Alberta Energy Regulator | AGS ALBERTA GEOLOGICAL SURVEY

Alberta Geological Survey Map 601

Surficial Geology of Alberta

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Scale 1:1 000 000

kilometres / miles

Projection: 10 Degree Transverse Mercator
Datum: North American Datum, 1983

Legend on accompanying page

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Alberta Geological Survey Map 601 Legend

Surficial Geology of Alberta

Holocene

Modern Glaciers: Permanent snow and ice polygons circa 1994, simplified from CanVec topographic data (Natural Resources Canada, 2012), includes icefields, valley and cirque glaciers.

Organic Deposits: Undifferentiated peat (woody to fibrous muck) occurring in wetlands; commonly underlain by fine-grained, poorly drained glaciolacustrine or lacustrine deposits; in some places underlain by till; includes marshes, swamps, bogs, and fens.

Colluvial Deposits: Sediments that have reached their present position as a result of direct, gravity-induced movement; commonly occurs as slope and slump deposits confined to valley sides and floors; includes bedrock and surficial materials; in places, includes a significant component of fluvial deposits, as these two units are inseparable at this map scale.

Fluvial Deposits: Sediments deposited by streams and rivers; synonymous with alluvium; includes poorly to well-sorted, stratified to massive sand, gravel, silt, clay, and organic sediments occurring in channel and overbank deposits; in places, includes a significant component of colluvial deposits as these two units are inseparable at this map scale.

Lacustrine Deposits: Sediments deposited in and adjacent to recent and modern lakes; includes offshore sand, silt, and clay, minor organic deposits; may also include minor littoral (nearshore) beaches and bars composed of sand, silt, and minor gravel.

Pleistocene to Holocene

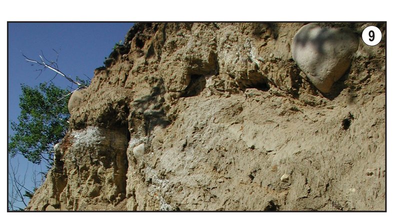
Eolian Deposits: Wind-deposited sediments comprising well-sorted, medium- to fine-grained sand and minor silt; generally massive to locally cross-bedded or ripple laminated; includes both active and vegetated dunes and sand sheets.

Pleistocene

Glaciolacustrine Deposits: Sediments deposited in or along the margins of glacial lakes; includes a) offshore sediment; rhythmically laminated to massive fine sand, silt, and clay, locally containing debris released by the melting of floating ice; and b) littoral (nearshore) sediments; massive to stratified, well-sorted silty sand, pebbly sand, and minor gravel; occurs in beaches, bars, and deltas.

Glaciofluvial Deposits: Sediments deposited by glacial meltwater in subaerial, subaqueous, and subglacial environments; sediment ranges from massive to stratified, poor to well sorted, coarse to fine grained; in places, this unit includes till; may show evidence of ice melting (slumped structures).

Moraine: Diamicton (till) deposited directly by glacial ice with a mixture of clay, silt, and sand, as well as minor pebbles, cobbles, and boulders; characterized by a lack of distinctive topography. Locally, this unit may contain blocks of bedrock, stratified sediment, or lenses of glaciolacustrine and/or glaciofluvial sediment.



Fluted Moraine: Glacially streamlined sediments, mainly till; terrain varies from alternating furrows and ridges to elongated smoothed hills which parallel the inferred local ice-flow direction; includes flutes, drumlins, and drumlinoids.

Stagnant Ice Moraine: Sediments resulting from the collapse and slumping of englacial and supraglacial debris due to the melting of buried stagnant ice at the glacier margin; sediment is mainly till but locally includes stratified glaciolacustrine or glaciofluvial sediments; characterized by low- to high-relief hummocky topography.

Ice-Thrust Moraine: Material formed from the glaciotectonic displacement of blocks or rafts in a more or less intact state; may include syngenetic till and masses of pre-existing sediments and/or bedrock; characterized by high- to moderate-relief glaciotectonic moraines; includes hill-hole pairs, rubble moraine, and thrust-block moraine.

Paleogene to Neogene

Preglacial Fluvial Deposits: Sediments transported and deposited by streams and rivers prior to glaciation; Cordilleran source; predominantly well-sorted quartzite and chert gravel and cobbles with minor sand; unit generally forms erosional remnants capping isolated upland and midland peneplains.

Precambrian to Cretaceous

Bedrock: Mapped primarily in northeastern Alberta (igneous and minor metamorphic rock), the foothills (clastic rocks including conglomerate, sandstone, siltstone, and shale), and in the mountains (clastic rocks, limestone, and dolostone); minor exposure on the plains (clastic rocks).

Introduction

Map 601 portrays a generalized compilation of the surficial geology of Alberta at 1:1 000 000 scale using previously published maps from the Alberta Geological Survey, the Geological Survey of Canada, and Environment Canada, as well as university theses and new data. If detailed information is required on the surficial geology of specific areas, the original source maps (Figure 1) should be consulted.

Data Sources

The Surficial Geology Map of Alberta is based on an amalgamation of 65 previously published surficial geology maps that cover about 90% of the province (Figure 1). These maps date back to the 1960s, some of which used unstandardized legends and were published at scales ranging from 1:50 000 to 1:500 000. These maps were digitized using ArcGIS and unit polygons were reclassified according to the Map 601 legend to produce a seamless mosaic of the surficial geology of Alberta. The remaining unmapped areas of Alberta were completed by field-tested Light Detection and Ranging (LiDAR) and airphoto interpretations and predictive mapping at 1:500 000 to 1:1 000 000 scale as part of this compilation (Figure 2) and were incorporated into the seamless provincial mosaic.

Boundary discrepancies between units in adjacent map areas were largely resolved during the reclassification process. However, in areas with significant discrepancies, unit-specific reclassification was undertaken along polygon boundaries. Furthermore, if original maps included symbology rather than unit polygons, then these symbols were used to reclassify units according to the standard legend and incorporated into Map 601. Further unit reclassification included data from other published sources, such as in areas where fluting was not recognized on an original map but was subsequently detected on digital elevation models (e.g., Ó Cofaigh et al., 2010).

