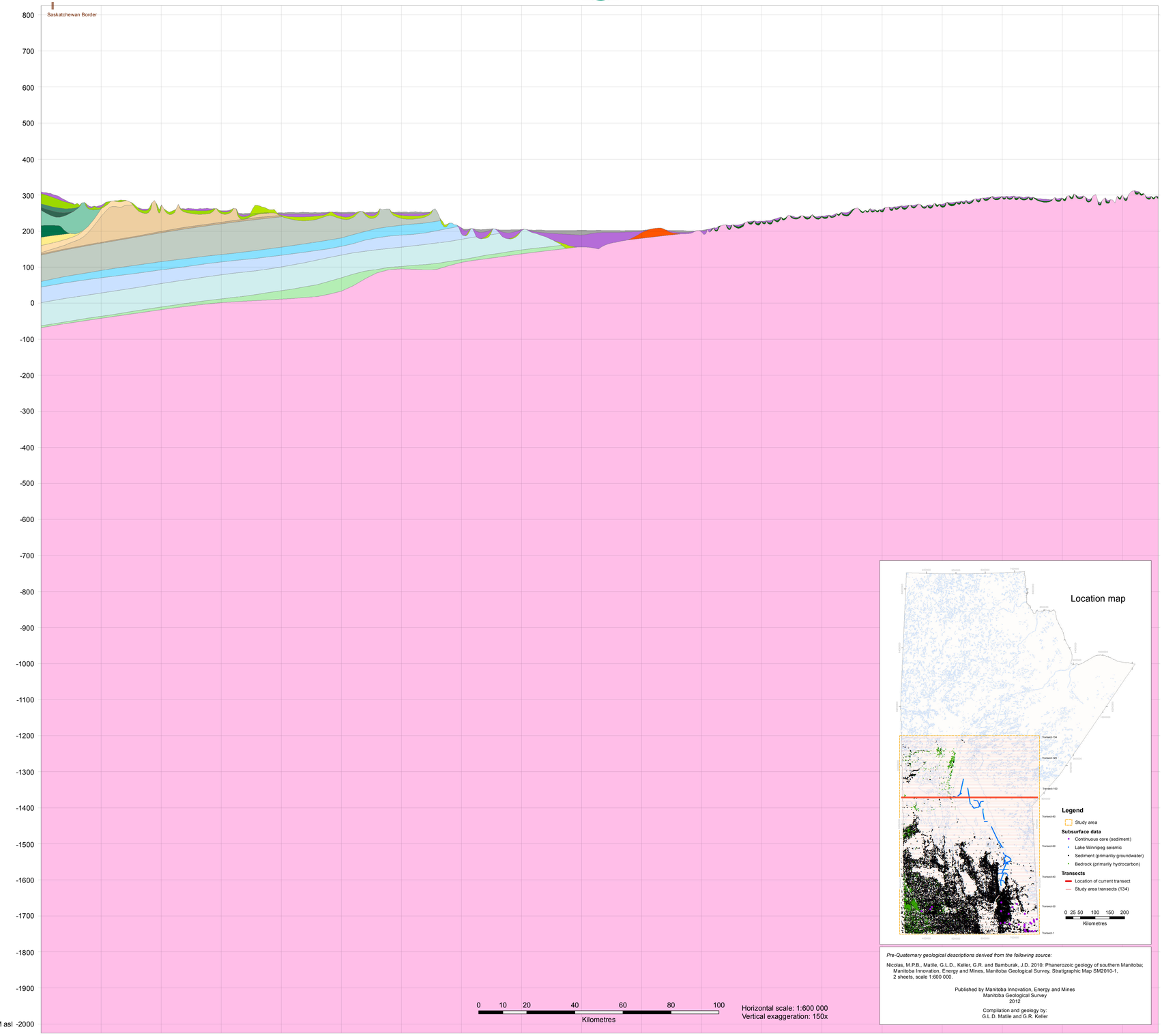
# Stratigraphic Map SM2012-1
# Transect 93







*Pre-Quaternary geological descriptions derived from the following source:*

Nicolas, M.P.B., Matile, G.L.D., Keller, G.R. and Bamburak, J.D. 2010: Phanerozoic geology of southern Manitoba; Manitoba Innovation, Energy and Mines, Manitoba Geological Survey, Stratigraphic Map SM2010-1, 2 sheets, scale 1:600 000.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SM2012-1

