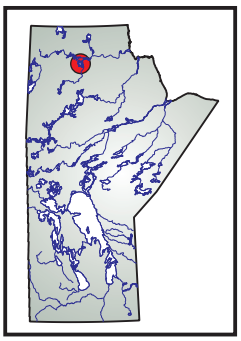
GS-5 Community Mapping Program with the Sayisi Dene First Nation, Tadoule Lake, north-central Manitoba: stromatolitic marble occurrence in the Ryan Lake area (part of NTS 64J10)

by L.A. Murphy and A.R. Carlson



Murphy, L.A. and Carlson, A.R. 2010: Community Mapping Program with the Sayisi Dene First Nation, Tadoule Lake, north-central Manitoba: stromatolitic marble occurrence in the Ryan Lake area (part of NTS 64J10); *in* Report of Activities 2010, Manitoba Innovation, Energy and Mines, Manitoba Geological Survey, p. 62–68.

Summary

The second part of the two-year community mapping program in 2010 continued to build on an information-sharing relationship between First Nation communities and the Manitoba Geological Survey (MGS). Two MGS staff geologists and four members of the Sayisi Dene First Nation partnered in a fly camp to geologically map the extent and assess the quarry potential of a stromatolitic marble occurrence in the Ryan Lake area. The project in Tadoule Lake provides the participants with basic skills needed to work in a mineral-exploration camp and fosters awareness of geology and land-use opportunities in Manitoba's far north. Four members of the community were hired as student trainees and completed the program.

The fieldwork in 2010 focused on a marble occurrence located 25 km southwest of Tadoule Lake, within the Sayisi Dene traditional land-use area. The impure, cream to buff marble is layered, dolomitic, stromatolitic and interbedded with pebbly carbonate sandstone beds. The occurrence is approximately 1.8 km long and 800 m wide, and encompasses a peninsula on the southeast shore of Ryan Lake.

The marble can be quarried using a modified feather-and-wedge system that utilizes natural benches and competency contrasts within the rock. The Sayisi Dene First Nation is interested in quarrying the marble at Ryan Lake to contribute to a network of raw material used by traditional artists in northern Manitoba. Sculptors can use natural stromatolitic laminations within the stone to produce a high-quality signature commodity called 'Dene-Tzi Marble'.

Introduction

The Sayisi Dene First Nation of Tadoule Lake is located approximately 250 km west of Churchill and is accessible by commercial air transportation or charter float plane. Figure GS-5-1a shows the location of the Tadoule Lake and Ryan Lake areas with respect to major geological domains in Manitoba's far north, and Figure GS-5-1b shows the simplified geology of the Tadoule Lake area. The extent of the marble at Ryan Lake, as determined from the 2010 fieldwork, is shown in Figure GS-5-2.

In the summer of 2010, the Manitoba Geological Survey (MGS) completed a two-year community mapping program in the Sayisi Dene traditional land-use area as part of ongoing multiyear bedrock mapping programs in northern Manitoba under the auspices of the Manitoba Far North Geomapping Initiative (Anderson et al., 2009; Murphy and Carlson, 2009; Anderson et al., GS-1, this volume; Kremer et al., GS-4, this volume). The community mapping initiative at Tadoule Lake is supported by Manitoba Entrepreneurship, Training and Trade (Labour Market Skills Division), Manitoba Innovation, Energy and Mines (Manitoba Geological Survey) and the Sayisi Dene First Nation.

Discussions with community members in 2009 (Murphy and Carlson, 2009) indicated that the Sayisi Dene First Nation was interested in investigating the economic potential of a marble occurrence at Ryan Lake, located approximately 25 km southwest of the community.

Methodology

The community mapping program in 2010 continued to build on a working relationship established between MGS staff geologists and the Sayisi Dene First Nation during the 2009 field season. Several visits to the Tadoule Lake community by MGS staff prior to the 2009 field season engaged community and Council members in the planning process for the mapping program. Continued meetings with the Chief and Council prior to and during the 2010 summer program encouraged community participation in work leading to the geological mapping and assessment of the marble located at Ryan Lake.

