Natural Resources Canada
Ressources naturelles Canada

Groundwater Resources of the Lake Saint-Martin Area, Manitoba

Sheet 1 of 6

Surficial and Bedrock Geology

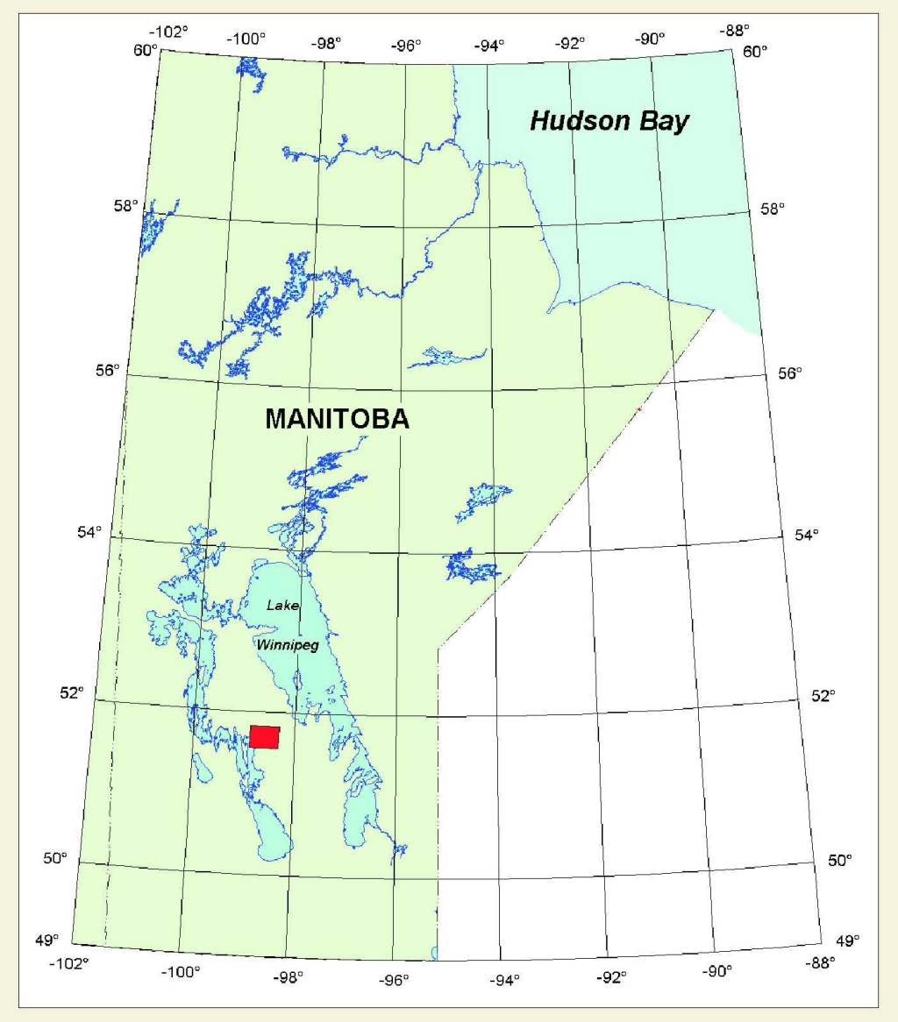


Figure 1: Location of study area

Recommended citation:

Desbarats, A.J. and Pyne, M. (2004),
Groundwater Resources of the
Lake Saint-Martin Area, Manitoba,
Geological Survey of Canada
Open File 4624, 6 sheets, Scale 1:100 000.

Available from
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario K1A 0E8

OPEN FILE
DOSSIER PUBLIC
4624
GEOLOGICAL SURVEY OF CANADA
COMMISSION GÉOLOGIQUE DU CANADA
2004
SHEET 1 OF 6
FEUILLET 1 DE 6

Map Notes

Introduction

Between 1998 and 2001, the Geological Survey of Canada conducted hydrogeological and hydrogeochemical investigations in the Gypsumville Lake Saint-Martin area of Manitoba (Figure 1). The purpose of these investigations was to assess the abundance and quality of groundwater resources. Locally, groundwater quantity and quality are closely associated with the 208 Million year old Lake Saint-Martin Impact Structure (McCabe and Bannatyne, 1970; Bannatyne and McCabe, 1984; Kohn et al., 1995). Uplift and fracturing of country rock caused by the meteorite impact and the nature of the sediments that subsequently filled the crater have resulted in a unique geological environment for the establishment of groundwater flow systems. This environment is described through the maps and cross-sections presented here.

