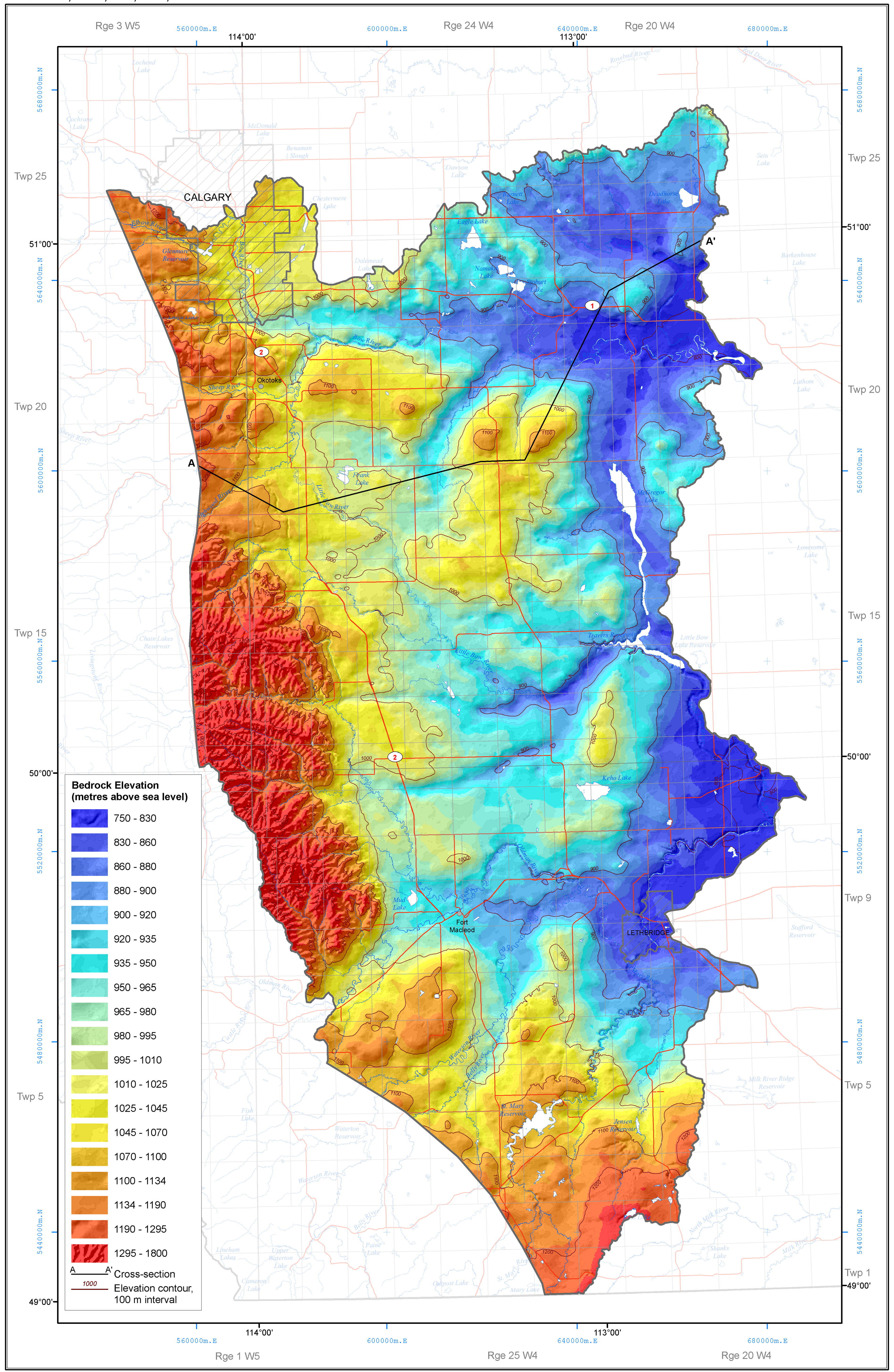


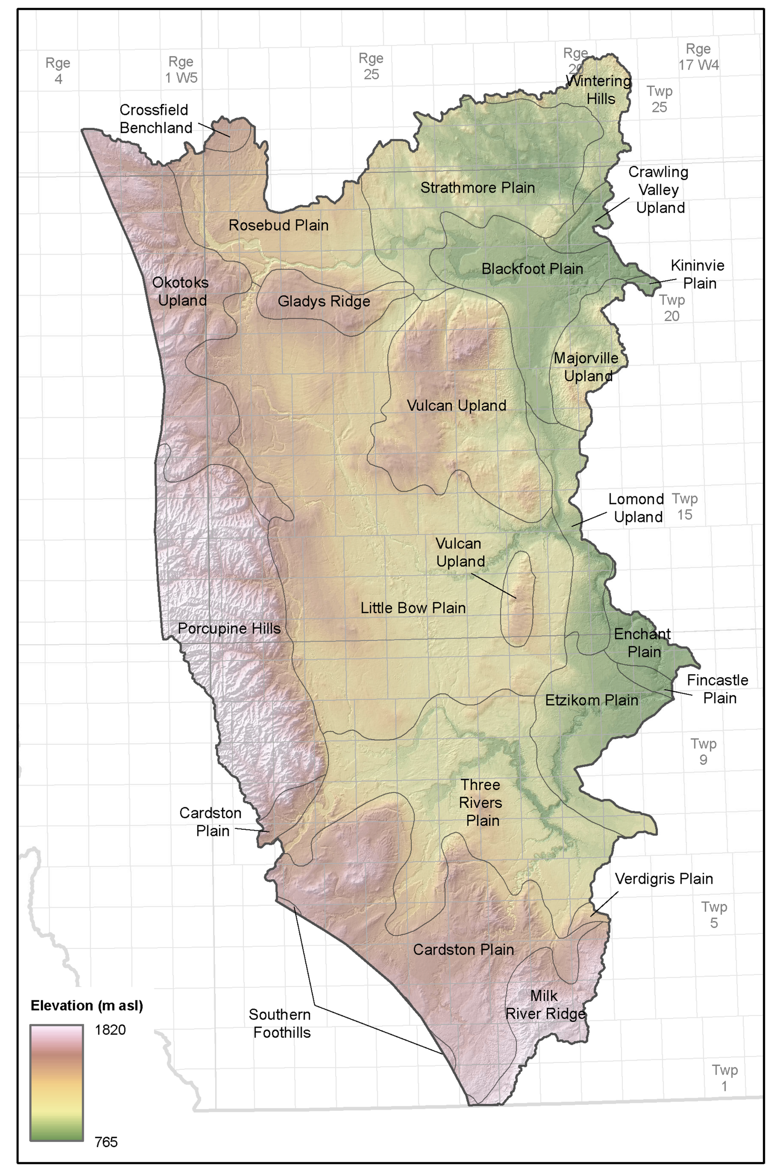


Figure 1: Hillshaded digital elevation model (DEM) of the CLC showing physiographic districts (from Pettapiece, 1986).