The Tadoule Lake mapping program took place in part at Tadoule Lake, with geological fieldwork completed at Ryan Lake. The 2010 training program focused on the planning, logistics, management and maintenance of field equipment in a fly camp. Due to poor exposures of marble at Ryan Lake, mapping strategies were developed to maximize geological information on the marble that would be required to ascertain the size of blocks that could be quarried. The mapping program gave participants an opportunity to learn safe work practices according to MGS standards, use field equipment, input GIS data and gain hands-on geological mapping experience within their traditional land-use area. Each individual was responsible for various aspects of geological fieldwork, including maintaining field equipment, camp organization and logistics, and recording of geological data.

Fieldwork was conducted during six days along an east-trending peninsula located on the southeast shore

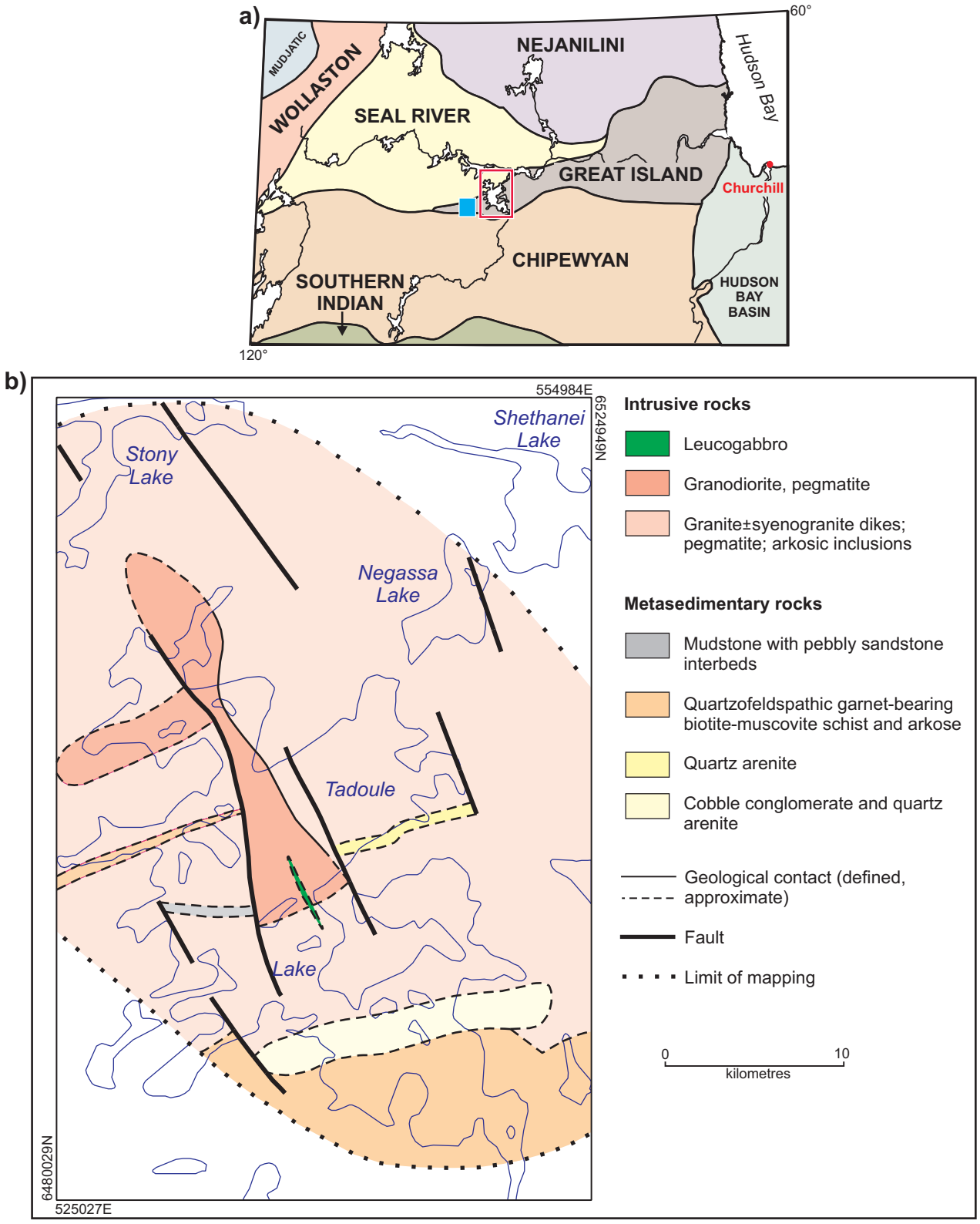