# Subsurface Phanerozoic geology of southern Manitoba

## Transect 93 (UTM 5890870N)

Universal Transverse Mercator
North American Datum 1983
Zone 14

## Legend

### Quaternary

**Postglacial sediment** (24 m maximum thickness):
Sand, silt, clay and organic deposits; thin deposits that poststate deglaciation; consists of alluvium of the Saskatchewan River delta near The Pas and the Assiniboine River downstream from Portage la Prairie, lake-bottom sediments and alluvial fans along the escarpment; peat is also included.

**Late Lake Agassiz sand and gravel** (29 m maximum thickness):
Fossiliferous carbonate-rich sand and gravel; berms, spits and associated littoral aprons; shoreline and nearshore deposits of Lake Agassiz formed after a major regression of the lake; most prominent is the upper Campbell shoreline; includes littoral aprons below the Assiniboine delta, the Sandilands and the Swan River valley.

**Rossendale alluvium** (79 m maximum thickness):
Sand, silt, clay and organic material; two alluvial-fill terraces along the Assiniboine, Souris and Pembina Rivers; two transgressions of Lake Agassiz caused aggradation in these valleys, one at the Norcross level and one at the lower Campbell level.

**Sherack silt and clay:**
***Calcareous silt*** (10 m maximum thickness): thin and extensive deposits at surface south and southeast of Winnipeg; deposited on the floor of Lake Agassiz from meltwater plumes from the ice margin to the north, preferentially deposited in iceberg grooves that are now positive features due to greater compaction of adjacent clay.

***Calcareous silt and clay*** (48 m maximum thickness); preferentially in regional topographic lows; late Lake Agassiz glaciolacustrine silt and clay, largely derived from the west; occurring as iceberg-ploughed deposits in the Red River Valley and Whiteshell, and varved deposits in Lake Winnipeg and northeastern Manitoba; draped over northwest-southeast till ridges in the Red River Valley; separation from the underlying Brenna clay is extrapolated from the clear stratigraphic break related to subaerial exposure in the Lake of the Woods region and the United States.

**Sky Pilot sediments:**
***Sand and gravel*** (45 m maximum thickness): radiating eskers and outwash fans.

***Silty till*** (17 m maximum thickness); streamlined deposits northeast of Lake Winnipeg; Hudson Bay Lowland–derived carbonate- and greywacke-rich sediments; a large ice stream transported calcareous till to Lake Winnipeg, and formed the Hargrave-Hudwin and additional small moraines, while annual meltwater discharges formed large glaciofluvial deposits, and thick varves in Lake Winnipeg.

**The Pas silty till** (55 m maximum thickness):
Carbonate-rich silty till; includes The Pas moraine that projects into Lake Winnipeg, and till to the northeast; the ridge is a grounding-line moraine, deposited as a till wedge at the ice-margin, with a streamlined gentle proximal slope and a steep distal slope; lack of greywacke pebbles indicates nearby provenance.

**Washow Bay sediments:**
***Sand and gravel*** (17 m maximum thickness): eskers and elongated hills.

***Mixed-provenance calcareous silty till*** (36 m maximum thickness); thin, streamlined surface till deposits in the eastern Interlake; occurs in an area of arcuate southward ice flow east of the Mantagao ridge, in a data-poor area where greater Precambrian sediment derivation is inferred.

**Arran sediments:**
***Sand and gravel*** (18 m maximum thickness): poorly developed, scattered glaciofluvial deposits near the margin, as well as the noteworthy interlobate Mantagao ridge.

***Carbonate-rich silty till*** (172 m maximum thickness): thin, lineated surface till of the Interlake; orientation strongly radiating; Harvey Lake, Petfura, Teulon and Pearson Reef moraines at the margin; deformation sediment transport by a low-profile ice mass that deposited till much more calcareous than deposits to the west up to a clear elevation limit on the escarpment; surface is ploughed by icebergs, producing a soft diamict; made contact with the Assiniboine delta.