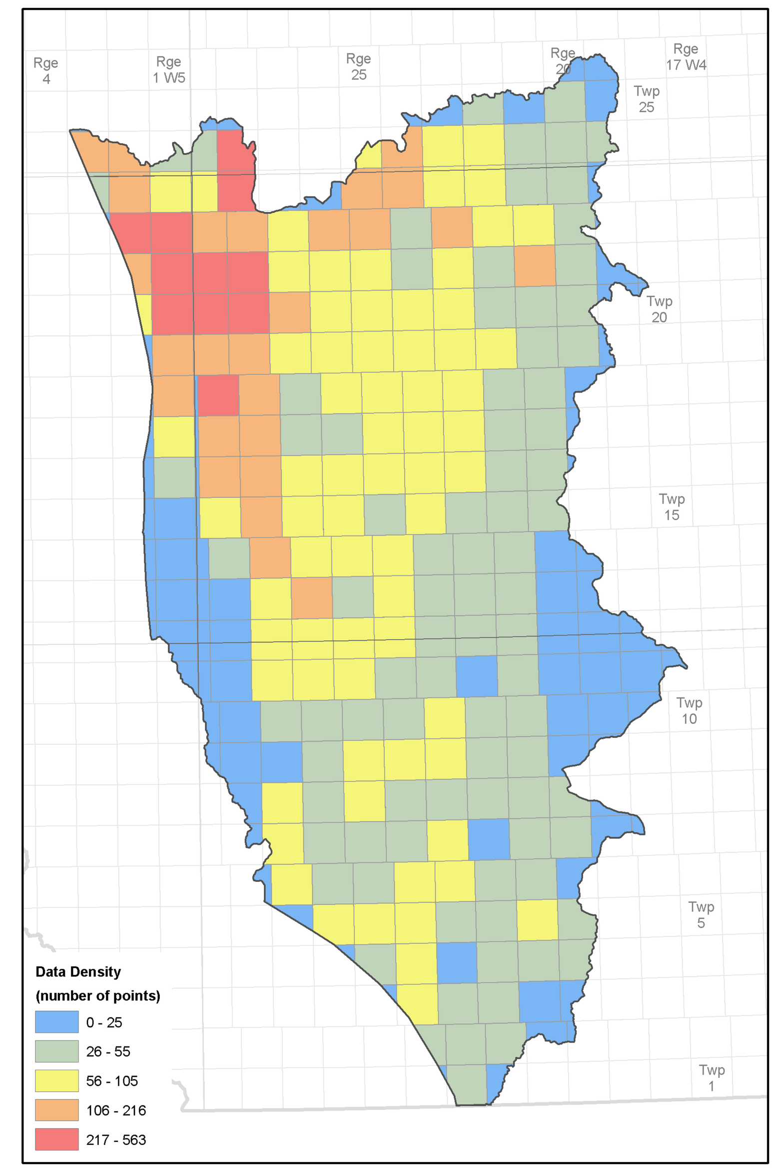


Figure 2: Total number of data points per township used to create the bedrock topography.

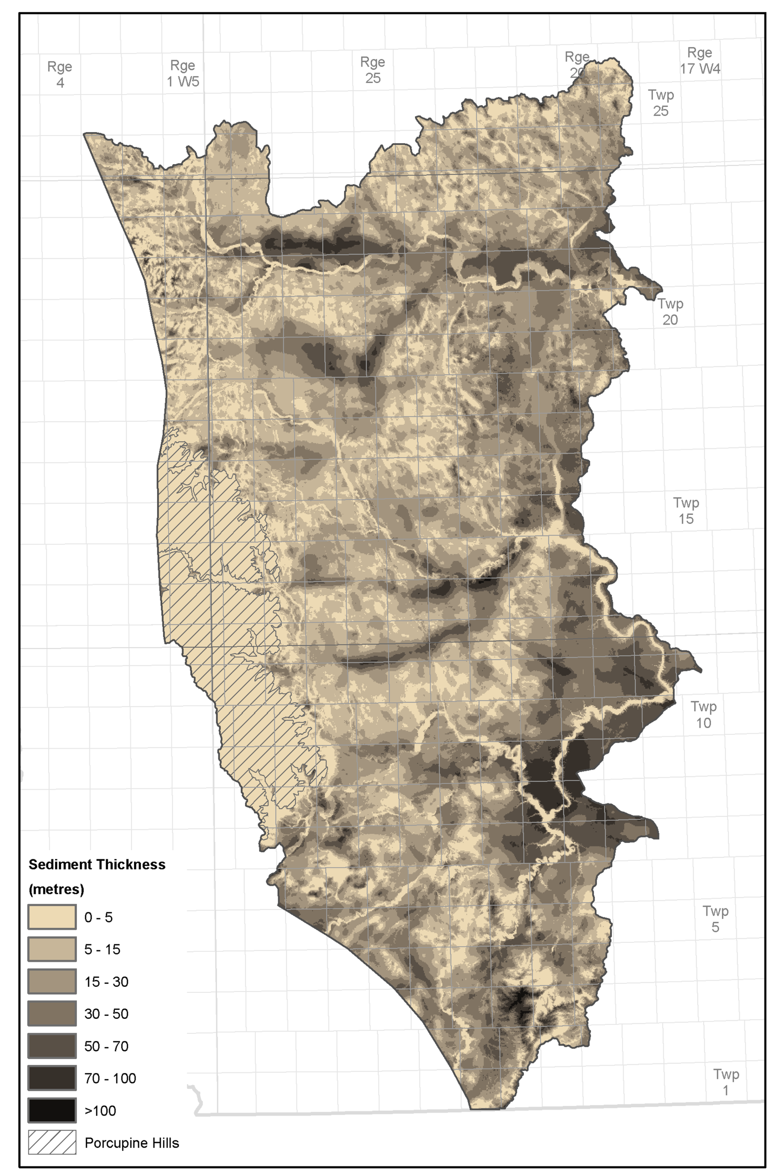


Figure 3: Thickness of Neogene–Quaternary sediments overlying the bedrock topography.