Figure GS-5-1: a) *Principal geological domains in northern Manitoba from Schledewitz (1986), modified from Manitoba Industry, Trade and Mines (2002), highlighting the Ryan Lake and Tadoule Lake areas in blue and red, respectively.* ***b)*** *Simplified geology of the Tadoule Lake area, modified from Murphy and Carlson (2009), integrated with previous mapping by Schledewitz (1986).*

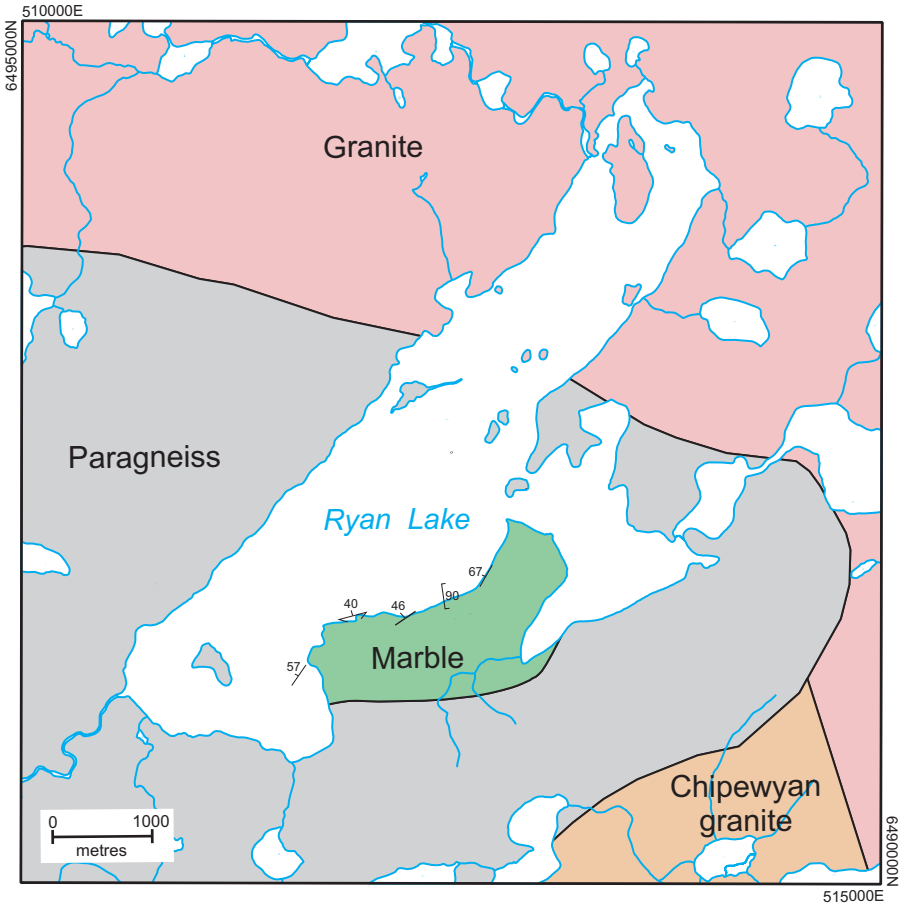


Figure GS-5-2: *Simplified geology (modified from Manitoba Industry, Trade and Mines, 2002; Viljoen et al., 1999), showing the extent of the marble occurrence in the Ryan Lake area.*

of Ryan Lake (Figure GS-5-2). Part of the fieldwork involved removing overburden from the marble outcrops with a Wajax water pump and hose assembly along the lakeshore. Some of the outcrops cleared in this manner encompass 30 m of shoreline about 5 m above the water line. Detailed geological mapping included an assessment of the extent, composition and competency of the newly exposed marble. The work provides the community of Tadoule Lake with information that identifies the suitability of the marble for sculpting and the possible maximum size of marble blocks that can be quarried.

