AER/AGS Open File Report 2017-09

Alberta Energy Regulator

3D Provincial Geological Framework Model of Alberta, Version 1 – Methodology

AGS
ALBERTA GEOLOGICAL SURVEY

AER/AGS Open File Report 2017-09

3D Provincial Geological Framework Model of Alberta, Version 1 – Methodology

P. Branscombe, K.E. MacCormack and M. Babakhani

Alberta Energy Regulator
Alberta Geological Survey

April 2018

ISBN 978-1-4601-2061-3

If you use information from this publication in other publications or presentations, please acknowledge the AER/AGS. We recommend the following reference format:

Branscombe, P., MacCormack, K.E. and Babakhani, M. (2018): 3D Provincial Geological Framework Model of Alberta, Version 1 – methodology; Alberta Energy Regulator, AER/AGS Open File Report 2017-09, 25 p.

Publications in this series have undergone only limited review and are released essentially as submitted by the author.

Published April 2018 by:
Alberta Energy Regulator
Alberta Geological Survey
4th Floor, Twin Atria Building
4999 – 98th Avenue
Edmonton, AB T6B 2X3
Canada

Tel: 780.638.4491
Fax: 780.422.1459
Email: AGS-Info@aer.ca
Website: www.ags.aer.ca

Contents

Tables

Figures

Appendices

Acknowledgements

The authors wish to thank the following Alberta Geological Survey (AGS) geoscientists who provided geological data, conceptual cross-sections and/or models, and a wealth of geological knowledge:

- H.J. Corlett
- B. Hathway
- T.E. Hauck
- J.T. Peterson

This valuable input, throughout the modelling process, greatly improved this 3D geological model.

We thank L.A. Atkinson, B. Hathway, H.J. Corlett, S.D.A. Anderson, and M. Grobe for their review and comments on this document.

Abstract

The three-dimensional (3D) Provincial Geological Framework Model of Alberta, Version 1 (3D PGF model) covers 602 825 km^2 of the province and excludes an area representing the approximate extent of Cordilleran deformation.

A total of 620 812 data points were used during an iterative modelling approach. The 3D PGF model represents a multilayer, stratigraphically related, conceptual understanding of select intervals and groupings within the subsurface of Alberta.

This report describes the methodology used to develop this version of the 3D PGF model. It introduces our current geomodelling workflow, used as best practice at the Alberta Geological Survey (AGS); defines the terminology of various model inputs and outputs; and provides model construction details that enable users to reconstruct this model using the digital datasets associated with this report.

The 3D PGF model contains 32 geological zones ranging in resolution from member, formation, or group level to mixed formation, group, and/or period level. The modelled zones from surface to the base of the model are

- sediment above bedrock,
- Paskapoo Formation,
- Scollard Formation,
- Battle Formation,
- undifferentiated Horseshoe Canyon Formation / Wapiti Formation / St. Mary River Formation / Belly River Group / Bearpaw Formation equivalent interval,
- upper Bearpaw interval,
- Strathmore Member,
- lower Bearpaw interval,
- Dinosaur Park Formation,
- Oldman Formation,
- Foremost Formation,
- undifferentiated Lea Park Formation / Colorado Group / Smoky Group / Fort St. John Group equivalent interval,
- Pakowki Formation,
- Milk River Formation to base of the Fish Scales Formation interval,
- base of the Fish Scales Formation to Viking Formation / Bow Island Formation / Peace River Formation equivalent interval,
- Viking Formation / Bow Island Formation / Peace River Formation equivalent interval to Mannville Group equivalent interval,
- Mannville Group equivalent interval to sub-Cretaceous unconformity interval,
- undifferentiated Jurassic / Triassic / Permian / Carboniferous to Banff Formation interval,
- Banff Formation to Wabamun Group interval,
- Wabamun Group,
- Winterburn Group,
- undifferentiated Woodbend Group shales above Leduc or Duvernay formations (WOOD A),
- undifferentiated Woodbend Group shales with no Leduc or Duvernay formations below (WOOD B),

- Duvernay Formation,
- Leduc Formation,
- Cooking Lake Formation,
- Majeau Lake Formation,
- Waterways Formation,
- Swan Hills / Slave Point formations interval,
- Fort Vermilion Formation,
- Elk Point Group to Precambrian interval, and
- Precambrian to 5000 m below sea level interval.

The model was created in Schlumberger’s Petrel 2015 (Petrel) and has been exported in nonproprietary formats for use in other software. A series of datasets from the 3D PGF model are available for download in the form of deconstructed-model products and digital data.

The standard format of the deconstructed-model digital data available for download includes

- a tab-delimited tabular dataset of stratigraphic picks and point data used to create the model,
- a deconstructed-model dataset composed of discrete and continuous model horizons as Esri format grids and zone model extent shapefiles, and
- an iMOD model dataset package.

All of the standard format digital datasets can be viewed in iMOD (Section 7.2), an open-source software, enabling users to visualize, rotate, slice, explode, and toggle data on and off in 3D. The iMOD software provides end users with an interactive geospatial environment where they can manipulate 3D geological models and import their own geospatially referenced subsurface and surface data.

1 Introduction

The three-dimensional (3D) Provincial Geological Framework Model of Alberta, Version 1 (3D PGF model) is the foundational output of the Provincial Geological Framework Project at the Alberta Geological Survey (AGS). The 3D PGF model is used to deliver geological information and convey geological understanding in an engaging 3D geospatial environment. In addition to the obvious visualization value, the 3D PGF model is a platform capable of integrating any geospatially referenced subsurface and surface data from multiple sources. This capability supports science-based decision-making and informs regulatory decisions related to the safe and sustainable management of Alberta's surface and subsurface natural resources.

The 3D PGF model leverages decades of geological knowledge from reports, maps, the *Alberta Table of Formations* (Alberta Geological Survey, 2015), and conceptual models, and incorporates hundreds of thousands of stratigraphic picks from the Alberta Energy Regulator/ Alberta Geological Survey (AER/AGS). Additional published data, such as outcrop data or map lineaments, were used to infill areas of sparse data control or to trend surfaces in areas of poor data distribution. This model conveys our current understanding of select provincial-scale Alberta geology in 3D. The model is based on data provided by AER/AGS geologists and guided by conceptual models reflecting our current state of geological understanding.

The model covers most of the province and only excludes an area representing the approximate extent of Cordilleran deformation (Figure 1). The model area covers 602 825 km^2 and extends from ground surface to a flat base arbitrarily assigned within the Precambrian at 5000 m below sea level (m bsl).

Figure 1. Extent of the 3D Provincial Geological Framework Model of Alberta, Ver. 1 (602 825 km^2; blue) within Canada and the Alberta provincial boundary.

1.1 Objectives

This report documents the methodology used to develop the 3D Provincial Geological Framework Model of Alberta, Ver. 1 and familiarizes the reader with modelling terminology and workflows used at the AGS. The report will outline the current modelling workflow and provide the parameters used during the modelling, thus enabling model reproducibility and increasing the efficiency of future updates.

2 Stratigraphic Framework

The Western Canada Sedimentary Basin (WCSB) extends through the province of Alberta. It is a sedimentary wedge that trends southeast, dips southwest towards the deformation belt, and thins to non-presence in northeastern Alberta. Generally, there are two main sedimentary packages in the WCSB: siliciclastic rocks of the Mesozoic and Cenozoic eras, and carbonate and evaporitic rocks of the Paleozoic Era (Figures 2, 3, and 4). The sub-Cretaceous unconformity separates these two general packages in this model. The WCSB is underlain by the Precambrian basement (igneous and metamorphic rocks), which outcrops in northeastern Alberta. Please refer to the *Alberta Table of Formations* (Alberta Geological Survey, 2015) for a detailed stratigraphic column of the WCSB. Additional information and description of the geological units contained within this model are not provided in this report.

The western boundary of the 3D PGF model represents an approximate limit of Cordilleran deformation. Although faulting likely occurs close to this edge, no structural analysis, interpretation, or components were used in the construction of the model. The 3D PGF model is considered to be a simplified nonstructural model.

Figure 2 illustrates the generalized model column for the 3D PGF model. This model includes 32 zones from ground surface to an elevation within the Precambrian of 5000 m bsl (Table 1; Appendix 1). Zones were created from surfaces interpolated from 30 distinct datasets: 28 geological point datasets and 2 surfaces previously prepared at the AGS (Appendices 1 and 2).

While some zones in the model have tops and bases defined, others are groupings of formation-, group- and/or period-level geological intervals (Table 1). The generalized model column (Figure 2) depicts a simple and singular cross-sectional view (one of sometimes multiple geological scenarios) of the lateral and vertical extent of each zone.

3 Model Definitions

The 3D PGF model has a variety of input and output data. This section provides common terminology and defines model inputs and outputs. This standardized terminology is introduced in the current AGS Geomodelling Workflow (Section 4).

Common Terminology

- **3D simple grid:** A simplified process/step when creating 3D grids with no faults in Petrel.
- **3D geocellular grid:** A 3D geological model divided into cells/voxels resulting from the 3D simple grid process.
- **Discrete surface:** An interpolated surface that does not span the entire model extent (Figure 5).

Model Inputs

- **source data:** A set of unfiltered, original, multisource point data defining the stratigraphic pick of a zone top or base. These data include geospatial coordinates (x, y) and elevation (z) information. Most of the data are from well boreholes and have a unique well identifier (UWI); however, a UWI is not provided for outcrop or lineament sampled data.

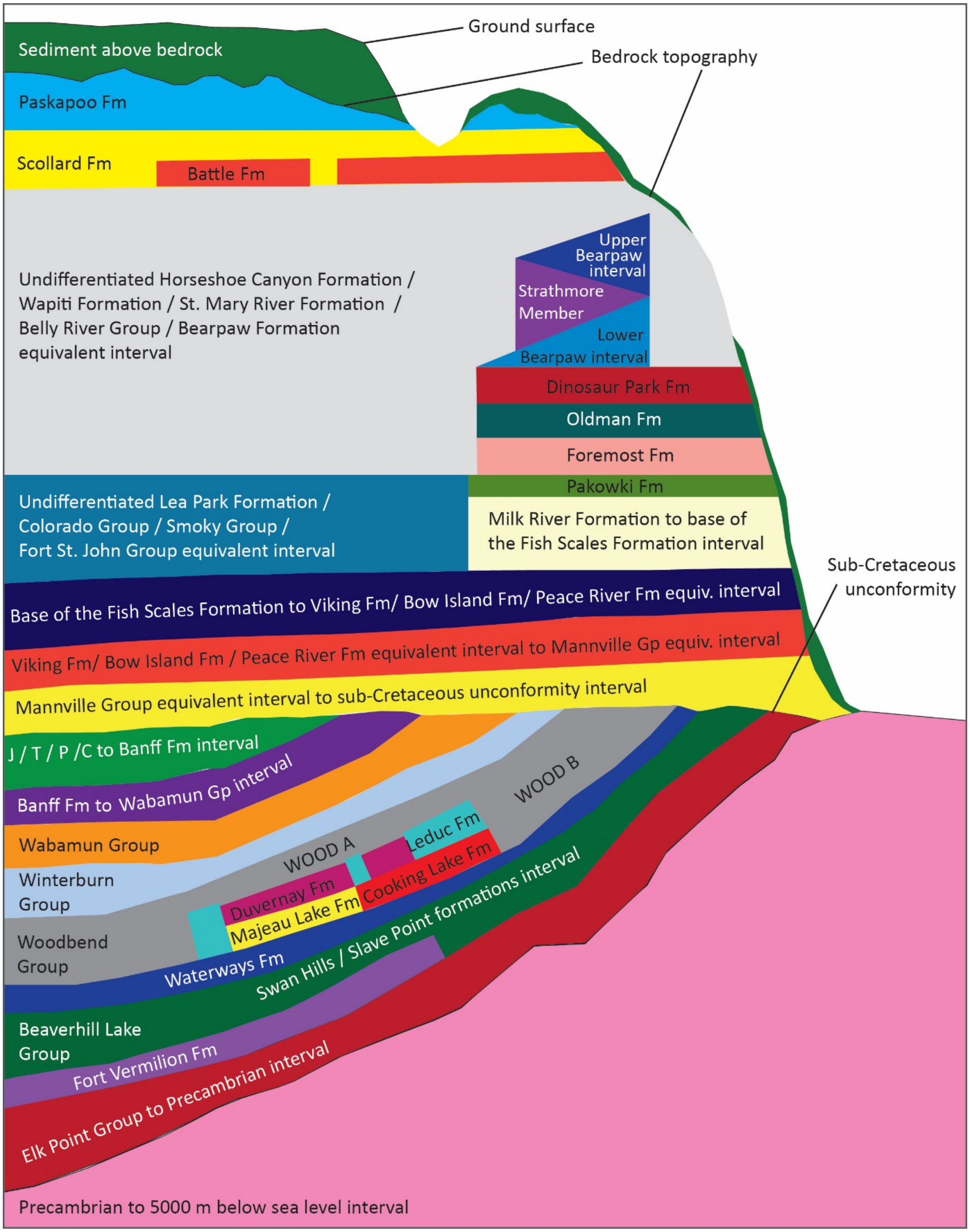


Figure 2. Generalized conceptual model column of the 3D Provincial Framework Model of Alberta, Ver. 1, showing the 32 zones modelled (ground surface to 5000 m bsl). Abbreviations: J / T / P / C, undifferentiated Jurassic / Triassic / Permian / Carboniferous to Banff Formation interval; WOOD A, undifferentiated Woodbend Group shales above Leduc or Duvernay formations; WOOD B, undifferentiated Woodbend Group shales with no Leduc or Duvernay formations below.

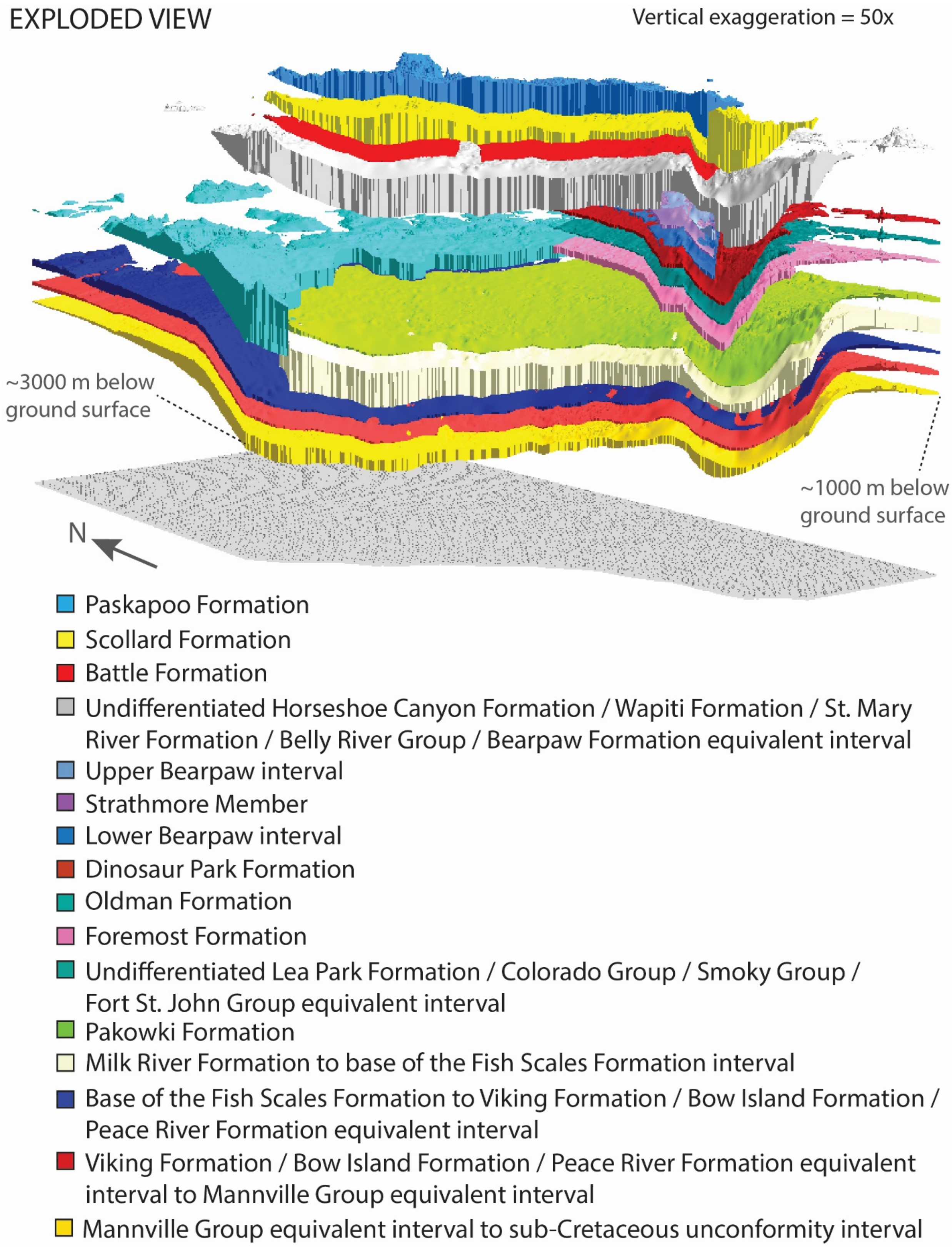


Figure 3. Exploded view of the modelled zones in the 3D Provincial Geological Framework Model of Alberta, Ver. 1 from the Paskapoo Formation to the sub-Cretaceous unconformity (vertical exaggeration = 50x).

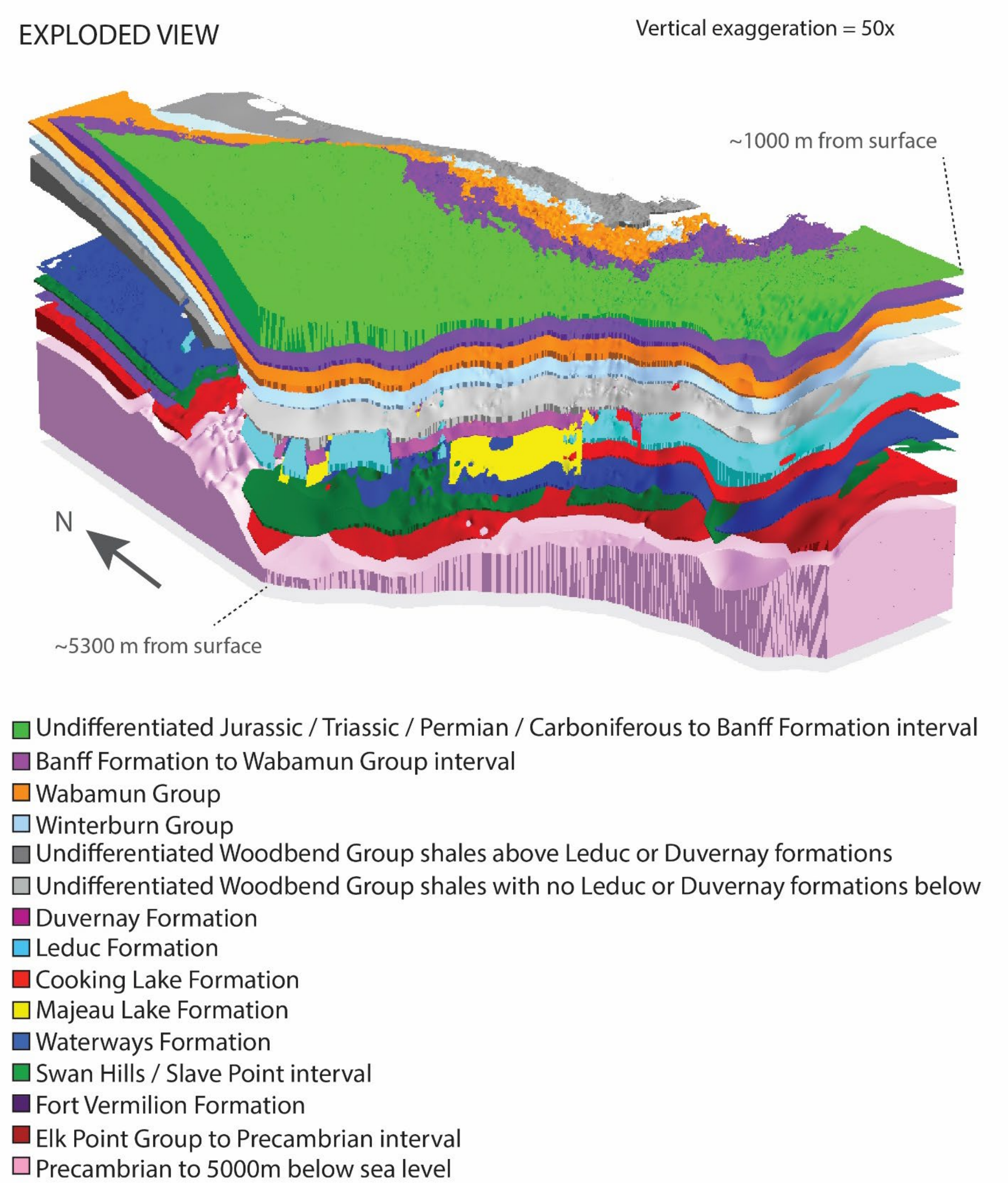


Figure 4. Exploded view of the modelled zones in the 3D Provincial Geological Framework Model of Alberta, Ver. 1 from beneath the sub-Cretaceous unconformity to the base of the 3D PGF model (vertical exaggeration = 50x).

Table 1. Geological components in each modelled zone of the 3D Provincial Geological Framework Model of Alberta, Ver. 1.

Discrete Model Zone	Zone Geological Components
sediment above bedrock	sediment above bedrock (surficial deposits)
Paskapoo Formation	Paskapoo Formation
Scollard Formation	Scollard Formation
Battle Formation	Battle Formation
undifferentiated Horseshoe Canyon Formation / Wapiti Formation / St. Mary River Formation / Belly River Group / Bearpaw Formation equivalent interval	grouping of undifferentiated Horseshoe Canyon Formation and/or Wapiti Formation and/or St. Mary River Formation and/or Belly River Group and/or Bearpaw Formation equivalents
upper Bearpaw interval	upper Bearpaw interval
Strathmore Member	Strathmore Member
lower Bearpaw interval	lower Bearpaw interval
Dinosaur Park Formation	Dinosaur Park Formation
Oldman Formation	Oldman Formation
Foremost Formation	Foremost Formation
undifferentiated Lea Park Formation / Colorado Group / Smoky Group / Fort St. John Group equivalent interval	grouping of undifferentiated Lea Park Formation and/or Colorado Group and/or Smoky Group and/or Fort St. John Group equivalents
Pakowki Formation	Pakowki Formation
Milk River Formation to base of the Fish Scales Formation interval	Milk River Formation and grouping of all of geology below the Milk River Formation down to the base of the Fish Scales Formation
base of the Fish Scales Formation to Viking Formation / Bow Island Formation / Peace River Formation equivalent interval	grouping of geology below the base of the Fish Scales Formation down to the top of the Viking Formation and/or Bow Island Formation and/or Peace River Formation equivalents
Viking Formation / Bow Island Formation / Peace River Formation equivalent interval to Mannville Group equivalent interval	grouping of Viking Formation and/or Bow Island Formation and/or Peace River Formation equivalents down to the top of the Mannville Group equivalents
Mannville Group equivalent interval to sub-Cretaceous unconformity interval	Mannville Group equivalents down to the sub-Cretaceous unconformity
undifferentiated Jurassic / Triassic / Permian / Carboniferous to Banff Formation interval	grouping of all of the Jurassic, Triassic, Permian and Carboniferous strata (not including Banff Formation; sub-Cretaceous unconformity down to the Banff Formation top)
Banff Formation to Wabamun Group interval	Banff Formation and Exshaw Formation
Wabamun Group	Wabamun Group
Winterburn Group	Winterburn Group
undifferentiated Woodbend Group shales above Leduc or Duvernay formations (WOOD A)	undifferentiated Woodbend Group shales above the Leduc or Duvernay formations
undifferentiated Woodbend Group shales with no Leduc or Duvernay formations below (WOOD B)	undifferentiated Woodbend Group shales with no Leduc or Duvernay formations below
Duvernay Formation	Duvernay Formation
Leduc Formation	Leduc Formation
Cooking Lake Formation	Cooking Lake Formation
Majeau Lake Formation	Majeau Lake Formation
Waterways Formation	Waterways Formation
Swan Hills / Slave Point formations interval	interval of Swan Hills and Slave Point formations
Fort Vermilion Formation	Fort Vermilion Formation
Elk Point Group to Precambrian interval	interval of Elk Point Group, Silurian, Ordovician, and Cambrian down to the Precambrian top
Precambrian to 5000 m below sea level	Precambrian top to an arbitrary model base depth of 5000 m below sea level

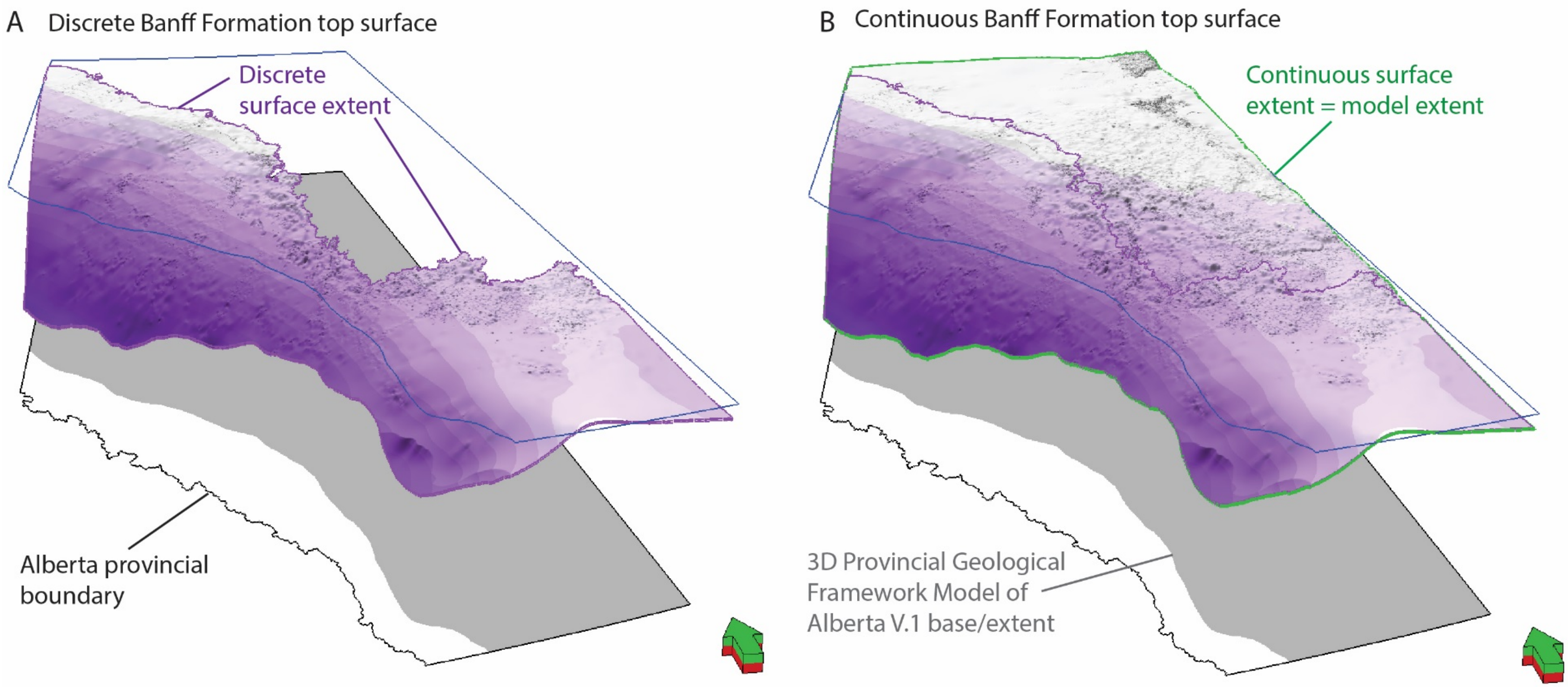


Figure 5. Illustration of the difference between discrete and continuous surfaces using the Banff Formation top surfaces as an example (vertical exaggeration = 50x). The continuous surface of the Banff Formation top (B) is a merging of the discrete Banff Formation top surface (A) and the sub-Cretaceous unconformity, the bedrock topographic surface, and the ground surface.

- **input filtered data:** A set of geostatistically filtered, multisource point data defining the stratigraphic pick of a zone top or base. These data include UWI, geospatial coordinates (x, y), and elevation (z) information. This dataset excludes outliers and erroneous data captured in the *source data*. The outliers and erroneous data were eliminated in a series of successive culls to reduce global uncertainty (Section 5.2).
- **input extent/lineament(s):** A set of discrete polygons or polylines delineating a zone top or base zero-edge, subcrop-edge, or other GIS information outlining a zone top or base and attributed with elevation (z) values.
- **interpolated surface:** A discrete gridded surface interpolated in modelling software over the geospatial extent of a zone top or base from *input filtered data* and *input extents/lineament(s)* (if applicable). Defines the elevation (z) of a zone top or base and is manipulated where necessary to eliminate crossovers with adjacent *interpolated surfaces* and/or to honour unconformities. *Interpolated surfaces* are considered primary input data for the construction of a model and are used for constraining the top and base of a model as well as discretizing the model within. Each *interpolated surface* is defined as a particular type to define the geological relationship to other contacts (e.g., erosional, conformable, etc.), which ensures that the geospatial and temporal relationships of all zone tops and bases are honoured.
- **geo-edge:** A set of polygons or polylines used to constrain (or clip) an *interpolated surface* to areas where the zone is present, as defined by a zero-edge and/or a subcrop-edge. *Geo-edges* are primarily defined by the geologist or geomodeller based on the distribution of zone stratigraphic picks and/or from external supporting data such as previously published literature.
- **continuous surface:** A gridded surface generated from discrete *interpolated surfaces* and modelled to span the entire model extent. Although a formation may only exist in part of the province, the surface must be modelled to cover entire province to ensure the zone is completely sealed for continuous-style model construction. To do this, we merge the discrete surface with the nearest surface or unconformity if the discrete surface is subcropping or outcropping (Figure 5).

Model Outputs (illustrated in Figure 6)

- **model tabular data:** The set of finalized stratigraphic data selected from the *input filtered data* with lowest global uncertainty; published with UWI, geospatial coordinates (x, y), elevation (z), and dataset source for zone top and bases as a point dataset.
- **model extent:** A polygon that defines the boundary of a zone top or base *model horizon* and is attributed with elevation (z) values.
- **model horizon:** A grid that represents the 3D distribution and elevation of a zone top or base. It captures the geospatial extent and elevation (z) values of discrete *interpolated surfaces*; however, where sufficient minimum vertical 3D geocellular grid cell sizes are not achieved, the horizon does not exist. The collection of all model horizons partitions the 3D geocellular grid into a series of *model zones*.
- **model zone:** Defines the vertical resolution of the 3D simple grid between *model horizons*.
- **model:** The combination and construction of all model zones in correct stratigraphic sequence.

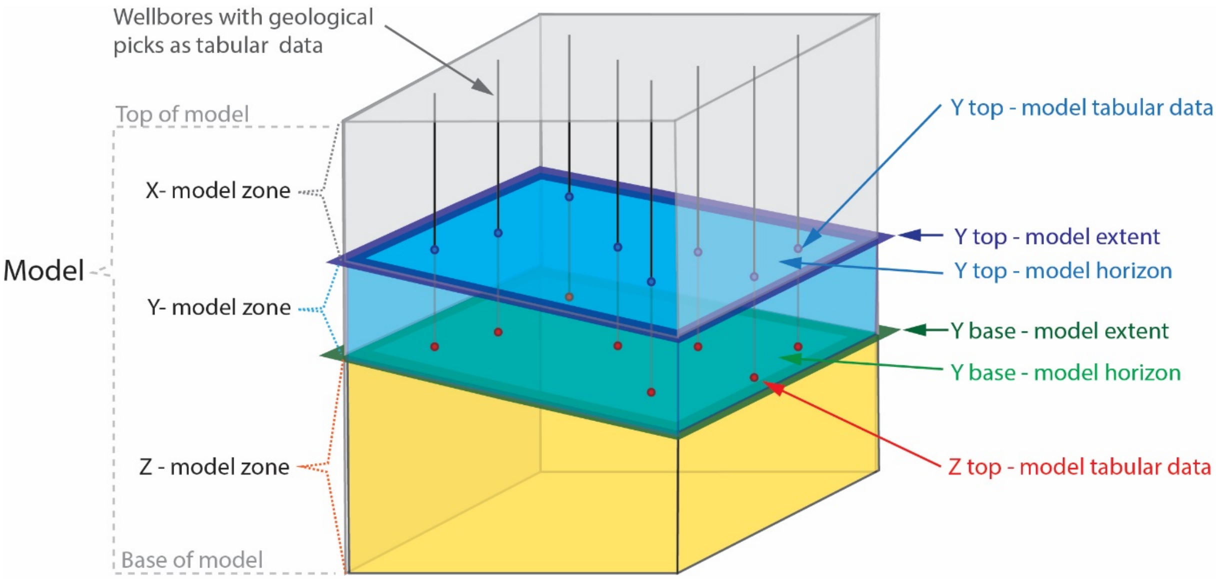


Figure 6. Illustration of model outputs, showing the relationship between the model, model tabular data, model extents, model horizons, and model zones.

4 Modelling Workflow

This section outlines the AGS Geomodelling Workflow (Figure 7). The workflow was developed to provide a defined modelling approach and guide to all 3D model production at the AGS.

The AGS Geomodelling Workflow is grouped into six main parts:

Part 1: Input Data and Stratigraphic Framework (Section 5.1)

a) compile all source data (input points, lineaments, and extents)
b) combine multisource input data defining the top and base of each zone
c) establish conceptual geological model(s) and convey to geomodeller(s)
d) done by geologists and geomodellers

Part 2: Geostatistical Analysis (Section 5.2)

a) geostatistically filter source data
b) achieve stabilization of global uncertainty
c) completed by geomodellers

Part 3: Input Surface Interpolation and Manipulation (Sections 5.3 and 5.4)

a) create interpolated surfaces for tops and bases of zones
b) manipulate interpolated surfaces to honour unconformable surfaces
c) manipulate interpolated surfaces to ensure no crossovers with adjacent surfaces
d) manipulate interpolated surfaces to geo-edges (if applicable)
e) assess alignment with conceptual model(s)
f) completed by geomodellers

Part 4: Uncertainty Analysis (Section 5.5)

a) provide uncertainty analysis for interpolated surfaces
b) completed by geomodellers

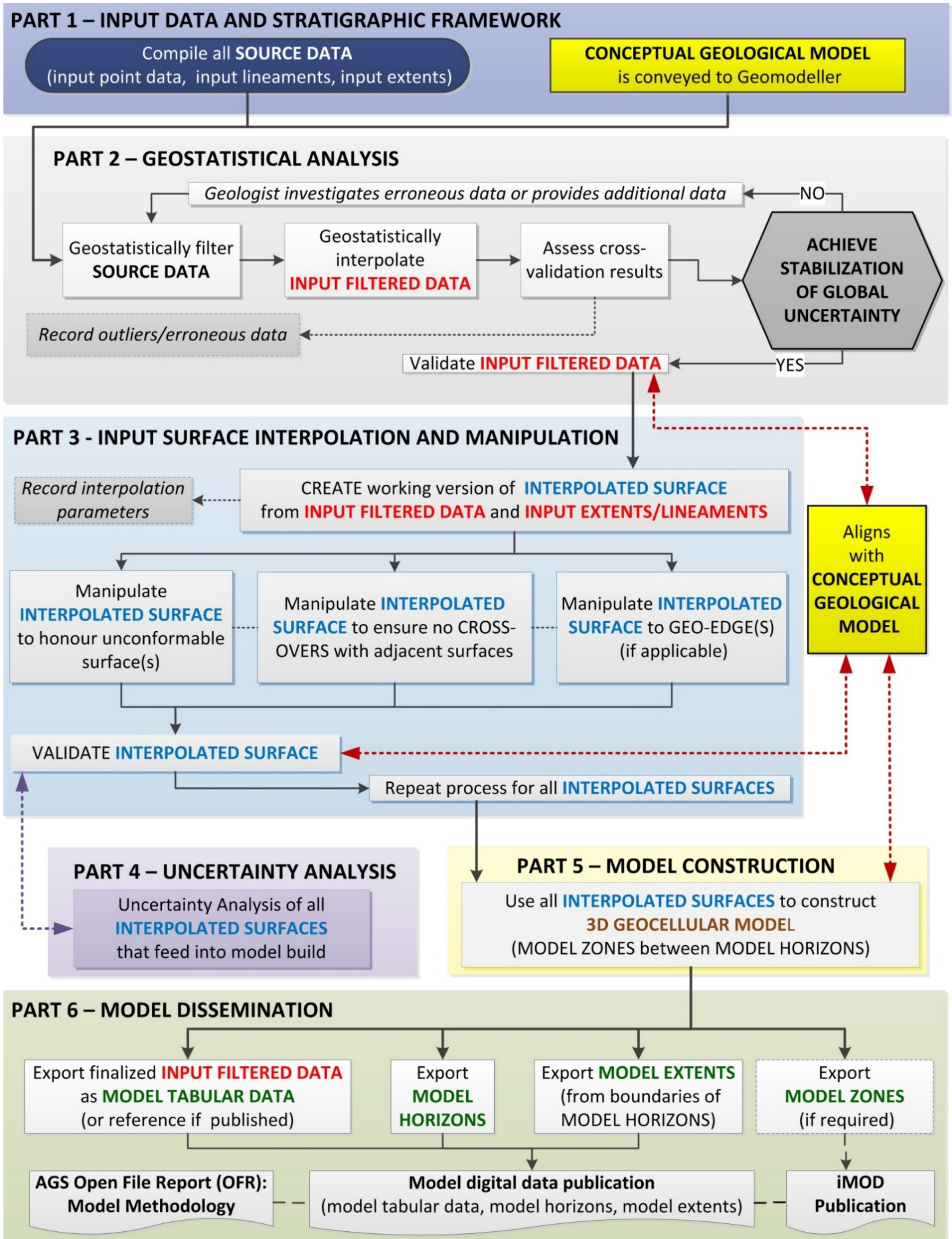


Figure 7. Current AGS geomodelling workflow.

Part 5: Model Construction (Section 6)

a) generate a 3D geological model of all zones from specified input parameters

b) completed by geomodellers

Part 6: Model Dissemination (Section 7)

a) disseminate deconstructed 3D model outputs

b) disseminate iMOD package for 3D visualization of model

c) completed by geomodellers

There are three major phases in this workflow. The preconstruction phase (Parts 1 to 4), the construction phase, and the dissemination phase. The first two phases have an iterative nature, since multiple cycles of data examination, geostatistical analysis, surface interpolation, and simple grid creation can occur to get the surfaces and zones to represent the geology as accurately as possible.

5 Model Inputs

This section describes the preconstruction front-end phase of the geomodelling workflow (Parts 1 through 4). Detailed information about the model input data, geostatistical analyses, surface interpolation, surface manipulation, and uncertainty analyses are provided in this section.

5.1 Input Source Data

Compilation and management of all available source data is a fundamental part of the geomodelling workflow. This section describes the input data used to create the interpolated surfaces used during model construction.

There are four input data types in this model: stratigraphic picks, sampled modified lineaments, outcrop data, and previously created surfaces (modified from the ground surface and bedrock topography surfaces that were ready for use). Stratigraphic picks are the bulk of the input data in the 3D PGF model (n = 618 998 of 620 812 data points). The stratigraphic picks were interpreted from downhole geophysical logs from oil and gas wells by geologists. The picks were compiled and exported as x, y, and z (elevation) from IHS Petra (geological interpretation software) and imported into Esri's ArcGIS (geographic information system software) as a point dataset. Sampled modified lineaments were digitized, modified (z values snapped to the sub-Cretaceous or bedrock topography unconformities), and resampled to fill in data gaps in the provincial datasets. These datasets were assigned lower quality but were critical in improving the regional-scale interpolated surfaces where they subcropped at the unconformities. Outcrop data (n = 21) were available for the base of the Fish Scales Formation dataset. The incorporation of these data greatly improved the quality of the base of the Fish Scales Formation surface in the shallow data-poor areas of the Birch and Caribou mountains. Previously created surfaces that were ready for use in this model included the ground surface (modified from Alberta Environment and Parks, 2015) and the bedrock topography surface (modified from MacCormack et al., 2015).

The quality of the input data is variable and the level of quality was accounted for by assigning appropriate data weights during surface interpolation (see Appendix 2 for data weights for all components used in modelling the 3D PGF model; MacCormack and Eyles, 2010). Stratigraphic picks recently interpreted by AGS geoscientists were given the highest weighting (1.0). Historical data from the AGS/AER and outcrop data were given a lower weighting (0.8). Data modified from map lineaments were assigned the lowest weighting due to the approximate nature of the lineament on a map, estimation errors in digitization, and errors in translating from the scale of maps.

Applying a different data weight to input data of different quality ensured that input data with the highest quality had a larger influence on the surface interpolation than the data with the lowest quality

(MacCormack and Eyles, 2010). The influence on surface interpolation is translated to the influence on model results.

Two-dimensional (2D) maps of the data distribution for all datasets are provided in Appendix 3. The distribution of data played a large role in the quality of the interpolated surfaces (described in Section 5.5). The standard deviation tends to increase near data-poor areas (e.g., area paralleling the deformation edge or the southwestern part of the model area). The standard-deviation plots can be seen in the uncertainty maps in Appendix 4.

5.2 Geostatistical Analysis

A first-pass culling exercise, by simply visualizing the dataset in 3D space, was completed on all source datasets prior to geostatistical analysis. During this exercise, any obviously erroneous points were flagged or removed (most errors were likely due to incorrect kelly bushing values leading to incorrect pick elevations). Where data were abundant, these erroneous points were removed because an additional single point would not have an impact on the interpolation. In data-poor areas, these data points were flagged, examined, corrected (if possible), and reintroduced into the dataset for the next step: geostatistical filtering.

The datasets were then geostatistically filtered using the Geostatistical Analyst extension for ArcGIS, Version 10.1. The data were interpolated using ordinary kriging, and a local first-order trend was removed to account for the southwestward-dipping trend of most of the modelled intervals in the WCSB. Short-range variation in the residuals was modelled and the previously removed southwestward trend was added back into the prediction. Cross-validation was completed to identify potential outliers that deviated significantly from the nearby data points (~50 m), with the criteria for culling the outliers varying depending on the variability of the surface.

These outliers were examined and either removed from the dataset, reinterpreted by a geoscientist and reintroduced to the dataset, or used to flag areas that needed more stratigraphic picks. The adjusted dataset was then reinterpolated and rechecked for outliers. This method of culling took place until stabilization of global uncertainty was achieved. The stabilization of global uncertainty occurs when a reduction in the root mean square error (RMSE) levels off. The RMSE provides a global measure of the difference between the predicted interpolated surface and measured values from the input filtered data (MacCormack et al., 2013).

After the successive outlier culls took place and stabilization of global uncertainty was achieved, the data were then considered input filtered data and ready for import into Petrel.

5.3 Input Surface Interpolation

Input filtered data were imported into Petrel, visualized in 3D, and checked once more for outliers. Twenty-eight distinct surfaces were interpolated using the convergent interpolation algorithm and rendered at a 500×500 m grid increment without a bounding polygon (see Appendix 2 for a description of the input data and interpolation details). Each surface was visualized in 3D and inspected for anomalous peaks. The data near these anomalous peaks were inspected by the geomodeller and then, if needed, by the geologist to confirm fit with the conceptual understanding. The effect of input filtered data weights were considered individually for each surface and appropriate weights were assigned during the interpolation step. The variable quality of the input filtered data is documented in Appendix 2 (data weight).

The second round of interpolation used either the convergent interpolation algorithm or conformal gridding algorithm (a variant of the convergent interpolator). The latter algorithm allows the modeller to assign bounding surfaces (above and/or below the surface being interpolated) to ensure the interpolated surface does not cross the identified adjacent surfaces. This interpolation method helps reduce crossovers, especially in data-poor areas. Interpolation methods used to create the surfaces are shown in Appendix 2.

If the conformable gridding interpolation method was used, the associated conformable gridding surfaceswere documented (above and/or below bounding interpolated surfaces). Some of the interpolated surfaces that were created using the conformable gridding algorithm method still had crossovers and required the implementation of additional manipulations, which are documented in Appendix 2.

All interpolated surfaces were visualized in 3D and checked to ensure they correspond with the geologist's current understanding of the geology.

5.4 Input Surface Manipulation

The interpolated surfaces described in Section 5.3 were then manipulated to honour relationships with unconformities, conform to interpreted geological limits (geo-edges), and deal with any remaining crossovers. No minimum thickness or grid math was applied to any of the interpolated surfaces. For surfaces with elevations equal to those above or below them, a replacement manipulation was used to honour the basic principle of stratigraphic layering: no crossovers. All surfaces were clipped to the 3D PGF model extent.

The sub-Cretaceous unconformity and bedrock topography surfaces represent major unconformities in the model. The sub-Cretaceous unconformity interpolated surface was eliminated below the Precambrian top surface and eliminated above the bedrock topography surface to remove crossovers. All surfaces representing geology below the sub-Cretaceous unconformity were manipulated to ensure they did not extend above the sub-Cretaceous unconformity interpolated surface. All interpolated surfaces that intersected with the bedrock topography were truncated at the bedrock topography surface. If a surface was truncated by either (or both) unconformities, then the surface was spilt into two components—a noneroded and an eroded surface expression—and the associated subcrop edge was generated and documented. A complete discrete surface represents the combination of the eroded and noneroded portions of the surface and does not extend across the entire modelling area like a continuous surface (Figures 5 and 8).

Some datasets required the use of geo-edges to constrain the interpolated surface to areas where the geological zone was considered to be present (e.g., Battle, Milk River, Duvernay, Leduc, Cooking Lake, and Majeau Lake formations). The interpolated surfaces were clipped to these polygons or eliminated across polylines accordingly. This clipping manipulation typically results in surfaces (and zones) that abruptly terminate in the model. When surfaces do not have lateral equivalents to merge with, they are merged with adjacent surfaces and a shelf-like geometry of the continuous surface may occur (Figure 9). This could be resolved by adding laterally equivalent zones in subsequent versions of this model.

5.5 Input Surface Uncertainty

Uncertainty analysis was completed on the noneroded portions of all 28 interpolated surfaces. The eroded portions of the geological units are represented by either or both major unconformities (bedrock topography or sub-Cretaceous unconformity). Global uncertainty was evaluated using RMSE values (Appendix 2).

Local uncertainty was characterized using standard-deviation maps (Appendix 4). The two analyses represent the uncertainty at a provincial (RMSE) and a local (standard deviation) scale, and provide insight into the magnitude of errors that are present within each interpolated geological surface.

The RMSE was computed for each geological surface by comparing the input filtered data to values of the interpolated surface. The RMSE values ranged from 1.33 to 15.19, with the highest occurring in the Leduc Formation surface (likely due to the elevation change of the reefs and platforms). The average RMSE of all 28 surfaces was 3.78, which is quite low considering the large extent of the model and the scale of the geological features and topographic variability that are present within many of the geological units for this model.

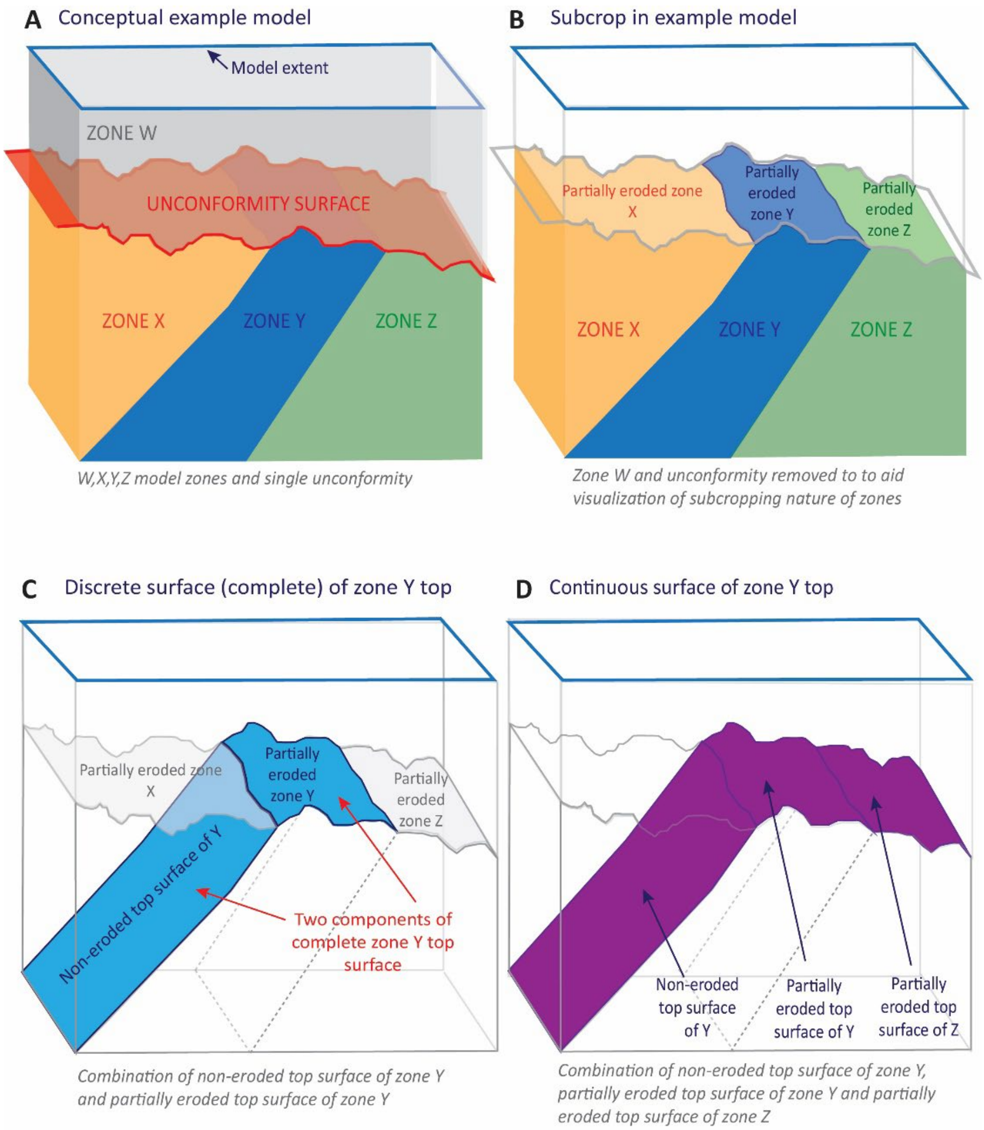


Figure 8. Graphical description of A) a conceptual example model; B) subcropping nature of the zones in conceptual example model; C) components of a discrete (complete) top surface (noneroded versus eroded top surface and how they are related to adjacent surfaces and unconformities); and D) depiction of a continuous surface.

Standard-deviation maps were created using the methodology of Babakhani (2016). A standard-deviation map was created for each of the 28 geological-top datasets by randomly selecting 80% of the input filtered data for each top (10 realizations). These ten subsets were interpolated using the convergent interpolator algorithm and identical gridding parameters. The 10 surfaces were converted to points and the standard deviation was calculated at the same grid-node location for all realizations (Babakhani, 2016). This methodology provides a graphical representation of variations in uncertainty across the interpolated surface. Areas with lower standard-deviation values represent areas of the interpolated surface that have lower uncertainty.

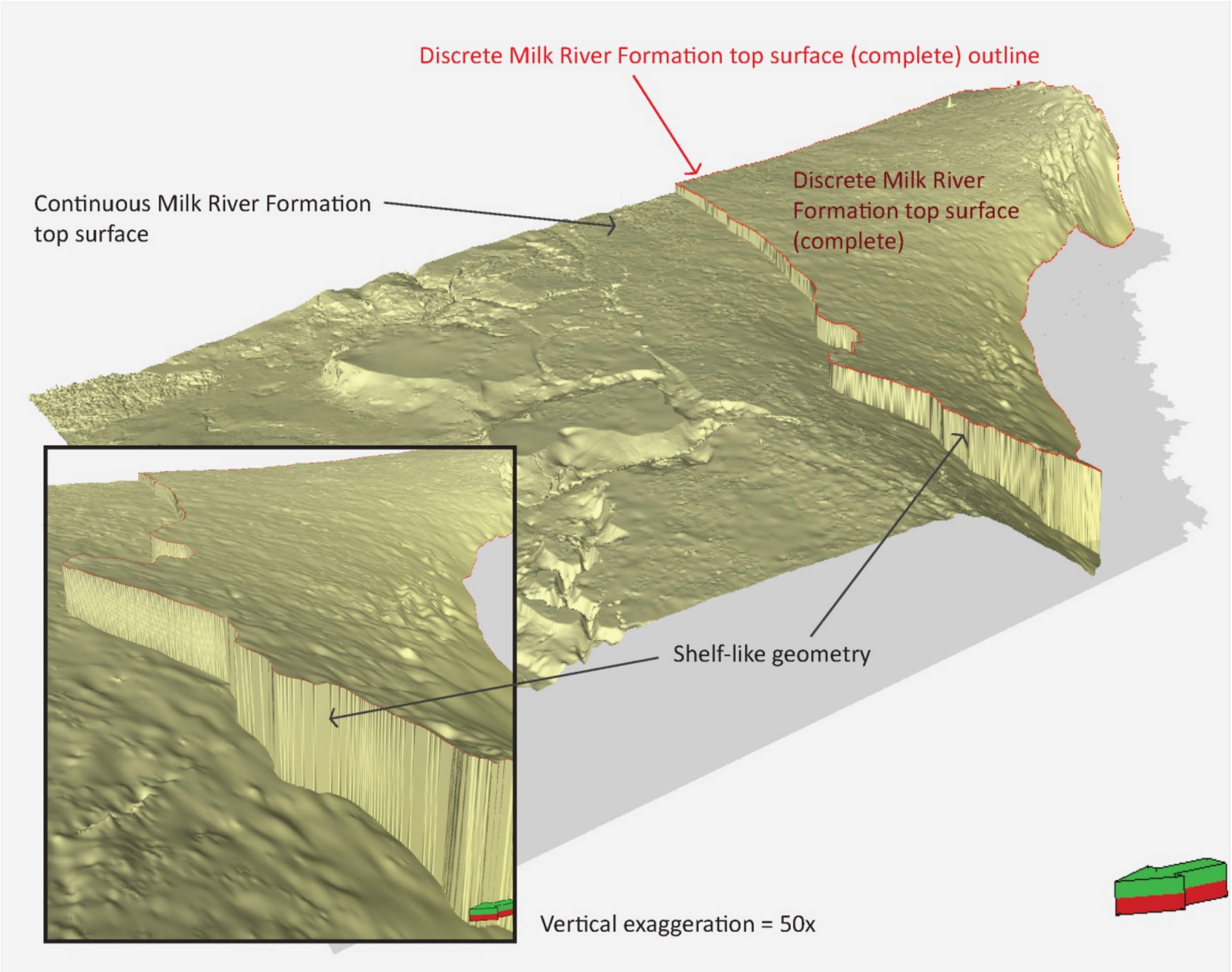


Figure 9. Oblique view of Milk River Formation top surface (continuous), showing shelf-like geometry. Grey flat surface is the 3D Provincial Geological Framework Model, Ver. 1 extent set at an arbitrary elevation (vertical exaggeration = 50x).

The uncertainty-analysis results confirm that areas of sparse data and/or close proximity to the deformation belt have the highest uncertainty and could benefit from additional data. The uncertainty for each of the surfaces was deemed acceptable for this regional-scale modelling effort, and the interpolated surfaces were accepted as satisfactory inputs for model construction.

6 Model Construction

The 3D PGF model was built in Petrel using the 3D Simple Grid (nonstructural model) tool. Two versions of the model were built: a discrete-surface input construction and a continuous-surface input construction.

The discrete-surface construction was built first to help understand the complex top- and base-surface relationships and the unconformities truncating them. Each discrete top surface had the noneroded and eroded portions of the surface merged to form a ‘complete’ discrete surface, using the appropriate unconformity surface(s). This complete discrete surface represents where the geological unit top exists in its noneroded and partially eroded form. A discrete surface terminates at the subcrop edge of the base of the geological unit (equivalent to that of the noneroded top of the underlying interval; Figure 8B). The grouping of some intervals, such as undifferentiated zones, was driven by the lack of discrete-surface definition or by the lack of a geological lateral equivalent (lack of equivalent data provincially). The discrete model construction is considered an interim step in the modelling process because it is not volumetrically sealed (although it is useful for discrete interval visualization).

The continuous-surface input construction is defined by merging the discrete noneroded top surface with the provincial-scale unconformities (see Figure 5 for an example and Figure 8C for concept illustration) to ensure that the volumes for each zone (representing geological units) are fully sealed to avoid gaps within the model. The 3D PGF model described from this point onwards was created using continuous surfaces.

6.1 Model Parameters

The following model parameters were used in the 'Make Simple Grid' step in Petrel:

1) Geospatial extent: 3D Provincial Geological Framework Model of Alberta, Ver. 1 extent polygon (Figure 1)
2) Grid Increment: 500 × 500 m
3) Input surfaces and their stratigraphic ordering: detailed in Appendix 1

6.1.1 Grid Discretization

Twenty-eight stratigraphically ordered continuous surfaces were used as inputs in the 3D simple grid tool to create a volumetrically sealed 3D model with 32 zones (see Figure 10 for an oblique view of all 31 bedrock zones and Figure 11 for all 32 zones). Five of the zones created contained groups of undifferentiated geology (or geology that was considered undifferentiated in some parts of the province; Figure 2, Table 1).

The input surfaces were differentiated by geological type (conformable, erosional, or base), based on their nature and relationships to other surfaces. Three of the input surfaces were set to erosional (ground surface, bedrock topography, and sub-Cretaceous unconformity), two were set to base (Precambrian top and the model base, 5000 m below sea level), and the remaining surfaces were set to conformable type.

The continuous-surface input construction of the 3D PGF model contains 32 zones and 111 514 788 grid cells. For documentation purposes, the interim 3D model created using discrete top and base input surfaces had 252 970 500 grid cells.

7 Model Outputs

This section describes the postconstruction part of the geomodelling workflow (Part 6) after the 3D PGF model construction was finalized. This describes how the model (and components of the model) are disseminated to the end user without the need for Petrel software. Digital-data outputs generated from the 3D PGF model include model tabular point data, model extents, discrete and continuous model horizons, and model surfaces in iMOD format (see Section 3 for definitions).

7.1 Digital Data

The 3D PGF model was deconstructed to provide digital data in a standard format to the stakeholder. This allows the end user to download the information they are interested in or to reconstruct the model in accordance with the methodology outlined in this report.

There are four digital-data outputs from the deconstructed 3D PGF model available in standard formats:

- Model tabular point data: finalized input filtered data database (n = 620 812) for all zones in tab-delimited format
- Model extents: zone model extents published as GIS data polygon features

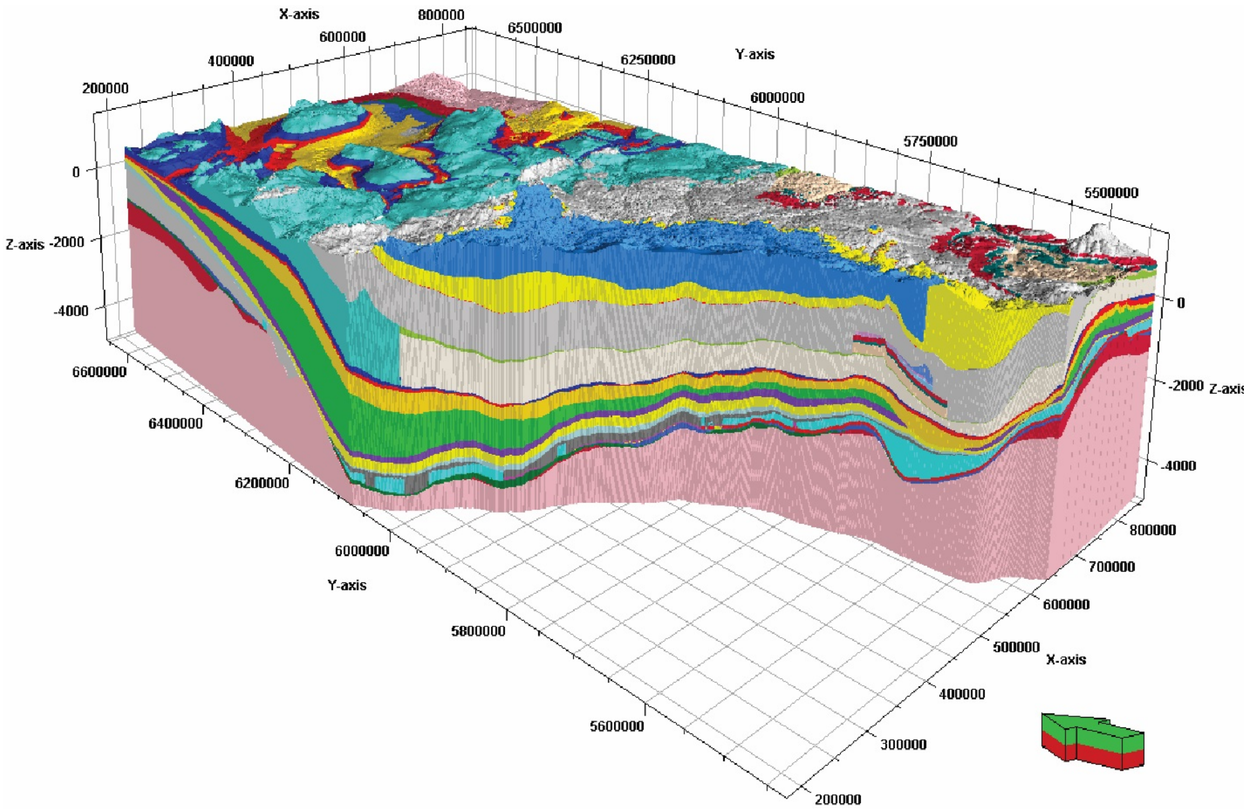


Figure 10. Oblique view of all zones below the bedrock topography surface to the 3D PGF model base (vertical exaggeration = 50x). Refer to Appendix 5 for oblique views of all discrete model zones and Appendix 6 for model zone colour legend.

