Jesse T. Peterson
Kelsey E. MacCormack

Alberta Geological Survey
402, Twin Atria Building
4999-98 Avenue
Edmonton, AB
www.ags.gov.ab.ca

Structural Mapping and Modelling of the Sub-Cretaceous Unconformity and Delineation of Subcropping Formations, West-Central Alberta

Introduction

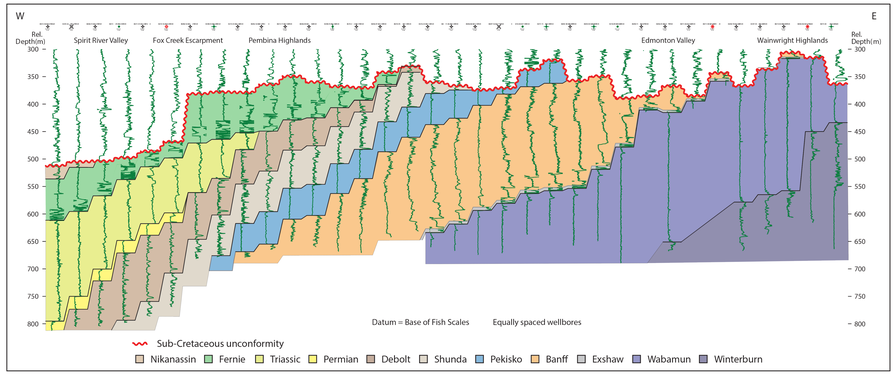
The sub-Cretaceous unconformity is an important regional surface across the Alberta Basin, which represents a significant period of nondeposition and erosion initiated after the deposition of Upper Jurassic / Lower Cretaceous sediments of the first foreland basin clastic wedge. This major unconformity surface also separates much of the basin into two distinct depositional settings: a lower passive margin and an upper foreland basin. Structural modelling of the sub-Cretaceous unconformity and zero-edge delineation of subcropping formations are an integral part of a larger project at the Alberta Geological Survey (AGS) to create a provincial-scale 3D geological model of the subsurface in Alberta.

Initial modelling of the sub-Cretaceous unconformity surface was completed using data from a variety of sources with inconsistent pick criteria, resulting in a variable-quality dataset with a clustered distribution. Data filtering techniques were applied to identify and remove potential outliers and anomalous data. However, this procedure increased the potential of removing good data that accurately characterized areas of increased complexity. These dataset characteristics resulted in higher levels of uncertainty and reduced confidence in the initial unconformity surface. Therefore, the data for this crucial surface were re-evaluated and picked in a consistent manner based on logs and core, using an intelligent sampling configuration to optimize data coverage. This resulted in a higher-confidence surface model that was able to more accurately characterize the true geological complexity.

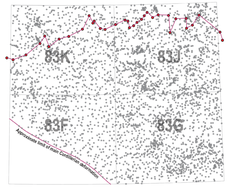
Methods

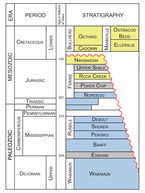
The study area covers NTS map sheets 83G, 83F, 83J, and 83K. The southwest limit of the study area is defined by the approximate limit of main Cordilleran deformation. Geophysical wireline logs for over 4100 wells were reviewed to identify the depth of the unconformity, the corresponding subcropping formation, and other stratigraphic units found below the unconformity surface. Select cores from each subcropping formation were viewed to validate log responses at the unconformity surface.

