GS-9 Preliminary results from geological investigations into gypsum, Harcus area, southwestern Manitoba (NTS 62J10)

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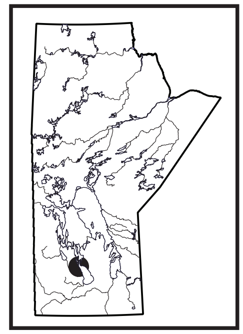

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Summary

The Upper Amaranth Member of the Amaranth Formation has been mined and quarried for over 115 years in Manitoba, and gypsum from this member continues to be an important industrial mineral to this day. The last Manitoba Geological Survey report on gypsum in Manitoba was published more than 50 years ago, with a few minor updates published more recently. This report describes the first stage of a project initiated this year that will provide a comprehensive update on the geology and history of production of gypsum in the province. This project is currently focused on the Harcus area, where gypsum is currently being quarried. Detailed lithological descriptions of a stratigraphic section in a quarry and of six drillcores were completed over the summer of 2015. The Upper Amaranth Member is composed entirely of fine-grained, white to light grey, yellow, pink or orange gypsum, with varying amounts of grey clay and dolomudstone present as beds, laminae or brecciated clasts. Manitoba Mineral Resources assessment files were used to generate isopach maps of the thickness of overburden and of the Upper Amaranth Member. They demonstrate that whereas the thickness of gypsum and overburden is highly variable in places, both generally thicken toward the southwest. Future work to be completed includes additional stratigraphic sections in the two active quarries in Harcus, creating structure and isopach maps of the Harcus area, and extending the scope of this project to encompass the Gypsumville and Silver Plains areas of Manitoba.

Introduction

Gypsum is an important industrial mineral that has been in near constant production from the Jurassic Upper Amaranth Member of the Amaranth Formation in Manitoba since 1901 (Bannatyne, 1959). Its primary end product is wallboard, but it is also used to produce concrete (Bannatyne, 1959, 1977; Gunter, 1987). Historically, there have been quarries and underground mines producing gypsum from Gypsumville, Silver Plains and Harcus (Bannatyne, 1977; Gunter, 1987); currently, the only production of gypsum comes from two quarries in the Harcus area. A wallboard plant still exists in northwest Winnipeg, which processes most of the gypsum that is quarried in the province.

In the spring of 2015, a project to provide a comprehensive update on gypsum resources in Manitoba was initiated. Previous work by Bannatyne (1959) documented the historical production of gypsum in the province and provided geological descriptions of known gypsum deposits. Later work by Bannatyne (1977) and Gunter (1987) captured additional production and geological data. Very few detailed geological investigations have been undertaken on gypsum since these reports were published. The main objectives of this project are to

- review the last 56 years of gypsum quarrying, mining, exploration and production in Manitoba;
- provide detailed description of the gypsum-bearing Upper Amaranth Member of the Amaranth Formation, and to define its contacts through structure and isopach maps; and
- compile data from Manitoba Mineral Resources assessment files to define the Upper Amaranth Member's contacts through structure and isopach maps.

Harcus is currently the only locality in Manitoba actively quarrying gypsum, and is the first area of focus for this project (Figure GS-9-1). A preliminary stratigraphic section was completed at one of the quarries, six drillcores from that area were logged and assessment files were used to create isopach maps.

Regional geology

Mesozoic strata of southwestern Manitoba were deposited within the Williston Basin, a sub-basin of the larger Western Canada Sedimentary Basin (Nicolas, 2009). The Williston Basin is centred in North Dakota, and is present in southwestern Manitoba. It is composed of a 2.3 km thick package of Phanerozoic sedimentary rocks, which dip gently toward the southwest (Nicolas, 2009).

In the Williston Basin, Mesozoic and Paleozoic strata are separated by a significant unconformity. The main cause of this large angular unconformity has been attributed to tectonic uplift and an associated regression coupled with subaerial erosion (McCabe, 1959; Bamburak and Christopher, 2004; Nicolas, 2009). During the late Paleozoic Permian period, a possible meteorite impact formed the Lake St. Martin igneous and metamorphic complex, resulting in a paleotopographic low adjacent to the northeastern edge of the Williston Basin (McCabe and Bannatyne, 1970). In the early Mesozoic, marine waters inundated the interior of North America. Erosional irregularities in the Paleozoic surface of the Williston Basin,