- Model horizons (discrete): discrete model horizons published as gridded data in ASCII format
- Model horizons (continuous): continuous model horizons published as gridded data in ASCII format for use with iMOD 3D visualization (Section 7.2)

Petrel models are not published for this version; however, the finalized Petrel models are archived internally for modifications or future updates.

7.2 iMOD 3D Visualization

Visualization of the 3D PGF model can be done in iMOD, an open-source 3D digital-data viewing software available for download from Deltares (n.d.). All deconstructed-model digital data can be viewed in 2D and 3D (model tabular point data, extents, and horizons). In this software, 3D models can be rotated, toggled on and off, or exploded for viewing (Figures 3, 4, and 11 for examples of exploded views). Additional functionality of iMOD includes the ability to create cross-sections and clip the model using an intersection plane. The user can import any data into the model domain and visualize how they relate to the zones within the 3D PGF model.

8 Model Quality

The 3D PGF model is a visual representation of select geology (largely at group level) as rendered from the available input data described in this report. The uncertainty of the input surfaces is variable (Section 5.5) and the quality of the model varies as well, mostly due to the distribution of the data (data-poor areas with lower quality data versus data-rich areas with higher quality data). This section discusses the model

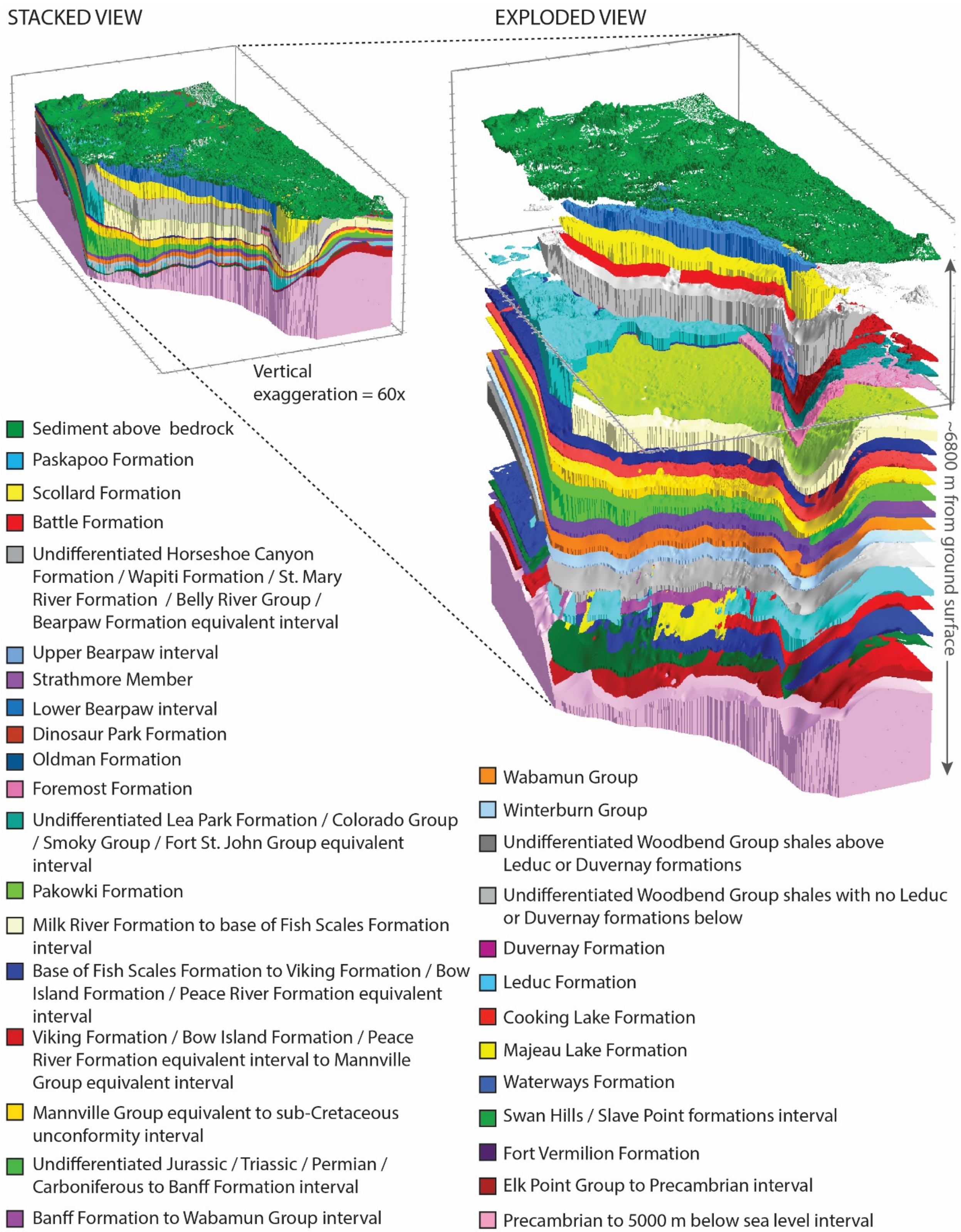


Figure 11. Oblique stacked and exploded view of all 32 zones within the 3D Provincial Geological Framework Model of Alberta, Ver. 1 (vertical exaggeration = 60x).

quality using a qualitative approach. This assessment, along with the uncertainty analysis of the input surfaces, can be used to identify areas to focus on in future updates, which will improve the model's ability to characterize the geological complexity of Alberta.

The 3D PGF model is generally considered to be a high-quality representation of the current geological understanding in the province. The modelled truncation of the Paleozoic (modelled largely at the group level) by the sub-Cretaceous unconformity (Figure 12) in the 3D PGF model is remarkably similar to that of the detailed sub-Cretaceous subcrop mapping completed by Peterson et al. (2016). This corroborates the belief that the model is of high quality.

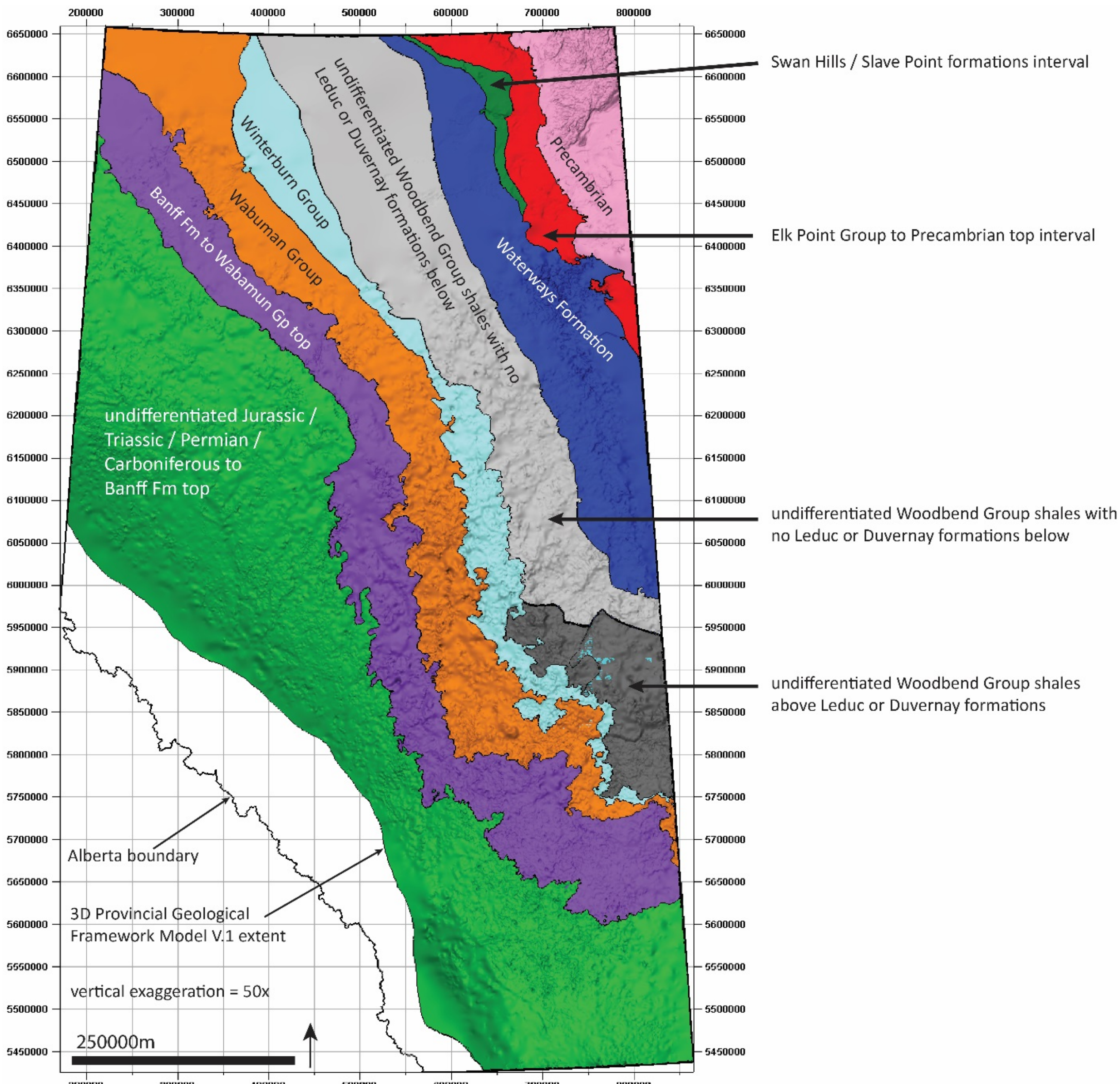


Figure 12. Map view of the zones in the 3D Provincial Geological Framework Model of Alberta, Ver. 1 that subcrop at the sub-Cretaceous unconformity. The Precambrian top is visible in the northeast at the approximate Phanerozoic extent.

The qualitative assessment provides a confidence level (low to high) for each zone based on three quality categories: 1) data quality, 2) data quantity, and 3) trueness to geological complexity. Model quality of the zones ranges from medium to high (Table 2). All categories are scored between 1 and 3 (1 = low; 2 = medium; and 3 = high). For each model zone, the categories are added to a maximum of 9. Confidence levels are determined based on the range in total score, with 3–4 being low, 5–7 being medium, and 8–9 being high. Lower confidence levels were influenced by lack of data in certain areas of the province and are better communicated in the uncertainty-analysis discussion in Section 5. Higher confidence levels were influenced by more abundant data (Appendix 4) and whether the model zone provided an accurate representation of its geological complexity.

The model quality varies due to 1) uncertainty related to the varied quality of data inputs, 2) the large extent of the model (602 825 km^2), 3) the large grid increment of the model (500 $\times$ 500 m; compared to finer scale geological variations within the province), and 4) the groupings of the geological intervals. The variability of the model quality is shown in Table 2.

A noticeable limitation of the model is the ability to accurately characterize the relationship between the present-day Precambrian surface high in the Peace River area and the Paleozoic surfaces that intersect it. In reality, the Precambrian surface looked different in Paleozoic times than it does today; therefore, the modelled intersections do not represent the true geological relationship. The model grossly and inaccurately simplifies the relationship between the Precambrian and Paleozoic geology in this region. The structural complexity of the Peace River area was not accounted for, since this model is nonstructural. There were three options to deal with this: 1) complete geological reconstructions of the Precambrian and Paleozoic (currently out of scope for this project); 2) remove the entire area of inaccuracy (use a polygon to clip out the Peace River area entirely), or 3) simplify the relationship with modelled Paleozoic surfaces pseudo-onlapping the present-day structure of the Precambrian and convey to the reader why this is geologically incorrect. The latter option was selected due to limited structural data and interpretation in the area, and the fact that this version of the 3D PGF model is a simplified nonstructural type. Figure 13 shows some of the major structural elements in Alberta draped over the Precambrian top surface, including the Peace River Embayment and Peace River Arch axis.

9 Summary

The 3D Provincial Geological Framework Model, Ver. 1 (3D PGF model) was constructed for Alberta excluding an area representing the approximate extent of Cordilleran deformation. The model represents a multilayer, stratigraphic, conceptual representation of select intervals and groupings within the subsurface of Alberta (Appendix 6). This report describes the methodology used to develop the provincial model, the geomodelling workflow, and all model parameters. The 3D PGF model was deconstructed and all components are available in standard-format digital data.

The 3D PGF model covers 602 825 km^2 and includes 32 model zones: a sediment above bedrock zone and 31 bedrock zones (ranging in resolution from formation- or group-level to mixed-formation, group- and/or period-level geology). The 3D PGF model was created using a total of 620 812 input filtered data points from stratigraphic picks interpreted from geophysical logs, sampled modified lineaments from maps, and outcrop data of varying quality and data distribution. The variable data quality of the input data was accounted for by adjusting the data weighting during surface interpolation.

Interpolated surfaces were created based on the weighted input data and fed into a 3D simple grid for discretization. The 3D PGF model (continuous-surface construction) contains 111 514 788 grid cells in 32 zones: 1) sediment above bedrock; 2) Paskapoo Formation; 3) Scollard Formation; 4) Battle Formation; 5) undifferentiated Horseshoe Canyon Formation / Wapiti Formation / St. Mary River Formation / Belly River Group / Bearpaw Formation equivalent interval; 6) upper Bearpaw interval; 7) Strathmore Member; 8) lower Bearpaw interval; 9) Dinosaur Park Formation; 10) Oldman Formation; 11) Foremost

Table 2. Confidence level of all model zones. All three categories are scored from 1 to 3 (1 being poor, 2 being average, and 3 being good). The category values are then summed for each zone (minimum of 3 and maximum of 9). The Model Zone Confidence Level is based on this total summed value, with low being 3–4, medium being 5–7, and high being 8–9. Abbreviations: BFS, base of the Fish Scales Formation; FM, formation; GP, group; MB, member; VBP, Viking Formation / Bow Island Formation / Peace River Formation.

Discrete Model Zone	Data Quality	Data Quantity	Trueness to Geological Complexity	Model Zone Confidence Level	
Sediment above bedrock	3	3	3	9	High
Paskapoo Fm	3	2	2	7	Medium
Scollard Fm	3	2	2	7	Medium
Battle Fm	3	3	3	9	High
Undifferentiated Horseshoe Canyon Fm / St. Mary River Fm / Wapiti Fm / Belly River Gp / Bearpaw Fm interval	3	2	2	7	Medium
Upper Bearpaw Interval	3	3	2	8	High
Strathmore Mb	3	3	2	8	High
Lower Bearpaw interval	3	3	2	8	High
Dinosaur Park Fm	3	3	3	9	High
Oldman Fm	3	3	3	9	High
Foremost Fm	3	3	3	9	High
Undifferentiated Lea Park Fm / Colorado Gp / Smoky Gp / Fort St. John Gp interval	3	3	2	8	High
Pakowki Fm	3	3	2	8	High
Milk River Fm to BFS interval	3	3	3	9	High
BFS to VBP interval	3	2	3	8	High
VBP to Mannville Gp equivalent interval	3	2	3	8	High
Mannville Gp equivalent interval to sub-Cretaceous unconformity interval	3	2	3	8	High
Undifferentiated Jurassic / Triassic / Permian / Carboniferous to Banff Fm interval	3	2	2	7	Medium
Banff Fm To Wabamun Gp interval	3	3	2	8	High
Wabamun Gp	3	3	2	8	High
Winterburn Gp	3	3	2	8	High
Undifferentiated Woodbend Gp shales above Leduc Fm or Duvernay Fm (WOOD A)	2	2	2	6	Medium
Undifferentiated Woodbend Gp shales with no Leduc Fm or Duvernay Fm below (WOOD B)	2	2	2	6	Medium
Duvernay Fm	3	3	3	9	High
Leduc Fm	3	3	3	9	High
Cooking Lake Fm	3	1	3	7	Medium
Majeau Lake Fm	3	1	3	7	Medium
Waterways Fm	3	2	2	7	Medium
Swan Hills Fm / Slave Point Fm interval	3	2	2	7	Medium
Fort Vermilion Fm	3	2	2	7	Medium
Elk Point Gp to Precambrian interval	3	2	2	7	Medium
Precambrian to 5000 m below sea level interval	2	2	2	6	Medium

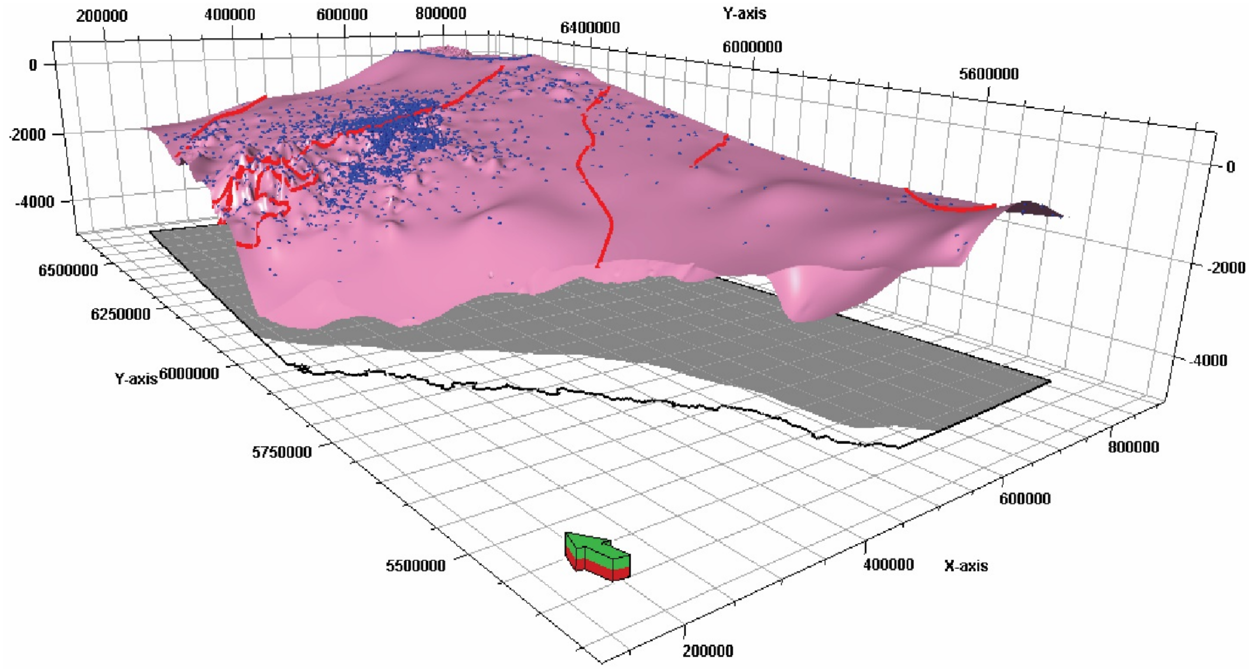


Figure 13. Oblique view of the Precambrian top surface (Precambrian input filtered data in blue) with the major structural-element lineaments draped over it (from Mossop and Shetsen, 1994). Grey flat surface is the base of the 3D PGF model. Black outline is the Alberta provincial boundary. Red lineaments from top left to bottom right are Great Slave Lake Shear Zone, Peace River Embayment and Peace River Arch axis, Snowbird Tectonic Zone, Meadow Lake Escarpment, and Bow Island Arch (vertical exaggeration = 50x).

Formation; 12) undifferentiated Lea Park Formation / Colorado Group / Smoky Group / Fort St. John Group equivalent interval; 13) Pakowki Formation; 14) Milk River Formation to base of the Fish Scales Formation interval; 15) base of the Fish Scales Formation to Viking Formation / Bow Island Formation / Peace River Formation equivalent interval; 16) Viking Formation / Bow Island Formation / Peace River Formation equivalent interval to Mannville Group equivalent interval; 17) Mannville Group equivalent interval to sub-Cretaceous unconformity interval; 18) undifferentiated Jurassic / Triassic / Permian / Carboniferous to Banff Formation interval; 19) Banff Formation to Wabamun Group interval; 20) Wabamun Group; 21) Winterburn Group; 22) undifferentiated Woodbend Group shales above Leduc or Duvernay formations; 23) undifferentiated Woodbend Group shales with no Leduc or Duvernay formations below; 24) Duvernay Formation; 25) Leduc Formation; 26) Cooking Lake Formation; 27) Majeau Lake Formation; 28) Waterways Formation; 29) Swan Hills / Slave Point formations interval; 30) Fort Vermilion Formation; 31) Elk Point Group to Precambrian interval; and 32) Precambrian to 5000 m below sea level interval.

A multidisciplinary and iterative approach was taken in constructing the 3D PGF model. Collaboration of geoscientists, geostatisticians, and geomodellers was pivotal in developing a 3D model that represents the conceptual understanding of the included geological zones. The iterative contributions ensured that the current 3D PGF model characterizes the complex geology of Alberta as reasonably as possible at a regional scale. This model is not intended for local-scale or site-specific investigations. It could, however, support science-based decision-making and act as a geological framework to inform regulatory decisions related to the management of the subsurface.

10 References

Alberta Environment and Parks (2015): Provincial DEM, digital topographic data; AltaLIS, 25 m cell, Esri Grid format, URL <http://www.altalis.com/products/terrain/dem.html> [April 2018].

Alberta Geological Survey (2015): Alberta Table of Formations; Alberta Energy Regulator, URL <http://ags.aer.ca/document/Table-of-Formations.pdf> [April 2018].

Babakhani, M. (2016): Uncertainty analysis in geological surface modelling; poster presented at AAPG Annual Convention and Exhibition, Calgary, Alberta, Canada, June 19–22, 2016.

Deltares (n.d.): Why iMOD – the iMOD approach; Deltares, URL <http://oss.deltares.nl/web/imod/about-imod> [April 2018].

Halbertsma, H.L. (1994): Devonian Wabamun Group of the Western Canada Sedimentary Basin; Chapter 13 *in* Geological Atlas of the Western Canada Sedimentary Basin, G.D. Mossop and I. Shetsen (comp.), Canadian Society of Petroleum Geologists, Calgary, Alberta and Alberta Research Council, Edmonton, Alberta, URL <http://ags.aer.ca/publications/chapter-13-devonian-wabamun-group.htm> [April 2018].

Hathway, B. (2011): Tops of the Horseshoe Canyon, Wapiti and Battle formations in the west-central Alberta Plains: subsurface stratigraphic picks and modelled surface; Energy Resources Conservation Board, ERCB/AGS Open File 2011-08, 24 p., URL <http://ags.aer.ca/publications/OFR_2011_08.html> [April 2018].

Hauck, T.E. and Corlett, H. (2017): Precambrian basement top picks in Alberta (elevation; tabular data, tab-delimited format); Alberta Energy Regulator, AER/AGS Digital Data 2016-0043, URL <http://ags.aer.ca/publications/DIG_2016_0043.html> [April 2018].

Lyster, S., Corlett, H.J. and Berhane, H. (2017): Hydrocarbon resource potential of the Duvernay Formation in Alberta – update; Alberta Energy Regulator, AER/AGS Open File Report 2017-02, 44 p., URL <http://ags.aer.ca/publications/OFR_2017_02.html> [April 2018].

MacCormack, K.E. and Eyles, C.H. (2010): Enhancing the reliability of 3D subsurface models through differential weighting and mathematical recombination of variable quality data; Transactions in GIS, v. 14, no. 4, p. 401–420.

MacCormack, K.E., Brodeur, J.J. and Eyles, C.H. (2013): Evaluating the impact of data quantity, distribution and algorithm selection on the accuracy of 3D subsurface models using synthetic grid models of varying complexity; Journal of Geographical Systems, v. 15, no. 1, p. 71–88.

MacCormack, K.E., Atkinson, N. and Lyster, S. (2015): Bedrock topography of Alberta, Canada; Alberta Energy Regulator, AER/AGS Map 602, scale 1:1 000 000, URL <http://ags.aer.ca/publications/MAP_602.html> [April 2018].

Mossop, G.D. and Shetsen, I., comp. (1994): Geological atlas of the Western Canada Sedimentary Basin; Canadian Society of Petroleum Geologists, Calgary, Alberta and Alberta Research Council, Edmonton, Alberta, URL <http://ags.aer.ca/reports/atlas-of-the-western-canada-sedimentary-basin.htm> [April 2018].

Okulitch, A.V. and Fallas, K.M. (2007): GIS dataset of Phanerozoic geological features, Slave River, Peace River, and Lake Athabasca map areas, Northwest Territories, Alberta, and Saskatchewan; Geological Survey of Canada, Open File 5338, doi: 10.4095/223451.

Prior, G.J., Hathway, B., Glombick, P.M., Pană, D.I., Banks, C.J., Hay, D.C., Schneider, C.L., Grobe, M., Elgr, R. and Weiss, J.A. (2013): Bedrock geology of Alberta; Alberta Energy Regulator, AER/AGS Map 600, scale 1:1 000 000, URL <http://ags.aer.ca/publications/MAP_600.html> [April 2018].

Peterson, J.T., Hauck, T.E., Hathway, B. and MacCormack, K.E. (2016): Regional-scale modelling of the sub-Cretaceous unconformity surface in northern and central Alberta: elevation, subcrop zero-edge delineation, and paleotopographic reconstruction; poster presented at AAPG Annual Convention and Exhibition, Calgary, Alberta, Canada, June 19–22, 2016, URL <http://ags.aer.ca/document/Presentations/PR_Peterson_AAPG2016.pdf> [April 2018].

Appendices

Tables

Figures

Appendix 1 – Discrete Model Zone Nomenclature and Horizon Definition

Table 3. Discrete model zone nomenclature and horizon definitions.

Discrete Model Zone	Model Horizon Top (Zone Top)	Model Horizon Base (Zone Base)	Model Horizon Top Input(s)	Model Horizon Base Input(s)
Sediment above bedrock	ground surface	bedrock topography surface	ground surface	bedrock topography surface
Paskapoo Formation	Paskapoo Formation top surface	Paskapoo Formation base surface	bedrock topography surface	Paskapoo base picks
Scollard Formation	Scollard Formation top surface	Scollard Formation base surface	Paskapoo Formation base surface	Battle Formation top surface or undifferentiated Horseshoe Canyon Formation / Wapiti Formation / St. Mary River Formation / Belly River Group / Bearpaw Formation equivalent interval top surface
Battle Formation	Battle Formation top surface	Battle Formation base surface	Battle Formation top picks	undifferentiated Horseshoe Canyon Formation / Wapiti Formation / St. Mary River Formation / Belly River Group / Bearpaw Formation equivalent interval top surface
Undifferentiated Horseshoe Canyon Formation / Wapiti Formation / St. Mary River Formation / Belly River Group / Bearpaw Formation equivalent interval	undifferentiated Horseshoe Canyon Formation / Wapiti Formation / St. Mary River Formation / Belly River Group / Bearpaw Formation equivalent interval top surface	undifferentiated Horseshoe Canyon Formation / Wapiti Formation / St. Mary River Formation / Belly River Group / Bearpaw Formation equivalent interval base surface	Horseshoe Canyon / Wapiti equivalent top picks and St. Mary River top picks	undifferentiated Lea Park Formation / Colorado Group / Smoky Group / Fort St. John Group equivalent interval top surface (Belly River Group base surface)
Upper Bearpaw interval	upper Bearpaw interval top surface	upper Bearpaw interval base surface	upper Bearpaw interval top picks	Strathmore Formation top surface
Strathmore Member	Strathmore Member top surface	Strathmore Member base surface	Strathmore Member top picks	lower Bearpaw interval top surface (within Strathmore Member top extent)
Lower Bearpaw interval	lower Bearpaw interval top surface	lower Bearpaw base surface	lower Bearpaw interval top picks	Belly River Group top surface (within lower Bearpaw interval extent)
Dinosaur Park Formation	Dinosaur Park Formation top surface	Dinosaur Park Formation base surface	Belly River Group top picks	Oldman Formation top surface
Oldman Formation	Oldman Formation top surface	Oldman Formation base surface	Oldman Formation top picks	Foremost Formation top surface
Foremost Formation	Foremost Formation top surface	Foremost Formation base surface	Foremost Formation top picks	Belly River Group base (within Foremost Formation extent)
Undifferentiated Lea Park Formation / Colorado Group / Smoky Group / Fort St. John Group equivalent interval	undifferentiated Lea Park Formation / Colorado Group / Smoky Group / Fort St. John Group equivalent interval top surface	undifferentiated Lea Park Formation / Colorado Group / Smoky Group / Fort St. John Group equivalent interval base surface	Belly River Group base picks	base of the Fish Scales Formation surface (outside Milk River Formation extent)
Pakowki Formation	Pakowki Formation top surface	Pakowki Formation base surface	Belly River Group base surface (within Milk River Formation top extent)	Milk River Formation top surface
Milk River Formation to base of the Fish Scales Formation interval	Milk River Formation top surface	base of the Fish Scales Formation surface	Milk River Formation top picks	base of the Fish Scales Formation surface (within Milk River Formation extent)
Base of the Fish Scales Formation to Viking Formation / Bow Island Formation / Peace River Formation equivalent interval	base of the Fish Scales Formation surface	Viking Formation / Bow Island Formation / Peace River Formation equivalent interval top surface	base of the Fish Scales Formation picks	Viking Formation / Bow Island Formation / Peace River Formation equivalent interval top surface

Discrete Model Zone	Model Horizon Top (Zone Top)	Model Horizon Base (Zone Base)	Model Horizon Top Input(s)	Model Horizon Base Input(s)
Viking Formation / Bow Island Formation / Peace River Formation equivalent interval to Mannville Group equivalent interval	Viking Formation / Bow Island Formation / Peace River Formation equivalent interval top surface	Mannville Group equivalent interval top surface	Viking Formation / Bow Island Formation / Peace River Formation equivalent interval top picks	Mannville Group equivalent interval top surface
Mannville Group equivalent interval to sub-Cretaceous unconformity interval	Mannville Group equivalent interval top surface	sub-Cretaceous unconformity surface	Mannville Group equivalent interval top picks	sub-Cretaceous unconformity surface
Undifferentiated Jurassic / Triassic / Permian / Carboniferous to Banff Formation interval	sub-Cretaceous unconformity surface	Banff Formation top surface	sub-Cretaceous unconformity picks	Banff Formation top surface
Banff Formation to Wabamun Group interval	Banff Formation top surface	Wabamun Group top surface	Banff Formation top picks	Wabamun Group top surface
Wabamun Group	Wabamun Group top surface	Winterburn Group top surface	Wabamun Group top picks	Winterburn Group top surface
Winterburn Group	Winterburn Group top surface	Woodbend Group top surface	Winterburn Group top picks	Woodbend Group top surface
Undifferentiated Woodbend Group shales above Leduc or Duvernay formations (WOOD A)	undifferentiated Woodbend Group shales above Leduc or Duvernay formations (WOOD A) top surface	undifferentiated Woodbend Group shales above Leduc or Duvernay formations (WOOD A) base surface	Woodbend Group top picks	Leduc Formation top surface or Duvernay Formation top surface
Undifferentiated Woodbend Group shales with no Leduc or Duvernay formations below (WOOD B)	undifferentiated Woodbend Group shales with no Leduc or Duvernay formations below (WOOD B) top surface	undifferentiated Woodbend Group shales with no Leduc or Duvernay formations below (WOOD B) base surface	Woodbend Group top picks	Waterways Formation top surface
Duvernay Formation	Duvernay Formation top surface	Duvernay Formation base surface	Duvernay Formation top picks	Majeau Lake Formation top surface or Cooking Lake Formation top surface
Leduc Formation	Leduc Formation top surface	Leduc Formation base surface	Leduc Formation top picks	Cooking Lake Formation top surface or Beaverhill Lake Group top surface
Cooking Lake Formation	Cooking Lake Formation top surface	Cooking Lake Formation base surface	Cooking Lake Formation top picks	Beaverhill Lake Group top surface
Majeau Lake Formation	Majeau Lake Formation top surface	Majeau Lake Formation base surface	Majeau Lake Formation top picks	Beaverhill Lake Group top surface
Waterways Formation	Waterways Formation top surface	Waterways Formation base surface	Beaverhill Lake Group top picks	Swan Hills / Slave Point formations interval top surface
Swan Hills / Slave Point formations interval	Swan Hills / Slave Point formations interval top surface	Swan Hills / Slave Point formations interval base surface	Swan Hills / Slave Point formations interval top picks	Fort Vermilion Formation top surface
Fort Vermilion Formation	Fort Vermilion Formation top surface	Fort Vermilion Formation base surface	Fort Vermilion Formation top picks	Elk Point Group top surface
Elk Point Group to Precambrian interval	Elk Point Group to Precambrian top interval top surface	Elk Point Group to Precambrian top interval base surface	Elk Point Group top picks	Precambrian top surface
Precambrian to 5000 m below sea level	Precambrian top surface	5000 m below sea level surface	Precambrian top picks	5000 m below sea level surface

Appendix 2 – Input Data and Interpolation Details

Table 4. Input data and interpolation details.

Stratigraphic Data/Pick *(or ready to use surfaces)*	Input Data Set Type	Total Number of Filtered Input Data Points	Count Breakdown (where applicable)	Data Weight	Data Source	Data Distribution Map	Resultant Interpolated Surface(s)	Interpolation Method	Conformable Gridding Associated Surfaces	Manipulations (assume merge of eroded and non–eroded portions to make a complete surface & assume eliminate above Bedrock topography)	Uncertainty Map (STD DEV)	RMSE (m)
Ground surface	*existing surface*	*N/A*	*N/A*	*N/A*	*Modified from Alberta Environment and Parks (2015)*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
Bedrock topography surface	*existing surface*	*N/A*	*N/A*	*N/A*	*Modified from MacCormack et al. (2015)*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
Paskapoo Formation top surface	*existing surface*	*N/A*	*N/A*	*N/A*	*Modified from MacCormack et al. (2015)*	*N/A*	*N/A*	*N/A*	*N/A*	*copy of Bedrock topography surface; eliminate outside Paskapoo Formation base extent*	*N/A*	*N/A*
Paskapoo Formation base	stratigraphic picks	3122	N/A	1.0	Recent AGS data	YES	Paskapoo Formation base surface (~Scollard Formation top surface)	conformable gridding	Battle Formation top surface (below); built along TST	eliminate above bedrock topography surface; eliminate outside Battle Formation extent	YES	7.66
							Scollard Formation top surface	conformable gridding	Battle Formation top surface (noneroded; below); built along TST	copy of Paskapoo Formation base surface; eliminate above bedrock topography; eliminate outside Battle Formation extent; extrapolate within boundary to fix tiny holes		
Battle Formation top	stratigraphic picks	8145	N/A	1.0	Recent AGS data from OFR11–08 (Hathway, 2011)	YES	Battle Formation Formation top surface	conformable gridding	undifferentiated Horseshoe Canyon Formation / Wapiti Formation / St. Mary River Formation / Belly River Group / Bearpaw Formation equivalent interval top surface (below); built along TST	eliminate above bedrock topography; Replace with undifferentiated Horseshoe Canyon Formation / Wapiti Formation / St. Mary River Formation / Belly River Group / Bearpaw Formation equivalent interval top surface when below undifferentiated Horseshoe Canyon Formation / Wapiti Formation / St. Mary River Formation / Belly River Group / Bearpaw Formation equivalent interval top surface; extrapolate within boundary to fix tiny holes	YES	1.81
Horseshoe Canyon / Wapiti formations equivalent top picks and St. Mary River Formation top	stratigraphic picks	9953	8319	1.0	Recent AGS data from OFR11–08 (Hathway, 2011)	YES	undifferentiated Horseshoe Canyon Formation / Wapiti Formation / St. Mary River Formation / Belly River Group / Bearpaw Formation equivalent interval top surface	conformable gridding	Belly River Group top surface (below); built along TST	eliminate isolated polygons (no pick data) in the Caribou mountain area; merge with bedrock topography within Belly River Group base extent	YES	2.15
	stratigraphic picks		1634	1.0	AGS data							

Stratigraphic Data/Pick *(or ready to use surfaces)*	Input Data Set Type	Total Number of Filtered Input Data Points	Count Breakdown (where applicable)	Data Weight	Data Source	Data Distribution Map	Resultant Interpolated Surface(s)	Interpolation Method	Conformable Gridding Associated Surfaces	Manipulations (assume merge of eroded and non–eroded portions to make a complete surface & assume eliminate above Bedrock topography)	Uncertainty Map (STD DEV)	RMSE (m)
upper Bearpaw interval top	stratigraphic picks	8779	N/A	1.0	Recent AGS data	YES	upper Bearpaw interval top surface	convergent interpolation	N/A	Eliminate outside Strathmore Member extent	YES	1.35
Strathmore Member top	stratigraphic picks	3557	N/A	1.0	Recent AGS data	YES	Strathmore Member top surface	conformable gridding	upper Bearpaw interval top surface (above); lower Bearpaw interval top surface (below)	replace with upper Bearpaw interval top surface when above upper Bearpaw interval top surface; replace with lower Bearpaw interval top surface when below lower Bearpaw interval top surface	YES	1.33
lower Bearpaw interval top	stratigraphic picks	2641	N/A	1.0	Recent AGS data	YES	lower Bearpaw interval top surface	conformable gridding	Belly River Group top surface (below); built along TST	replace with Belly River Group top surface when below Belly River Group top surface; replace with upper Bearpaw interval base when above upper Bearpaw interval base; eliminate outside Belly River Group extent; clip to upper Bearpaw interval extent in south and east areas	YES	1.59
Belly River Group top	stratigraphic picks	14904	N/A	1.0	AGS data	YES	Belly River Group top surface	conformable gridding	Belly River Group base surface (below); built along TST	N/A	YES	3.39
						YES	Dinosaur Park Formation top surface			copy of Belly River Group top surface; clip to lower Bearpaw interval extent in north and west areas; after merging with bedrock topography surface, eliminate outside Oldman Formation noneroded extent		
Oldman Formation top	stratigraphic picks	13396	N/A	1.0	AGS data	YES	Oldman Formation top surface	conformable gridding	Belly River Group top (noneroded; above); Foremost Formation top surface (noneroded; below)	eliminate outside Foremost Formation noneroded extent; replace with Foremost Formation top surface where below Foremost Formation top surface; merge with eroded portion; replace with Belly River Group top surface when above Belly River Group top surface; replace with Oldman Formation base surface when below Oldman Formation base surface	YES	2.80
Foremost Formation top	stratigraphic picks	11827	N/A	1.0	AGS data	YES	Foremost Formation top surface	conformable gridding	Belly River Group base surface (undifferentiated Lea Park Formation / Colorado Group / Smoky Group / Fort St. John Group equivalent interval top surface; below); build along TST	clip to lower Bearpaw interval extent in north and west areas; replace with Belly River Group base surface when below Belly River Group base surface; eliminate outside Belly River Group base surface noneroded; extrapolate within boundary to fix tiny holes; Foremost Formation top surface merge to bedrock topography until Belly River Group base noneroded extent: this had issues because the bedrock topography cuts into half of the Foremost Formation top surface but doesn't cut into the other half of the surface in the northwest and southwest – a hand drawn polygon was used to clip the merged surface at a rough line where the Foremost Formation top surface stops being eroded by the bedrock topography (NW–SE line in the south part of the Foremost Formation top surface – Figure 23), the area clipped forms part of the **undifferentiated Horseshoe Canyon Formation / Wapiti Formation / St. Mary River Formation / Belly River Group / Bearpaw Formation equivalent interval**	YES	3.58

Stratigraphic Data/Pick *(or ready to use surfaces)*	Input Data Set Type	Total Number of Filtered Input Data Points	Count Breakdown (where applicable)	Data Weight	Data Source	Data Distribution Map	Resultant Interpolated Surface(s)	Interpolation Method	Conformable Gridding Associated Surfaces	Manipulations (assume merge of eroded and non–eroded portions to make a complete surface & assume eliminate above Bedrock topography)	Uncertainty Map (STD DEV)	RMSE (m)
Belly River Group base	stratigraphic picks	20350	N/A	1.0	AGS data	YES	undifferentiated Lea Park Formation / Colorado Group / Smoky Group / Fort St. John Group equivalent interval top surface; Pakowki Formation top surface	conformable gridding	base of the Fish Scales Formation (below): built along TST	copy Belly River Group base surface; eliminate inside Pakowki Formation extent; eliminate outside Milk River Formation base extent; eliminate inside isolated nondata supported polygon; merge with remaining interval above it in the Caribou, Birch, Clearhills and Pelican highs	YES	2.27
			N/A			YES	Pakowki Formation top surface	conformable gridding	base of the Fish Scales Formation (below): built along TST	copy Belly River Group base surface; eliminate outside Milk River Formation top extent		
Milk River Formation top	stratigraphic picks	25792	N/A	1.0	AGS data	YES	Milk River Formation top surface	conformable gridding	base of the Fish Scales Formation (below): built along TST	replace with Belly River Group base surface when above Belly River Group base surface; merge noneroded and eroded portions	YES	2.12
base of the Fish Scales Formation	stratigraphic picks	26203	22078	1.0	Recent AGS data	YES	base of the Fish Scales Formation	convergent interpolation	N/A	Eliminate above bedrock topography surface	YES	3.95
	stratigraphic picks		11	1.0	Recent AGS data							
	stratigraphic picks		5	1.0	Recent AGS data							
	stratigraphic picks		658	0.8	AGS data							
	stratigraphic picks		2377	0.8	AGS data							
	stratigraphic picks		1053	0.8	AGS data							
	outcrop data		21	0.8	Recent AGS data							
Viking Formation / Bow Island Formation / Peace River Formation equivalent interval top	stratigraphic picks	114409	18257	1.0	Recent AGS data	YES	Viking Formation / Bow Island Formation / Peace River Formation equivalent interval top surface	conformable gridding	base of the Fish Scales Formation (above); Mannville Group equivalent interval top surface (below)	eliminate above bedrock topography; extrapolate within boundary to fix tiny holes	YES	3.32
	stratigraphic picks		14918	0.8	AGS data							
	stratigraphic picks		19	0.8	AGS data							
	stratigraphic picks		7285	0.8	AGS data							
	stratigraphic picks		411	0.8	AGS data							
	stratigraphic picks		73519	0.8	AGS data							

Stratigraphic Data/Pick *(or ready to use surfaces)*	Input Data Set Type	Total Number of Filtered Input Data Points	Count Breakdown (where applicable)	Data Weight	Data Source	Data Distribution Map	Resultant Interpolated Surface(s)	Interpolation Method	Conformable Gridding Associated Surfaces	Manipulations (assume merge of eroded and non–eroded portions to make a complete surface & assume eliminate above Bedrock topography)	Uncertainty Map (STD DEV)	RMSE (m)
Mannville Group equivalent interval top	stratigraphic picks	140397	14704	1.0	Recent AGS data	YES	Mannville Group equivalent interval top surface	conformable gridding	base of the Fish Scales Formation surface (above); sub-Cretaceous unconformity surface (below)	merge with sub-Cretaceous unconformity surface when below sub-Cretaceous unconformity surface within main extent; merge with bedrock topography surface when below bedrock topography surface within main extent; eliminate outside Mesozoic base (interim polygon); extrapolate within boundary to fix tiny holes	YES	2.07
	stratigraphic picks		15256	0.8	AGS data							
	stratigraphic picks		89157	0.8	AGS data							
	stratigraphic picks		3344	0.8	AGS data							
	stratigraphic picks		17368	0.8	AGS data							
	stratigraphic picks		568	0.8	AGS data							
sub-Cretaceous unconformity	stratigraphic picks	107467	17916	1.0	Recent AGS data	YES	sub-Cretaceous unconformity surface	convergent interpolation	N/A	eliminate below Precambrian top surface; eliminate above bedrock topography surface; replace with bedrock topography surface in polygons where the bedrock topography surface has eroded the sub-Cretaceous unconformity surface	YES	3.35
	stratigraphic picks		89551	0.8	AGS/AER data							
Banff Formation top	stratigraphic picks	6055	N/A	1.0	AGS/AER data	YES	Banff Formation top surface	conformable gridding	Wabamun top surface (noneroded; below); built along TST	eliminate above sub-Cretaceous unconformity surface; replace with sub-Cretaceous unconformity surface inside main extent when sub-Cretaceous unconformity surface has eroded down into the Banff Formation top surface	YES	2.39
Wabamun Group top	stratigraphic picks	13961	13717	1.0	AGS/AER data	YES	Wabamun Group top surface	convergent interpolation	N/A	eliminate above sub-Cretaceous unconformity surface	YES	2.11
	sampled modified lineament		244	0.6	Modified from Okulitch and Fallas (2007)							
Winterburn Group top	stratigraphic picks	13084	12981	1	AGS/AER data	YES	Winterburn Group top surface	conformable gridding	Wabamun Group top surface (noneroded; above); Woodbend Group top surface (noneroded; below)	eliminate above sub-Cretaceous unconformity surface; eliminate isolated polygons near Peace River area	YES	2.42
	sampled modified lineament		44	0.6	Modified from Okulitch and Fallas (2007)							
	sampled modified lineament		59	0.4	Modified from Halbertsma (1994)							

Stratigraphic Data/Pick *(or ready to use surfaces)*	Input Data Set Type	Total Number of Filtered Input Data Points	Count Breakdown (where applicable)	Data Weight	Data Source	Data Distribution Map	Resultant Interpolated Surface(s)	Interpolation Method	Conformable Gridding Associated Surfaces	Manipulations (assume merge of eroded and non–eroded portions to make a complete surface & assume eliminate above Bedrock topography)	Uncertainty Map (STD DEV)	RMSE (m)
Woodbend Group top	stratigraphic picks	12053	11987	1	AGS/AER data	YES	Woodbend Group top surface	conformable gridding	Wabamun Group top surface (noneroded; above); built along TST	eliminate above sub-Cretaceous unconformity surface; eliminate outside main boundary polygon; merge with sub-Cretaceous unconformity surface when sub-Cretaceous unconformity surface eroded into surface inside main polygon; replace with Waterways Formation top surface when below Waterways Formation top surface; eliminate below Precambrian top surface; eliminate isolated polygons near Peace River area	YES	10.93
	sampled modified lineament		66	0.6	Modified from Okulitch and Fallas (2007)							
Duvernay Formation top	stratigraphic picks	3223	1525	1.0	Recent AGS data (extent modified from Lyster et al. (2017)	YES	Duvernay Formation top surface	conformable gridding	Waterways Formation top (complete; below); built along TST	replace with Waterways Formation top surface when below Waterways Formation top surface; replace with Woodbend Group top surface when above Woodbend Group top surface; eliminate when above Precambrian top surface	YES	2.65
	stratigraphic picks		1698	0.8	AER data							
Leduc Formation top	stratigraphic picks	971	676	1	Recent AGS data	YES	Leduc Formation top surface	conformable gridding	Woodbend Group top surface (complete; above); Waterways Formation top (complete) surface (below)	replace with Waterways Formation top surface when below Waterways Formation top surface; replace with Woodbend Group top surface when above Woodbend Group top surface; eliminate where Waterways Formation doesn't exist	YES	15.19
	stratigraphic picks		295	0.8	AER data							
Cooking Lake Formation top	stratigraphic picks	274	55	1.0	Recent AGS data	YES	Cooking Lake Formation top surface	conformable gridding	Waterways Formation top (complete) surface (below) ; build along TST	eliminate to Cooking Lake Formation extent/geo-edge; replace with Woodbend Group top surface when above Woodbend Group top surface	YES	1.67
	stratigraphic picks		219	0.8	AER data							
Majeau Lake Formation top	stratigraphic picks	2768	1258	1.0	Recent AGS data	YES	Majeau Lake Formation top surface	conformable gridding	Duvernay Formation top surface (above); Waterways Formation top surface (complete; below)	replace with Waterways Formation top surface when below Waterways Formation top surface; replace with Duvernay Formation top surface when above Duvernay Formation top surface; eliminate to Majeau Lake Formation extent/geo-edge	YES	2.77
	stratigraphic picks		1510	0.8	AER data							
Beaverhill Lake Group top (BHLK)	stratigraphic picks	12881	5661	1	Recent AGS data	See Waterways Formation top	Beaverhill Lake Group top surface	convergent interpolation	N/A	eliminate above sub-Cretaceous unconformity surface; merge with sub-Cretaceous unconformity surface until Waterways Formation base extent polygon; eliminate below Precambrian top surface; eliminate isolated polygons with no data; eliminate outside Waterways Formation top extent; replace Waterways Formation top surface with Waterways Formation base surface when top is below base	See Waterways Formation	See Water ways Format ion
	stratigraphic picks		6968	0.8	AER data							
	sampled draft AGS lineament		252	0.6	AGS lineament data							

Stratigraphic Data/Pick *(or ready to use surfaces)*	Input Data Set Type	Total Number of Filtered Input Data Points	Count Breakdown (where applicable)	Data Weight	Data Source	Data Distribution Map	Resultant Interpolated Surface(s)	Interpolation Method	Conformable Gridding Associated Surfaces	Manipulations (assume merge of eroded and non–eroded portions to make a complete surface & assume eliminate above Bedrock topography)	Uncertainty Map (STD DEV)	RMSE (m)
Waterways Formation top	see BHLK	see BHLK	see BHLK	see BHLK	see BHLK	YES	see BHLK	see BHLK	see BHLK		YES	3.91
Swan Hills / Slave Point formations interval top	stratigraphic picks	15838	6923	1.0	Recent AGS data	YES	Swan Hills / Slave Point formations interval top surface	conformable gridding	Waterways Formation top surface (noneroded; above); Fort Vermilion Formation top (below)	eliminate above sub-Cretaceous unconformity surface; eliminate outside Beaverhill Lake Group base surface; replace with Fort Vermilion Formation top surface when below Fort Vermilion Formation top surface; replace with Beaverhill Lake Group base surface where below Beaverhill Lake Group base surface; replace with Beaverhill Lake Group top surface where above Beaverhill Lake Group top surface; eliminate inside isolated Beaverhill Lake Group top polygons near Peace River area; merge with sub-Cretaceous unconformity surface in isolated polygons where sub-Cretaceous unconformity surface has eroded into the surface (northeast area)	YES	7.02
	stratigraphic picks		8915	0.8	AER data							
Fort Vermilion Formation top	stratigraphic picks	7319	N/A	1.0	Recent AGS data	YES	Fort Vermilion Formation top surface	conformable gridding	Beaverhill Lake Group top surface (above); Beaverhill Lake Group base surface (below)	eliminate above sub-Cretaceous unconformity surface; issue in northeast due to thinning – eliminate outside Beaverhill Lake Group base extent; merge with Beaverhill Lake Group base where there are holes; merge with sub-Cretaceous unconformity surface in isolated polygons where sub-Cretaceous unconformity surface has eroded into the surface	YES	2.31
Elk Point Group top	stratigraphic picks	14225	5989	1.0	Recent AGS data	YES	Elk Point Group top surface	convergent interpolation	N/A	replace where below Precambrian top surface; replace with sub-Cretaceous unconformity surface and bedrock topography surface when above them; eliminate where there are isolated polygons (with no data basis) east of the Precambrian top original intersection; eliminate isolate polygons with no data in Peace River area	YES	2.56
	stratigraphic picks		8082	0.8	AER data							
	sampled modified lineament		154	0.6	Sampled Watt Mountain lineament from Prior et al. (2013)							

Stratigraphic Data/Pick *(or ready to use surfaces)*	Input Data Set Type	Total Number of Filtered Input Data Points	Count Breakdown (where applicable)	Data Weight	Data Source	Data Distribution Map	Resultant Interpolated Surface(s)	Interpolation Method	Conformable Gridding Associated Surfaces	Manipulations (assume merge of eroded and non–eroded portions to make a complete surface & assume eliminate above Bedrock topography)	Uncertainty Map (STD DEV)	RMSE (m)
Precambrian top	stratigraphic picks	7218	2549	1.0	Recent AGS data from Hauck and Corlett (2017)	YES	Precambrian top surface	convergent interpolation	N/A	replace with bedrock topography surface when above bedrock topography surface; replace with Elk Point Group top surface when above it	YES	7.32
	stratigraphic picks		6	1.0	Recent AGS data from Hauck and Corlett (2017)							
	stratigraphic picks		3	0.8	AGS/AER data							
	stratigraphic picks		3665	0.8	AGS/AER data							
	sampled modified lineament		995	0.6	Sampled Phanerozoic Limit lineament from Prior et al. (2013)							
Total Data/Pick Count		620812										

Appendix 3 − Input Filtered Data Distribution

Paskapoo Formation base

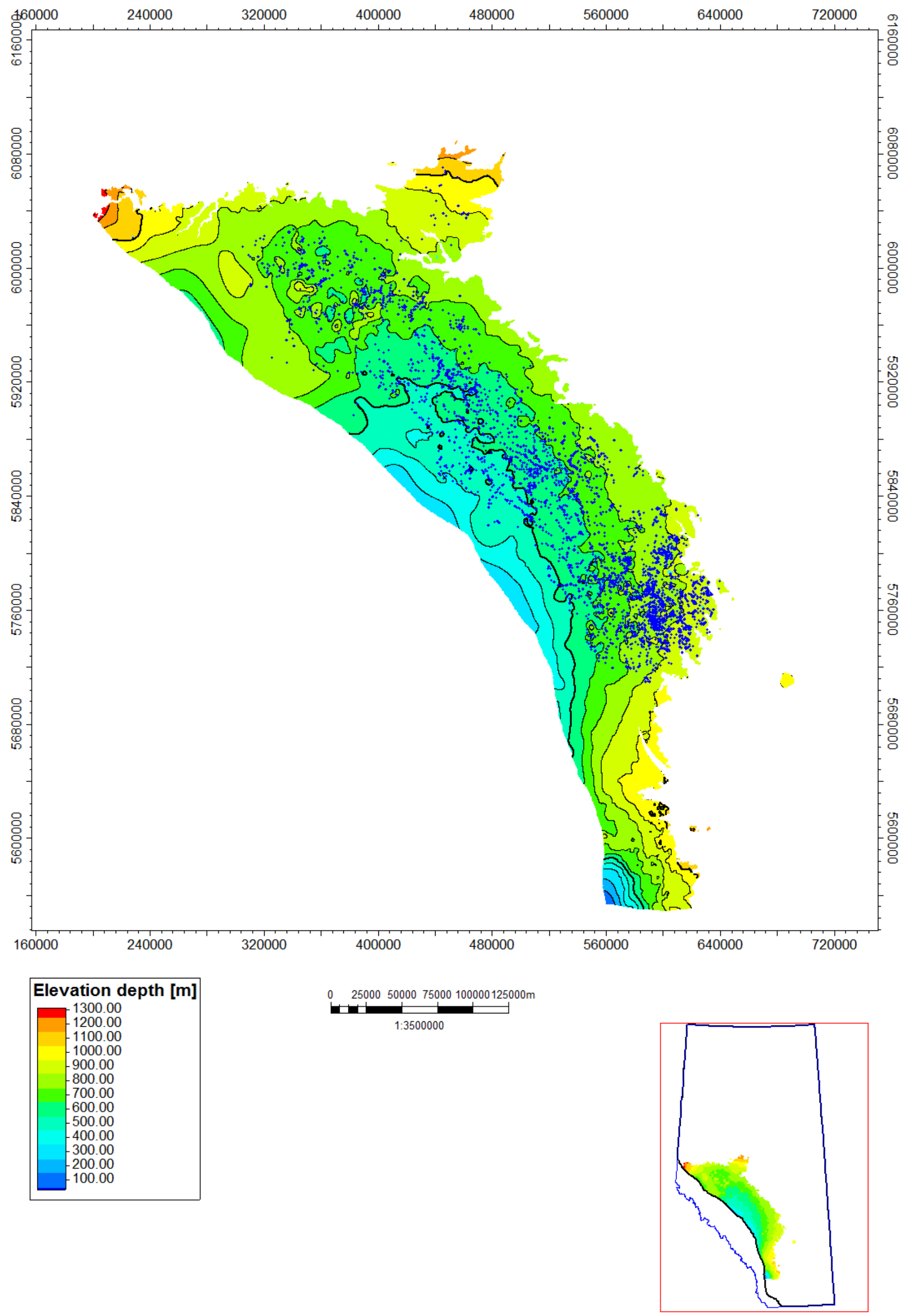


Figure 14. Data distribution (blue points) and structure map for the interpolated surface of the Paskapoo Formation base.

Battle Formation top

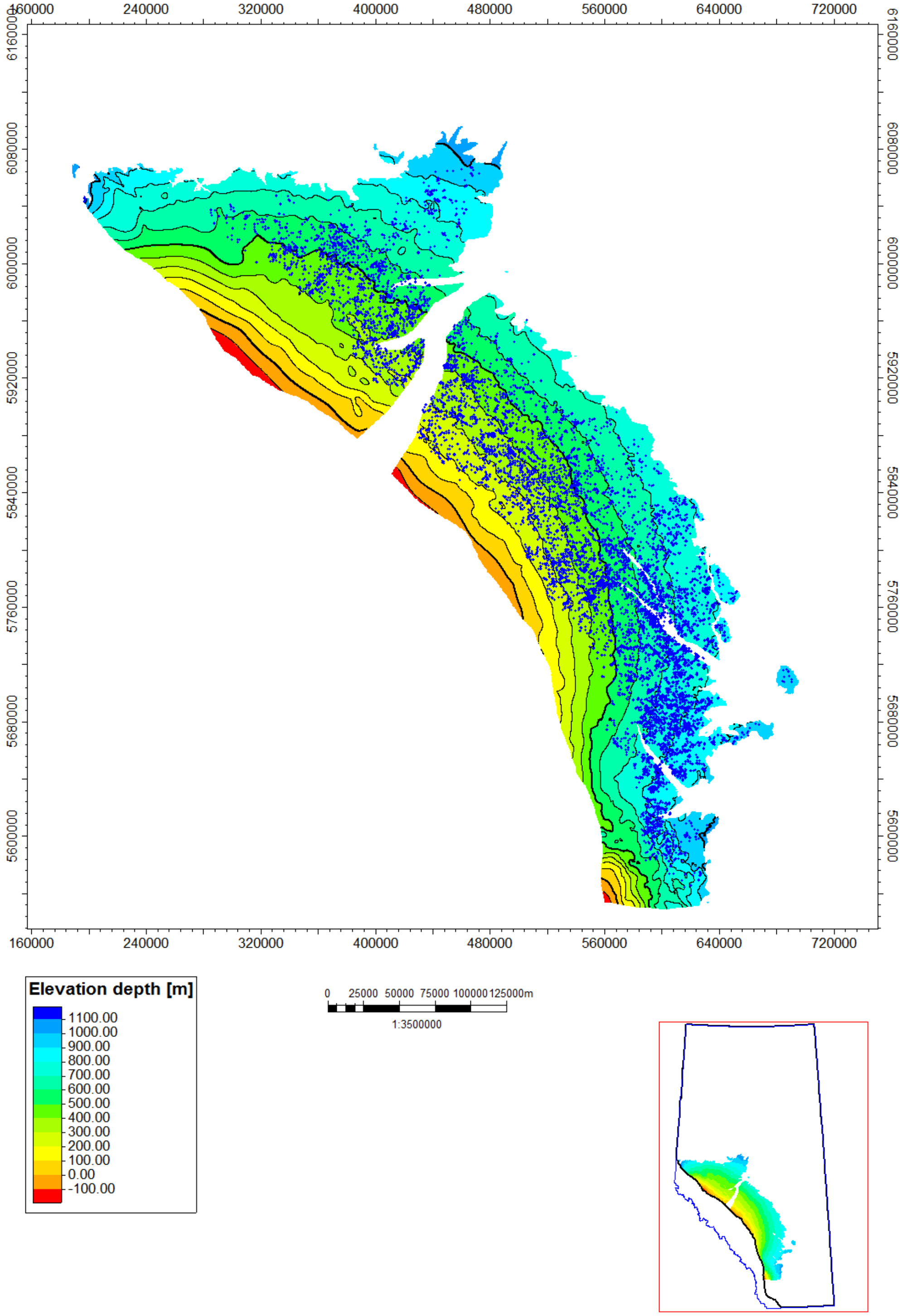


Figure 15. Data distribution (blue points) and structure map for the Battle Formation top interpolated surface.

Undifferentiated Horseshoe Canyon Formation / Wapiti Formation / St. Mary River Formation / Belly River Group / Bearpaw Formation equivalent interval top

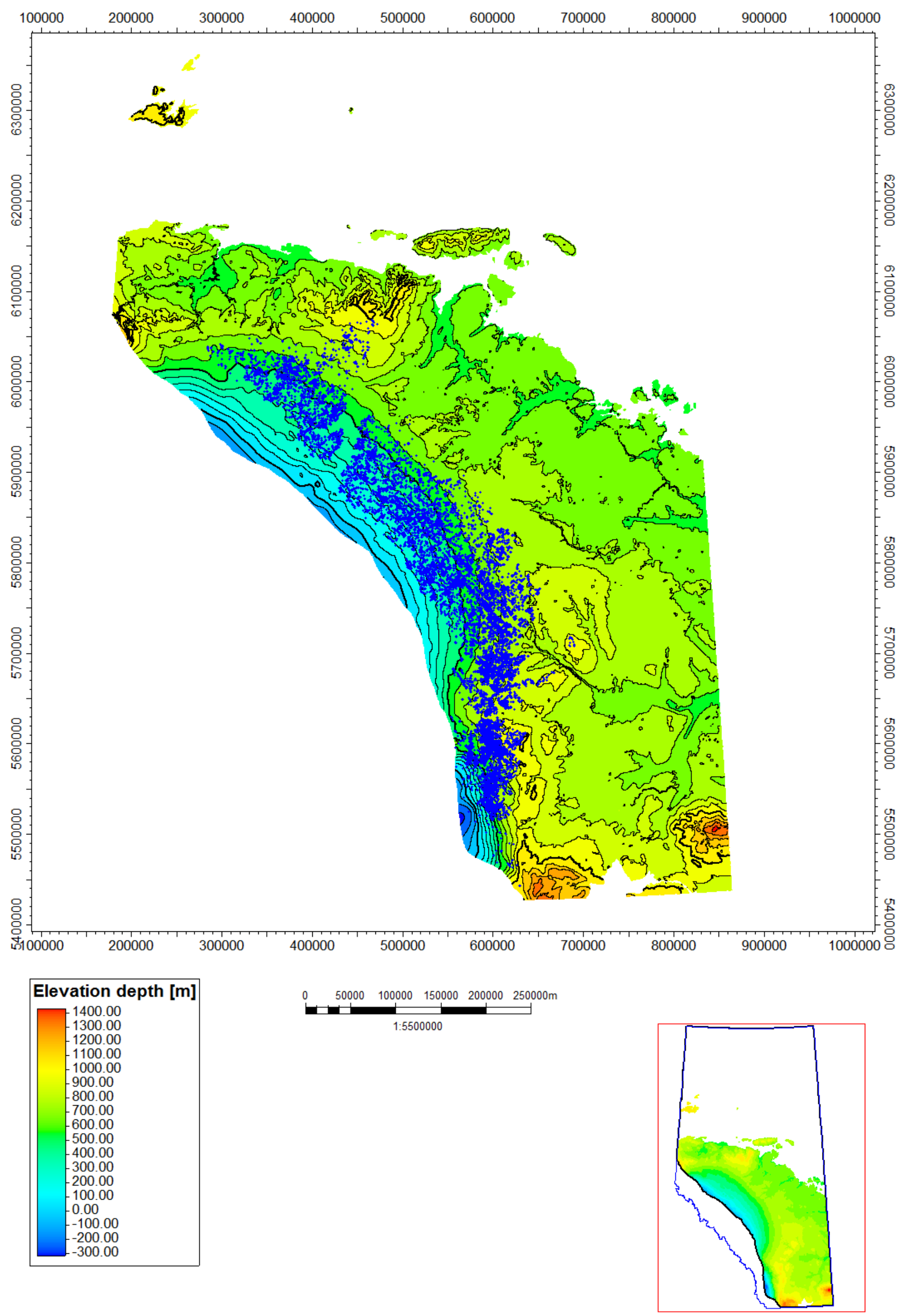


Figure 16. Data distribution (blue points) and structure map for the undifferentiated Horseshoe Canyon Formation / Wapiti Formation / St. Mary River Formation / Belly River Group / Bearpaw Formation equivalent interval top interpolated surface.

