

3-D Geological and Hydrogeological Modelling of the Bedrock Geology of Southern Ontario

Terry R. Carter¹, Frank R Brunton², Jordan K. Clark³, Eric DeKemp⁴, Charles Logan⁴, Hazen A. J. Russell⁴, Shuo Sun⁵, Kei H. Yeung²

¹Cartergeologic, ²Ontario Geological Survey, ³ Oil Gas and Salt Resources Library, ⁴Geological Survey of Canada, ⁵University of Western Ontario

Summary

A regional 3-D lithostratigraphic model of the Paleozoic bedrock of southern Ontario has been released (Carter et al, 2019) (Figure 1). The model encompasses an area of 110,000 km² and up to 1600 m of sedimentary strata underlying southern Ontario between the Appalachian Basin and the Michigan Basin, with 54 bedrock layers representing 70 Paleozoic bedrock formations, plus unconsolidated sediment, with Precambrian basement forming the model base. Modelled volume is over 75,000 km³. Model layer horizontal spatial resolution is 400 m. Challenges encountered in model construction included: hardware demands, widely varying spatial and stratigraphic density of data, data gaps of tens of km, anomalies and discontinuities in model layers, thin formations, control over model layer truncation at cuestas, extrapolation beneath Lake Huron, incomplete/incorrect formation top records, incorrect borehole coordinates. Addition of measured sections and control points was required where data was sparse or absent.

Work has begun on a revised lithostratigraphic model to reduce inconsistencies in model layer thicknesses and improve layer continuity. Important additions will include regional faults, oil/gas and gas storage reservoirs, salt mines, hydrocarbon storage caverns, and Precambrian lithostratigraphic domains. Final project objective is to advance from the lithostratigraphic model to a hydrostratigraphic model for physical attribute assignment of available hydrogeologic data including hydrochemical regime boundaries, static level surfaces, hydraulic conductivity, etc. A quantitative analysis of model layer uncertainty will be made.

Methodology and Data Sources

The published model was constructed using Leapfrog® Works (Seequent Limited) implicit modelling software. Model development comprised an iterative cycle of interim model construction, expert geological appraisal to identify errors/issues, followed by QA/QC re-evaluation of formation top depths in boreholes by project geologists using geophysical logs, drill cuttings and core. Primary borehole data comprised 194,000 formation top/bottom depths in 27,000 wells from the Ontario Petroleum Data System (OPDS), supplemented by a data table of 52,000 formation tops, OGS test boreholes, measured sections, control points and Michigan borehole records. Edits were made to 30,320 formation tops in a total of 7,812 wells. A revised bedrock topography erosional surface combined with updated subcrop geology were used to control the surface expression of model layers. 3-D polyline and point constraints were needed to maintain plausible layer thicknesses.

Further QA/QC edits in the revised model will focus on quality and quantity of formation top picks for the Early Silurian Lockport Group, the Detroit River Group and the Collingwood Formation, and revise formation assignments for water intervals in the edited well records. A hydrostratigraphic chart will be developed for assignment of hydrostratigraphic units. A detailed study of geologic controls on porosity and permeability variations in the Lockport Group will

inform the hydrogeologic modelling process. Model construction will utilize both Leapfrog Works and SKUA-GOCAD software. Public outreach will include a 3-D printed model and augmented/virtual reality implementation.

Acknowledgements

Collection of Ontario petroleum well data was initiated by the Geological Survey of Canada (GSC) in the late 1800's and continued by the Ontario Ministry of Natural Resources beginning in 1971. Since 1998 this data has been maintained by the Oil, Gas and Salt Resources Library using funds largely provided by the petroleum and salt industries of Ontario. Funding for the revised model is provided by the Nuclear Waste Management Organization in support of in-kind contributions by the GSC and Ontario Geological Survey.

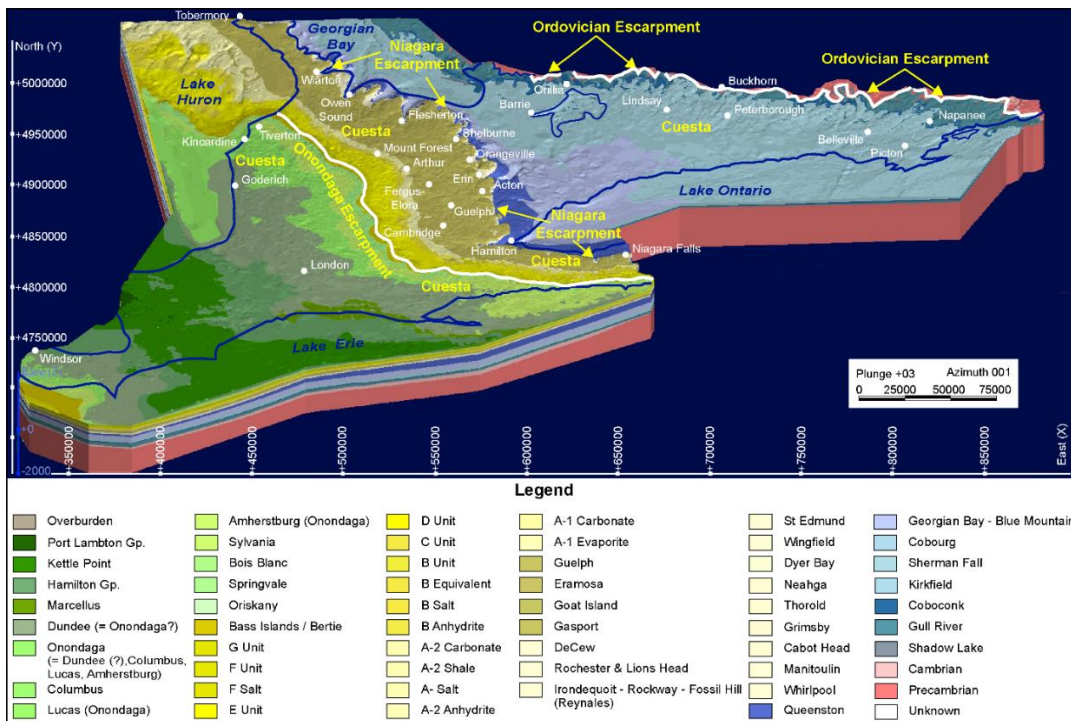


Figure 1. 3-D model of the Paleozoic bedrock of southwestern and southcentral Ontario, sediment cover removed (from Carter et al, 2019).

References

Carter, T.R., Brunton, F.R., Clark, J.K., Fortner, L., Freckelton, C., Logan, C.E., Russell, H.A.J., Somers, M., Sutherland, L. and Yeung, K.H. 2019. A three-dimensional geological model of the Paleozoic bedrock of southern Ontario; Geological Survey of Canada, Open File 8618, <https://doi.org/10.4095/315045>, Ontario Geological Survey, Groundwater Resources Study 19