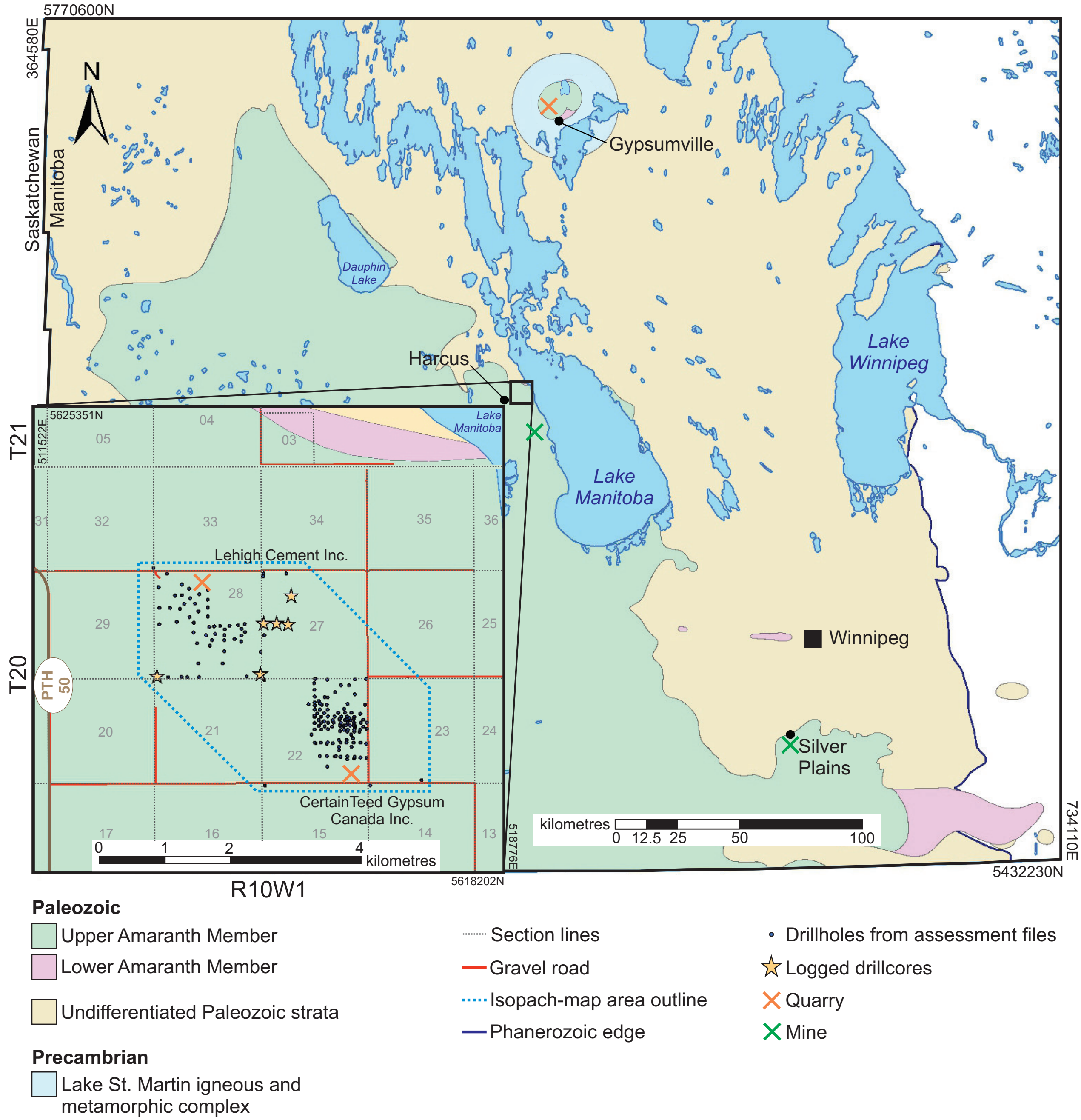

Figure GS-9-1: *Simplified geology map of southern Manitoba, with inset showing the area around Harcus. Locations of drillholes, logged drillcores and the isopach-map area are shown.*

including the Lake St. Martin igneous and metamorphic complex, were infilled during this period with the Triassic to Middle Jurassic Amaranth Formation.

The Amaranth Formation is divided into the Triassic Lower Amaranth Member and the Jurassic Upper Amaranth Member (Nicolas, 2009). The Lower Amaranth Member is primarily composed of red, argillaceous, dolomitic sandstone and siltstone. The Upper Amaranth Member is composed of gypsum and/or anhydrite (Bannatyne, 1959). The member is interpreted as being deposited in a restricted basin margin (Nicolas, 2009).

Due to the intimate association between gypsum and anhydrite, it is unknown if the Upper Amaranth Member was deposited as gypsum, anhydrite or a combination of both. Pettijohn (1957) hypothesized that the member was initially precipitated primarily as anhydrite, and that gypsum formed as a result of hydration due to circulating fluids postburial or postexhumation. It has also been proposed that the member was originally precipitated as gypsum, and only after burial was anhydrite formed (Stott, 1955). Increased pressure and temperatures would have dehydrated the gypsum, converting it into anhydrite.

Recent exhumation and groundwater circulation would have converted the upper portion of the member into gypsum.

Although the Upper Amaranth Member was deposited as a primary evaporite, diagenesis has significantly altered any original textures or structures that may have formed during deposition. The presence of alabastine and fibrous (satinspar) gypsum indicate exhumation and exposure to flowing groundwater, which has overprinted any primary or secondary textures (Warren, 2006). Furthermore, alabastine and satinspar textures would place the gypsum of the Upper Amaranth Member in the 'tertiary' evaporites scheme proposed by Warren (2006). Fine-grained, equidimensional alabastine forms in the active phreatic zone, and is often associated with karst terrain. Karst terrain is common in places where gypsum occurs at or very near the surface, such as around Harcus and Gypsumville (McRitchie and Voitovici, 1990; McRitchie and Monson, 2000). Toward the southwestern corner of Manitoba, the Upper Amaranth Member occurs as anhydrite at depths over 1000 m (Bannatyne, 1959).