Figure 2 shows a schematic east-west cross-section through the centre of the impact structure. This figure (after Bannatyne and McCabe, 1984; Kohn et al., 1995) provides an idealized conceptual representation of geological units within the impact structure and in the surrounding uplifted area. Figure 3 shows actual geological cross-sections based on lithological logs from wells located along three partial transects of the impact structure. Where indicated, the logs are from wells drilled under Manitoba's stratigraphic core hole program (McCabe and Bannatyne, 1970; McCabe, 1977; 1983; Bezys, 1990). Otherwise, the logs were derived from driller's logs obtained from provincial water well records. Figure 4 shows a map of bedrock geology (after Bannatyne and McCabe, 1984).The concentric pattern of geological units surrounding the impact structure may be somewhat idealized given the poor bedrock exposure over most of the study area. Figure 5 shows a simplified map of surficial geology (after Betcher, 1987). A more detailed map has been prepared by Nielsen and Matile (1984). In the following section, the main geological units are reviewed, proceeding from the oldest to the most recent. Detailed descriptions of each unit can be found in McCabe and Bannatyne (1970).

Geological Units

Precambrian : Granitic rocks of the Superior province (2600 Ma) outcrop on the eastern rim of the impact structure and in the central uplifted core (Figure 4). Structural uplift on the eastern rim is estimated at 220m. On the western rim, it is estimated at 60m (McCabe and Bannatyne, 1970) and basement rocks are expected at a depth of approximately 190m. Because of their low permeability compared to that of overlying Paleozoic units, rocks of the Precambrian basement represent barriers to groundwater flow.

Ordovician Winnipeg Formation : This unit consists mainly of unconsolidated to poorly-consolidated, medium to coarse-grained, quartzose sandstone interbedded with shale layers. Total formation thickness is estimated at 33m in the study area. Although the unit does not outcrop locally, it has been encountered at a depth of 11m in a stratigraphic core hole sited on the uplifted eastern rim of the impact structure (Figure 2). Because of its excellent permeability, this basal clastic unit forms an important aquifer in southern Manitoba, east of the Red River where groundwater salinity levels are acceptable.

Ordovician Red River Formation : Conformably overlying the Winnipeg Formation, this unit consists of a thick sequence of mottled dolomitic limestones, cherty dolomites and dolomites with several thin argillaceous marker beds. The thickness of the formation is estimated at 95 m in the study area. The uppermost Fort Garry member is known to be a stratigraphic interval of enhanced permeability, possibly as a result of karst development (Betcher et al., 1995). Locally, the uplifted formation is believed to outcrop beneath the drift cover in a concentric belt surrounding the impact structure.

Ordovician Stony Mountain Formation : The Stony Mountain Formation overlies the previous unit conformably and has an estimated total thickness of 40m. Like the previous unit, it outcrops beneath drift in a concentric belt around the impact structure. The lowest member, known as the Gunn member or Stony Mountain Shale, is a reddish-green, fossiliferous, calcareous shale forming a distinctive marker bed. As a result of karst development or dissolution features, it represents a 16m interval of enhanced permeability. Uplifted Stony Mountain Shale has been identified at a depth of 31m in stratigraphic hole LSM-7 on the western rim of the impact structure and, more tentatively, at similar depths, in driller's logs from water wells on the southern and western rim (Figure 3). Upper members of the formation consist of fairly uniform massive yellowish dolomites with few distinguishing features.

Ordovician Stonewall Formation : Conformably overlying the previous unit, this 11m thick formation consists of grayish-yellow bedded dolomites very similar in appearance to those of the formations above and below. Because its permeability is rather low, this unit is generally regarded as an aquitard (Betcher et al., 1995).