Upper Bearpaw interval top

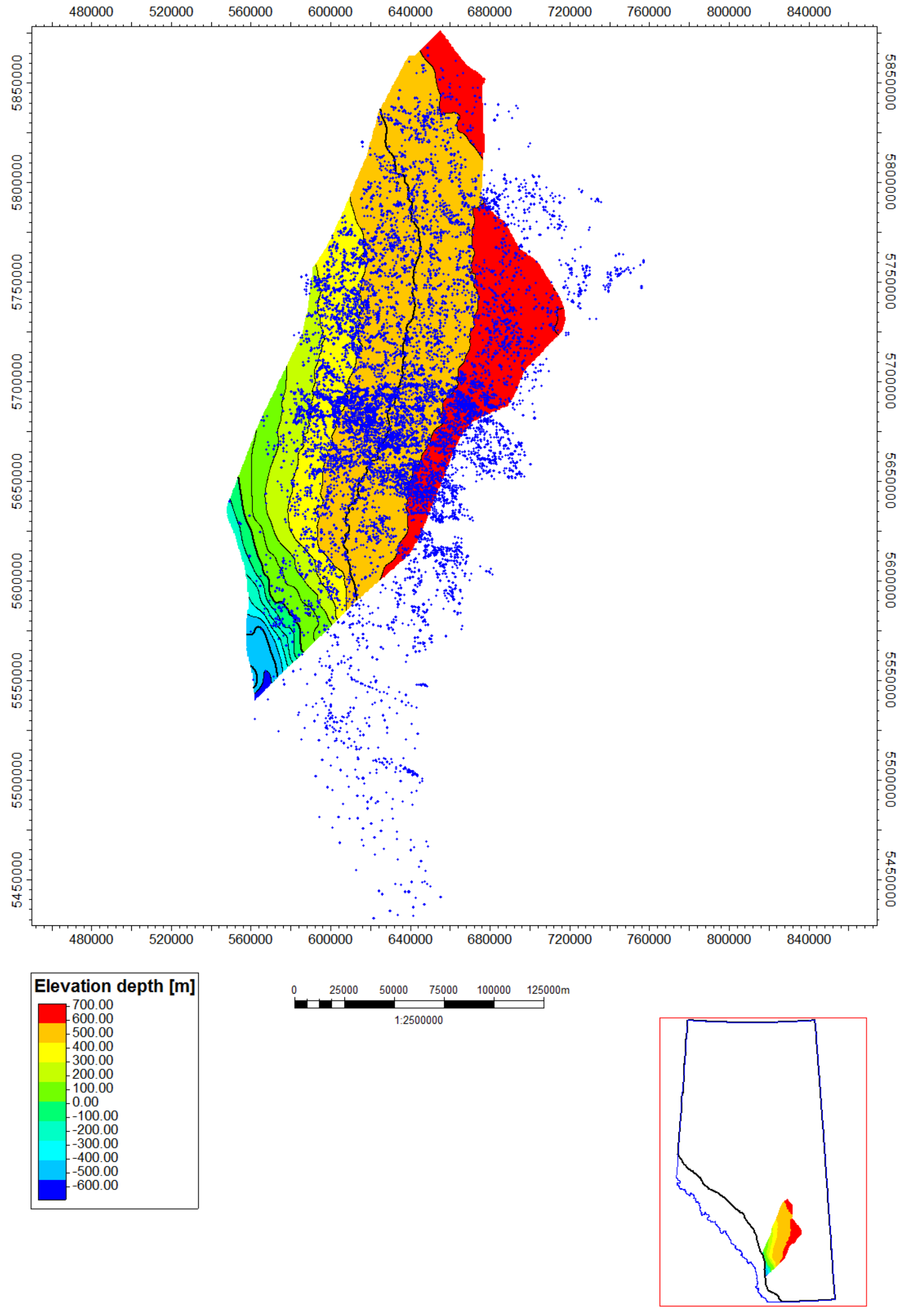


Figure 17. Data distribution (blue points) and structural map for the upper Bearpaw interval top interpolated surface.

Strathmore Member top

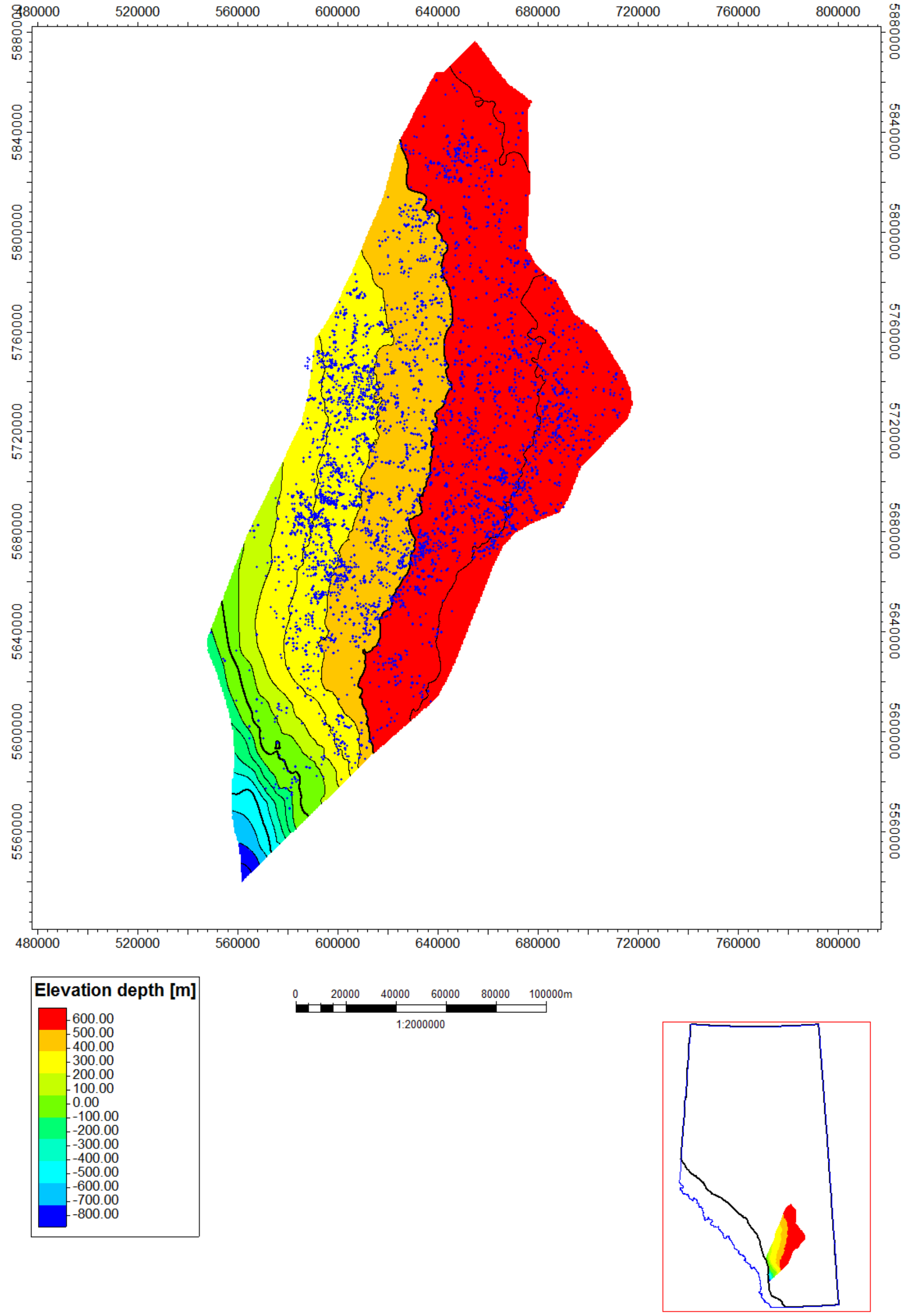


Figure 18. Data distribution (blue points) and structural map for the Strathmore Member top interpolated surface.

Lower Bearpaw interval top

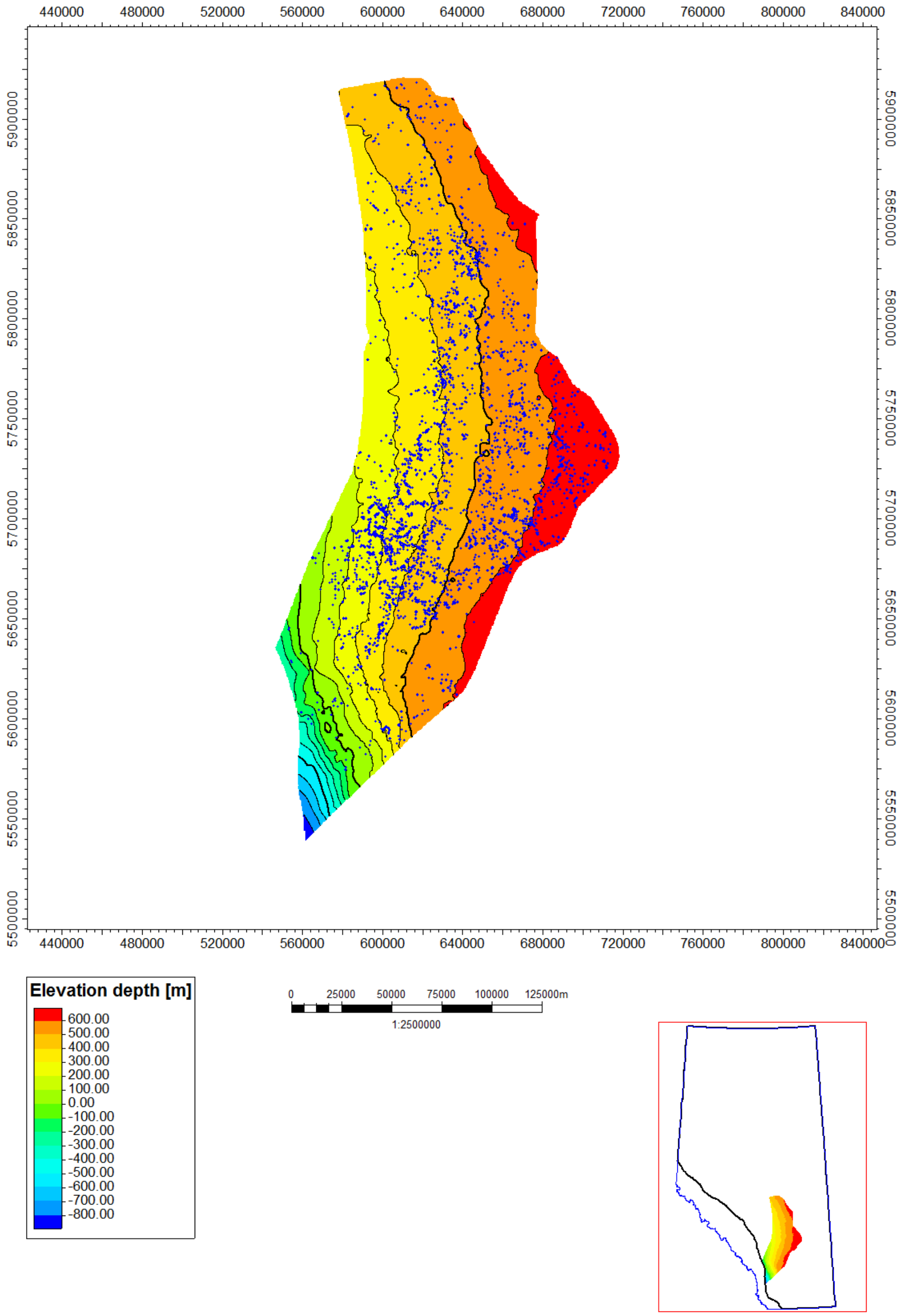


Figure 19. Data distribution (blue points) and structural map for the lower Bearpaw interval top interpolated surface.

Belly River Group top

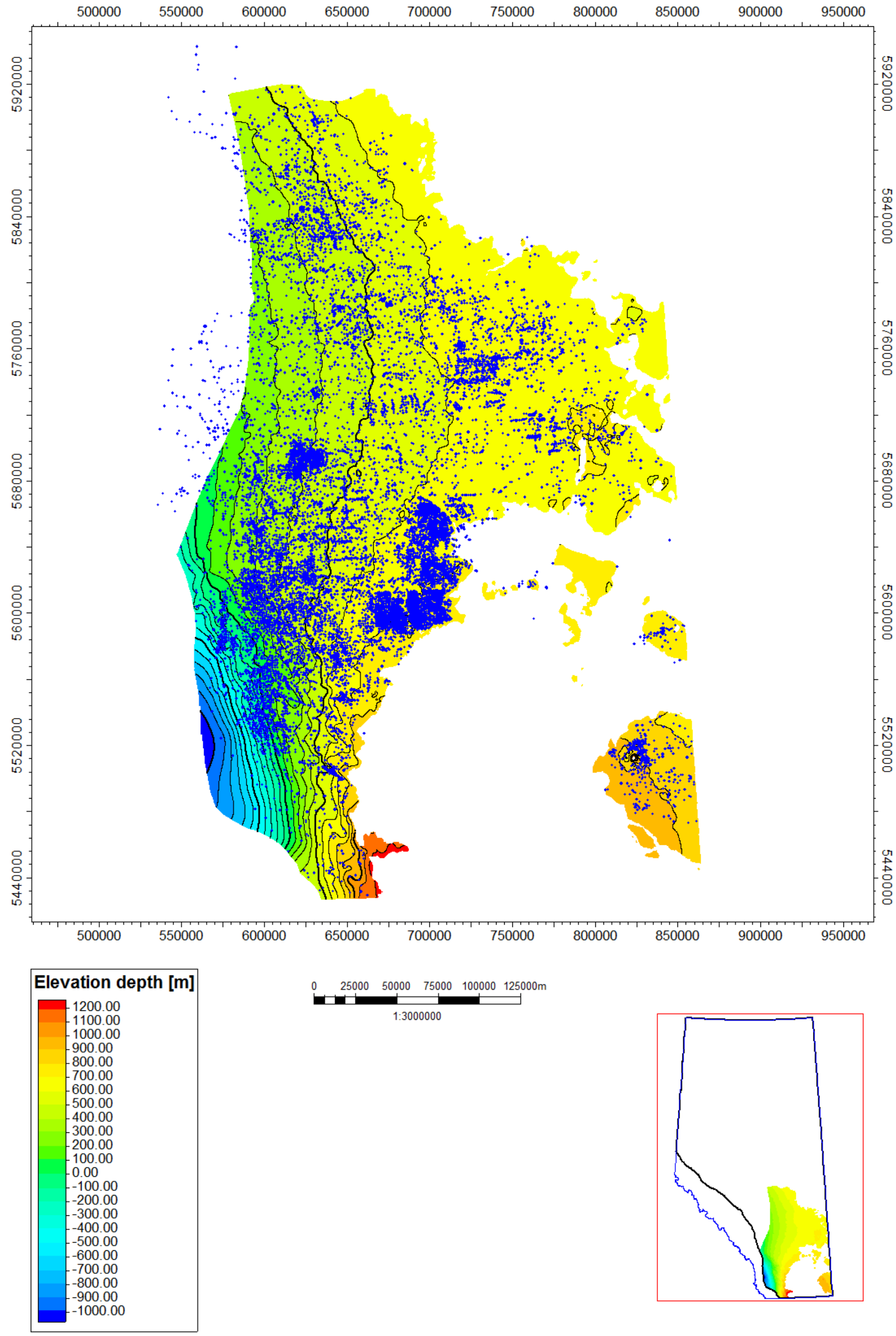


Figure 20. Data distribution (blue points) and structural map for the Belly River Group top interpolated surface.

Dinosaur Park Formation top

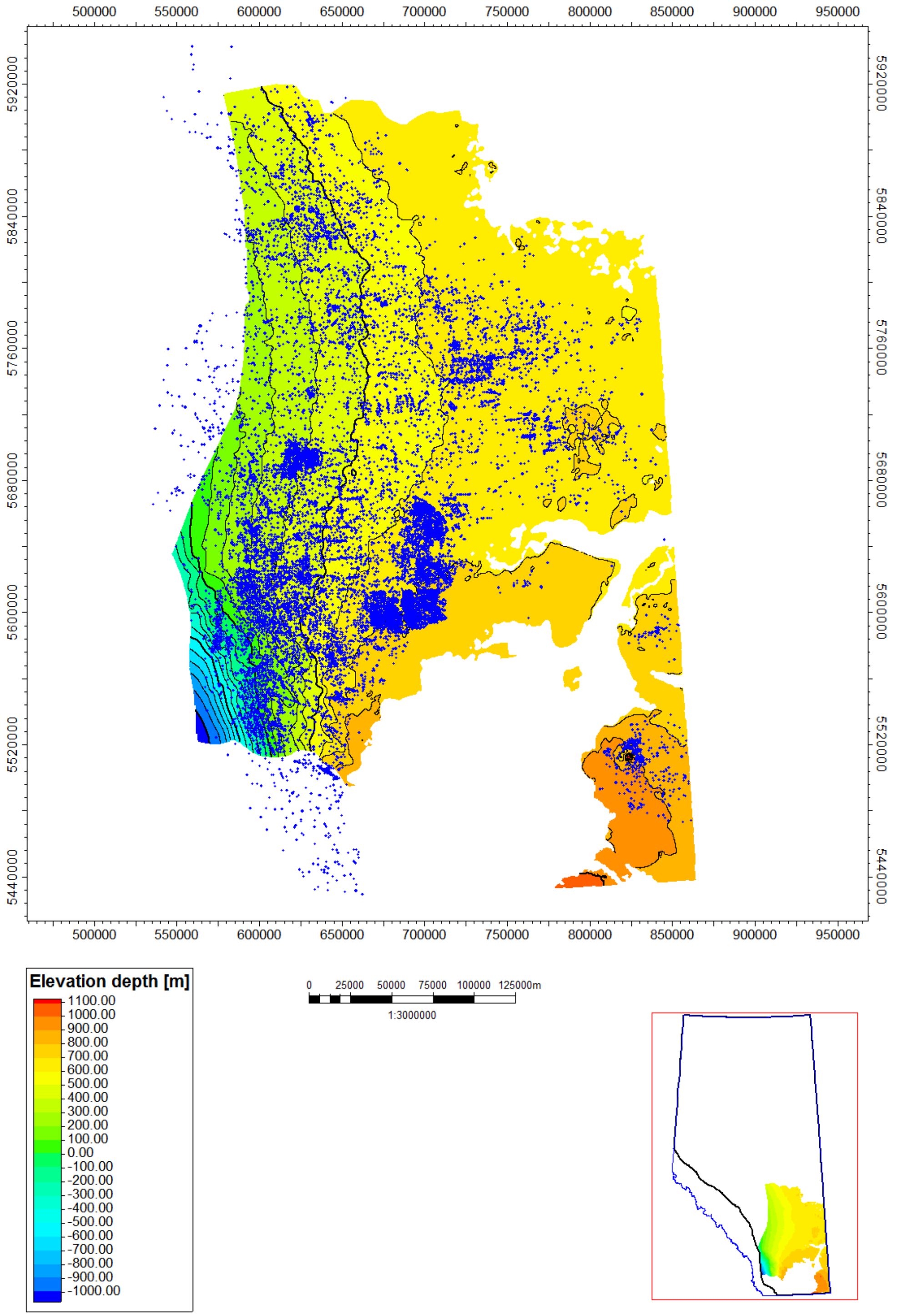


Figure 21. Data distribution (blue points) and structural map for the Dinosaur Park Formation top interpolated surface (all Belly River top data points are shown).

Oldman Formation top

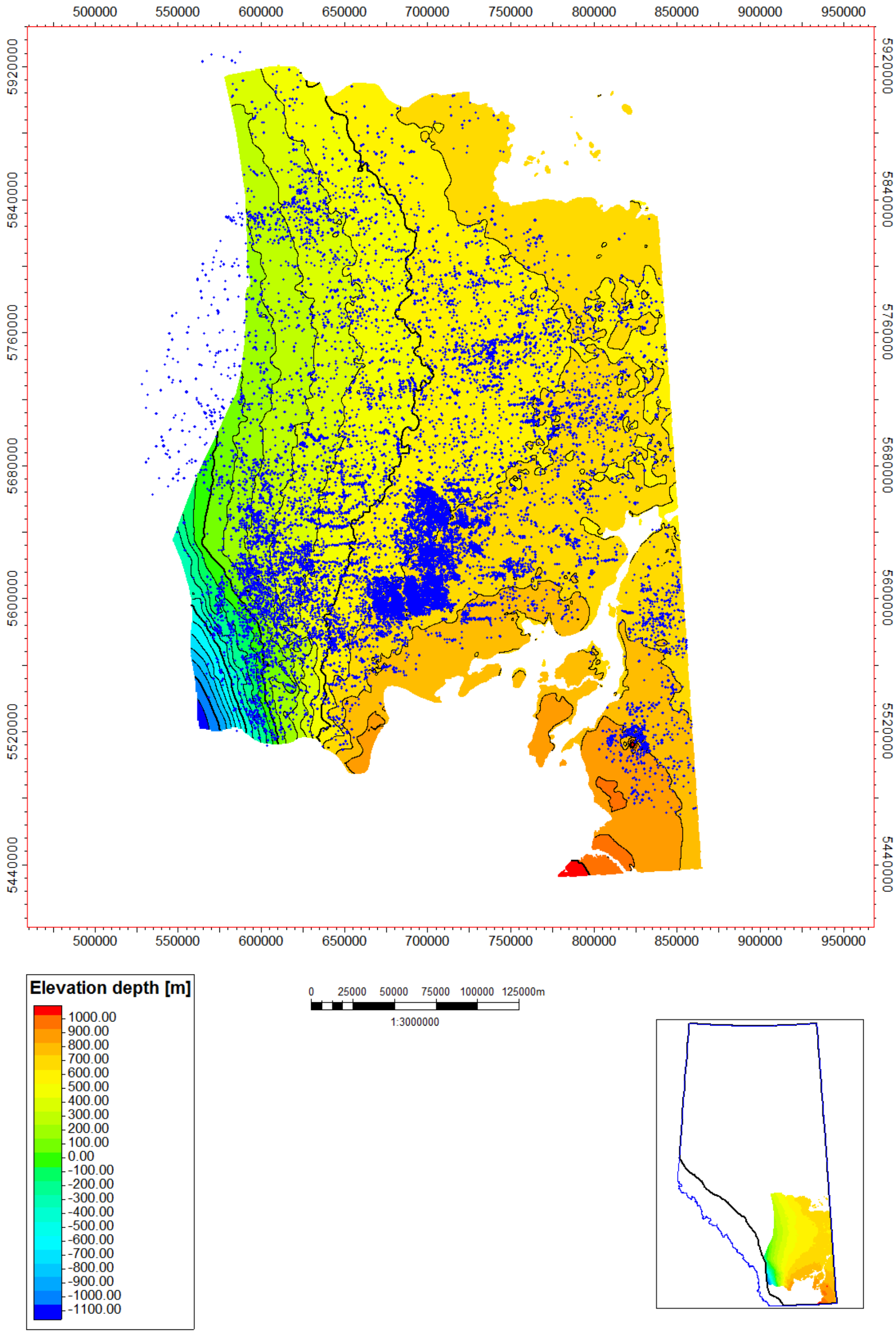


Figure 22. Data distribution (blue points) and structural map for the Oldman Formation top interpolated surface.

Foremost Formation top

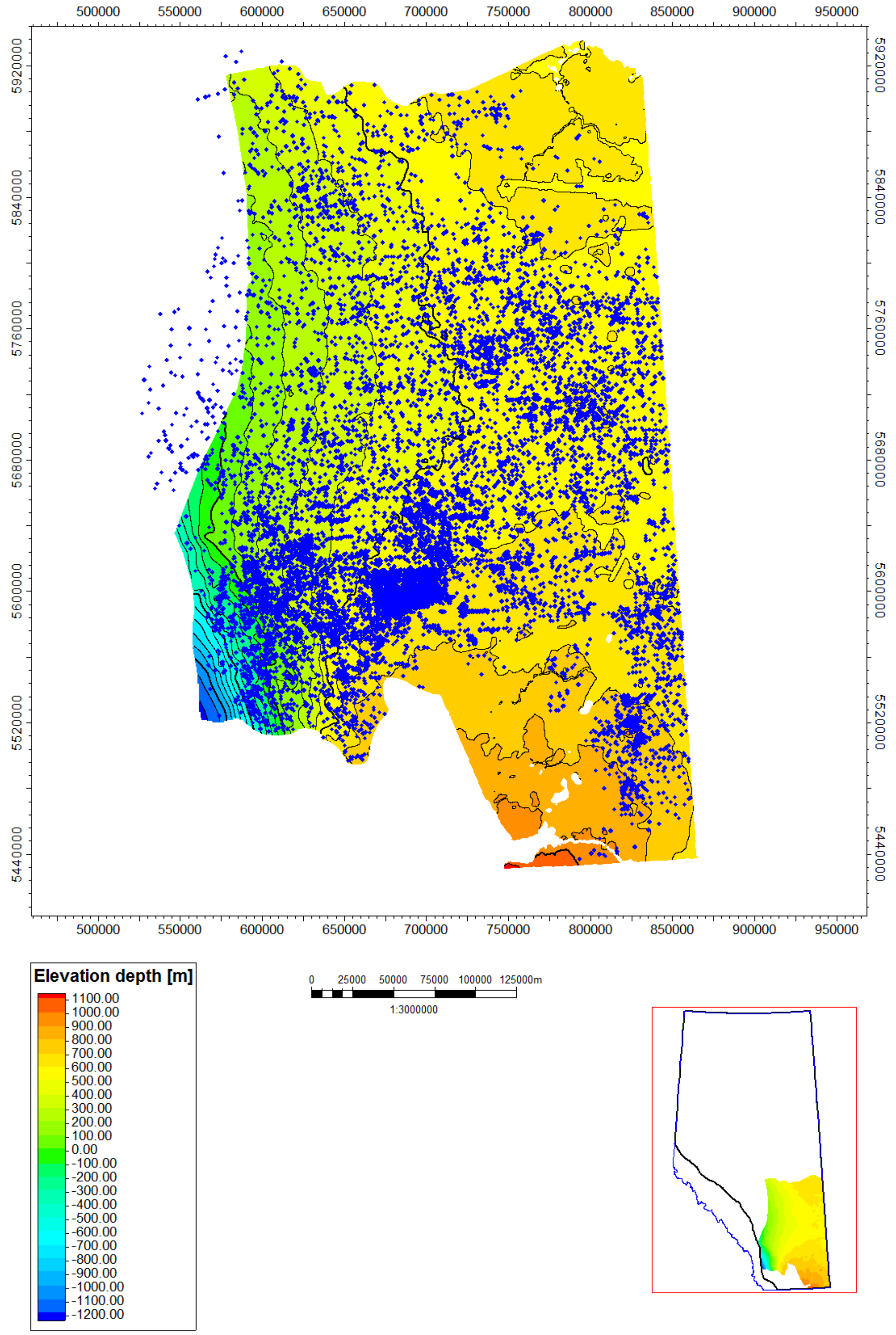


Figure 23. Data distribution (blue points) and structural map for the Foremost Formation top interpolated surface.

Belly River Group base (undifferentiated Lea Park Formation / Colorado Group / Smoky Group / Fort St. John Group equivalent interval top surface)

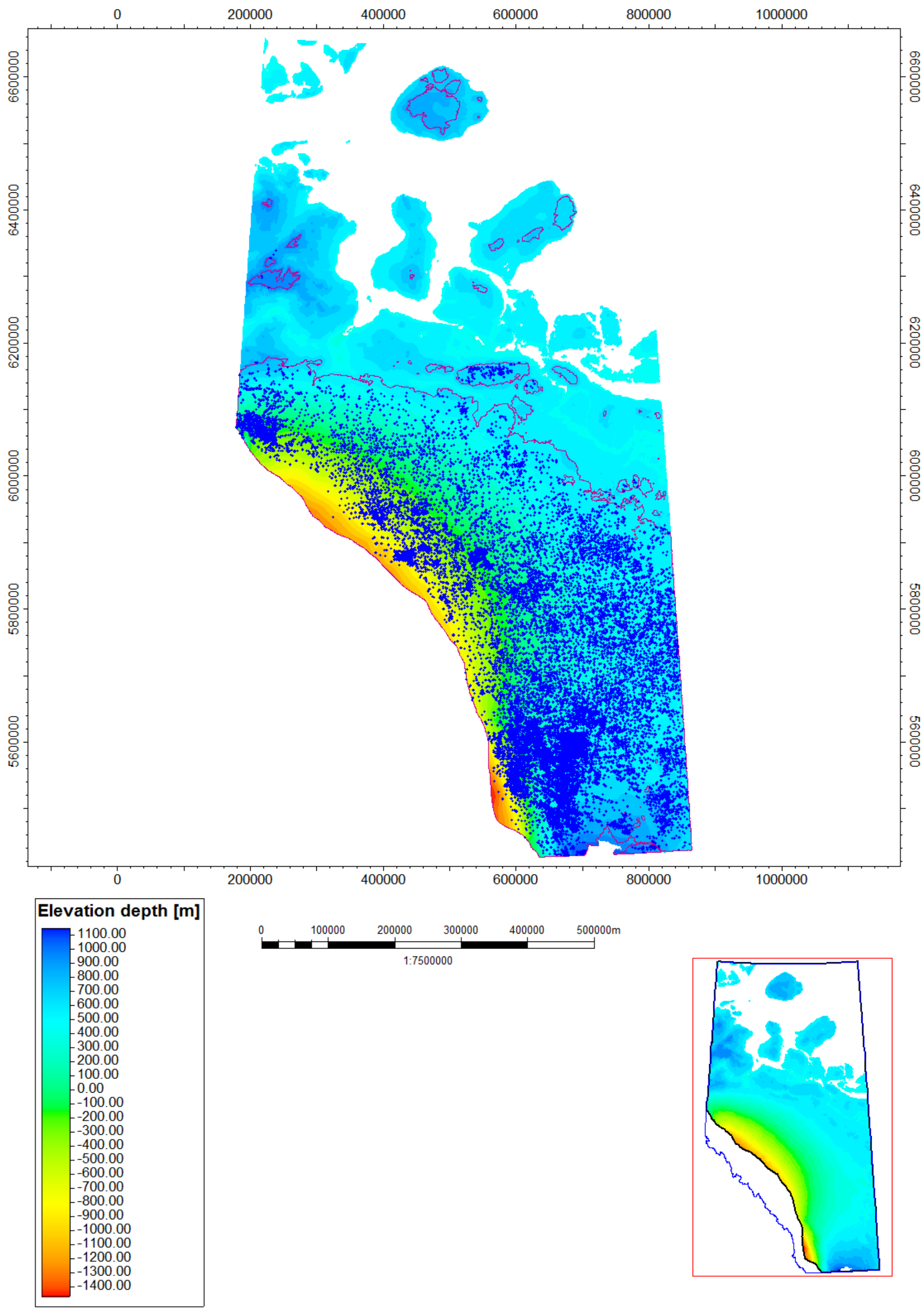


Figure 24. Data distribution (blue points) and structural map for the Belly River Group base (undifferentiated Lea Park Formation / Colorado Group / Smoky Group / Fort St. John Group equivalent interval top surface / Pakowki Formation top surface); the red line delineates the eroded versus noneroded extents) interpolated surface.

Milk River Formation top

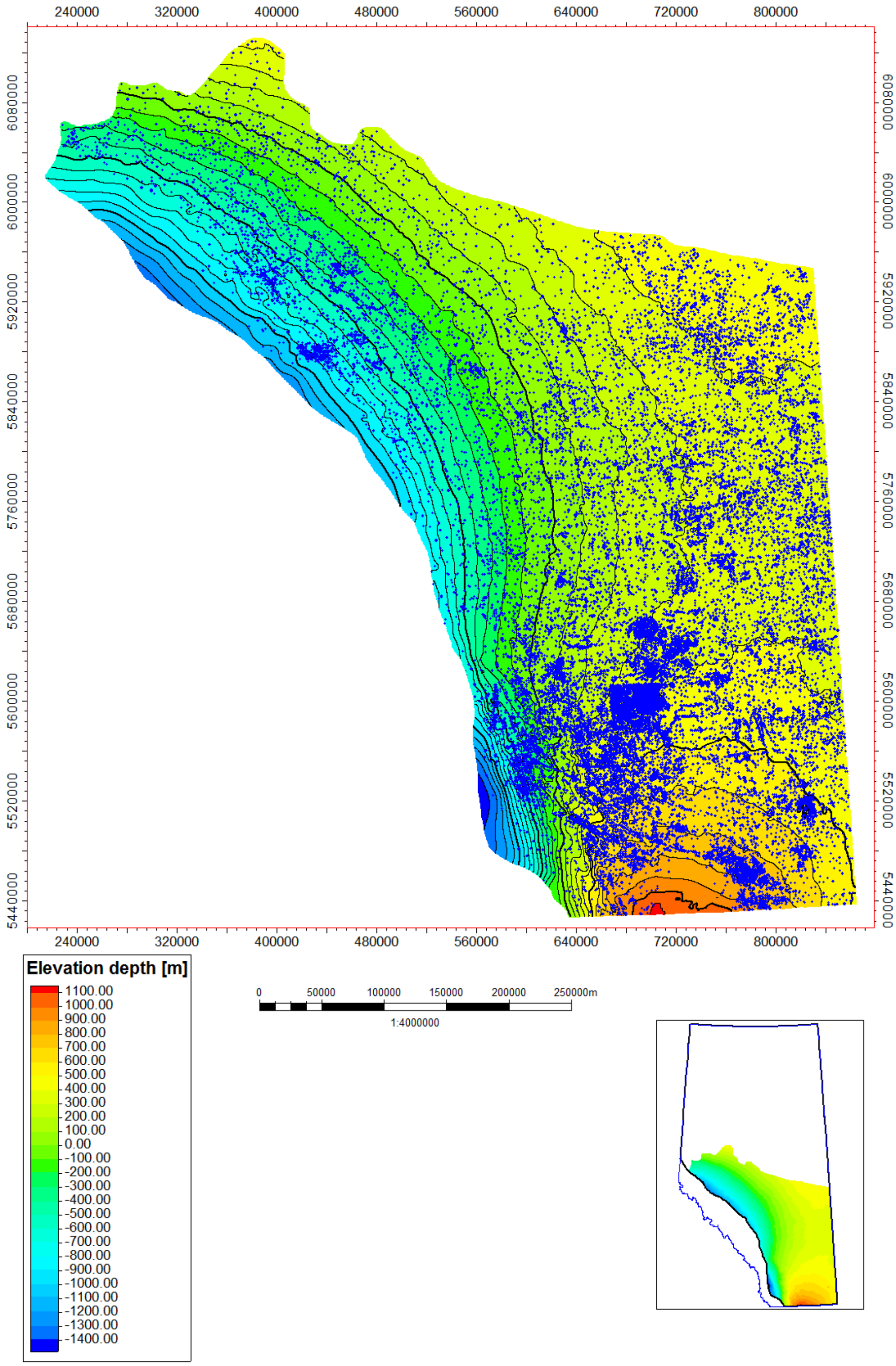


Figure 25. Data distribution (blue points) and structural map for the Milk River Formation top interpolated surface.

Base of the Fish Scales Formation top

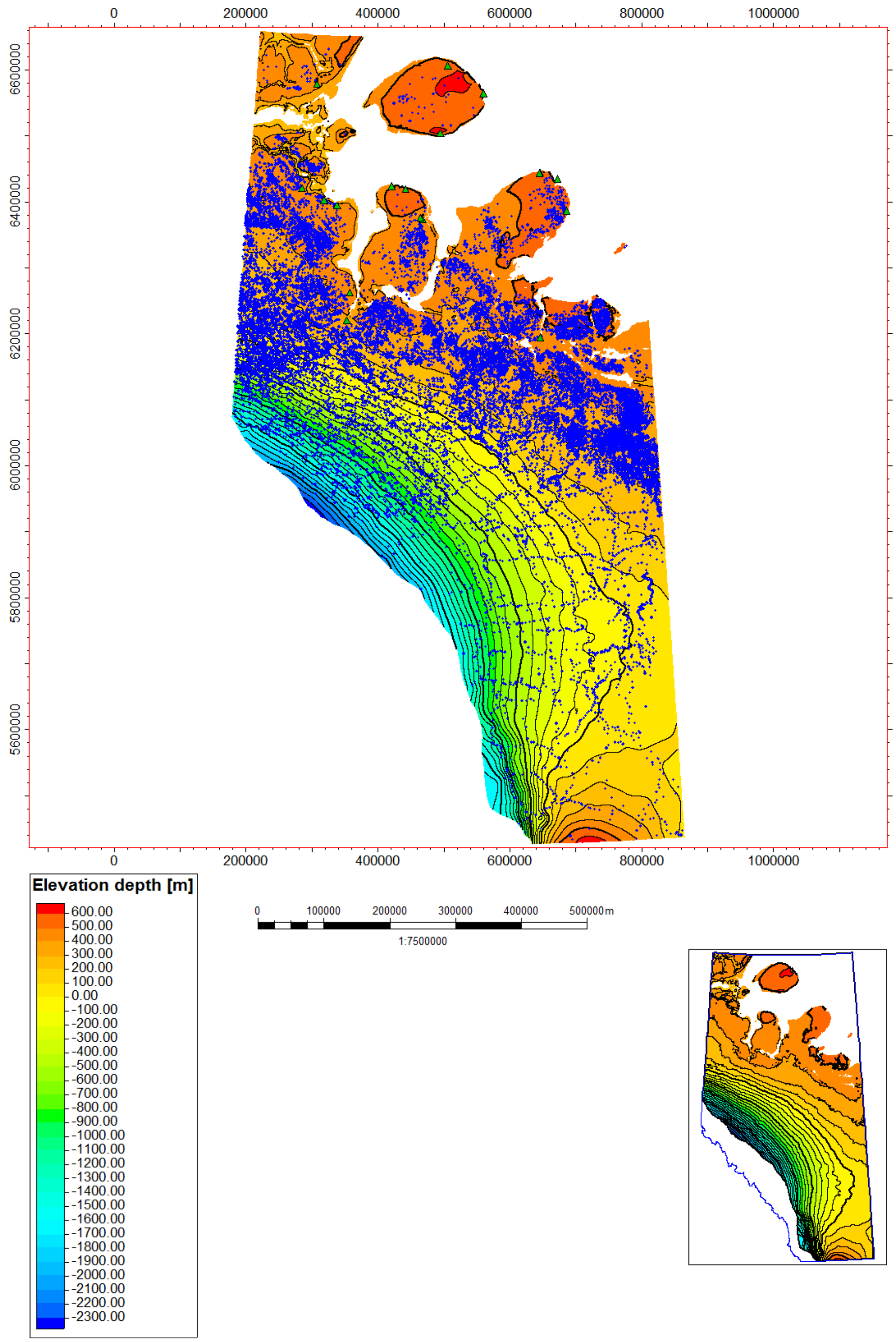


Figure 26. Data distribution (blue points = stratigraphic picks; green triangles = outcrop data) and structural map for base of the Fish Scales Formation top interpolated surface.

Viking Formation / Bow Island Formation / Peace River Formation equivalent interval top

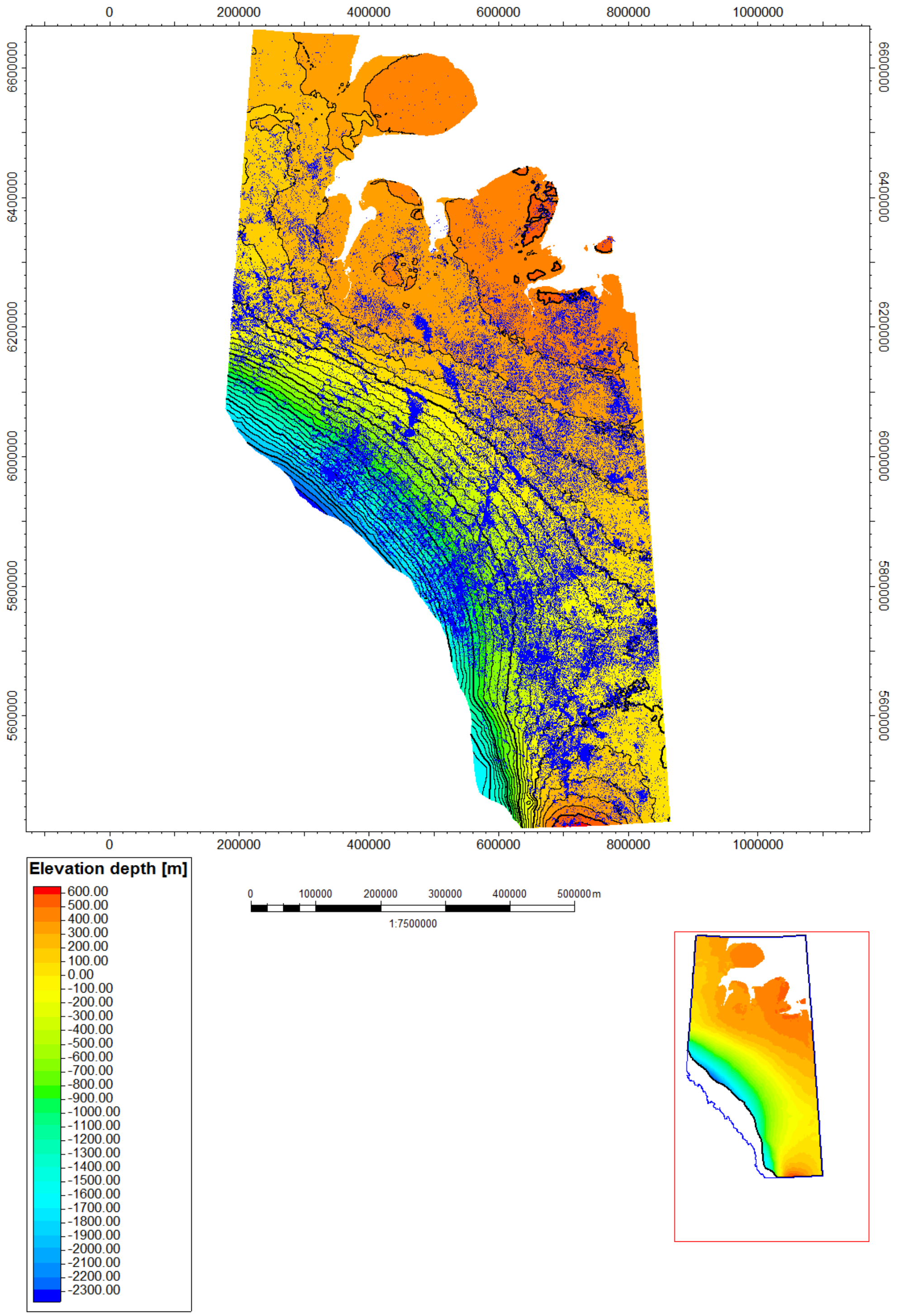


Figure 27. Data distribution (blue points) and structural map for the Viking Formation / Bow Island Formation / Peace River Formation equivalent interval top interpolated surface.

Mannville Group equivalent interval top

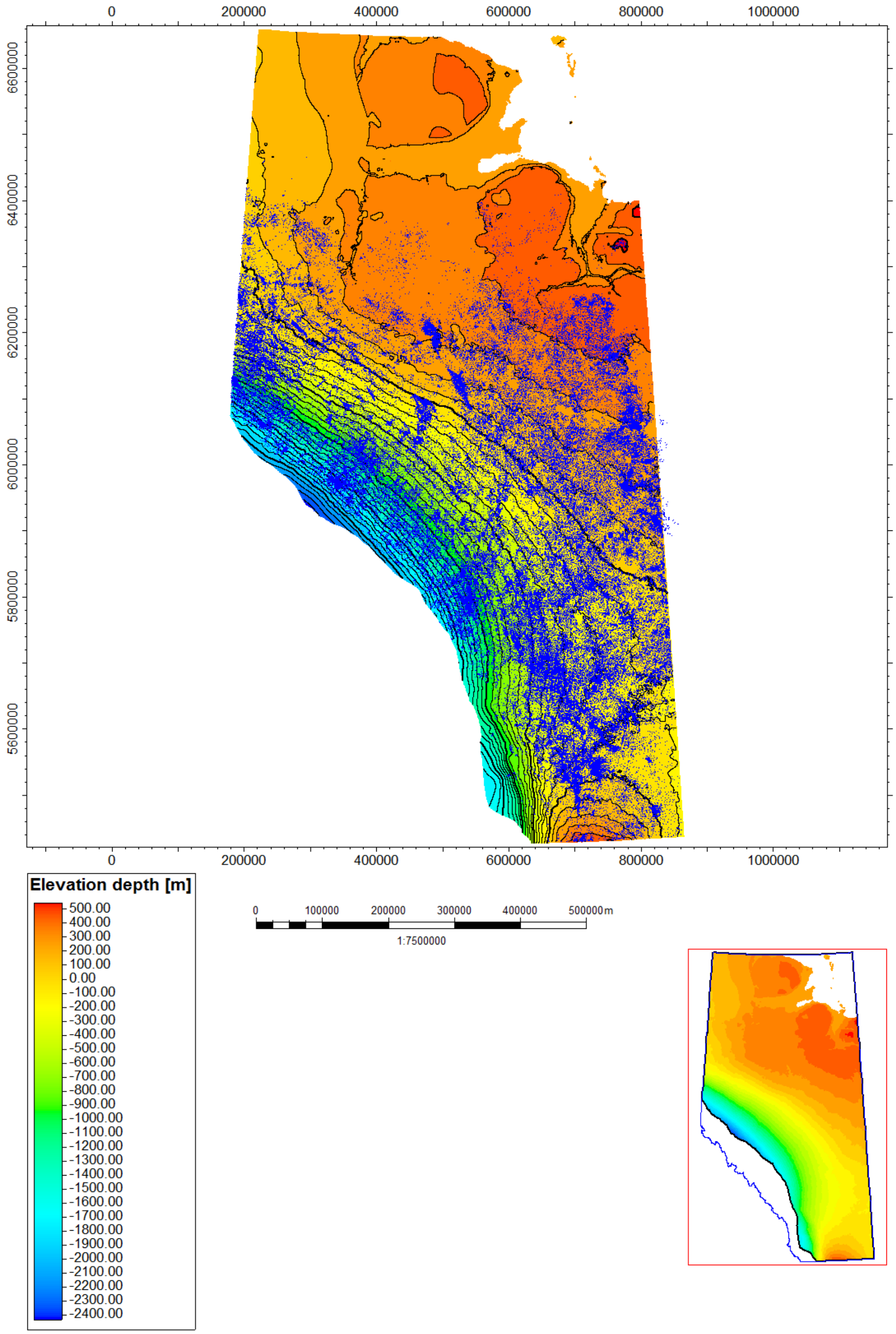


Figure 28. Data distribution (blue points) and structural map for the Mannville Group equivalent interval top interpolated surface.

Sub-Cretaceous unconformity

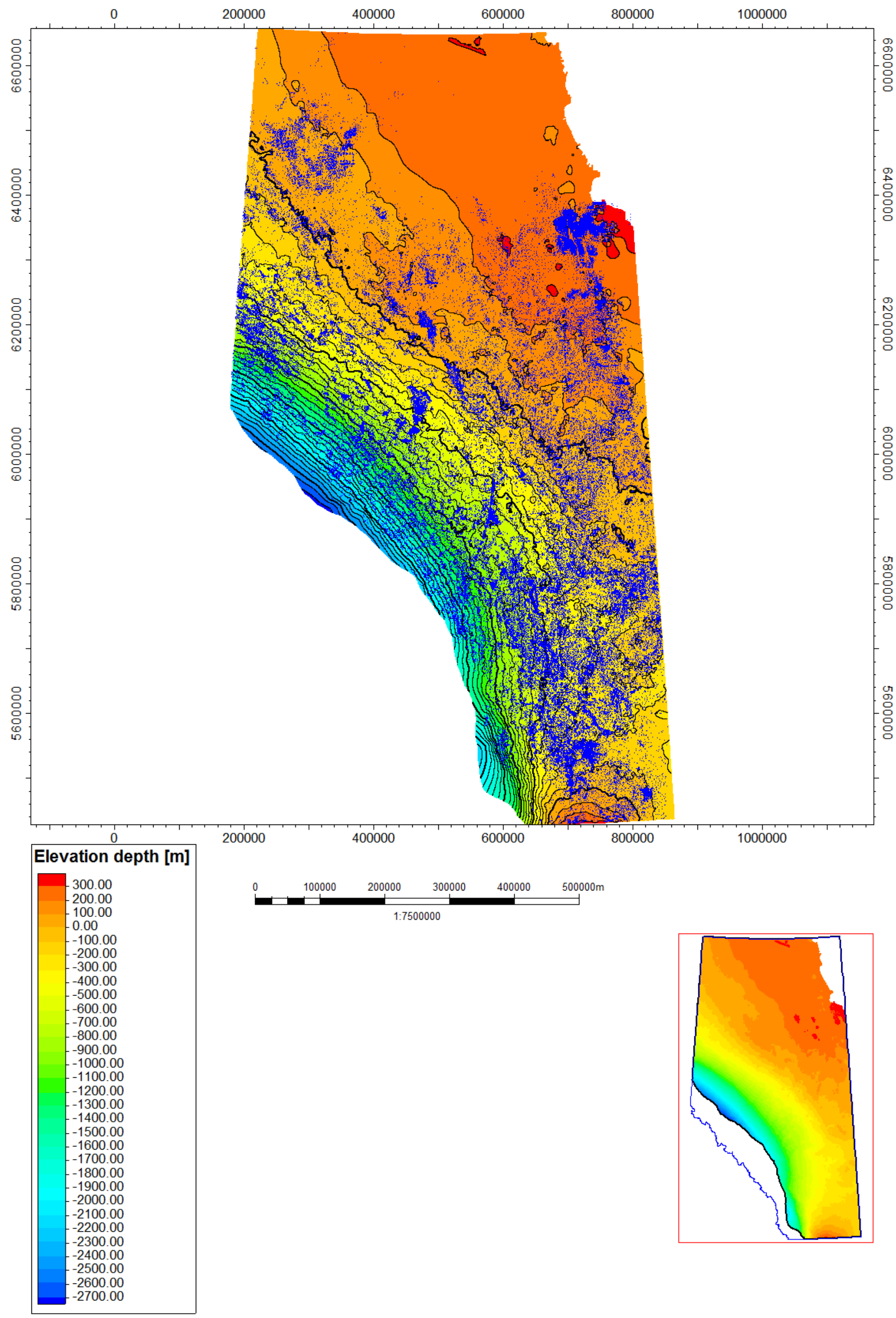


Figure 29. Data distribution (blue points) and structural map for sub-Cretaceous unconformity interpolated surface.

Banff Formation top

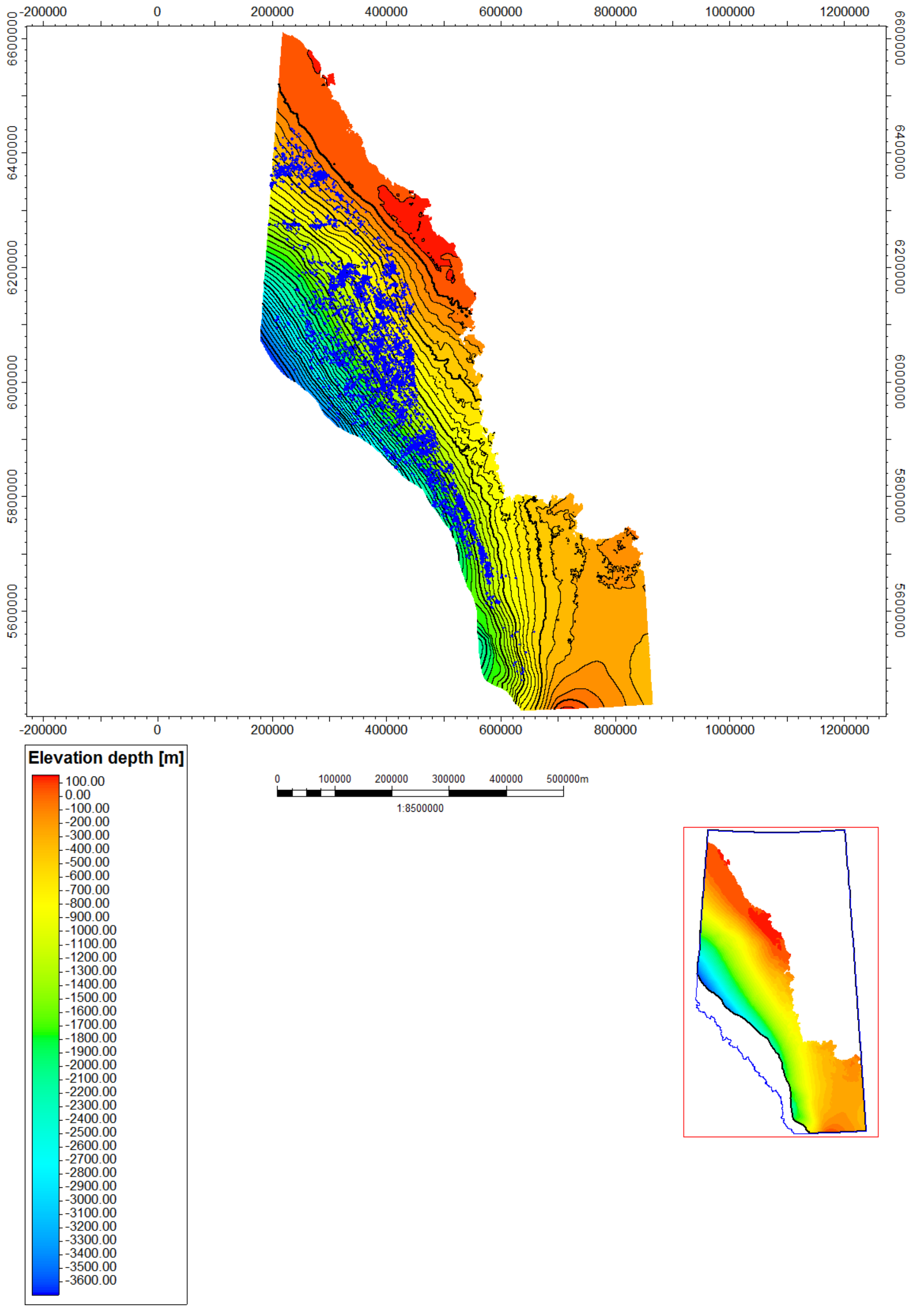


Figure 30. Data distribution (blue points) and structural map for Banff Formation top interpolated surface.

Wabamun Group top

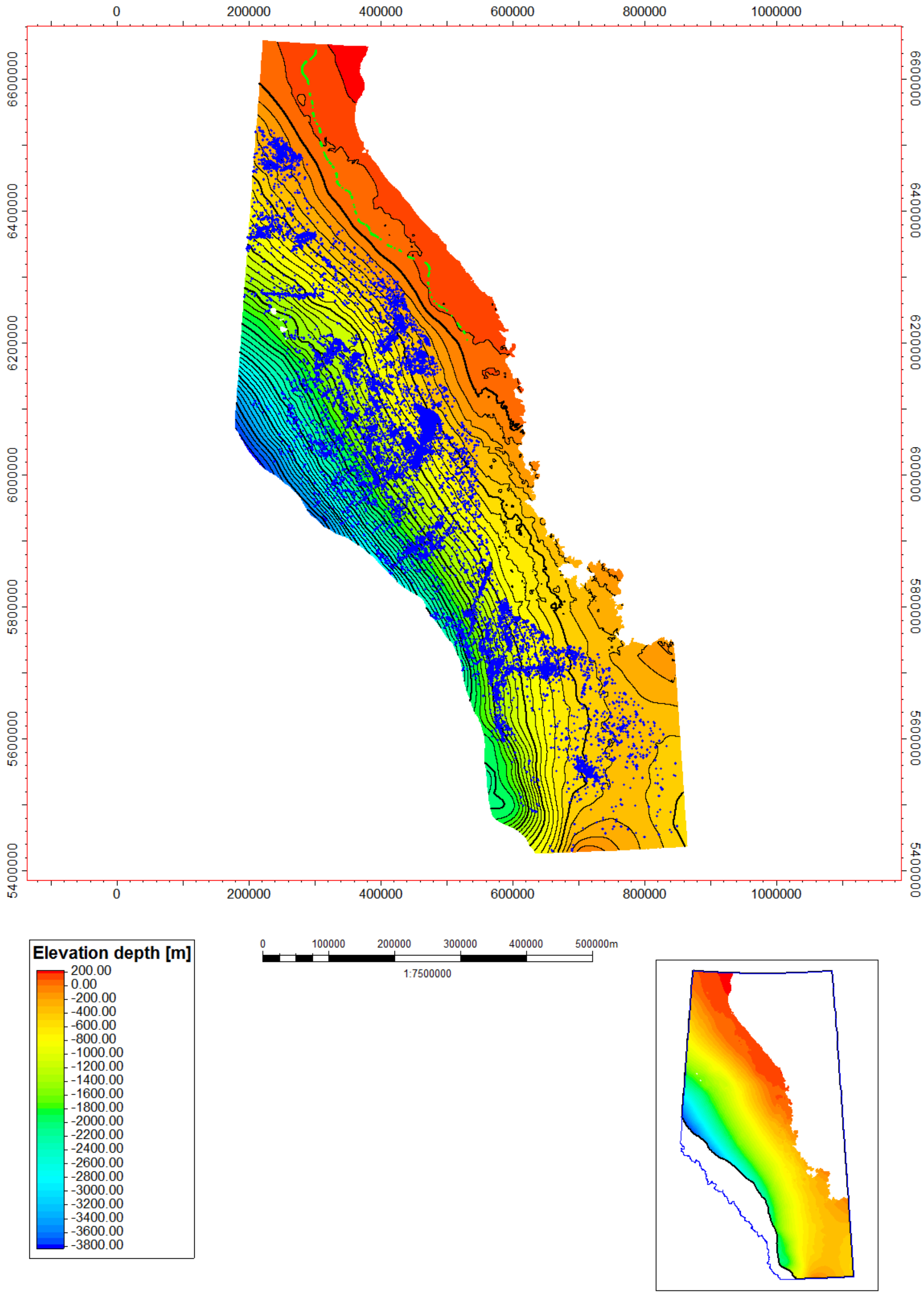


Figure 31. Data distribution (blue points = stratigraphic picks; green points = sampled modified lineament data) and structural map for Wabamun Group top interpolated surface.

Winterburn Group top

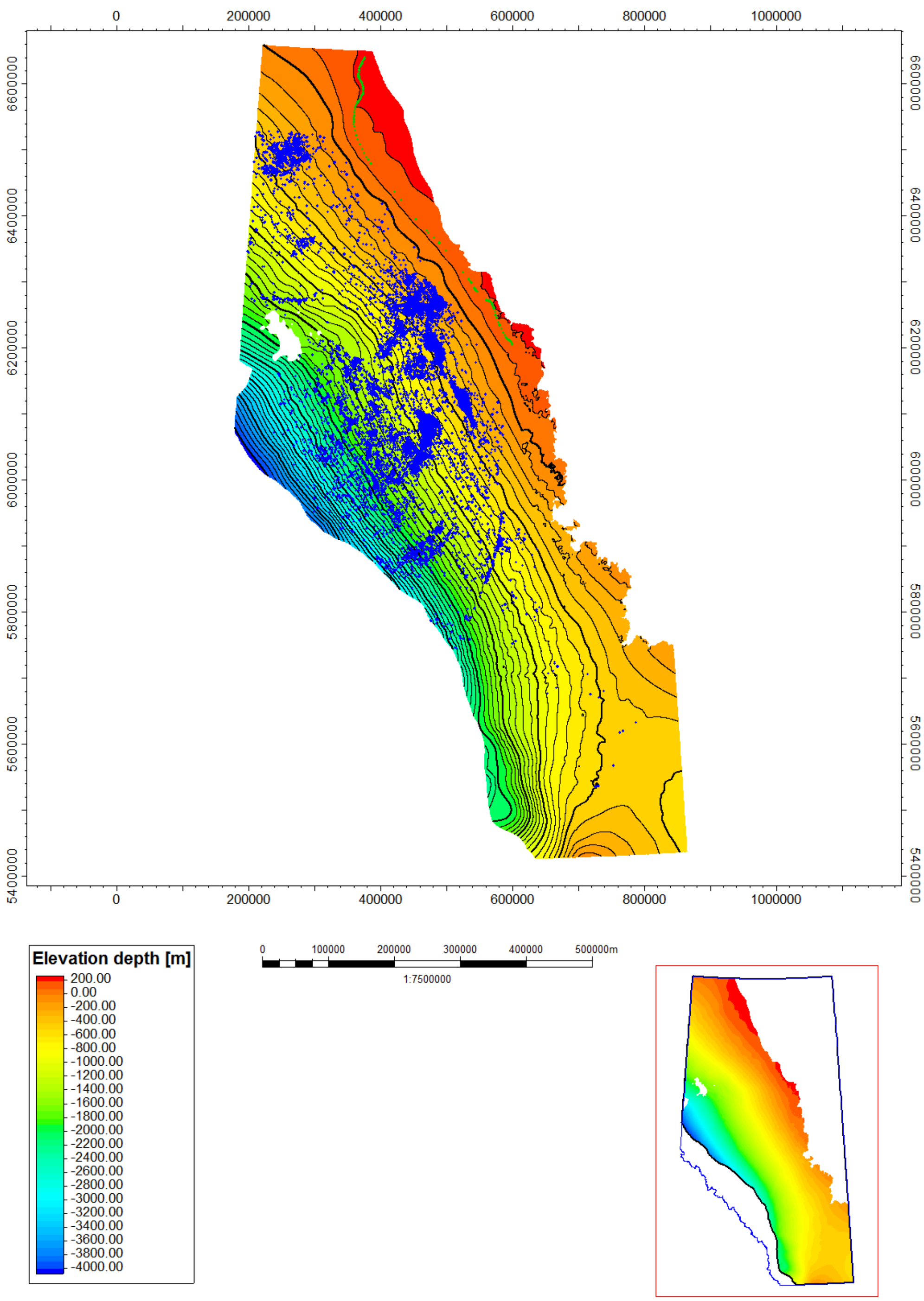


Figure 32. Data distribution (blue points = stratigraphic picks; green points = sampled modified lineament data) and structural map for the Winterburn Group top interpolated surface.