Current investigations

Preliminary stratigraphic section

A preliminary stratigraphic section was completed at the CertainTeed Gypsum Canada Inc. quarry in Harcus. Due to high water levels, additional stratigraphic sections elsewhere in the quarry and in the nearby Lehigh Cement Ltd. quarry could not be completed during the summer of 2015.

The stratigraphic section (Figure GS-9-2) was completed on a north-facing wall in an upper pit within the quarry area. The wall trended roughly westward, striking 260°. The bottom of the pit was partially filled with water, and the elevation taken at this level was used as the datum for the stratigraphic section. The section was approximately 23 m wide, and in places the wall was covered by slumped material. The thickness of the section ranged from 5.3 to 4.1 m from east to west. The top of the section roughly represents the erosional top of the Upper Amaranth Member. The basal contact with the Lower Amaranth Member was not observed. The GPS co-ordinates of the section were taken at the base of the westernmost side (NAD83, UTM Zone 14, 516241E, 5619676N).

The section is composed of light greyish-white to light buff, massive, argillaceous, dolomitic, crystalline gypsum (Figure GS-9-3a). It weathers to a very light grey to white, and the surface of the gypsum appears smooth to pitted. Near the lower part of the section, the gypsum is occasionally a very light orange or pink. The gypsum is microcrystalline to coarsely (<2 mm) crystalline, and composed of equant grains, giving it a sugary texture. Three clay- and dolomudstone-rich beds occur in this section (Figure GS-9-3b). They are greenish to brownish grey. The beds dip between 2 and 6° toward the west and are all roughly parallel to each other. The beds are composed of approximately equal ratios of a) dark greenish-grey, variably calcareous clay, b) light buff, variably calcareous dolomudstone and c) gypsum. In places, the

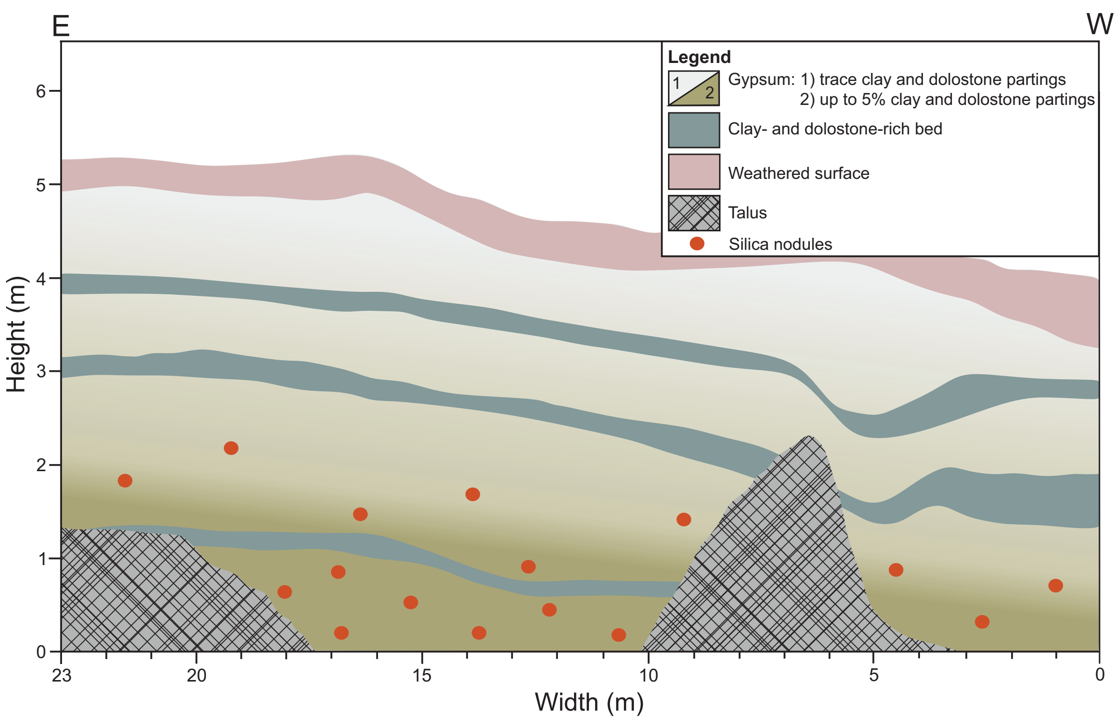

Figure GS-9-2: Simplified stratigraphic section from the north-facing wall of the upper pit of the CertainTeed Gypsum Canada Inc. quarry, Harcus, southwestern Manitoba.

