Update on Investigations of Industrial Mineral Commodities: Gypsum and High-Purity Silica Sand

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Other Industrial Minerals

Brick Clay

Leary's brick plant, Roseisle

- Abundant outcrops of brick clays in SW Manitoba
- Historically, >40 brick plants in operation in MB

Cretaceous clay pits, Ste. Rose du Lac

Natural Cement

Boyne Formation, Roseisle Creek

- Babcock beds, Boyne Formation; geochemistry similar to that of Portland cement

Bentonite

Pembina Member, Morden area

- Interlayered altered volcanic ash and black shale
- Previously quarried; many industrial uses

Bentonite quarry, Morden area

Gypsum

Summary

The evaporitic Upper Amaranth Member, Amaranth Formation in the Williston Basin, has been producing gypsum since the turn of the 20th century in Manitoba. Gypsum is used in the manufacturing of cement and wallboard. The Manitoba Geological Survey (MGS) is currently investigating this resource, with the primary objective of providing valuable information to industry in the form of updated structure contour and isopach maps for areas of economic interest. In 2016, these maps were modelled using mineral exploration drillcore and water well data for the Harcus-Amaranth area.

The Project

In 2015, the MGS initiated an investigation into the gypsum resources of Manitoba (Lapenskie and Bamburak, 2015). The aim of this project is to provide a comprehensive update on this commodity, which has been utilized for industrial purposes in Manitoba for over 100 years (Bannatyne, 1959, 1977; Gunter, 1987). Economic deposits of gypsum occur in the evaporitic Upper Amaranth Member of the Amaranth Formation. The member is composed predominantly of gypsum and/or anhydrite.

Objectives of this investigation are aimed at improving our knowledge of gypsum resources in Manitoba to encourage exploration and aid in future land-use planning:

- compile the history of gypsum quarrying, exploration, and production;
- provide a comprehensive update on the geological description and correlation of the evaporites of the Upper Amaranth Member; and
- general detailed structure contour and isopach maps of the overlying Quaternary sediments and Upper Amaranth Member.

Structure contour and isopach maps

Drillcore data, as well as water well data, for the Harcus-Amaranth area have been compiled, and detailed structure contour and isopach maps of the Quaternary sediments and Upper Amaranth Member have been generated (Figures 1 and 2). Drillcore and water well data were computer generated to create the structure contour and isopach maps. The underlying grids for the map were created using Spatial Analyst for ArcGIS, with the Spline with Barriers interpolation method. The grids were then contoured using the Contour with Barriers method in Spatial Analyst. In much of the map area, known member thickness is sparse; therefore, the accuracy of the contours can be low. Due to the highly variable thickness of the Quaternary sediments and gypsum in this area, these maps should only be used to guide exploration as a current best estimate. Karsting and/or erosional features are common in the Upper Amaranth Member, which provides additional caveats when modelling sediment and rock thicknesses.

Quaternary isopach map (Figure 1)