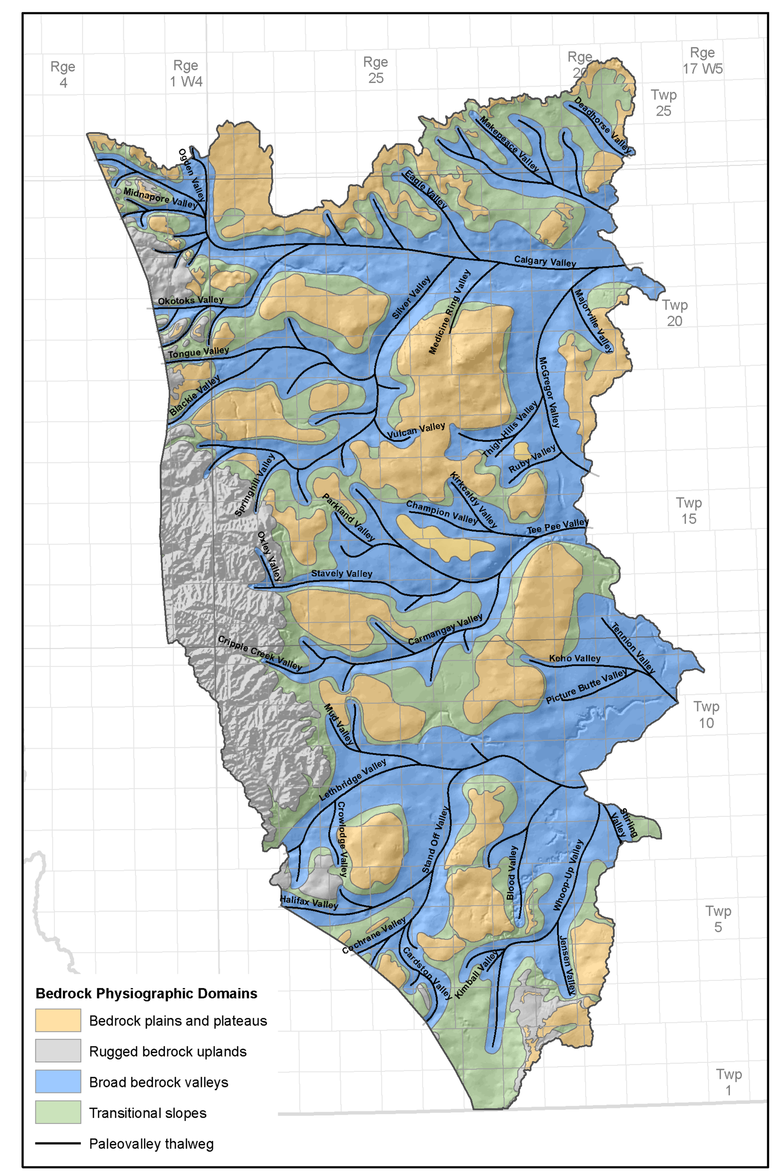


Figure 4: Bedrock physiographic domains, based on interpretation of the elevation and relief of the bedrock surface. Paleovalley thalwegs modified from Geiger (1968).

