The 3D Provincial Geological Framework Model of Alberta, Version 2: updating a province-wide 3D geocellular model to incorporate 30 new model zones

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Summary

The three-dimensional Provincial Geological Framework Model of Alberta (3D PGF model) is an ongoing modelling effort at the Alberta Geological Survey (AGS). It provides a geological framework for all stakeholders and is used to deliver geological information and convey geological understanding in a representational three-dimensional geospatial environment.

The objective of updating the 3D PGF model is to ensure that represent our current understanding of Alberta's regional-scale subsurface geology. The evolution of the 3D PGF model includes adding stratigraphic resolution by incorporating additional zones to those found in previous 3D PGF models or reducing the subsurface uncertainty of zones already modelled.

Version 1 was published in 2018 (Branscombe et al., 2018b). This presentation highlights version 2 (v2) of the model, which contains thousands of new picks used to refine the surfaces present in the first version of the model, as well as serving as input for the 30 new model zones added to update the model largely from the late Permian to Upper Cretaceous.

Introduction

The 3D PGF model v2 is a 3D representation of the subsurface for 602,825 km^2 of the province of Alberta, excluding parts of western Alberta affected by Cordilleran deformation. It spans from ground surface to a depth of 6 km below sea level.

It is built on decades of geological interpretation by AGS geologists, largely from stratigraphic picks interpreted from wellbore logs. It was built using 1,235,761 input data points. Integration of this large amount of geological interpretation allows for cross-validation of geological concepts at a regional scale.

The sixty-two zones of the model represent rock volumes at stratigraphic member, formation or group level, or a combination thereof. The surfaces represent tops and bases of members, formations, and groups, or combined zones and/or major unconformities. This is a deterministic model, built leveraging the AGS geologists' conceptual knowledge of known geological complexities and strata relationships within each model zone.

Method / Workflow

An iterative approach was used in order to build this model. The overall workflow consists of data compilation , geostatical analysis of the source data, creation and manipulation of input surfaces, and model constructionl. The model was split at the sub-Cretaceous unconformity, and two geomodellers worked in collaboration with the AGS Geological Framework project staff to build it using Petrel 2015 modelling software. The use of automated workflows enables updates of the entire model (or portions of it) in an efficient manner, and allows for incorporation of new data added to refine areas and zones needing more stratigraphic control.

Results

In the Mississippian to Upper Jurassic strata, new zones have been introduced, the lowermost of which is an undifferentiated zone encompassing the Rundle, Stoddart, Ishbel, and Ellis groups. Multiple zones have been modelled within the Montney Formation. The Doig Formation is also defined, as well as the Schooler Creek Group. Another new addition is the uppermost zone below the sub-Cretaceous unconformity encompassing the Fernie and Nikanassin/Monteith formations.

New zones are introduced for Lower and Upper Cretaceous strata. Within the Mannville Group and equivalents, four additional zones are defined, including the lowermost parts of the McMurray Formation. Within the Colorado Group and equivalents, sixteen subdivisions are now included such as the Dunvegan Formation, Doe Creek Member of the Kaskapau Formation, and Cardium Formation.

Figures 1 through 3 show different views or sections of the 3D PGF v2 model.