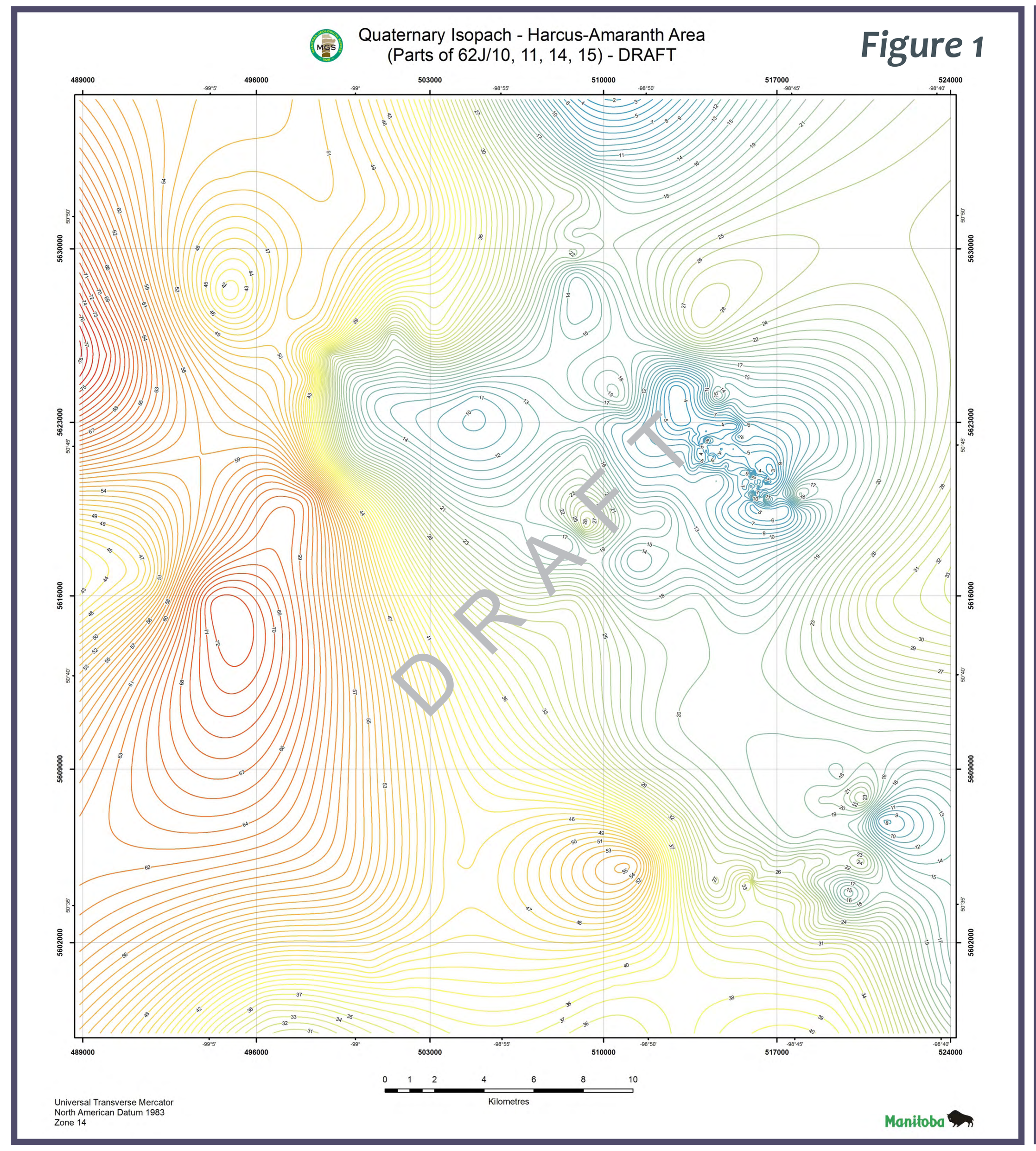
Quaternary sediments are generally thinnest in the central to eastern regions of the map area, and range from <2m to >78m in thickness. Gypsum quarrying is currently taking place in the northeastern region of the map area, where thin Quaternary cover allows easy access.

