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Development of a Hydrogeologic Database for Fractured Crystalline Rock Settings in the Canadian Shield

Andrew P. Snowdon, Stefano D. Normani and Jonathon F. Sykes
Department of Civil and Environmental Engineering, University of Waterloo

Summary
The Canadian Shield covers a significant portion of Canada and its hydrogeology is of interest for both environmental and industry purposes. Permeability in fractured crystalline rock settings can vary by many orders of magnitude and can have a profound influence on groundwater flow and solute transit times. As such, a permeability and TDS (total dissolved solids) versus depth database has been compiled for the Canadian Shield. From the permeability data, both the mean trend and variability can be determined for both rock mass and fracture zones. Combined with temperature and fluid pressure profiles, fluid density and viscosity can be computed to yield hydraulic conductivity profiles. These TDS and hydraulic conductivity profiles can then be used in numerical models to improve understanding of fluid migration in fractured crystalline rock settings.

Method
A database was created using data collected by many scientists over the past 40 years. Many of these studies were compiled by Achtziger-Zupancic et al. (2017) and through the collection and analysis of Atomic Energy of Canada Limited (AECL) reports at the University of Waterloo, many data points were added, verified, and classified as either rock mass or fracture zones. Missing data was calculated using alternative sources. For example, a generalized temperature gradient was calculated based upon work by Perry et al. (2006). The temperature gradient used average values from their study to determine both surface temperature and temperature gradient with respect to depth. Along with average TDS values (with respect to depth) from Frape and Fritz (1987) and AECL reports, fluid density and viscosity are calculated using Batzle and Wang's approach (1992). This allowed for a complete database that includes hydraulic conductivity with depth in the rock mass and fracture zones while accounting for TDS. The crystalline rock permeability database contains over 600 data points from insitu hydraulic testing in boreholes from five AECL sites all situated on the Canadian Shield, ranging from Manitoba to Quebec.

Results
The database can be used to provide a more comprehensive understanding and characterization of Shield hydrogeology for use in modelling. Figures 1 and 2 show the depth-dependent permeability relationships determined with the database for rock mass and fracture zones respectively. As can be seen, there is more data classified as rock mass data than as fracture zones. The rock mass permeability is approximately 2-3 orders of magnitude lower than in the fracture zones.

Acknowledgements
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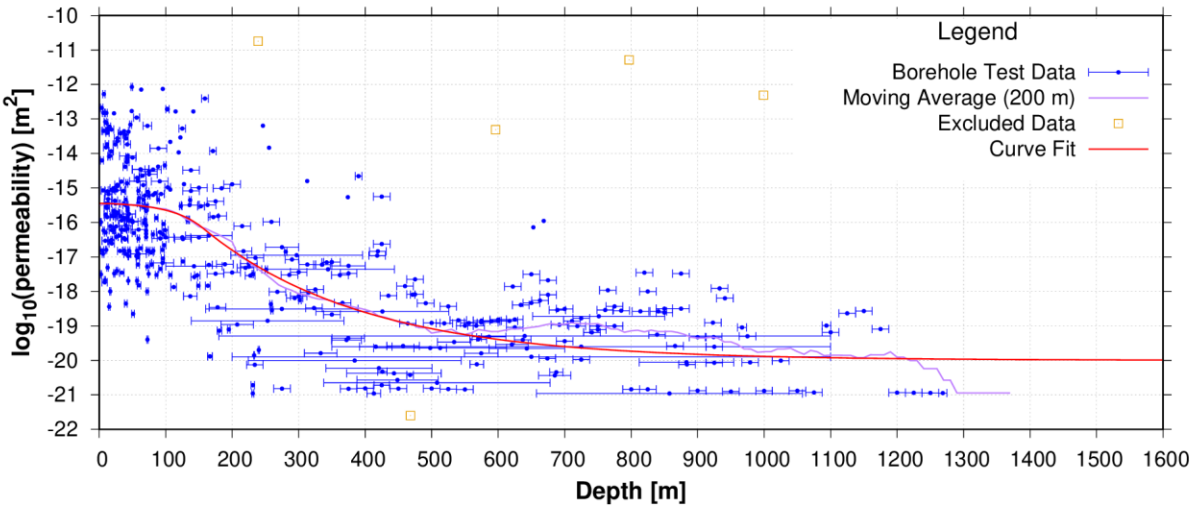

Figure 1: Rock mass borehole hydraulic test data, statistics, and curve fit.

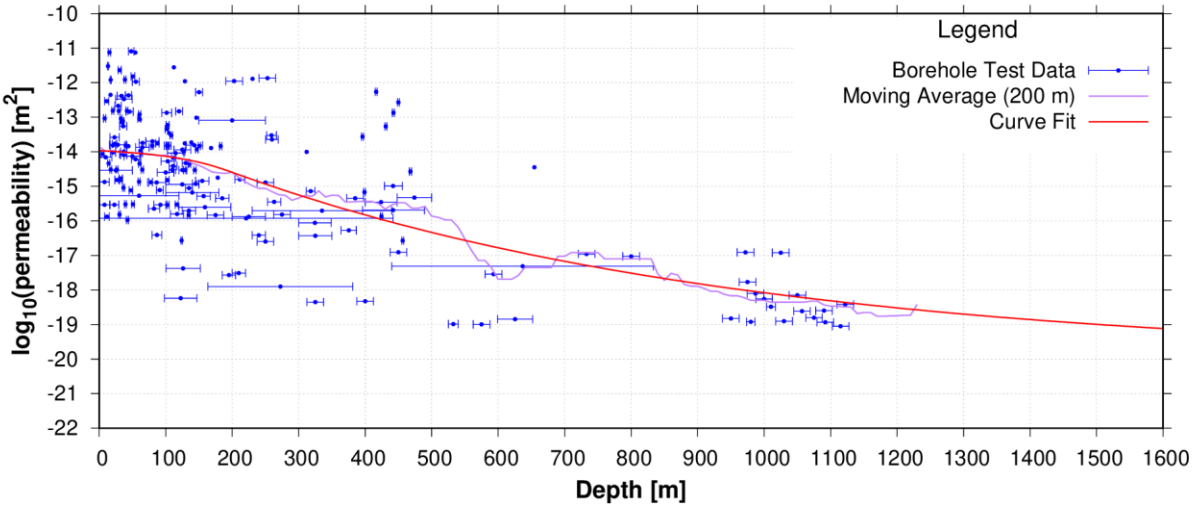

Figure 2: Fracture zone borehole hydraulic test data, statistics, and curve fit.

References

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