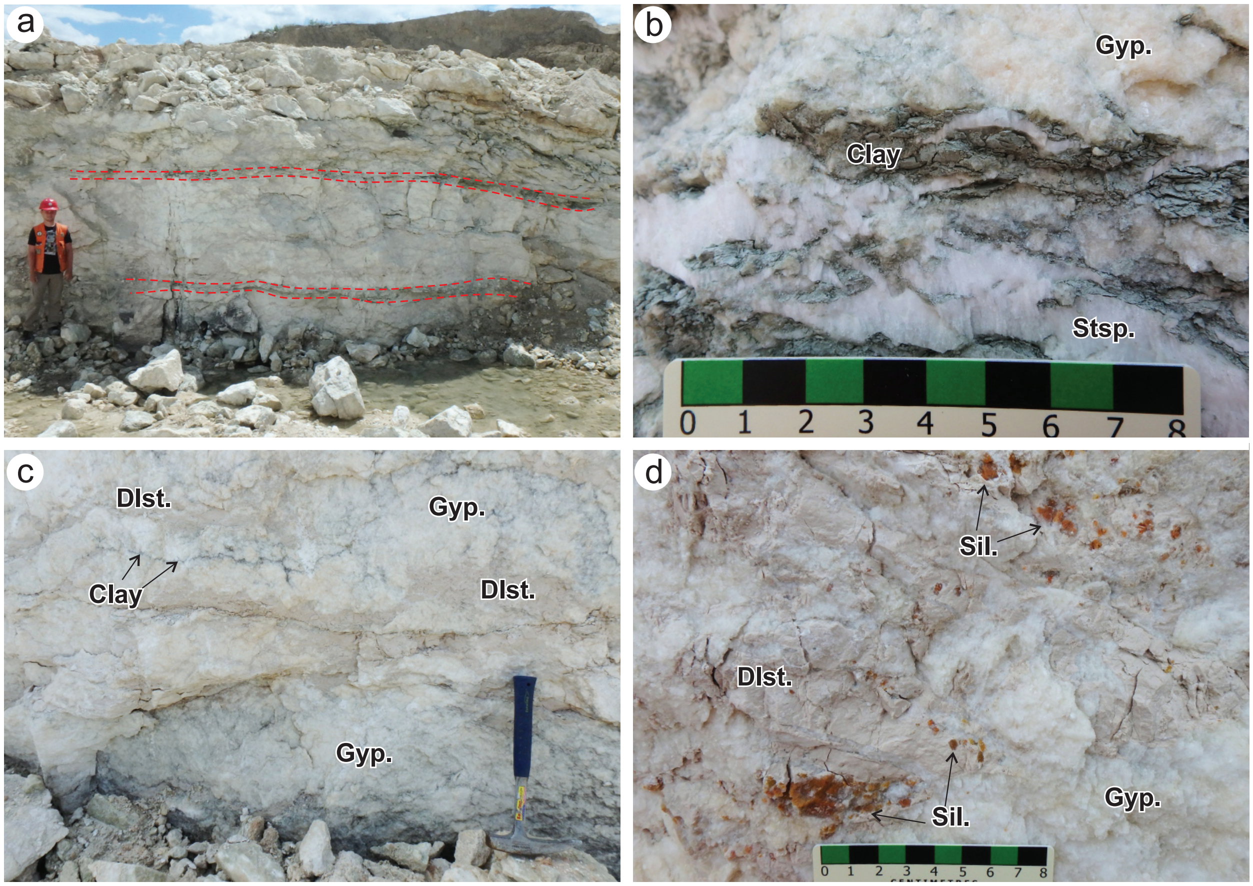

***Figure GS-9-3:** Representative photographs of the lithology and sedimentary structures from the stratigraphic section: **a)** section of the north-facing wall from approximately 16 to 11 m (see Figure GS-9-2), the two lower clay- and dolostone-rich beds are outlined in dashed red lines; **b)** upper contact of a clay- and dolomudstone-rich bed, clay appears as grey parting, with associated satinspar fracture-fill and light orange gypsum above (scale in centimetres); **c)** lower part of stratigraphic section with dolomudstone occurring as brecciated, irregular beds; **d)** orange to red silica nodules associated with light buff dolomudstone in white gypsum (scale in centimetres). Abbreviations: Dlst., dolomudstone; Gyp., gypsum; Stsp., satinspar fracture; Sil., silica nodules.*

clay and dolomudstone become disseminated and the beds can be difficult to recognize. Clay and dolomudstone are often fractured by irregular satinspar fracture-fill, and dolomudstone clasts are often brecciated by gypsum. The beds range in thickness from 15 to 48 cm. Gypsum becomes decreasingly argillaceous and dolomitic upward through the section (Figure GS-9-3c). Silica nodules occur from the base of the section up to the second clay- and dolomudstone-rich bed, decreasing in abundance upward. Silica nodules are equant, subangular, orange to red, and range in size from 0.2 to 60 mm in diameter (Figure GS-9-3d).

Drillcore logs

Lehigh Cement Ltd. conducted an exploration program in 2006 in the Harcus area, drilling a total of 20 holes. The MGS acquired eight of these cores, six of which transected the Upper Amaranth Member. These cores were logged in detail over the summer of 2015 and logs are shown in Figure GS-9-4.

The thickness of the Upper Amaranth Member ranges from 1.29 to 8.79 m (Table GS-9-1). The member is composed of argillaceous, dolomitic, white to very light grey, fine-grained gypsum (Figure GS-9-5a). Gypsum is white and opaque in the uppermost portion of the cores, and varies between light grey to very light pink, yellow and orange in places (Figure GS-9-5b). Grey, variably calcareous clay occurs as beds, laminae or infilling irregular partings (Figure GS-9-5b), and becomes less abundant upward. Light buff, variably calcareous dolomudstone occurs as beds, partings or brecciated clasts (Figure GS-9-5c), and also becomes less abundant upward. Some larger beds, up to nearly 0.5 m thick, are composed of a mixture of clay, dolomudstone and gypsum, and are frequently fractured by satinspar. In drillcores NW27-20-10-6[1] and NW28-20-10-1 there are trace amounts of silica

[1] Drillhole numbers describe the section, township, range and how many cores were drilled in that area. For example, NW27-20-10-6 would be the sixth core drilled on NW ¼, Sec. 27, Twp. 20, Rge. 10, W 1st Mer.