Information on composition and competency, and interpretations of the marble occurrence are based on a combination of field observations and petrological study of thin sections of five rock samples taken from key elements of the marble outcrops. One sample was stained with Alizarin Red™ to enhance detail of internal fine laminations, and one sample was sent to the University of Manitoba for carbon and oxygen stable-isotope analysis.

Regional setting

The Tadoule Lake and Ryan Lake areas were previously mapped by the Geological Survey of Canada in the 1960s (Davidson, 1962) and the MGS in the 1970s (Schledewitz, 1986). The area transects marginal zones of the Great Island, Seal River and Chipewyan domains of the southeastern Hearne craton (Figure GS-5-1a).

The geological data compiled during the 2010 field season, as shown in Figure GS-5-2, utilize the geological contacts from the original Seal River Project mapping by Schledewitz (1986). Calcsilicate and dolomitic marble occur elsewhere in the Sayisi Dene traditional land-use area in Manitoba's far north, such as in the Great Island area (Anderson et al., 2009; Anderson et al., GS-1, this volume) and the Askey Lake to Nejanilini Lake area (Schledewitz, 1986; Anderson et al., 2005).

Bedrock geology

The Tadoule Lake area is underlain mainly by a plutonic complex that includes granite, syenogranite, granodiorite and pegmatite, with subordinate sedimentary rocks and rare mafic dikes within or along margins of the plutonic suite (Murphy and Carlson, 2009). The ca. 1.86 Ga Chipewyan Batholith (Van Schmus and Schledewitz, 1986) to the south may have contributed to the abundance of pegmatitic granitoid rocks in the Tadoule Lake area.

The Ryan Lake area is underlain in the south by calcsilicate to marble and to the north by interbedded semipelitic metatexite, which grades into schist ± impure quartzite (Schledewitz, 1986). All rocks in the area have been metamorphosed to upper amphibolite grade. Originally, the metamorphic rocks were a sequence of limestone, quartz-rich sandstone and mudstone interpreted to mark the transition from continental to marine environment.

The contact between the marble and the metatexite was not located. The sedimentary rocks are possibly faulted and/or intruded by the felsic plutonic complex that dominates the geology eastward toward Tadoule Lake (Murphy and Carlson, 2009).

Ryan Lake marble

Poorly exposed, creamy white to buff, impure dolomitic stromatolitic marble forms a moderately dipping, east- to southwest-trending body that encompasses a peninsula on the southeast shore of Ryan Lake (Figure GS-5-2). Components of the Ryan Lake marble are described in this section and illustrated by the outcrop photographs in Figures GS-5-3 and -4.

Uniformly layered beds

The layered marble beds vary from about 4 to 40 cm in thickness, are aphanitic to fine grained and make up approximately 30% of the exposed unit (Figure GS-5-3a). Uniform layering within the centimetre- to decimetre-scale beds comprises 1) closely spaced, thin (1–3 mm), dark brown cherty stringers spaced up to 5 cm apart; and 2) thin (0.5–2 mm) red laminae.

Podiform brecciated beds

Podiform brecciated beds are about 20 cm thick and contain ovoid, brecciated marble pods, measuring about 10 by 60 cm (Figure GS-5-3b). Each marble pod appears to surround a small rounded marble nodule up to 7 cm in diameter. The pods are locally aligned and commonly upright in contact with each other, but are mostly enveloped by the dolomitic carbonate-quartz matrix.