Stratigraphy

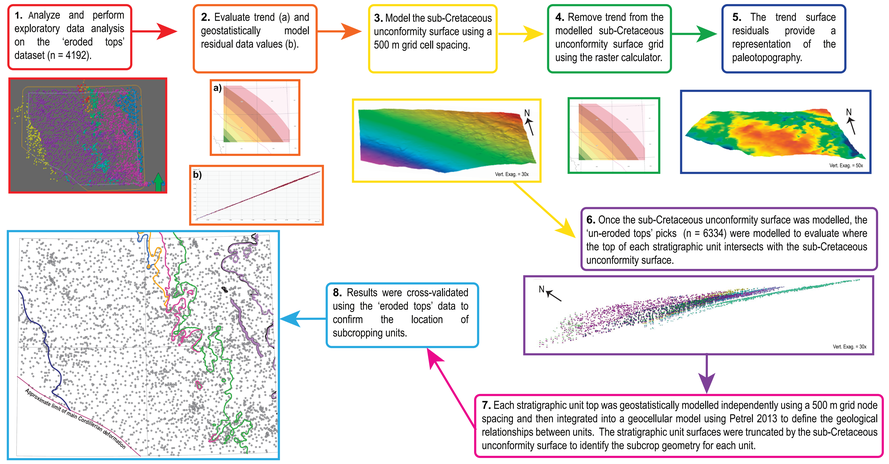


- Varying depositional settings, changing structural regimes, and numerous unconformities led to a complex arrangement of formation extents in the subsurface.
- Not all formations in the stratigraphic framework are eroded by the sub-Cretaceous unconformity (e.g., the Permian and Triassic).
- Unconformity surface has variable topography.
- Erosion associated with the sub-Cretaceous unconformity affected stratigraphic units ranging from the Upper Jurassic / Lower Cretaceous Nikanassin Formation to the Upper Devonian Wabamun Group.

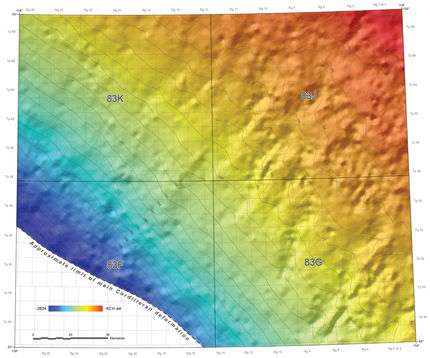




Modelling Overview



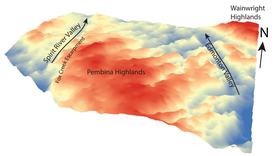
Structural Elevation

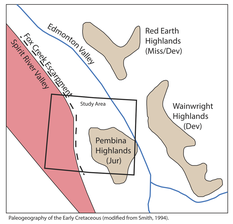


- Structural elevation of the sub-Cretaceous unconformity surface ranges from −2642 metres above sea level in the southwest to −82 metres above sea level in the northeast.
- The overall dip of the surface is to the southwest, with a gradient of ~6 m/km in the northeast quadrant and ~14 m/km in the southwest quadrant, highlighting the effect of the proximity to the deformation front on regional structure.
- Smaller-scale variability seen in the eastern half of the study area is due to erosion of Paleozoic strata.

Paleogeography

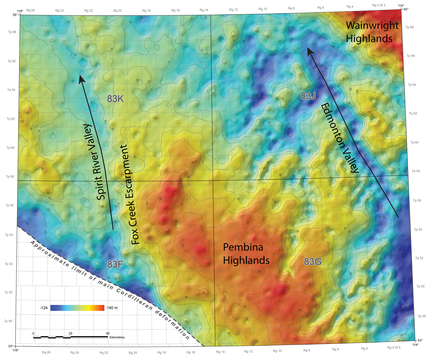
- An oblique view of the sub-Cretaceous unconformity surface (Vert. Exag. = 100×).





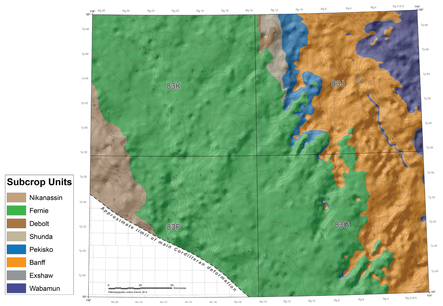
- Paleotopography of the unconformity surface corresponds to features seen in Early Cretaceous paleogeography.

Paleotopography



- Paleotopography is delineated by removing the dominant trend surface to highlight the paleodrainage network formed on the sub-Cretaceous unconformity.
- Relative elevations vary from −124 m to 140 m.
- A Jurassic-aged topographic high, known as the Pembina Highlands, is found in the central part of the study area with the Fox Creek Escarpment and the Spirit River Valley to the west, and the Edmonton Valley to the east.
- Tributaries draining the Pembina Highlands are approximately perpendicular to the main paleovalleys.
- The Wainwright Highlands appear in the northeast, formed of Paleozoic strata.