Woodbend Group top

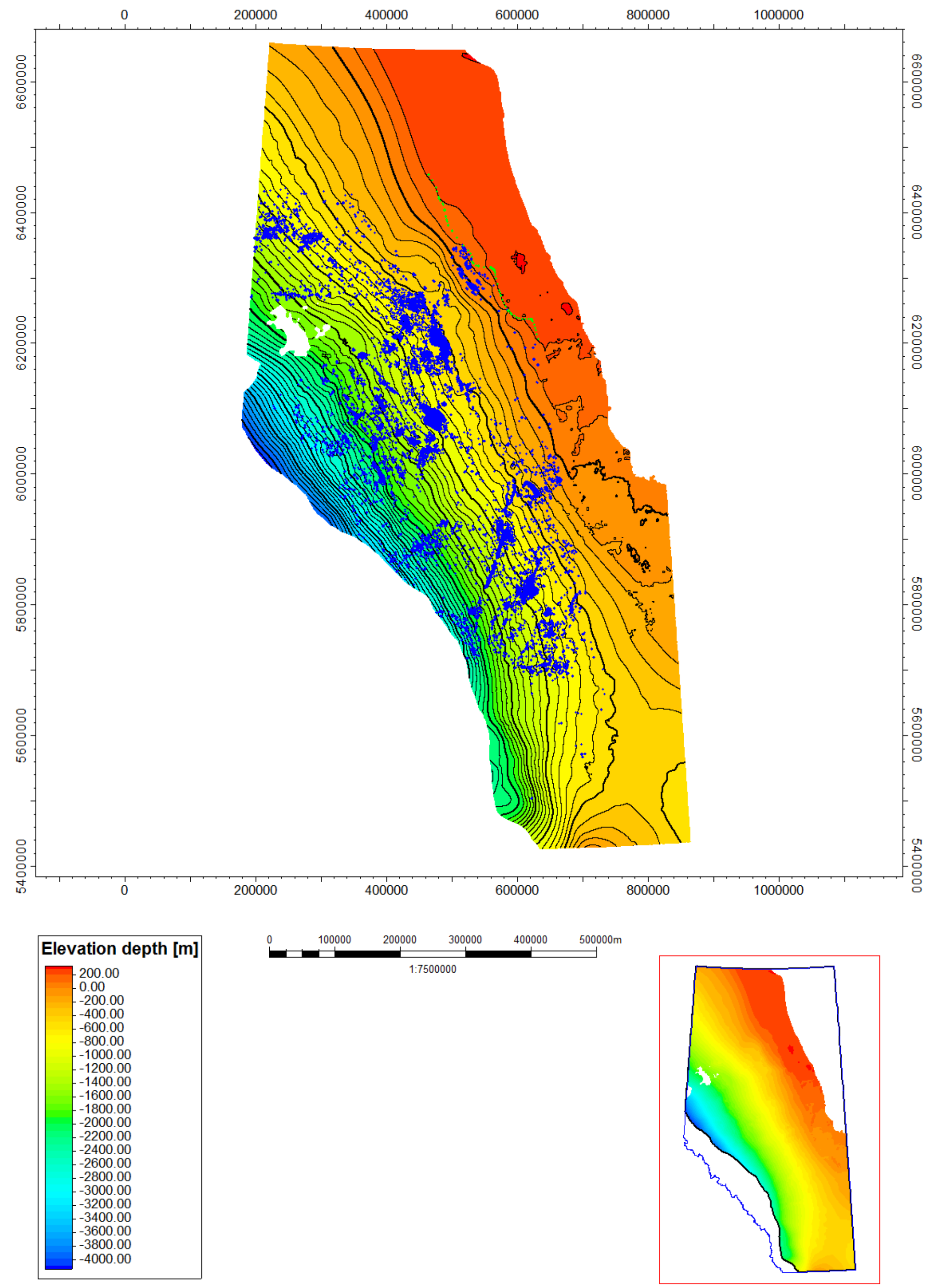


Figure 33. Data distribution (blue points = stratigraphic picks; green points = sampled modified lineament data) and structural map for Woodbend Group top interpolated surface.

Woodbend Group shales (WOOD A) top

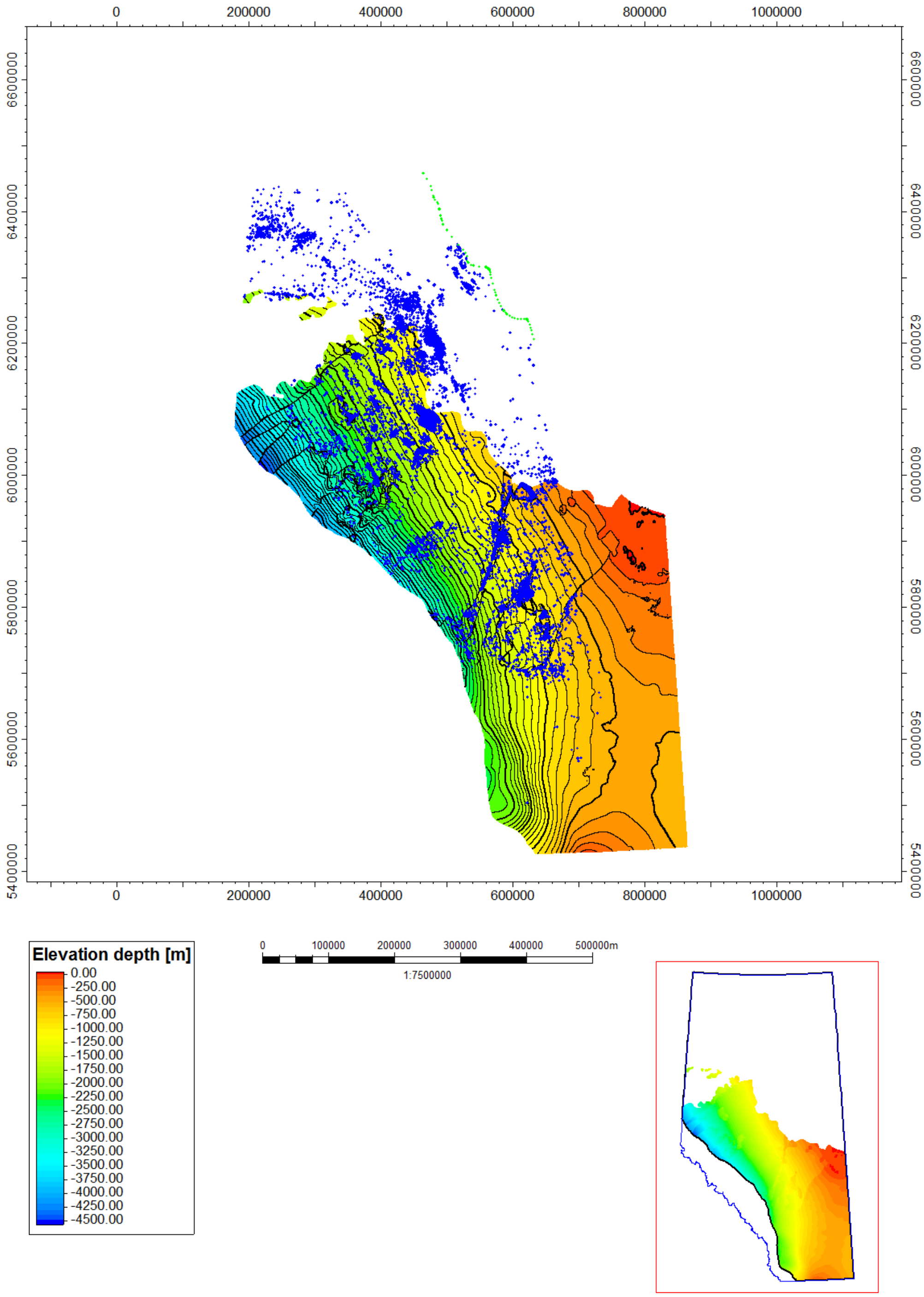


Figure 34. Data distribution and structural map for Woodbend Group Shales (WOOD A) top-interpolated surface (blue points, all Woodbend Group top stratigraphic picks; green points, all Woodbend Group top sampled modified lineament data).

Woodbend Group shales (WOOD B) top

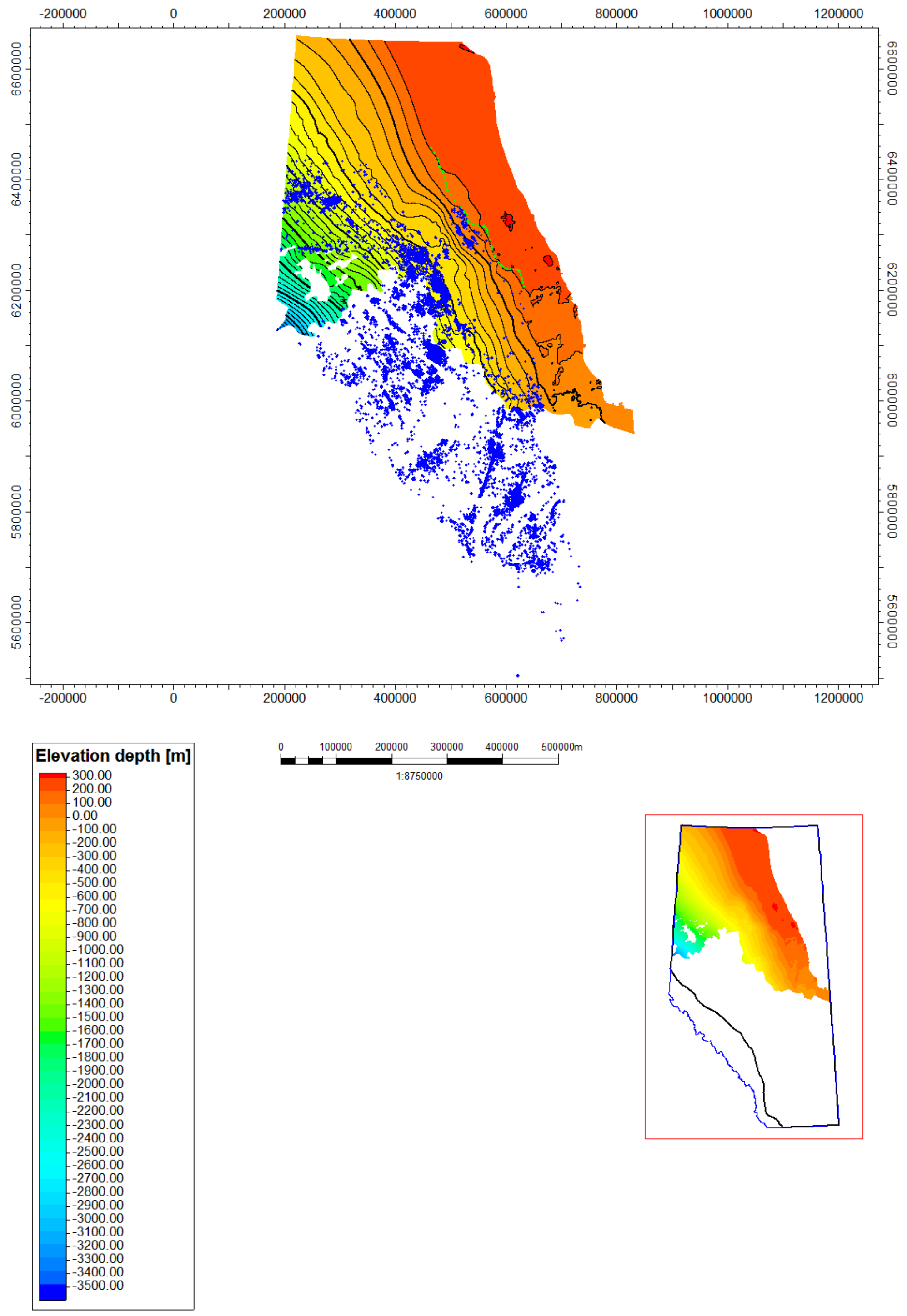


Figure 35. Data distribution and structural map for the Woodbend Group shales (WOOD B) top interpolated surface (blue points, all Woodbend Group top stratigraphic picks; green points, all Woodbend Group top sampled modified lineament data).

Duvernay Formation top

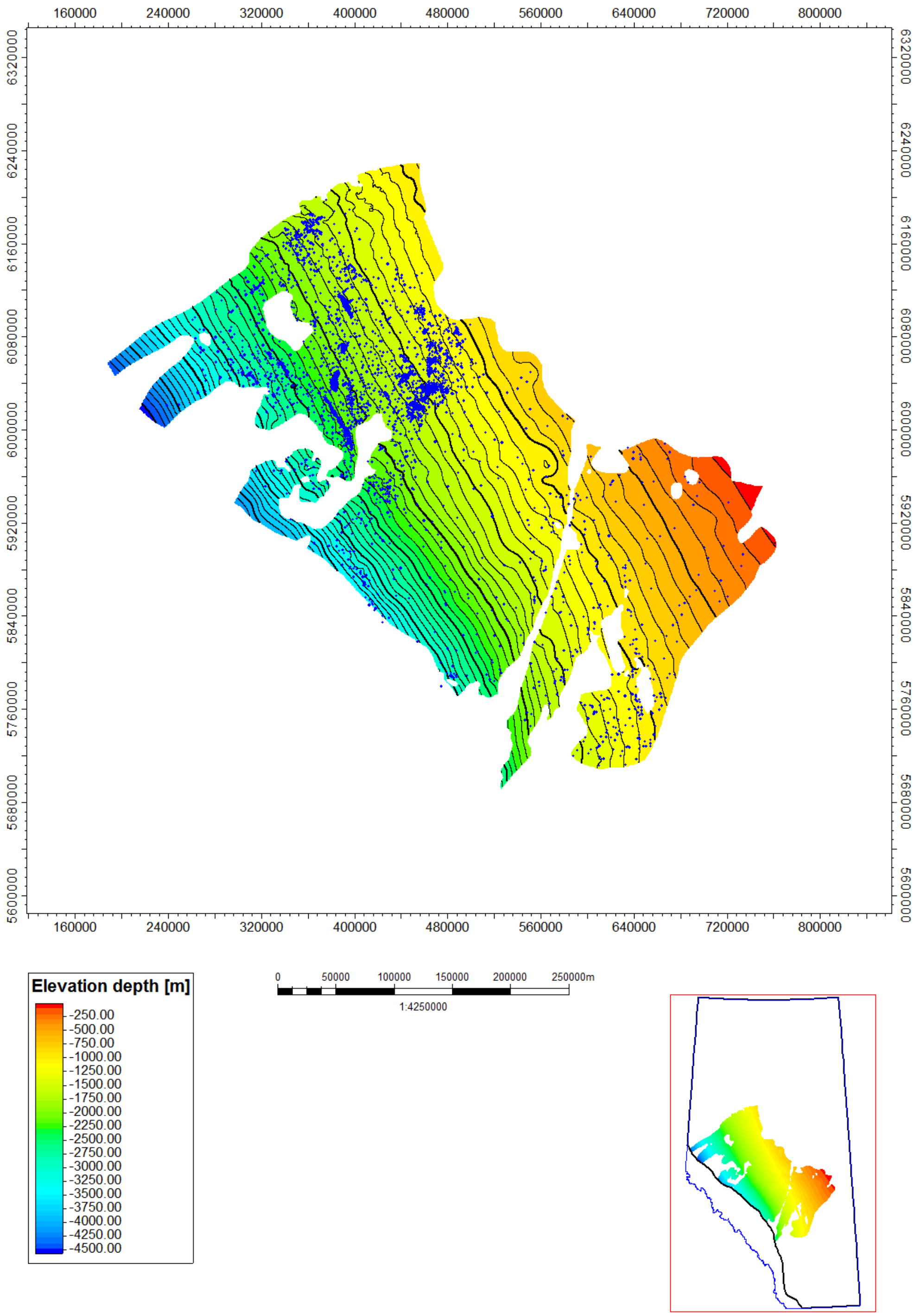


Figure 36. Data distribution (blue points) and structural map for the Duvernay Formation top interpolated surface.

Leduc Formation top

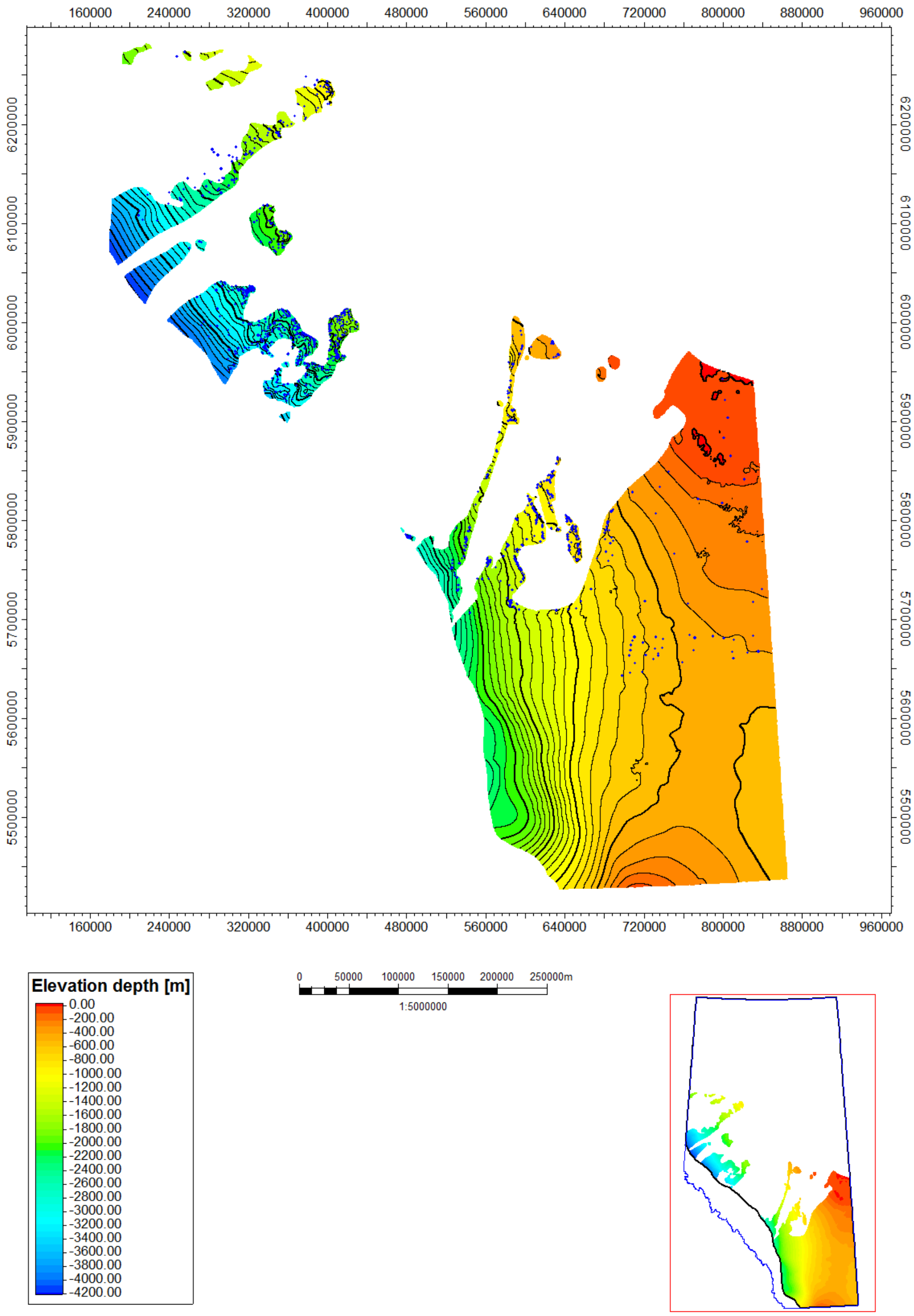


Figure 37. Data distribution (blue points) and structural map for the Leduc Formation top interpolated surface.

Cooking Lake Formation top

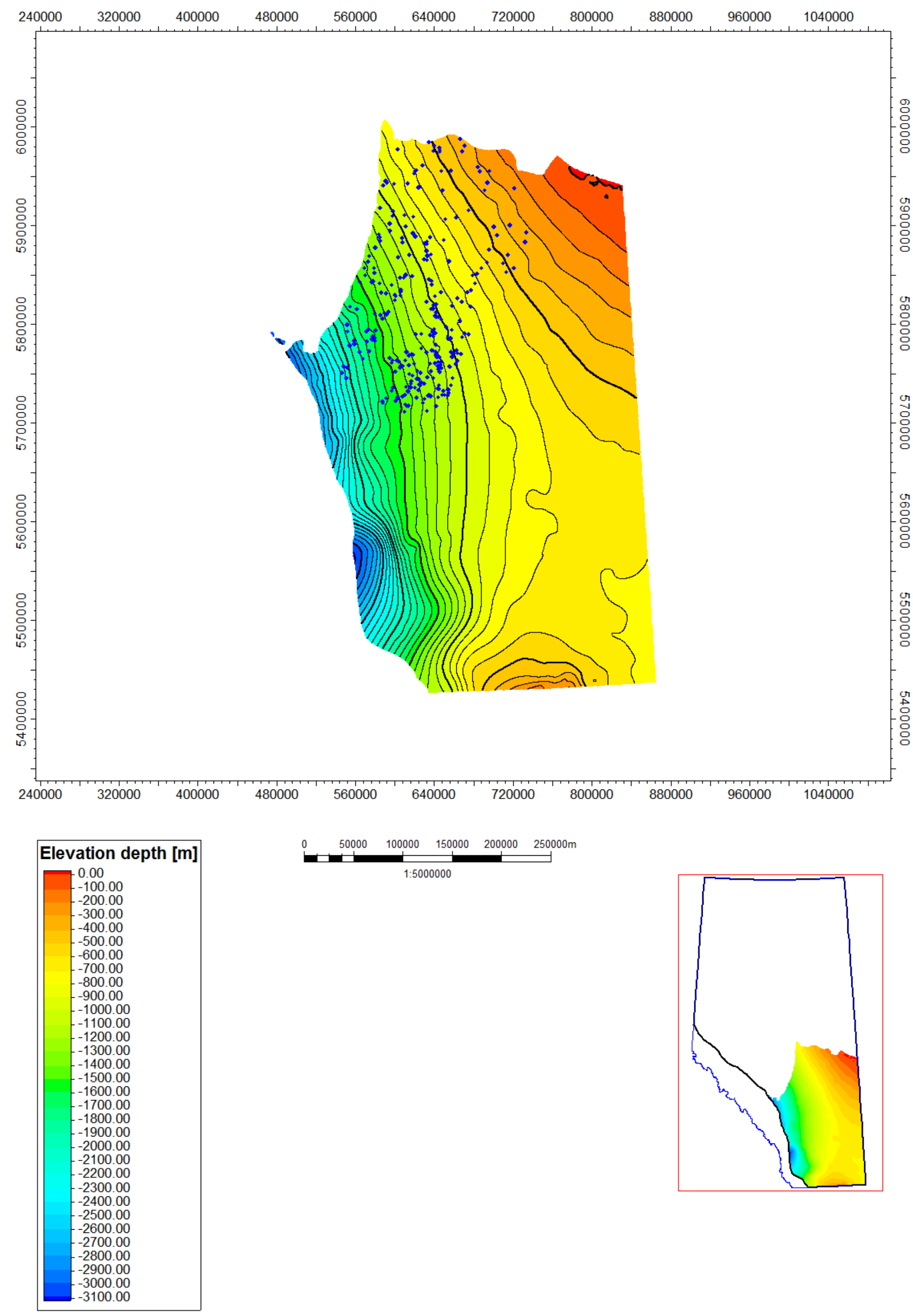


Figure 38. Data distribution (blue points) and structural map for the Cooking Lake Formation top interpolated surface.

Majeau Lake Formation top

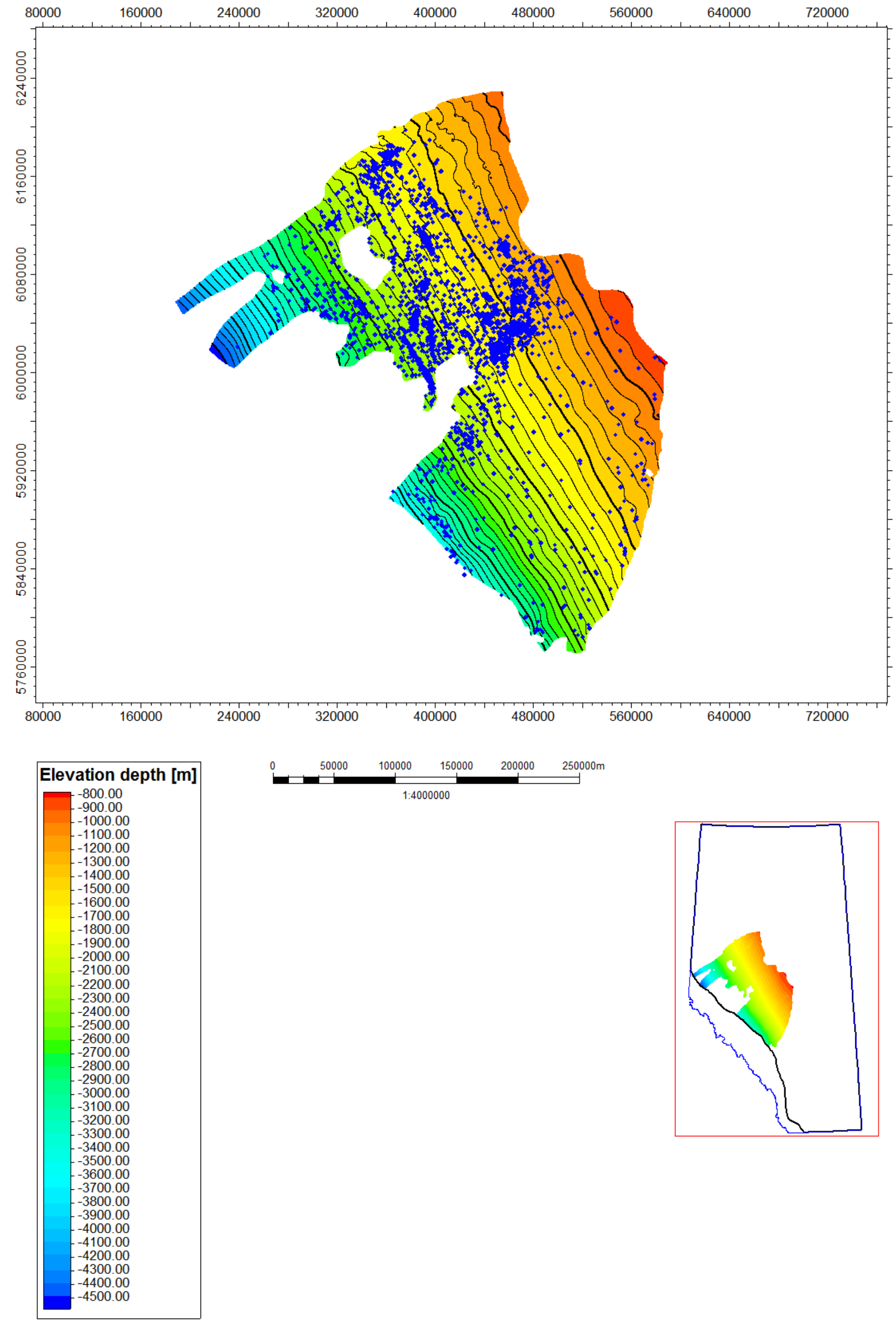


Figure 39. Data distribution (blue points) and structural map for the Majeau Lake Formation top interpolated surface.

Beaverhill Lake Group top

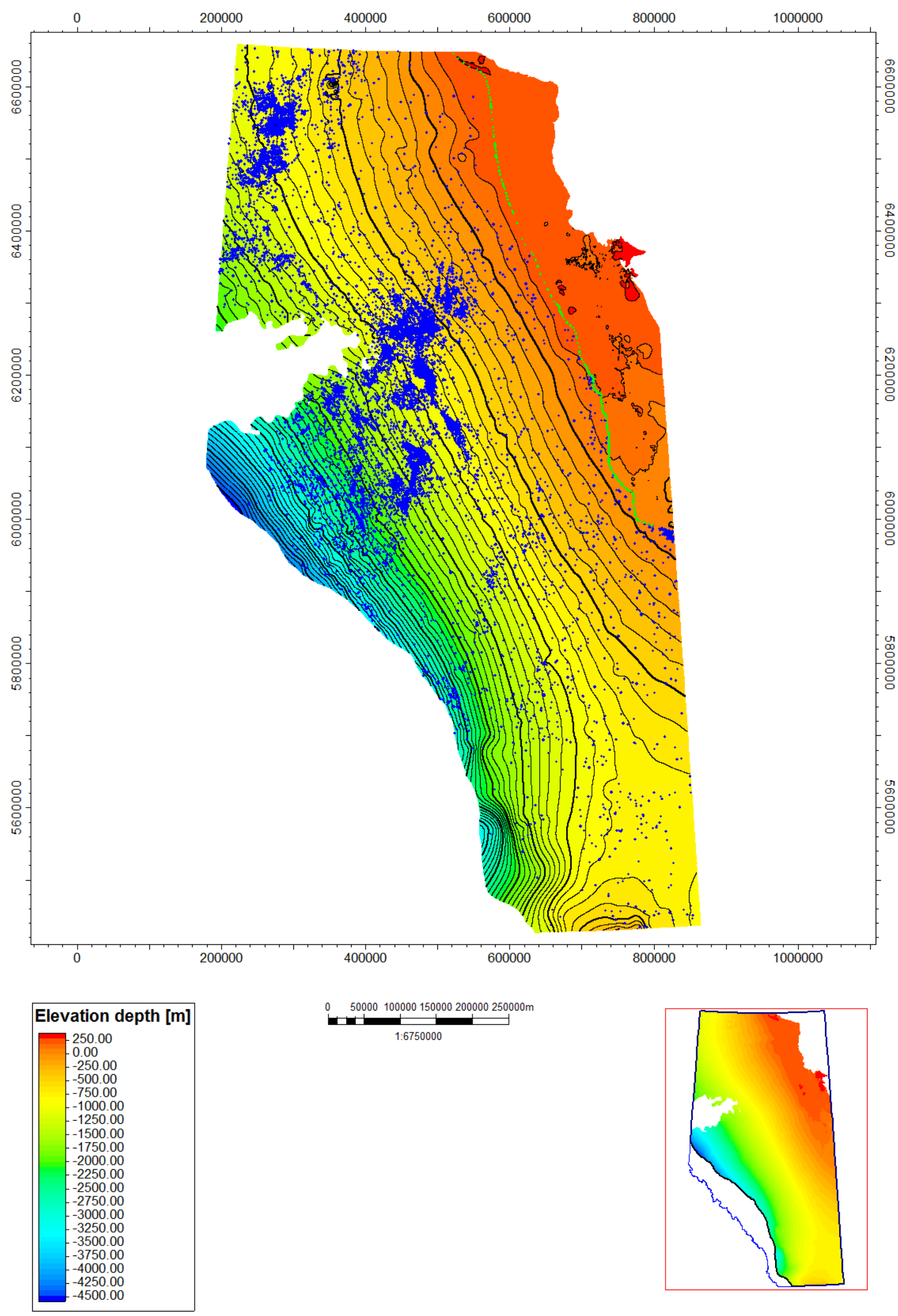


Figure 40. Data distribution and structural map for the Beaverhill Lake Group top interpolated surface (blue points, stratigraphic picks; green points, sampled draft AGS lineament).

Waterways Formation top

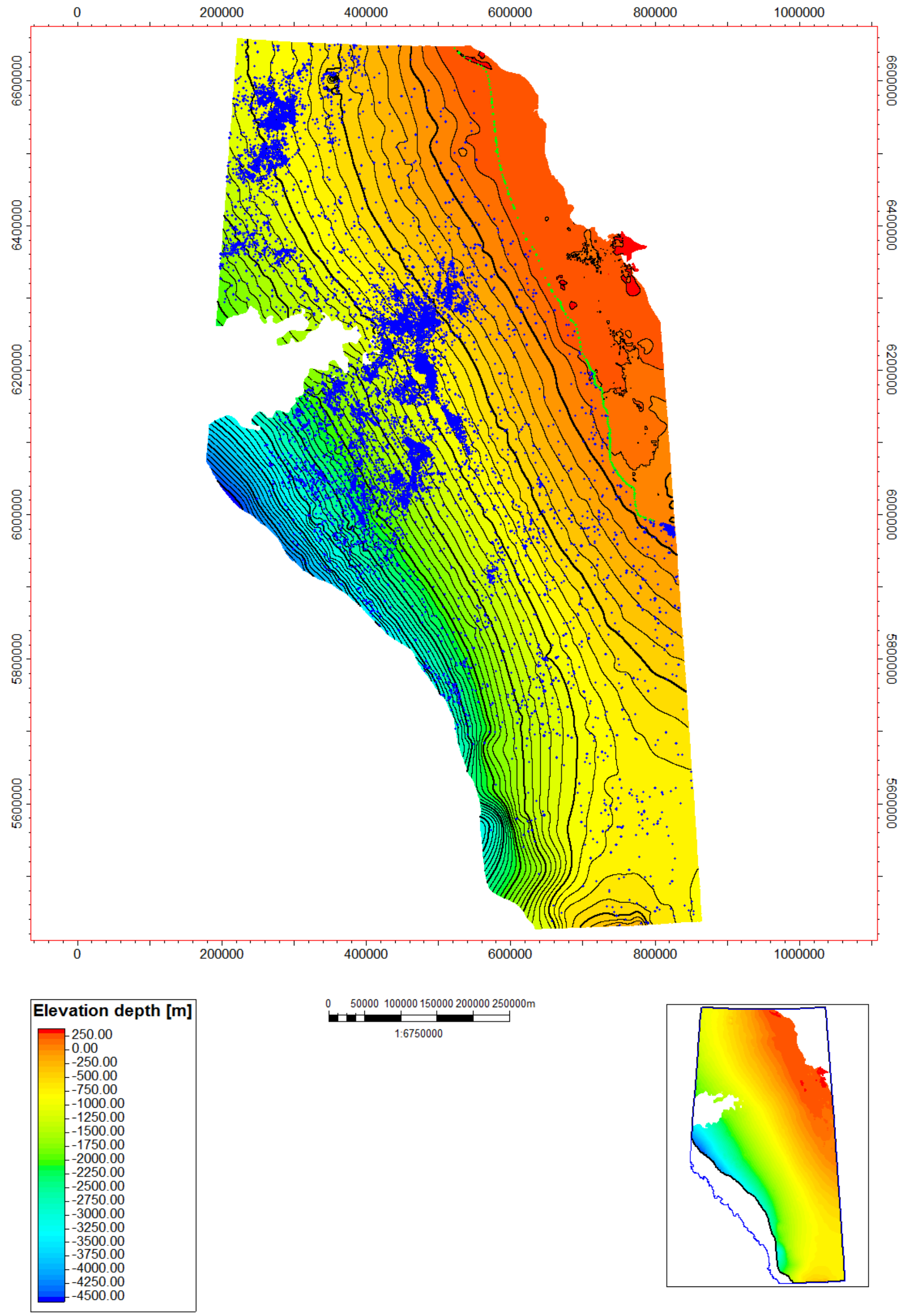


Figure 41. Data distribution and structural map for the Waterways Formation top interpolated surface (blue points, Beaverhill Lake Group top stratigraphic picks; green points, sampled draft AGS lineament).

Swan Hills / Slave Point formations interval top

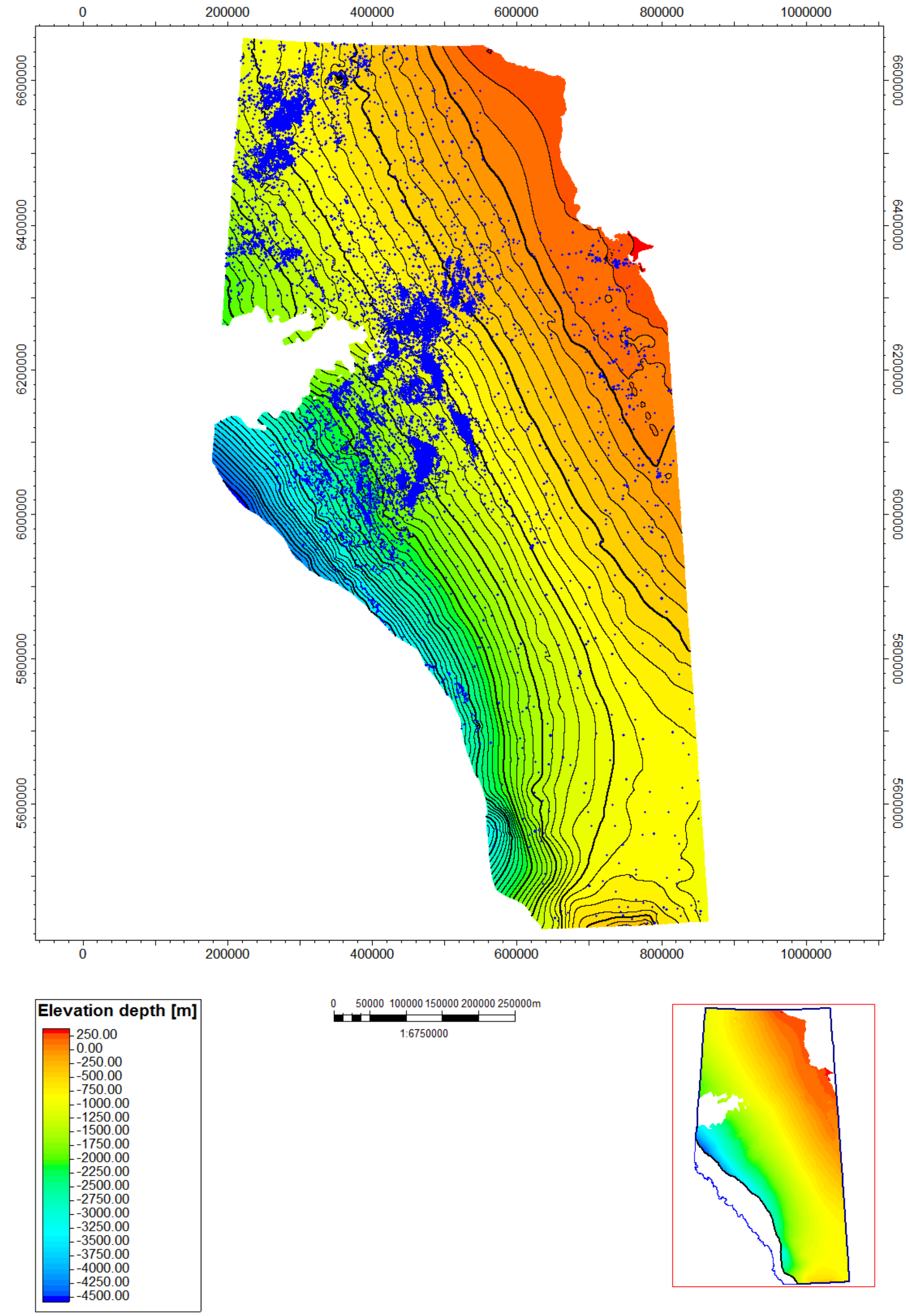


Figure 42. Data distribution (blue points) and structural map for the Swan Hills / Slave Point formations interval top interpolated surface.

Fort Vermilion Formation top

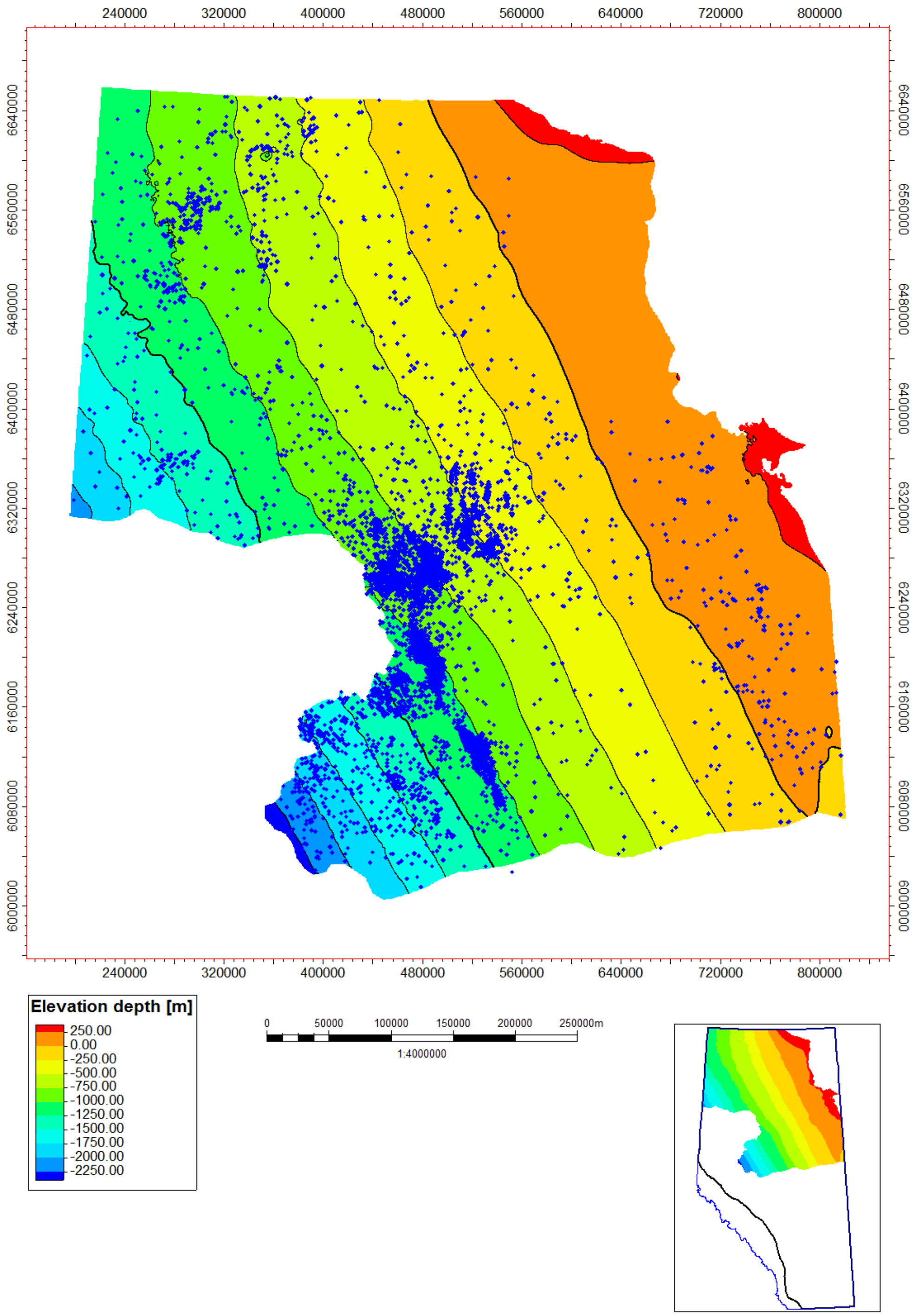


Figure 43. Data distribution (blue points) and structural map for the Fort Vermilion Formation top interpolated surface.

Elk Point Group top

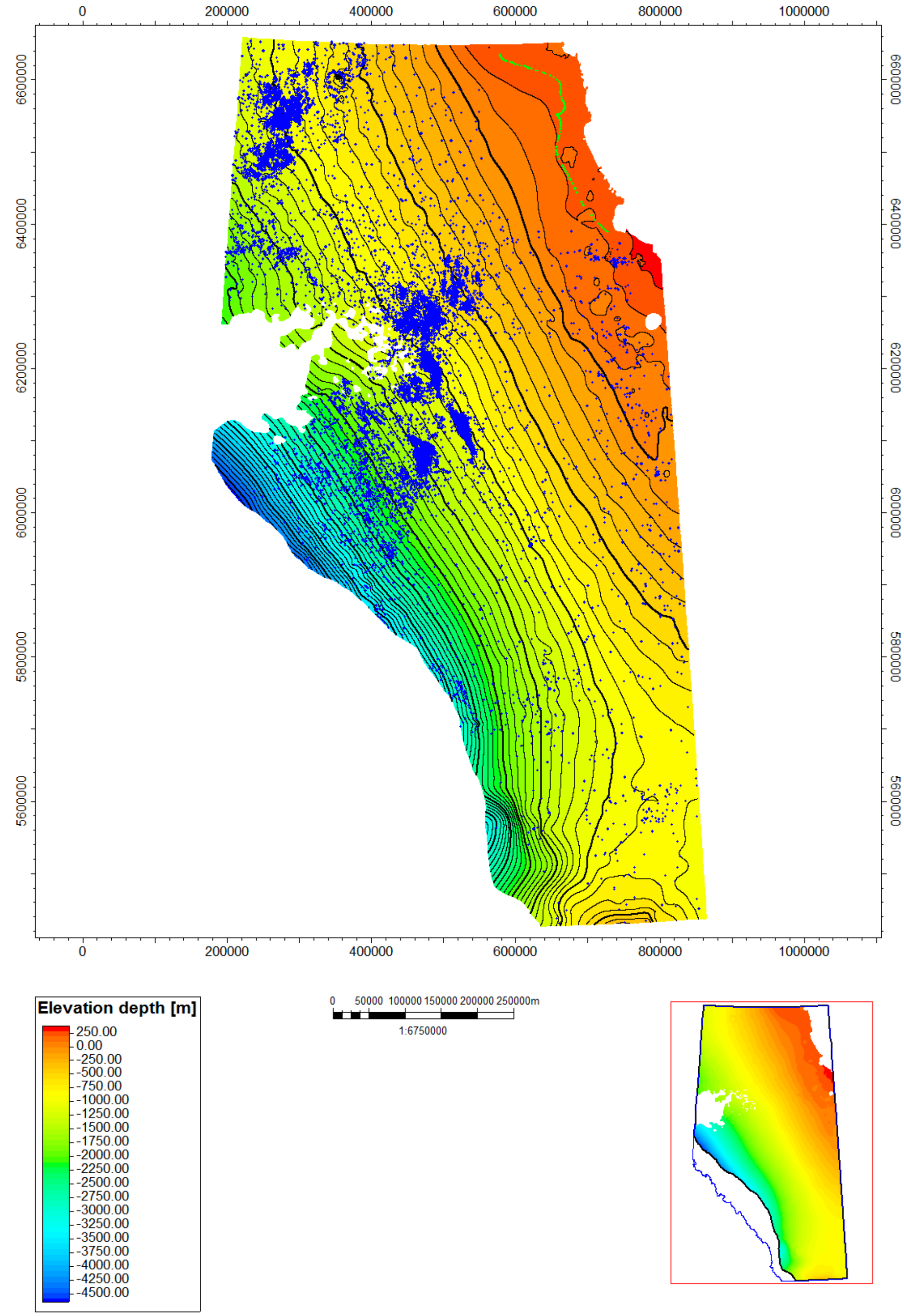


Figure 44. Data distribution and structural map for the Elk Point Group top interpolated surface (blue points, stratigraphic picks; green points, sampled Watt Mountain lineament from Prior et al. [2013]).

Precambrian top

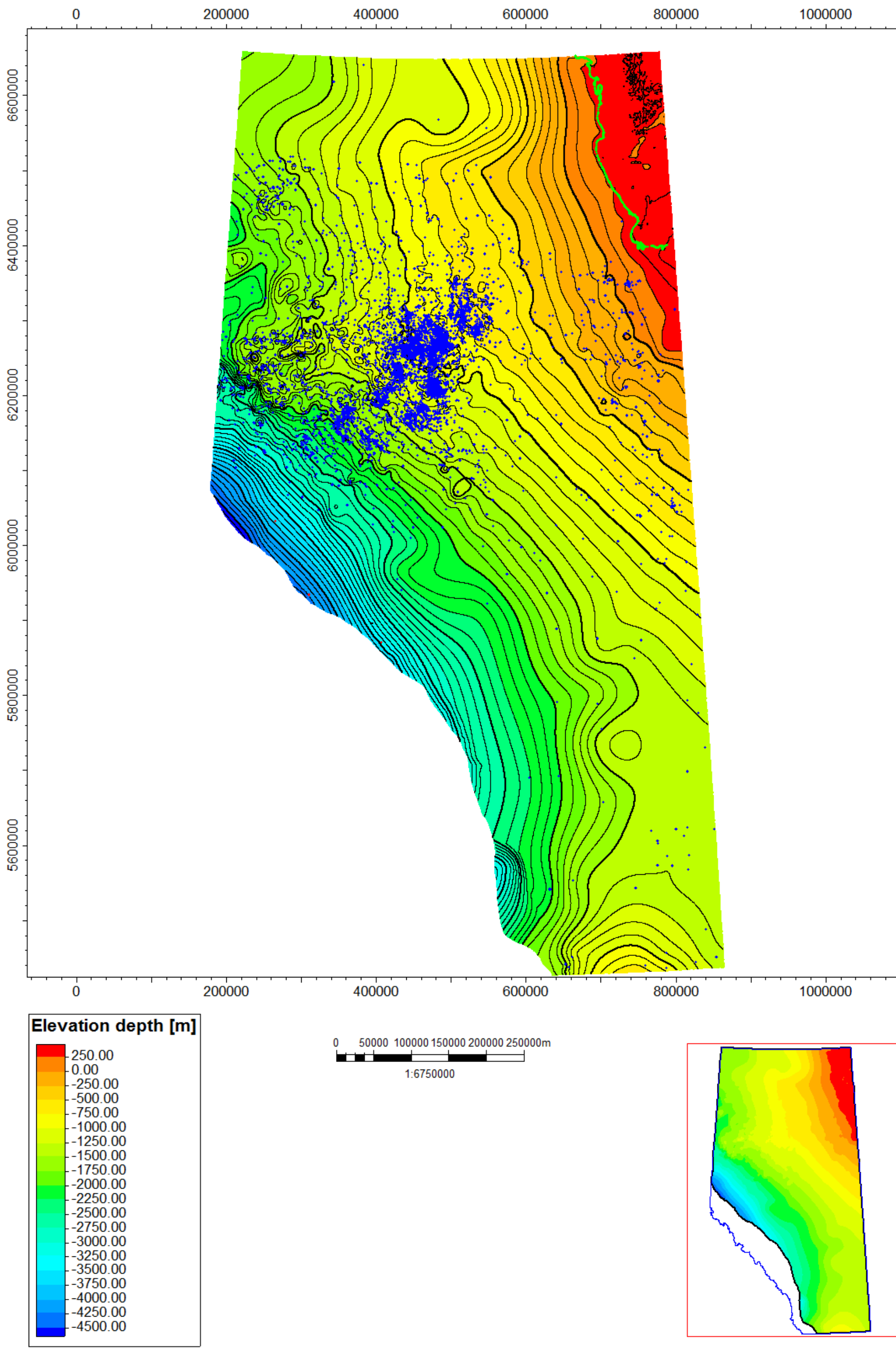


Figure 45. Data distribution and structural map for Precambrian top interpolated surface (blue points, stratigraphic picks; green points, sampled Phanerozoic Limit lineament from Prior et al. [2013]).

Appendix 4 − Uncertainty Maps (Standard Deviation)

Paskapoo Formation base

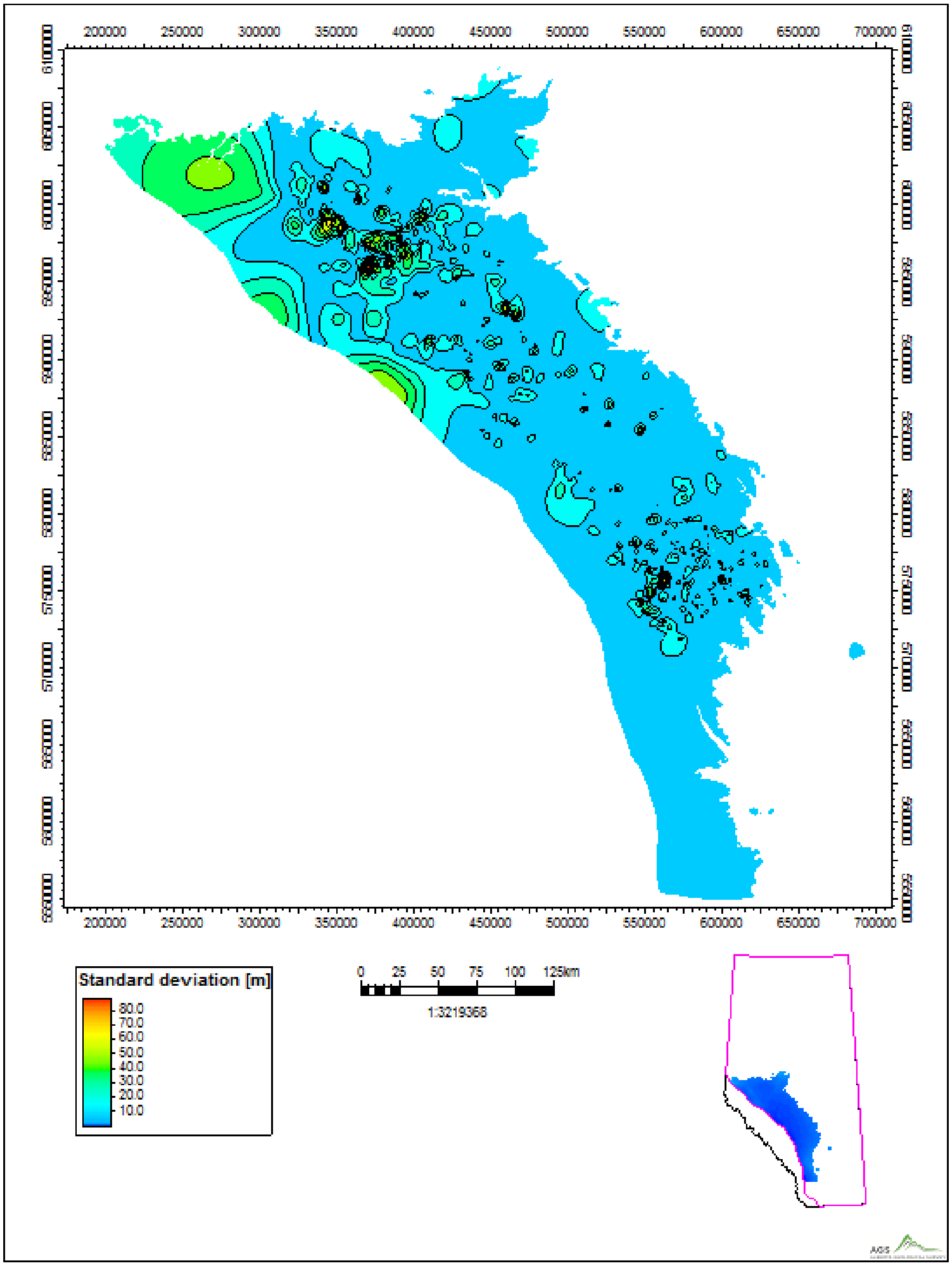


Figure 46. Standard-deviation map for the surface of the Paskapoo Formation base.

Battle Formation top

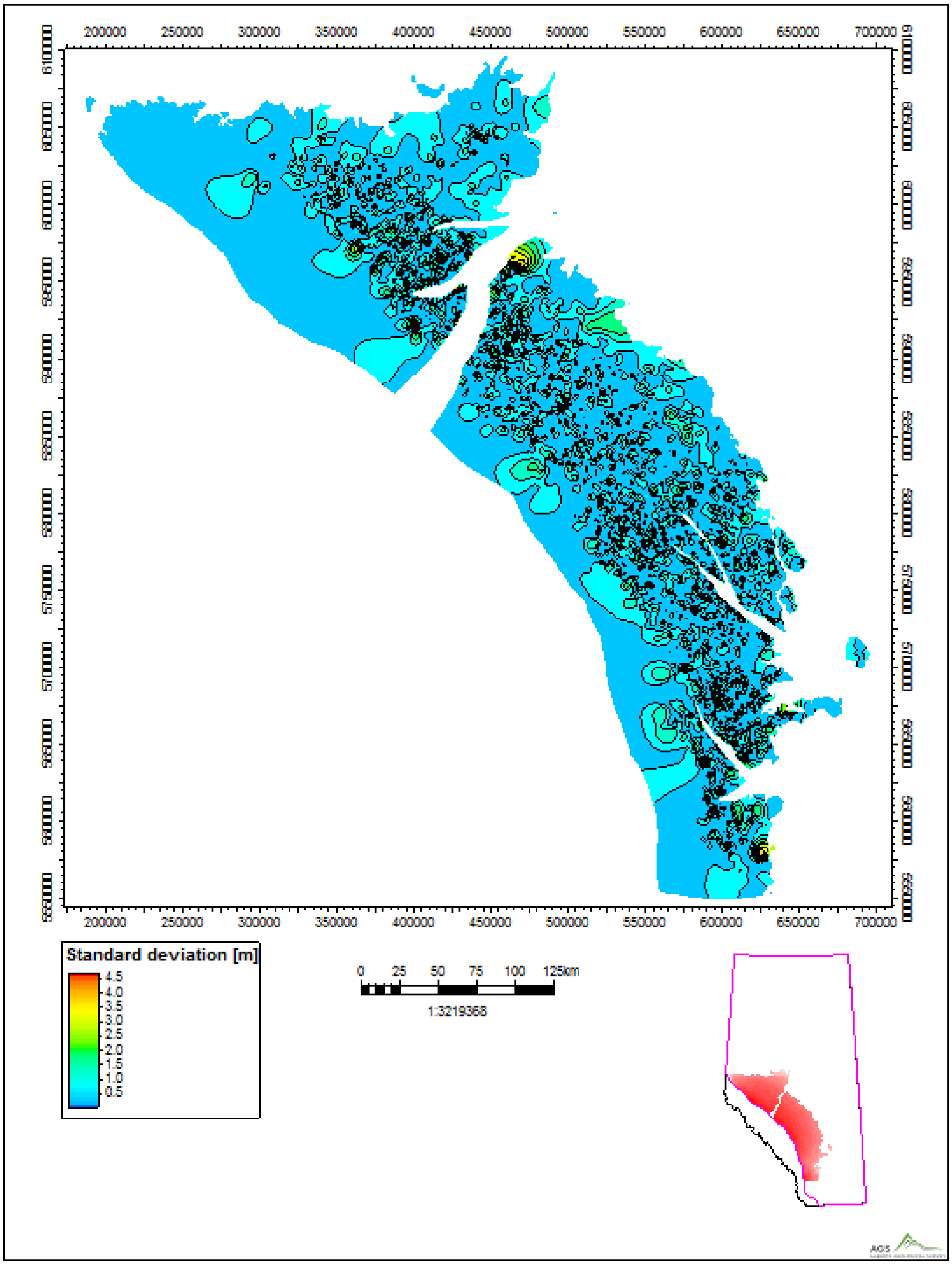


Figure 47. Standard-deviation map for the Battle Formation top surface.

