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Formation-Scale Geothermal Favourability Mapping and the Geothermal Atlas of Alberta

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ABSTRACT

Geothermal energy in the Alberta portion of the Western Canada Sedimentary Basin (WCSB) remains largely untapped. The basin, known for its vast hydrocarbon resources, also features subsurface geological conditions conducive to hosting geothermal energy resources. Recent efforts by the Alberta Geological Survey (AGS) have focused on identifying and characterizing geothermal reservoirs at the formation scale.

The study involves creating new geothermal favourability maps for several geological units, applying a multi-criteria mapping approach that incorporates geological, petrophysical, and hydrogeological information to generate three key spatial data layers: temperature, porosity thickness, and aquifer indication. These layers were subsequently utilized in a geographic information system (GIS) weighted overlay analysis to produce formation-scale geothermal favourability maps showing areas with varying geothermal resource potential.

A key outcome of this work is the development of a Geothermal Atlas of Alberta: a publicly available digital platform designed to support geothermal exploration and development. The platform interacts with a rich repository of geological data and offers users interactive access to geothermal energy-related spatial data. It facilitates the identification of potential areas for geothermal exploration, assists in selecting geologically favourable subsurface targets, and provides tools for cartographic visualization and data analysis.

1 BACKGROUND AND PREVIOUS WORK

Sedimentary basins like the Western Canada Sedimentary Basin (WCSB) hold strong geothermal potential due to their large size, high heat content, transmissive formations, and proximity to users (Birdsell et al., 2024). The WCSB, bounded by the Rocky Mountains and the Canadian Shield, features diverse lithologies and geothermal gradients shaped by its complex geological history (Bachu and Burwash, 1994). In the Alberta Basin, geothermal gradients range from 23–50°C/km, with temperature reaching over 180°C at depths greater than 6 km. Numerous studies have evaluated its geothermal potential for power generation and district heating (Jessop, 2008; Majorowicz and Grasby, 2010; 2021), identified key aquifers (Ardakani and Schmitt, 2016), and modelled geothermal systems across Alberta (Weides et al., 2013; Hofmann et al., 2014; Banks and Harris, 2018).

Despite these efforts, a basin-wide, formation-scale assessment of Alberta's geothermal aquifers has been lacking. The Alberta Geological Survey (AGS) has addressed this gap through an integrated, multi-criteria approach focusing on deep (>1000 m) aquifers. Unlike earlier favourability maps that relied primarily on temperature data (e.g., CanGEA, 2013), this approach also incorporates assessments of pore volume and potential brine producibility as a measure of the reservoirs' capacity to store and transmit fluid for heat transfer. Drawing on existing GIS-based favourability mapping methods (Noorallahi et al., 2007; Poux and Suemnicht, 2012; Trumpy et al., 2015) and prior work in British Columbia (Palmer-Wilson et al., 2018), the AGS framework uses data from core analyses, well logs, and drillstem tests to systematically screen, identify, and characterize potential geothermal reservoirs in Alberta.

2 OBJECTIVE

The primary objective is to develop a robust, formation-scale methodology for assessing geothermal potential in Alberta, focusing on geological favourability. This includes:

- Establishing practical criteria and mapping techniques for screening and characterizing geothermal reservoirs.

Security Classification: Protected A

- Quantitatively assessing geothermal energy resources (thermal energy, thermal power, electrical power).
- Hosting all results in the interactive Geothermal Atlas of Alberta, which provides technical details, data layers, and query tools for users.

3 METHODS & RESULTS

3.1 Geothermal Favourability Mapping

Following Palmer-Wilson et al. (2018), an integrated multi-criteria GIS-based approach was developed to identify geologically favourable areas for conventional geothermal systems within specific formations (Devonian Granite Wash, Leduc, and combined Swan Hills and Slave Point formations). The method applies a weighted overlay analysis using three key spatial criteria: subsurface temperature, aquifer indication, and porosity thickness (PHI*H) representing heat availability, fluid presence, and reservoir capacity, respectively. Regional temperature data (Brinsky et al., 2022) were integrated with geological, petrophysical, and hydrogeological datasets to generate three spatial data layers corresponding to these criteria (Figure 1). Each parameter was evaluated to define favourable value ranges and assigned a corresponding favourability score. The resulting grids were classified into four favourability classes and weighted based on their relative importance such as Temperature (50%), Aquifer Indication (30%), and Porosity (20%). Sensitivity analyses were then performed to evaluate different weighting scenarios.