**Upper Brenna clay** (33 m maximum thickness):
Calcareous silty clay; middle portion of Red River valley-bottom silt and clay; fine-grained sediments that were deposited in Lake Agassiz near the upper limit of the lake, and thus predate the Moorhead low-water phase, and that overlie Assiniboine delta sediments.

**Assiniboine delta sand** (123 m maximum thickness):
Shale-rich sand with gravel at the apex and silt to the east; fan emanating eastward from the Assiniboine spillway mouth, from Brandon to Austin, where sediments of the fan were reworked as an upper Campbell–level littoral apron to Portage la Prairie, as well as spillway-floor sediments; sand commonly reworked by wind as dunes; at least two large floods, one from the Qu'Appelle River and one from the upper Assiniboine River, cut the outer and inner Assiniboine spillway; the spillway has attributes indicating a subglacial initiation, although it meets the delta at the Herman level of Lake Agassiz, a subaerial feature; underflow currents carried sediments offshore in Lake Agassiz, although the fan was built up to lake level; waning-flow clay and silt over sand floor of the spillway.

**Lower Brenna clay** (60 m maximum thickness):
Calcareous silty clay; lower portion of Red River Valley silt and clay; fine-grained sediments of Lake Agassiz throughout the Red River Valley that predate Assiniboine delta sediments; thickest deposits underlie the Assiniboine delta; northern limit is the Teulon moraine.

**Birds Hill sediments:**
***Carbonate-rich silty till*** (34 m maximum thickness): thin, lineated surface till similar to the Arran, occurring north and west of the moraines, as well as above and below the ice-marginal sand and gravel deposits.

***Sand and gravel*** (71 m maximum thickness): large ice-marginal outwash fans of Birds Hill and Bélair moraines and extensions thereof; carbonate-rich at Birds Hill, and Precambrian-rich at Bélair, which was down-ice of subcropping Precambrian rock in Lake Winnipeg; construction of the Birds Hill–Bélair ice-marginal deposits is attributed to large meltwater-discharge events. Outwash deposits are stratigraphically above the associated till.

**Pembina spillway sediments** (112 m maximum thickness):
Sand, silt, clay; spillway-floor deposits; a large flood cut the Pembina spillway and deposited a delta in North Dakota; waning-flow sediments were deposited on the spillway floor.

**Early Lake Agassiz sand and gravel** (9 m maximum thickness):
Carbonate-rich sand and gravel; poorly developed shoreline berms; shoreline deposits of Lake Agassiz formed before the Moorhead Phase major regression of the lake; as Lake Agassiz occupied the Red River Valley during deglaciation, shorelines predating and associated with the Assiniboine delta were deposited on the Sandilands and the Manitoba Escarpment south of Riding Mountain.

**Lake Souris sediments:**
***Sand*** (30 m maximum thickness): shale-rich; extensive surface sandy deposits.

***Clay*** (55 m maximum thickness): extensive silty clay deposits, commonly underlying sand; sand over clay glaciolacustrine sequence of glacial Lake Souris, southwest of Brandon, and other proglacial lakes above the Manitoba Escarpment; sand commonly reworked by wind as dunes.

**Darlingford sediments:**
***Carbonate-rich silty till*** (89 m maximum thickness): in the west, includes the Brandon Hills, Darlingford moraine, Tiger Hills; in the east, includes till that drapes the Sandilands; also includes till to the north; in the west, a glacial readvance reached Brandon, transported calcareous till and built moraines largely by glacial thrusting of shale; in the east, large meltwater discharges were a major factor in sedimentation.

***Sand and gravel*** (71 m maximum thickness): scattered very large and complex ice-contact glaciofluvial and outwash deposits/subaerial above the escarpment, subaqueous below the escarpment; includes the Winkler aquifer. Outwash deposits are stratigraphically above the associated till.

**Whitemouth Lake clayey till** (39 m maximum thickness):
Carbonate-rich, very clayey diamict; a subsurface deposit intersected in drillholes in the Whitemouth Lake area; attributed to glacial reworking of glaciolacustrine sediment.