Undifferentiated Horseshoe Canyon Formation / Wapiti Formation / St. Mary River Formation / Belly River Group / Bearpaw Formation equivalent interval top

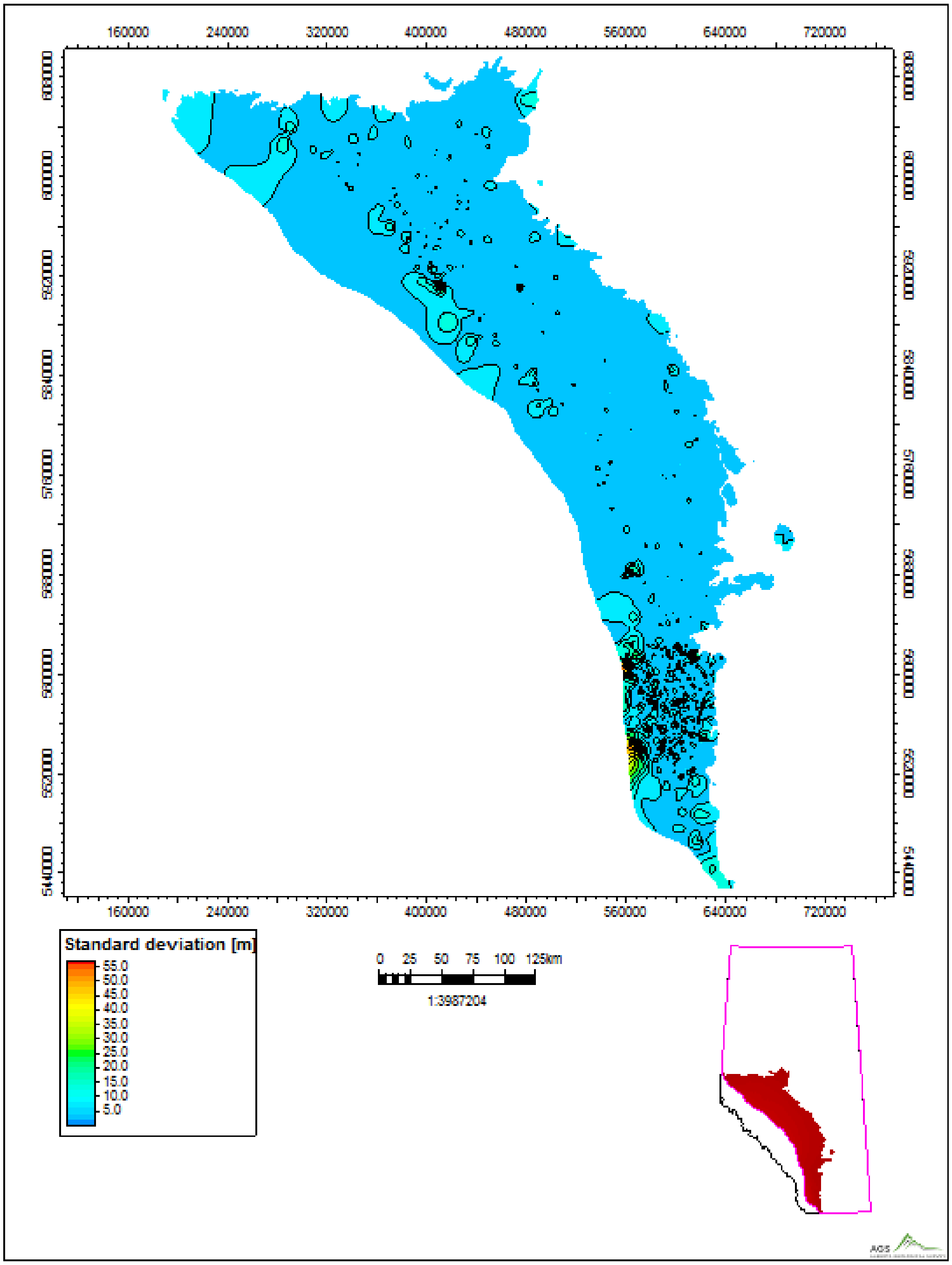


Figure 48. Standard-deviation map for the undifferentiated Horseshoe Canyon Formation / Wapiti Formation / St. Mary River Formation / Belly River Group / Bearpaw Formation equivalent interval top surface.

Upper Bearpaw interval top

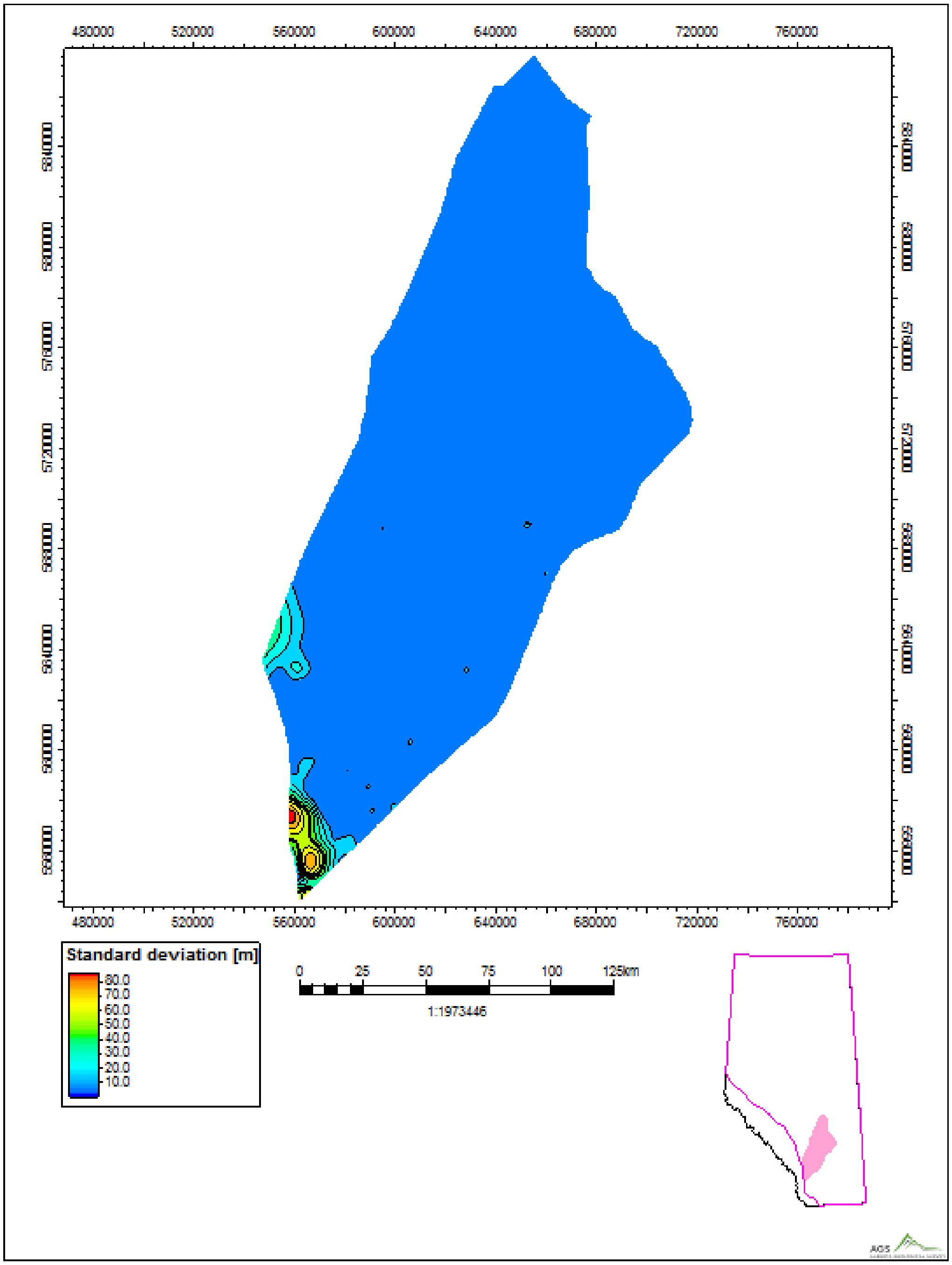


Figure 49. Standard-deviation map for the upper Bearpaw interval top surface.

Strathmore Member top

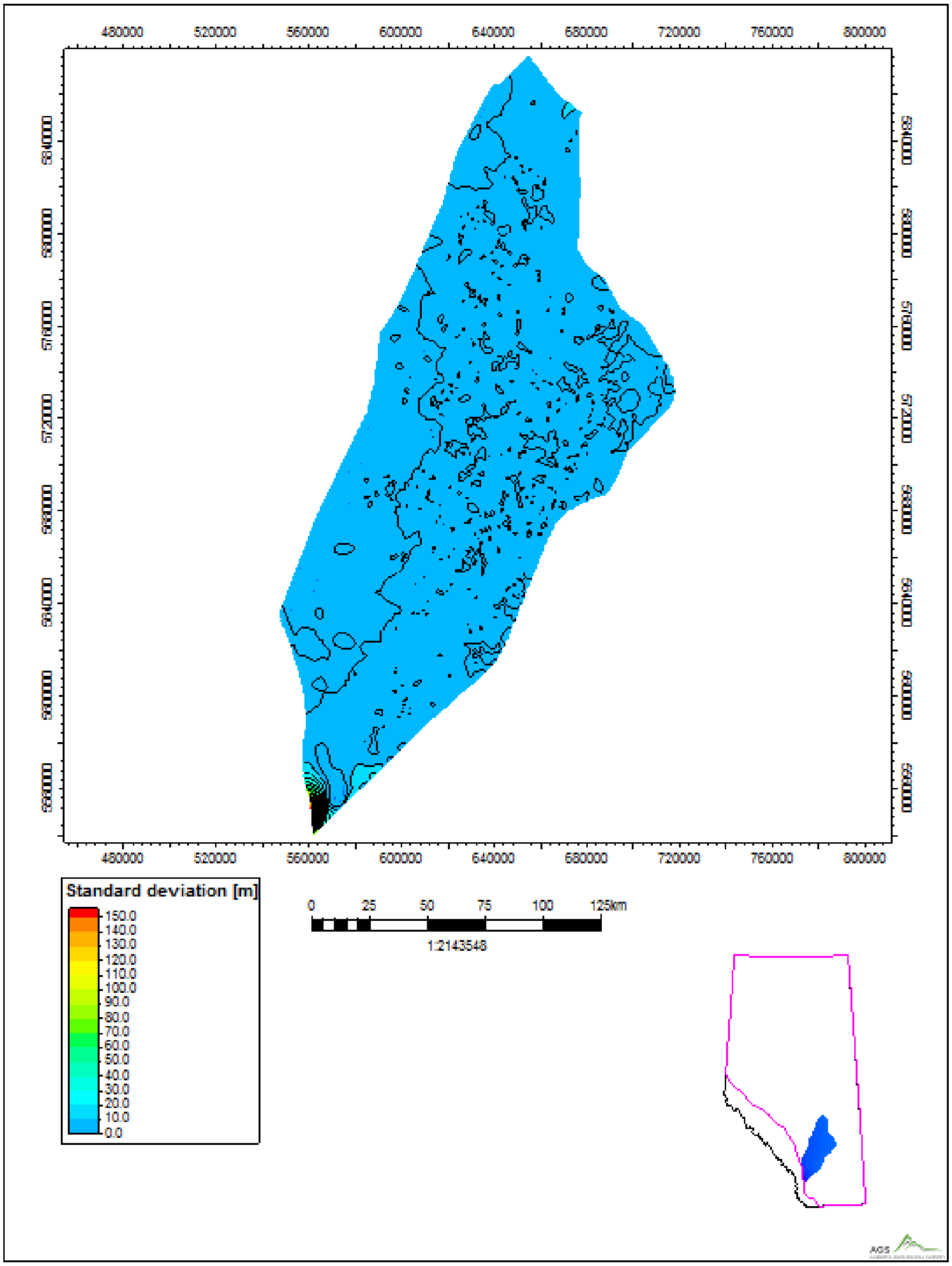


Figure 50. Standard-deviation map for the Strathmore Member top surface.

Lower Bearpaw interval top

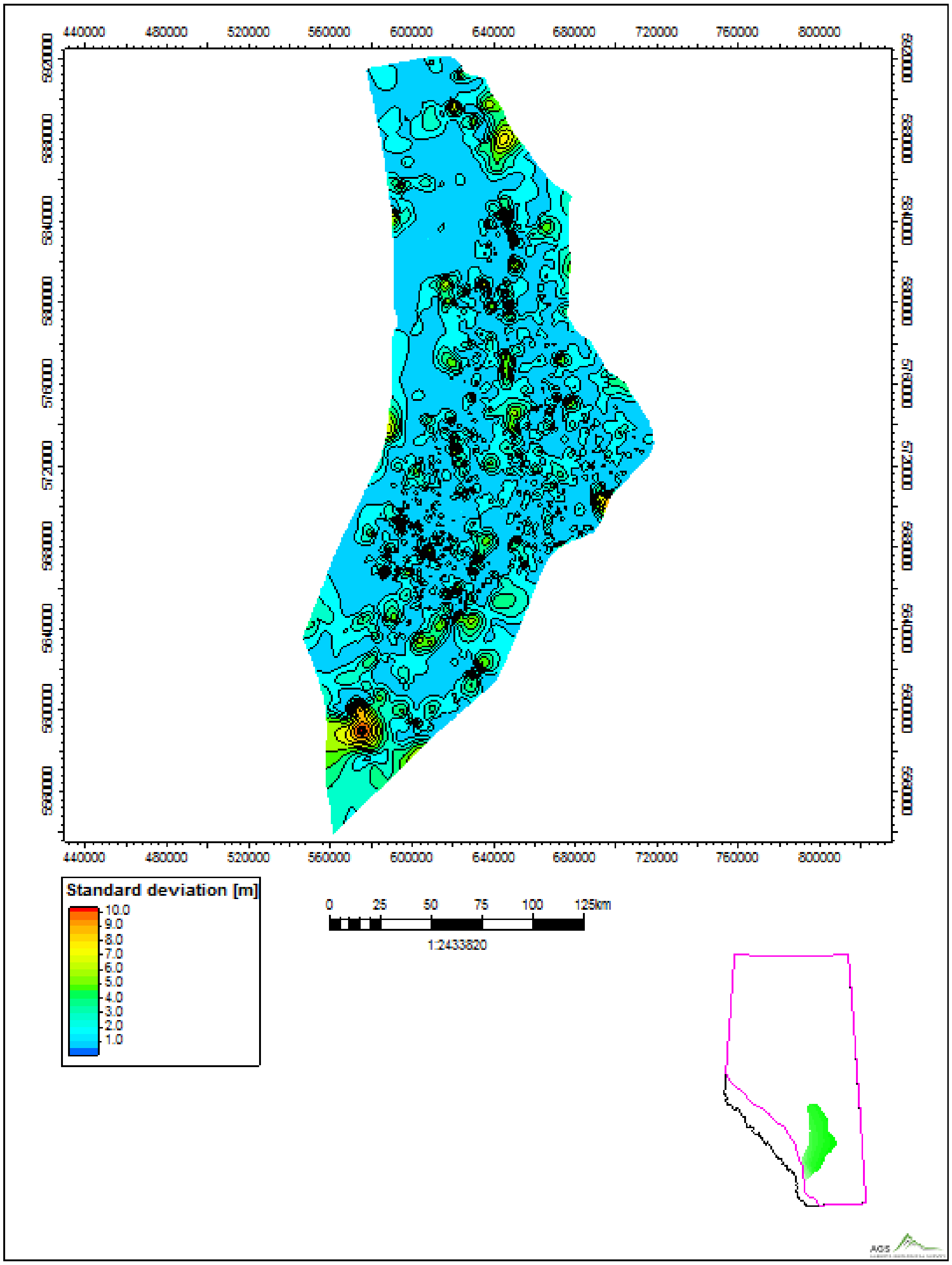


Figure 51. Standard-deviation map for the lower Bearpaw interval top surface.

Belly River Group top

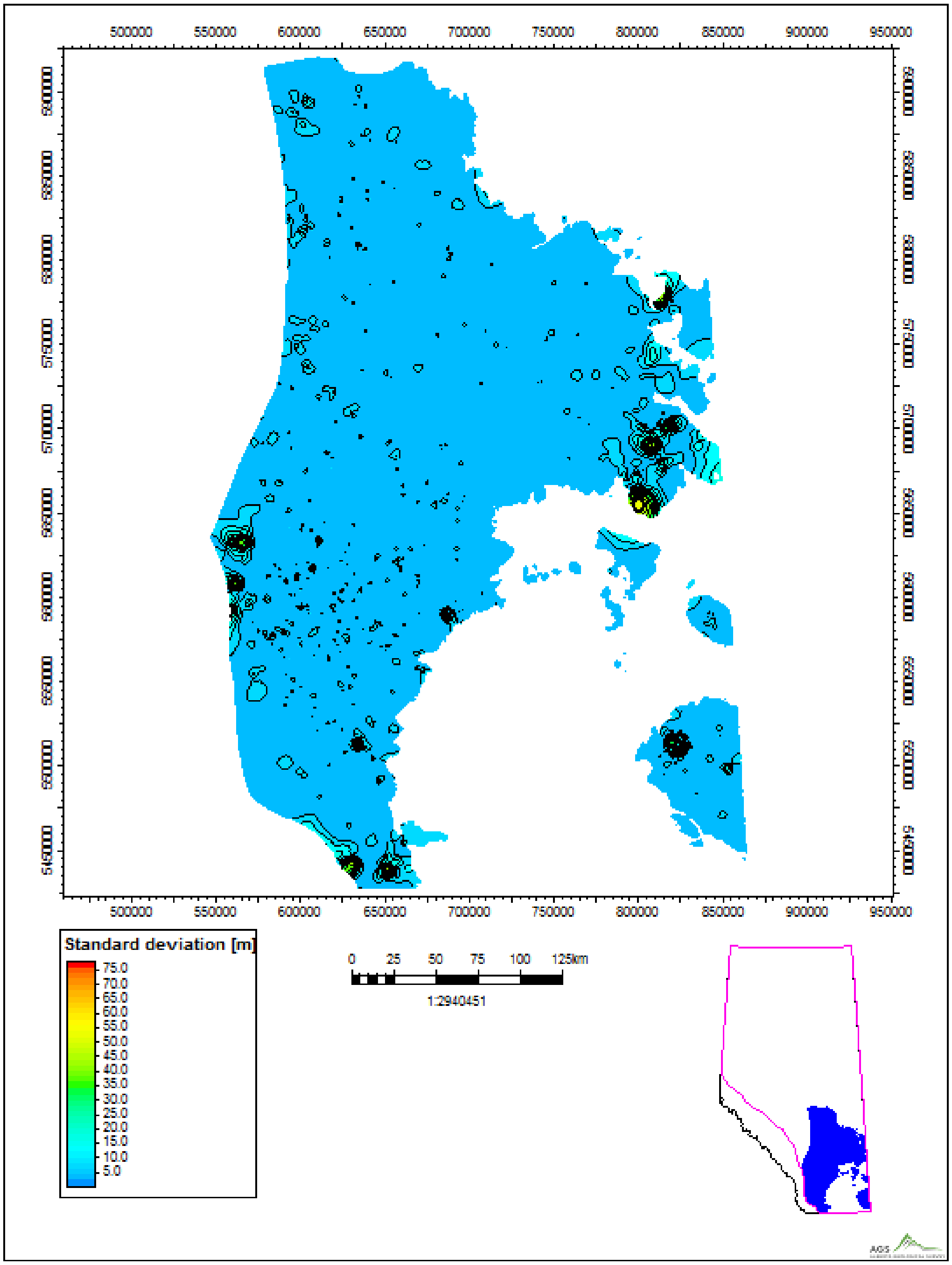


Figure 52. Standard-deviation map for the Belly River Group top surface.

Oldman Formation top

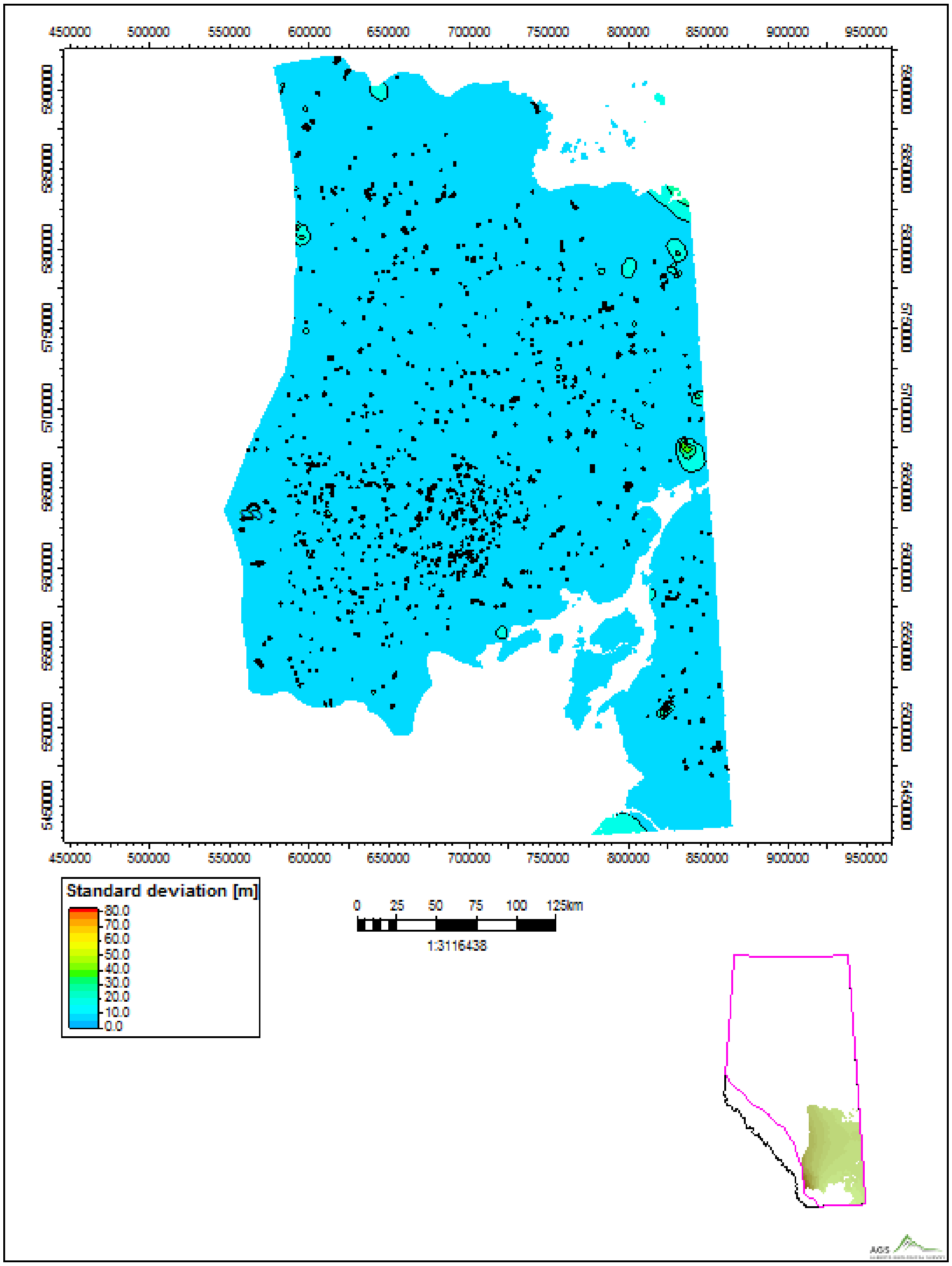


Figure 53. Standard-deviation map for the Oldman Formation top surface.

Foremost Formation top

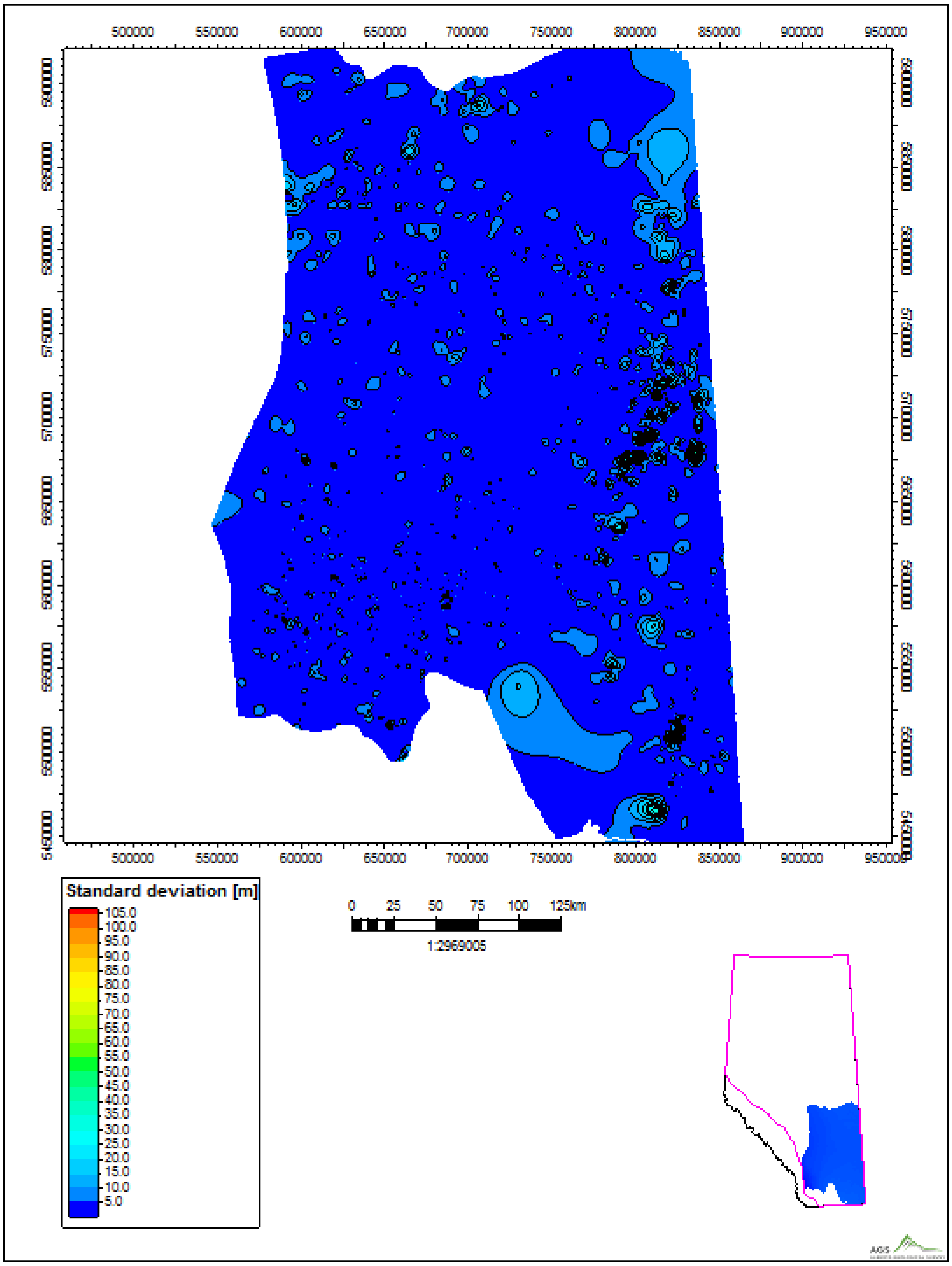


Figure 54. Standard-deviation map for the Foremost Formation top surface.

Belly River Group base (undifferentiated Lea Park Formation / Colorado Group / Smoky Group / Fort St. John Group equivalent interval top / Pakowki top)

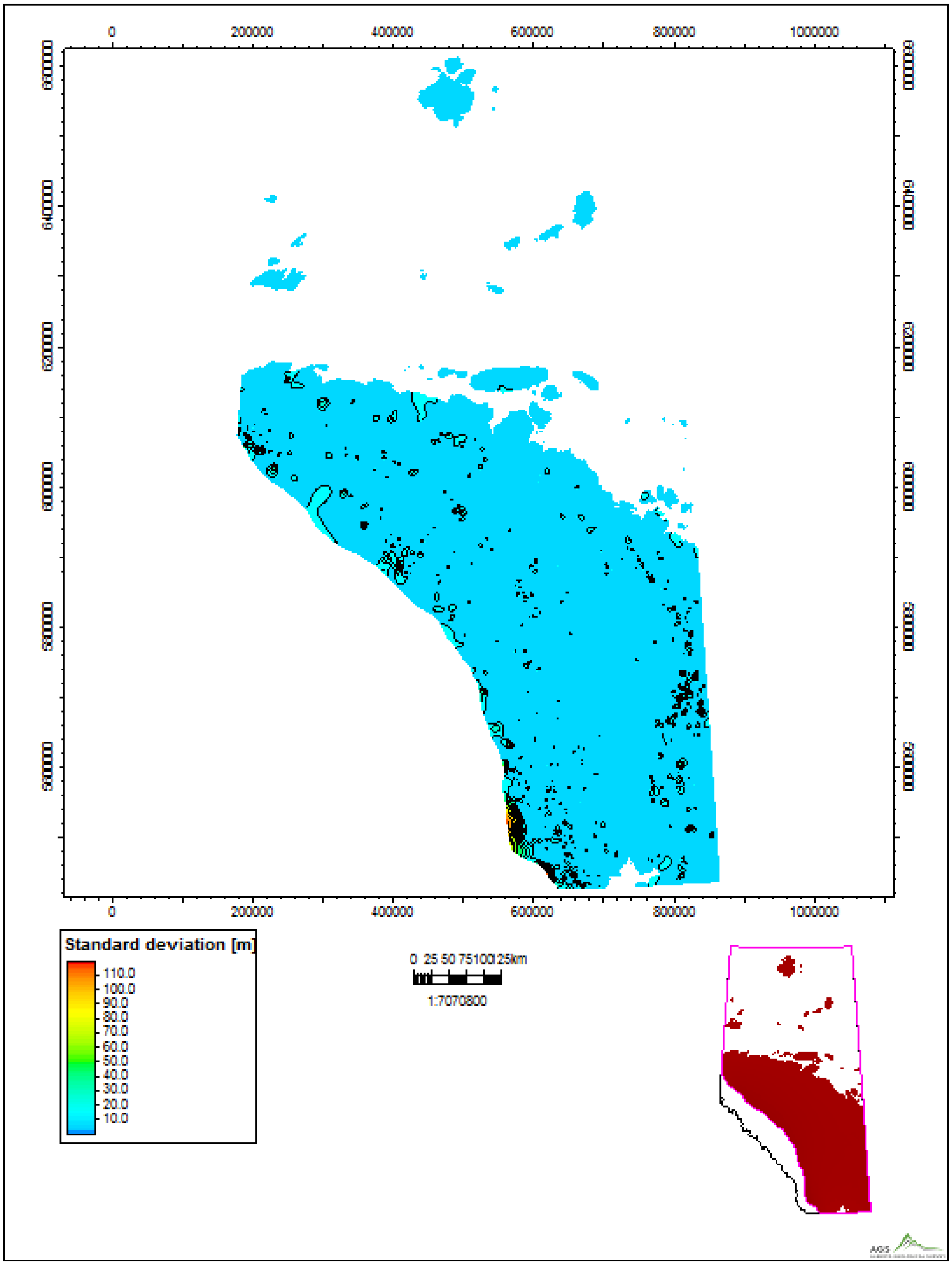


Figure 55. Standard-deviation map for Belly River Group base (undifferentiated Lea Park Formation / Colorado Group / Smoky Group / Fort St. John Group equivalent interval top / Pakowki top) surface.

Milk River Formation top

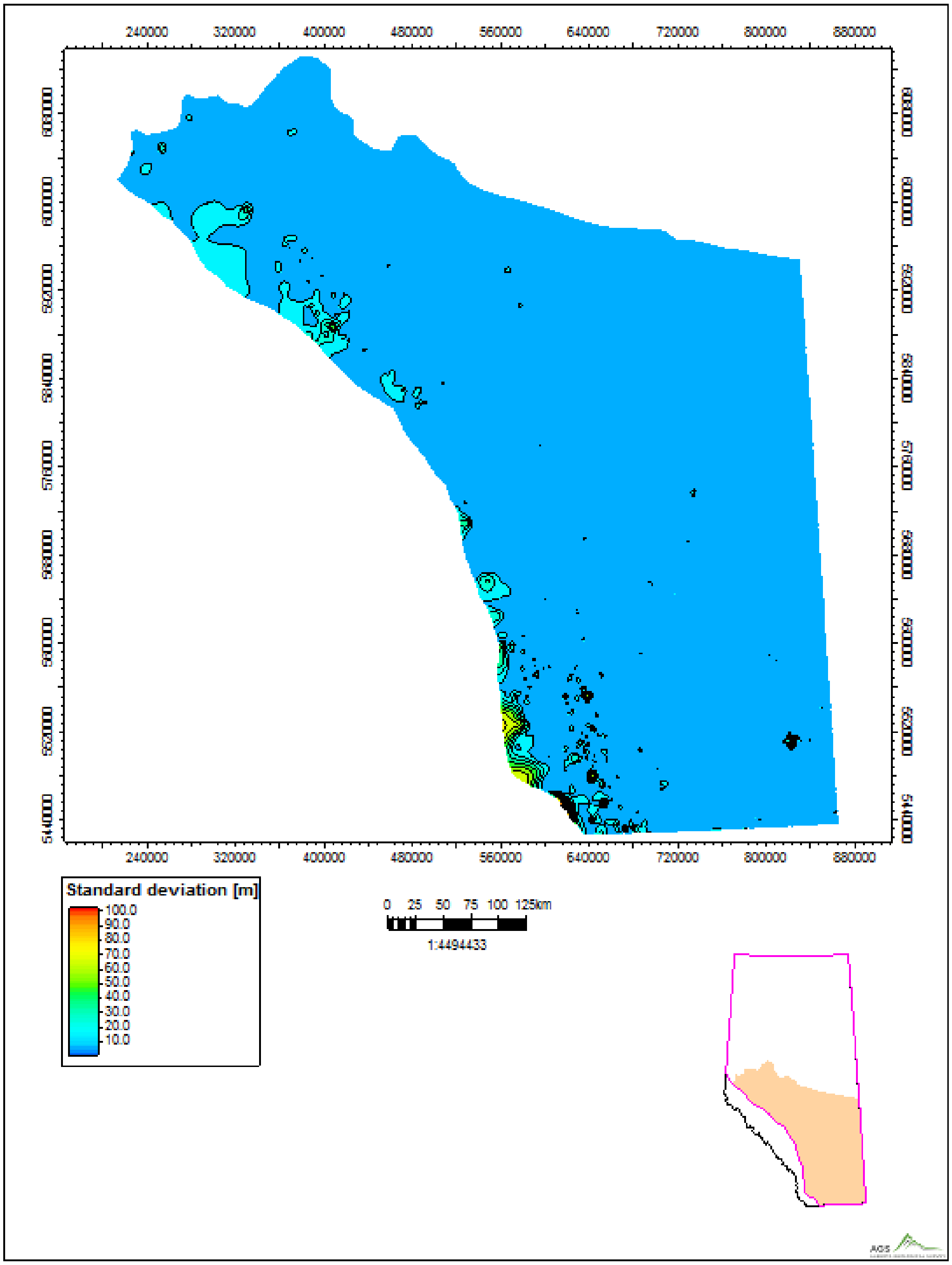


Figure 56. Standard-deviation map for the Milk River Formation top surface.

Base of the Fish Scales Formation

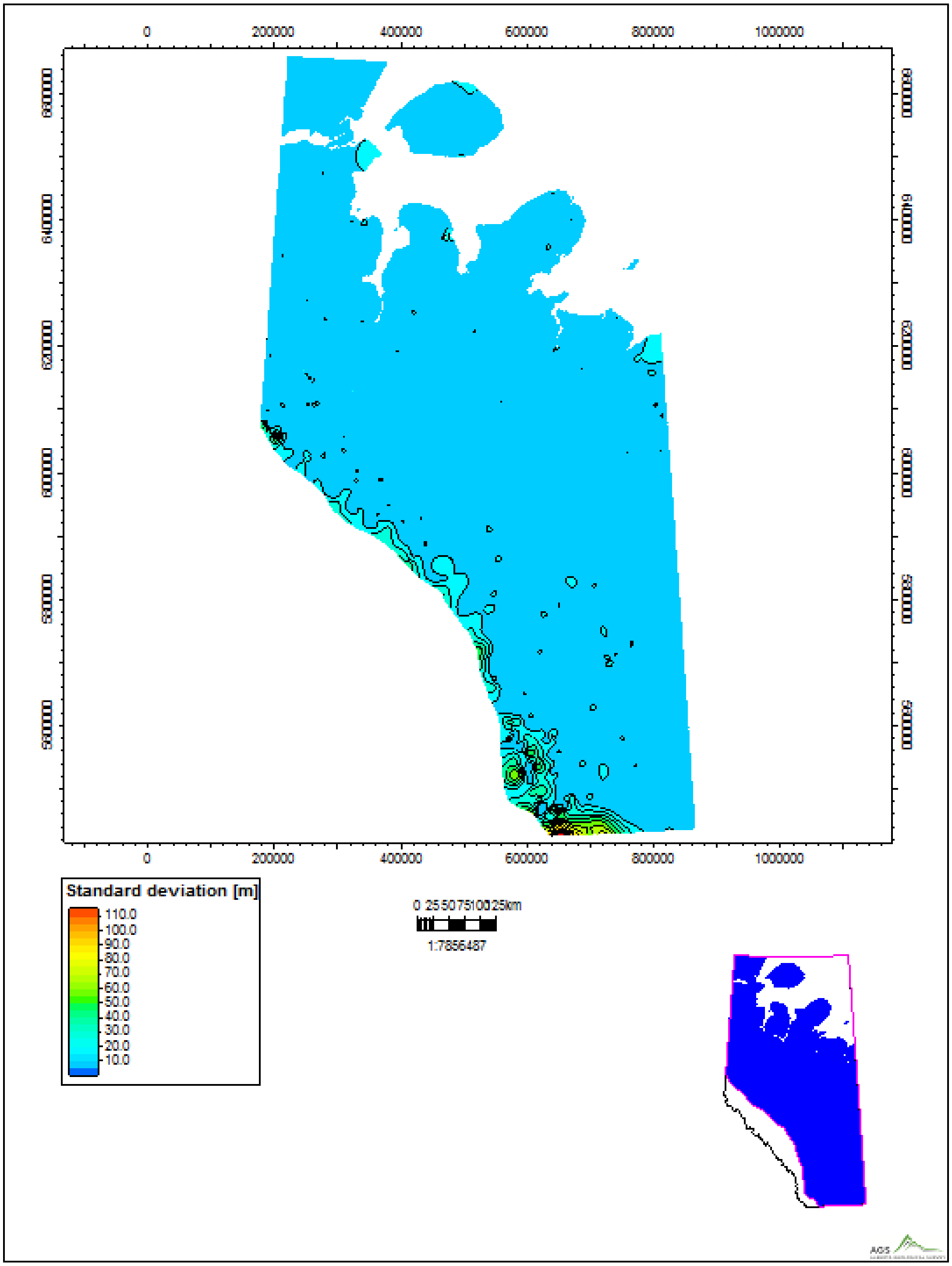


Figure 57. Standard-deviation map for the base of the Fish Scales Formation top surface.

Viking Formation / Bow Island Formation / Peace River Formation equivalent interval top

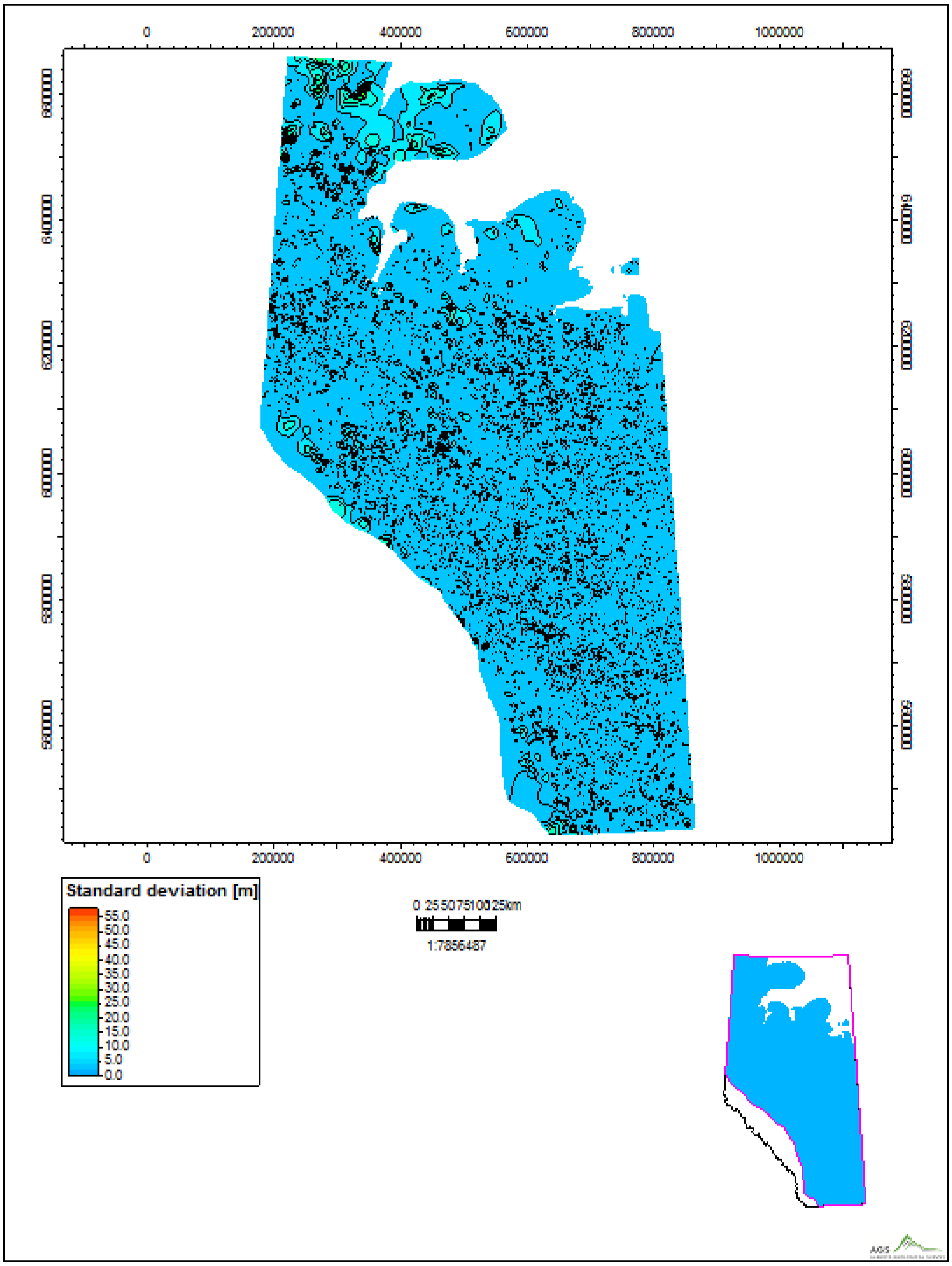


Figure 58. Standard-deviation map for the Viking Formation / Bow Island Formation / Peace River Formation equivalent interval top surface.

Mannville Group equivalent interval top

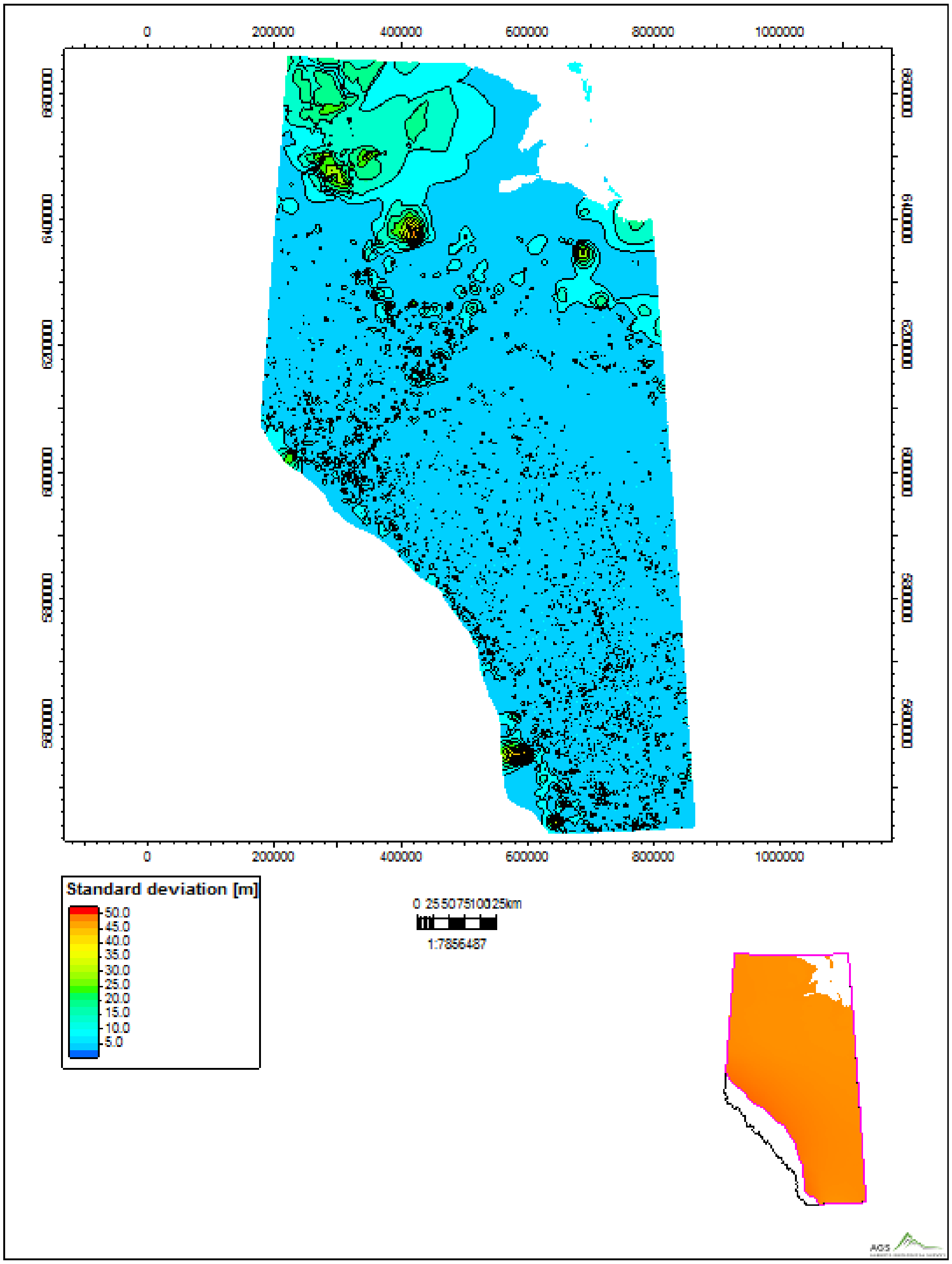


Figure 59. Standard-deviation map for the Mannville Group equivalent interval top surface.

Sub-Cretaceous unconformity

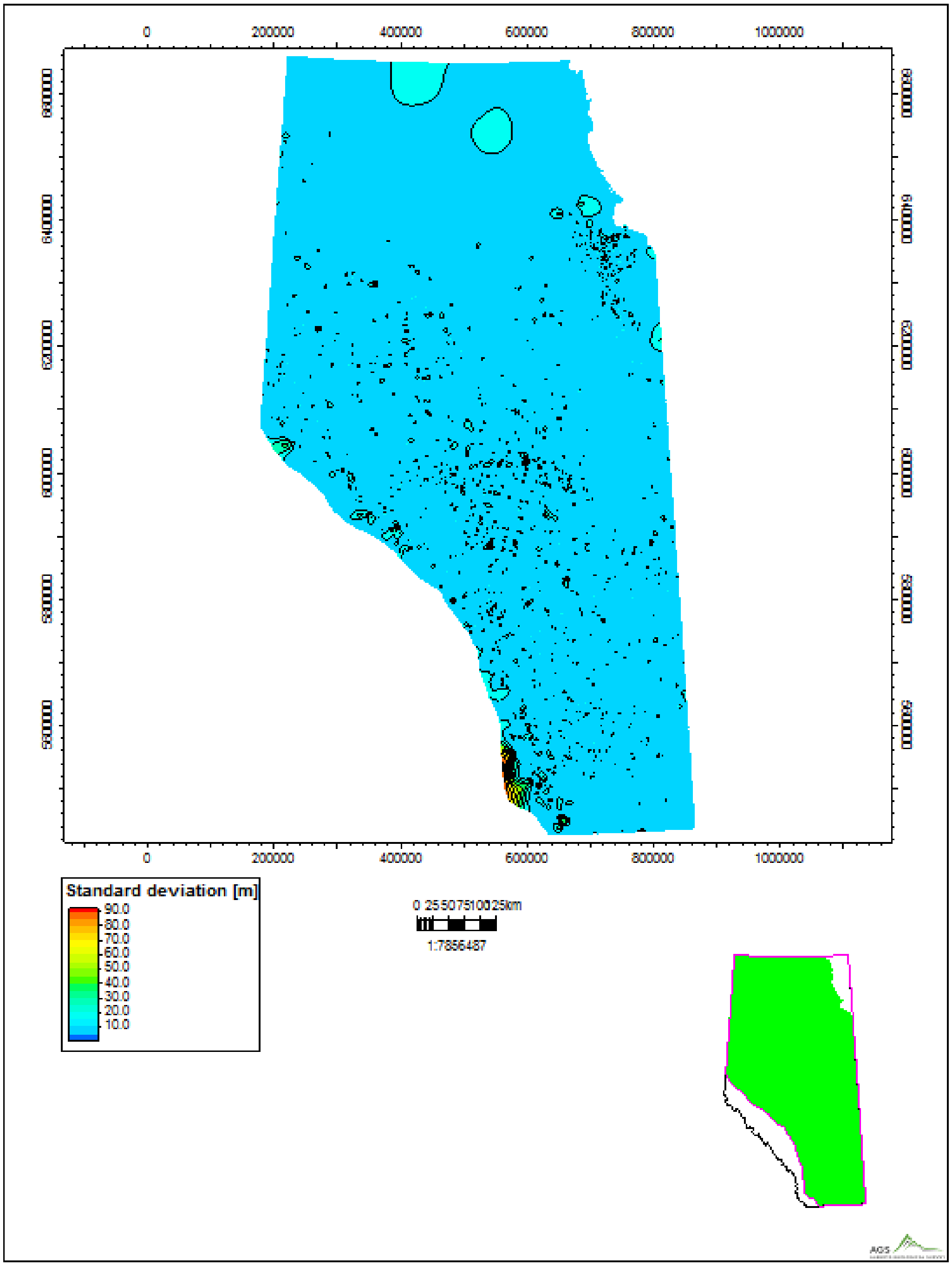


Figure 60. Standard-deviation map for the sub-Cretaceous unconformity surface.

Banff Formation top

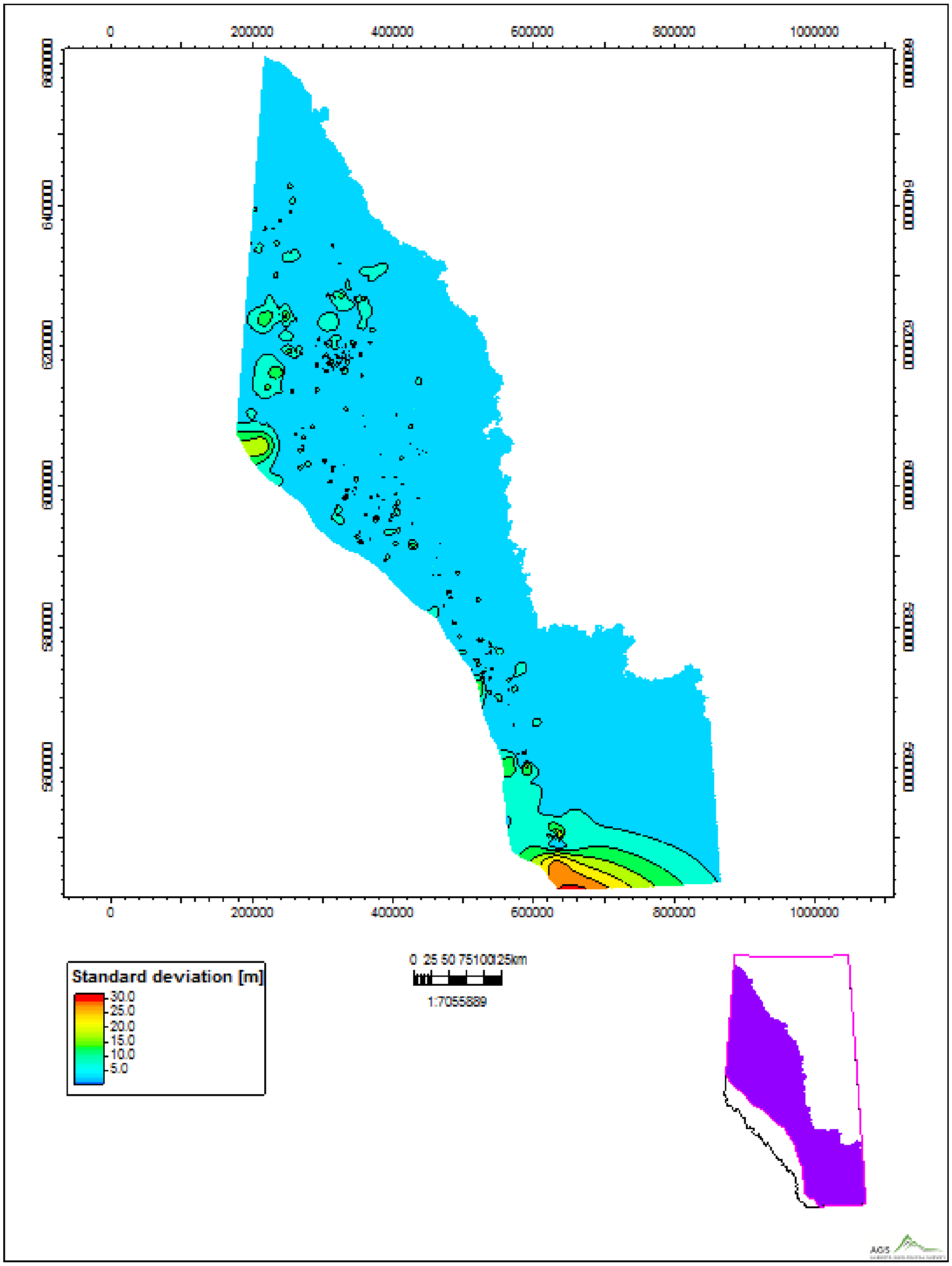


Figure 61. Standard-deviation map for the Banff Formation top surface.

Wabamun Group top

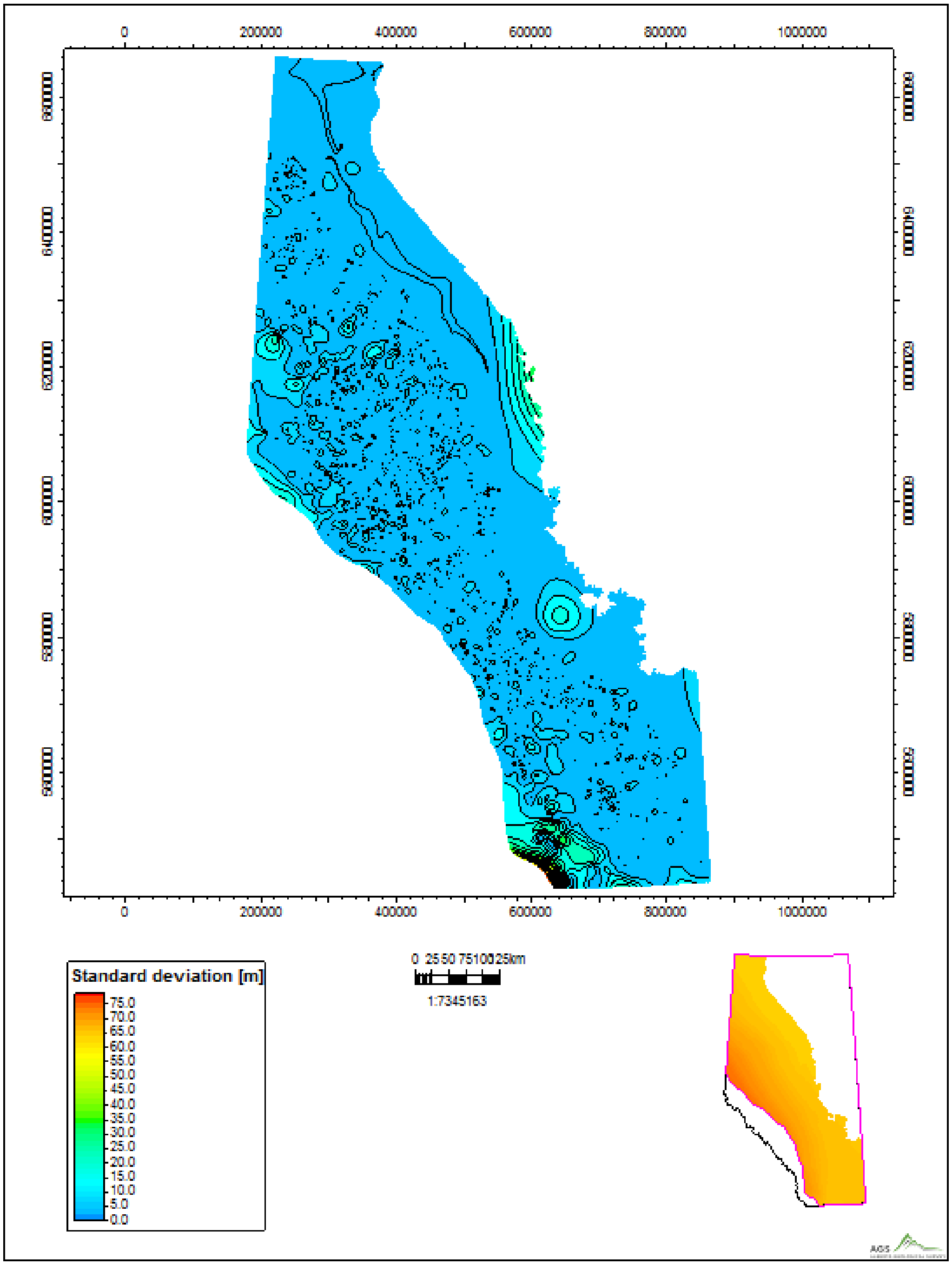


Figure 62. Standard-deviation map for the Wabamun Group top surface.

Winterburn Group top

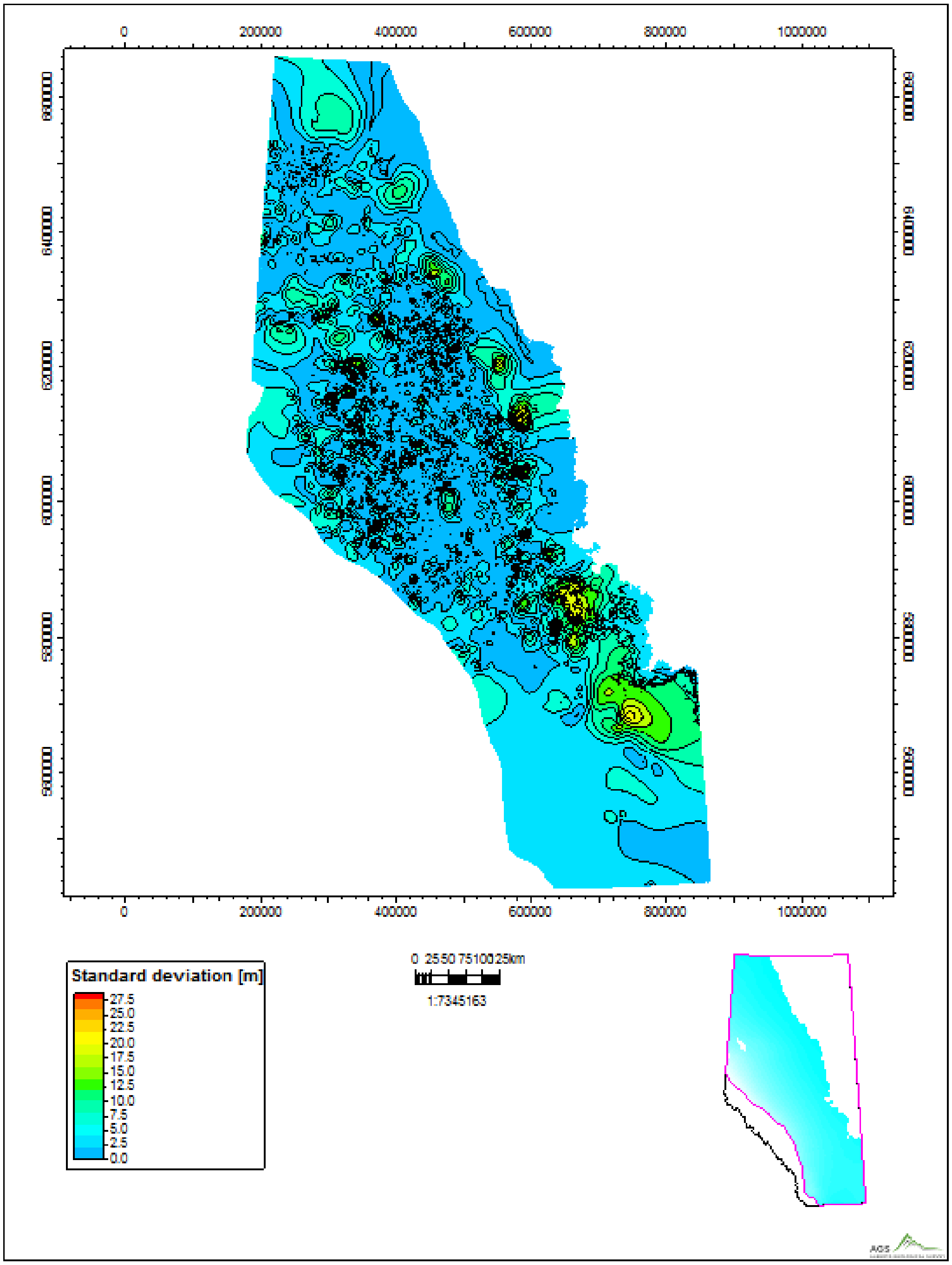


Figure 63. Standard-deviation map for the Winterburn Group top surface.