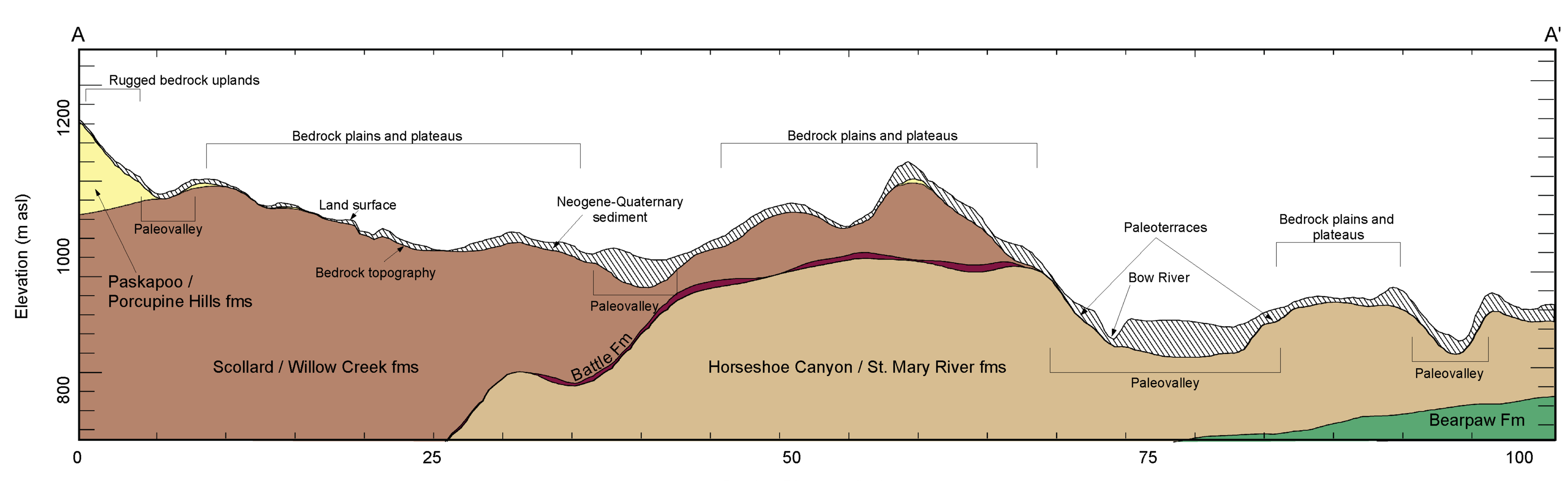


Figure 5: Cross-section of the modern land surface, bedrock topography, and underlying Upper Cretaceous–Paleogene bedrock units across the CLC. Bedrock physiographic domains outlined in Figure 4 are also illustrated. Line of section shown on main map. 50x vertical exaggeration.

Introduction

This map portrays a rendering of the bedrock topography of the Calgary-Lethbridge Corridor (CLC) that has been constructed as part of a three-dimensional hydrostratigraphic model of this part of southern Alberta (Atkinson et al., 2017). The bedrock topography surface represents a well-constrained unconformity upon which Neogene−Quaternary sediments were deposited, and is modelled at a greater resolution than that provided by the provincial-scale renderings (MacCormack et al., 2015). This is a significant boundary for shallow modelling studies, as it provides the lowermost surface for modelled Neogene−Quaternary units, and acts as the bounding surface for Upper Cretaceous−Paleogene bedrock strata.

Map Area

The CLC (21,160 km^2) is delineated by eight watershed sub-basins and covers portions of NTS map sheets 82G, H, I, J, O, and P. The physiography of the modern land surface of the CLC is classified as plains (760−1220 m asl) and uplands (950−1810 m asl), which cover 70% and 30% of the study area respectively (Figure 1; Pettapiece, 1986). Two small areas in the southwest portion of the CLC are classified as Rocky Mountain Foothills.

Data Sources and Methodology

Input Data and Preparation

Numerous data sources of varying quality and distribution (Figure 2) were compiled for the construction of the CLC bedrock topography. The most significant data source was derived from lithological descriptions in the Alberta Water Well Information Database (AWWID; Alberta Environment and Sustainable Resource Development, 2013). These data are of variable quality due to errors in location and inaccuracies in geological descriptions. However, AWWID records have the most widespread distribution across the study area.

Two methods were used to identify the top of bedrock from the lithological descriptions within AWWID. The first involved a database query, in which the uppermost occurrence of bedrock in a well record was automatically picked (cf. Slattery et al., 2011). This method was employed due to the large number of well records available in the CLC (23,808 lithologs). The second method involved manual picking, and where necessary amending automatic picks. The manual method was necessary: 1) where well records had ambiguous lithological information; 2) where wells were interpreted to be close to, but did not reach the bedrock surface; and 3) where an automatic pick was deemed an outlier (e.g., glaciotectonically displaced bedrock) and was therefore deleted from the final dataset.

An inherent ambiguity within the AWWID is the co-location of wells. Co-location of two or more wells may represent an inability to locate a well with greater accuracy than a Dominion Land Survey quarter-section (~800 x 800 m) or legal site description (~400 x 400 m). Alternatively, co-location of wells may indicate that a well has been deepened, altered, or that nested wells have been installed. Where three or more co-located wells were encountered in the database, the deepest and shallowest well logs were selected to include wells that were completed in bedrock and to also characterize near surface sediments respectively.

