GS-24 Manitoba Geological Survey’s Stratigraphic Corehole Drilling Program, 2006 (parts of NTS 62N16 and 63C1)

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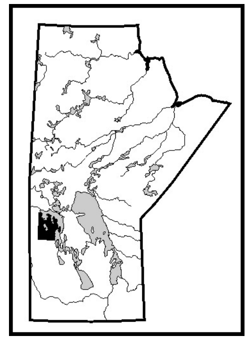

Summary

Under the 2006 Corehole Drilling Program of the Manitoba Geological Survey (MGS), two stratigraphic coreholes were drilled west of Lake Winnipegosis. Corehole M-1-06, completed to a depth of 75.4 m, confirmed the presence, at surface, of the Devonian Winnipegosis Formation further to the south than previously thought. The hole ended in Devonian Ashern Formation and provided core samples in an area where it had not been previously intersected. Corehole M-2-06 was drilled to 90.7 m into the Winnipegosis Formation and is the deepest and furthest west corehole to be drilled along PR 271.

The area west of Lake Winnipegosis has been indicated as a potential region for Upper Mississippi Valley-type (MVT) mineralization in several studies previously carried out by the MGS. Vertical movements within the Superior Boundary Zone of the Precambrian basement are believed to have induced fracturing in the overlying Paleozoic carbonates providing pathways for metal-rich fluids. Anomalous concentrations of lead, zinc, copper and nickel have been found in previously analyzed drillcore. Split samples from the new holes will be chemically analyzed and the results added to the Survey’s Phanerozoic Geochemical Database.

The presence of anomalous mineralization, from previous studies, seems to indicate that MVT mineralization extends southwest of Pemmican Island (in the north basin of Lake Winnipegosis) for over 100 km along the trend of the Superior Boundary Zone. The Pine Point mining district of the Northwest Territories, with its association with the Great Slave Shear Zone, may possibly serve as a model for MVT mineralization in Manitoba.

Introduction

Under the Manitoba Geological Survey (MGS) Corehole Drilling Program conducted in 2006, two coreholes (Figure GS-24-1) were drilled in west-central Manitoba, near Lake Winnipegosis. The coreholes were selected to enhance the Survey’s stratigraphic knowledge of the Devonian stratigraphy in an area where carbonate outcrops appear to be very similar and limited drilling has been conducted. According to McCabe and Barchyn (1982), the Devonian sequence, shown from bottom to top in Figure GS-24-2, comprises a series of four complex shallowing-upward shale-carbonate-evaporite cycles:

1) The Elk Point Group, consisting of the basal Ashern Formation overlain by the Winnipegosis/Elm Point Formation and the Prairie Evaporite, is the first, thickest and best defined cycle.
2) The second cycle is represented by five members of the Dawson Bay Formation. The basal member of the cycle is the Second Red Beds overlain by the Lower, Middle and Upper members of the Dawson Bay Formation and the Hubbard Evaporite (now dissolved in Manitoba).
3) The third cycle comprises the Point Wilkins Member of the Souris River Formation, initiated by the First Red Beds. The basal unit is overlain by the Lower, Middle and Upper beds of the Point Wilkins Member and culminating with the Davidson Evaporite (now dissolved in Manitoba).
4) The fourth cycle consists of a basal shale overlain by a carbonate bed within the Sagemace Member of the Souris River Formation. The presence of an evaporite at the top of the member is suspected.

A secondary objective was to provide drillcore samples from the west side of Lake Winnipegosis for the Survey’s geochemical database. In 1981, the MGS initiated the chemical analysis of 30 cm intervals of stratigraphic drillcore (Gale et al., 1981). By 1985, a total of 6301 core samples had been analyzed from 66 coreholes, mainly within the Paleozoic outcrop belt of southwestern Manitoba (Gale and Conley, 2000). The study indicted the potential for ‘widespread’ Upper Mississippi Valley-type (MVT) mineralization within Paleozoic rock in the vicinity of the buried Precambrian Superior Boundary Zone (SBZ) on the basis of anomalous base-metal values detected west of Lake Winnipegosis. Gale and Conley (2000) documented previous studies that suggested MVT mineralization may have occurred in Manitoba in the following succession:

1) vertical fractures penetrated upwards into the overlying Paleozoic rock due to basement re-activation along the SBZ;
2) basement and interformational fluids used the fractures as pathways, allowing the brines to dissolve out evaporite beds, such as the Prairie Evaporite (Figure GS-24-2);
3) collapse of the overlying stratigraphic units occurred due to the removal of the evaporites;

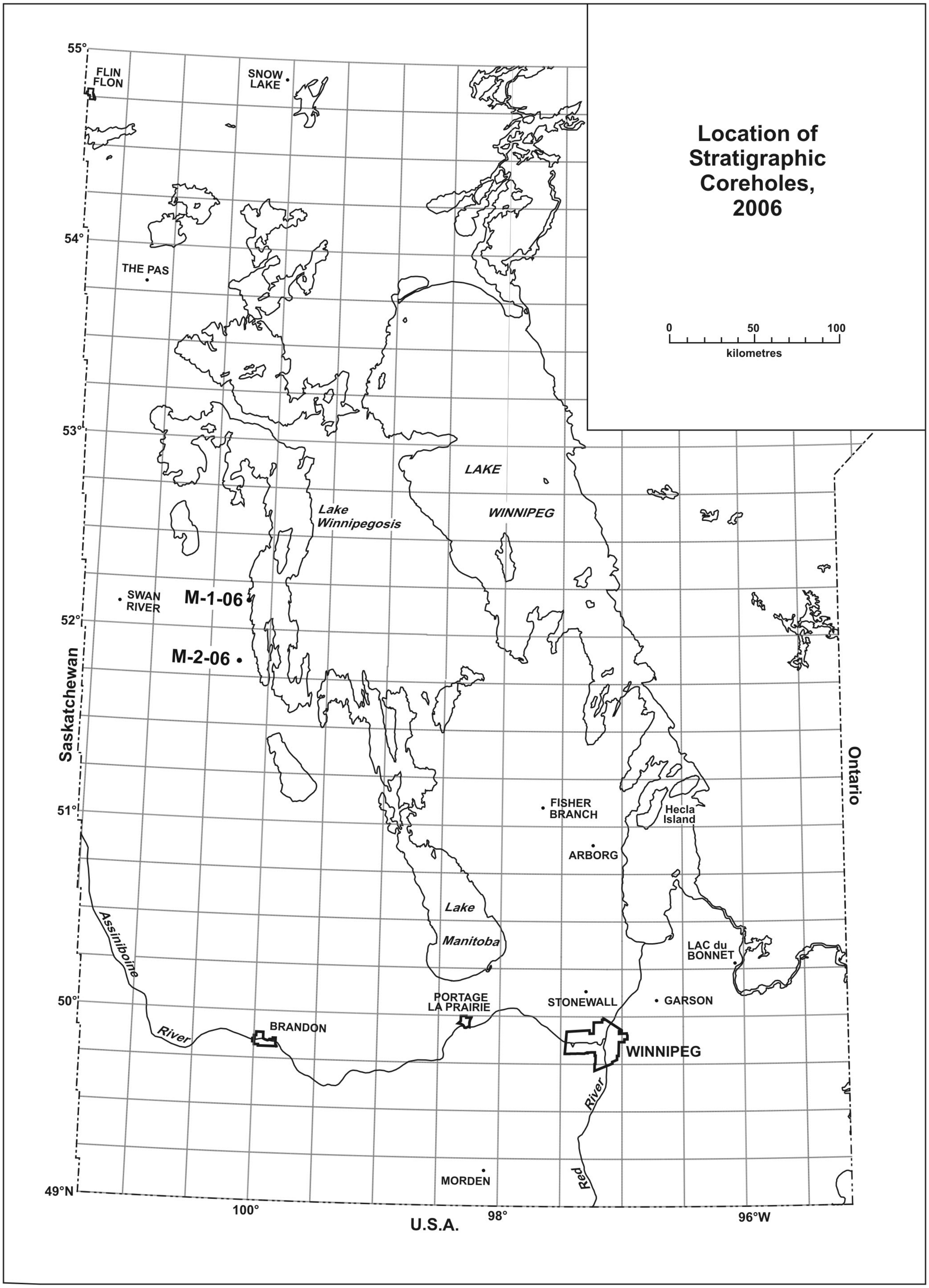

Figure GS-24-1: *Location of Manitoba Geological Survey's stratigraphic coreholes, 2006.*