Pebbly carbonate sandstone beds

Pebbly carbonate sandstone beds range from 0.25 to 1 m in thickness and contain up to 1% sporadic, rounded carbonate and angular quartz and feldspar pebbles up to 1 cm in diameter (Figure GS-5-3c). Red hematite occurs in both beds and pebbles.

Chert clasts, nodules and stringers

Prominent, erosion-resistant, dark grey to pink and brick red to dark purple chert nodules and clasts form up 1% of the marble outcrop and stand in positive relief up to 3 cm high on the outcrop (Figure GS-5-3d*)*. Rounded chert nodules up to 3 cm in diameter are scattered throughout the marble. Angular chert clasts up to 1 by 6 cm, and quartz-rich layers up to 10 cm by 1 m long are layered in or near the core of the dolomitic carbonate matrix. Although the clasts appear angular on the outcrop, thin-section analysis revealed solution rims around fine detrital carbonate and silica grains, indicating erosion surfaces.

Brown, phlogopite-bearing chert stringers less than 1 cm wide and spaced up to 5 cm apart mark bedding planes separating the marble beds, define open folds within marble beds and surround individual breccia pods (Figure GS-5-3e). Thin fractures along marble-chert interfaces may contain secondary infill of siliceous clay, which locally contains phlogopite altered to muscovite and chlorite.

Dolomitic carbonate-quartz matrix

Matrix-rich marble forms up to 10% of the mapped outcrops. Dolomitic carbonate-quartz matrix up to 4 cm wide is concordant and slightly oblique to original bedding planes between the uniformly layered marble and the brecciated podiform beds. The matrix commonly wraps around individual pods in the breccia beds (Figure GS-5-3b). In places, softer minerals such as calcite are weathered out (Figure GS-5-3f). The matrix is nonmagnetic and does not react with hydrochloric acid (HCl), suggesting that all remaining carbonate in the matrix is recrystallized dolomitic limestone, with silica as chert and detrital quartz.

Thin red laminae

Abundant thin (0.5–2 mm), red to brown laminae spaced 1–5 mm apart occur throughout the marble. The laminae are straight in the uniformly layered marble, and folded and draped within each pod in the breccia beds (Figure GS-5-4a). The laminae are composed mainly of tremolite, diopside, phlogopite and hematite. The red colouring may be from fine-grained oxides that were reduced to hematite and/or possibly from inherited titanite (Figure GS-5-4b).

Interpretations

The marble at Ryan Lake is interpreted to be a metamorphosed stromatolite bioherm that formed during the Paleoproterozoic in a shallow marine-platform environment. Fossil evidence of stromatolite development has been found in rock records throughout Earth's history, from Archean (Allwood et al., 2009) to Proterozoic (Knoll and Semikhatov, 1998) to Phanerozoic (Bezys, 1990), and they are still developing in modern-day ocean environments (Spadafora et al., 2010). Stromatolites are organosedimentary structures that form by the proliferation of photosynthesizing cyanobacteria, which induce carbonate precipitation (Hofmann et al., 1991). These