The variable quality AWWID lithologs were constrained, where possible, by higher quality data including: Alberta Geological Survey (AGS) borehole logs and field data; stratigraphic picks made from oil and gas geophysical logs; and, outcrops in areas where bedrock is at the modern land surface. AWWID lithologs were also constrained by interpretive data such as airborne resistivity maps (covering approximately 53% of the study area), thematic maps including buried valleys (Geiger, 1968), provincial-scale bedrock geology and surficial geology maps (Prior et al., 2013; Fenton et al., 2013), and a provincial-scale geostatistically rendered model of bedrock topography (MacCormack et al., 2015).

All point data, irrespective of quality, were coded with an x, y position and corresponding bedrock topography elevation (z) value and compiled and interpolated in an ArcGIS® project. All information on data quality and data source was recorded in a Microsoft Access™ database and is presented in Atkinson et al. (2017).

Modelling

Bedrock topography data were interpolated using the ordinary kriging function of the Geostatistical Analyst ArcGIS® extension at a 400 m grid cell size. This interpolated bedrock topography grid was truncated by the DEM of the modern land surface (Figure 1) using RockWorks16® to ensure the bedrock topography did not exceed surface elevation. The resulting bedrock topography grid has a root mean square error of 7.23 m. This error measures the deviation of a point from the grid, with the highest deviations in the western portion of the CLC (Porcupine Hills; Figure 1), and in areas of steeply sloping bedrock topography such as at the edges of bedrock valleys or upland plateaus.

Due to the numerous data points used to model the bedrock topography (17,252; Figure 2), data were incrementally refined by the authors in the following three situations: 1) to better define areas of high topographic complexity; 2) to remove outliers (irregular topographic highs or lows); and 3) to better define areas of high importance for hydrostratigraphic modelling.

The Calgary urban region and the Porcupine Hills (Figure 1) required different modelling approaches due to variations in data quality and distribution (Figure 2; Atkinson et al., 2017). For example, the disproportionately large amount of bedrock topography data available in the topographically low Calgary urban region caused the modelled bedrock topography in adjacent uplands to be generally subdued. To mitigate this issue, a suite of high quality geological borehole logs, distributed across the Calgary urban region were used instead of AWWID records (Moran, 1986). Removal of all low quality data points within a 400 m radius of a high quality geological log in the final dataset corrects the over-representation of topographically low data. In the Porcupine Hills, a paucity of point data precludes interpolation of the bedrock topography. Therefore, the land surface DEM minus one metre was accepted as a proxy of the bedrock topography based on a geomorphological interpretation that indicates a veneer of Quaternary sediment overlying bedrock (Fenton et al., 2013). The final product is a seamless representation of the bedrock topography of the CLC.

A rendering of the thickness of Neogene−Quaternary sediments lying above bedrock in the CLC (Figure 3) was calculated by subtracting the DEM from the bedrock topography using the grid math function in RockWorks16®.

Bedrock Topography and Sediment Thickness

The elevation of the bedrock topography in the CLC ranges from 750–1795 m asl, with the highest elevation and relief occurring in the Porcupine Hills and Milk River Ridge, and lowest within the Blackfoot, Enchant, and Etzikom plains (Pettapiece, 1986; Figure 1). Sediment is relatively thin (typically <10 m) where it overlies higher elements of bedrock topography (e.g., Porcupine Hills, Vulcan Uplands, and Gladys Ridge; Figure 1), and thicker (typically >20 m; Figure 3) where bedrock relief is low. The thickest sediment is along the axis of paleovalleys (Figures 3 and 4) where it exceeds 50 m, with the exception of where sediment has been excavated by the modern drainage system. Thick sediments have also been erroneously modelled in the Milk River Ridge district (Figures 1 and 3) due to a paucity of data (Figure 2) in the area and model resolution issues. At a local scale, the Milk River Ridge would only have a thin veneer of sediment.

In higher upland areas where sediment is relatively thin, the physiographic character of the land surface (Figure 1) largely reflects that of the underlying bedrock surface (Figure 5). However, in the lower plains where sediment is thick, the surface topography is little influenced by the bedrock topography surface (Figure 5). For example, buried bedrock valleys within the plains (Figures 1 and 4) are commonly unrecognizable at surface, being infilled and masked by sediment.

Bedrock Physiography

Classification of bedrock physiographic domains includes: bedrock plains and plateaus, rugged bedrock uplands, broad bedrock valleys with associated terraces, and transitional slopes (Figure 4). Relatively narrow valleys incised into the bedrock surface along glacial meltwater outlets or modern fluvial channels are also recognizable in the bedrock topography; however, these are of limited areal extent and do not comprise a major domain at the scale of this map.