Silurian Interlake Group : Lying conformably over the rocks below, the Interlake Group is the uppermost unit throughout most of the study area. It consists mainly of yellowish buff, dense, microcrystalline, sparsely fossiliferous dolomites with a few shaly interbeds. Because it lacks features identifiable in water well driller's logs, it is not differentiated from underlying dolomitic units in the cross-sections of Figure 3. The thickness of the Interlake group ranges between 15m and 45m in the study area. However, the upper half of the unit has been truncated by the present day erosional surface. This erosional surface may be, in fact, much older since several paleo-karst features, infilled with Cretaceous sands, shales and lignite, have been encountered in water wells on the southwestern rim of the impact structure. Because of these features and intense impact-related fracturing, this unit and those below are highly permeable in the uplifted zone surrounding the impact structure.

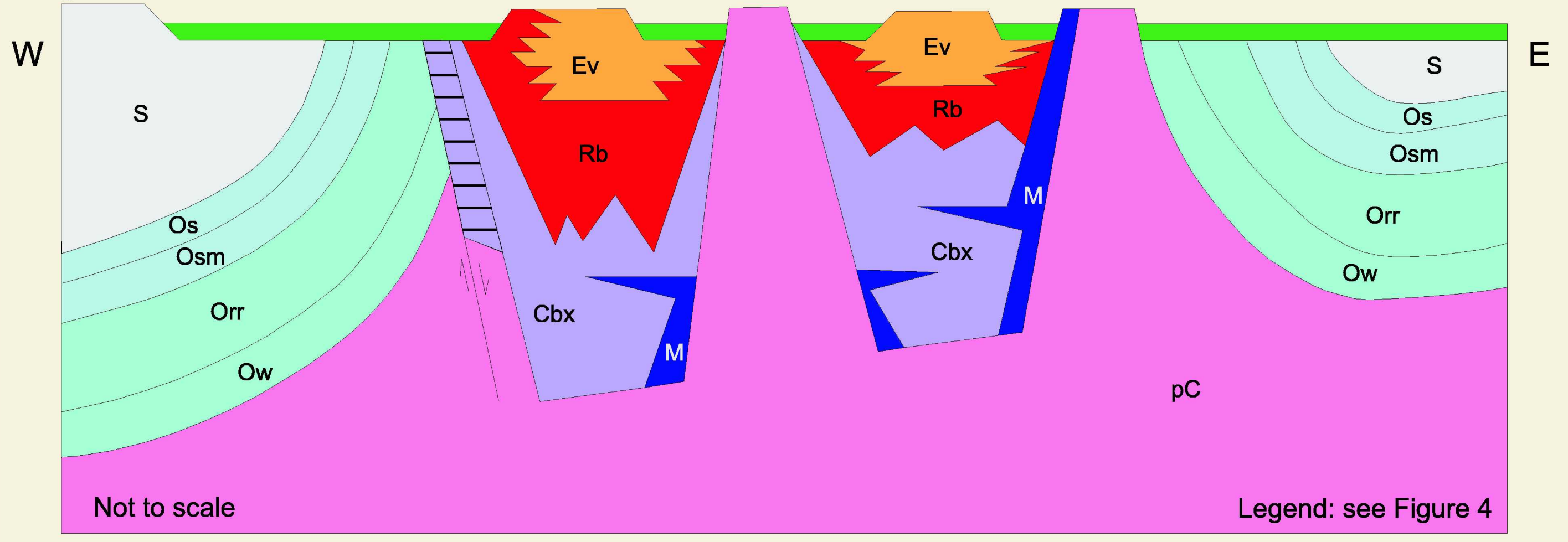
Devonian Ashern Formation : This unit overlies the Interlake group uncomformably in the westernmost part of the study area where it outcrops beneath a drift cover. It consists of a brick-red dolomitic shale with a basal rubbly zone.