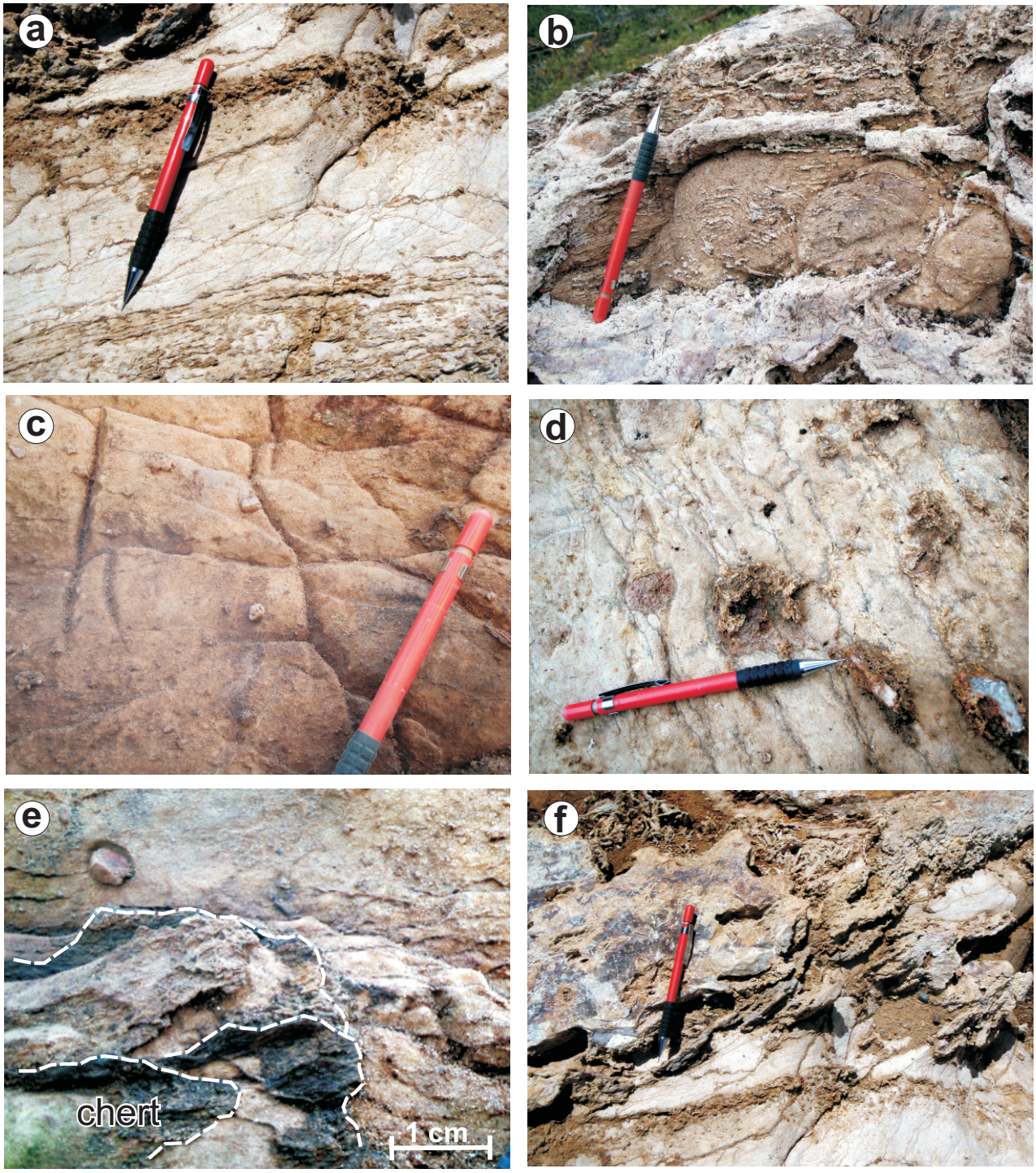


Figure GS-5-3: *Outcrop photographs of different components of the Ryan Lake marble (pen for scale is about 14 cm in length):* ***a)*** *uniformly layered marble;* ***b)*** *brecciated pods with enveloping carbonate matrix;* ***c)*** *pebbly carbonate sandstone bed;* ***d)*** *chert clasts and nodules;* ***e)*** *dolomitic carbonate-quartz matrix; and,* ***f)*** *thin cherty stringers.*

expansive algal mats capture nutrients and collect sediment from the water column.