**Roseau sediments:**
***Carbonate-rich silty till*** (34 m maximum thickness): till that occurs throughout southeastern Manitoba and underlies the Sandilands.
Till of this unit is attributed to glacial action that occurred while the ice margin was well to the south in the United States, large glaciofluvial deposits, such as the Sandilands, were deposited in an interlobate position during retreat of the ice margin into Manitoba, as shield ice encroached west of the calcareous-sediment limit.

***Sand and gravel*** (96 m maximum thickness): very large, ice-contact glaciofluvial and outwash deposits of the Sandilands. Outwash deposits are stratigraphically above the associated till.

**Lennard sediments:**
***Sand and gravel*** (59 m maximum thickness): scattered small ice-contact glaciofluvial and outwash deposits.

***Shale-rich clayey till*** (44 m maximum thickness): till that occurs at surface throughout southwestern Manitoba, above the Escarpment; on the plains, the till is thin, streamlined and commonly resting on a striated boulder pavement; on the highs, the lateral-equivalent Zelena Formation, attributed to stagnation, is hummocky, discontinuous and relatively thick.

**Minnedosa sediments:**
***Sand and gravel*** (9 m maximum thickness): scattered small ice-contact glaciofluvial and outwash deposits.

***Shale-rich clayey till*** (58 m maximum thickness): subsurface till that occurs throughout southwestern Manitoba, above the Escarpment.
Underlie the Lennard till.

**Precambrian shield sediments:**
***Sand and gravel*** (52 m maximum thickness): scattered ice-contact glaciofluvial and outwash deposits; includes the George Island moraine and eskers on the shield.

***Precambrian-rich sandy till*** (40 m maximum thickness): discontinuous till that occurs throughout shield terrain, preferentially in lows and down-ice sides of topographic highs.
In shield terrain, topography is dominated by bedrock-surface morphology; bedrock surface is striated; these sediments occur at surface on igneous and metamorphic rocks that resisted glacial erosion and yielded little sediment, or buried in the subsurface in areas of the shield down ice from a sediment supply in Phanerozoic rocks where fine-grained till was transported onto the shield.

**Upper pre–last interglacial sediments** (79 m maximum thickness):
Shale-rich clayey till in southwestern Manitoba; fossiliferous subtill glaciolacustrine clay overlying carbonate-rich silty till in southeastern Manitoba; erosional remnants of pre-Wisconsinan tills; above the escarpment, recognized as till less calcareous than overlying tills; in southeastern Manitoba, underlies nonglacial sediments; divided from lower pre–last interglacial by significant sand and gravel deposits.

**Pre–last interglacial sand and gravel** (43 m maximum thickness):
Shale-rich sand and gravel in southwestern Manitoba; carbonate-rich sand and gravel in southeastern Manitoba; sand and gravel occurring below old subsurface till deposits; thought to be subglacial meltwater channels, perhaps preserved due to being cut into underlying till.

**Lower pre–last interglacial till** (164 m maximum thickness):
Shale-rich clayey till in southwestern Manitoba; carbonate-rich silty till in southeastern Manitoba; thick erosional remnants of pre-Wisconsinan tills; divided from upper pre–last interglacial by significant sand and gravel deposits; in data-poor areas, where regional trends and isolated drill holes indicate that anomalously thick sediments are present, commonly in bedrock lows, pre-Wisconsinan sediments are inferred to make up the lower portion of the sequence.

**Buried valley sand and gravel** (43 m maximum thickness):
Quartzite-bearing sand and gravel; subglacial meltwater channel fills cut into bedrock; these channel fills comprise sediments that tend to be derived from the west and were washed from tills and preglacial gravels, such as the quartzite-bearing Souris River gravel.

### Tertiary

**Wynyard Formation** (59 m maximum thickness):
Chert and quartzite gravel, overlain by a fining-upward sequence of olive-coloured friable sand and light grey to white silt and clay.

**Turtle Mountain Formation** (186 m maximum thickness):
*Goodlands member:* bentonitic carbonaceous sand, silt and clay; thin lignite beds.
*Peace Garden Member:* grey silty shale and minor sand.

