Report of Activities 2003

Published by:
Manitoba Industry, Economic Development and Mines
Manitoba Geological Survey, 2003.

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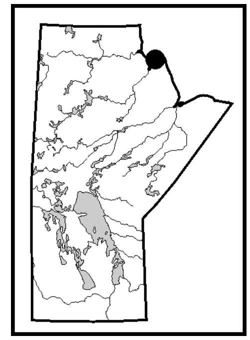
The publisher/department name in the bibliographic reference cited immediately below the title of each GS report should read **Manitoba Industry, Economic Development and Mines** instead of **Manitoba Industry, Trade and Mines**.

GS-22 Metallic and silica resource potential of the Churchill area, northern Manitoba (parts of NTS 54K13SE and 54L16SW)

by J.D. Bamburak



Bamburak, J.D., 2003: Metallic and silica resource potential of the Churchill area, northern Manitoba (parts of NTS 54K13SE and 54L16SW); *in* Report of Activities 2003, Manitoba Industry, Trade and Mines, Manitoba Geological Survey, p. 165–170.

Summary

The presence of metallic and silica occurrences within exposed Precambrian and Paleozoic bedrock in the Churchill area has been briefly documented by various geologists for over 50 years. However, the results of detailed trace element analyses for metallic occurrences are unknown and no studies have been done to determine if improvements in the silica content of the Churchill Quartzite are possible. During 2000 and 2003, a few weeks were spent near Churchill collecting new samples for trace element analyses and beneficiation of the quartzite. The results of the trace element analyses of the Precambrian Churchill Quartzite and Paleozoic dolomite indicate that they are barren of economic mineralization. An attempt is being made to recover a high-purity silica source from a crushed composite Churchill Quartzite sample through selective screening, washing and sorting.

Introduction

The shoreline in the vicinity of Churchill, Manitoba, shown in Figure GS-22-1, is composed of a core of Precambrian quartzite surrounded by Ordovician and Silurian carbonate. This exposed bedrock has been used, and is still being used locally, as aggregate (Fig. GS-22-2) and building stone. The use of crushed stone for aggregate was described by Bamburak (2000) and outlined in greater detail, along with a discussion of sand and gravel resources, by Groom (2001).

Figure GS-22-2 shows the recently completed Churchill Weir constructed from over 200 000 m^3 of Churchill Quartzite aggregate. The weir was designed to raise the water level in the vicinity of Churchill to enhance the use of the river by the public and to improve aquatic life, which had been affected by the Churchill River Diversion at