The corrected seamless provincial mosaic was then generalized using GeoScaler software published by the Geological Survey of Canada (Huot-Vézina et al., 2009). The resulting simplified surficial geology layer is shown overlaid on a hill-shaded Shuttle Radar Topography Mission digital elevation model (U.S. Geological Survey, 2000) to convey the effects of topography.

Due to the compilation of surficial geology maps spanning five decades and published at a range of scales, base features shown on this map do not always conform to the generalized geological unit boundaries, since these features were derived from the most up-to-date 1:1 000 000 scale digital data (Natural Resources Canada, 2009). Consequently, there may be areas on the map that appear inconsistent; for example, where modern rivers flow outside of fluvial sediment polygons. Nonetheless, at this map scale, the base features and the geological units have a positional accuracy of ± 1.5 km.

Surficial Geology Map of Alberta

Map 601 illustrates the geology at or near the modern land surface (to a depth of approximately 2 m). The relative abundance of the map units is undivided moraine (24%), fluted moraine (7%), stagnant ice moraine (19%), and ice-thrust moraine (2%), as well as glaciolacustrine (18%), organic (10%), colluvial (5%), fluvial (4%), glaciofluvial (4%), eolian (3%), lacustrine (1%), and preglacial fluvial (0.1%) deposits. Outcrops of bedrock comprise approximately 3% of the surficial geology of Alberta and primarily occur within the Rocky Mountains and in the Canadian Shield adjacent to Lake Athabasca (Pană et al., 2013; Prior et al., 2013).

The age, origin, thickness, and distribution of the sedimentary succession overlying the bedrock surface in Alberta varies greatly, with thickness ranging from less than 1 m to as much as 445 m (Figures 3 and 4). These sediments document geological processes that were active across the Alberta landscape during the Cenozoic, the most recent geological era, and include Paleogene to Neogene fluvial deposits and glaciogenic materials deposited during Quaternary glaciation, as well as postglacial deposits. The general relationship between the bedrock topography and the origin and distribution of surficial deposits shows that large parts of the modern Alberta landscape relate to the topography of the underlying bedrock.

Sediment Distribution

Paleogene to Neogene

Preglacial fluvial deposits occupy isolated, gravel-capped uplands within widely dispersed settings across the Interior Plains of Alberta, including Cypress Hills, Hand Hills, Swan Hills, and Marten Mountain (the western portion of the Pelican Mountains; Figures 5 and 6). The preglacial fluvial deposits occur within peneplains that represent the erosional remnants of eastward-flowing fluvial systems formed during the Paleogene to Neogene following regional uplift associated with the Laramide Orogeny (Leckie, 1989, 2006; Leckie and Cheel, 1989; Leckie et al., 2004). During ongoing uplift, eastward-flowing rivers continued to erode these peneplains, redepositing gravel at successively lower elevations across the landscape.

Pleistocene

Map 601 reveals that the most abundant geological units that cover the Alberta landscape originated during the Pleistocene, as a result of the advance and retreat of Quaternary ice sheets that deposited moraine (52%) and glaciolacustrine deposits (18%).

Ice advance was responsible for the widespread deposition of moraine extending from plains in the southern, central, and northeastern parts of Alberta, to uplands in the west and north (Figure 5). During the last glaciation (culminating approximately 22 000 years ago; Mix et al., 2001; Dyke et al., 2002), the Laurentide Ice Sheet advanced south to southwestwards across Alberta, against the regional topographic gradient, and converged with the Cordilleran Ice Sheet, which was advancing eastwards onto the Southern Alberta Plains from the Rocky Mountains (Figure 4).

Moraine is classified into four units, in descending order of its spatial distribution across the province: undivided, stagnant ice, fluted, and ice thrust.

Undivided moraine is widespread across uplands in northern Alberta, including the Cameron Hills, Caribou Mountains, the northern flank of the Clear Hills, and the eastern flank of the Birch Mountains (Figure 6). Undivided moraine also extends across parts of the Northern Alberta Lowlands, adjacent to the flanks of the Caribou and Birch mountains. It is also common across the Saskatchewan Plains, adjacent to the confluence of the Athabasca and Clearwater rivers, as well as across uplands and benchlands that parallel the Rocky Mountain Foothills in western and southern Alberta.

Stagnant ice moraine is a widespread unit in north-central Alberta, particularly across the Buffalo Head Hills and the southern flanks of the Birch Mountains, Clear Hills, and Swan Hills (Figure 6). It is also abundant across uplands within the western and eastern Alberta plains, particularly along the flanks of three prominent, low-relief corridors of fluted moraine extending south between Edmonton and Calgary, to the east and west of Red Deer, and southeast from Lac La Biche. The central and western corridors of fluted moraine terminate at a broad arc, originally termed the Lethbridge Moraine (Stalker, 1977), which extends from Strathmore to Medicine Hat and contains a suite of glacial landforms, including ice-thrust moraine. Ice-thrust moraine occurs in other places in Alberta, most commonly southeast of Lac La Biche, on the northern slopes of the Pelican Mountains and the Swan Hills, to the southwest of the Birch Mountains, and adjacent to the southern margins of many lakes in central Alberta.

During deglaciation of Alberta (initiating approximately 14 500 years ago; Dyke, 2004), the Laurentide Ice Sheet retreated northwards and eastwards into the Northwest Territories and Saskatchewan, and the Cordilleran Ice Sheet retreated westwards into the Rocky Mountains. The most widespread surficial geological unit associated with the retreat of the Laurentide Ice Sheet comprises late Pleistocene glaciolacustrine sediments. These were deposited in glacial lakes that ponded against the retreating ice margins, many of which extended distally along the axes of a number of major river valleys in Alberta. The most regionally extensive distribution of glaciolacustrine deposits occurs across the Northern Alberta Lowlands (Figure 5), extending from Lesser Slave Lake, northwards along the flanks of the Peace and Hay rivers towards the provincial boundary to the north and west, and Lake Athabasca to the east.