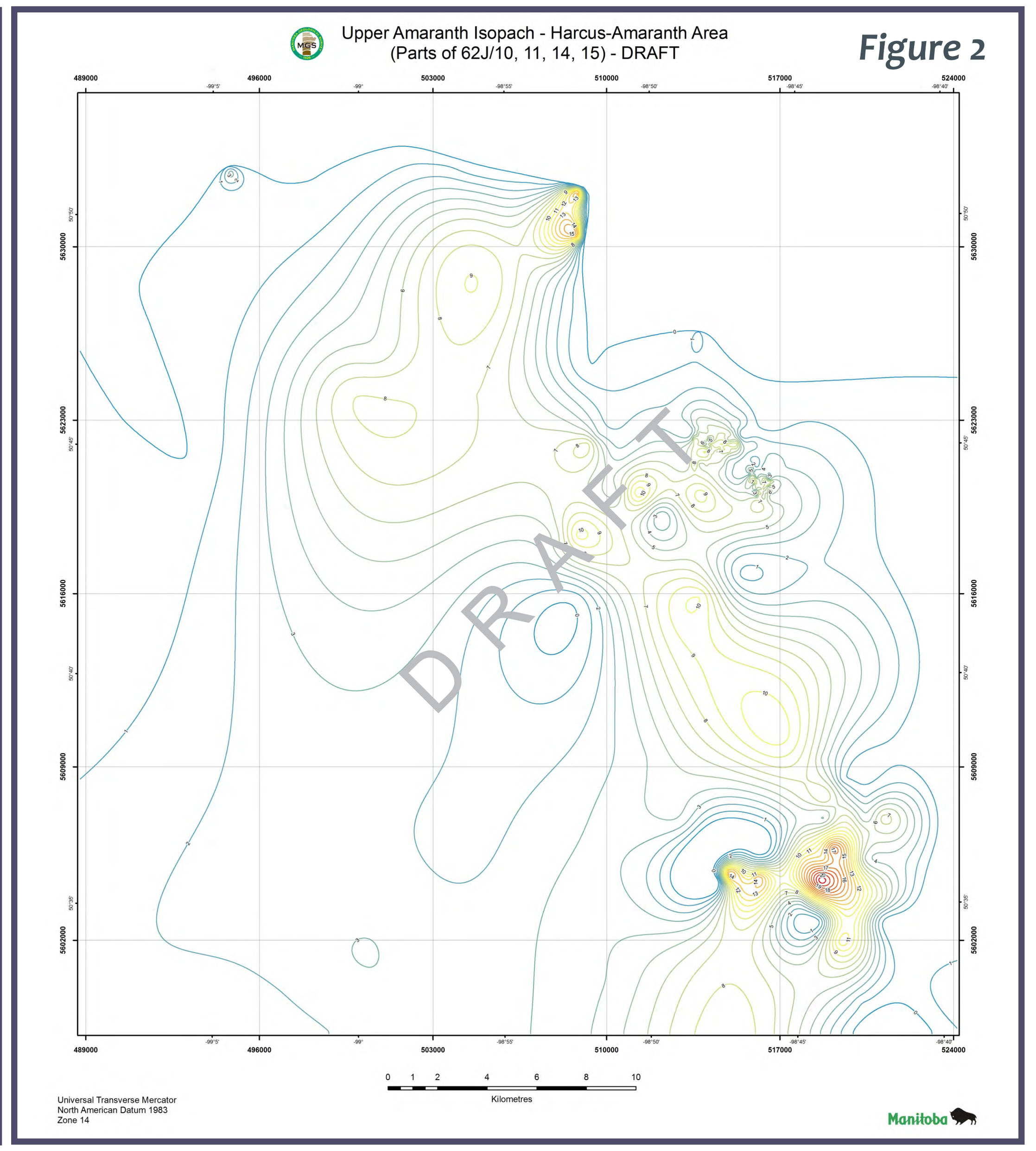
Elliptical areas of anomalously thicker Quaternary sediments may indicate the presence of large areas of karsting or sinkhole development. This would have occurred within the underling member before the deposition

Upper Amaranth Member isopach map (Figure 2)

The Upper Amaranth Member is generally thickest along a NNW-SSE trend on the right side of the map area. Thickness of the member ranges from 0 m to >20 m. Roughly elliptical areas of decreased gypsum thickness may represent sinkholes or karsted areas.

The edge of the Upper Amaranth Member trends irregularly east to west in the northern part of the map area.





Economic Considerations

Current gypsum quarrying activities significantly contribute to the cement and wallboard industries in the province. The gypsum-based wallboard manufacturing company in Winnipeg is the only one of its kind in Manitoba, and has strong economic significance as it exclusively serves a large geographic region. Detailed isopach and structure contour maps of the Harcus-Amaranth area will help operators guide expansion plans and identify future exploration targets. Investigations into the stratigraphy and karst development in the Upper Amaranth Member will provide valuable information for future land-use planning. Resolving the stratigraphic correlation between the Williston Basin and the Lake St. Martin igneous and metamorphic complex will add to the understanding of the depositional history of Phanerozoic strata in Manitoba.