Period	Group/Formation	Member	Unit	Depositional thickness (m)	Summary lithology
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DEVONIAN	SOURIS RIVER FORMATION		Sagemace Member	20+	Limestone, pale yellowish brown to reddish grey, microcrystalline, dense, minor argillaceous interbeds. Passes laterally to totally dolomitized sequence.
DEVONIAN	SOURIS RIVER FORMATION		basal shale	2-14	Shale, dolomitic, massive, medium brownish red with some greenish mottling.
DEVONIAN	SOURIS RIVER FORMATION	Point Wilkins Member	(evaporite dissolved)		(Davidson Evaporite)
DEVONIAN	SOURIS RIVER FORMATION	Point Wilkins Member	Upper Point Wilkins	10	Dolomite and dolomitic limestone, light grey to medium yellowish brown, partly mottled, coarsely microcrystalline, subsaccharoidal with remnant calcareous biomicrite.
DEVONIAN	SOURIS RIVER FORMATION	Point Wilkins Member	Middle Point Wilkins	14-21	Limestone (pure high-calcium), pale yellowish brown, faintly mottled, finely microcrystalline to cryptocrystalline, dense and tight (sublithographic), fossiliferous, in part intraclastic.
DEVONIAN	SOURIS RIVER FORMATION	Point Wilkins Member	Lower Point Wilkins	9-15	Limestone, slightly to moderately argillaceous with some interbeds calcareous shale, medium to light reddish and purplish grey, fossiliferous intramicrite, locally calcarenitic.
DEVONIAN	SOURIS RIVER FORMATION	Point Wilkins Member	First Red Beds	3-14	Shale, dolomitic, medium reddish grey to dark brownish red, in part mottled and brecciated. Several interbeds buff argillaceous limestone to brown argillaceous dolomite.
DEVONIAN	DAWSON BAY FORMATION		(evaporite dissolved)		(Hubbard Evaporite)
DEVONIAN	DAWSON BAY FORMATION		Upper Dawson Bay	6-17	Limestone, white to pale yellowish brown, highly fossiliferous with corals and stromatoporoids, in places grading to stromatoporoid biolithite. In part extremely pure high-calcium limestone (99.8% $CaCO_3$), but in places variably dolomitized, especially lower part of unit.
DEVONIAN	DAWSON BAY FORMATION		Middle Dawson Bay	11-18	Calcareous shale, fossiliferous, medium grey to dark greyish red, massive (recessive).
DEVONIAN	DAWSON BAY FORMATION		Lower Dawson Bay	9-25	Gradational sequence passing upward from brown partly laminated and bituminous dolomite to grey and reddish grey dense slightly argillaceous micrite and fossiliferous micrite, which in turn grades upward to highly fossiliferous brachiopod biomicrite at top. Lower two zones thin markedly to the north.
DEVONIAN	DAWSON BAY FORMATION		Second Red Beds	6-15	Red to greenish grey dolomitic shale, commonly brecciated as a result of salt collapse.
DEVONIAN	ELK POINT GROUP		PRAIRIE EVAPORITE	0-129	Prairie Evaporite: dominantly salt with potash interbeds and minor anhydrite in basinal areas; entirely anhydrite in shelf areas (at present). Originally present throughout the entire Devonian outcrop belt, but subsequently removed by subsurface salt solution. Where preserved in subsurface, overlaps and completely buries Winnipegosis reefs with resultant thinning of evaporite section.
DEVONIAN	ELK POINT GROUP	WINNIPEGOSIS FORMATION	Upper Winnipegosis (reef)	0-90	Reefal facies: dolomite, very fine to medium crystalline, ranges from compact dense to subsaccharoidal, massive to medium/thick bedded, variably fossiliferous but texture largely obscured by dolomitization. Reef thicknesses tend to be relatively uniform in a given area.
DEVONIAN	ELK POINT GROUP	WINNIPEGOSIS FORMATION	Upper Winnipegosis (inter-reef)	35	Inter-reef facies: dolomite, brown to black, finely laminated with black bituminous partings, in places calcareous. Lamination best defined towards top of unit.
DEVONIAN	ELK POINT GROUP	WINNIPEGOSIS FORMATION	Lower Winnipeg-osis	10-20	Lower Winnipegosis: dolomite, fine to medium crystalline, moderately granular to saccharoidal, medium to thin bedded. In part calcareous and grades laterally to Elm Point limestone facies.
DEVONIAN	ELK POINT GROUP		ELM POINT FORM.	10-20	Elm Point: limestone, pale yellowish brown, dense, fine grained, biomicrite. In part shows lighter yellowish dolomitic mottling. Pure high-calcium limestone to calcareous dolomite.
DEVONIAN	ELK POINT GROUP	ASHERN FORMATION		3-18	Argillaceous dolomite and dolomitic shale, medium to dark greyish and brownish red, in places reduced to greenish grey. Local basal dolomite breccia.
SIL.	INTERLAKE GROUP				Dolomite, white to pale yellowish buff, mostly microcrystalline dense, thin bedded, sublithographic, in part stromatolitic. Some porous biostromal interbeds towards top.