Glaciofluvial deposits (4%) represent a minor surficial geological unit and are associated with the deglaciation of Alberta during the late Pleistocene. These deposits generally form linear or irregularly shaped bodies and are found primarily within two major terrain types. The first is lowlands incised by major glacial meltwater channels, which include the Hay and Athabasca rivers in northwestern and northeastern Alberta, respectively. In these settings, glaciofluvial deposits occur along the margins of these channels. The second is along the flanks of stagnant ice moraine-dominated uplands, including the Buffalo Head Hills and the Caribou, Birch, and Stony mountains (Figure 6). However, the most extensive area of glaciofluvial deposits occurs between Lake Athabasca and Fort McMurray, near the sandstone-rich Athabasca Group (Slimmon and Pană, 2010).

Pleistocene to Holocene

Eolian deposits (3%) range in age from late Pleistocene to Holocene (Wolfe et al., 2004). Many were deposited immediately following deglaciation when newly exposed sediments were not yet stabilized by vegetation. Consequently, eolian deposits are commonly located adjacent to glaciofluvial units, as well as modern fluvial terraces and floodplains due to their derivation from redeposited fine-grained sediments. These deposits are particularly prevalent along the axes of the Athabasca and Peace rivers, where they occur within a succession of locally extensive dune fields. Eolian deposits also occur across areas of sandy moraine in northeastern Alberta.

Holocene

The most widespread, postglacial, surficial geological unit comprises organic deposits (10%), which occur throughout northern Alberta, and form a significant component of the boreal forest. Organic deposits are common across the lowlands between the Buffalo Head Hills, Birch Mountains, and Stony Mountain (Figure 6), where they typically overlie and are interspersed with glaciolacustrine deposits. Organic deposits are also associated with areas of poorly drained moraine that drape parts of the Caribou and Birch mountains and the Cameron Hills. At these elevations, many organic deposits contain discontinuous areas of permafrost.

Minor postglacial, surficial geological units across the Alberta landscape include colluvial (5%), fluvial (4%), and lacustrine (1%) deposits. Colluvium forms a locally significant unit fringing the slopes of the Rocky Mountains and Foothills, as well as on the flanks of the Swan Hills, and the Birch and Caribou mountains. Colluvial deposits are also prominent along the margins of major valley systems in Alberta. Due to its association with river valleys, colluvium and fluvial deposits, which are deposited adjacent to modern rivers, are often inseparable at the scale of this map. The ability to differentiate these two types of deposits within a particular valley segment depends on the relative proportion of the valley slopes and the floodplain.

Recently deposited lacustrine deposits are rare in Alberta (1%), the most extensive areas occurring around the margins of Zama and Lesser Slave lakes.

Significance to the History and Development of Alberta

The significance of fluvial, glacial, and postglacial processes and their associated deposits is evident across the modern Alberta landscape. The cumulative effect of these processes during the Cenozoic history of Alberta has strongly influenced the topography, hydrology, hydrogeology, pedology, and ecology of the province and has an important role in modern land-use patterns and development.

The location of many of Alberta's major rivers, including the North and South Saskatchewan, Athabasca, Peace, and Hay rivers, in part relate to the courses of ancestral Paleogene to Neogene river systems. Some paleovalley systems associated with these ancestral rivers are filled by a substantial thickness of Cenozoic sediment. In places, this sediment forms regionally significant near-surface aquifers (Figure 4; Barker et al., 2011). In some areas of Alberta, the continued evolution of these rivers during the Quaternary was influenced by the location of glacial meltwater channels that either drained glacial lakes or formed along successive ice-marginal positions as ice sheets retreated across the landscape. For example, in southern and eastern Alberta, many rivers follow courses oblique to the regional topographic gradient due to their deflection around broad lobes of retreating Laurentide ice that extended southwards into the drainage basins of these rivers during regional deglaciation (Klassen, 1989).

In addition to insights into the geological history of Alberta that these river courses provide, they also played a significant role in the historical development of the province. During the late 18th and early 19th centuries, Alberta's rivers were used as 'fluvial highways' that enabled access to much of the Interior Plains and Cordillera (Scheelar and Macyk, 1972). Because of the historical settlement of these river valleys, many of Alberta's cities now occupy the basins of former glacial lakes that were impounded by the Laurentide Ice Sheet as it retreated from the drainage basins of these rivers, including Medicine Hat, Lethbridge, Calgary, Red Deer, Edmonton, Peace River, Grande Prairie, and Fort McMurray.

Alberta's major soil zones and natural regions (Downing and Pettapiece, 2006) are significantly influenced by the underlying geology. For example, wetlands are preferentially developed in areas underlain by low permeability sediments, primarily glaciolacustrine deposits. Consequently, large areas of the boreal forest in the Northern Alberta Lowlands and Northern Plains (Figure 5) contain organic deposits that accumulated within the lowland basins of former glacial lakes. Glaciolacustrine deposits are typically associated with low-relief terrain, comprising stone-free, fine-grained sediment. Soils derived from this material are consequently more suitable to agriculture, as can be seen by the widespread distribution of arable land on the lowlands adjacent to the Peace River in northwest Alberta and along the North Saskatchewan River in the Edmonton region of central Alberta.

In contrast, areas of moraine, which comprise a heterogeneous mixture of rock fragments within a silty to sandy matrix, were historically more challenging for agriculture because farmers had to clear the cobbles and boulders from the surface to reduce damage to farm equipment during tillage. Furthermore, because some types of moraine are typically associated with rolling to higher relief topography, those landscape elements were generally less conducive to efficient agriculture prior to the development of modern farming technology. In addition to agriculture, areas of moraine are also associated with a range of other land uses, including grazing and forestry. Surficial deposits dominated by coarse-grained sediments form a minor component of the Alberta landscape. However, in northeast Alberta, extensive eolian and glaciofluvial deposits across the Athabasca Plain have a strong ecological influence on the landscape and contribute to the development of unique vegetation communities and Jack pine-dominated uplands (Downing and Pettapiece, 2006).