Woodbend Group top

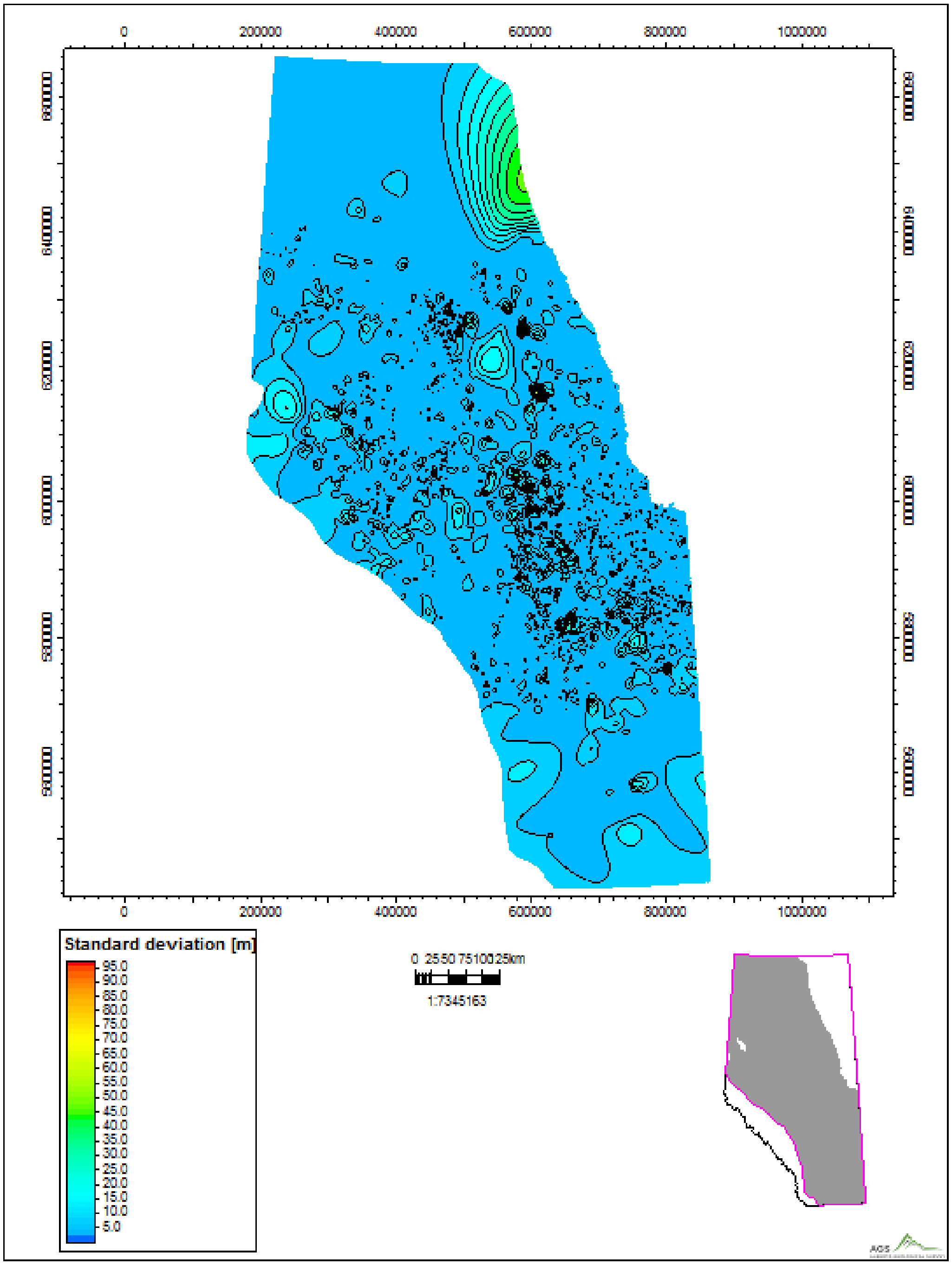


Figure 64. Standard-deviation map for the Woodbend Group top surface (no standard-deviation maps were created for the Woodbend Group shales [WOOD A] and the Woodbend Group shales [WOOD B] top surfaces).

Duvernay Formation top

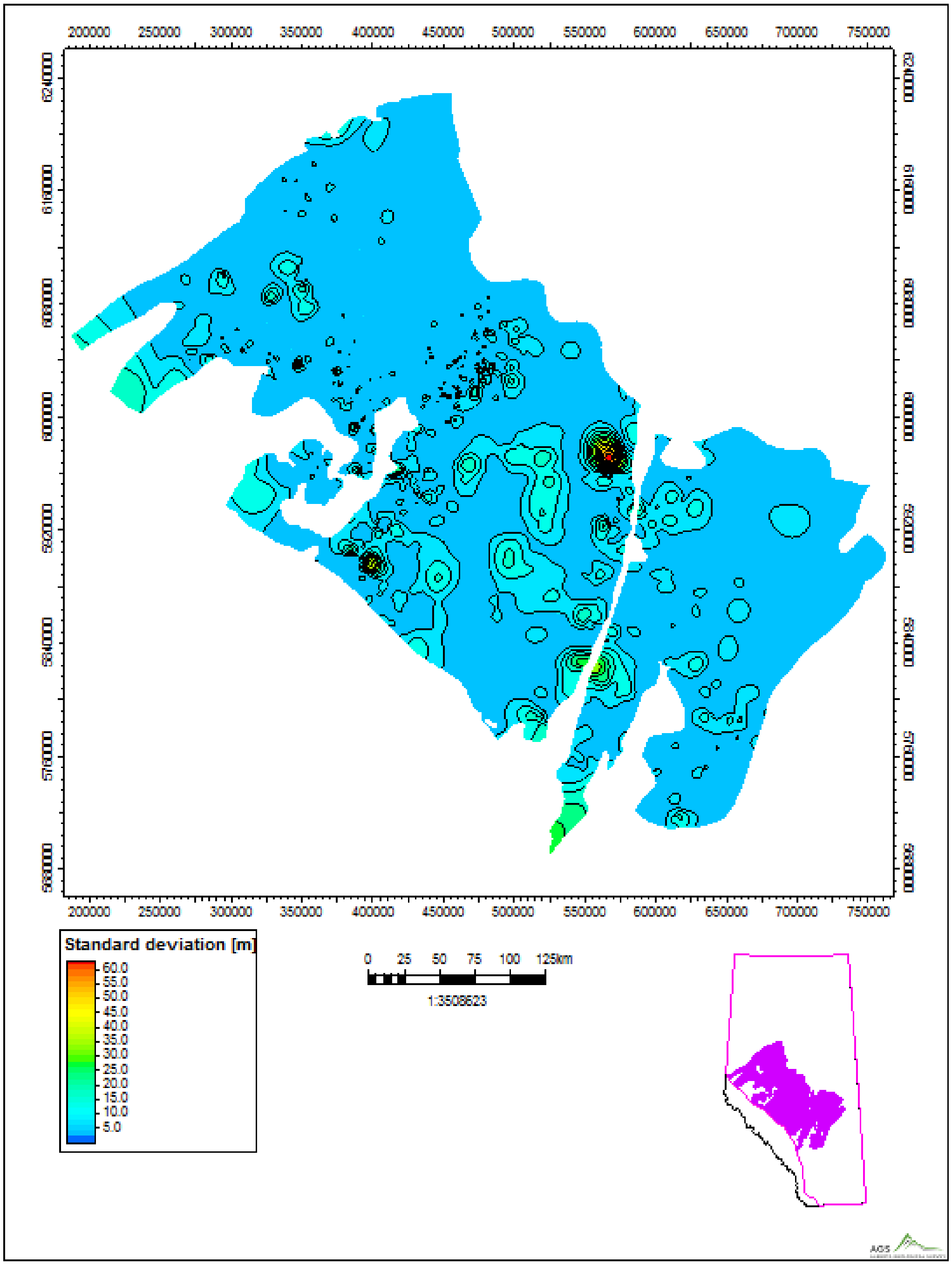


Figure 65. Standard-deviation map for the Duvernay Formation top surface.

Leduc Formation top

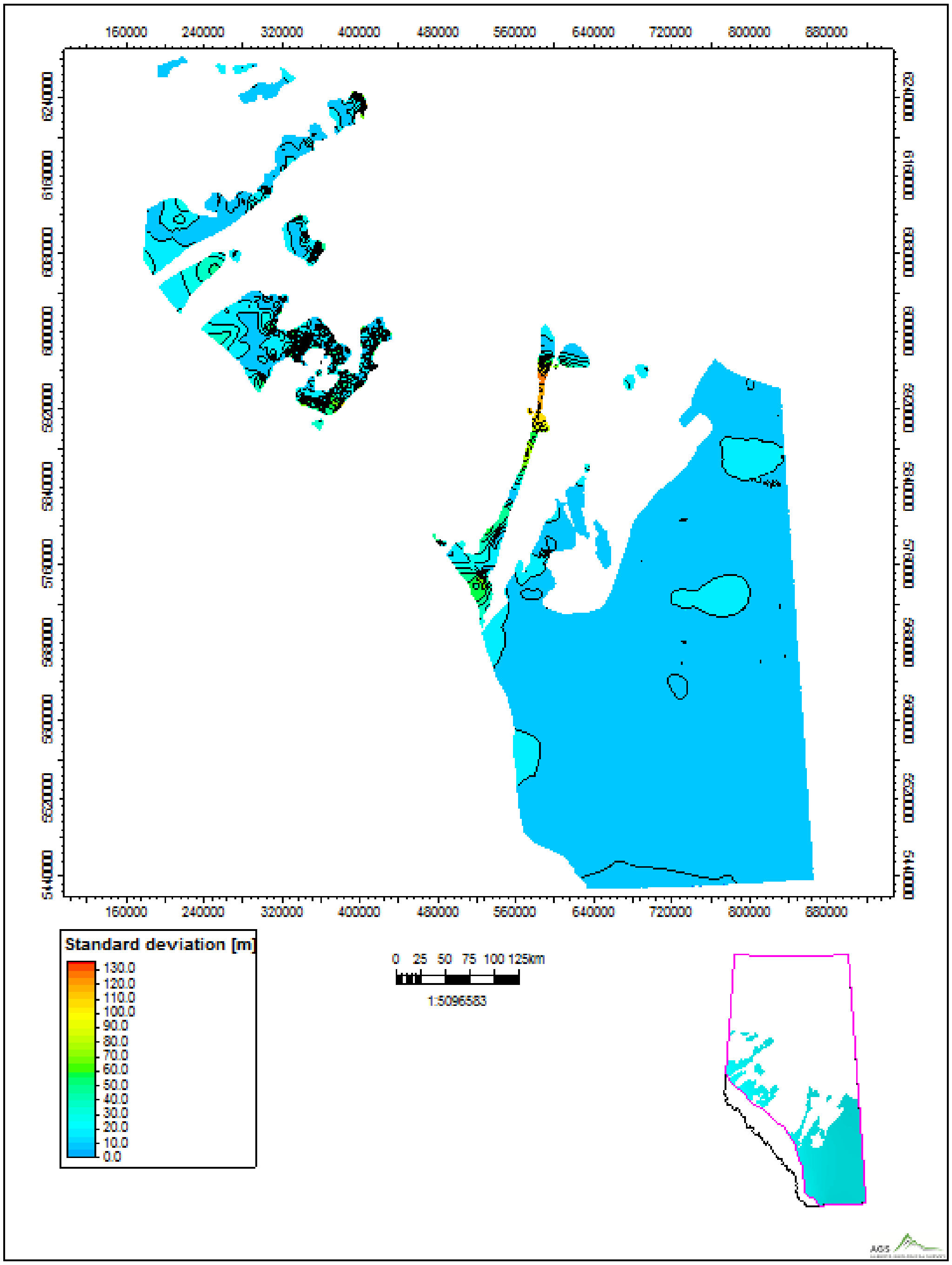


Figure 66. Standard-deviation map for the Leduc Formation top surface.

Cooking Lake Formation top

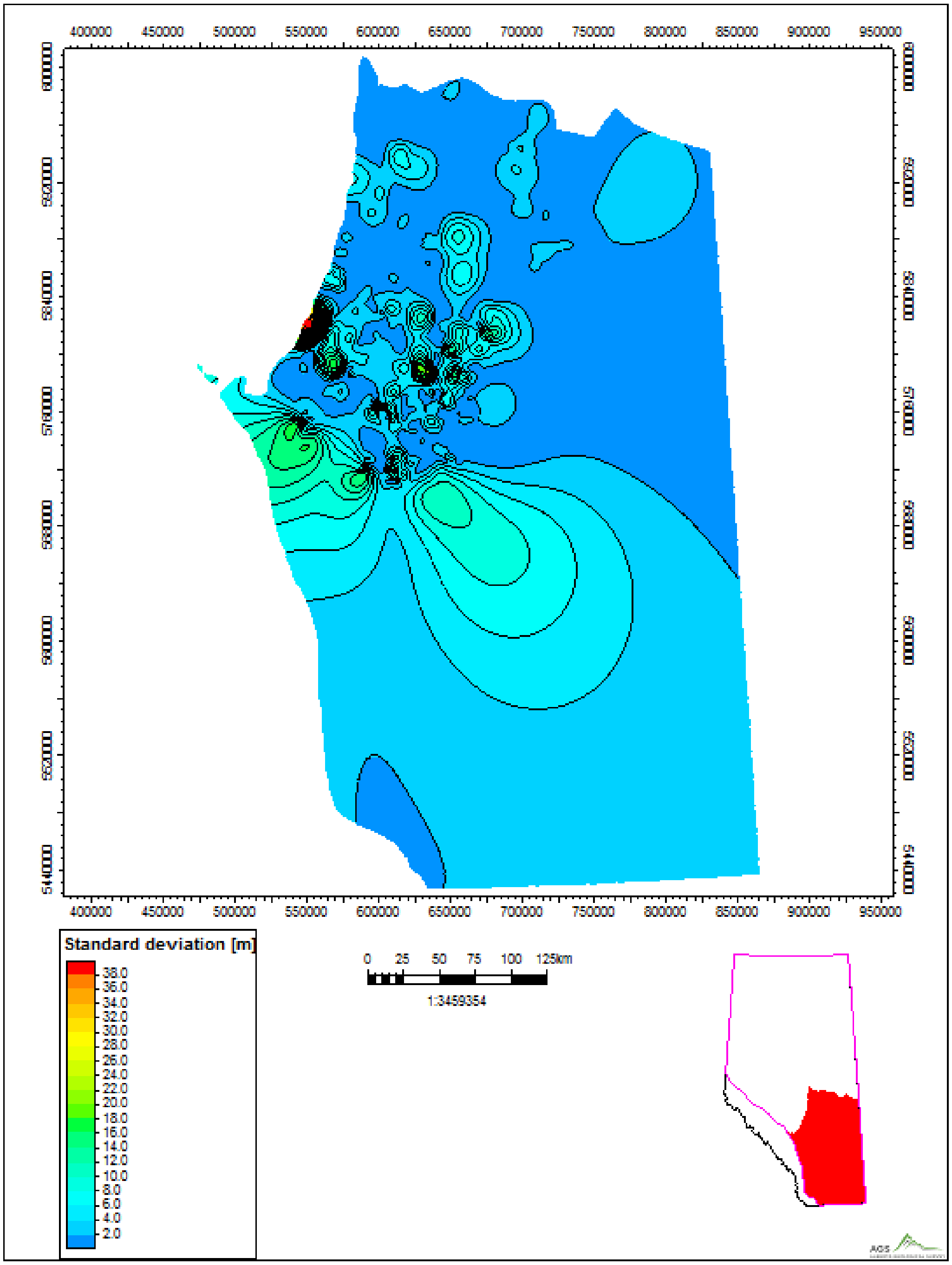


Figure 67. Standard-deviation map for the Cooking Lake Formation top surface.

Majeau Lake Formation top

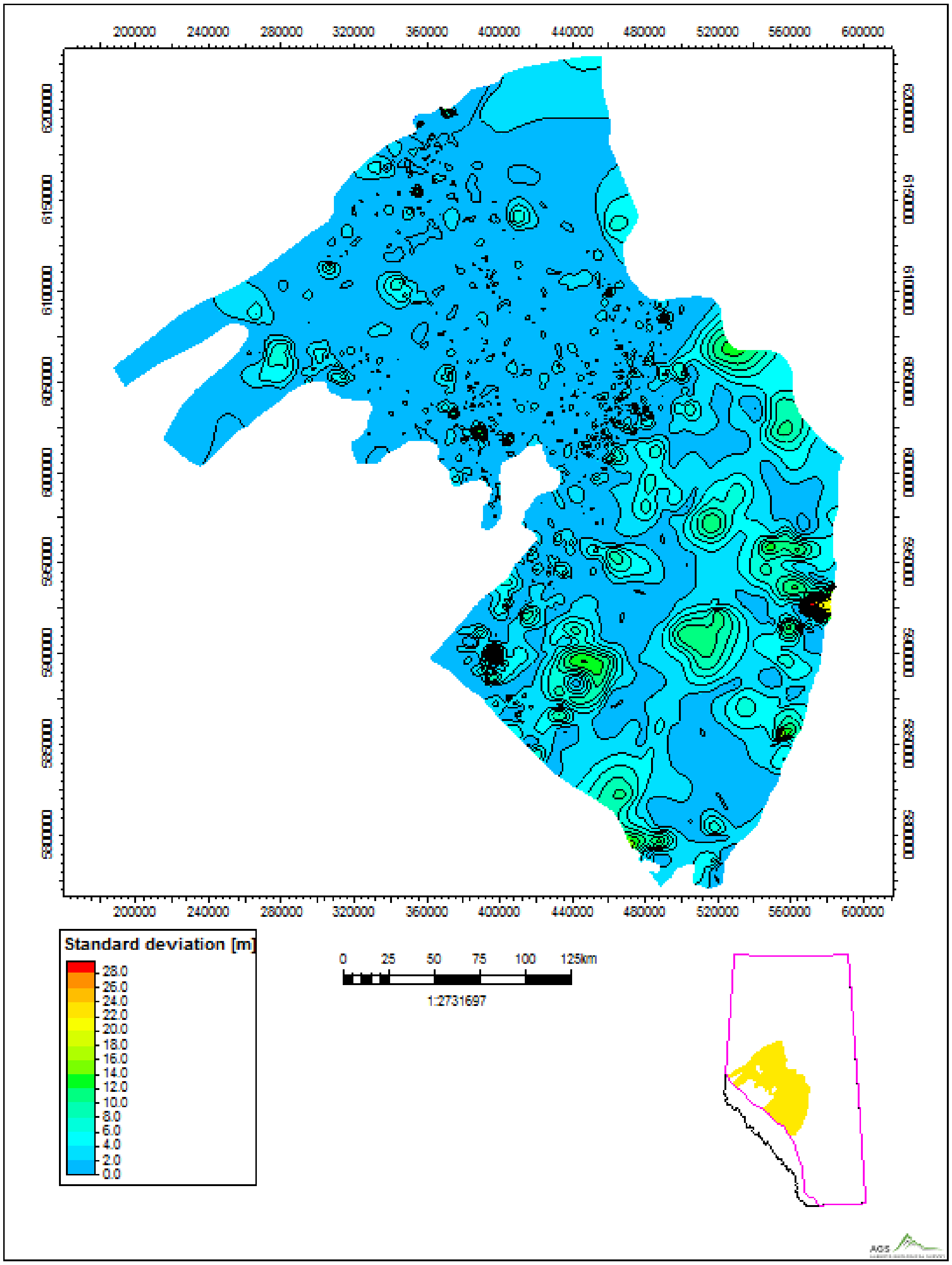


Figure 68. Standard-deviation map for the Majeau Lake Formation top surface.

Waterways Formation top

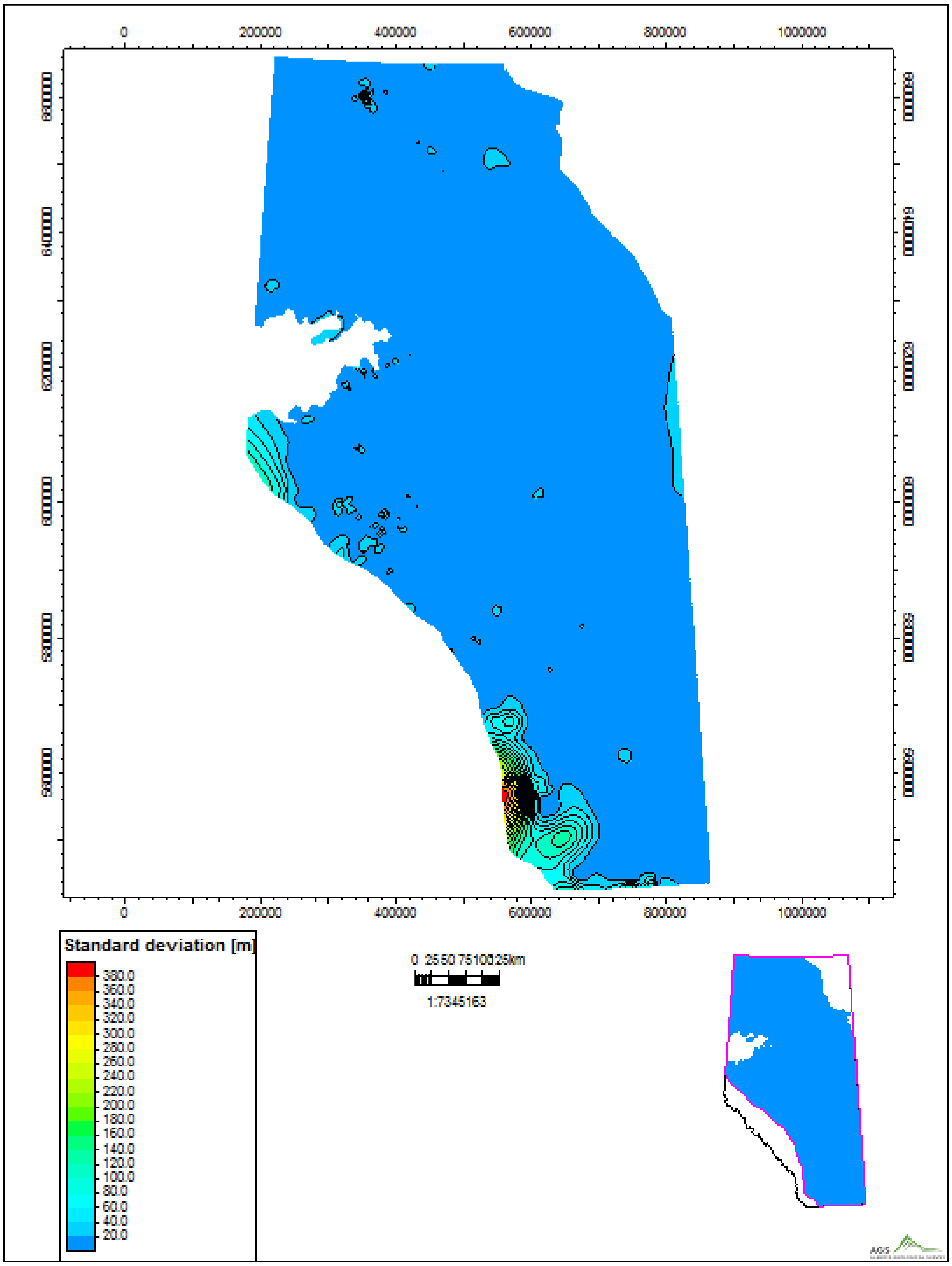


Figure 69. Standard-deviation map for the Waterways Formation top surface (no standard-deviation map was created for the Beaverhill Lake Group top surface).

Swan Hills / Slave Point formations interval top

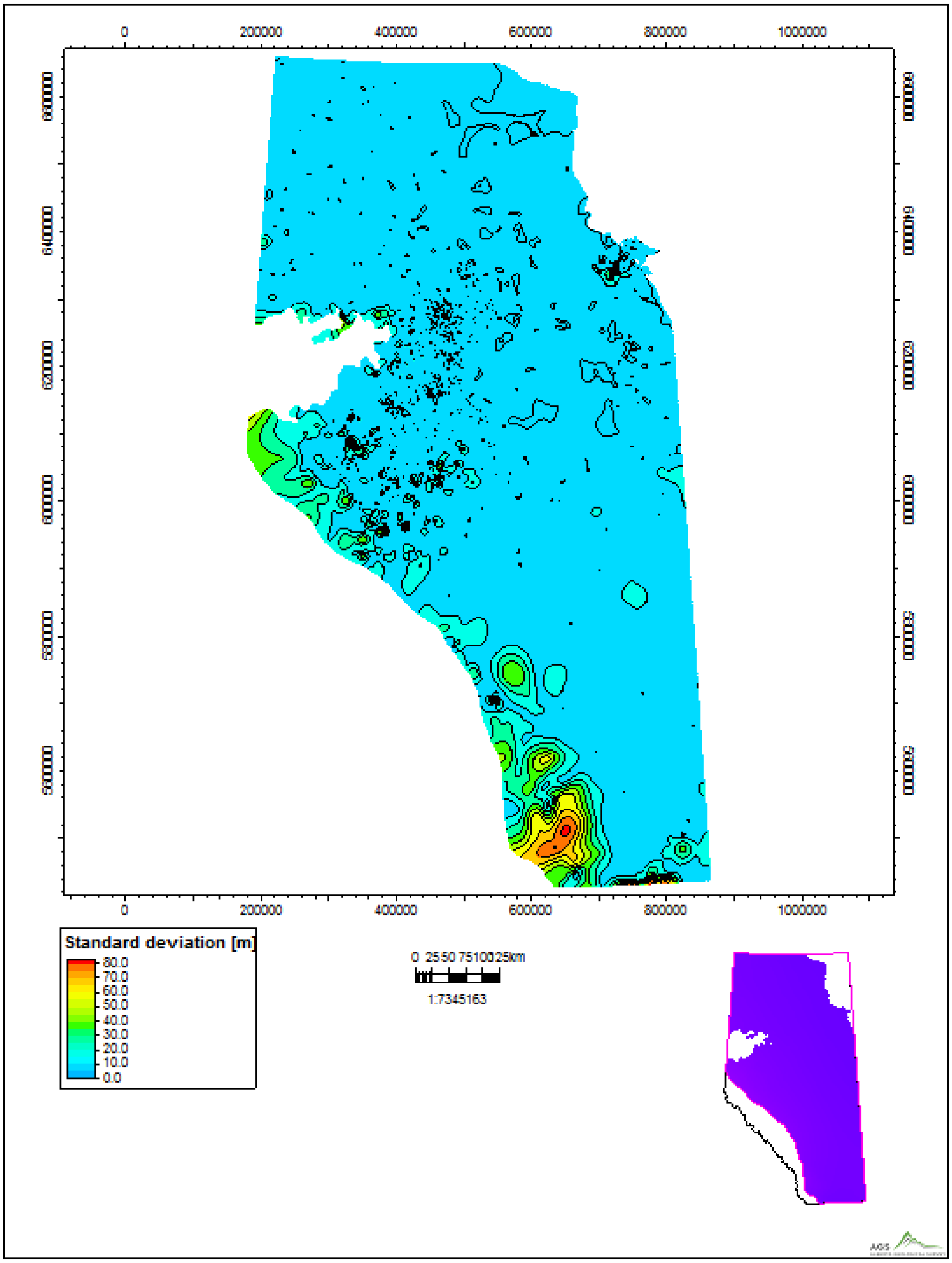


Figure 70. Standard-deviation map for the Swan Hills / Slave Point formations interval top surface.

Fort Vermilion Formation top

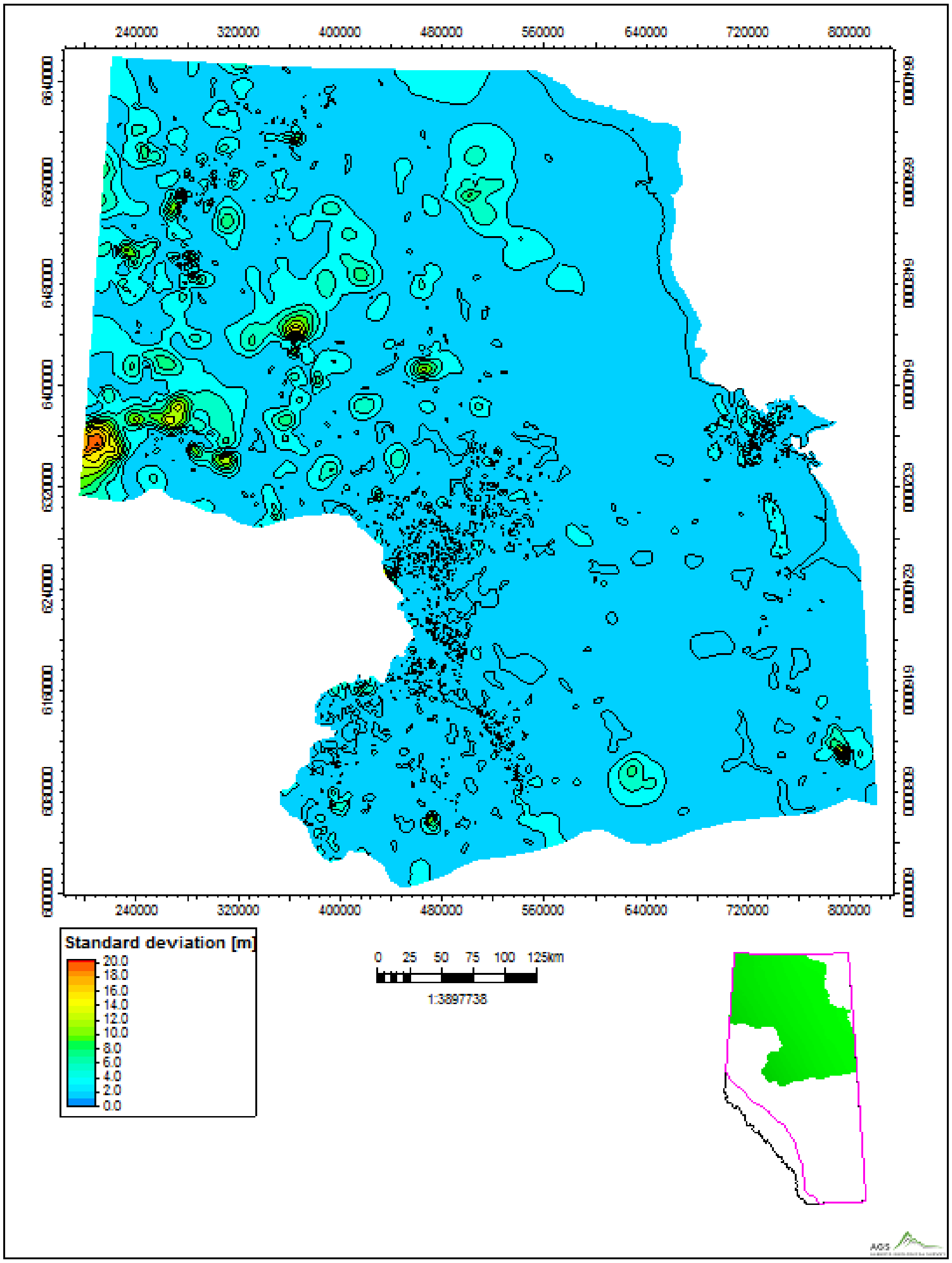


Figure 71. Standard-deviation map for the Fort Vermilion Formation top surface.

Elk Point Group top

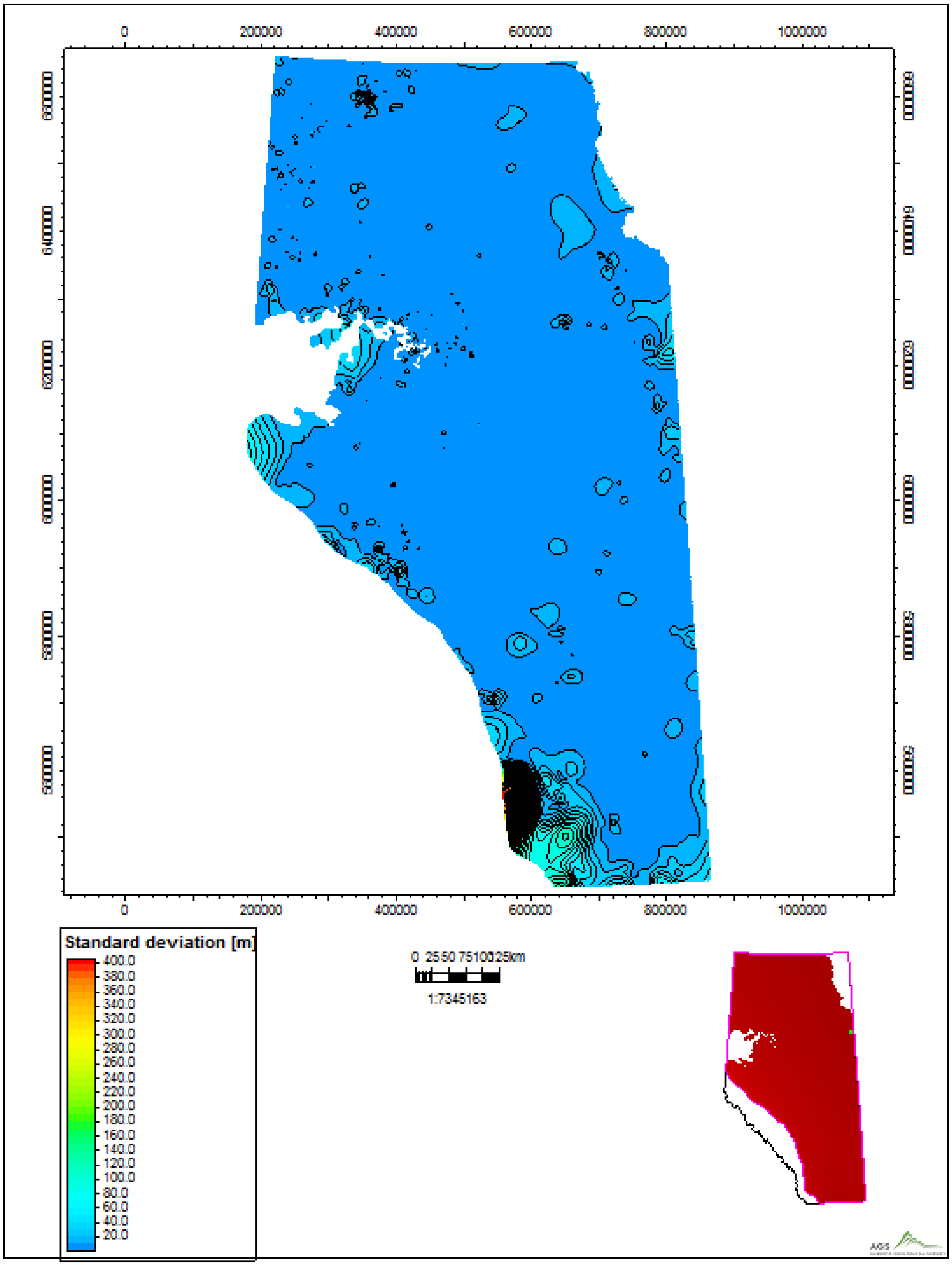


Figure 72. Standard-deviation map for the Elk Point Group top surface.

Precambrian top

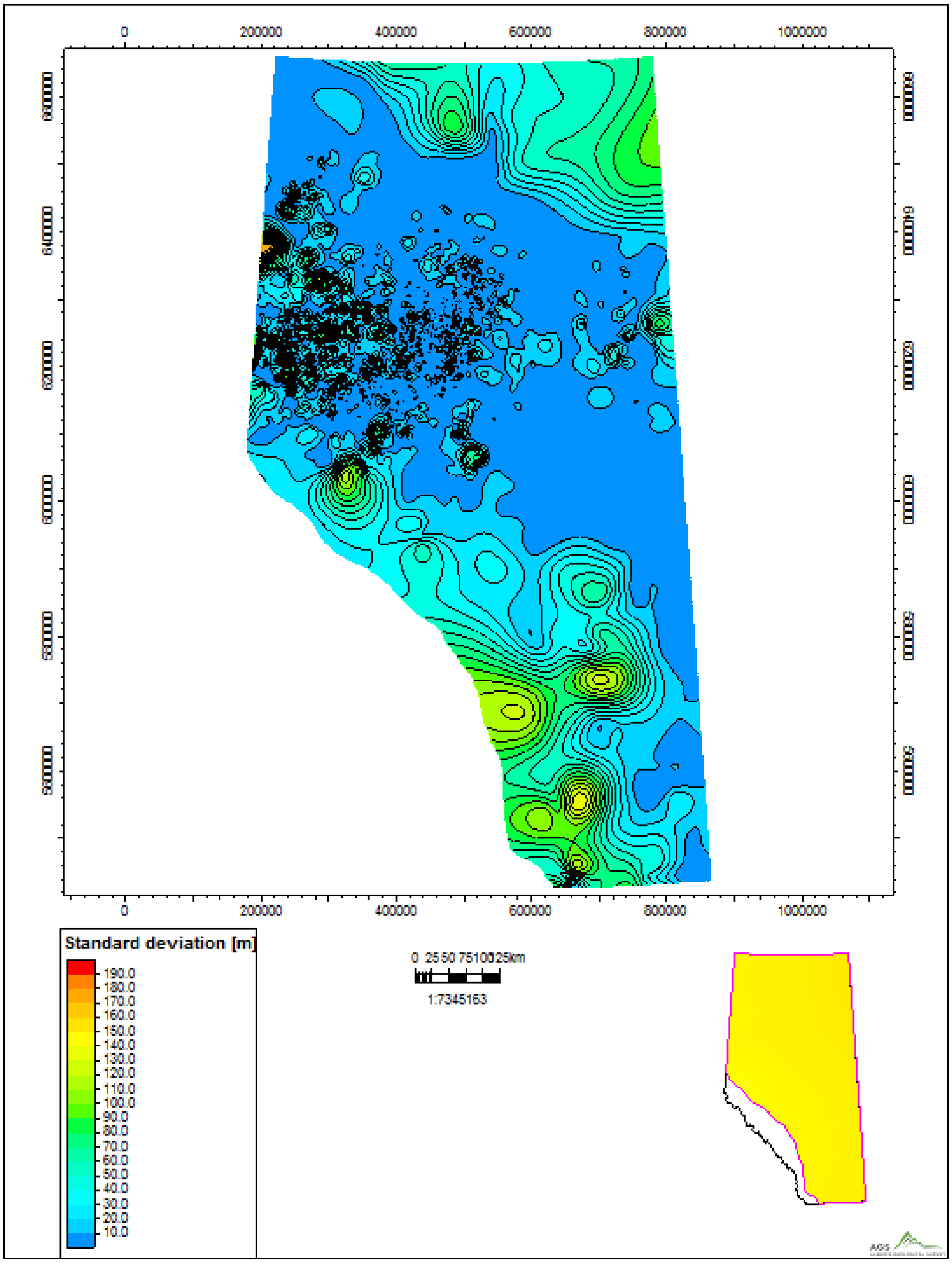


Figure 73. Standard-deviation map for the Precambrian top surface.

Appendix 5 − Oblique Views of Modelled Zones

Sediment above bedrock

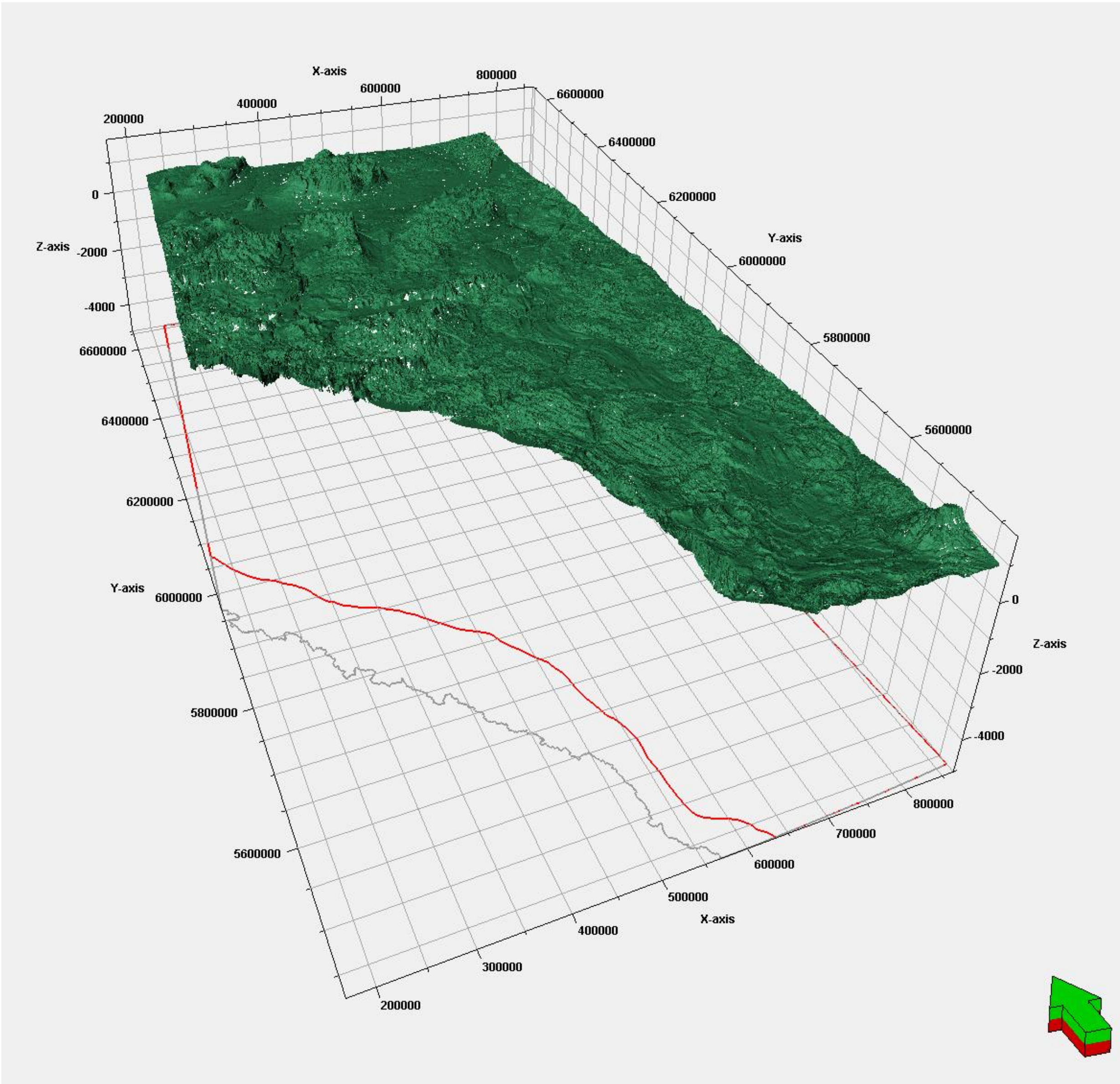


Figure 74. Oblique view of the model zone for sediment above bedrock (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Paskapoo Formation

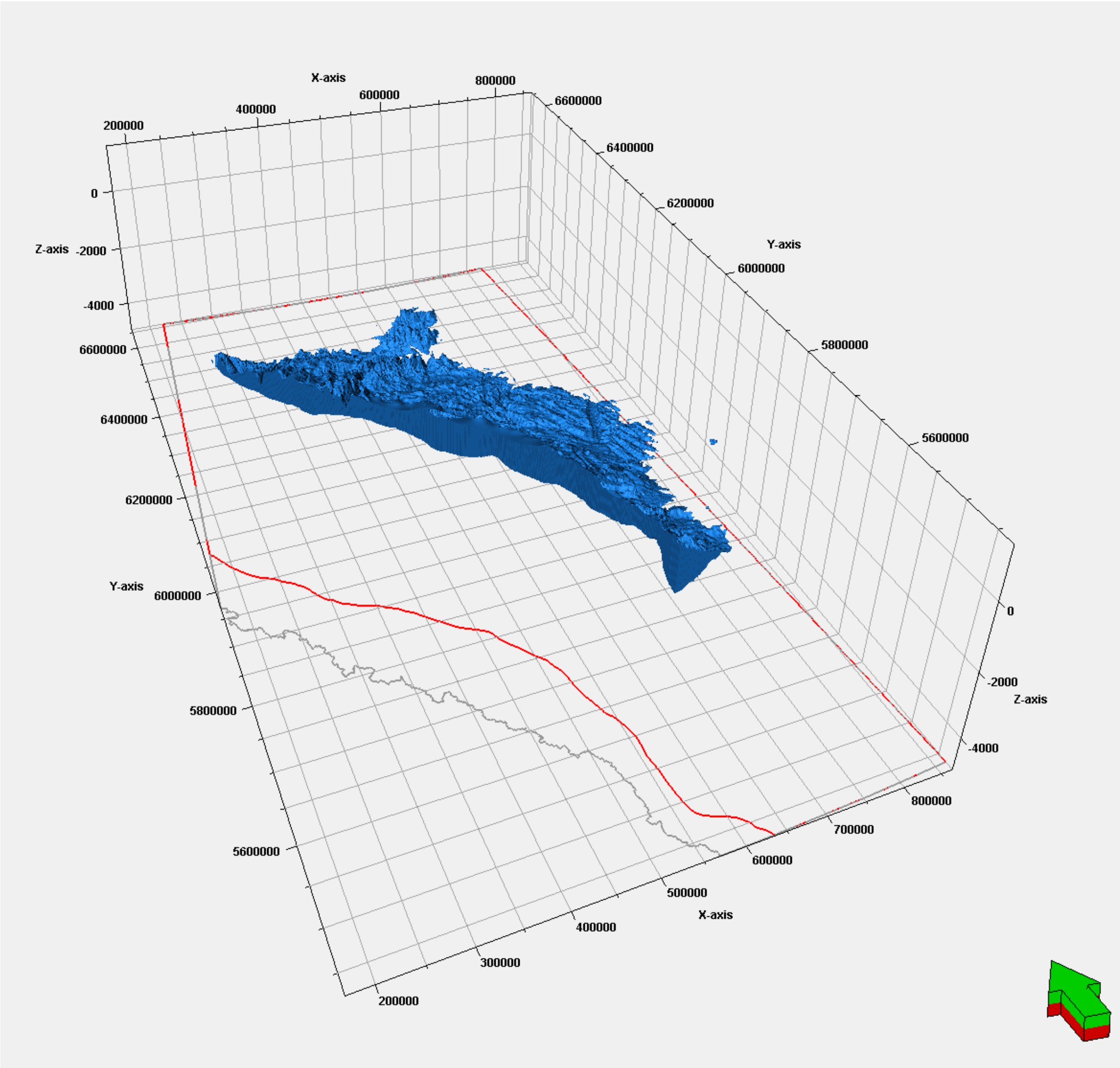


Figure 75. Oblique view of the Paskapoo Formation model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Scollard Formation

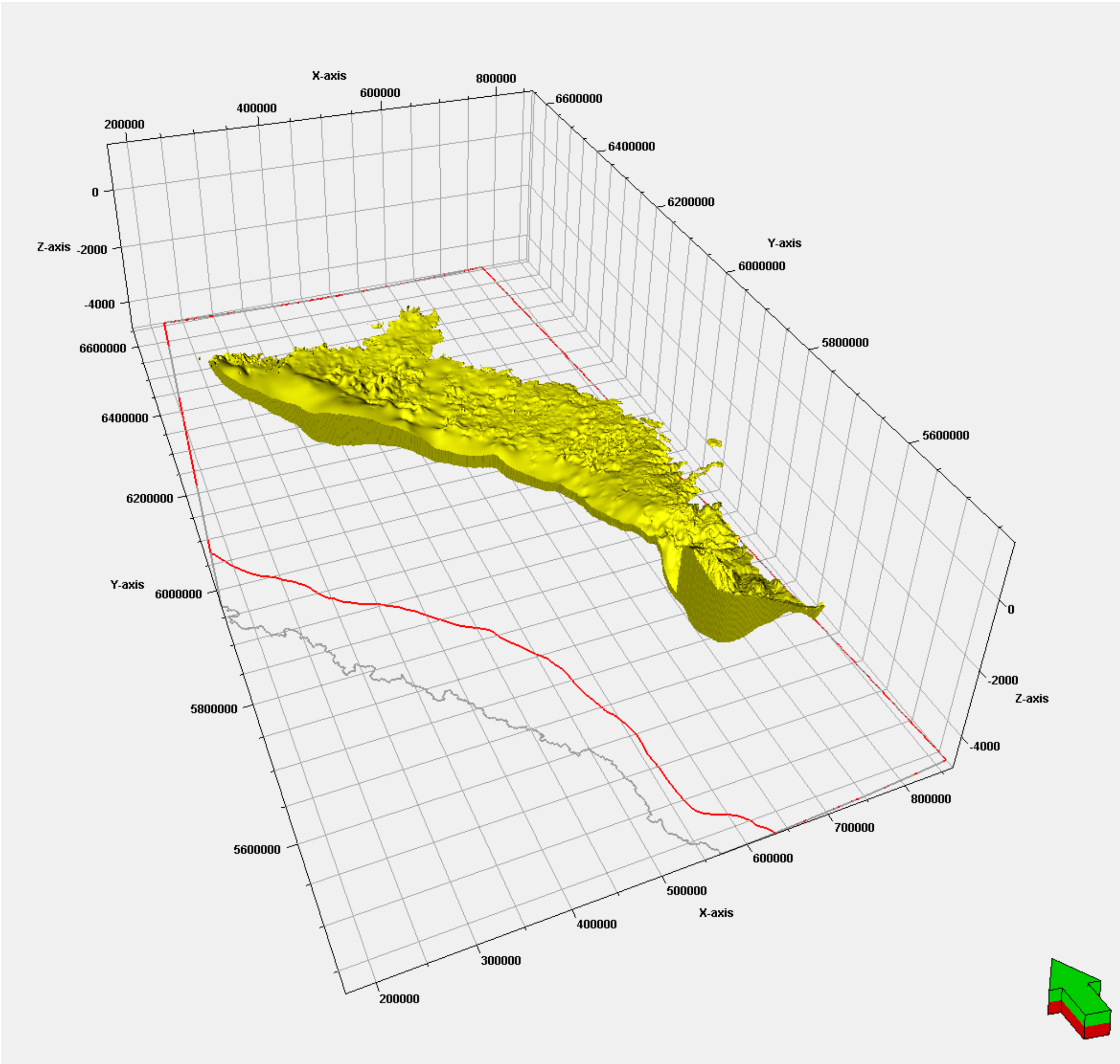


Figure 76. Oblique view of the Scollard Formation model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Battle Formation

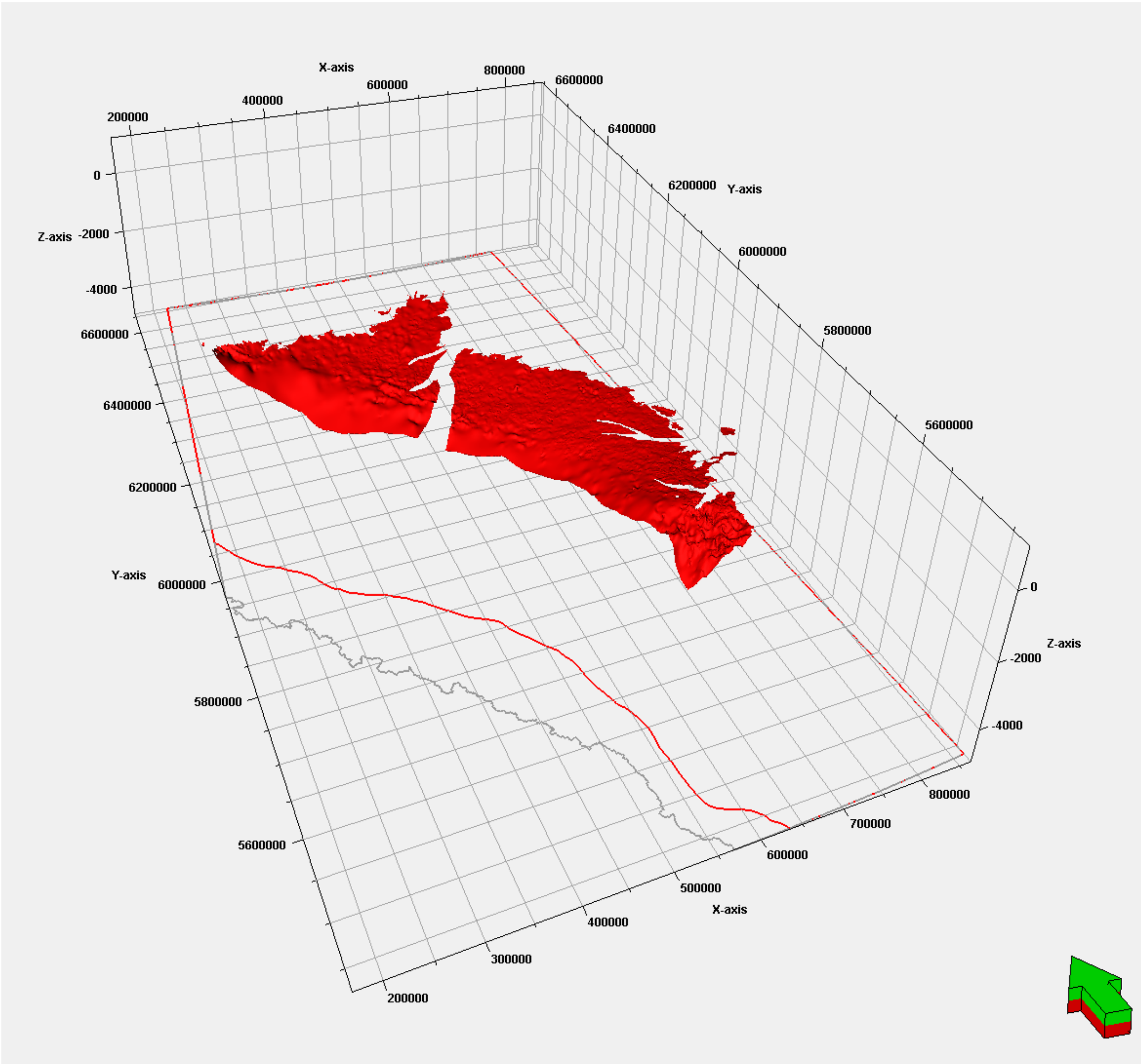


Figure 77. Oblique view of the Battle Formation model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Undifferentiated Horseshoe Canyon Formation / Wapiti Formation / St. Mary River Formation / Belly River Group / Bearpaw Formation equivalent interval

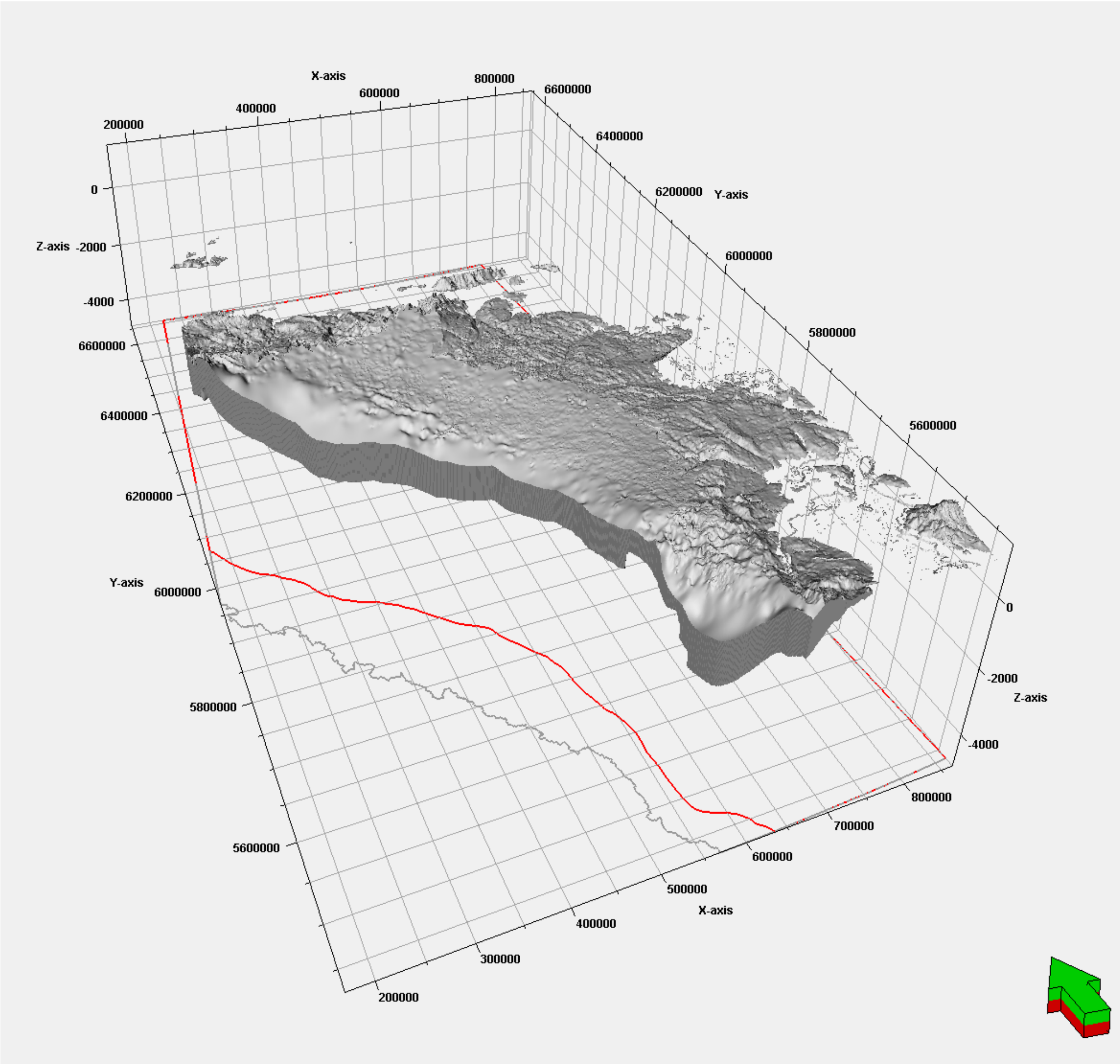


Figure 78. Oblique view of the undifferentiated Horseshoe Canyon Formation / Wapiti Formation / St. Mary River Formation / Belly River Group / Bearpaw Formation equivalent interval model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Upper Bearpaw interval

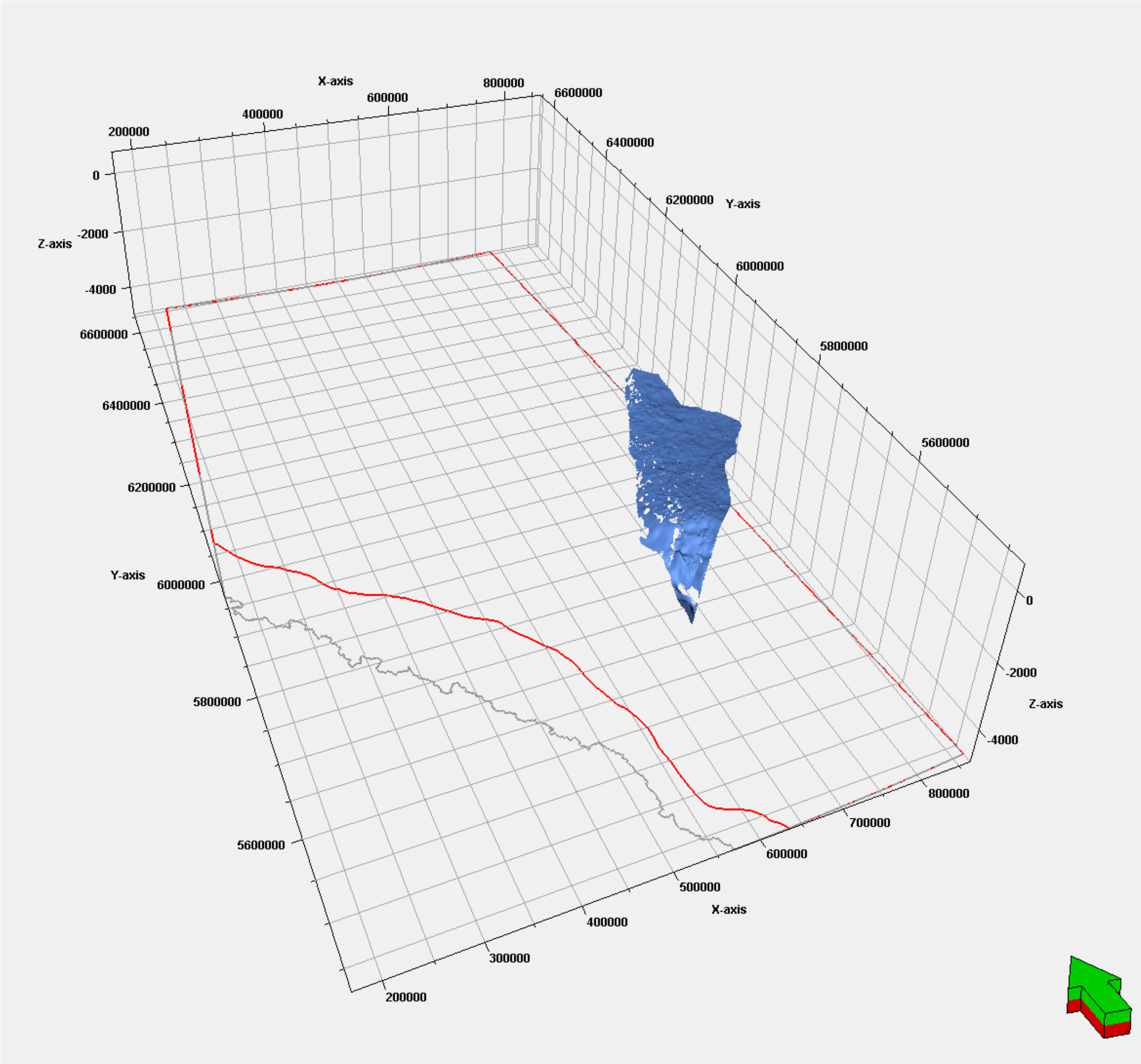


Figure 79. Oblique view of the upper Bearpaw interval model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Strathmore Member