Acknowledgments

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High-Purity Silica Sand

Summary

The Winnipeg Formation contains some of the purest silica sand deposits in North America. Historically, this silica sand has been quarried and processed in the province to produce glass. The MGS is re-examining this formation to determine the economic potential of the silica sand for a variety of applications, including as a very high quality proppant for fracking. The SiO_2 content and the morphology of the sand grains will need to be defined for the various sandstone lithofacies of the Winnipeg Formation. Several objectives must be achieved:

- **compile detailed geological descriptions of outcrops and drillcore to correlate lithofacies variations across the subcrop-outcrop belt of the basin;**
- **determine quality of the silica sand as it pertains to the various lithofacies through geochemical analyses and quantitative descriptions of sand; and**
- **create isopach and structure contour maps where necessary using drillhole and water well data.**

Regional Geology

The Winnipeg Formation occurs in southwest Manitoba at the base of the Williston Basin strata (Figure 1). It comprises the oldest Ordovician rocks in Manitoba and is the oldest outcropping Phanerozoic rock in the province. The formation noncomformably overlies Precambrian bedrock, except in the southwestern corner of Manitoba where it unconformably overlies the Cambrian Deadwood Formation (McCabe, 1978). The Winnipeg Formation is overlain by the Red River Formation.

The Winnipeg Formation is subdivided into Upper and Lower units, with a vestigial off-shore sand bar, termed the Carman sand, occurring between these units in southern Manitoba (Vigrass, 1971; Nicolas, 2008). The formation is comprised of quartz-rich sandstones and variably arenaceous mudstones. The maximum thickness of the Winnipeg Formation is 60 m.

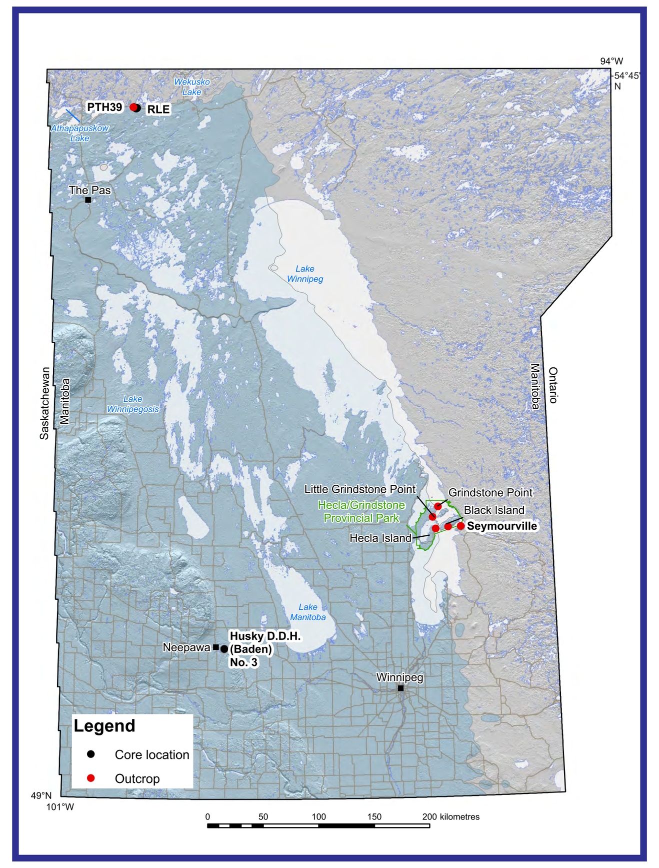
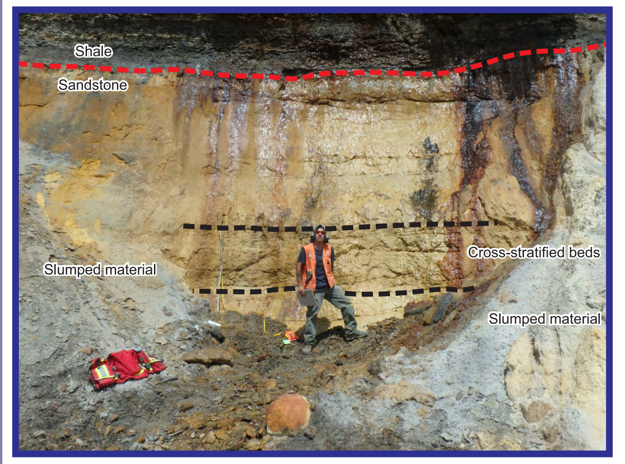


Figure 1: Map of southern Manitoba; blue area indicates extent of the Winnipeg Formation.