The underlying geology also influences postglacial processes, and in some areas of Alberta, these processes may have a significant effect on modern infrastructure development. For example, the lowlands flanking the Peace River are one of the most historically active mass-movement areas in Western Canada. This mass-movement activity is influenced by the distribution of glaciolacustrine deposits in the area, particularly where thick deposits of glaciolacustrine sediment infill preglacial paleovalleys, which are prone to slope instabilities, particularly when undercut by present-day rivers. Infrastructure associated with urban development in these areas, such as the town of Peace River, has been, and continues to be, affected by these instabilities (Morgan et al., 2012).

Figure 6. Surface Topography and Photo Locations

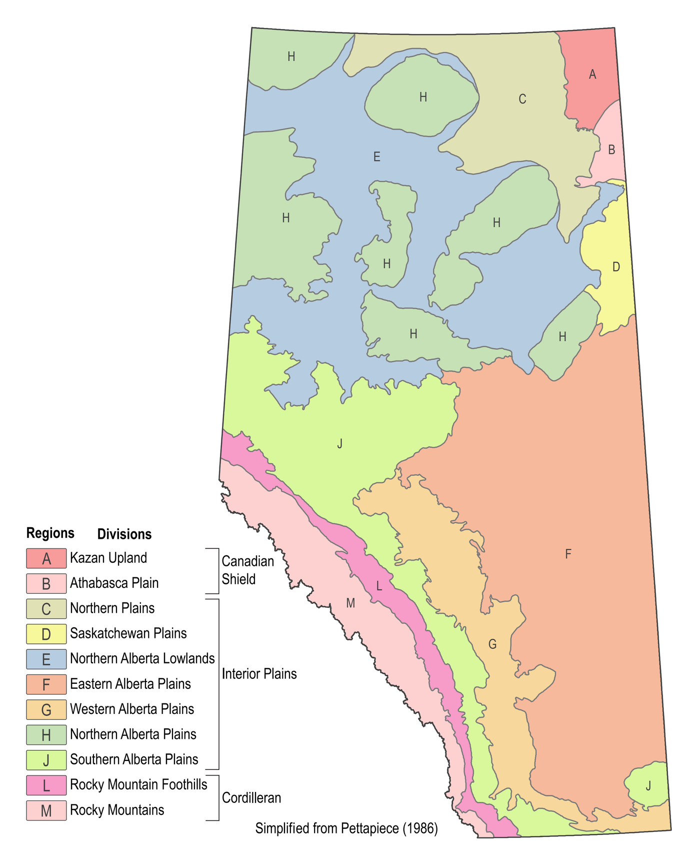


Figure 5. Physiographic Regions of Alberta

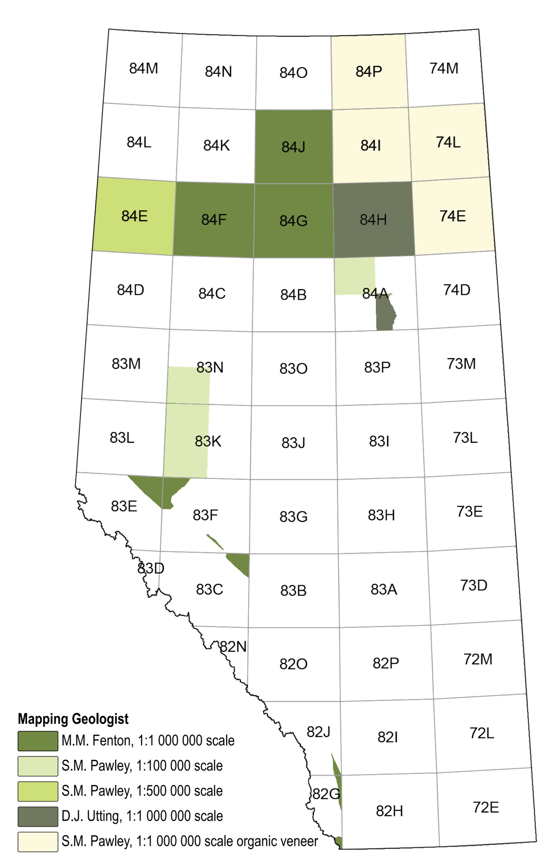


Figure 2. New AGS Mapping for this Compilation

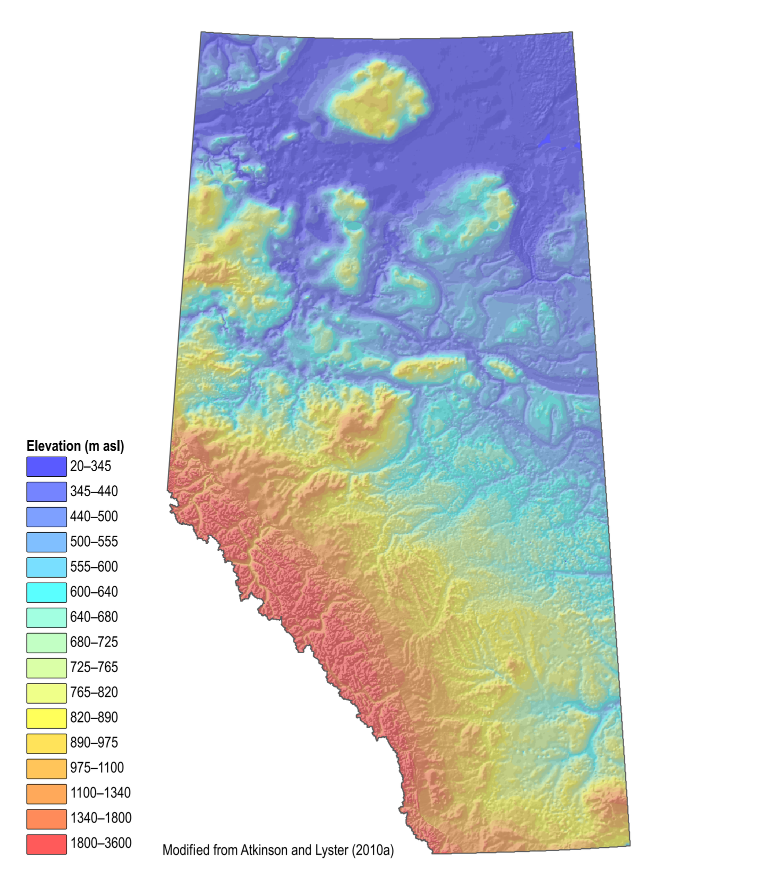


Figure 3. Bedrock Topography

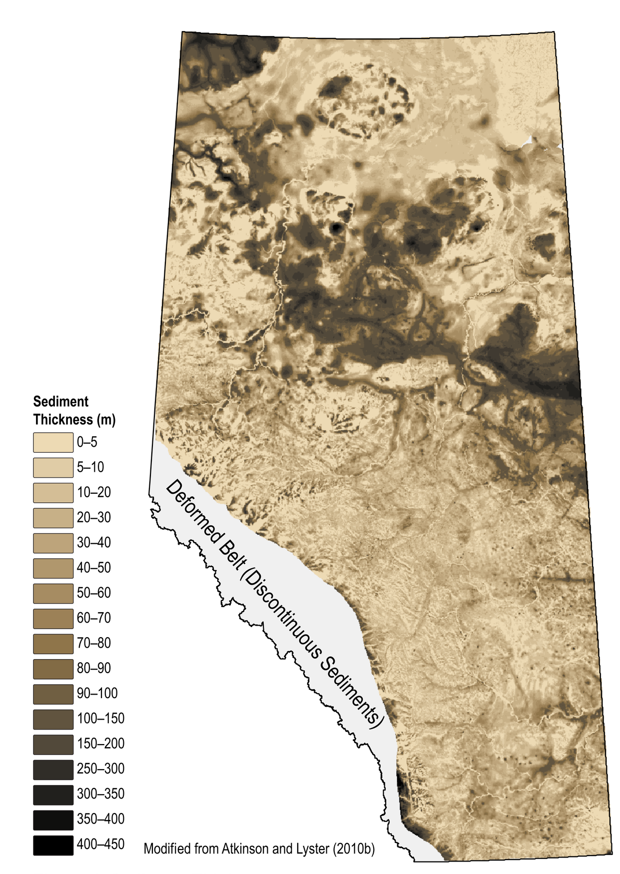


Figure 4. Sediment Thickness

References for Compiled Data Sources (See Figure 1)

1. Andriashek, L.D. (2001): Surficial geology of the Wapiti area, Alberta (NTS 83L); Alberta Energy and Utilities Board, EUB/AGS Map 239, scale 1:250 000.

2. Andriashek, L.D. (2003): Quaternary geological setting of the Athabasca Oil Sands (in situ) Area, northeast Alberta; Alberta Energy and Utilities Board, EUB/AGS Earth Sciences Report 2002-03, 286 p.

3. Andriashek, L.D., Fenton, M.M. and Root, J.D. (1979): Surficial geology Wabamun Lake, Alberta (NTS 83G); Alberta Research Council, Alberta Geological Survey, Map 149, scale 1:250 000.

4. Atkinson, N. (2008): Surficial geology of the High Prairie area (NTS 83N/SE); Energy Resources Conservation Board, ERCB/AGS Map 421, scale 1:100 000.

5. Atkinson, N. (2011): Surficial geology of the Faust area (NTS 83O/SW); Energy Resources Conservation Board, ERCB/AGS Map 554, scale 1:100 000.

6. Atkinson, N. (2012): Surficial geology of the Ray Lake area (NTS 84D/NW); Energy Resources Conservation Board, ERCB/AGS Map 557, scale 1:100 000.