Subcropping Stratigraphic Units



- Stratigraphic units subcropping at the sub-Cretaceous unconformity in the study area include, in descending stratigraphic order, the Nikanassin, Fernie, Debolt, Pekisko, Shunda, Banff, Exshaw, and Wabamun.

Conclusions

The results of this study were compared with a previous unconformity surface generated using pick data from numerous sources of varying quality, revealing an overall improvement in the surface prediction and enhanced identification of erosional features associated with the sub-Cretaceous unconformity.

Modelling of the unconformity surface will continue across the province and will be a major component of the provincial-scale 3D geological model of the subsurface in Alberta.

Acknowledgements

The authors thank R. Elgr and J. Weiss for cartography and GIS work.

References

Asgar-Deen, M., Riediger, C. and Hall, R. (2004): The Gordondale Member: designation of a new member in the Fernie Formation to replace the informal "Nordegg Member" nomenclature of the subsurface of west-central Alberta; Bulletin of Canadian Petroleum Geology, v. 52, p. 201–214.

Cant, D.J. and Abrahamson, B. (1996): Regional distribution and internal stratigraphy of the Lower Mannville; Bulletin of Canadian Petroleum Geology, v. 44, p. 508–529.

Leckie, D.A. (2009): Geomorphology of the basinwide sub-Cretaceous unconformity, Western Canada Foreland Basin; 2009 CSPG CSEG CWLS Convention abstract, p.131, URL <http://www.geoconvention.org/archives/2009abstracts/022.pdf> [June 2014].

Losert, J. (1986): Jurassic Rock Creek Member in the subsurface of the Edson area (west-central Alberta); Alberta Research Council, Alberta Geological Survey, Open File Report 1986-03, 39 p., URL <http://ags.gov.ab.ca/publications/abstracts/OFR_1986_03.html> [June 2014].

Losert, J. (1990): The Jurassic-Cretaceous boundary units and associated hydrocarbon pools in the Niton Field, west-central Alberta; Alberta Research Council, Alberta Geological Survey, Open File Report 1990-01, 41 p., URL <http://ags.gov.ab.ca/publications/abstracts/OFR_1990_01.html> [June 2014].

Marion, D.J. (1984): The Middle Jurassic Rock Creek Member and associated units in the subsurface of west-central Alberta; *in* The Mesozoic of Middle North America, D.F. Stott and D.J. Glass (ed.), Canadian Society of Petroleum Geologists, Memoir 9, p. 319–343.

Poulton, T.P., Tittemore, J. and Dolby, G. (1990): Jurassic strata of northwestern (and west-central) Alberta and northeastern British Columbia; Bulletin of Canadian Petroleum Geology, v. 38A, p. 159–175.

Poulton, T.P., Christopher, J.E., Hayes, B.J.R., Losert, J., Tittemore, J. and Gilchrist, R.D. (1994): Jurassic and lowermost Cretaceous strata of the Western Canada Sedimentary Basin; *in* Geological atlas of the Western Canada Sedimentary Basin, G.D Mossop and I. Shetsen (comp.), Canadian Society of Petroleum Geologists and Alberta Research Council, p. 297–316.

Richards, B.C., Barclay, J.E., Bryan, D, Hartling, A., Henderson, C.M. and Hinds, R.C. (1994): Carboniferous strata of the Western Canada Sedimentary Basin; *in* Geological atlas of the Western Canada Sedimentary Basin, G.D Mossop and I. Shetsen (comp.), Canadian Society of Petroleum Geologists and Alberta Research Council, p. 221–250.

Smith, D.G. (1994): Paleogeographic evolution of the Western Canada foreland basin; *in* Geological atlas of the Western Canada Sedimentary Basin, G.D Mossop and I. Shetsen (comp.), Canadian Society of Petroleum Geologists and Alberta Research Council, p. 277–296.