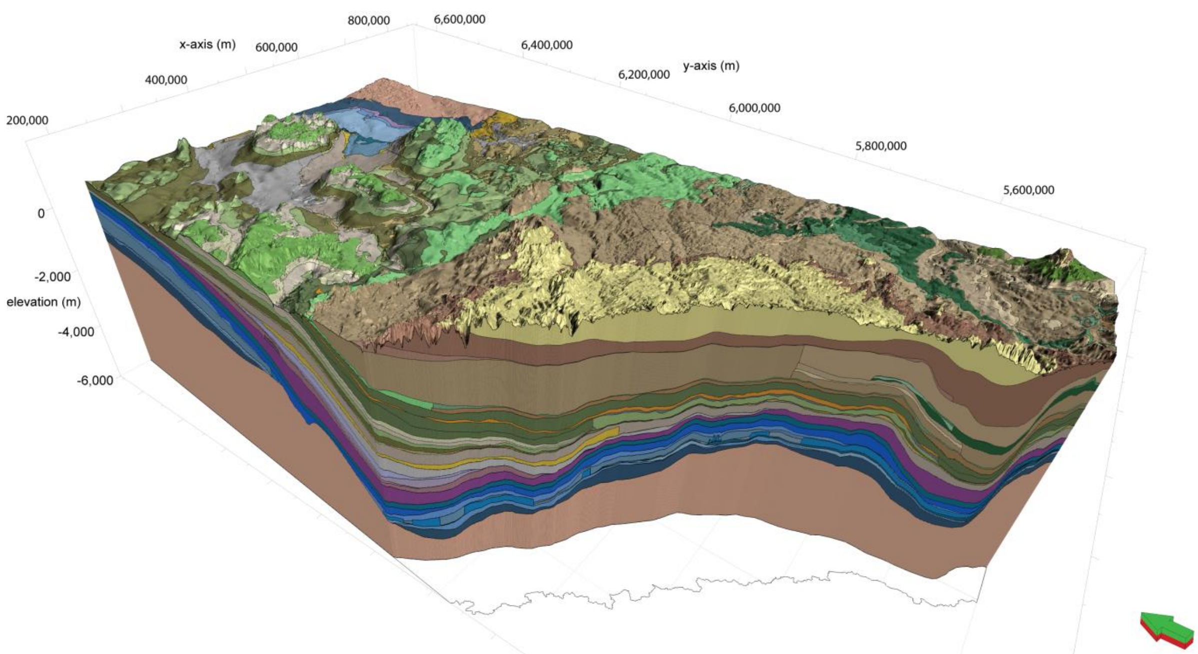

Figure 1: oblique 3D view of the 3D PGF v2 model, at 50X VE. For color scheme and zone names, please refer to AGS (in progress).

Quality control is an important step taken during all stages of model construction. Notable processes utilized are: 1) initial geostatistical analysis of the source data and verification of potential anomalies, 2) an iterative approach to reducing potential errors through collaboration between stratigraphers and geomodellers, and 3) an uncertainty analysis of the interpolated surfaces for uncertainty quantification and management.

A unique workflow developed at the AGS is used to assess the local and global uncertainty of the interpolated surfaces (Babakhani, 2018). The workflow calculates the global uncertainty with RMSE values, and represents the local uncertainty with standard deviation uncertainty maps. The uncertainty analysis provides insight into the magnitude and the location of errors present within each interpolated geological surface.