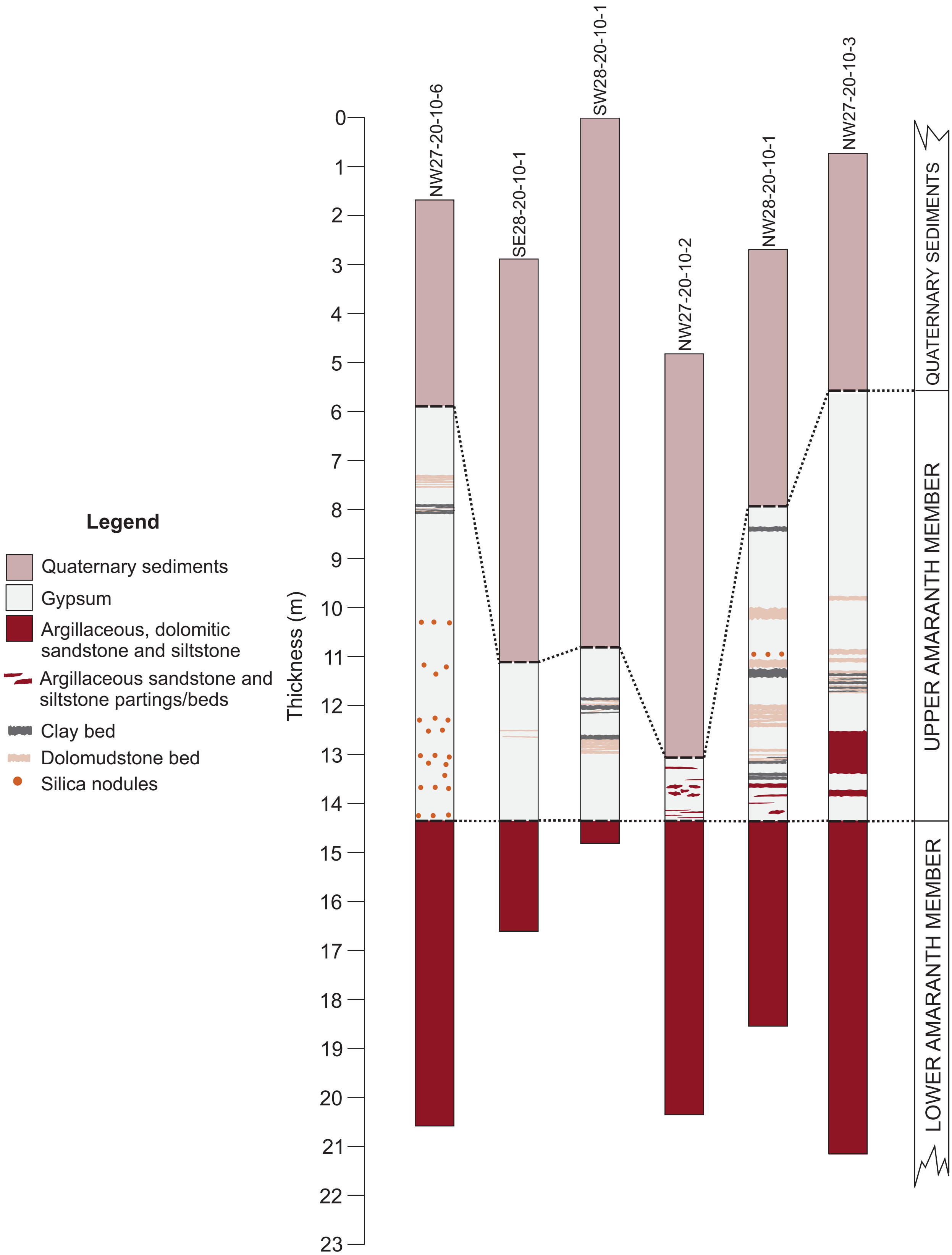

Figure GS-9-4: *Stratigraphic sections of the Upper Amaranth Member of Amaranth Formation from cores NW27-20-10-6, SE28-20-10-1, SW28-20-10-1, NW27-20-10-2, NW28-20-10-1 and NW27-20-10-3, Harcus area, southwestern Manitoba.*

Table GS-9-1: Drillhole locations, in both UTM co-ordinates and by township and range, as well as total depth of the drillhole and total thickness of the Upper Amaranth Member of the Amaranth Formation, Harcus area, southwestern Manitoba.