Formation-scale favourability maps display areas of low, medium, high, and very high geothermal potential across four weighting scenarios. The workflow used to generate these maps is available on the Geothermal Favourabilty Mapping - Technical Information page of the Geothermal Atlas of Alberta.

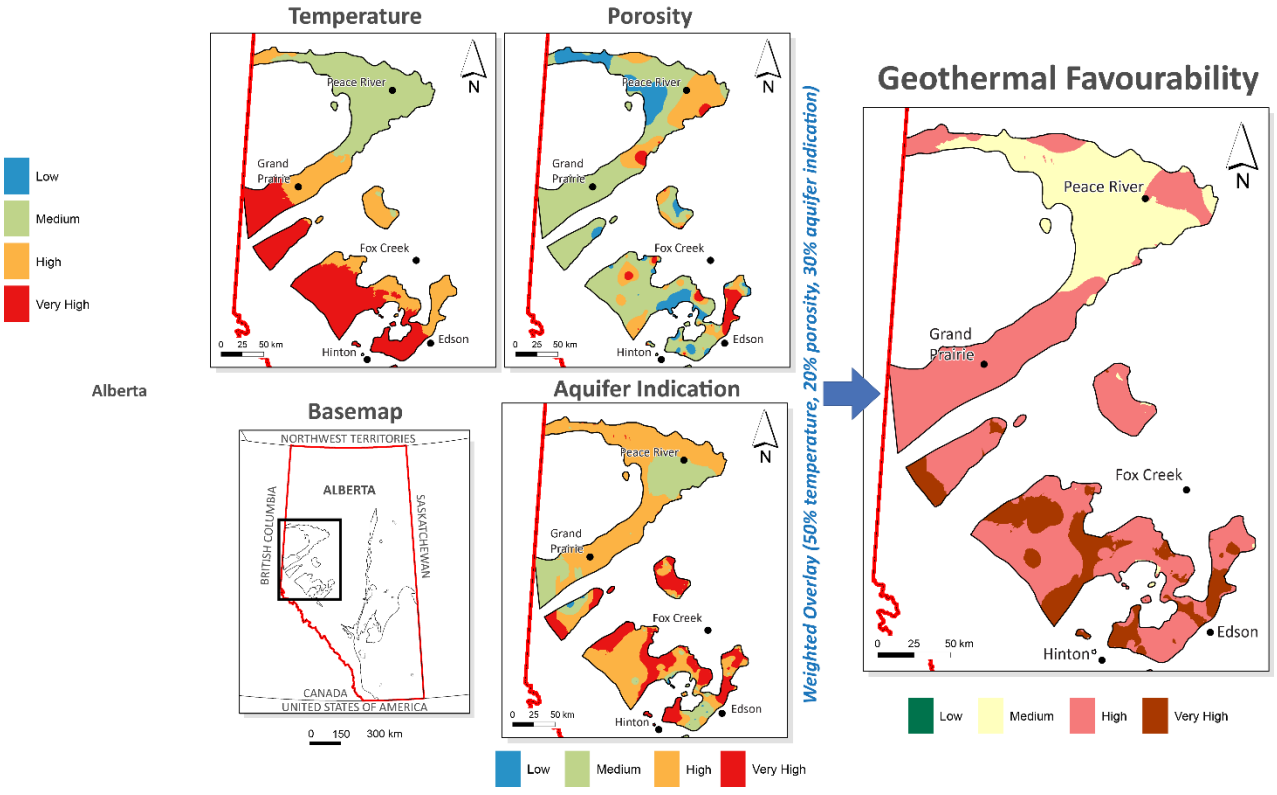


Figure 1. Example of geothermal favourability mapping using spatial analysis of geological criteria focusing on the Upper Devonian Leduc Formation in west-central Alberta.