***Figure GS-24-2:** Detailed Devonian stratigraphic succession and lithology (from McCabe and Barchyn, 1982; Bezys and McCabe, 1996).*

4) continued migration of basement and inter-formational fluids, some possibly containing metallic sulphides, into fractured and brecciated carbonates; and
5) precipitation of metals in a trap below an unfractured shale aquitard, such as the Ashern Formation (Figure GS-24-2).

Duck Bay

The community of Duck Bay is situated on the west shore of Lake Winnipegosis, approximately 20 km north of Camperville, and on the northern end of PR 272. In 1973, corehole M-8-73 (Figure GS-24-3) was drilled on the southern margin of the community to a depth of 28.9 m. The lack of a distinct marker within the dolomitic interval initially produced difficulties in the regional correlation of the hole according to McCabe (1973). The Winnipegosis Formation designation of the core was only reached with much reservation. To confirm the 1973 interpretation, a deeper corehole was to be drilled in 2006 at the site of corehole M-8-73. However, because of

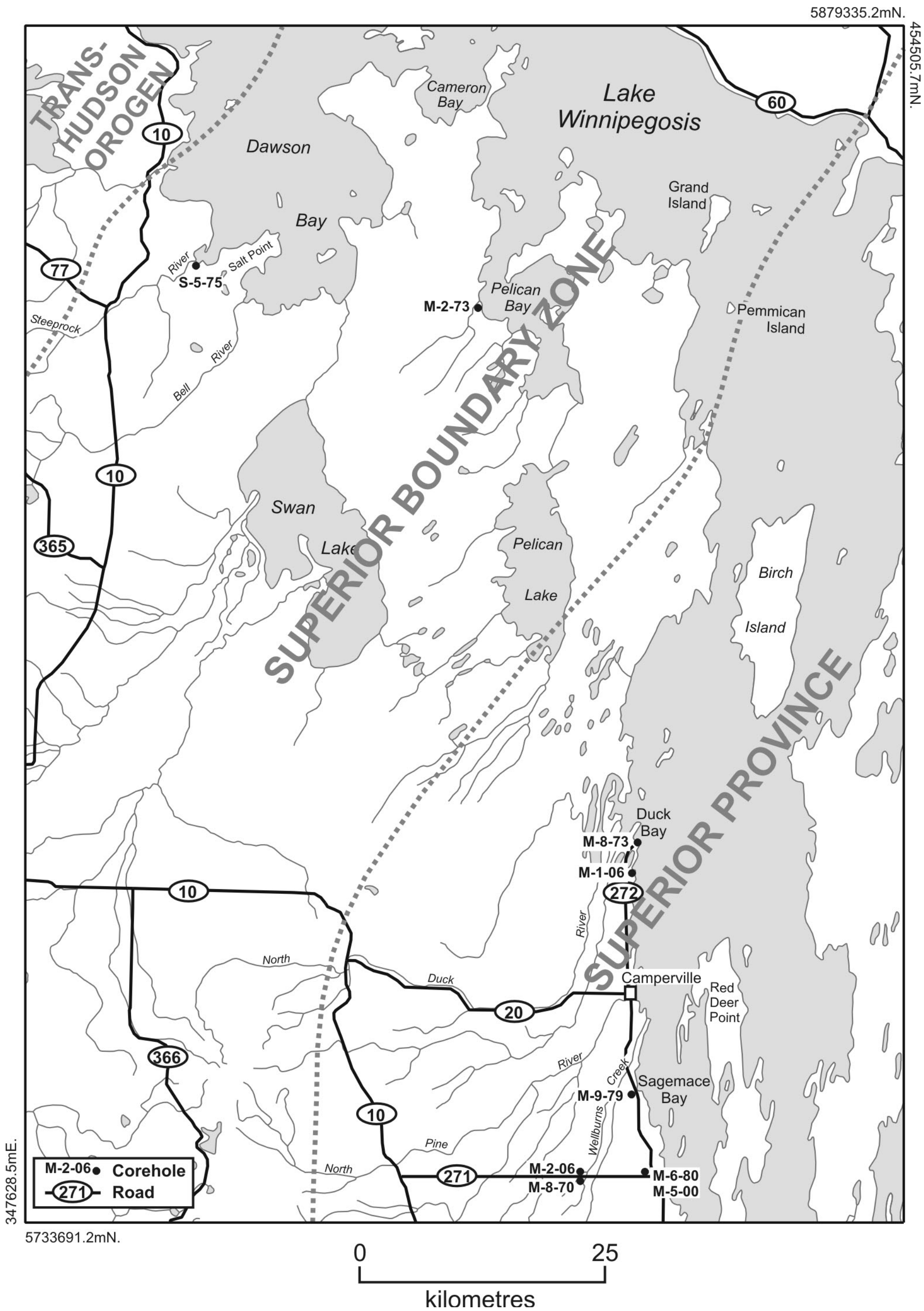

***Figure GS-24-3:** Selected stratigraphic holes west of Lake Winnipegosis and the location of Pemmican Island.*

surface development since 1973, it was discovered that the previously exposed outcrop was buried beneath overburden and a new drill site was selected in the vicinity of a bedrock quarry situated 5 km to the south.