Triassic Saint-Martin Complex : Recently dated at 208 Ma (Kohn et al., 1995), the Saint-Martin Complex consists of a highly heterogeneous assemblage of rock-types associated with the formation of the impact structure. Shock-metamorphosed, brecciated, granitic gneiss, intruded by a reddish glass-like rock known as pseudotachylyte, is found in the central uplifted core of the structure and near its bottom, at depths of over 300m. Fine-grained, brownish-purple, vesicular trachyandesite containing rock fragments outcrops along the eastern rim of the impact structure and is encountered in deep boreholes within the structure. Thick intervals of granitic micro-breccia, derived from basement rocks of the central uplifted core and the crater rim, are found in wells from Gypsumville eastward. Highly permeable carbonate breccias derived from the impacted Paleozoic sequence are found mainly in the south and western portions of the crater where they were preserved from erosion as a result of the westward tilt of the impact structure (Figure 2). Some of these breccias consist of large down-faulted blocks, possibly of Devonian age. Polymict breccias consisting of gneiss, carbonate and trachyandesite fragments are also found within the structure.

Jurassic Amaranth Formation : A sequence of crater-fill sediments, generally believed to be correlative with the Amaranth Formation, rests unconformably on the breccias of the Saint-Martin Complex. The elevation of the contact is quite variable (Figure 3) suggesting that it may represent a highly dissected erosional surface. The lower Red Bed member of the formation, up to 40m thick, consists of red dolomitic shales, siltstones and sandstones with a few conglomeratic beds and black organic-rich layers. These sediments appear to have been derived locally, by reworking of rocks of the Saint-Martin Complex, or by slumpimg from the crater rim. The red beds grade laterally and vertically into the upper Evaporite member. This unit consists of reddish-brown argillaceous dolomite, anhydrite and gypsum, with red shaly interbeds and minor seams of glauberite (sodium-calcium sulfate). The evaporites outcrop throughout the northern part of the impact structure and exhibit extensive karst development (McRitchie and Voitovici, 1990). Because of the rapid lateral transitions between red beds and evaporites (Figure 3), these may represent channel-fill deposits (McCabe and Bannatyne, 1970).

Quaternary deposits : Surficial deposits, reaching over 50m in thickness on the north shore of Lake Saint-Martin, cover most of the study area. These deposits consist mainly of silty, sandy tills containing gravel or boulder inter-beds. Deposits of glacio-lacustrine silt and clay are found in the low-lying agricultural lands extending north from Lake Pineimuta. Because of their low permeability, the tills and clays form an extensive confining layer over the bedrock aquifers. In upland areas surrounding the impact structure, glacio-fluvial sand and gravel deposits form a thin, discontinuous, cover on outcrops of the Interlake Group.

Figure 2: Schematic East-west Cross-section



References

Bannatyne, B.B. and H.R. McCabe (1984) : Manitoba Crater Revealed; Geos, 13(3), p. 10-13.

Betcher, R.N. (1987) : Groundwater Availability Map Series : Dauphin Lake (620); Water Resources Branch, Manitoba Natural Resources, Winnipeg, Manitoba.

Betcher, R.N, G. Grove and C. Pupp (1995) : Groundwater in Manitoba : Hydrogeology, Quality Concerns, Management, National Hydrology Research Institute, NHRI Contribution No. CS-93017.

Bezys, R.K. (1990) : GS-30 Stratigraphic Mapping (NTS 63G) and Core Hole Program 1990, In Manitoba Energy and Mines, Minerals Division, 1990, p.140-151.

Kohn, B.P., K.G. Osadetz and R.K. Bezys (1995) : Apatite fission-track dating of two crater structures in the Canadian Williston Basin, Bull. Of Canadian Petroleum Geology, 43(1) p.54-64.

McCabe, H.R. and B.B Bannatyne (1970) : Lake St. Martin Crypto-explosion crater and geology of the surrounding area, Geological Paper 3/70, 79pp., Manitoba Mines Branch, Dept. of Mines and Natural Resources, Winnipeg, Manitoba.

McCabe, H.R. (1977) : GS-18 Stratigraphic Core Hole Programme, in Manitoba Dept. of Mines, Resources and Environmental Management, Mineral Resources Division, Report of Field Activities 1977, p.93-97.

McCabe, H.R. (1983) : GS-22 Stratigraphic Mapping and Stratigraphic and Industrial Minerals Core Hole Programme, In Manitoba Dept. of Energy and Mines, Mineral Resources Division, Report of Field Activities 1983, p.122-130.