7. Atkinson, N. (2012): Surficial geology of the South Whitemud Lake area (NTS 84D/NE); Energy Resources Conservation Board, ERCB/AGS Map 558, scale 1:100 000.

8. Atkinson, N. and Paulen, R.C. (2009): Surficial geology of the Cleardale area (NTS 84D/SW); Energy Resources Conservation Board, ERCB/AGS Map 422, scale 1:100 000.

9. Atkinson, N. and Paulen, R.C. (2010): Surficial geology of the George Lake area (NTS 84D/SE); Energy Resources Conservation Board, ERCB/AGS Map 539, scale 1:100 000.

10. Bayrock, L.A. (1971): Surficial geology Bitumount (NTS 74E); Research Council of Alberta, Alberta Geological Survey, Map 140, scale 1:250 000.

11. Bayrock, L.A. (1972): Surficial geology Fort Chipewyan (NTS 74L); Research Council of Alberta, Alberta Geological Survey, Map 141, scale 1:250 000.

12. Bayrock, L.A. (1972): Surficial geology of the Lake Claire area, Alberta (NTS 84I); Research Council of Alberta, Alberta Geological Survey, Map 144, scale 1:250 000.

13. Bayrock, L.A. (1972): Surficial geology Peace Point and Fitzgerald, west of 111 20' (NTS 84P, 74M); Research Council of Alberta, Alberta Geological Survey, Map 145, scale 1:250 000.

14. Bayrock, L.A. and Reimchen, T.H.F. (1974): Surficial geology Waterways (NTS 74D); Research Council of Alberta, Alberta Geological Survey, Map 148, scale 1:250 000.

15. Bayrock, L.A. and Reimchen, T.H.F. (1980): Surficial geology Alberta Foothills and Rocky Mountains; Alberta Research Council, Alberta Geological Survey, Map 150, scale 1:250 000.

16. Bednarski, J.M. (1999): Surficial geology, Baril Lake, Alberta; Geological Survey of Canada, "A" Series Map 1941A, scale 1:100 000.

17. Bednarski, J.M. (1999): Surficial geology, Barrow Lake, Alberta; Geological Survey of Canada, "A" Series Map 1939A, scale 1:100 000.

18. Bednarski, J.M. (1999): Surficial geology, Dog River, Alberta; Geological Survey of Canada, "A" Series Map 1937A, scale 1:100 000.

19. Bednarski, J.M. (1999): Surficial geology, Florence Lake, Alberta; Geological Survey of Canada, "A" Series Map 1940A, scale 1:100 000.

20. Bednarski, J.M. (1999): Surficial geology, Potts Lake, Alberta; Geological Survey of Canada, "A" Series Map 1938A, scale 1:100 000.