3.2 Geothermal Resource Quantification

Geothermal resource quantification in Alberta was conducted using the United States Geological Survey (USGS) volumetric estimation method (White and Williams, 1975; Williams et al., 2008; Garg et al., 2010; Palmer-Wilson et al., 2018), a widely accepted and standardized approach for estimating geothermal energy potential. This method calculates stored thermal energy (heat-in-place, PJ) from key reservoir parameters such as temperature, porosity, thickness, and areal extent, and includes the contribution of thermal energy stored in

pore fluids. From these estimates, gross thermal power potential (MWth) and gross electrical power potential (MWe) were derived following Palmer-Wilson et al. (2018) and Banks and Harris (2018).

Two approaches were applied to validate results: a deterministic (well-based) approach and a probabilistic (area-based) approach, allowing for comparison and uncertainty evaluation. The advantages of the USGS volumetric method include its broad utilization, consistency, and ability to integrate geological and physical parameters. However, its limitations—including reliance on geological assumptions, lack of production data validation, and uncertainties in estimating reservoir volume and recovery factors—can lead to over- or under-estimation of resources. These constraints highlight the importance of careful geological interpretation and conservative evaluation.

Assumptions of the dependency of gross electrical power capacity on the electrical utilization factor, which varies with reservoir temperature, were carefully considered. Lower temperatures can occasionally generate geothermal electrical power, but the estimated conversion efficiency for temperatures below 90°C is less than approximately 10%, based on a temperature-dependent utilization factor. Therefore, our estimates for gross electrical power capacity are restricted to reservoir temperatures exceeding 90°C to ensure viable geothermal electrical power generation.

The estimates were classified according to the Canadian Geothermal Code for Public Reporting (2010). Under this classification system, we assessed resources between the inferred and indicated categories reflecting the relative certainty of our estimates and the early stages of assessment.

Detailed equations, assumptions, and input parameters used in the calculations are available on the Geothermal Resource Quantification - Technical Information page of the Geothermal Atlas of Alberta.

3.3 Results

The results of the geothermal favourability mapping have been consolidated into the Geothermal Atlas of Alberta, a publicly accessible digital platform developed by the Alberta Geological Survey (AGS) to support geothermal exploration, development, and decision-making by industry, government, and researchers.

Formation-scale favourability maps have been developed for the Devonian Granite Wash, Leduc, and combined Swan Hills and Slave Point formations. These maps identify zones with favourable geological conditions for conventional geothermal systems, highlighting regions where suitable temperature, pore volume, and fluid presence coincide. Notably, regions of medium to high favourability often align with existing geothermal development sites, demonstrating the methodology's ability to reliably identify water-dominated formations with suitable temperature and porosity for geothermal utilization. This approach is adaptable and can be applied to other geological formations within the Alberta Basin to identify new exploration opportunities.

The Geothermal Atlas of Alberta provides users with powerful query tools to explore geothermal information at both regional and local scales. Users can search for depth, thickness, and temperature at specific locations, retrieve geological and geothermal statistics calculated over areas of at least one legal subdivision (LSD), and visualize data layers including temperature distributions, pore volume, aquifer indications, hydraulic head, and water chemistry.

The interactive Resource Quantification Tool enables users to query heat-in-place and potential power generation estimates for specific areas. Figure 2 shows the Resource Quantification Tool applied to a user-selected area in the Leduc Formation, displaying summary statistics of geological attributes, heat-in-place, and power generation estimates.