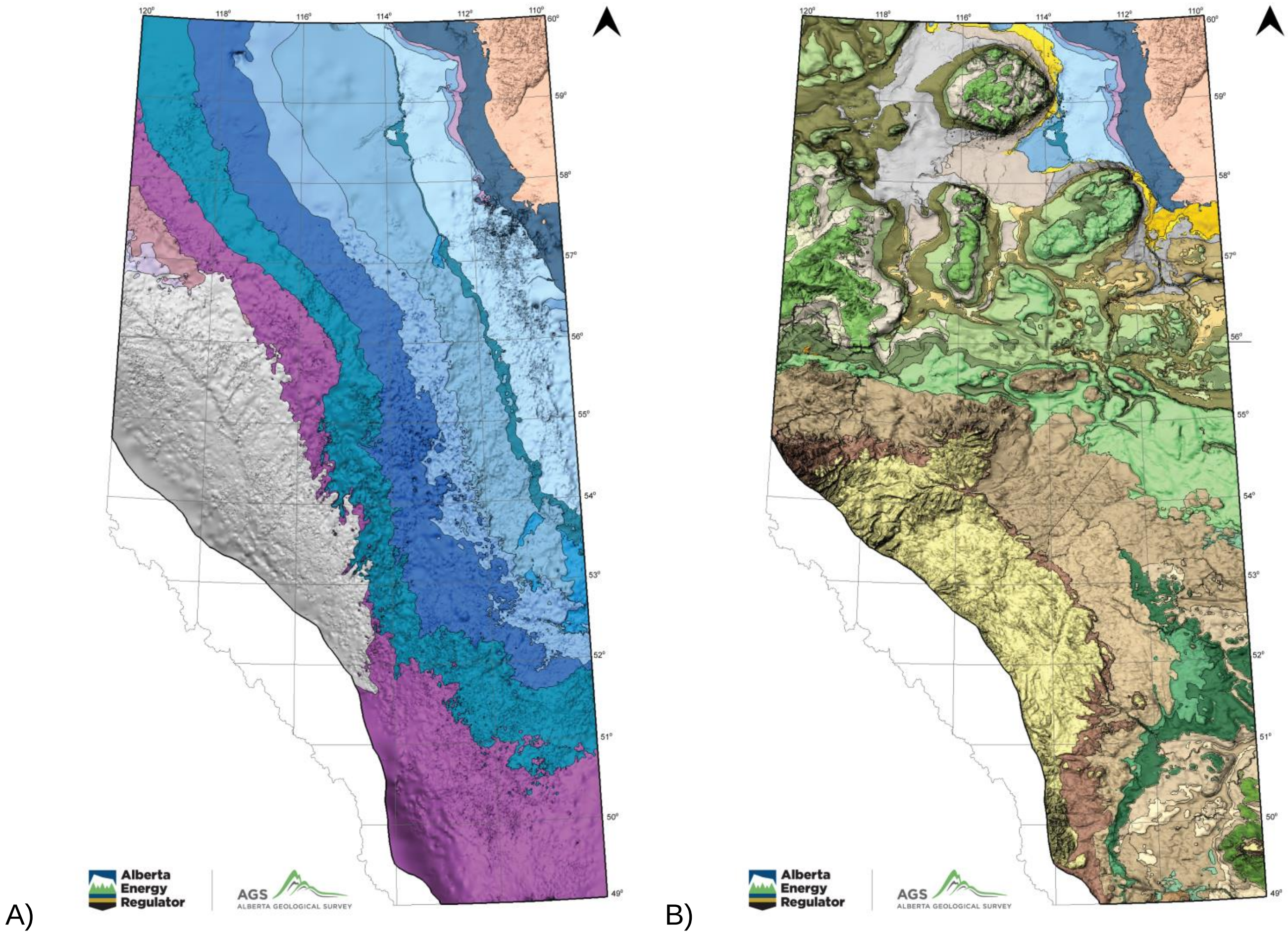

Figure 2: View from above of the PGF v2 model. Shading represents structural relief (magnified at 50X VE). A) The Precambrian to Paleozoic/Triassic/Jurassic zones are displayed, with shading representing the sub-Cretaceous unconformity. B) All zones of the PGF v2 model, except for sediment above bedrock.

Limitations/Next Steps

There are known limitations to this version of the 3D PGF model. This includes regions with known structural deformation (e.g., easternmost margin of Cordillera, Steen River impact structure); however, these regions have not been structurally modelled. The current process for modelling units up to their zero edges results in unrealistic thickness anomalies near their respective geo-edges (i.e., they do not pinch out as conceptualized), or near nomenclature boundaries where units end abruptly. The use of hand-drawn geo-edges based on well control results in an inherent bias in some unit extents. Some known bedrock topography errors have not been addressed in the 3D PGF v2. Lastly, a lack of data for the Granite Wash Formation results in a gap in Devonian strata on top of Peace River Arch.

Future updates to the 3D PGF model may address these limitations as the model is updated based on Alberta Geological Survey / Alberta Energy Regulator priority and data availability.

A structural analysis within and near the deformation belt would improve the accuracy of the model, and AGS' goal is to include structural features in a future version. Future versions will continue to build on previous versions to reduce errors and uncertainty, increase the number of geological units within the model, as well as improve the resolution of zones already contained within the 3D model.