Drillhole no.	Twp. and rge.	Easting[1]	Northing[1]	Total drillhole depth (m)	Total thickness of Upper Amaranth Member (m)
NW27-20-10-6	12-27-20-10W1	515250	5622033	18.90	8.46
NW27-20-10-3	12-27-20-10W1	515052	5622032	20.42	8.79
NW27-20-10-2	14-27-20-10W1	515477	5622457	15.82	1.29
NW28-20-10-1	11-28-20-10W1	514127	5622017	15.85	6.43
SE28-20-10-1	01-28-20-10W1	515001	5621250	13.72	3.18
SW28-20-10-1	04-28-20-10W1	513406	5621214	14.48	3.54

[1] NAD83, Zone 14U

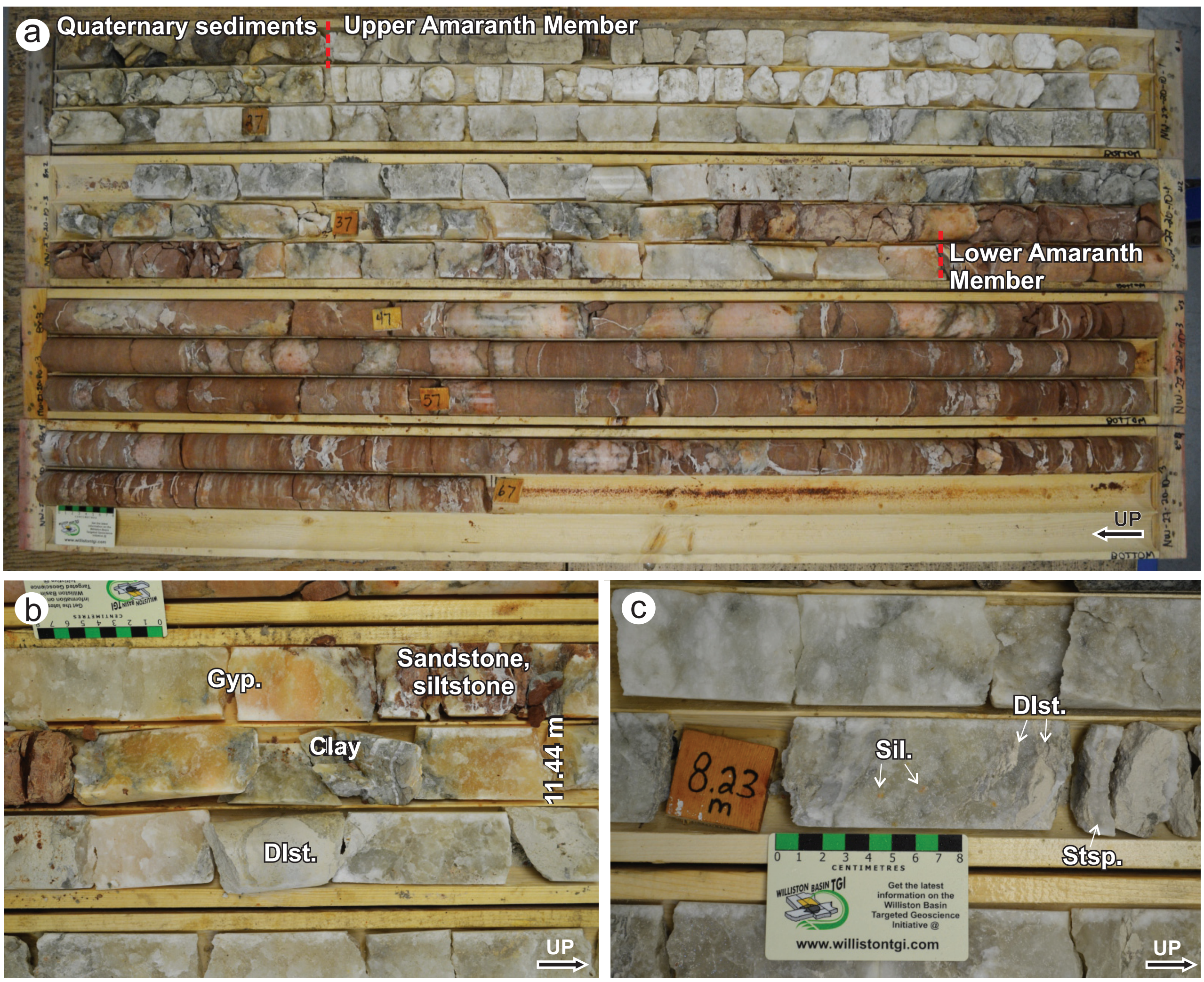

Figure GS-9-5: *Representative photographs of the lithology and structures from the logged cores:* ***a)*** *core NW27-20-10-3, dashed lines represent contacts between the three lithological units, depth markers in feet;* ***b)*** *grey to light orange gypsum with dolomudstone clasts, clay partings and argillaceous sandstone to siltstone beds;* ***c)*** *core NW28-20-10-1, typical white to light grey-yellow gypsum with brecciated dolomudstone clasts and silica nodules. Abbreviations: Dlst., dolomudstone; Gyp., gypsum; Stsp., satinspar fracture; Sil., silica nodules.*

nodules (Figure GS-9-5c). In drillcores NW27-20-10-2, NW28-20-10-1 and NW27-20-10-3, beds and clasts of the lower member occur in the basal part of the gypsum. The upper contact with Quaternary sediments is gradational, and the upper surface of the gypsum often appears weathered. The lower contact with the Lower Amaranth Member is gradational, and the uppermost portion of this member is often fractured by satinspar or contains thick beds of gypsum.

Isopach maps

Two isopach maps (Twp. 20, Rge. 10, W 1st Meridian) were generated using drillhole data from assessment files 96000, 96011, 96021, 96026 and 96061 (Manitoba Mineral Resources, Winnipeg). Figure GS-9-6 represents the depth of overburden covering the Upper Amaranth Member and Figure GS-9-7 represents the total thickness of the Upper Amaranth Member gypsum.