Quarrying of the Ryan Lake marble

The stromatolitic marble at Ryan Lake is structured into southeast-trending linear benches up to 2 m in width that typically dip 40–46°, with uniform layered beds and brecciated podiform beds separated by concordant interbeds of carbonate-quartz matrix. The depth continuation of the marble blocks is uncertain but at least 2 m deep where exposed. The combination of bedding and late jointing perpendicular to bedding naturally produces marble blocks up to 2 m in length. Although the largest

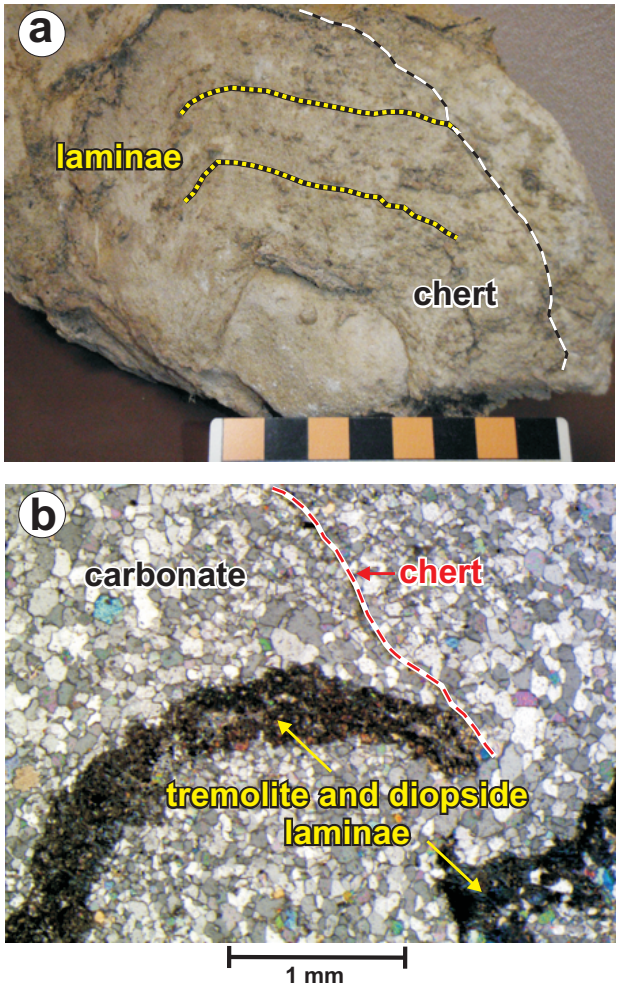


Figure GS-5-4: *Macro- and microscopic views of the laminae and chert layers in the stromatolitic podiform marble (white dashed lines follow thin chert and yellow dashed lines follow laminae):* ***a)*** *photograph of a pod with draping laminae, terminated by a thin chert layer (scale card with 1 cm intervals); and* ***b)*** *photomicrograph in cross-polarized light showing laminae and chert (scale bar is 1 mm).*

blocks quarried could be up to 2 m long and 1.5 m wide, they would more likely be about 1 m long and less than 1 m wide after trimming.

The marble is variable and includes uniformly layered, dolomitic stromatolitic marble; brecciated stromatolitic marble and interbedded carbonate sandstone; and local cherty layers and laminae. The competency of the different rock types is fundamental to quarrying. Most parts of the layered marble are compositionally similar. The uniformly layered marble beds may produce larger, metre-sized blocks, whereas brecciated podiform beds would likely produce smaller pieces. The pebbly carbonate sandstone weathers more easily and may not be competent enough to accept sustained carving. Where no natural benches and blocks appear in the marble, a modified feather-and-wedge system could target less competent sandstone layers to produce blocks of more competent marble.

Economic considerations

The community mapping program promotes relationship building and geological-information sharing between First Nation leadership and MGS staff geologists. These programs create partnerships that enhance local and provincial economic development, assist mineral explorationists, contribute to the Manitoba geological database and encourage land-use resolution.

Artists from the Tadoule Lake area have used raw material imported from Lac Brochet, Churchill, Thompson and Winnipeg to produce and export a variety of traditional sculpture, carvings, paintings and beadwork. The marble occurrence at Ryan Lake provides a source of carving stone that can be locally quarried, which would allow artists from the community to export quality raw material and locally finished stone sculptures. Due to high transportation costs, the economic viability of a quarry at Ryan Lake is lessened by the remote locations of the marble commodity and community. High-quality marble sculptures, however, are rare in Manitoba, and the Dene-Tzi Marble from Ryan Lake represents an opportunity for the Sayisi Dene First Nation to develop and promote a part of their traditional land and fill a commercial niche.