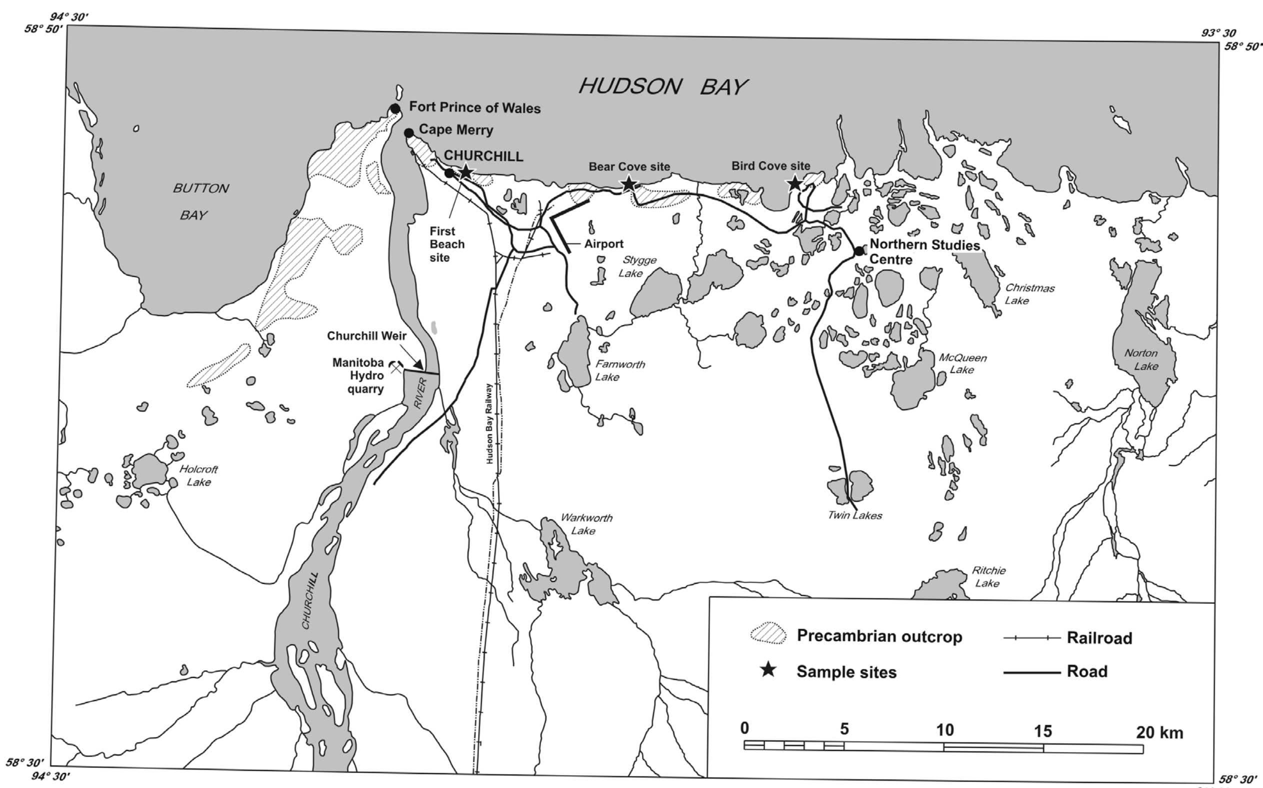


Figure GS-22-1: Churchill and vicinity with sample sites.

Figure GS-22-2: Churchill Weir constructed with Churchill Quartzite aggregate.

Southern Indian Lake. Crushed stone for construction of the weir was quarried from the Manitoba Hydro quarry, located 0.5 km to the west.

Although various geologists have briefly documented the presence of metallic occurrences within exposed Precambrian and Paleozoic bedrock in the Churchill area (Bamburak, 2000); the results of previous detailed trace element analyses are unknown. Similarly, there are no known follow-up studies to determine if improvements in the silica content of the Churchill Quartzite can be achieved.

To correct these deficiencies, field samples were collected during 2000 and 2003. Precambrian and Phanerozoic bedrock outcrops and quarry locations in the Churchill area were inventoried over a nine-day period in July 2000. The results of the sample analyses are discussed below. Additional quartzite samples for silica analyses were collected during five days of field investigation in June 2003. The Manitoba Geological Survey carried out diamond drilling, also in June 2003, for the Manitoba Museum (Young et al., GS-23, this volume).

Precambrian and Paleozoic geology

The Precambrian and Paleozoic geology of the Churchill area is outlined in Table GS-22-1 (*modified from* Bostock [1969] and Schledewitz [1986]). The Precambrian Churchill Quartzite is unconformably overlain by the Ordovician Churchill River Group, which is overlain by the Silurian Severn River Formation.

Precambrian Churchill Quartzite forms a low ridge rising above dipping Ordovician Churchill River Group beds. The beds are draped over the flanks of the quartzite, which had been eroded prior to the deposition of the younger sediment. Breccia clasts, which have spalled from the quartzite, are cemented by carbonate infill.

Precambrian

Williams (1948) described the Precambrian Churchill Quartzite as being roughly 70% well-rounded quartz and 30% interstitial sericite. Bostock (1969) applied the term “subgreywacke” to the unit. Schledewitz (1986) concluded that the Churchill Quartzite is an interlayered series of orthoquartzite, protoquartzite and minor conglomerate. He stated

Table GS-22-1: Geological units, Churchill area (modified from Bostock [1969] and Schledewitz [1986]).

Geological unit	Maximum thickness (m)	Lithology
Silurian		
Severn River Formation	150	dolomitic limestone, with up to 25% quartz sand in lower beds
Ordovician		
Churchill River Group	90	dolomite and limestone
Precambrian		
Churchill Quartzite	730	interlayered orthoquartzite, protoquartzite and subgreywacke

that the clastic component usually consists of over 80% fine- to medium-grained, rounded quartz grains. Clasts of quartzite, when present, form 0–3% of the total volume. Authigenic sericite content ranges from 3–20%, and occasionally up to 25%. Hematite (1–5%) and minor, very fine-grained chlorite (0–3%) can also occur locally.

Paleozoic

The Ordovician Churchill River Group is composed of cherty limestone and dolomite, bituminous limestone and mottled dolomitic limestone. Some beds are crinoidal, and minor brecciated beds are also present (Sanford et al., 1968). Large trilobite, coral and gastropod fossils have been found in the Churchill River Group.