The isopach maps were initially created using natural neighbourhoods modelling in ArcGIS Spatial Analyst, then were re-interpreted and in some cases redrawn to better suit the observed geology in the area. In general, the thickness of the gypsum and of the Quaternary sediments decreases toward the northeast. However, there is a fair amount of variability in both the thickness of gypsum and the overlying sediments within the study area.

The Quaternary sediments are composed of a mixture of cobbles, sand, silt and clay, deposited as glacial till and as lakebottom sediment from glacial Lake Agassiz. Thickness of the Quaternary sediments may be influenced by a variety of factors, including the paleotopography on the upper surface of the gypsum, deposition of glacial till and sediment from glacial Lake Agassiz and postdeposition erosion at the surface.

The total thickness of the gypsum shows some parallels with the total thickness of Quaternary sediments. The area of anomalously thicker gypsum in the northwest corner of the map corresponds approximately to an area where the Quaternary sediments are thinner. Quaternary sediments are anomalously thick in the south, which is

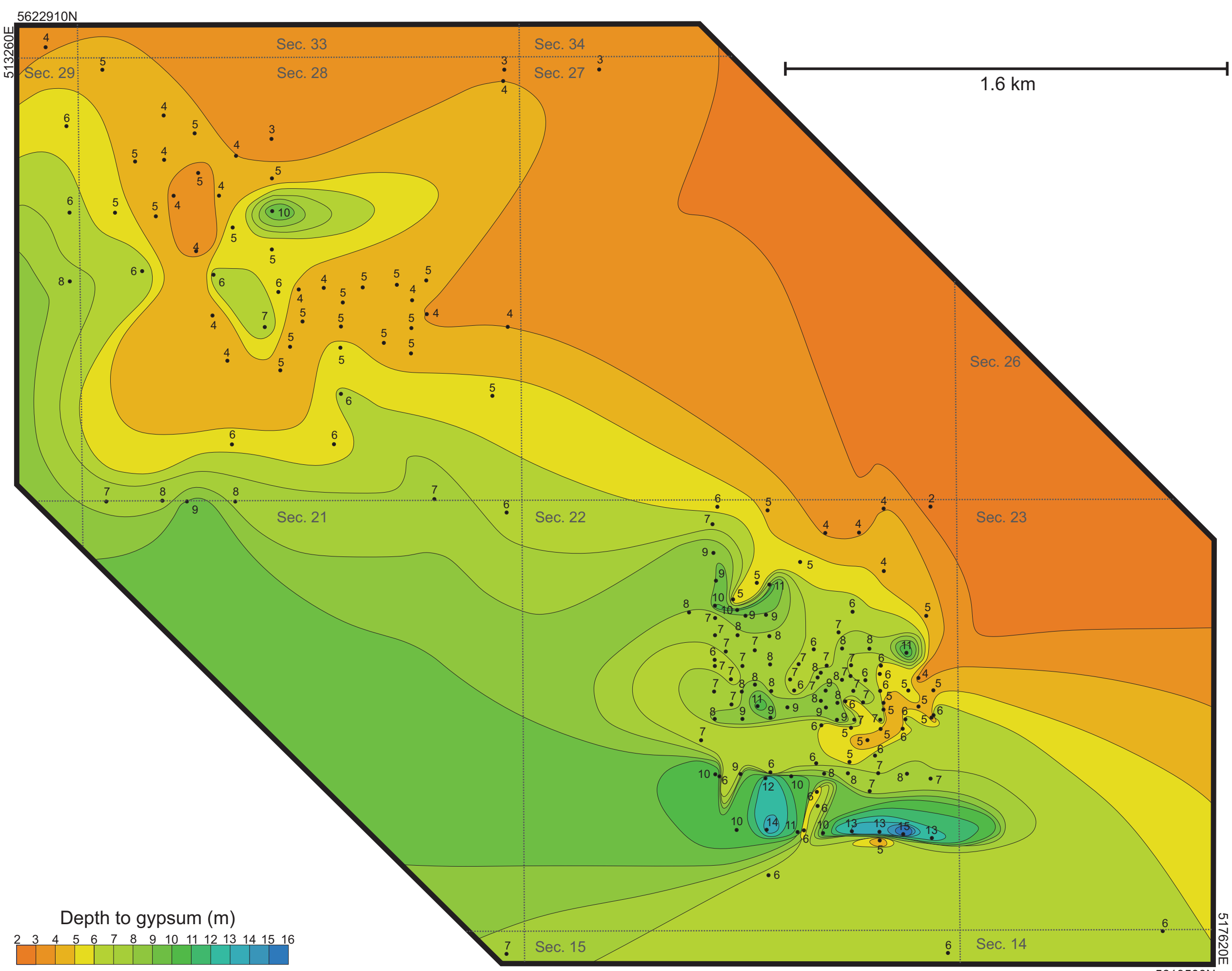

Figure GS-9-6: *Isopach map showing the total thickness of Quaternary sediments overlying the Upper Amaranth Member of the Amaranth Formation, Harcus area, southwestern Manitoba. Black dots represent drillholes and the thickness at each hole is displayed in metres.*