21. Boydell, A.N., Bayrock, L.A. and Reimchen, T.H.F. (1974): Surficial geology Rocky Mountain House (NTS 83B); Research Council of Alberta, Alberta Geological Survey, Map 146, scale 1:250 000.

22. Campbell, J.E., Fenton, M.M. and Pawlowicz, J.G. (2002): Surficial geology of the Pelican area, Alberta (NTS 83P); Alberta Energy and Utilities Board, EUB/AGS Map 251, scale 1:250 000.

23. Fenton, M.M. (2008): Surficial geology of the McLennan area (NTS 83N/NE); Energy Resources Conservation Board, ERCB/AGS Map 418, scale 1:100 000.

24. Fenton, M.M. and Andriashek, L.D. (1983): Surficial geology of the Sand River area, Alberta (NTS 73L); Alberta Research Council, Alberta Geological Survey, Map 178, scale 1:250 000.

25. Fox, J.C., Richardson, R.J.H., Gowan, R. and Sham, P.C. (1987): Surficial geology of the Peace River-High Level area, Alberta; Alberta Research Council, Alberta Geological Survey, Map 205, scale 1:500 000.

26. Harrison, J.E. (1976): Quaternary geology, Waterton Lakes National Park, Alberta; Geological Survey of Canada, "A" Series Map 1422A, scale 1:50 000.

27. Holland, W.D. and Coen, G.M., ed. (1982): Ecological (biophysical) land classification of Banff and Jasper national parks; Environment Canada, Alberta Institute of Pedology, map supplement, 24 maps.

28. Jackson, L.E., Jr., Leboe, E.R., Little, E.C., Holme, P.J., Hicock, S.R., Shimamura, K. and Nelson, F.E.N. (2008): Quaternary stratigraphy and geology of the Rocky Mountain Foothills, southwestern Alberta; Geological Survey of Canada, Bulletin no. 583, 61 p.

29. Liverman, D.G.E. (1989): Surficial geology of the Grande Prairie area; Ph.D. thesis, University of Alberta, 360 p.

30. Mougeot, C. and Fenton, M.M. (2010): Surficial geology of the Whitesand River area, Alberta (NTS 84O); Energy Resources Conservation Board, ERCB/AGS Map 541, scale 1:250 000.

31. Paulen, R.C. (2004): Surficial geology of the Grimshaw area (NTS 84C/SW); Alberta Energy and Utilities Board, EUB/AGS Map 291, scale 1:100 000.

32. Paulen, R.C. (2004): Surficial geology of the Manning area (NTS 84C/NW); Alberta Energy and Utilities Board, EUB/AGS Map 292, scale 1:100 000.

33. Paulen, R.C. (2004): Surficial geology of the Utikuma area (NTS 83O/NW); Alberta Energy and Utilities Board, EUB/AGS Map 312, scale 1:100 000.

34. Paulen, R.C. (2004): Surficial geology of the Willow River area (NTS 83O/NE); Alberta Energy and Utilities Board, EUB/AGS Map 313, scale 1:100 000.

35. Paulen, R.C. and Plouffe, A. (2007): Surficial geology of the Bushe River - Ponton River area (NTS 84K/NE); Alberta Energy and Utilities Board, EUB/AGS Map 413, scale 1:100 000.

36. Paulen, R.C. and Plouffe, A. (2007): Surficial geology of the La Crete area (NTS 84K/SE); Alberta Energy and Utilities Board, EUB/AGS Map 412, scale 1:100 000 (also Geological Survey of Canada Open File 5526).

37. Paulen, R.C. and Plouffe, A. (2008): Surficial geology of the Slavey Creek area (NTS 84N/SW); Energy Resources Conservation Board, ERCB/AGS Map 419, scale 1:100 000 (also Geological Survey of Canada Open File 5832).

38. Paulen, R.C. and Plouffe, A. (2009): Surficial geology of the Cameron Hills area (NTS 84N/NW), Alberta; Energy Resources Conservation Board, ERCB/AGS Map 420, scale 1:100 000 (also Geological Survey of Canada Open File 6104).

39. Paulen, R.C., Fenton, M.M. and Pawlowicz, J.G. (2004): Surficial geology of the Southwest Buffalo Head Hills area (NTS 84C/NE); Alberta Energy and Utilities Board, EUB/AGS Map 289, scale 1:100 000.

40. Paulen, R.C., Pawlowicz, J.G. and Fenton, M.M. (2004): Surficial geology of the Cadotte Lake area (NTS 84C/SE); Alberta Energy and Utilities Board, EUB/AGS Map 290, scale 1:100 000.

41. Paulen, R.C., Fenton, M.M., Pawlowicz, J.G., Smith, I.R. and Plouffe, A. (2005): Surficial geology of the Little Hay River area (NTS 84L/NW); Alberta Energy and Utilities Board, EUB/AGS Map 315, scale 1:100 000.

42. Paulen, R.C., Fenton, M.M., Plouffe, A., Smith, I.R. and Weiss, J.A. (2005b): Surficial geology of the Hay Lake area (NTS 84L/NE); Alberta Energy and Utilities Board, EUB/AGS Map 316, scale 1:100 000.

43. Paulen, R.C., Plouffe, A. and Smith, I.R. (2006a): Surficial geology of the Beatty Lake area (NTS 84M/NE); Alberta Energy and Utilities Board, EUB/AGS Map 360, scale 1:100 000.

44. Paulen, R.C., Fenton, M.M., Pawlowicz, J.G., Smith, I.R. and Plouffe, A. (2006): Surficial geology of the Peerless Lake area (NTS 84B); Alberta Energy and Utilities Board, EUB/AGS Map 269, scale 1:250 000.

45. Paulen, R.C., Plouffe, A., Smith, I.R., Kowalchuk, C.J. and Ward, B.C. (2006): Surficial geology of the Zama City area (NTS 84M/SE); Alberta Energy and Utilities Board, EUB/AGS Map 361, scale 1:100 000.

46. Pawley, S.M. (2011): Surficial geology of the Lesser Slave River area (NTS 83O/SE); Energy Resources Conservation Board, ERCB/AGS Map 553, scale 1:100 000.