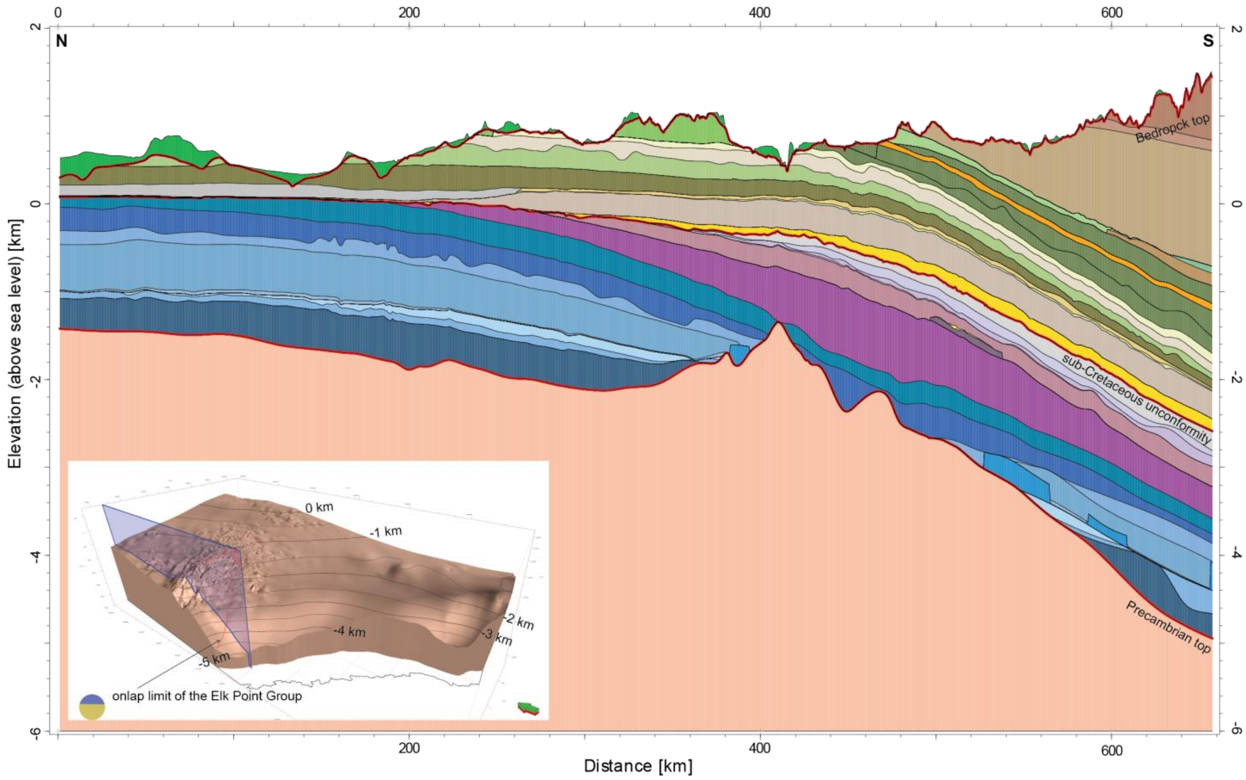

Figure 3: N-S cross section showing the 3D PGF v2 model zones over the Peace River Arch. Inset: Precambrian model zone shown in an oblique 3D view (50 times vertical exaggeration), with the elevation contours of the top of Precambrian shown in black (500 m contour interval) as well as the plane of the cross-section.

Conclusions

This model covers the majority of the province of Alberta (exclusive of the Cordilleran deformation belt), from ground elevation to 6 km below sea level. It is created from a compilation of over a million filtered input data points, the vast majority originating from a stratigraphic pick database created by AGS geoscientists. The result is a multi-layer representation of select lithostratigraphic units within the subsurface of Alberta. It contains 62 model zones and is built using 51 continuous input surfaces, each constructed from specific filtered input datasets. Integration of this vast amount of geological interpretation provides a geological framework for use across the Alberta Energy Regulator, as well as for all stakeholders.

This model is not intended for local-scale or site-specific investigations. However, it can be used to support regional-scale science-based decision-making, and act as a geological framework to inform regulatory decisions related to the management of Alberta’s subsurface.

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