### Cretaceous

**Boissevain Formation** (51 m maximum thickness):
Greenish-grey sandstone; minor shale, in part kaolinitic.

**Pierre Formation, Coulter Member** (47 m maximum thickness):
Soft grey, bentonitic, clayey siltstone and shale.

**Pierre Formation, Odanah Member** (341 m maximum thickness):
Hard grey siliceous shale.

**Pierre Formation, Millwood Member** (175 m maximum thickness):
Soft greenish bentonitic shale.

**Pierre Formation, Pembina Member** (39 m maximum thickness):
Thinly interbedded carbonaceous shale, bentonite and bentonitic shale.

**Pierre Formation, Gammon Ferruginous Member** (73 m maximum thickness):
Dark grey to brown mudstone or silty shale.

**Carlile Formation, Boyne Member** (formerly Niobrara Formation; 69 m maximum thickness):
Grey calcareous speckled shale, carbonaceous shale and brown siltstone.

**Carlile Formation, Morden Member** (formerly Morden Formation; 66 m maximum thickness):
Black carbonaceous shale.

**Favel Formation** (Second Specks equivalent; 50 m maximum thickness):
Calcareous speckled shale, minor limestone, calcarenite, bentonite and oil shale; includes the Assiniboine Member and Keld Member.

**Ashville Formation, Belle Fourche Member** (53 m maximum thickness):
Grey-black to black carbonaceous, organic shale with abundant fish fragments and occasional bentonite seams, including the prominent X-bentonite seam.

**Ashville Formation, Westgate Member** (43 m maximum thickness):
Dark grey noncalcareous shale, with occasional silt and fine-grained sand lenses; rare bentonite seams.

**Ashville Formation, Newcastle Member (eastern limit;** 26 m maximum thickness):
Fine-grained sand with interbeds of silt and clay.

**Ashville Formation, Skull Creek Member** (57 m maximum thickness):
Dark grey shale with occasional sandy lenses and siltstone beds.

**Swan River Formation** (145 m maximum thickness):
Sandstone, in places glauconitic; kaolinitic shale, minor lignite; channel and karst infill within Paleozoic outcrop belt; locally missing from outcrop sequence due to nondeposition.

**Success Formation, $S_2$ Member (eastern limit;** 47 m maximum thickness):
Weathered red shale with sphaerosiderite concretions and sandy beds with white kaolinitic matrix; formerly mapped as part of the Lower Melita Member of the Melita Formation.

### Jurassic–Triassic

**Waskada Formation** (**eastern limit;** 69 m maximum thickness):
Green bentonitic shale with minor beds of carbonaceous shale, red shale and calcareous cemented sandstone.

**Melita Formation** (161 m maximum thickness):
*Upper Melita Member:* greenish-grey to brownish-grey, slightly calcareous shale with thin coquina beds and dense limestone.
*Lower Melita Member:* varicoloured shale with interbeds of calcareous sandstone.

**Reston Formation** (61 m maximum thickness):
Lower beds of greenish-grey and grey shale; middle beds of dense, argillaceous, light-coloured limestone; and upper oolitic to sandy beds.

**Amaranth Formation** (105 m maximum thickness):
*Upper (Evaporite) Member:* Widespread, thick gypsum and anhydrite.
*Lower (Red Beds) Member:* Red argillaceous dolomitic siltstone and sandstone.

### Mississippian

**Charles Formation** (70 m maximum thickness):
Massive anhydrite and minor dolostone.

**Kisby Interval** (23 m maximum thickness):
Silty dolomite and calcareous sandstone.

**Mission Canyon Formation** (124 m maximum thickness):
*MC-3 Member:* Fragmental limestone, dolomitic limestone and dolostone.
*MC-2 Member:* Interbedded anhydrite and shaly carbonate rocks with a dense to earthy argillaceous dolostone marker bed.
*MC-1 Member:* Crinoidal fragmental and oolitic limestone and dolostone; cherty.

**Lodgepole Formation** (223 m maximum thickness):
Shelf to slope sequence of argillaceous, oolitic, crinoidal and cherty limestone.

**Bakken Formation** (35 m maximum thickness):
*Upper Member:* massive black organic shale.
*Middle Member:* grey mottled to laminated siltstone and sandstone; Devonian–Mississippian boundary at base of this unit.
*Lower Member* (locally preserved): massive black organic shale.