47. Pawley, S.M. (2011): Surficial geology of the Thickwood Hills area (NTS 84A/NE); Energy Resources Conservation Board, ERCB/AGS Map 555, scale 1:100 000.

48. Pawley, S.M. (2011): Surficial geology of the Yates River area (NTS 84N/NE); Energy Resources Conservation Board, ERCB/AGS Map 552, scale 1:100 000.

49. Pawley, S.M. (2013): Surficial geology of the Wabasca area (NTS 84A/SW); Energy Resources Conservation Board, ERCB/AGS Map 561, scale 1:100 000.

50. Pawley, S.M., Mougeot, C. and Fenton, M.M. (2010): Surficial geology of the Dizzy Creek area (NTS 84N/SE); Energy Resources Conservation Board, ERCB/AGS Map 540, scale 1:100 000.

51. Plouffe, A. and Paulen, R.C. (2007): Surficial geology, Caribou Creek, Alberta; Geological Survey of Canada, Open File 5460, scale 1:100 000 (also Alberta Energy and Utilities Board, EUB/AGS Map 415).

52. Plouffe, A., Smith, I.R., Paulen, R.C., Fenton, M.M. and Pawlowicz, J.G. (2004): Surficial geology, Bassett Lake, Alberta; Geological Survey of Canada, Open File 4637, scale 1:100 000.

53. Plouffe, A., Paulen, R.C. and Smith, I.R. (2006): Surficial geology, Tinahtea Creek, Alberta; Geological Survey of Canada, Open File 5070, scale 1:100 000 (also Alberta Energy and Utilities Board, EUB/AGS Map 396).

54. Plouffe, A., Kowalchuk, C.J. and Paulen, R.C. (2007): Surficial geology, Meander River, Alberta; Geological Survey of Canada, Open File 5461, scale 1:100 000 (also Alberta Energy and Utilities Board, EUB/AGS Map 414).

55. Richard, S.H. (1986): Surficial geology, Amisk Lake, West of Fourth Meridian, Alberta; Geological Survey of Canada, Preliminary Map 7-1985, scale 1:100 000.

56. Richard, S.H. (1987): Surficial geology, Cross Lake, West of Fourth Meridian, Alberta; Geological Survey of Canada, Preliminary Map 9-1986, scale 1:100 000.

57. Roed, M.A. (1970): Surficial geology Edson (NTS 83F); Research Council of Alberta, Alberta Geological Survey, Map 139, scale 1:250 000.

58. Shetsen, I. (1987): Quaternary geology, southern Alberta; Alberta Research Council, Alberta Geological Survey, Map 207, scale 1:500 000.

59. Shetsen, I. (1990): Quaternary geology, central Alberta; Alberta Research Council, Alberta Geological Survey, Map 213, scale 1:500 000.

60. Shipman, T.C., Atkinson, N. and Pawley, S.M. (2011): Surficial geology of the Falher area (NTS 83N/NW); Energy Resources Conservation Board, ERCB/AGS Map 556, scale 1:100 000.

61. Smith, I.R., Paulen, R.C. and Plouffe, A. (2007): Surficial geology, Mega River, Alberta; Geological Survey of Canada, Open File 5237, scale 1:100 000 (also Alberta Energy and Utilities Board, EUB/AGS Map 396).

62. Smith, I.R., Plouffe, A., Paulen, R.C., Fenton, M.M. and Pawlowicz, J.G. (2005): Surficial geology, Hay River, Alberta; Geological Survey of Canada, Open File 4754, scale 1:100 000.

63. St-Onge, D.A. (1975): Surficial geology, West of Fifth Meridian, Whitecourt, Alberta; Geological Survey of Canada, "A" Series Map 1367A, scale 1:250 000.

64. Utting, D.J. (2012): Surficial geology of the Meekwap Lake area (NTS 83K/NE); Energy Resources Conservation Board, ERCB/AGS Map 559, scale 1:100 000.

65. Utting, D.J. (2013): Surficial geology of the Fox Creek area (NTS 83K/SE); Energy Resources Conservation Board, ERCB/AGS Map 562, scale 1:100 000.

References Cited

Atkinson, N. and Lyster, S. (2010a): Bedrock topography of Alberta, Canada; Energy Resources Conservation Board, ERCB/AGS Map 550, scale 1:1 500 000.

Atkinson, N. and Lyster, S. (2010b): Thickness and distribution of Quaternary and Neogene sediment in Alberta, Canada; Energy Resources Conservation Board, ERCB/AGS Map 551, scale 1:1 500 000.

Barker, A.A., Riddell, J.T.F., Slattery, S.R., Andriashek, L.D., Moktan, H., Wallace, S., Lyster, S., Jean, G., Huff, G.F., Stewart, S.A. and Lemay, T.G. (2011): Edmonton–Calgary Corridor groundwater atlas; Energy Resources Conservation Board, ERCB/AGS Information Series 140, 90 p.

Downing, D.J. and Pettapiece, W.W., comp. (2006): Natural regions and subregions of Alberta; Natural Regions Committee, Government of Alberta, Pub. No. T/852, 254 p.

Dyke, A.S., Andrews, J.T., Clark, P.U., England, J.H., Miller, G.H., Shaw, J. and Veillette, J.J. (2002): The Laurentide and Innuitian ice sheets during the Last Glacial Maximum; Quaternary Science Reviews, v. 21, no. 1–3, p. 9–31.

Dyke, A. S. (2004): An outline of North American deglaciation with emphasis on central and northern Canada; in Quaternary Glaciation - Extent and Chronology, Part II, J. Ehlers and P.L. Gibbard (ed.), Developments in Quaternary Science, v. 26, pt. b, p. 373–424.

Huot-Vézina, G., Boivin, R., Smirnoff, A. and Paradis, S.J. (2009): GeoScaler: generalization tool (with a supplementary user guide in French); Geological Survey of Canada, Open File 6231, 82 p.

Klassen, R.W. (1989): Quaternary of the southern Canadian Interior Plains; in Quaternary Geology of Canada and Greenland, R.J. Fulton (ed.), Geological Survey of Canada, Geology of Canada, no. 1, p. 138–174.