The Silurian Severn River Formation disconformably overlies the Churchill River Group and may rest directly on the Precambrian quartzite (Bostock, 1969). The formation consists primarily of brown and tan, finely crystalline limestone and dolomite, and mottled limestone. The lower beds may contain imbedded sand and pebbles (Sanford et al., 1968). The distinct *Virgiana* brachiopods have been found near the base of this formation.

Metallic resource potential

Mineralized and sheared samples of Precambrian Churchill Quartzite and Paleozoic carbonate have been submitted in previous years to Activation Laboratories in Ancaster, Ontario, for instrumental neutron activation analysis (INAA) and inductively coupled plasma (ICP) trace element analysis. Results of these analyses are described below.

Precambrian

The presence of shear zones, specular hematite and lazulite within the Churchill Quartzite has been noted by numerous geologists in the Churchill area (Bamburak, 2000).

At the Bird Cove site (Fig. GS-22-1), three samples (99-00-CH-001A, -001B, -001C) from shear zones within the Churchill Quartzite were collected in 2000 (Table GS-22-2). The results of trace element analyses are shown in Table GS-22-3. The shear zone samples don’t show any economically significant mineralization. The elevated values for tungsten in most of the quartzite samples is due to the plates used to crush the samples in the laboratory.

Specular hematite occurs within quartz veins that intruded the Churchill Quartzite, and is also found along the bedding planes and as disseminated grains in the quartzite. In 2000, a sample of quartzite (99-00-CH-012B) containing visible specular hematite was collected at the Bear Cove site (Fig. GS-22-1, Table GS-22-2). Trace element analyses of the sample, shown in Table GS-22-3, does not show any mineralization of economic significance. The results are very similar to those of the shear zone samples, except for a very slight increase in iron (Fe) content, which is expected in a sample containing specular hematite.

Fractured pale blue lazulite can occasionally be seen as irregular masses, up to 4 cm in diameter, within the quartzite. Sample 99-00-CH-028 (Table GS-22-2) was collected from the western portion of the First Beach site (Fig. GS-22-1) in 2000. Results of the trace element analyses of the lazulite-bearing sample (Table GS-22-3) do not indicate any economic mineralization associated with the lazulite.

Table GS-22-2: Details of sample sites in the Churchill area.

Sample no.	Location	NAD	Zone	Easting	Northing	NTS	Geological unit	Lithology	Date collected
Paleozoic									
99-98-ED	First Beach-site 1-main site	27	15V	433950	6514980	54L16SE	Churchill River Group	Dolomite with pyrite	1998-07-17
99-99-ED-028	Bird Cove-site 3-Norford site	27	15V	450250	6514670	54L16SE	Severn River Formation	Dolomite with pyrite	1999-07-21
99-99-ED-038	Bird Cove-site 3-Norford site	27	15V	450250	6514670	54L16SE	Severn River Formation	Dolomite with pyrite	1999-07-21
99-00-CH-001D	Bird Cove-site 3-Norford site	27	15V	450257	6514407	54K13SW	Severn River Formation	Dolomite with pyrite	2000-07-18
99-00-CH-002G	First Beach-site 1-main site	83	15V	433936	6514995	54L16SE	Churchill River Group	Dolomite with pyrite	2000-07-19
99-00-CH-002AB	First Beach-site 1-main site	83	15V	433936	6514995	54L16SE	Churchill River Group	Dolomite with pyrite	2000-07-19
Precambrian									
99-00-CH-001A	Bird Cove-site 3-Norford site	27	15V	450257	6514407	54K13SW	Churchill Quartzite	Quartzite, sheared	2000-07-18
99-00-CH-001B	Bird Cove-site 3-Norford site	27	15V	450257	6514407	54K13SW	Churchill Quartzite	Quartzite, sheared	2000-07-18
99-00-CH-001C	Bird Cove-site 3-Norford site	27	15V	450257	6514407	54K13SW	Churchill Quartzite	Quartzite, sheared	2000-07-18
99-00-CH-012B	Bear Cove	27	15V	441952	6513914	54K13SW	Churchill Quartzite	Quartz vein with specular hematite	2000-07-22
99-00-CH-028	First Beach-site 1-main site west	27	15V	433472	6514791	54L16SE	Churchill Quartzite	Quartz vein with lapis lazulite	2000-07-25

Table GS-22-3: Trace element analyses of Churchill Quartzite and Paleozoic samples from the Churchill area (by instrumental neutron activation analysis [INAA] and inductively coupled plasma optical emission spectroscopy [ICP-OES] and inductively coupled plasma cold vapour [ICP-CV]).