Bedrock plains and plateaus (870 to 1390 m asl) are characterized as low relief, stepped surfaces on the bedrock topography (Figure 5). These surfaces are commonly overlain by a succession of coarse-grained Neogene fluvial sediments and Quaternary glaciogenic deposits. Rugged bedrock uplands (1010 to 1800 m asl) including the Porcupine Hills and portions of the Okotoks Upland, and part of Milk River Ridge (Pettapiece, 1986; Figure 1) comprise high-relief surfaces that are typically mantled by till veneer and colluvium. Broad bedrock valleys and associated terraces (750 to 1230 m asl) comprise extensive paleovalley networks (Figure 4) that are commonly infilled by sand and gravel overlain by a succession of predominantly fine-grained glaciogenic sediments. These sediments may be exposed where modern river channels have incised buried paleovalleys. Transitional slopes comprise low-gradient features that separate neighbouring bedrock physiographic domains.

Acknowledgements

The authors would like to thank the following people for their helpful comments and contributions:
- K. MacCormack and S. Lyster (AGS) for providing a subset of data used for the provincial-scale rendering of the bedrock topography of Alberta.
- N. Atkinson and L. Andriashek (AGS) provided review and constructive comments that greatly improved this map.
- K. Mckay (AGS) completed the digital cartography and GIS.

References

Alberta Environment and Sustainable Resource Development (2013): Alberta Water Well Information Database; Government of Alberta, URL <http://groundwater.alberta.ca/WaterWells> [November 2013].

Atkinson, L.A., Liggett, J.E., Hartman, G., Nakevska, N., Mei, S., MacCormack, K.E. and Palombi, D. (2017): Geological and hydrogeological characterization of the Calgary-Lethbridge Corridor in the South Saskatchewan regional planning area; Alberta Energy Regulator, AER/AGS Open File Report 91, 180 p.

Fenton, M.M., Waters, E.J., Pawley, S.M., Atkinson, N., Utting, D.J. and Mckay, K. (2013): Surficial geology of Alberta; Alberta Energy Regulator, AER/AGS Map 601, scale 1:1 000 000.

Geiger, K.W. (1968): Bedrock topography of the Gleichen map-area, Alberta; Research Council of Alberta, Edmonton, Report 67-2, 14 p.

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.

Moran, S.R. (1986): Surficial geology of the Calgary urban area; Alberta Research Council, Terrain Sciences Department, Bulletin No. 53, 46 p.

Pettapiece, W.W. (1986): Physiographic subdivisions of Alberta; Land Resources Research Centre, Research Branch, Agriculture Canada, scale 1:1 500 000.

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.

Slattery, S.R., Barker, A.A., Andriashek, L.D., Jean, G., Stewart, S.A., Moktan, H. and Lemay, T.G. (2011): Bedrock topography and sediment thickness mapping in the Edmonton–Calgary Corridor, central Alberta: an overview of protocols and methodologies; Energy Resources Conservation Board, ERCB/AGS Open File Report 2010-12, 16 p.

Recommended Reference Format

Atkinson, L.A. and Hartman, G.M.D. (2017): Bedrock topography of the Calgary-Lethbridge corridor; Alberta Energy Regulator, AER/AGS INF 150, scale 1:500 000.

Alberta Geological Survey
(780) 638-4491
www.ags.aer.ca

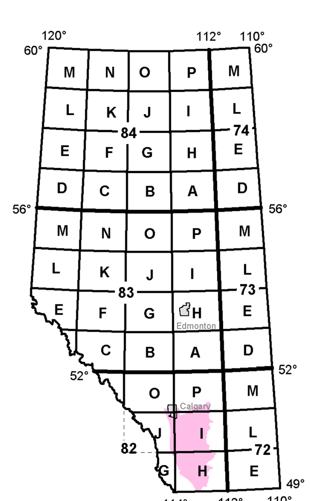
Published 2017
ISBN 978-1-4601-0168-1

INF 150

Bedrock Topography of the Calgary-Lethbridge Corridor

NTS 82G, 82H, 82I, 82J, 82O and 82P

Geology by: L.A. Atkinson and G.M.D. Hartman



Scale 1:500 000

Projection: Transverse Mercator
Datum: North American Datum, 1983