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A Rock Properties Database to Support Geothermal Research in Remote Northern Regions of Canada

Mafalda M. Miranda[1]*, Fiona Chapman[2], Ysaline Bacon[2], Jasmin Raymond[2], Andrew Wigston[3], Steven Gaines[4], Richard Fortin[5], Brad Harvey[5], Matthew Minnick[6], Maurice Colpron[7]

GRAnalytics Lda[1]*, Institute national de la recherche scientifique[2], CanmetENERGY-Ottawa[3], CanmetMINING-Ottawa[4], Geological Survey of Canada[5], RESPEC INC[6], Yukon Geological Survey[7]

mafalda.a.m.miranda@gmail.com

INTRODUCTION

- Thermal, hydraulic and mechanical properties of rocks play a key role in geothermal-related research. These properties are essential for the characterization of the subsurface and the parametrization of numerical models.
- As geothermal exploration grows in Canada, more subsurface information is becoming available that can help the development of future projects in areas with similar geological context but lacking data.
- A database was therefore developed in Borealis Dataverse (https://doi.org/10.5683/SP3/SBC6HA) with Excel spreadsheet files containing a summary of results for each location. This corresponds to the Beta version of the database and further improvements are foreseen.
- Currently, the database contains thermal, hydraulic and mechanical properties information from samples collected in geothermal exploration wells drilled on the communities of Kuujjuaq (15 core samples), Baker Lake (26 core samples), Whitehorse (27 core samples) and Carmacks (17 core samples; Figure 1). For Kuujjuaq, information of the thermophysical properties of 30 outcrop samples is also available.
- The database intends to be continuously updated as more information will become available.

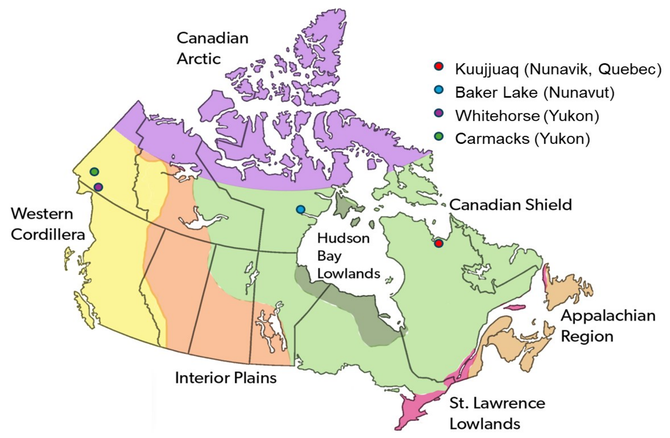


Figure 1. Physiographic regions of Canada and location of the data

DATABASE STRUCTURE AND DATA APPLICABILITY

- The Beta version of the database is structured by location (Figure 2), and for each location three main sets of laboratory tests were performed (Figure 3): 1) non-destructive characterization tests, 2) mechanical characterization tests, and 3) geochemical and mineralogical characterization tests. At a later stage, the concept of relational database management will be applied to organize the data in a more user-friendly and well-structured from.
- Each set of test was performed to obtain a specific rock property of interest for different applications (Figure 3). While thermal properties are essential to parameterize models to simulate heat transfer processes in the subsurface and assessing the subsurface temperature, the geothermal gradient, and heat transport and storage, petrophysical and mechanical properties are the primarily used parameters for reservoir exploration, production and stimulation scenarios.
- Some examples that use data from this database are (Figure 4): Bacon et al., (2024), Cavalerie et al. (2025) and Miranda et al., (2020a, b, 2021, 2023).