Black Island

The Winnipeg Formation is exposed in a quarry on the south shore of Black Island. The maximum thickness of the section is ~7.8 m. The outcrops on Black Island and in Hecla-Grindstone Provincial Park are from the Lower unit (McCabe, 1978; Watson, 1985).

There are two lithologic units on Black Island, a lower sandstone unit and an upper pyritic shale unit (Figure 2). The sandstone is composed of bedded to cross-bedded, burrowed, grain-supported quartz arenite. The sand is comprised entirely of well-rounded to rounded, equant, very coarse to fine-grained quartz grains. The overlying unit is composed of pyritic, bedded to laminated shale.

Figure 2: Section of the Winnipeg Formation in the Black Island quarry. Cross-stratified bed is approximately 1.75 m thick. Sulphide staining is visible below the contact between the lower sandstone and upper shale.

Hecla-Grindstone Provincial Park

Exposures of the Winnipeg Formation were observed on Grindstone and Little Grindstone points. The formation attains a maximum thickness of 1.4 m, although the base of the sections observed were covered with slumped material.

Here the Winnipeg Formation is only composed of a single sandstone unit. The sandstone is composed of massively bedded, pyritic, variably calcareous quartz arenite (Figure 3). Pyrite nodules occur concentrated in irregular laminations. The sane is comprised of well sorted, well rounded, equant, predominantly fine-grained quartz grains. The upper contact with the Red River Formation is sharp; the lower contact was not observed.

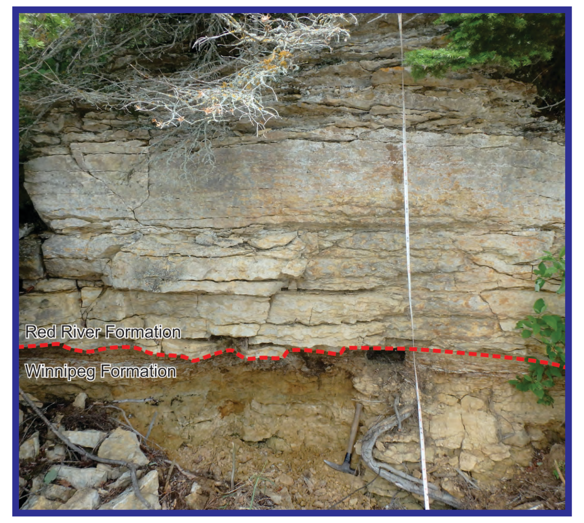
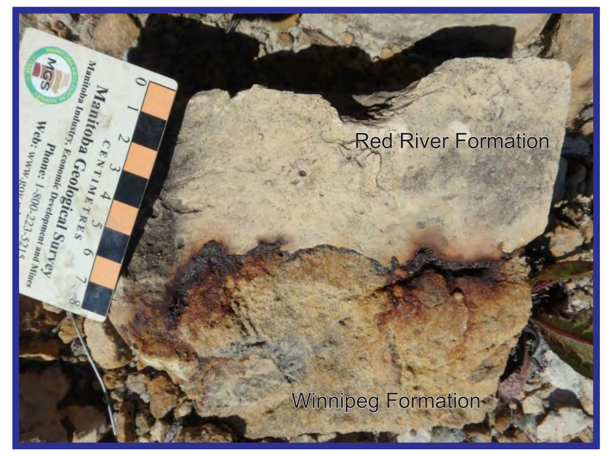


Figure 3: Section of the Winnipeg and Red River formations on Little Grindstone Point.



Northern edge of the Williston Basin

There are few outcrops of the Winnipeg Formation in the Wekusko Lake to Athapapuskow Lake area; more field work is needed in the area to identify and substantial sections.

Along provincial highway 39, a relatively recent excavation of the ditch adjacent to the road results in large blocks of the Winnipeg Formation being exposed. These boulders provide excellent examples of the contact between the Winnipeg and Red River formations in this region. Disseminated sulphides are abundant in the uppermost Winnipeg Formation and along the upper contact (Figure 4). These Winnipeg Formation is comprised of massive, fossiliferous, pyritic quartz arenite.

Figure 4: Contact between the Winnipeg and Red River formations; note disseminated sulphides along the contact.

