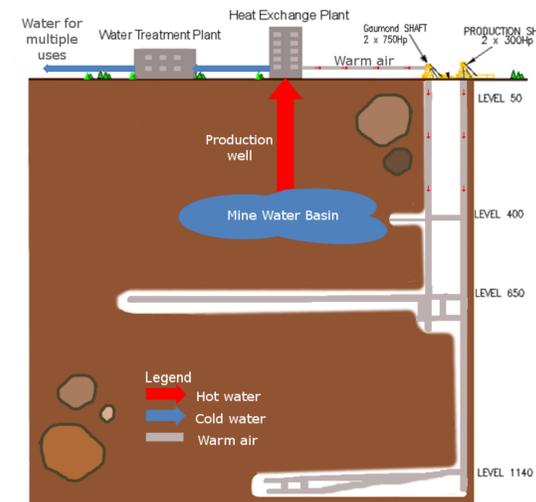


Figure 4. Schematic of the heat pump system at the Éléonore mine

The preliminary study at the Éléonore mine indicates:

- The discharge area of the mine's dewatering system would be the location with the highest geothermal potential with a mean flow rate of 337 m³/h and a mean temperature of 12.4 °C.
- Chemical analysis of water indicates that the water from the discharge area of the mine's dewatering system has a slight scale forming and corrosive potential.
- The preliminary arrangement of the geothermal heat pump system likely to be installed at the Éléonore mine is shown in the figure 4.
- Both the Perry and Springer mines have potential to be economic energy sources for Chapais due to their considerable reservoir volumes and proximity (<1km) to the townsite.

Future work

- Create an inventory of active and abandoned mines for the Plan Nord territory;
- Gather and analyze thermal properties of rock samples and temperature data of water at different mining sites;
- Develop numerical models to evaluate geothermal heat pump systems performance, as well as optimizing design and to ensure a sustainable exploitation of the geothermal resource;
- Promote the use of the GSHP technology.

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