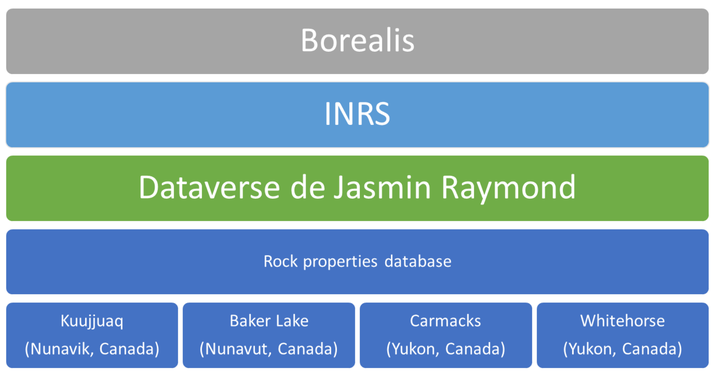


Figure 2. Structure of the database in Borealis Dataverse

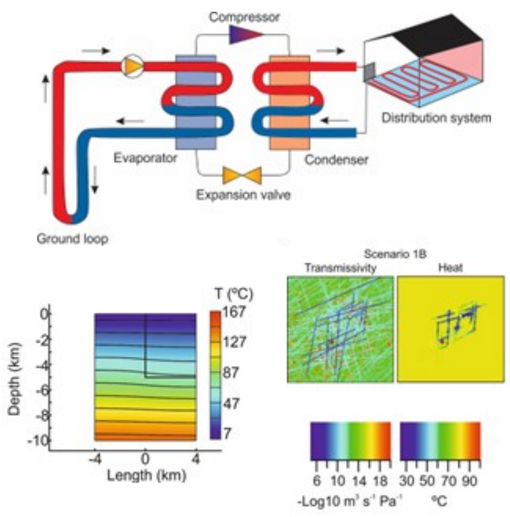


Figure 4. Data applicability examples. Top: geothermal heat pump system modeling, Down, left: Heat conduction modeling. Down, right: EGS modeling

Tests performed			Properties obtained	Applications
Geochemical analyses	X-Ray Difraction		Mineralogy	• Heat conduction models to simulate subsurface temperature • Estimation of terrestrial heat flux • Thermo-hydro-mechanical coupled processes to simulate EGS reservoir • Borehole stability • Geothermal heat pump simulation and sizing • Underground thermal energy storage simulation • Thermo-hydro coupled modeling • Shallow geothermal potential mapping • Energy geostructures modeling
	Inductively Coupled Plasma	ICP-AES	Major and minor geochemical elements	
		ICP-MS	Minor and trace geochemical elements	
	Gamma-ray spectrometry		Radiogenic elements	
Destructive geomechanical tests	Uniaxial Compressive Test		Material strength and elastic properties (Young's modulus and Poisson's ratio)	
	Triaxial Compressive Test			
	Brazilian Tensile Strength			
Non-destructive characterization tests	Petrophysical	Density	Dynamic Youngs modulus & Dynamic Poisson's ratio	
		P-wave velocity		
		S-wave velocity		
	Thermal	Thermal conductivity	Thermal properties as a function of temperature and saturation	
		Thermal diffusivity		
		Specific heat		
	Hydraulic	Porosity	Hydraulic properties as a function of pressure	
		Permeability		

Dry/water-sat; 20 – 160 °C; > 48 MPa confined pressure

Figure 3. Workflow illustrating the tests performed, the properties obtained, and some examples of the data applicability

DATA PROCESSING AND UPSCALING

- The database includes laboratory data analysed on core and outcrop samples, thus representing rock matrix properties only. Although some tests were run to simulate in-situ reservoir conditions (i.e., thermal properties measured at high temperature and hydraulic properties measured at high confining pressure), most of the data does not reflect in situ conditions. Depending on the aim and scale of future applications, the data need to be corrected for reservoir conditions and transferred to the reservoir scale.
- Furthermore, the laboratory analyses revealed the complexity of the geological materials. Even the same unit can show variability in their thermo-hydraulic-mechanical properties.
- Thus, upgridding and upscaling techniques are required that retain as much of the original structure, geometry, petrophysical characteristics and facies heterogeneity as possible to deliver the vital information needed for reservoir assessment and operation.

CONCLUSION

- Despite certain limitations, this northern geothermal database can be a useful tool to improve the planning and execution of future research projects.
- The characterization of thermophysical, petrophysical and mechanical properties of outcrop and reservoir core samples are paramount for profound reservoir characterization and should be considered in future geoscientific studies to enable a better representation of reservoir properties.
- The current structure of the database allows for easy modification and extension.

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