Element	Au	As	Ba	Br	Co	Cr	Cs	Fe	Hf	Ir	Na	Rb	Sb	Sc
Units	(ppb)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(%)	(ppm)	(ppb)	(%)	(ppm)	(ppm)	(ppm)
Method	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA
Detection limit	2	0.5	50	0.5	1	5	1	0.01	1	5	0.01	15	0.1	0.1
Paleozoic														
99-98-ED	-2	10	-50	15.4	39	-5	-1	21.7	-1	-5	0.03	-15	0.2	0.5
99-99-ED-028	-2	2	-50	13.3	-1	-5	-1	0.5	-1	-5	0.06	-15	-0.1	0.2
99-99-ED-038	-2	1.8	-50	15.9	-1	-5	-1	0.42	-1	-5	0.05	-15	-0.1	0.7
99-00-CH-001D	-2	1.4	-50	11.9	7	-5	-1	0.28	-1	-5	0.04	-15	-0.1	0.3
99-00-CH-002G	-2	19.5	-50	9.1	36	7	-1	27.6	-1	-5	0.04	-15	0.8	0.8
99-00-CH-002AB	-2	22	-50	4.1	48	13	-1	18.7	-1	-5	0.04	40	0.5	2.1
Precambrian														
99-00-CH-001A	-2	1.2	-50	2.2	1	16	-1	0.96	3	-5	0.04	63	0.3	4.4
99-00-CH-001B	-2	1.8	100	-0.5	15	21	-1	1.11	3	-5	0.04	61	0.3	4.5
99-00-CH-001C	3	1.1	150	-0.5	32	19	-1	1.67	-1	-5	0.04	50	0.3	5.4
99-00-CH-012B	-2	1.1	-50	1.8	46	6	-1	2.67	-1	-5	0.01	-15	-0.1	0.2
99-00-CH-028	-2	-0.5	-50	1.7	55	7	-1	2.43	-1	-5	0.02	-15	-0.1	0.5

Element	Se	Sn	Ta	Th	U	W	La	Ce	Nd	Sm	Eu	Tb	Yb	Lu
Units	(ppm)	(%)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
Method	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA
Detection limit	3	0.01	0.5	0.2	0.5	1	0.5	3	5	0.1	0.2	0.5	0.2	0.05
Paleozoic														
99-98-ED	-3	-0.01	-0.5	0.4	2	67	2.7	9	7	1.5	0.4	-0.5	0.3	-0.05
99-99-ED-028	-3	-0.01	-0.5	-0.2	-0.5	-1	0.9	-3	-5	0.1	-0.2	-0.5	-0.2	-0.05
99-99-ED-038	-3	-0.01	-0.5	0.6	0.7	-1	1.9	4	-5	0.2	-0.2	-0.5	-0.2	-0.05
99-00-CH-001D	-3	-0.01	0.5	-0.2	-0.5	45	1.2	-3	-5	0.2	-0.2	-0.5	-0.2	-0.05
99-00-CH-002G	-3	-0.01	-0.5	1.6	5.7	89	4.4	13	-5	1.3	-0.2	-0.5	0.3	-0.05
99-00-CH-002AB	-3	-0.01	1	3.3	3.1	124	11.9	18	13	2	0.5	-0.5	0.6	0.11
Precambrian														
99-00-CH-001A	-3	-0.01	0.7	6.9	0.9	-1	23.5	41	14	2.5	0.5	-0.5	1.1	0.2
99-00-CH-001B	-3	-0.01	1	7.8	1.2	131	24	41	12	2.5	0.4	-0.5	1.4	0.22
99-00-CH-001C	-3	-0.01	1.7	7.4	1.6	236	24.2	38	8	2.2	0.4	-0.5	1.2	0.18
99-00-CH-012B	-3	-0.01	1.4	-0.2	-0.5	393	2.4	4	-5	0.3	-0.2	-0.5	-0.2	-0.05
99-00-CH-028	-3	-0.01	1.5	2.2	-0.5	448	3.3	7	-5	0.6	-0.2	-0.5	0.3	0.05