Leckie, D.A. (1989): Sedimentology and sequences of the Paddy and Cadotte members along the Peace River; Canadian Society of Petroleum Geologists, Second International Research Symposium on Clastic Tidal Deposits, Calgary, Alberta, Field Guide, 78 p.

Leckie, D.A. (2006): Tertiary fluvial gravels and evolution of the Western Canadian Prairie landscape; Sedimentary Geology, v. 190, no. 1–4, p. 139–158.

Leckie, D.A. and Cheel, R.J. (1989): Sedimentology of the Cypress Hills Formation (L. Oligocene to M. Miocene): a semi-arid braidplain deposit resulting from intrusive uplift; Canadian Journal of Earth Sciences, v. 26, p. 1918–1931.

Leckie, D.A., Bednarski, J. and Young, H. (2004): Depositional environment and tectonic setting of Miocene Wood Mountain Formation, southern Saskatchewan; Canadian Journal of Earth Sciences, v. 41, p. 1319–1328.

Mix, A.C., Bard, E., Schneider, R. (2001): Environmental Processes of the ice age: land, oceans, glaciers (EPILOG); Quaternary Science Reviews, v. 20, no. 4, p. 627–657.

Morgan, A.J., Paulen, R.C., Slattery, S.R. and Froese, C.R. (2012): Geological setting for large landslides at the town of Peace River, Alberta (NTS 84C); Energy Resources Conservation Board, ERCB/AGS Open File Report 2012-04, 33 p.

Natural Resources Canada (2009): National framework data; Natural Resources Canada, Earth Sciences Sector, 1: 1 000 000 scale, URL <http://geogratis.cgdi.gc.ca/geogratis/en/download/framework.html> [February 2013].

Natural Resources Canada (2012): CanVec digital topographic data; Natural Resources Canada, Earth Sciences Sector, URL <http://ftp2.cits.rncan.gc.ca/pub/canvec/province_fgdb/ab/canvec10_gdb_AB_HD.zip> [December 2012].

Ó Cofaigh, C., Evans, D.J.A. and Smith, I.R. (2010): Large-scale reorganization and sedimentation of terrestrial ice streams during late Wisconsinan Laurentide Ice Sheet deglaciation; Geological Society of America Bulletin, v. 122, no. 5-6, p.743–756.

Pană, D.I. and Elgr, R. (2013): Geology of the Alberta Rocky Mountains and Foothills; Energy Resources Conservation Board, ERCB/AGS Map 560, scale 1:500 000.

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

Prior, G.J., Hathway, B., Glombick, P., 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.

Scheelar, M.D. and Macyk, T.M. (1972): Reconnaissance soil survey of the Mount Watt and Fort Vermilion area; Research Council of Alberta, Report 92, 51 p.

Slimmon, W.L. and Pană, D.I. (comp.) (2010): Geology and mineral resources of the Athabasca Basin and environs, Saskatchewan and Alberta (NTS 74L, M); Saskatchewan Ministry of Energy and Resources, Geoscience Map 2010-1 (also Energy Resources Conservation Board, ERCB/AGS Map 538), scale 1:500 000.

Stalker, A. MacS. (1977): The probable extent of classical Wisconsin ice in southern and central Alberta; Canadian Journal of Earth Sciences, v. 14, no. 11, p. 2614–2619.

U.S. Geological Survey (2000): Shuttle radar topography mission digital elevation model data (3-arc second resolution); Earth Resources Observation and Science Center, URL <http://seamless.usgs.gov> [April 2004].

United States Department of the Interior (2003): National atlas of the United States; United States Department of the Interior, URL http://www.nationalatlas.gov [February 2013].

Wolfe, S.A., Huntley, D.J. and Ollerhead, J. (2004): Relict late Wisconsinan dune fields of the Northern Great Plains, Canada; Géographie Physique et Quaternaire, v. 58, no. 2-3, p. 323–336

Recommended Reference Format

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.

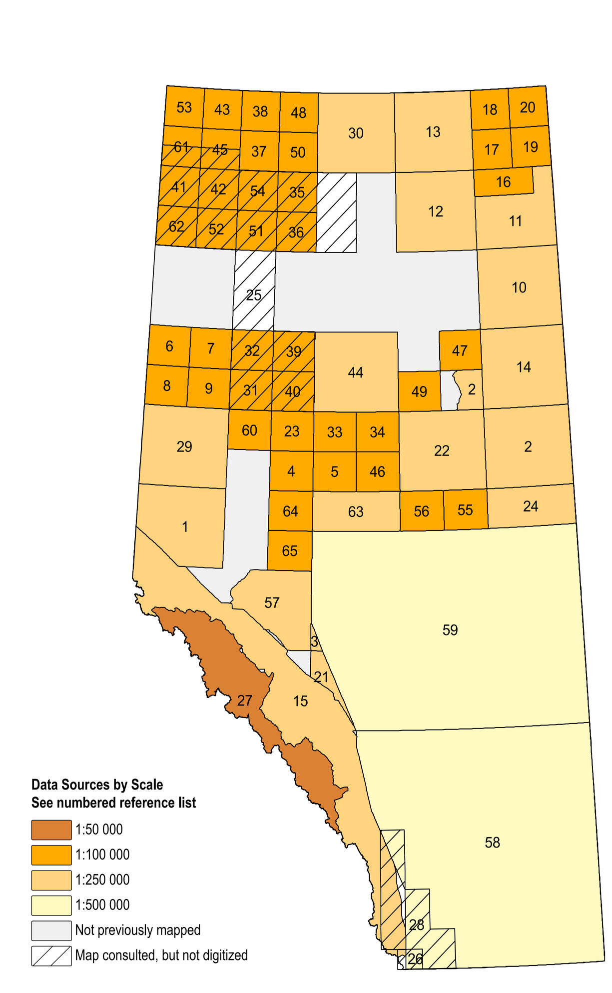


Figure 1. Location of Compiled Data Sources

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Alberta Energy Regulator

AGS ALBERTA GEOLOGICAL SURVEY