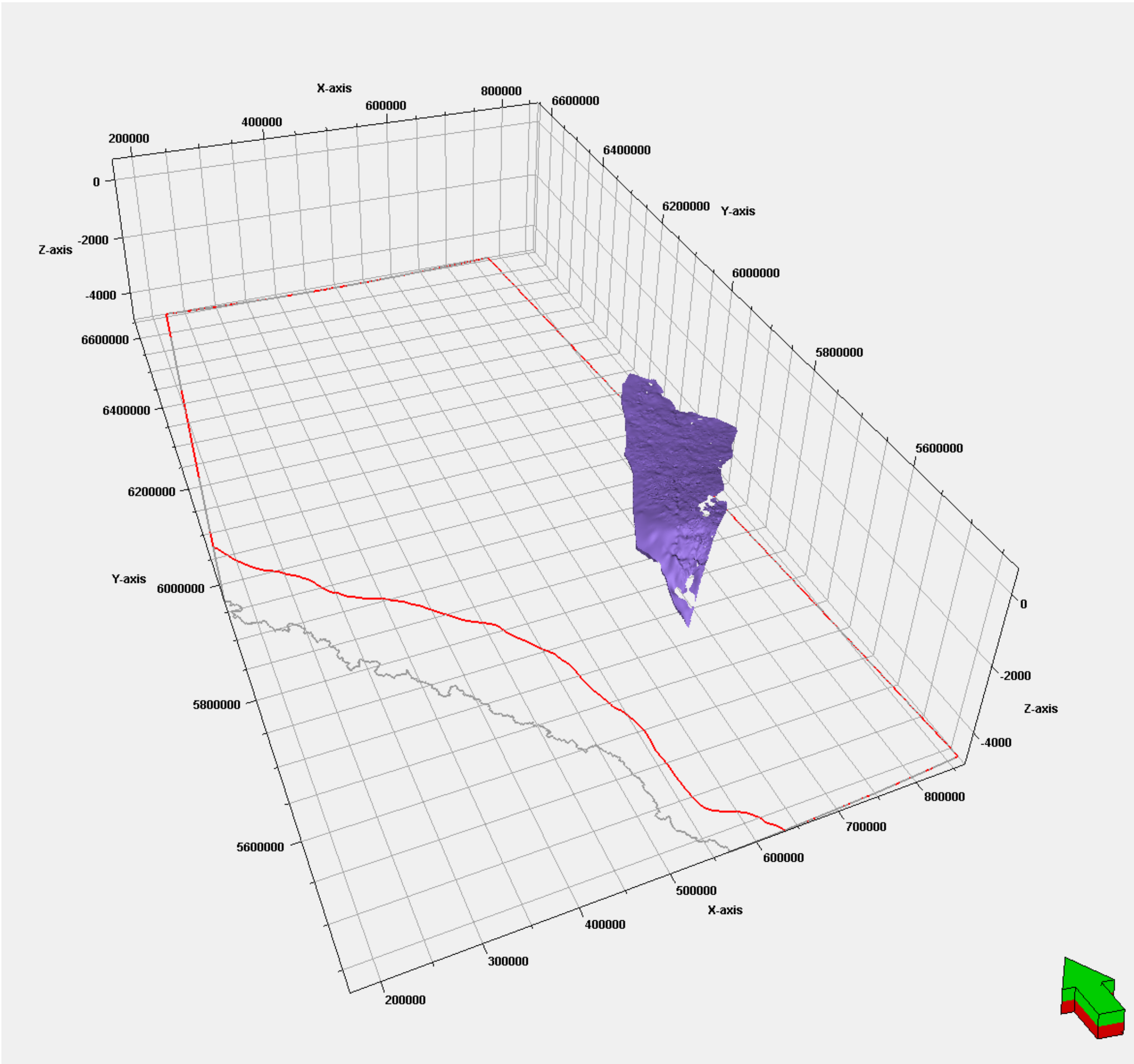


Figure 80. Oblique view of the Strathmore Member model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Lower Bearpaw interval

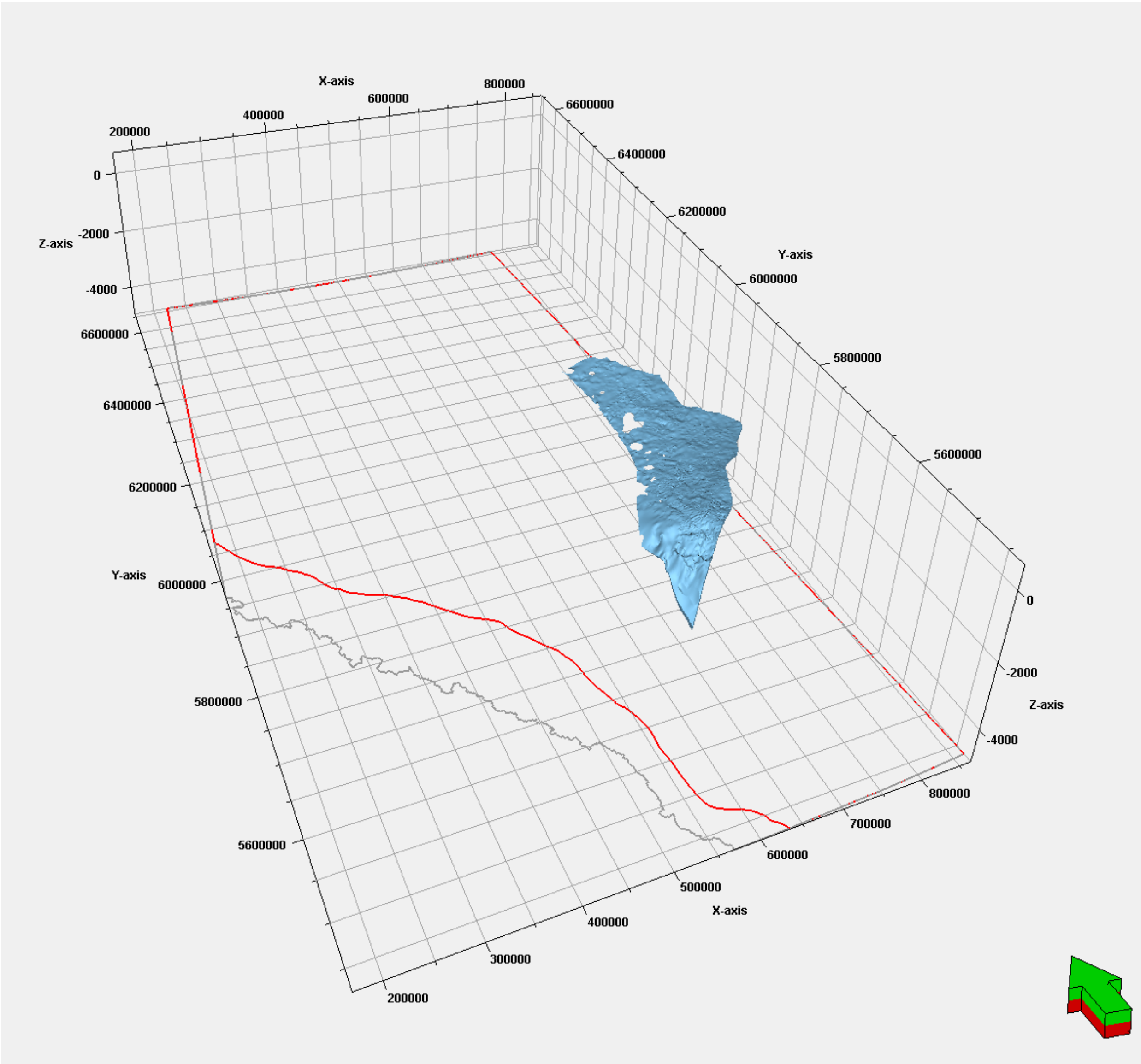


Figure 81. Oblique view of the lower Bearpaw interval model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Dinosaur Park Formation

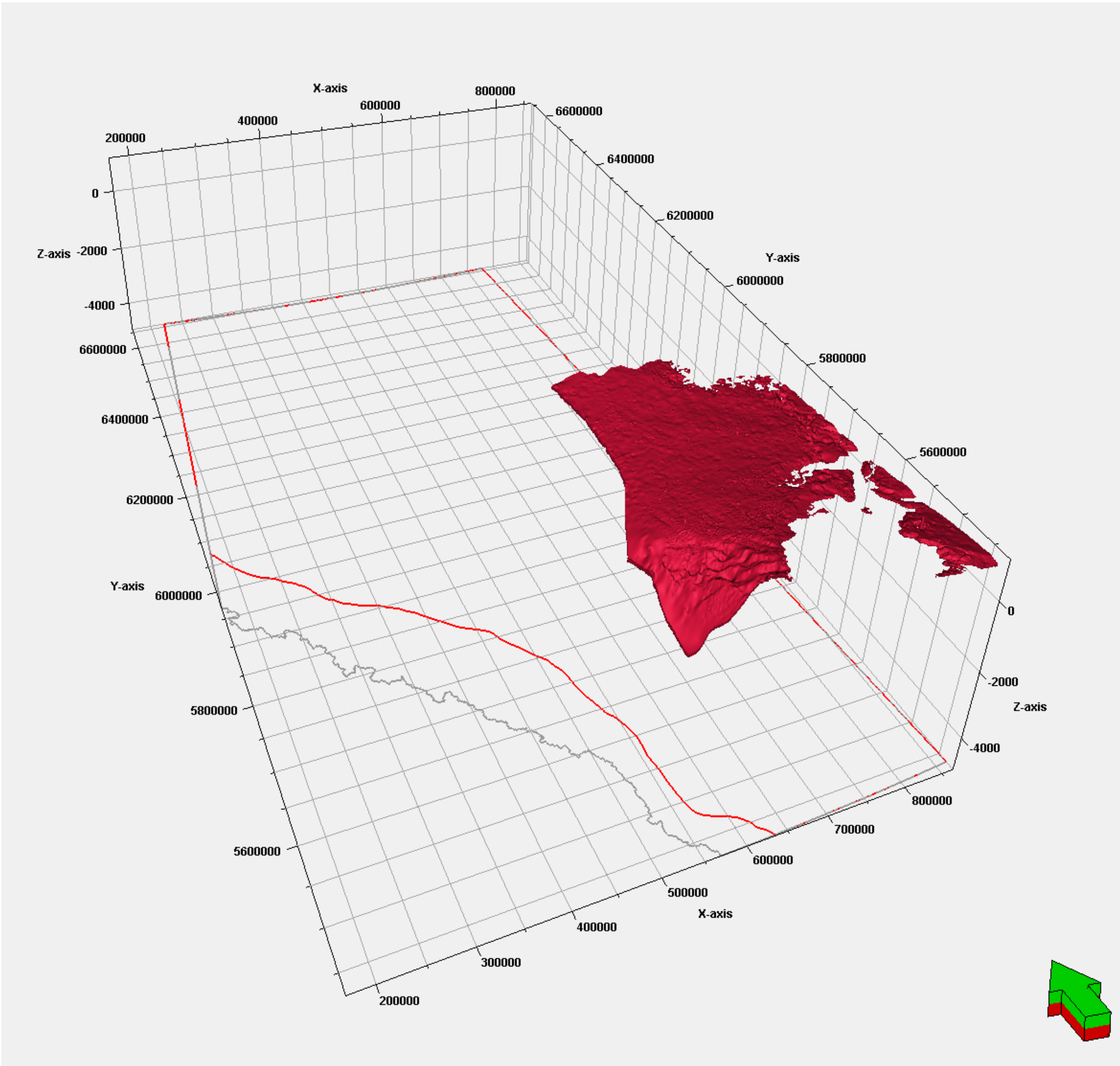


Figure 82. Oblique view of the Dinosaur Park Formation model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Oldman Formation

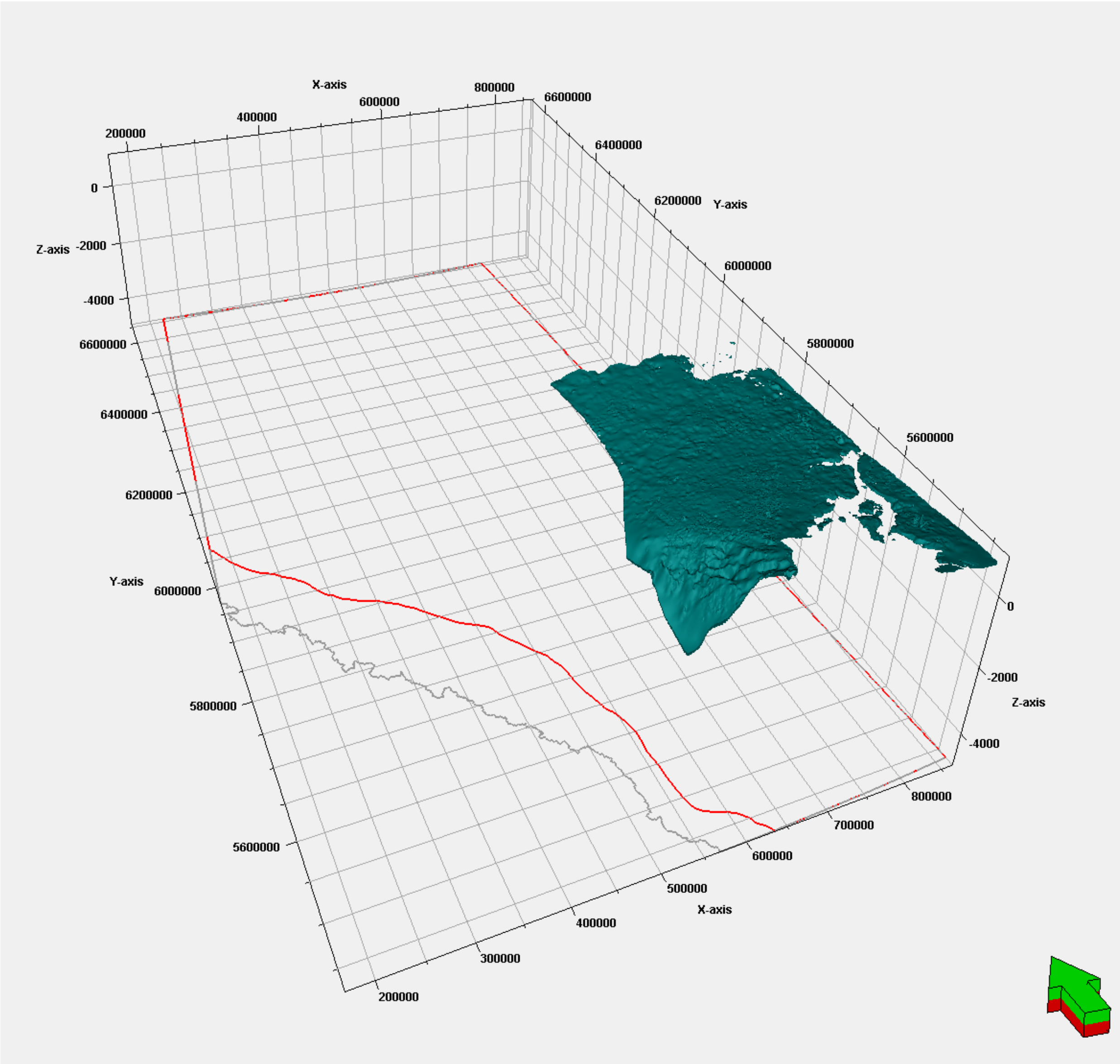


Figure 83. Oblique view of the Oldman Formation model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Foremost Formation

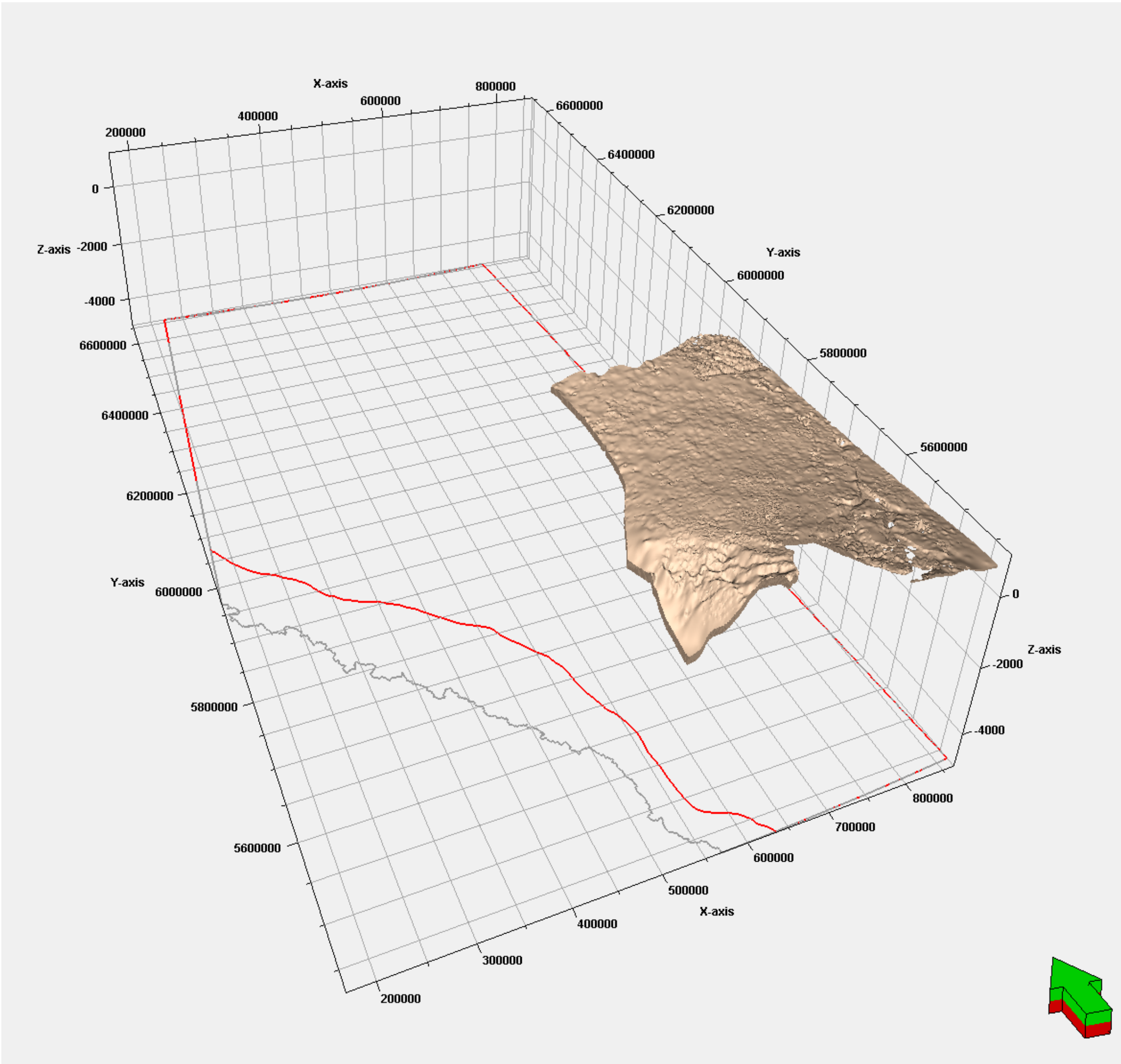


Figure 84. Oblique view of the Foremost Formation model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model boundary in red; vertical exaggeration = 50x).

Undifferentiated Lea Park Formation / Colorado Group / Smoky Group / Fort St. John Group equivalent interval

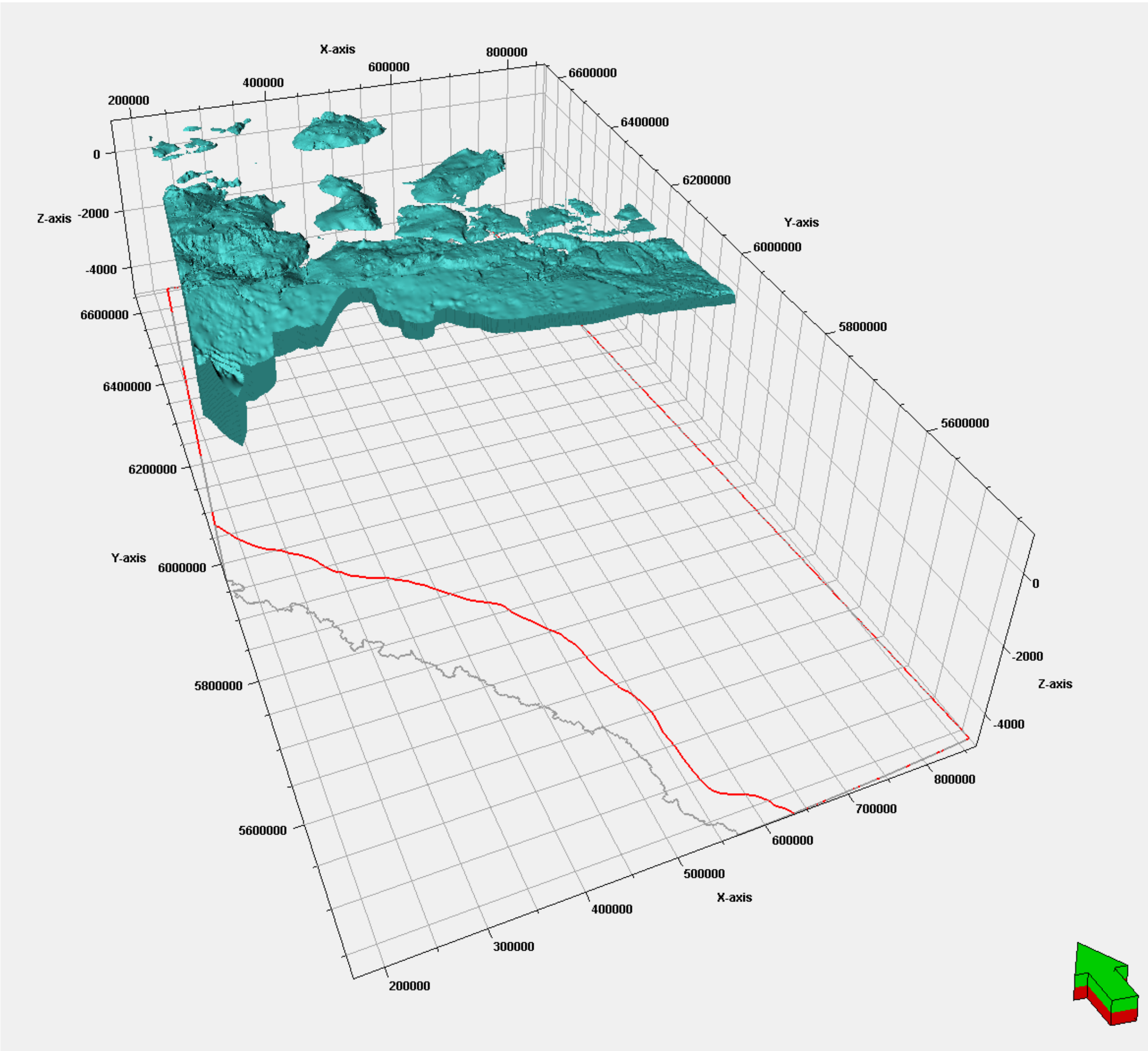


Figure 85. Oblique view of the undifferentiated Lea Park Formation / Colorado Group / Smoky Group / Fort St. John Group equivalent interval model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Pakowki Formation

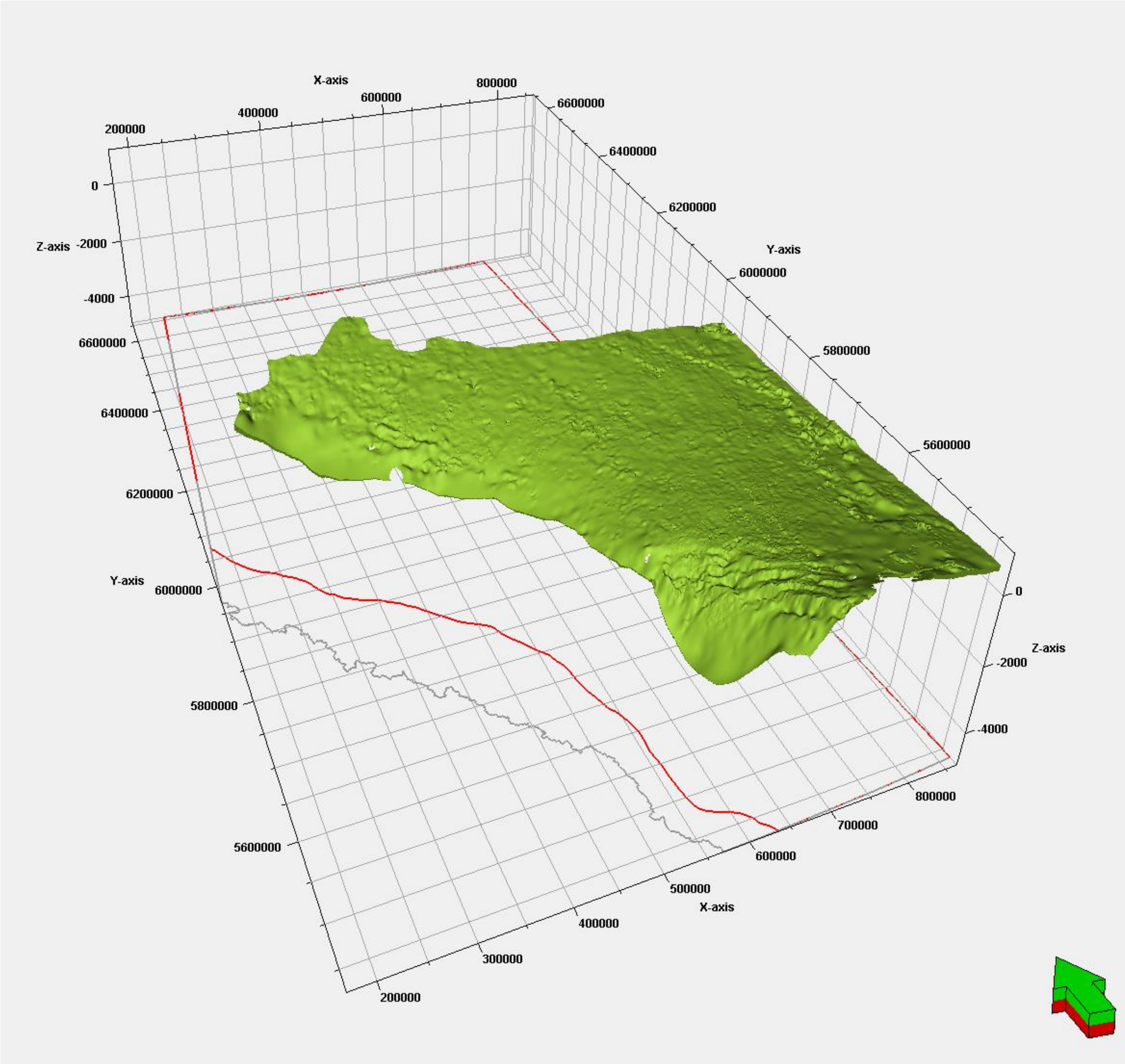


Figure 86. Oblique view of the Pakowki Formation model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Milk River Formation to base of the Fish Scales Formation interval

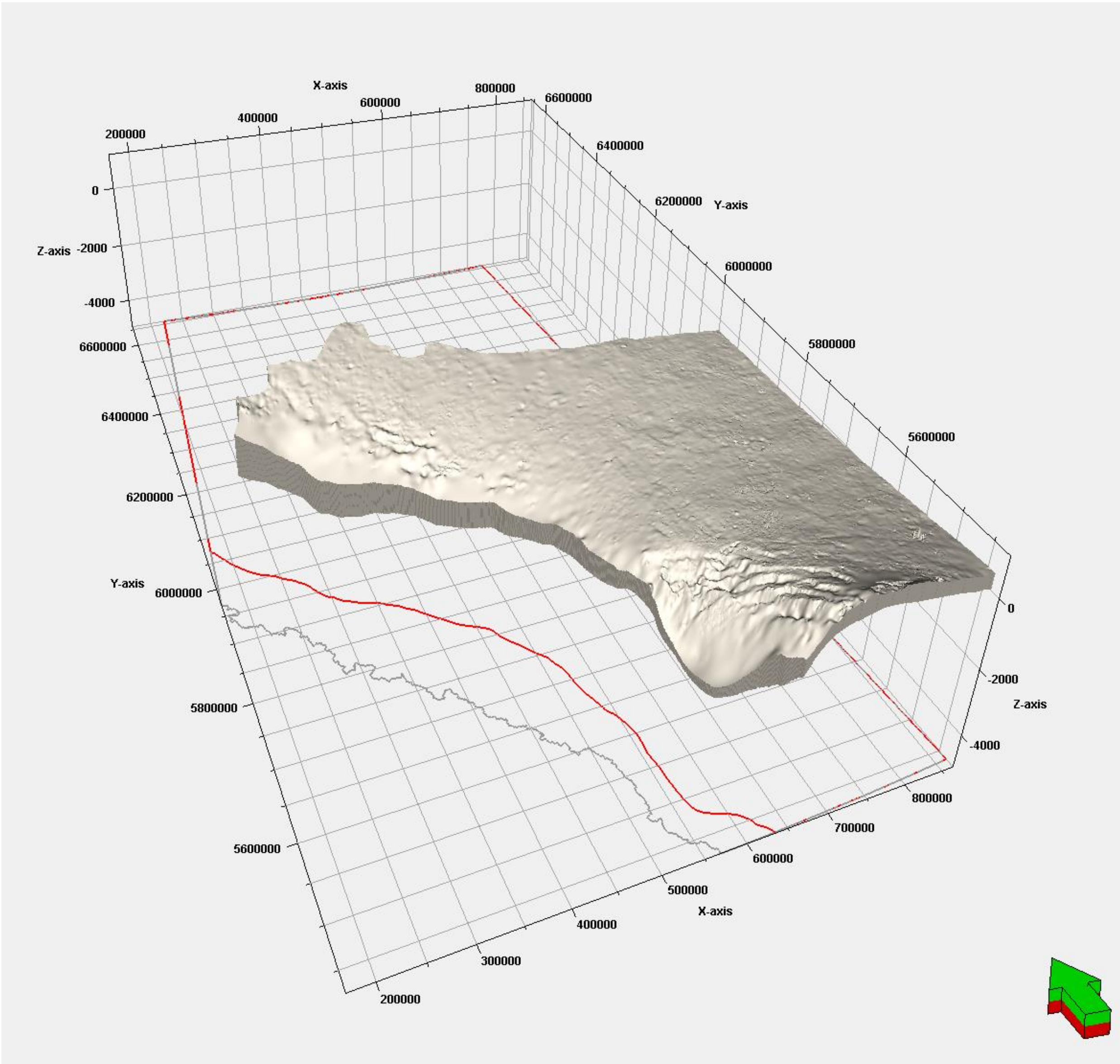


Figure 87. Oblique view of the Milk River Formation to base of the Fish Scales Formation interval model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Base of the Fish Scales Formation to Viking Formation / Bow Island Formation / Peace River Formation equivalent interval

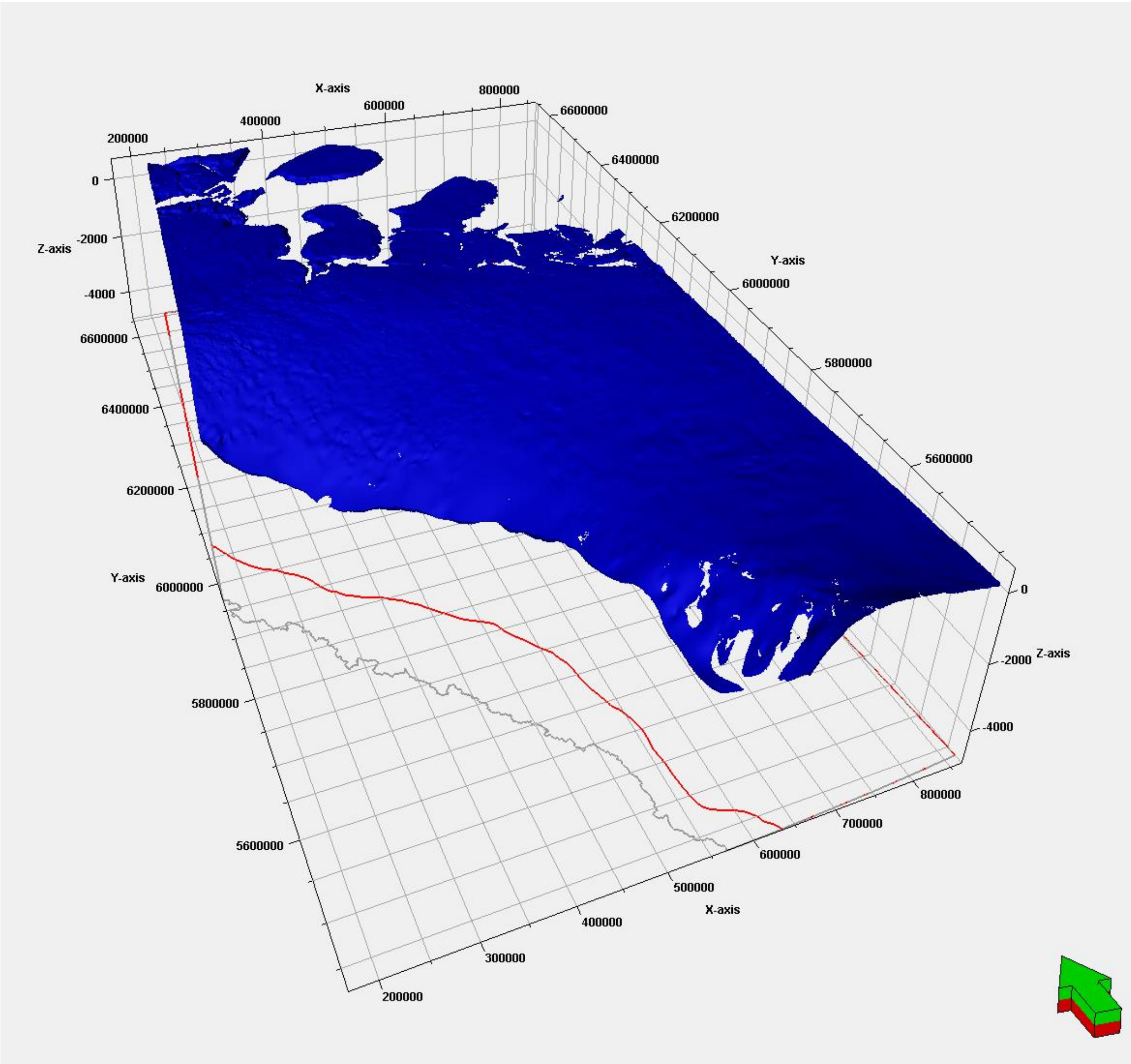


Figure 88. Oblique view of the base of the Fish Scales Formation to Viking Formation / Bow Island Formation / Peace River Formation equivalent interval model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Viking Formation / Bow Island Formation / Peace River Formation equivalent interval to Mannville Group equivalent interval

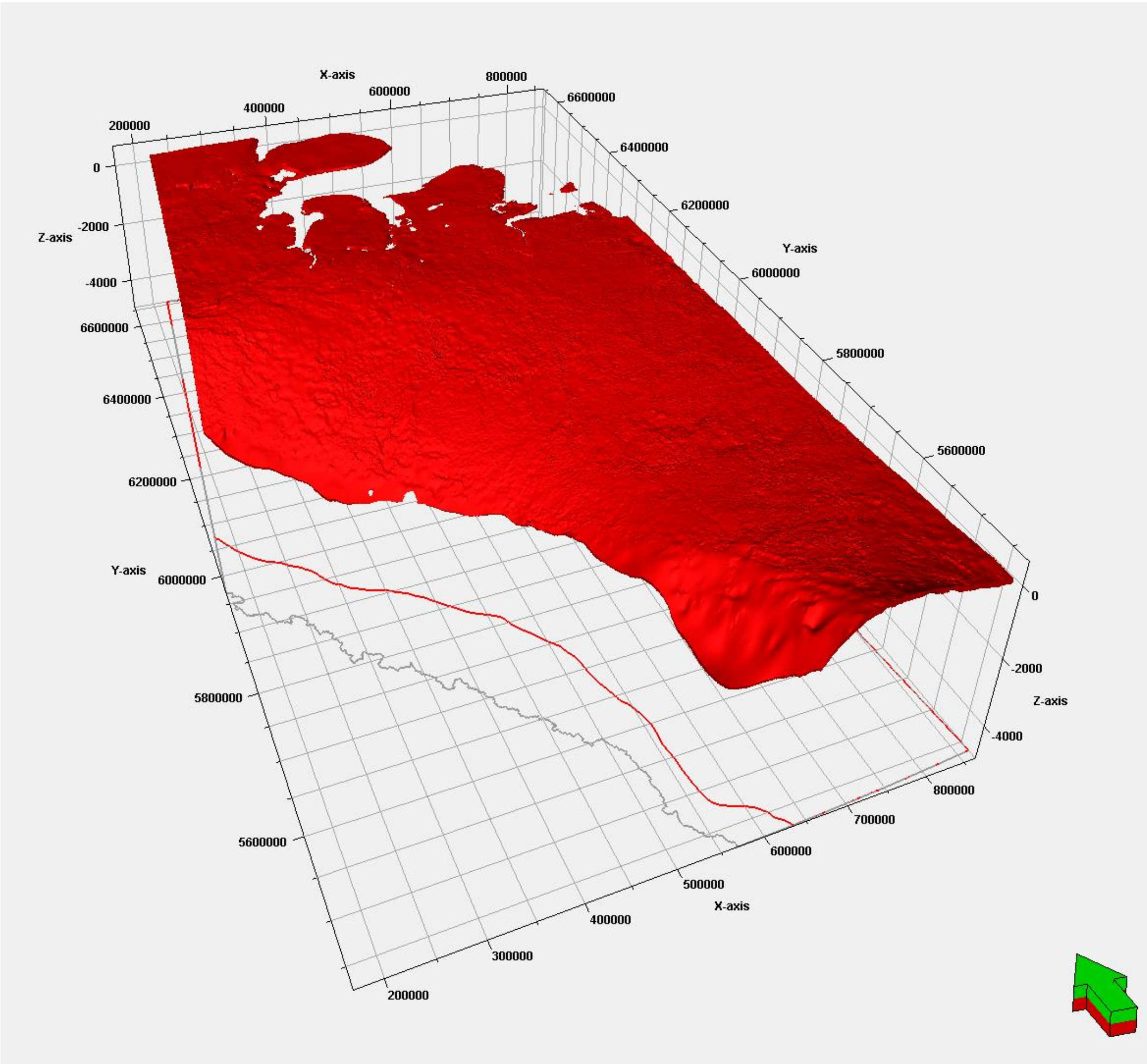


Figure 89. Oblique view of the Viking Formation / Bow Island Formation / Peace River Formation equivalent interval to Mannville Group equivalent interval model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Mannville Group equivalent interval to sub-Cretaceous unconformity interval

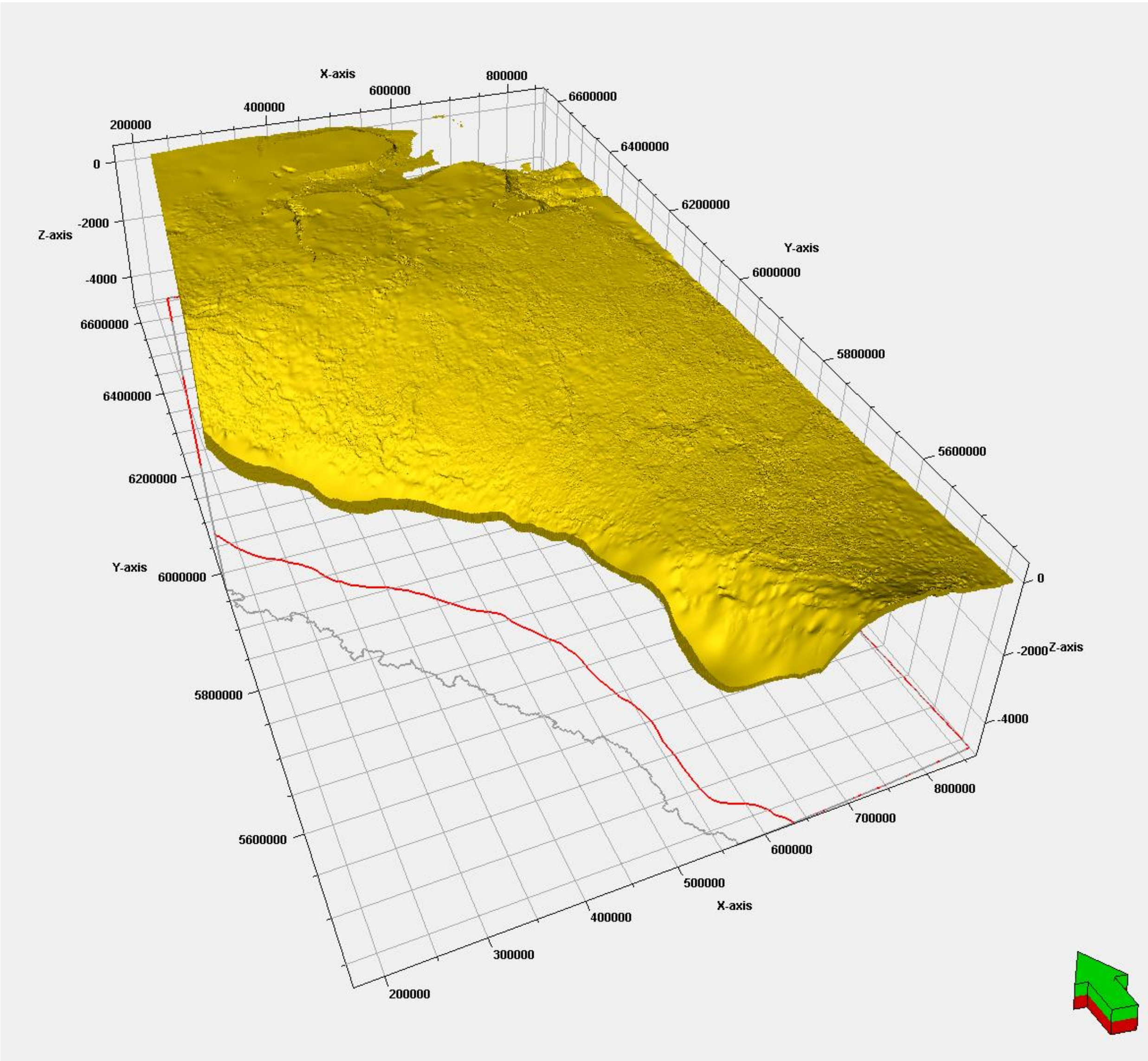


Figure 90. Oblique view of the Mannville Group equivalent interval to sub-Cretaceous unconformity interval model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Undifferentiated Jurassic / Triassic / Permian / Carboniferous to Banff Formation interval

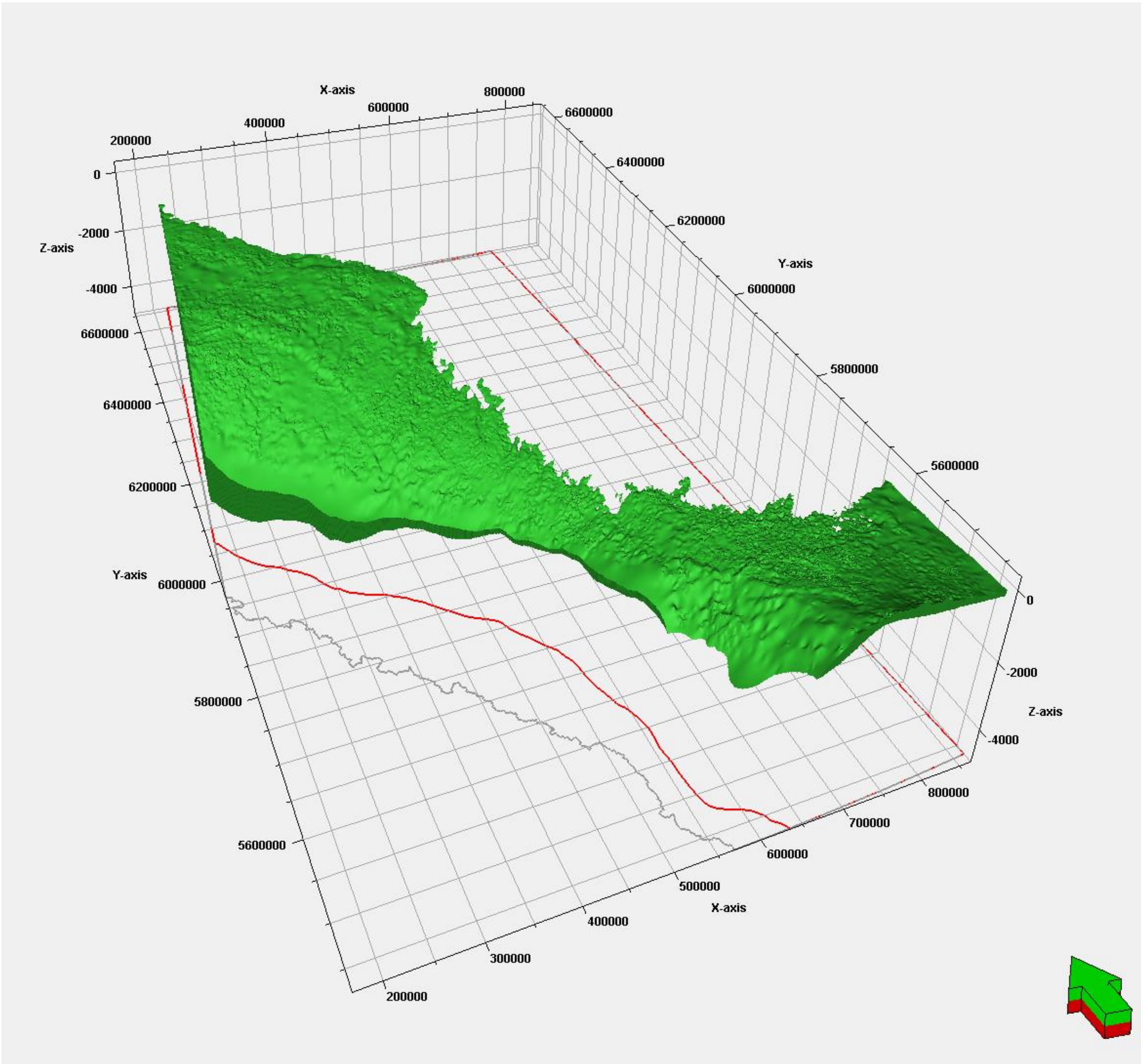


Figure 91. Oblique view of the undifferentiated Jurassic / Triassic / Permian / Carboniferous to Banff Formation interval model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Banff Formation to Wabamun Group interval

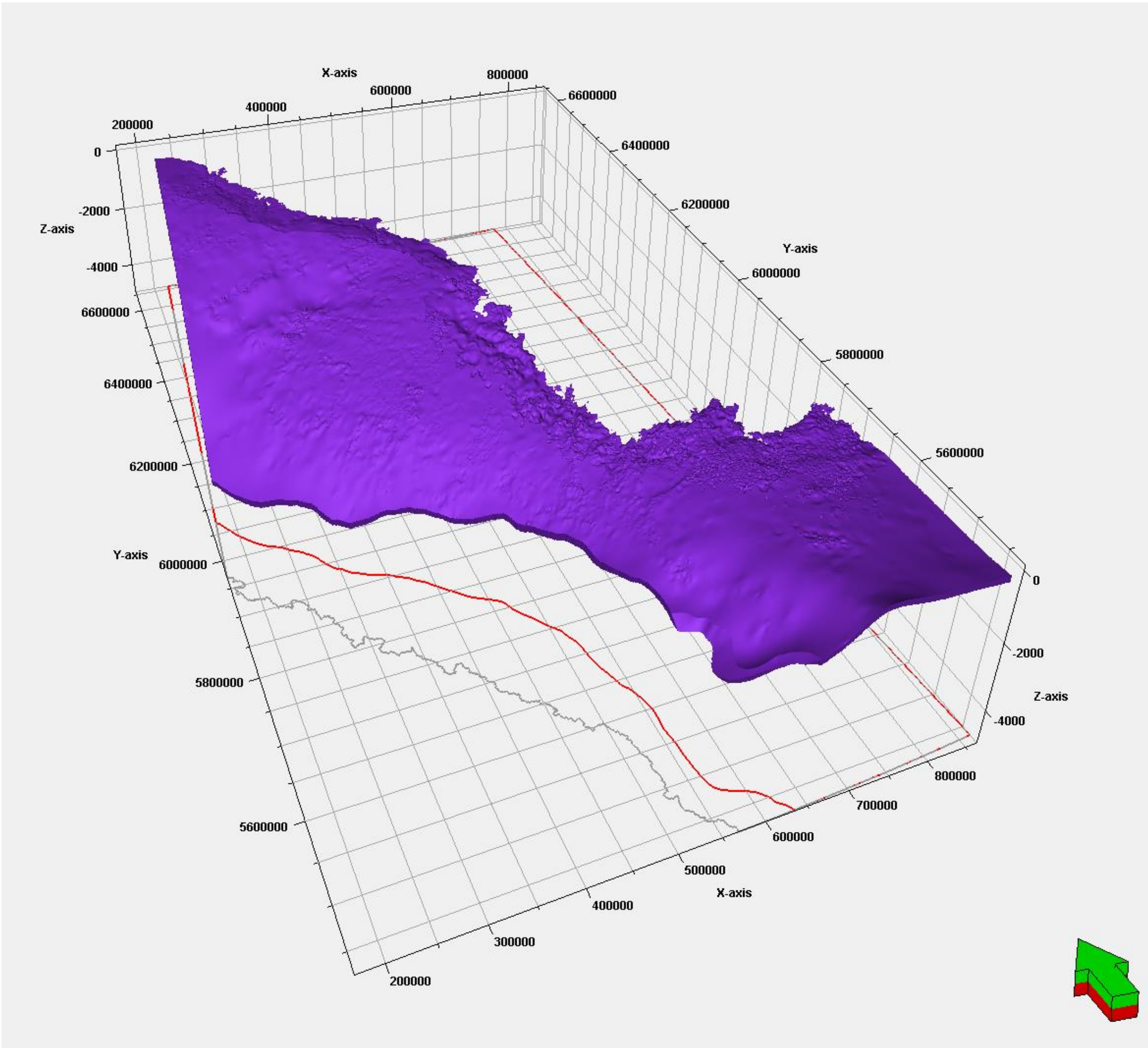


Figure 92. Oblique view of the Banff Formation to Wabamun Group interval model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Wabamun Group

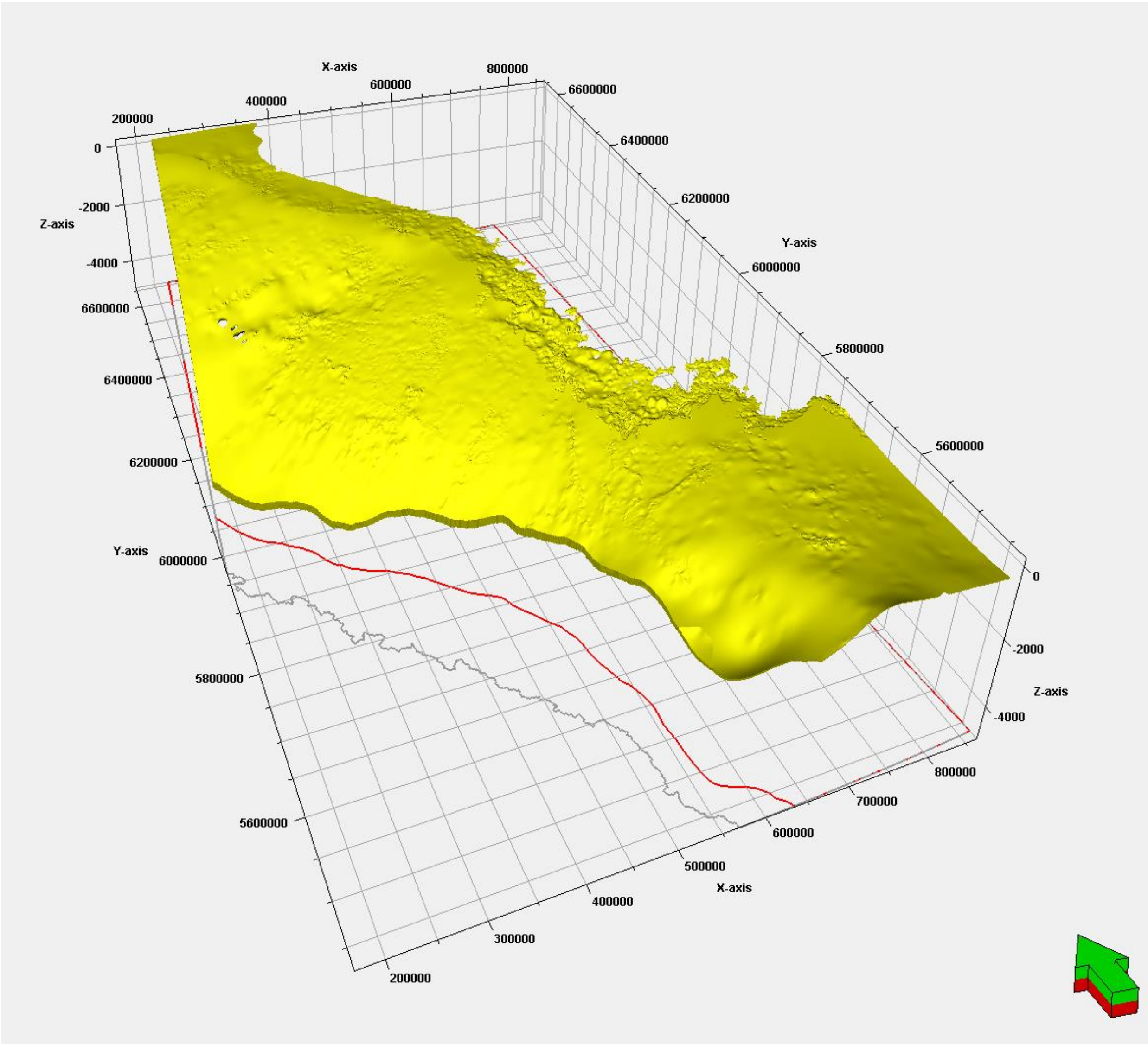


Figure 93. Oblique view of the Wabamun Group model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Winterburn Group

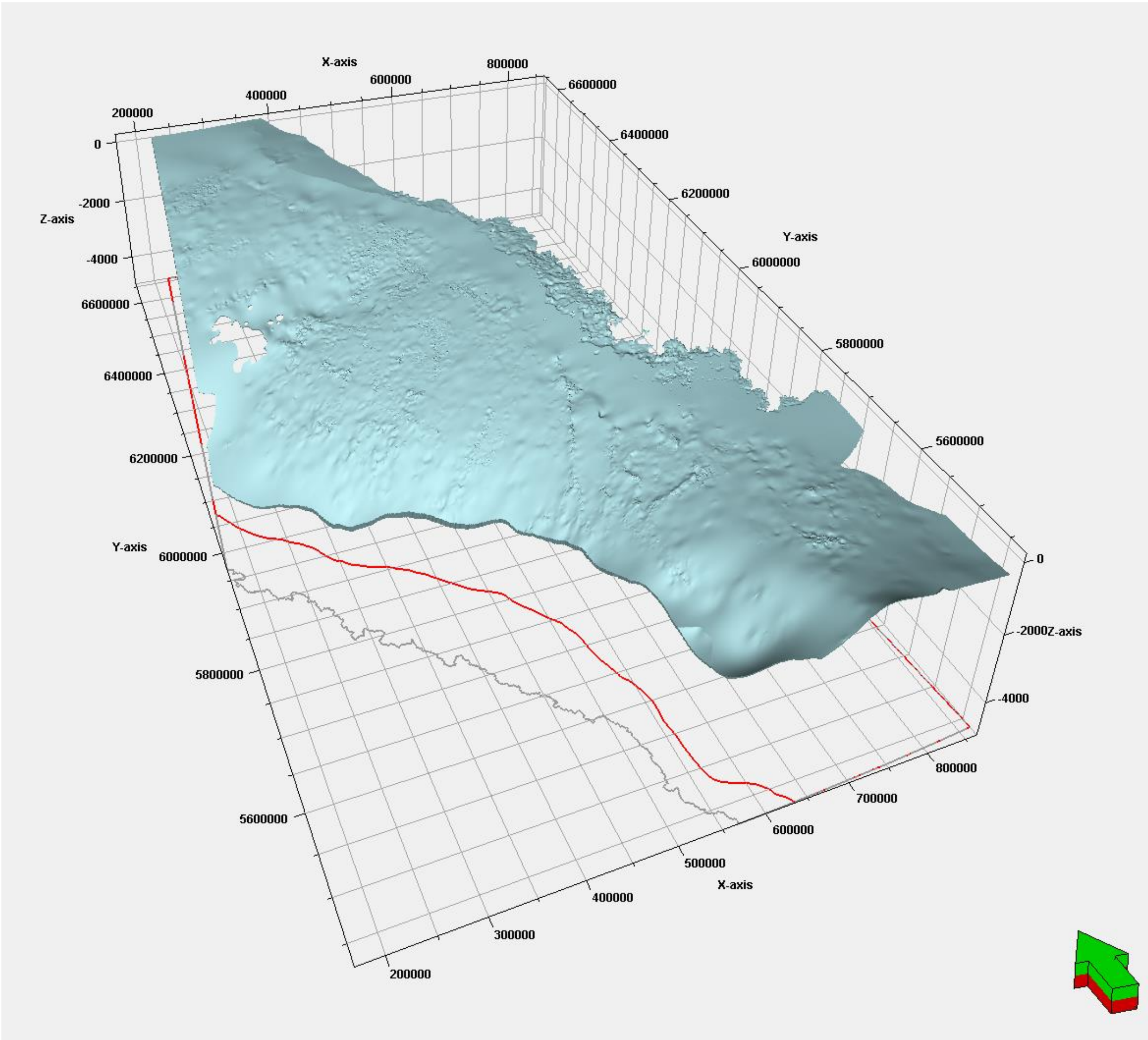


Figure 94. Oblique view of the Winterburn Group model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Undifferentiated Woodbend Group shales above Leduc or Duvernay formations (WOOD A)

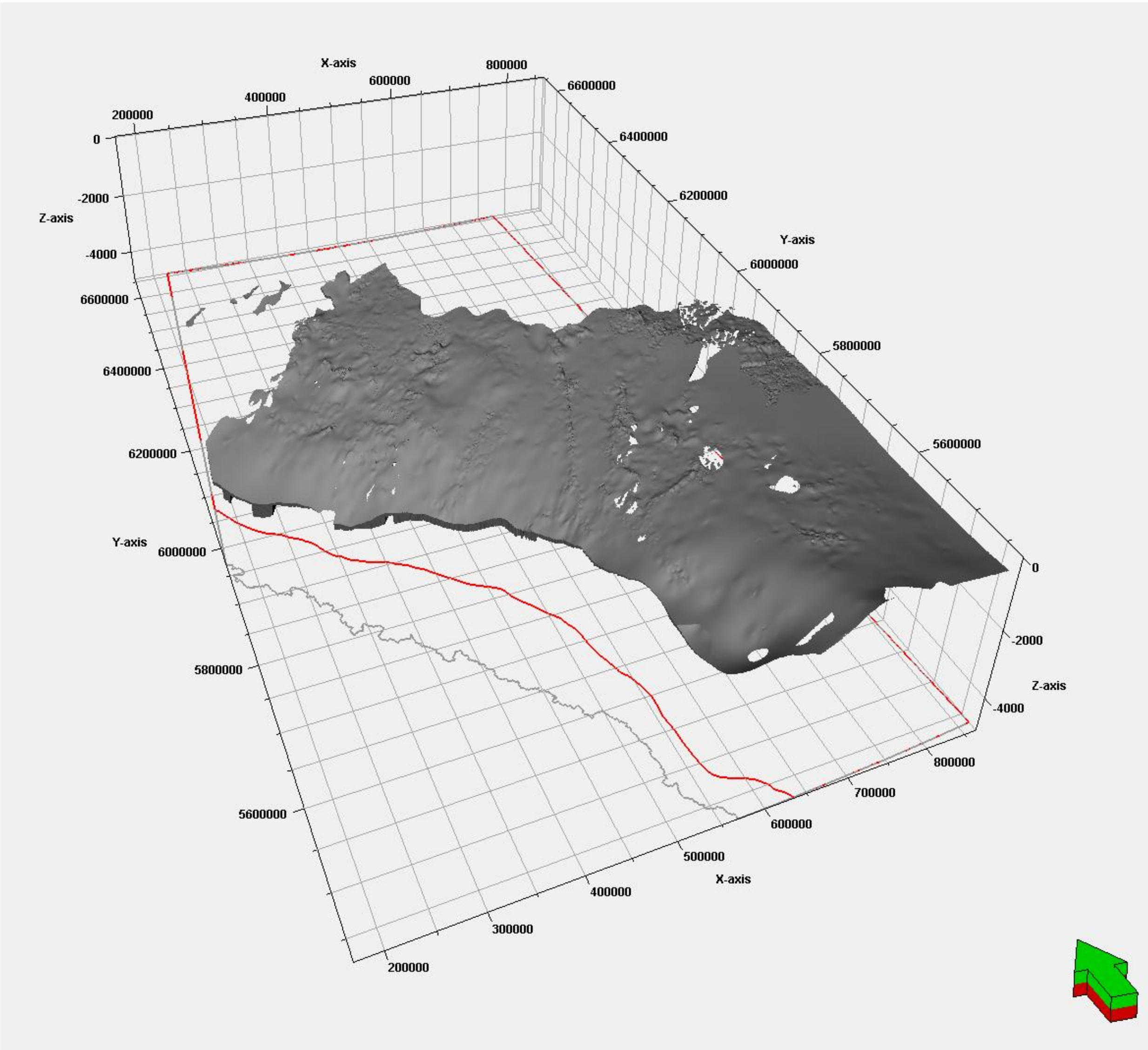


Figure 95. Oblique view of the undifferentiated Woodbend Group shales above Leduc or Duvernay formations (WOOD A) model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Undifferentiated Woodbend Group shales with no Leduc or Duvernay formations below (WOOD B)