### Devonian

**Torquay Formation** (58 m maximum thickness):
Interbedded grey-green dolomitic shale and light brown dolomitic arenitic siltstone; finely bedded to laminated; brecciated; often oxidized to earthy red-brown.

**Birdbear Formation** (73 m maximum thickness):
Fossiliferous porous limestone and dolostone, capped by anhydrite.

**Duperow Formation** (213 m maximum thickness):
Limestone and dolostone with occasional argillaceous and anhydritic units.

**Souris River Formation** (153 m maximum thickness):
Sequence of: basal red shale (First Red Beds); argillaceous micrite, high-Ca micritic limestone and upper dolomite in northern area; complex facies of limestone and dolomite to the south.

**Dawson Bay Formation** (120 m maximum thickness):
Sequence of: basal red shale (Second Red Bed); bituminous dolomite grading upward to micritic limestone to brachiopod biomicrite (high-Ca); red to grey fossiliferous calcareous shale; highly fossiliferous coral stromatoporoid limestone (high-Ca), locally dolomitized.

**Prairie Evaporite** (149 m maximum thickness):
Thick halite beds with occasional potash beds near the top; minor interbeds of anhydrite and shale; basal transition beds are the only remnants in places where salt is completely dissolved.

**Winnipegosis Formation** (119 m maximum thickness):
*Lower Member:* dolomitized platform facies; in part shows lighter yellowish dolomitic mottling; pure high-Ca limestone to calcareous dolomite; includes the Elm Point Formation (limestone, pale yellowish brown dense fine grained biomicrite), which grades laterally to the Winnipegosis Formation.
*Upper Member:* thin inter-reef bituminous laminates or thick reefal carbonate rocks.

**Ashern Formation** (51 m maximum thickness):
Dolomitic shale and argillaceous dolomite, red to greenish-grey; local basal breccia.

### Silurian

**Interlake Group** (150 m maximum thickness):
Micritic, fossiliferous, stromatolitic and biostromal dolomite with several sandy argillaceous marker beds; includes the Fisher Branch Formation, Moose Lake Formation, Atikameg Formation, East-Arm Formation and Cedar Lake Formation.

**Stonewall Formation** (59 m maximum thickness):
Dolomite, fine-grained, sparsely fossiliferous, in part conglomeratic; medial sandy argillaceous marker (t-marker) may define Ordovician–Silurian boundary.

### Ordovician

**Stony Mountain Formation** (60 m maximum thickness):
*Gunn and Penitentiary members:* calcareous shale, fossiliferous limestone and argillaceous dolomite.
*Gunton and William members:* nodular dolomite and sandy argillaceous dolomite.

**Red River Formation** (234 m maximum thickness):
*Upper Member:* massive to laminated dolomite, minor argillaceous dolomite and high-Ca limestone; in part cherty; thin anhydrite beds; includes the *Fort Garry Member* and Unit C in outcrop, and Coronach Unit and Lake Alma Unit in the subsurface.
*Lower Member:* mottled dolomitic limestone that passes northward to dolomite (*Dog Head Member* in outcrop); cherty dolomite that passes southward to mottled limestone (*Cat Head Member* in outcrop); mottled dolomitic limestone and limestone that passes northward to dolomite (*Selkirk Member* in outcrop); argillaceous sandy dolostone at base (Hecla Beds).

**Winnipeg Formation** (87 m maximum thickness):
Basal sandstone overlain by complex sequence of quartzose sandstone and shale.

### Cambrian

**Deadwood Formation** (45 m maximum thickness):
Interbedded, highly glauconitic argillaceous siltstone to fine sandstone.

### Precambrian

**Igneous and metamorphic rocks:**
Basement rocks underlying Phanerozoic cover: exposed Precambrian shield; includes brecciated and remelted rocks associated with the Permian-age Lake St. Martin and High Rock Lake meteorite impact craters.

NOTE:

Maximum thicknesses have been calculated as vertical thickness (isochore) from the cross-sections

Suggested reference:
Matile, G.L.D. and Keller, G.R. 2012: Subsurface Phanerozoic geology of southern Manitoba, Transect 93 (5890870N); Manitoba Innovation, Energy and Mines, Manitoba Geological Survey, Stratigraphic Map SM2012-1, scale 1:600 000.


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