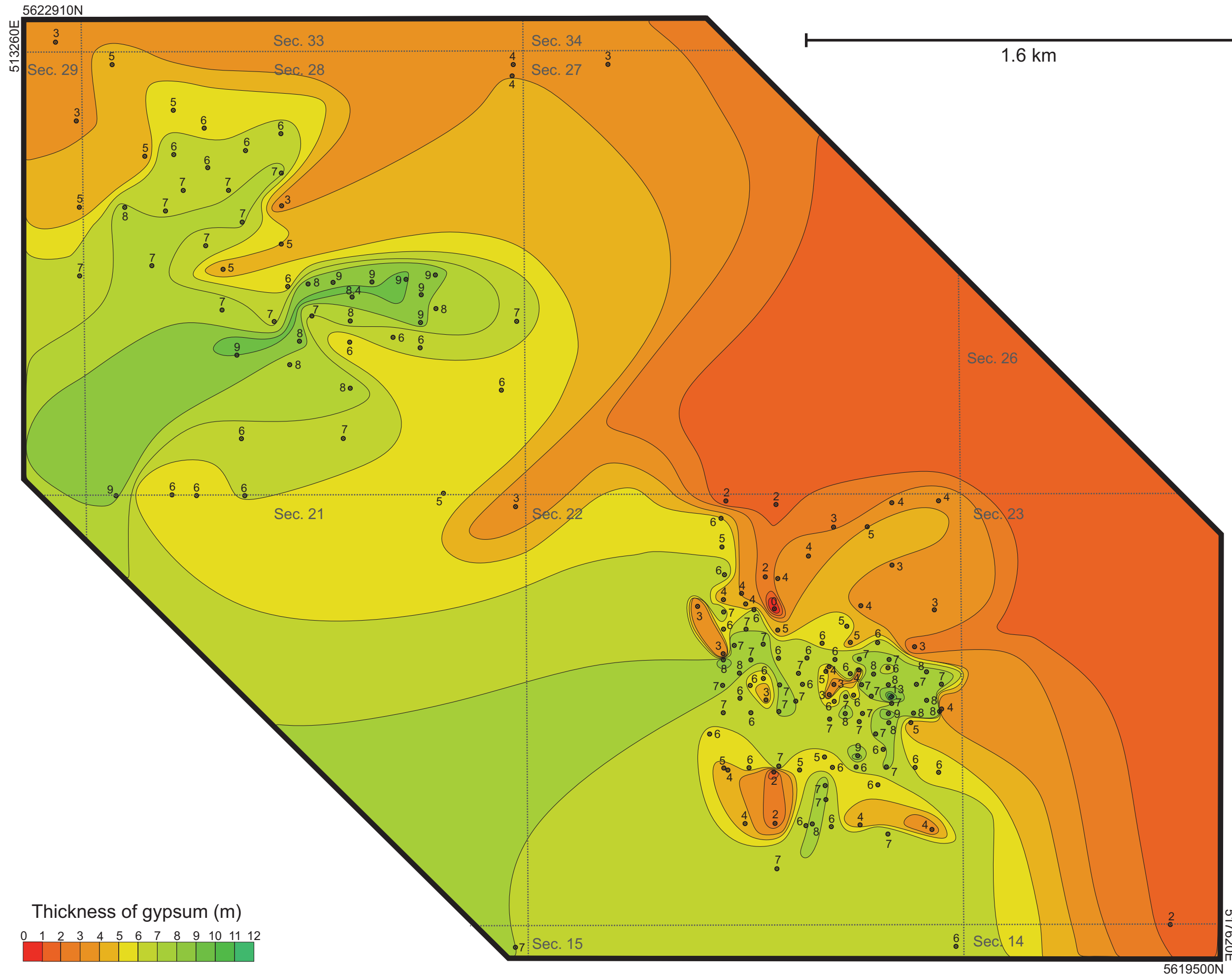

Figure GS-9-7: *Isopach map showing the total thickness of the Upper Amaranth Member of the Amaranth Formation, Harcus area, southwestern Manitoba. Black dots represent drillholes and the thickness at each hole is displayed in metres.*

associated with thinner intervals of gypsum. Factors influencing gypsum thickness may include postdepositional erosion and dissolution of gypsum from groundwater and associated karsting and sinkhole development.

Future work

Water levels in the two Harcus quarries were high this summer, and therefore most quarry walls were inaccessible. Once the quarries have been sufficiently drained, additional stratigraphic sections will be completed. After all stratigraphic sections are completed, they will be correlated with logged cores. Detailed structure and isopach maps will be constructed from the data and used to create the isopach maps in future reports. Historical records pertaining to quarrying, mining and production are being digitized and will be incorporated into future reports.

Gypsumville and Silver Plains have been important areas for exploration and gypsum extraction in the past. Providing an update on the geology and production history of these regions is an important aspect of this project. This will involve logging core, detailed thin-section work, examining quarry walls near Gypsumville, and using data from assessment files to create structure and isopach maps.

Economic considerations

Gypsum is an important industrial mineral in Manitoba, which has seen over 100 years of mining and quarrying in the province. A comprehensive report updating the geological knowledge of this resource will help to support industry in continuing to explore for and develop this resource. Detailed isopach maps will help guide industry in selecting future exploration targets. A better understanding of the stratigraphy and further investigations into the geochemistry of gypsum will help with proper land-use planning and future road development.

Acknowledgments

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