Preliminary Results

Samples of the silica sand were taken near the community of Seymourville, exploration drillcore from Reed Lake, and oil core were sent for lithogeochemical analyses to determine silica and other major element components (Table 1). These samples are all widely geographically separated and are from different stratigraphic levels within the Winnipeg Formation.

Purity of the silica sands is variable among samples, with the purest sample having a silica content of 98.89%, and the least pure being 61.07%. In general, the Reed Lake core samples have a lower silica content; sulphides and carbonate matrix were common in the Winnipeg Formation in these cores. Significant processing of the sand from the Reed Lake area would be required to upgrade their purity. These results tentatively indicate a wide variability in the purity of the silica sands across the Williston Basin in Manitoba and within different lithofacies of the Winnipeg Formation.

Sample Number	SiO_2	Al_2O_3	Fe_2O_3	MnO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	LOI	Total
114-16-RLE040, 11.0m	84.76	4.21	2.35	0.031	1.37	0.29	0.65	0.243	<0.01	3.28	98.53
114-16-RLE040, 8.42m	65.13	0.46	2.21	0.054	9.62	0.01	0.11	0.074	<0.01	14.65	98.94
114-16-Seymourville_1	98.10	0.56	0.86	0.005	0.03	<0.01	0.15	0.082	<0.01	0.59	100.40
114-16-RLE037, 14.9m	65.59	15.49	2.19	0.011	0.018	0.21	10.03	0.699	0.09	3.77	99.70
114-16-RLE037, 15.2m	87.45	4.93	2.66	0.017	0.07	<0.01	2.82	0.120	<0.01	1.45	100.90
114-16-RLE038, 9.04m	64.41	1.15	1.26	0.026	18.28	<0.01	0.27	0.203	<0.01	14.45	100.70
114-16-RLE038, 8.5m	69.68	0.67	7.31	0.034	9.27	<0.01	0.36	0.047	0.02	9.82	98.63
114-16-RLE042, 25.95m	91.31	0.85	1.01	0.017	2.08	<0.01	0.18	0.218	<0.01	3.29	100.20
114-16-Seymourville_2	98.89	0.50	0.69	0.004	0.03	<0.01	0.13	0.065	<0.01	0.51	100.90
114-16-RLE042, 25.35m	61.07	0.46	2.64	0.048	11.33	<0.01	0.18	0.059	<0.01	16.27	98.97
114-16-Husky, 762.76m	87.43	2.07	1.43	0.010	2.60	1.02	0.17	0.098	<0.01	5.60	110.50

Table 1: Lithogeochemical results of samples of the Winnipeg Formation. Depth that samples were collected from in specific cores are noted at the end of the sample number. RLE = Reed Lake cores. Husky = oil core.

Economic Considerations

The high-purity silica sands of the Winnipeg Formation are a possible source of foundry sand, and has a great deal of potential for being a very high quality frac sand. Other potential uses of the silica sand include creating silicon carbide, silicon metal, and enamels. Geological investigations into the quality and purity of these silica sands as they pertain to the various lithofacies changes across the Williston Basin will help guide industry in selecting areas of high economic potential.

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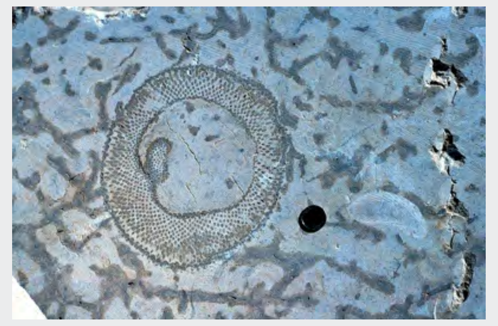
Other Industrial Minerals

Dimension Stone



Tyndall stone, Garson area

- Various types of stone used for building exteriors
- Sedimentary, igneous and metamorphic options

Granitic dimension stone slabs

'Manitoba marble' Snow Lake area

High-Mg Dolomite

Dolomudstone, lower Interlake Group Inwood Quarry

- Stonewall Formation and Interlake Group dolomudstones
- Abundant outcrops of high-purity dolomite

Kaolin

Exploration test pits, Arborg area

- Premium grade kaolin, as well as silica sand