Paleozoic

In July 1998, pyrite-rich Upper Ordovician Churchill River Group dolomite was found on the shore of Hudson Bay at the First Beach site (Fig. GS-22-1) by G. Young and others, of the Manitoba Museum (G. Young, pers. comm., 1998) The vuggy fossiliferous crystalline dolomite occurs as a cemented matrix between quartzite boulders. The vugs and fossil interiors contain millimetre-sized cubes of pyrite. E. Dobrzanski of the Manitoba Museum dissolved a 107 g dolomite sample, with finely disseminated pyrite, in 10% acetic acid. He noted an earthy green coating on all sulphide fragments (E. Dobrzanski, pers. comm., 1998). The location of a dolomite sample (99-98-ED) collected from the First Beach site (Fig. GS-22-1) is detailed in Table GS-22-2 and its trace element analysis is listed in Table GS-22-3. As expected in a sulphide sample, elevated values of iron and sulphur were found. However, other trace elements were not anomalous.

In July 1999, two samples, 99-99-ED-028 and -038, (Table GS-22-2) were collected from the Lower Silurian Severn River Formation dolomite at the Bird Cove site (Fig. GS-22-1) by G. Young. This site is stratigraphically higher in the section than the First Beach site. The results of the trace element analyses of these samples (Table GS-22-3) show much lower levels of iron and sulphur than sample 99-98-ED. Other trace elements in Bird Cove samples returned higher values than in the First Beach sample (99-98-ED) but are not anomalous.

In July 2000, additional sampling at the First Beach site (99-00-CH-002G and –002AB; Table GS-22-2) was

Table GS-22-3: Trace element analyses of Churchill Quartzite and Paleozoic samples from the Churchill area (by instrumental neutron activation analysis [INAA] and inductively coupled plasma optical emission spectroscopy [ICP-OES] and inductively coupled plasma cold vapour [ICP-CV]). *(continued)*

Element	Mo	Cu	Pb	Zn	Ag	Ni	Mn	Sr	Cd	Bi
Units	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
Method	ICP-OES	ICP-OES	ICP-OES	ICP-OES	ICP-OES	ICP-OES	ICP-OES	ICP-OES	ICP-OES	ICP-OES
Detection limit	2/1	1	0.5/0.3	1	0.5/0.3	1	1	1	0.5/0.3	5/2
Paleozoic										
99-98-ED	-2	15	37	2	-0.4	24	145	25	1.3	7
99-99-ED-028	-2	-1	-5	2	-0.5	2	229	35	-0.5	-5
99-99-ED-038	-2	-1	-5	3	-0.5	1	196	58	-0.5	-5
99-00-CH-001D	3	7	7	2	-0.3	2	92	40	-0.3	-2
99-00-CH-002G	3	26	42	4	-0.3	14	77	16	1.3	-2
99-00-CH-002AB	1	24	51	5	0.3	20	76	25	-0.3	-2
Precambrian										
99-00-CH-001A	4	3	5	3	-0.3	2	4	17	-0.3	-2
99-00-CH-001B	2	5	3	2	-0.3	2	5	19	-0.3	-2
99-00-CH-001C	1	4	-3	4	-0.3	16	20	16	-0.3	-2
99-00-CH-012B	-1	4	-3	3	-0.3	13	22	22	-0.3	-2
99-00-CH-028	3	3	-3	-1	-0.3	8	24	13	-0.3	-2

Element	V	Ca	P	Mg	Ti	Al	K	Y	Be	S	Hg
Units	(ppm)	(%)	(%)	(%)	(%)	(%)	(%)	(ppm)	(ppm)	(%)	(ppb)
Method	ICP-OES	ICP-OES	ICP-OES	ICP-OES	ICP-OES	ICP-OES	ICP-OES	ICP-OES	ICP-OES	ICP-OES	ICP-CV
Detection limit	2	0.01	0.001	0.01	0.01	0.1	0.01	2/1	2/1	0.01	5
Paleozoic											
99-98-ED	5	11.76	0.006	5.36	0.01	0.07	0.04	2	-2	26.2	26
99-99-ED-028	2	18.02	0.004	9.94	-0.01	0.05	0.06	-2	-2	0.2	n/a
99-99-ED-038	3	18.25	0.015	10.01	0.01	0.26	0.31	-2	-2	0.14	n/a
99-00-CH-001D	-2	10.85	0.001	6.68	-0.01	0.08	0.04	-1	-1	0.103	n/a
99-00-CH-002G	3	3.54	0.006	2.22	-0.01	0.22	0.09	2	-1	17.496	n/a
99-00-CH-002AB	9	1.64	0.012	0.98	0.02	1.11	0.50	5	-1	14.423	n/a
Precambrian											
99-00-CH-001A	24	0.01	0.005	0.07	0.08	2.15	1.29	4	-1	0.245	n/a
99-00-CH-001B	26	0.03	0.006	0.09	0.09	2.39	1.31	5	-1	0.312	n/a
99-00-CH-001C	30	0.03	0.014	0.24	0.09	2.85	1.54	3	-1	0.003	n/a
99-00-CH-012B	7	0.04	0.006	0.12	0.02	0.14	0.02	-1	-1	0.015	n/a
99-00-CH-028	7	0.05	0.012	0.07	0.02	0.43	0.08	1	-1	0.010	n/a