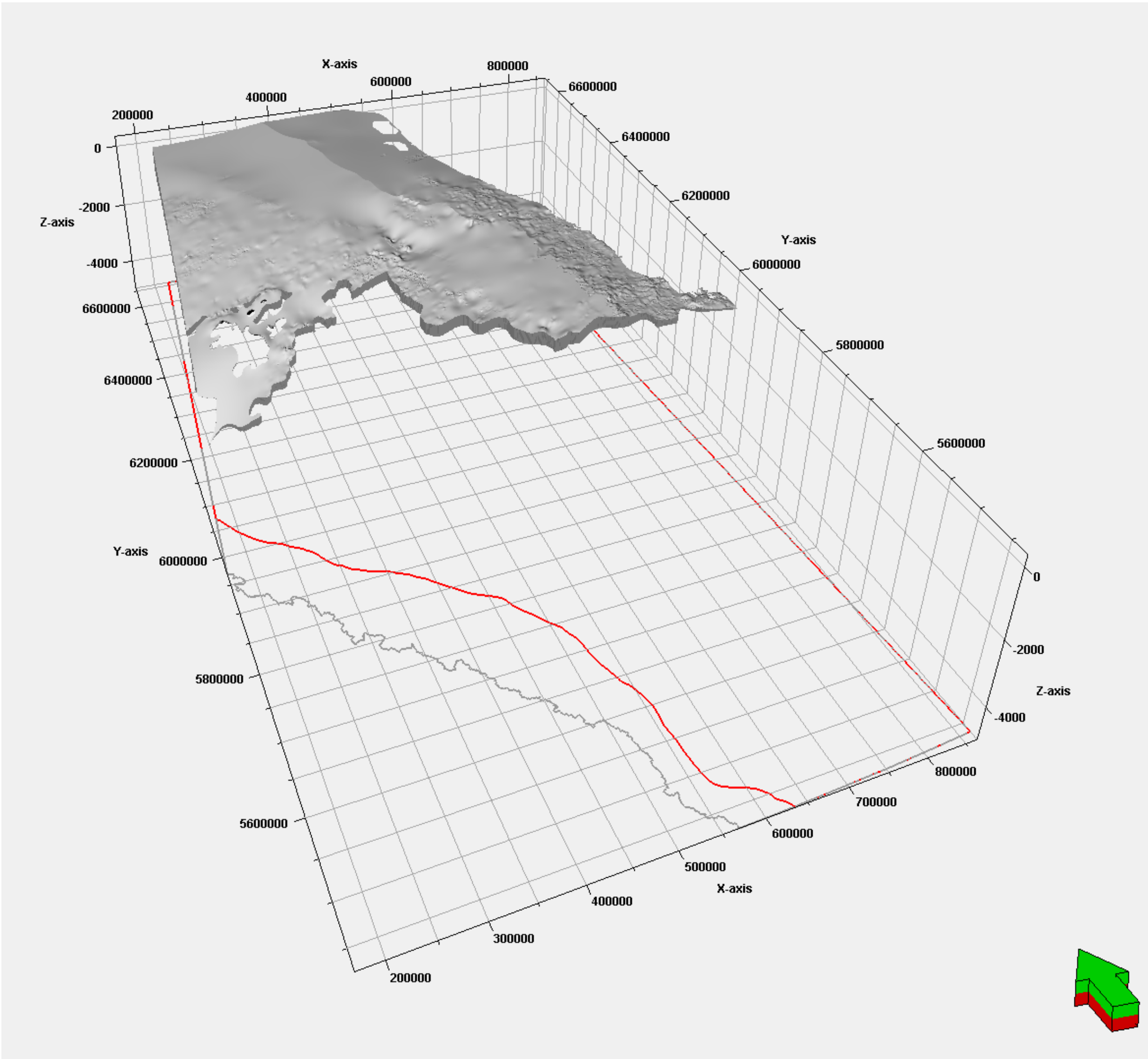


Figure 96. Oblique view of the undifferentiated Woodbend Group shales with no Leduc or Duvernay formations below (WOOD B) model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Duvernay Formation

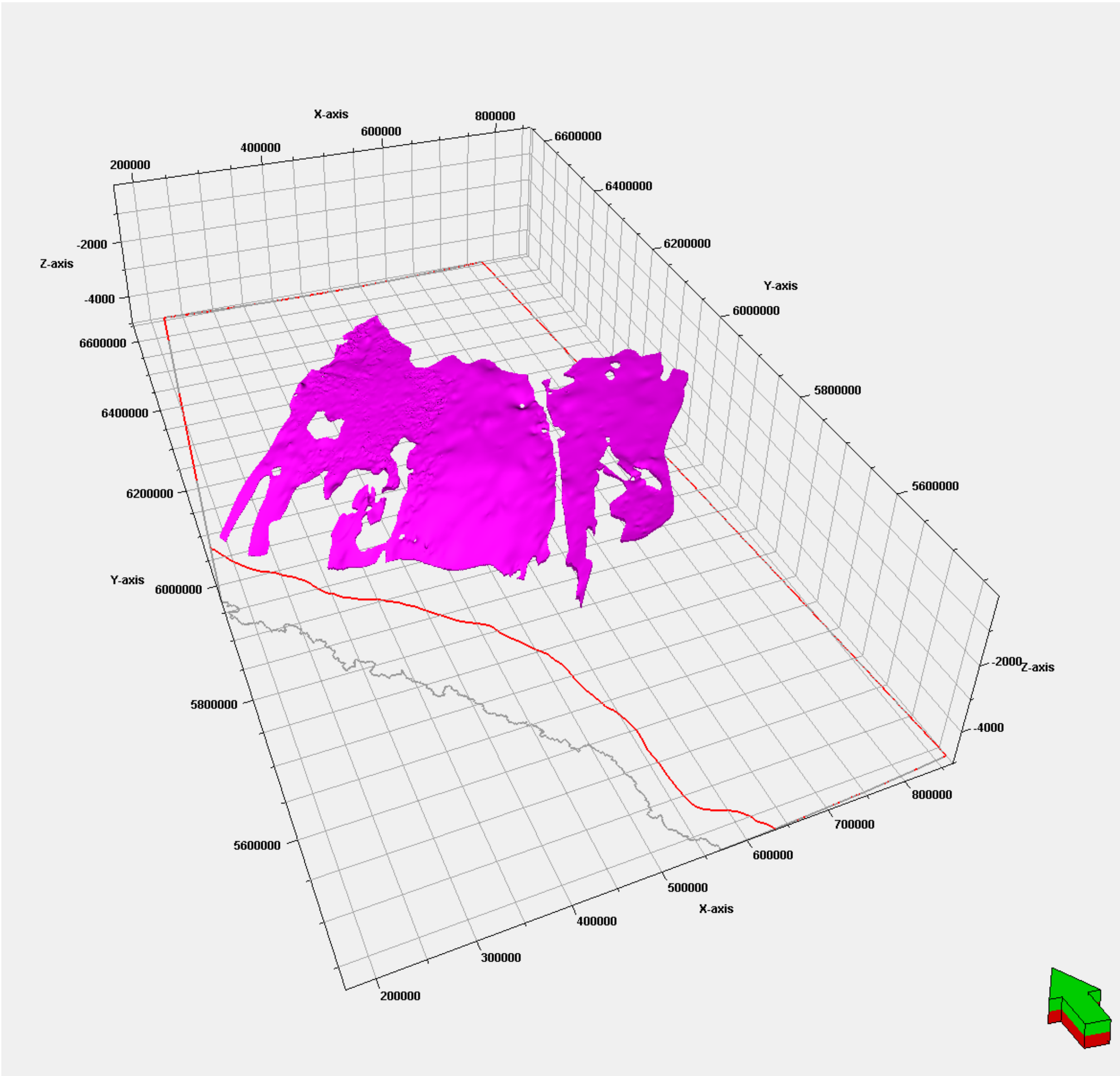


Figure 97. Oblique view of the Duvernay Formation model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Leduc Formation

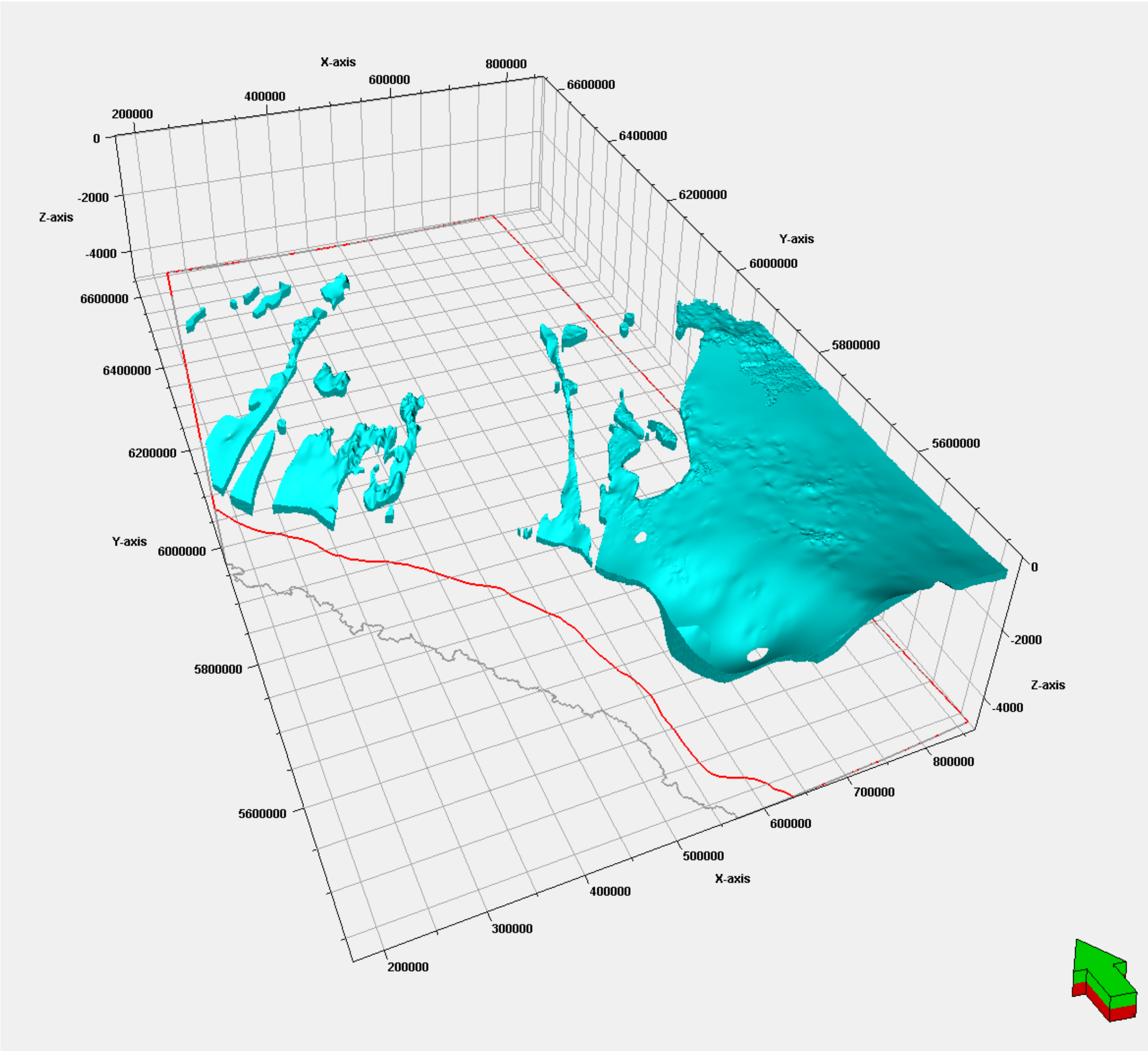


Figure 98. Oblique view of the Leduc Formation model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Cooking Lake Formation

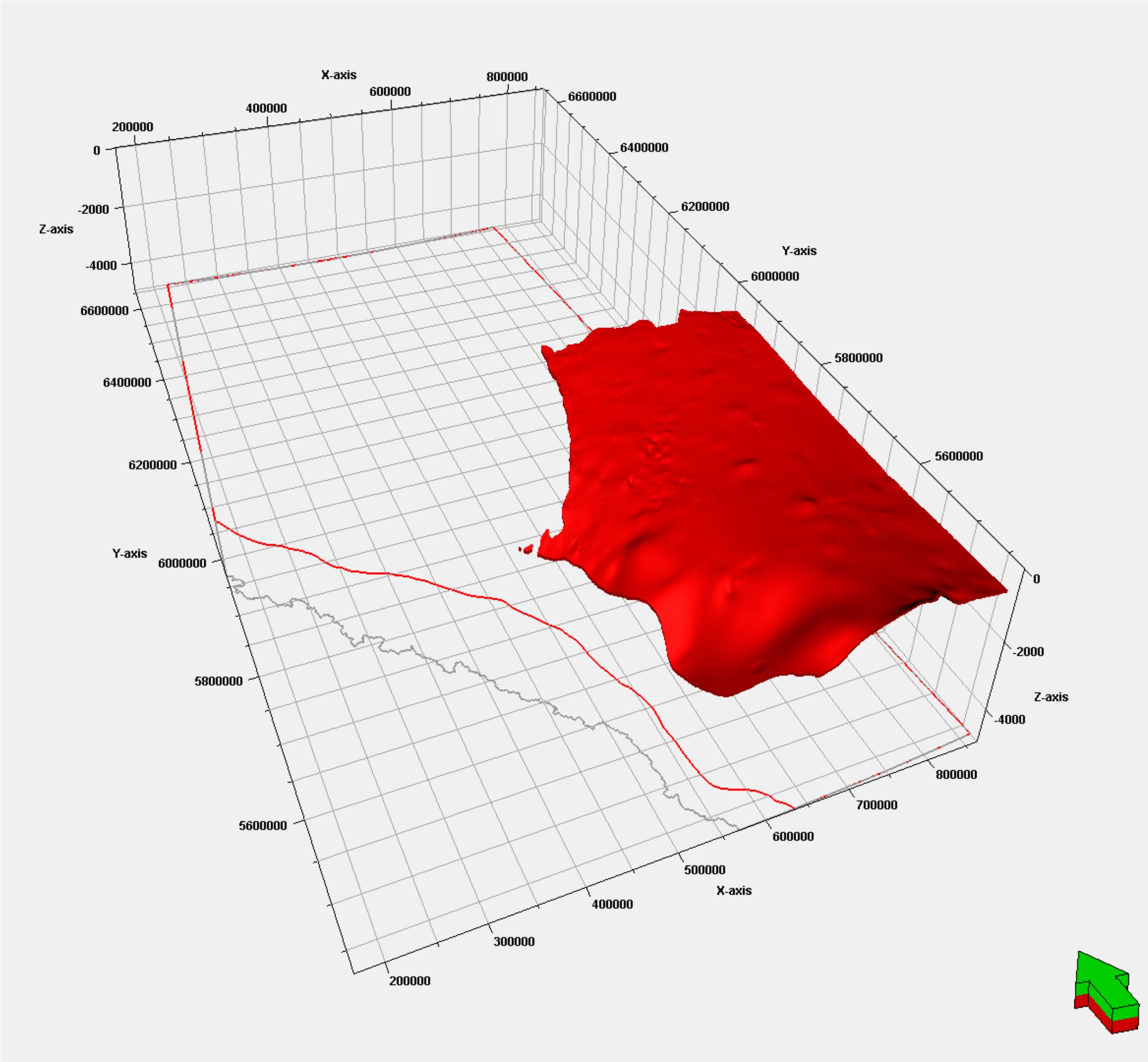


Figure 99. Oblique view of the Cooking Lake Formation model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Majeau Lake Formation

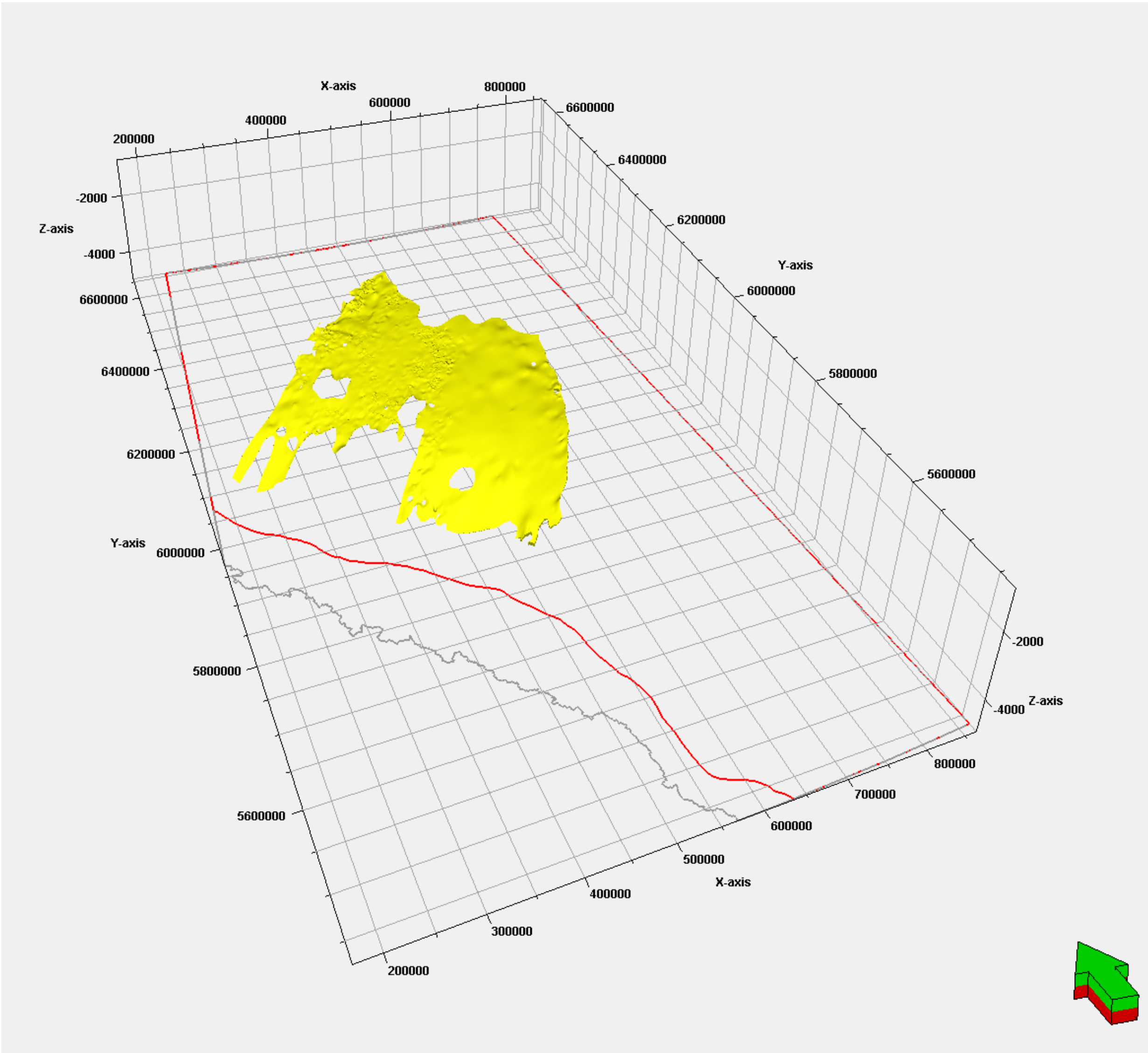


Figure 100. Oblique view of the Majeau Lake Formation model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Waterways Formation

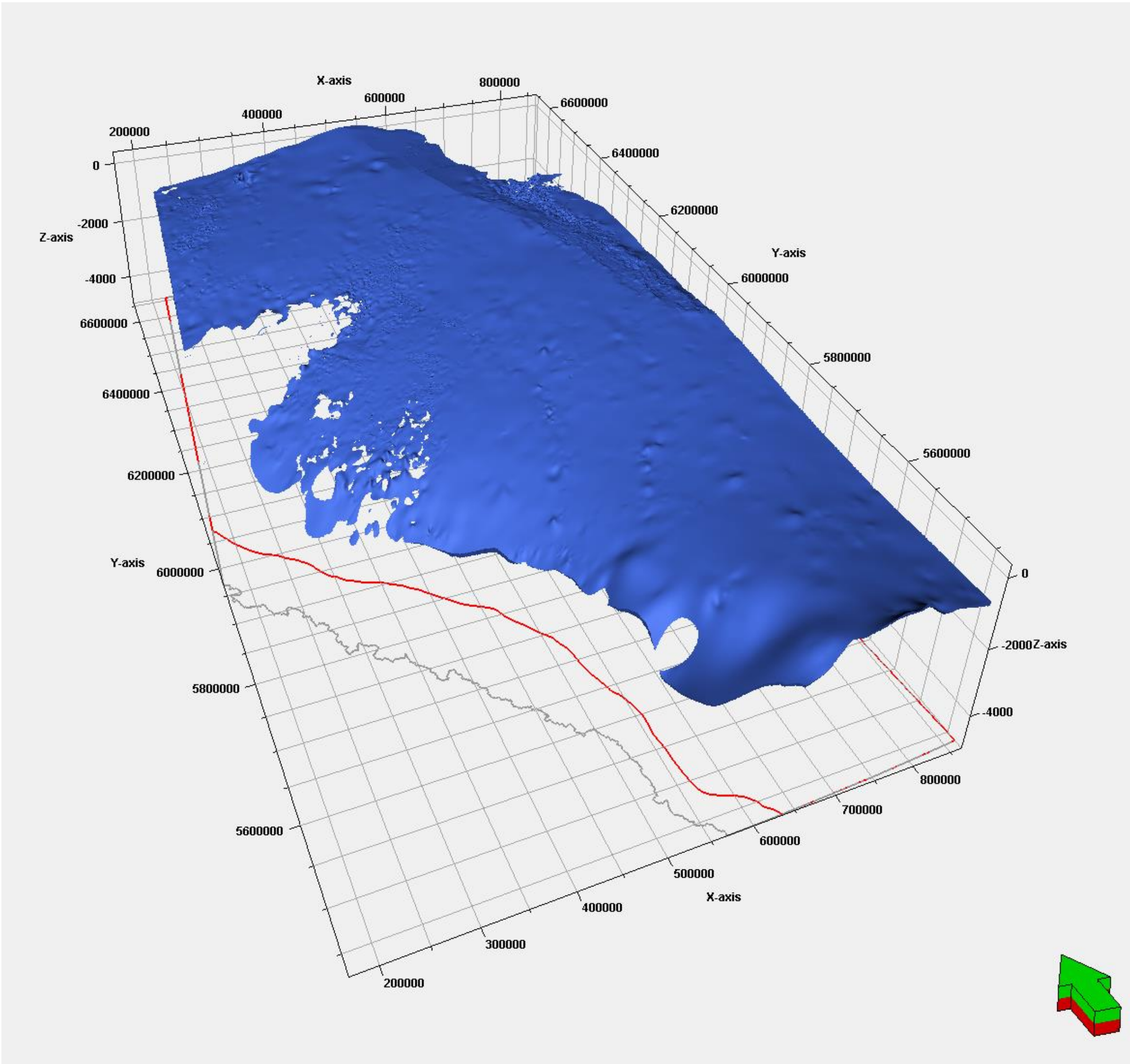


Figure 101. Oblique view of the Waterways Formation model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Swan Hills / Slave Point formations interval

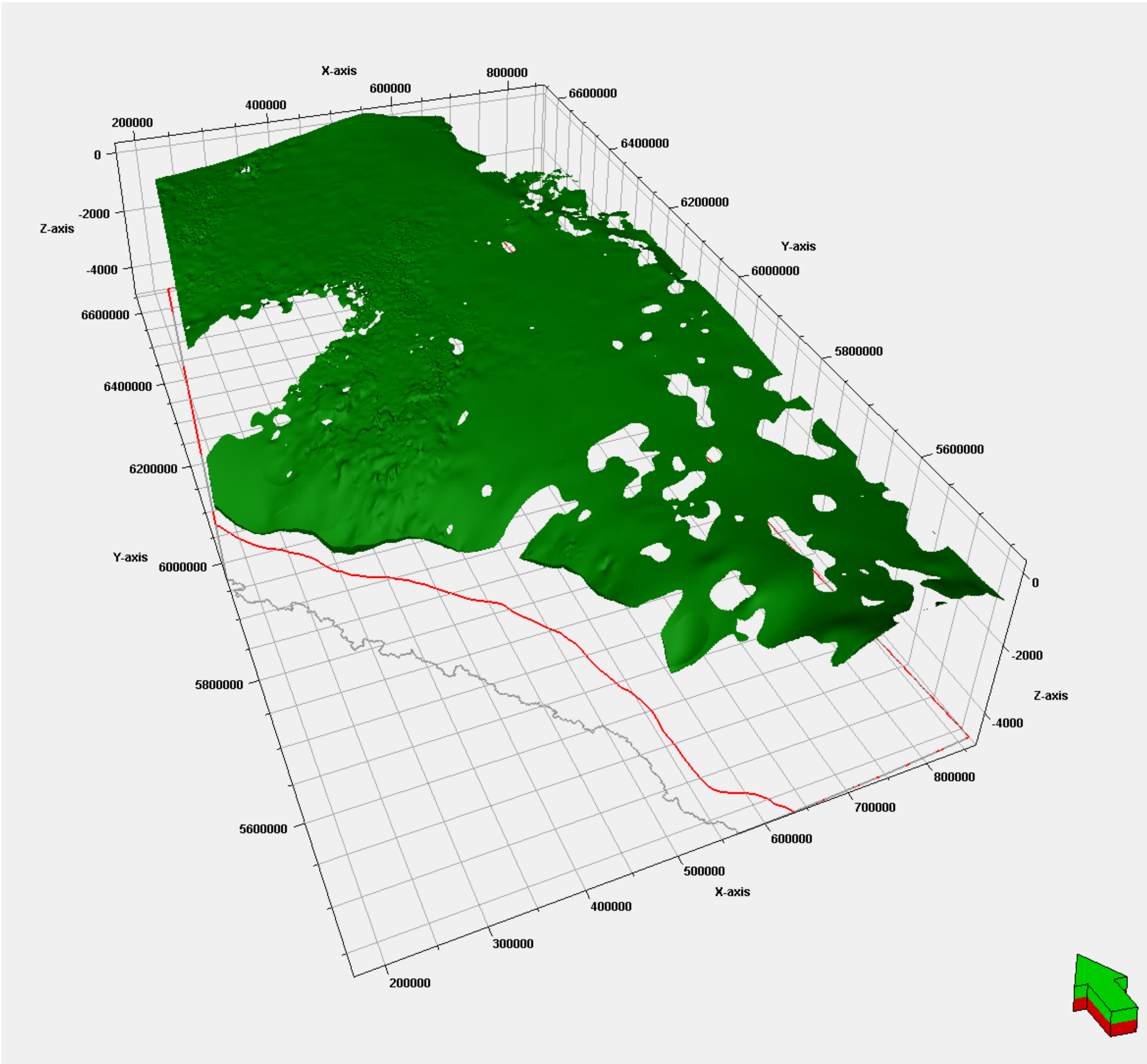


Figure 102. Oblique view of the Swan Hills / Slave Point formations interval model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Fort Vermilion Formation

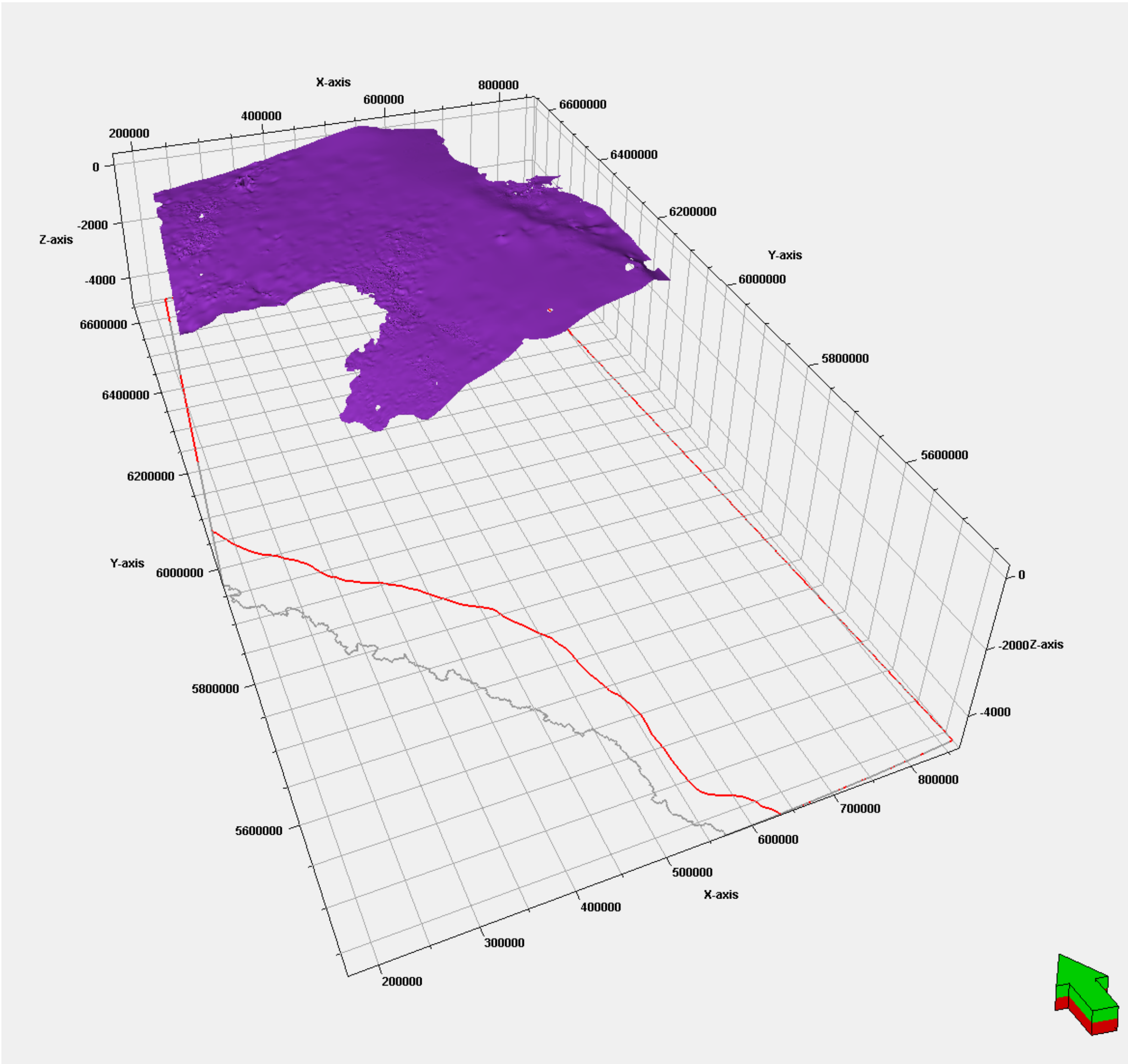


Figure 103. Oblique view of the Fort Vermilion Formation model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Elk Point Group to Precambrian interval

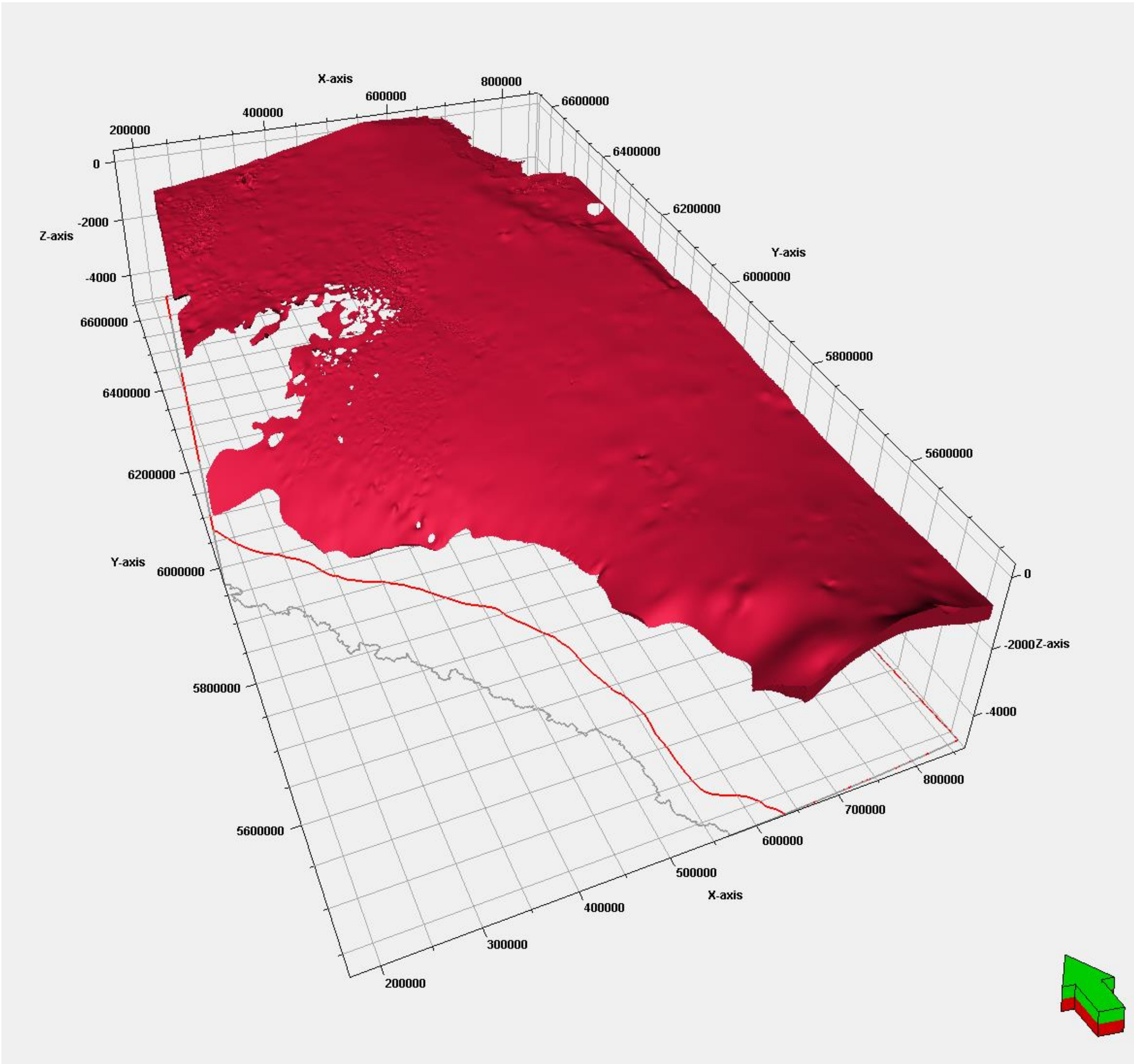


Figure 104. Oblique view of the Elk Point Group to Precambrian interval model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta boundary in red; vertical exaggeration = 50x).

Precambrian to 5000 m below sea level

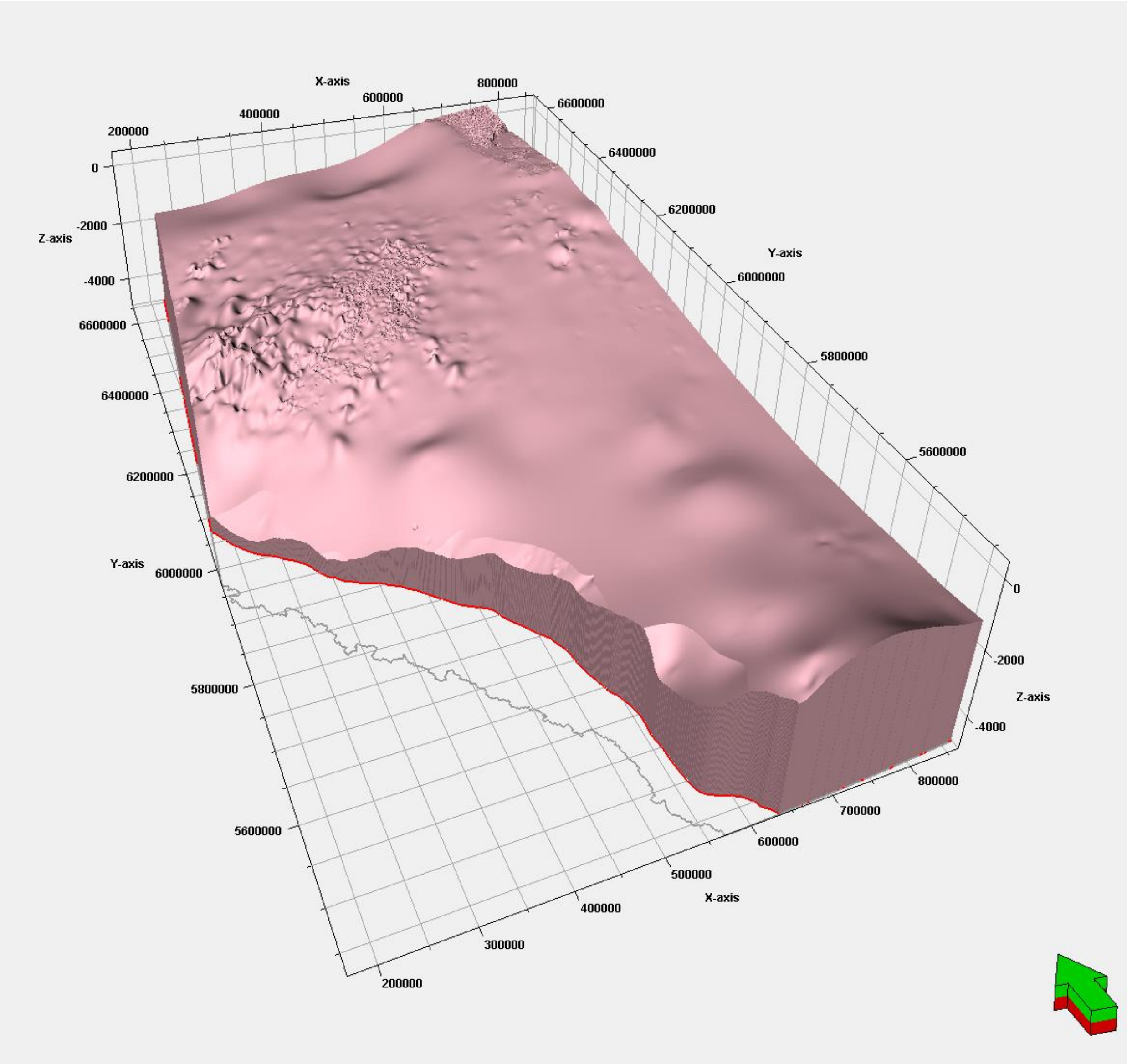


Figure 105. Oblique view of the Precambrian to 5000 m below sea level model zone (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

All zones from bedrock topography surface to sub-Cretaceous unconformity surface

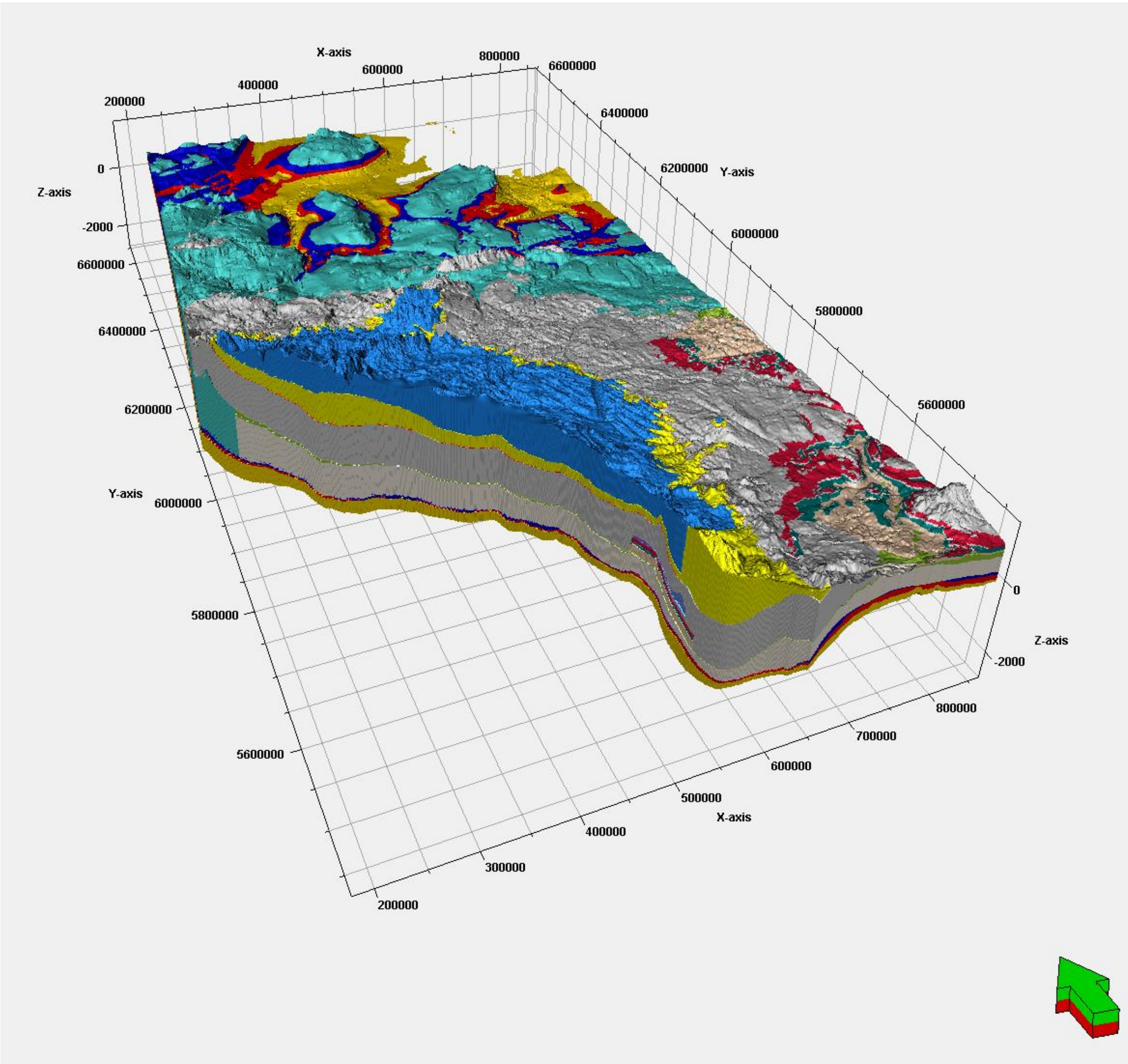


Figure 106. Oblique view of all zones from bedrock topography surface to sub-Cretaceous unconformity (vertical exaggeration = 50x). Refer to Appendix 6 for zone colour legend.

All zones from sub-Cretaceous unconformity to model base

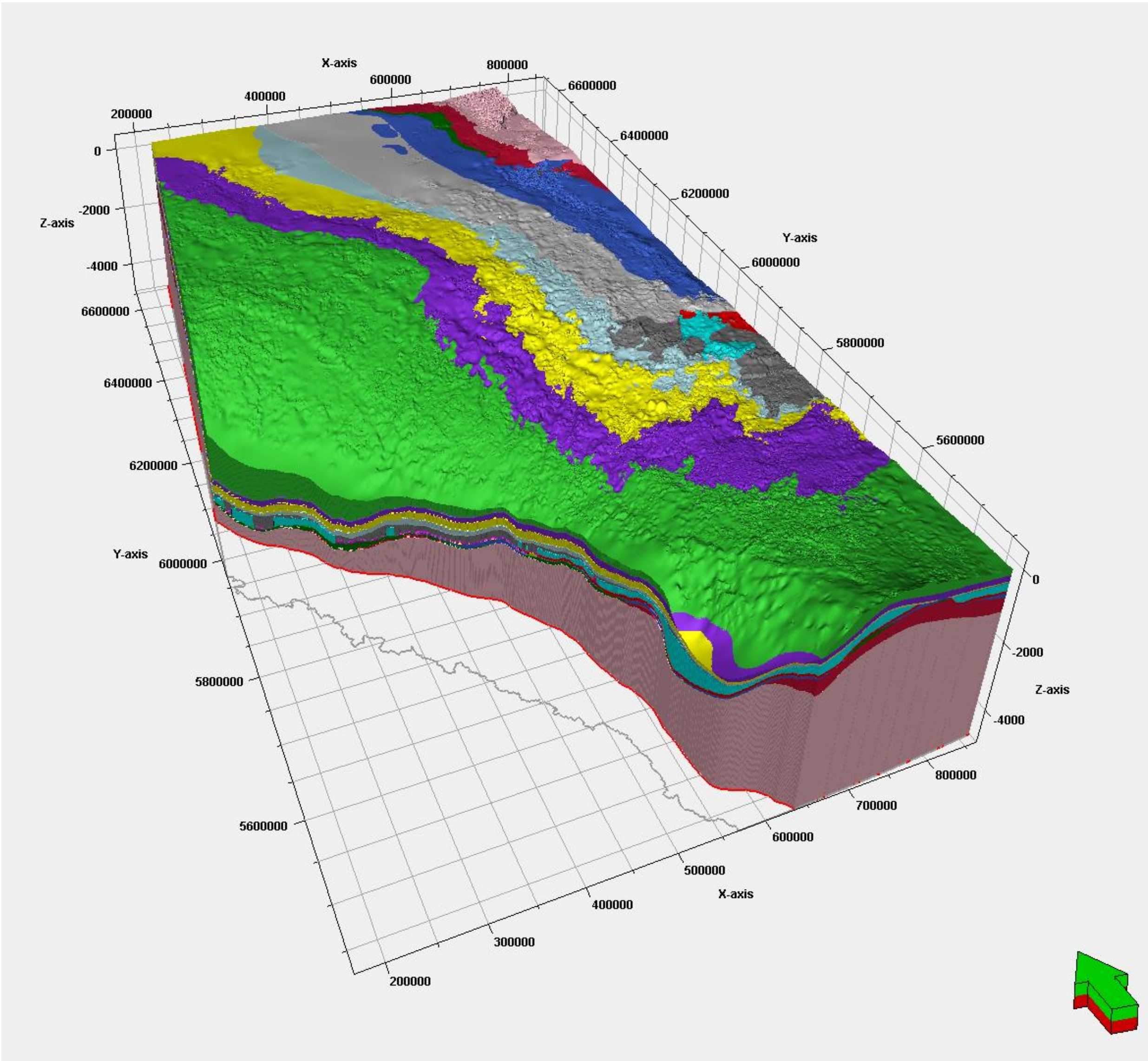


Figure 107. Oblique view of all zones from sub-Cretaceous unconformity surface to the base of the model. Subcropping nature of the Paleozoic geology is displayed (Alberta boundary in grey; 3D Provincial Geological Framework Model of Alberta Ver. 1 boundary in red; vertical exaggeration = 50x).

Appendix 6 − Model Cross-Sections

Model Zone Colouring Legend

- Sediment above bedrock
- Paskapoo Formation
- Scollard Formation
- Battle Formation
- Undifferentiated Horseshoe Canyon Formation / Wapiti Formation / St. Mary River Formation / Belly River Group / Bearpaw Formation equivalent interval
- Upper Bearpaw interval
- Strathmore Member
- Lower Bearpaw interval
- Dinosaur Park Formation
- Oldman Formation
- Foremost Formation
- Undifferentiated Lea Park Formation / Colorado Group / Smoky Group / Fort St. John Group equivalent interval
- Pakowki Formation
- Milk River Formation to base of the Fish Scales Formation interval
- Base of the Fish Scales Formation to Viking Formation / Bow Island Formation / Peace River Formation equivalent interval
- Viking Formation / Bow Island Formation / Peace River Formation equivalent interval to Mannville Group equivalent interval
- Mannville Group equivalent to sub-Cretaceous unconformity interval
- Undifferentiated Jurassic / Triassic / Permian / Carboniferous to Banff Formation interval
- Banff Formation to Wabamun Group interval
- Wabamun Group
- Winterburn Group
- Undifferentiated Woodbend Group shales above Leduc or Duvernay formations (WOOD A)
- Undifferentiated Woodbend Group shales with no Leduc or Duvernay formations below (WOOD B)
- Duvernay Formation
- Leduc Formation
- Cooking Lake Formation
- Majeau Lake Formation
- Waterways Formation
- Swan Hills / Slave Point formations interval
- Fort Vermilion Formation
- Elk Point Group to Precambrian interval
- Precambrian to 5000m below sea level

Figure 108. Legend showing model-zone colouring for the 3D Provincial Geological Framework Model of Alberta Ver. 1 and cross-sections in this Appendix 6. Note that the zones are in order from top to base, so you can distinguish between repeated colours based on the order in which they appear.

Model Cross-Section (Southwest to Northeast)

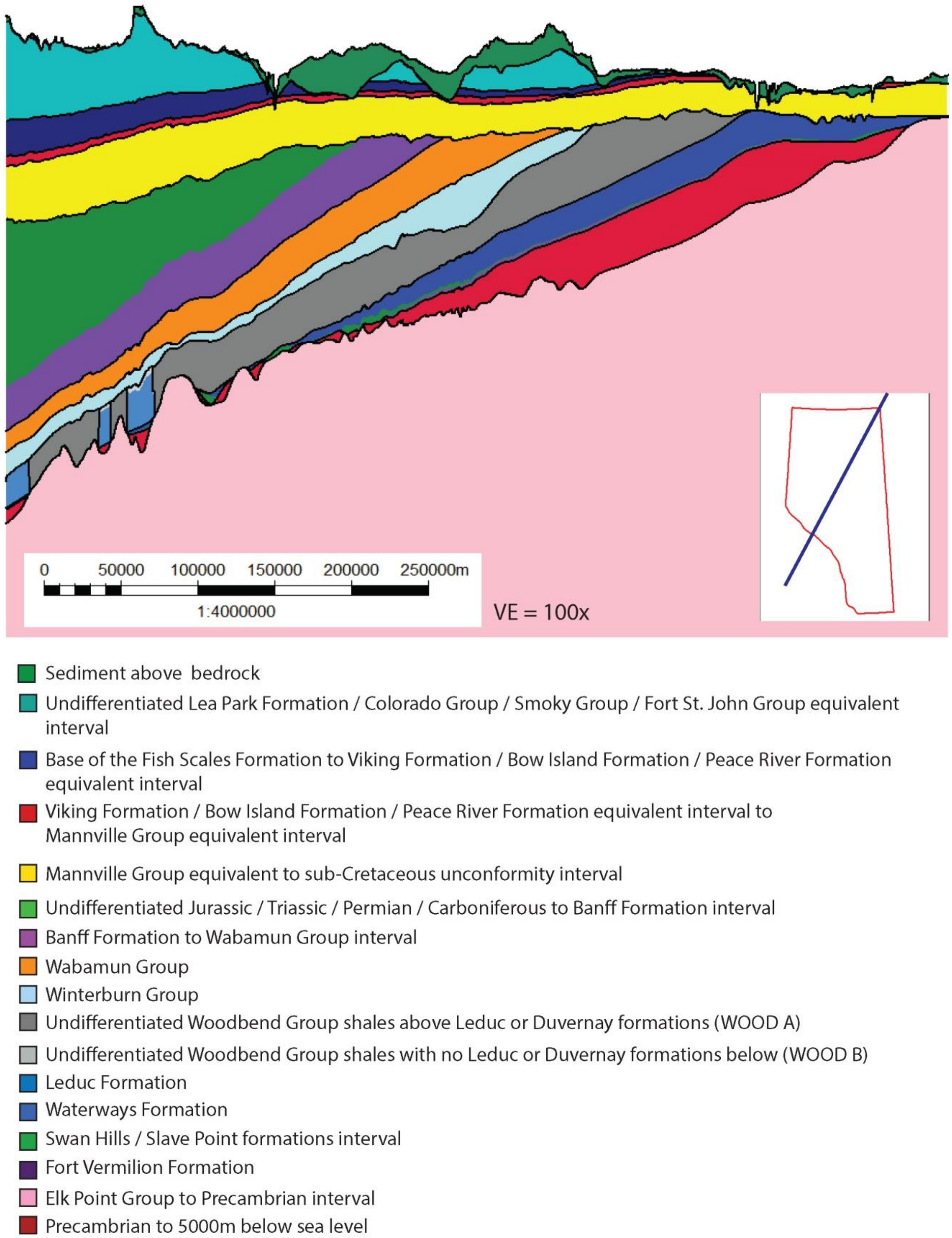


Figure 109. Model cross-section (southwest to northeast). Note that the zones are in order from top to base, so you can distinguish between repeated colours based on the order in which they appear.

Model Cross-Section (Northwest to Southeast)

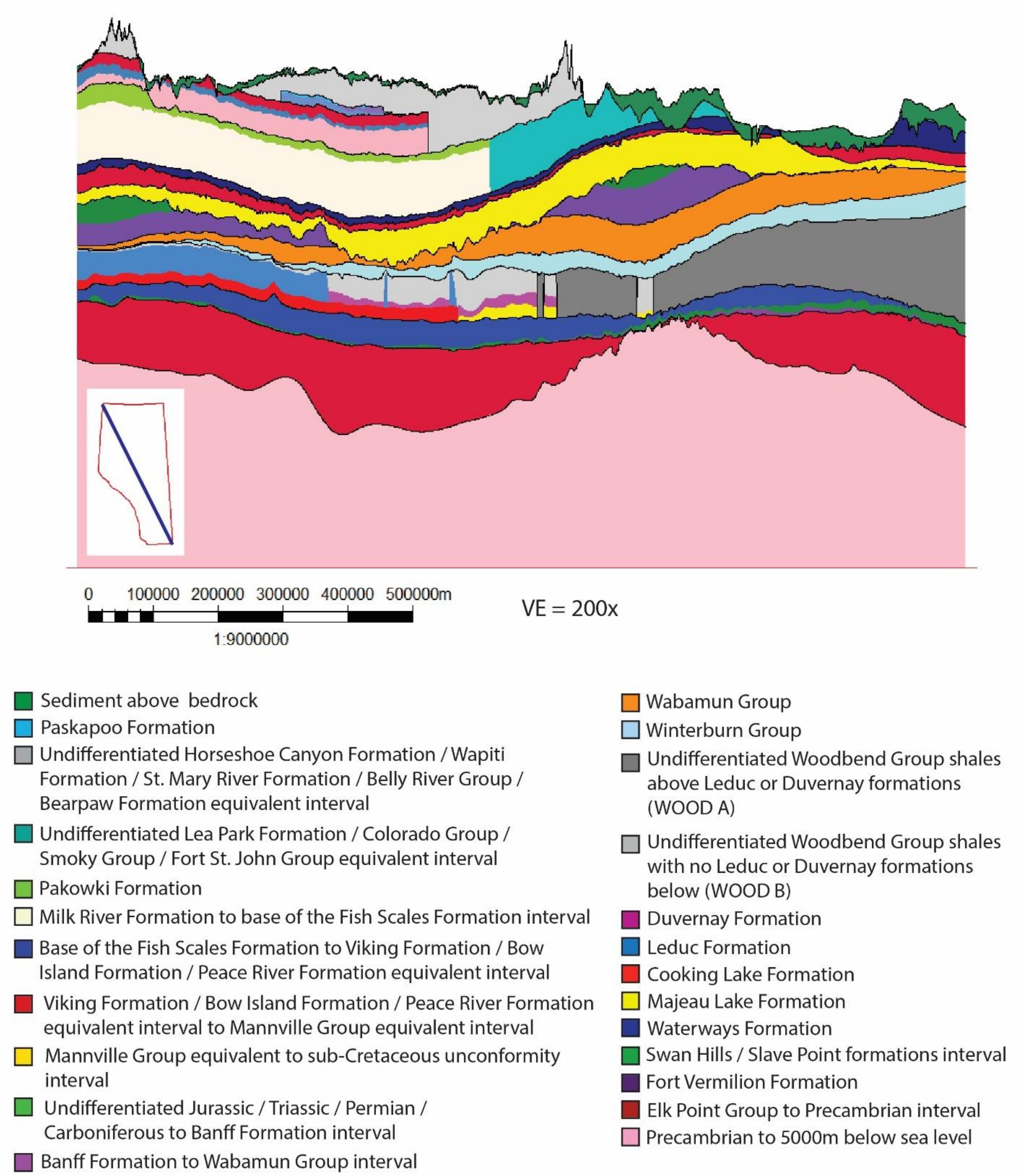


Figure 110. Model cross-section (northwest to southeast). Note that the zones are in order from top to base, so you can distinguish between repeated colours based on the order in which they appear.

Model Cross-Section (North to South)

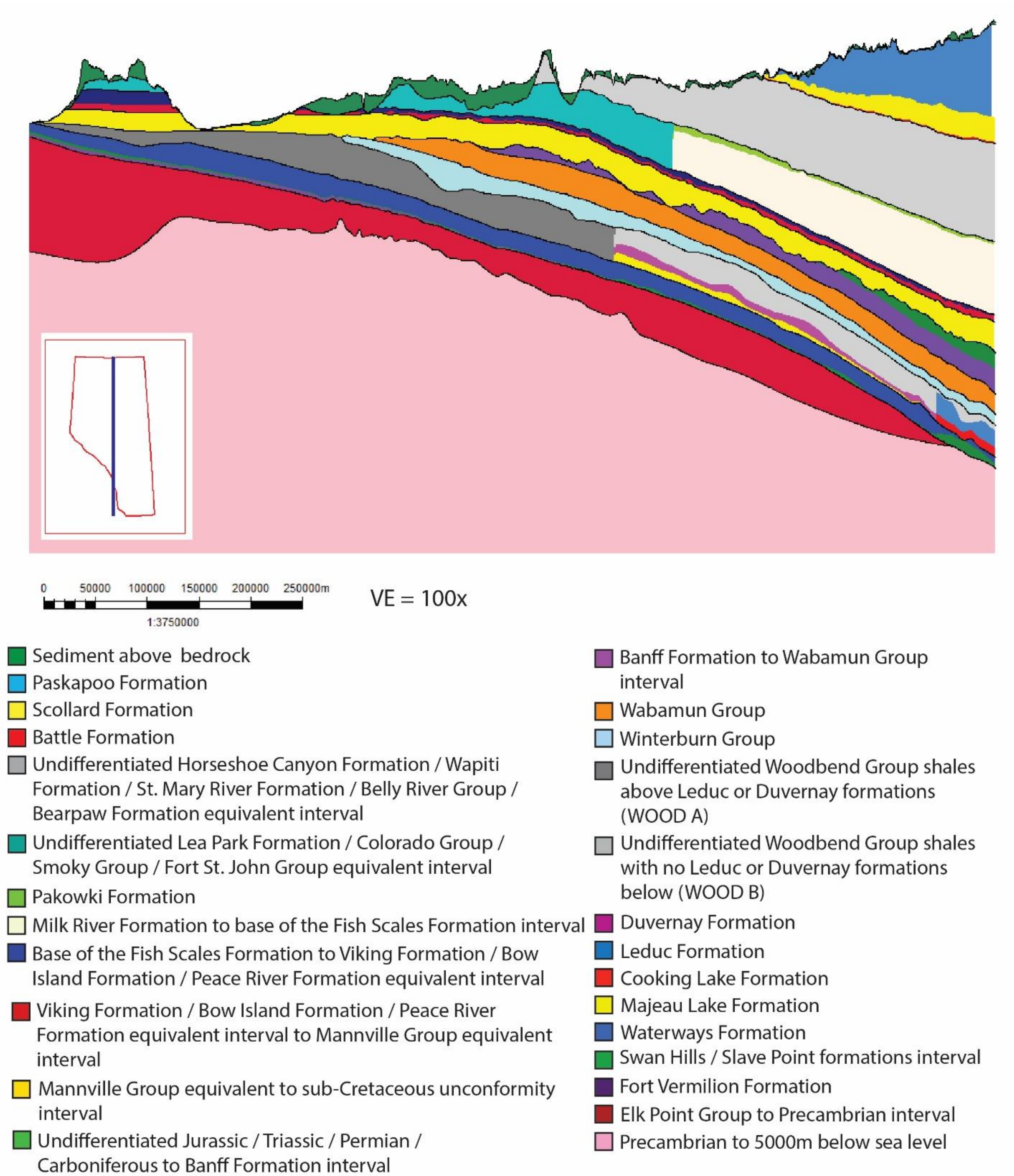
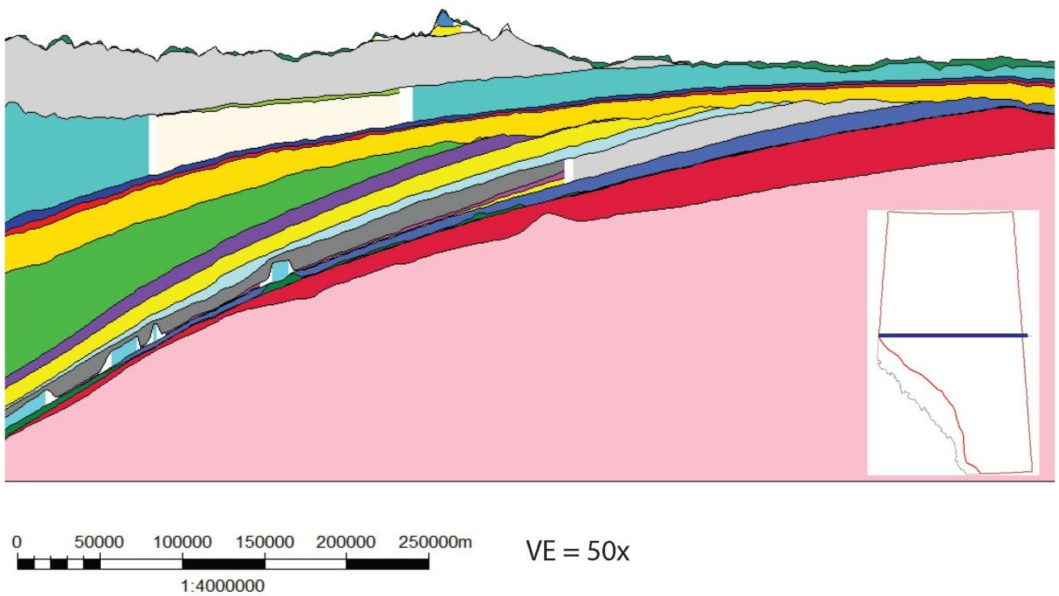


Figure 111. Model cross-section (north to south). Note that the zones are in order from top to base, so you can distinguish between repeated colours based on the order in which they appear.

Model Cross-Section (West to East)



- Sediment above bedrock
- Paskapoo Formation
- Scollard Formation
- Undifferentiated Horseshoe Canyon Formation / Wapiti Formation / St. Mary River Formation / Belly River Group / Bearpaw Formation equivalent interval
- Undifferentiated Lea Park Formation / Colorado Group / Smoky Group / Fort St. John Group equivalent interval
- Pakowki Formation
- Milk River Formation to base of the Fish Scales Formation interval
- Base of the Fish Scales Formation to Viking Formation / Bow Island Formation / Peace River Formation equivalent interval
- Viking Formation / Bow Island Formation / Peace River Formation equivalent interval to Mannville Group equivalent interval
- Mannville Group equivalent to sub-Cretaceous unconformity interval
- undifferentiated Jurassic / Triassic / Permian / Carboniferous to Banff Formation interval
- Banff Formation to Wabamun Group interval
- Wabamun Group
- Winterburn Group
- Undifferentiated Woodbend Group shales above Leduc or Duvernay formations (WOOD A)
- Undifferentiated Woodbend Group shales with no Leduc or Duvernay formations below (WOOD B)
- Duvernay Formation
- Leduc Formation
- Majeau Lake Formation
- Waterways Formation
- Swan Hills / Slave Point formations interval
- Fort Vermilion Formation
- Elk Point Group to Precambrian interval
- Precambrian to 5000m below sea level

Figure 112. Model cross-section (west to east). Note that the zones are in order from top to base, so you can distinguish between repeated colours based on the order in which they appear.