McRitchie, W.D. and P. Voitovici (1990) : GS-29 Karst Landforms in the Gypsum Lake Area; Character and Distribution, In Manitoba Energy and Mines, Minerals Division, Report of Activities 1990, p.128-139.

Nielsen, E. and G. Matile (1984) : Quaternary Geology of the Gypsumville Area, Map AR84-3, Scale 1:100000, Manitoba Energy and Mines, Winnipeg, Manitoba.

GEOLOGICAL SECTIONS

Figure 3

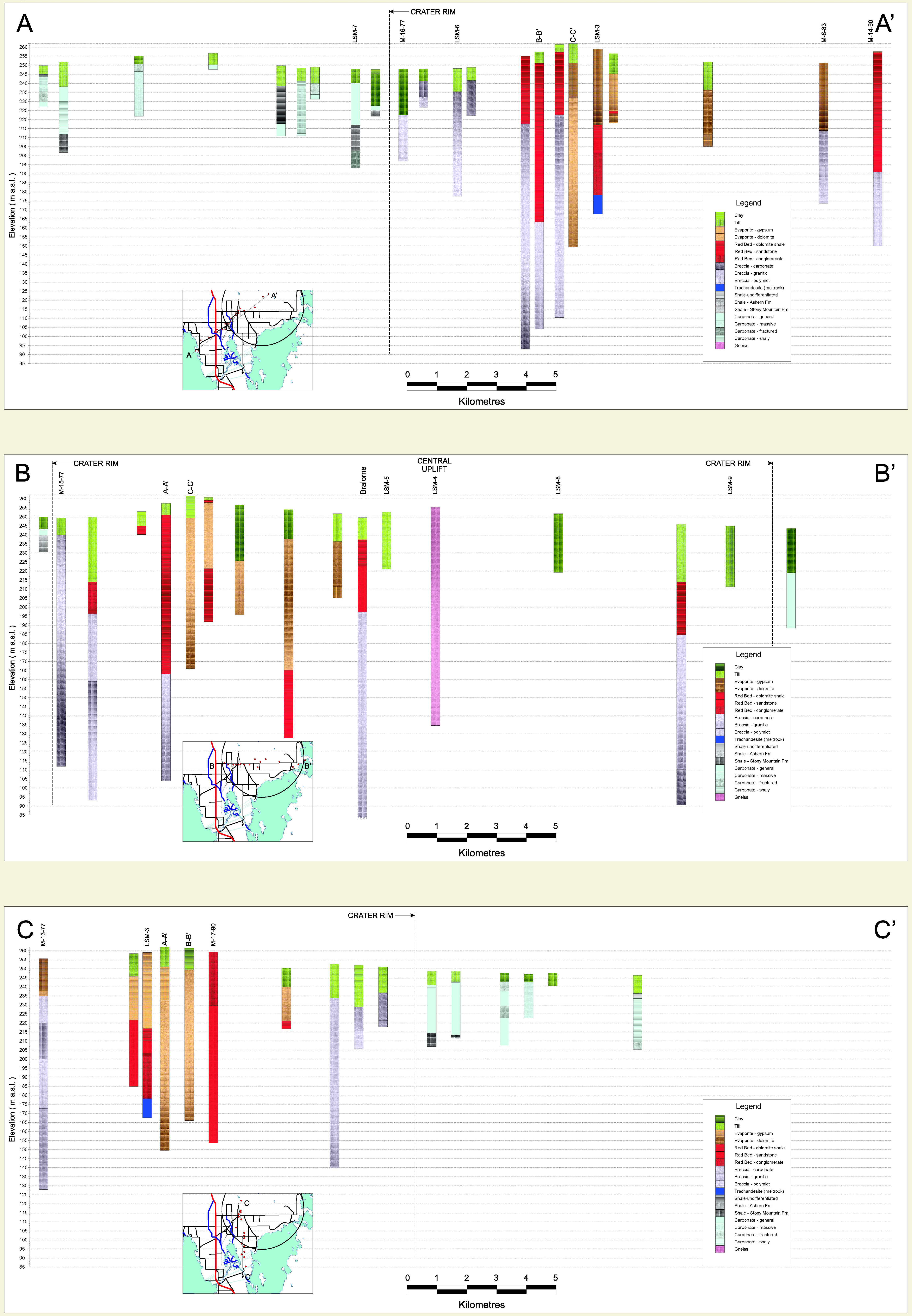


Figure 4

Bedrock Geology

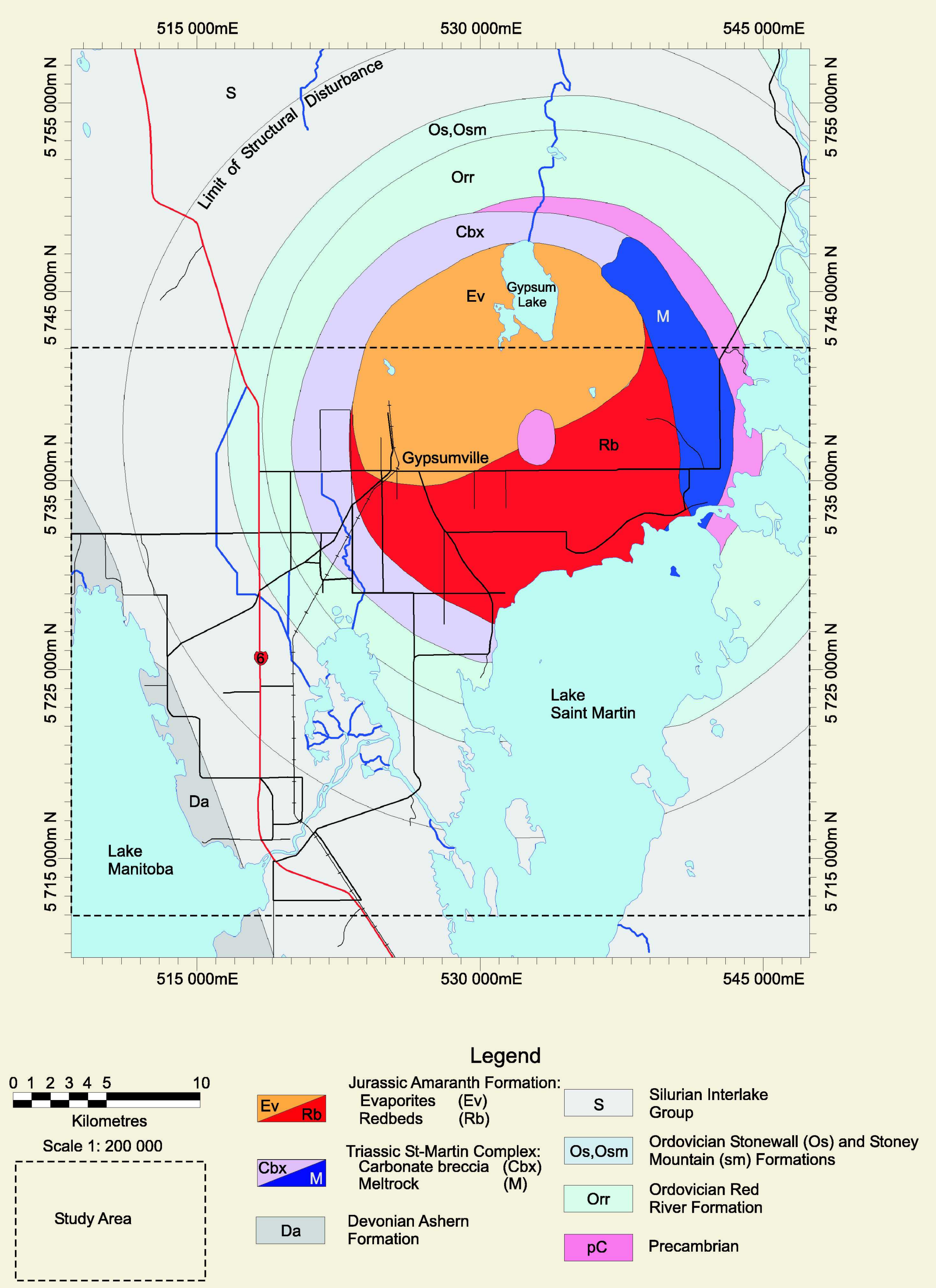


Figure 5

Surficial Geology