For interactive maps and further technical documentation, see the Leduc Formation Map , Swan Hills / Slave Point Map, and Granite Wash Map

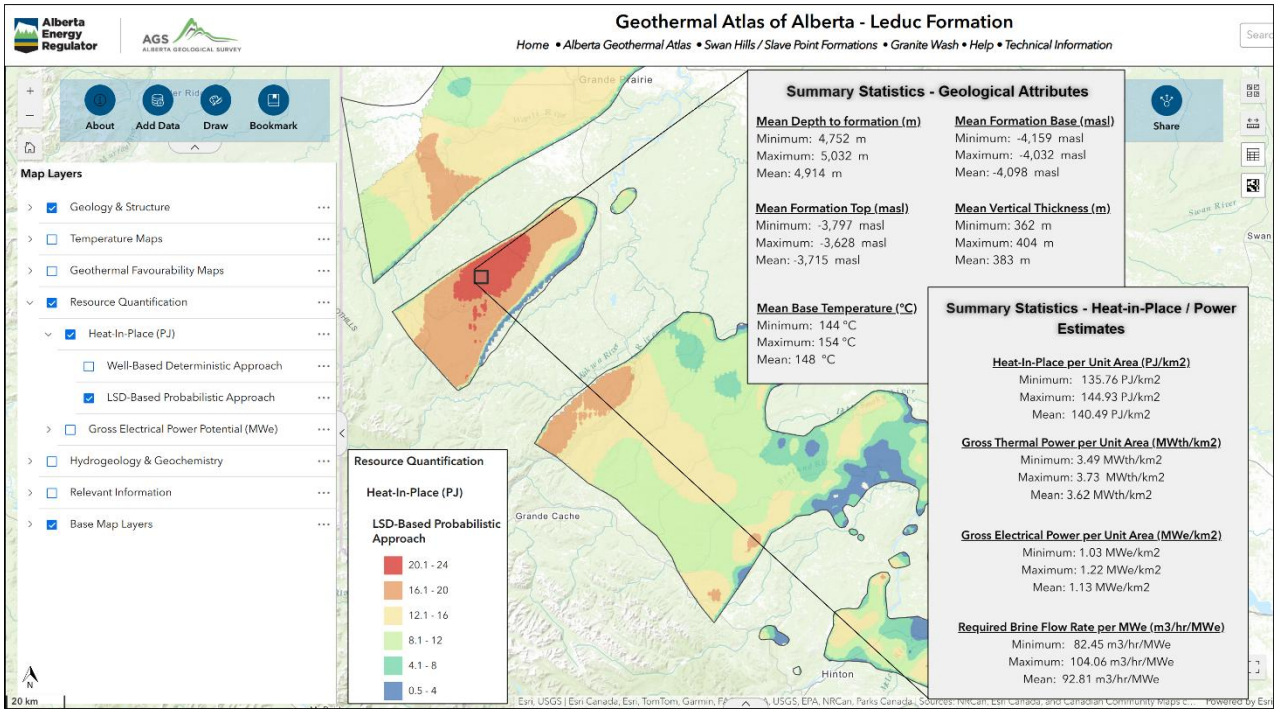


Figure 2. Example of the Resource Quantification Tool from the Geothermal Atlas of Alberta showing the spatial distribution of heat-in-place (map layer) and summary statistics of geological attributes, heat-in-place, and power generation estimates for a selected area in the Leduc Formation.

3.4 Discussion & Conclusion

The multi-criteria mapping approach reliably identifies geologically favourable areas for geothermal exploration. Regions of medium to high favourability often align with existing development sites, demonstrating the methodology's effectiveness. Limitations include uncertainties in geological parameters and biases in hydrocarbon-focused datasets. The Atlas is designed to incorporate new data and methodologies as they become available, supporting ongoing research and development, for example, shallow to intermediate-depth geothermal mapping and characterization of the Precambrian basement in Alberta.

The Geothermal Atlas of Alberta, Version 1.0, includes results for the Devonian Leduc, Swan Hills / Slave Point, and Granite Wash formations. Future updates are planned to expand coverage to 1) additional sedimentary geological units prospective for conventional geothermal resources, 2) Alberta's Precambrian basement as it relates to advanced and enhanced geothermal systems, and 3) sedimentary units in the top 1000 m of the sedimentary basin that may be favourable for geothermal heating, cooling, and storage. Iteratively evolving the Geothermal Atlas ensures that it continues to be a relevant and high-impact hub for new data, methodologies, visualization and calculation capabilities. By integrating geothermal favourability mapping and resource quantification into a single platform, the Atlas represents a significant step toward advancing geothermal energy development in Alberta.