Acknowledgments

The authors thank the Tadoule Lake participants M. Powderhorn, D. Summerville, L. Bussidor and S. Cutlip for providing enthusiastic and capable field assistance in difficult working conditions. Thanks also go to N. Brandson and E. Anderson for thorough logistical support. The project was supported by the Chief and Council, the Dene Land Claims office and community members of the Sayisi Dene First Nation at Tadoule Lake. The authors acknowledge H.V. Zwanzig for our preliminary stromatolite interpretation.

References

Allwood, A.C., Grotzinger, J.P., Knoll, A.H., Burch, I.W., Anderson, M.S., Coleman, M.L. and Kanik, I. 2009: Controls on development and diversity of Early Archean stromatolites; Proceedings of the National Academy of Sciences of the United States of America, v. 106, no. 24, p. 9548–9555.

Anderson, S.D., Böhm, C.O., Syme, E.C., Carlson, A.R. and Murphy, L.A. 2009: Far North Geomapping Initiative: geological investigations in the Great Island area, Manitoba (parts of NTS 54L13, 54M4, 64I15, 16, 64P1, 2); *in* Report of Activities 2009, Manitoba Innovation, Energy and Mines, Manitoba Geological Survey, p. 132–147.

Anderson, S.D., Böhm, C.O. and Matile, G.L.D. 2005: Bedrock and surficial geological field investigations in the Nejanilini Lake area, northern Manitoba (parts of NTS 64P5, 12 and 13); *in* Report of Activities 2005, Manitoba Industry, Economic Development and Mines, Manitoba Geological Survey, p. 92–103.

Bezys, R.K. 1990: Stratigraphic mapping (NTS 63G) and core hole program; *in* Report of Activities 1990, Manitoba Energy and Mines, Minerals Division, p. 140–151.

Davison, W.L. 1962: Geology, Tadoule Lake, Manitoba; Geological Survey of Canada, Preliminary Map 30-1962, scale 1:253 440.

Hofmann, H.J., Sage, R.P. and Berdusco, E.N. 1991: Archean stromatolites in Michipicoten Group siderite ore at Wawa, Ontario; Economic Geology. v. 86, p. 1023–1030.

Knoll, A.H. and Semikhatov, M.A. 1998: The genesis and time distribution of two distinct Proterozoic stromatolite microstructures; Palaios v. 13, no. 5, p. 408–422.

Manitoba Industry, Trade and Mines 2002: Nejanilini Lake, NTS 64P; Manitoba Industry, Trade and Mines, Manitoba Geological Survey, Bedrock Geology Compilation Map Series, NTS 64P, scale 1:250 000.

Murphy, L.A. and Carlson, A.R. 2009: Sayisi Dene Mapping Initiative, Tadoule Lake area, Manitoba (part of NTS 64J9, 10, 15, 16); *in* Report of Activities 2009, Manitoba Innovation, Energy and Mines, Manitoba Geological Survey, p. 154–159.

Schledewitz, D.C.P. 1986: Geology of the Cochrane and Seal Rivers area; Manitoba Energy and Mines, Geological Services, Geological Report GR80-9, 139 p.

Spadafora, A., Perri, E., Mckenzie, J.A. and Vasconcelos, C. 2010: Microbial biomineralization processes forming modern Ca:Mg carbonate stromatolites; Sedimentology, v. 57, no. 1, p. 27–40.

Van Schmus, W.R. and Schledewitz, D.C.P. 1986: U-Pb zircon geochronology of the Big Sand Lake area, northern Manitoba; *in* Report of Field Activities 1986, Manitoba Energy and Mines, Minerals Division, p. 207–210.

Viljoen, D., Chackowsky, L.E. and Lenton, P.G. 1999: Geology, magnetic and gravity maps of Manitoba: a digital perspective; Manitoba Energy and Mines, Geological Services and Geological Survey of Canada, Open File Report 99-12, 1 CD-ROM.