carried out (Bamburak, 2000) to determine if there are lateral changes in sulphide composition surrounding the sample collected in 1998 (99-98-ED). Table GS-22-3 shows the results of the trace element analyses of samples 99-00-CH-002G and -002AB. Most values are very low, with the exception of those for iron and sulphur. This indicates that lateral changes in sulphide composition along the First Beach site are unlikely.

At the Bird Cove site, a sample (99-00-CH-001D) of pyritiferous dolomite (Table GS-22-2) was collected (Bamburak, 2000) from the Silurian Severn River Formation. The result of the analysis, shown in Table GS-22-3, confirmed the relatively low trace element values obtained in samples 99-99-ED-028 and 038, described above.

Silica resource potential

The average silica grade of 19 Churchill Quartzite samples, collected by Watson (1985) and Shledewitz (1986), is 89.31% SiO_2. It should be noted that the average SiO_2 content of the quartzite samples collected west of the Churchill River is slightly higher than those to the east (Table GS-22-4). Watson concluded that most of the samples met the specifications for silicon carbide, ferro-silicon and various fluxes. However, the results also indicated that there was no potential for higher purity uses without further beneficiation (selective screening, washing and sorting). The main impurities in the quartzite are mica (sericite) and minor feldspar.

Table GS-22-4: Average whole rock analyses of Churchill Quartzite samples (from Schledewitz [1986] and Watson [1985]).

Element	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	FeO (%)	CaO (%)	MgO (%)	Na_2O (%)	K_2O (%)	TiO_2 (%)	P_2O_5 (%)	MnO (%)	H_2O (%)	S (%)	CO_2 (%)
West of Churchill River (13 samples)	90.07	4.84	2.17	0.20	0.04	0.12	0.05	1.20	0.14	0.03	0.00	0.76	0.03	0.14
East of Churchill River (6 samples)	87.68	6.32	1.69	0.33	0.07	0.41	0.05	2.03	0.20	0.03	0.02	0.96	0.01	0.13

Samples of Churchill Quartzite collected during 2000 and 2003 have been submitted for whole rock analyses to confirm previous results. Unused portions of these samples will then be combined into a bulk sample, which will be tested to see if the SiO_2 content can be efficiently and economically improved as suggested by Watson (1985).

Conclusions

The results of the trace element analyses of the Precambrian Churchill Quartzite and Paleozoic dolomite indicate that they are barren of economic mineralization.

Higher value end uses of the Churchill Quartzite, other than for construction, will depend on the success of selective screening, washing and sorting processes.

Economic considerations

The use of exposed Precambrian and Paleozoic bedrock as an aggregate source in the Churchill area will likely grow in the future, as the depletion of favourable sand and gravel resources continues and the need to preserve undisturbed habitat for ecotourism intensifies. Increased exposure of Paleozoic bedrock, through quarrying, would assist in the potential discovery of new fossils, such as 'the world's largest trilobite' found in 1998 (Bamburak, 2000). Such discoveries would help ensure Churchill was internationally recognized as a destination for ecotourists.

Churchill Quartzite meets the specifications for silicon carbide, ferro-silicon and various fluxes according to Watson (1985). However, the proving up, through beneficiation, of a high-purity silica deposit on the shore of Hudson Bay would be a welcome raw material source that could be easily exported by ship, as well as having potential for local production of value-added commodities, such as glass containers.

Acknowledgements

The Manitoba Museum is gratefully acknowledged for providing mineralized samples collected from the Churchill area in 1998 and 1999 for analyses, and for facilitating fieldwork carried out in July 2000. Staff of the Northern Studies Centre are thanked for providing good accommodations, transportation and food for Manitoba Geological Survey geologists and drillers. R. Bezys is gratefully acknowledged for critically reading the manuscript.

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