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Atlas Technical Pages:

- Geothermal Atlas of Alberta Technical Information
- Geothermal Favourability Mapping Methodology
- Resource Quantification Methodology
- Input Parameters
- Geothermal Atlas of Alberta Home Page

REFERENCES

Ardakani, O.H., and Schmitt, D.R.: Aquifer mapping for geothermal energy in the Athabasca region, Alberta, Proceedings, Workshop on Geothermal, Alberta, Canada (2016).

Bachu, S., and Burwash, R.: Geothermal regime in the Western Canada Sedimentary Basin, Geological Atlas of the Western Canada Sedimentary Basin, Calgary, Canada (1994).

Banks, J., and Harris, N.B.: Geothermal potential of foreland basins: A case study from the Western Canadian Sedimentary Basin, Geothermics, 76, (2018), 74–92.

Birdsell, D.T., Adams, B.M., Deb, P., Ogland-Hand, J.D., Bielicki, J.M., Fleming, M.R., and Saar, M.O.: Analytical solutions to evaluate the geothermal energy generation potential from sedimentary-basin reservoirs, Geothermics, 116, (2024), 102843.

Brinsky, J., Singh, A., Hauck, T.E., Grobe, M., and Palombi, D.: Temperature mapping of select Devonian strata in Alberta, Alberta Energy Regulator / Alberta Geological Survey, AER/AGS Open File Report 2021-05, (2022), 28 p.

CanGEA: Alberta Favourability Maps, Summary Report, Canadian Geothermal Energy Association, Calgary, Canada (2013).

Garg, S.K., and Combs, J.: Updated methods for geothermal resource assessment, Geothermics, 39, (2010), 169–180.

Hofmann, H., Weides, S., Babadagli, T., Zimmermann, G., Moeck, I., Majorowicz, J., and Unsworth, M.: Potential for enhanced geothermal systems in Alberta, Canada, Energy, 69, (2014), 578–591.

Majorowicz, J.A., and Grasby, S.E.: High potential regions for enhanced geothermal systems in Canada, Natural Resources Research, 19, (2010), 177–188.

Majorowicz, J.A., and Grasby, S.E.: Deep geothermal heating potential for the communities of the Western Canadian Sedimentary Basin, Energies, 14(3), (2021), 706.

Noorollahi, Y., Itoi, R., Fujii, H., and Tanaka, T.: GIS model for geothermal resource exploration in Akita and Iwate prefectures, northern Japan, Computers Sciences, 33, (2007), 1008–1021.

Palmer-Wilson, K., Banks, J., Walsh, W., and Robertson, B.: Sedimentary basin geothermal favourability mapping and power generation assessments, Renewable Energy, 127, (2018), 1087–1100.

Poux, B., and Suemnicht, G.: Use of GIS geoprocessing to select the most favorable sites for geothermal exploration in Oregon, Transactions – Geothermal Resource Council, 36, (2012), 1–10.

Trumpy, E., Donato, A., Gianelli, G., Gola, G., Minissale, A., Montanari, D., Santilano, A., and Manzella, A.: Data integration and favourability maps for exploring geothermal systems in Sicily, southern Italy, Geothermics, 56, (2015), 1–16.

Weides, S., Moeck, I., Majorowicz, J., Palombi, D., and Grobe, M.: Geothermal exploration of Paleozoic formations in Central Alberta, Canadian Journal of Earth Sciences, 50(5), (2013), 519–534.

White, D.E., and Williams, D.L.: Assessment of geothermal resources of the United States, Geological Survey Circular 726, U.S. Geological Survey, Washington, D.C., USA (1975), 155 p.

Williams, C.F., Reed, M.J., and Mariner, R.H.: A review of methods applied by the US Geological Survey in the assessment of identified geothermal resources, USGS Open-File Report 2008-1296, (2008), 27 p.