In early August 2006, corehole M-1-06 (Figure GS-24-1) was completed to a depth of 75.4 m, ending in the Ashern Formation (Figure GS-24-2; Table GS-24-1). The new hole proved that the Winnipegosis Formation not only underlies the community of Duck Bay, but also outcrops at least 5 km further to the south than previously thought. The core from M-1-06 will be split and half of the core will be crushed and sent for instrumental neutron activation analysis (INAA) and inductively couple plasma (ICP) analysis.

Wellburns Creek (formerly Point River)

McCabe and Bannatyne (1970) drilled corehole M-8-70 (Figure GS-24-3) in 1970, south of PR 271, immediately east of a tributary to Wellburns Creek (formerly Point River), west of Lake Winnipegosis. The corehole was drilled with a Winkie drill to a depth of 49.7 m, with poor core recovery (17.7 m). To improve upon the 1970 core recovery and to drill closer to the eastern margin of the SBZ, it was decided in 2006 to drill a deep hole west of the site for corehole M-8-70.

In mid-August 2006, corehole M-2-06 was completed to a depth of 90.7 m, ending in Upper Member of the Winnipegosis Formation (Figure GS-24-3; Table GS-24-1). Although the upper part of the new corehole was broken up and had some missing core, recovery was generally good below 38 m. Pyrite mineralization was noted throughout the corehole and a possible sphalerite/galena grain was noted in a fracture shear within the Second Red Beds of the Dawson Bay Formation at a depth of about 72.8 m. It should be noted that coreholes M-6-80 and M-5-00 (Figure GS-24-3), located at the rehabilitated Pine River Junction quarry, 8 km to the east of corehole M-2-06, both contained sphalerite crystals (Bamburak et al., 2000) and anomalous Zn values within the Winnipegosis Formation (Gale and Conley, 2000; Table GS-24-2).

The presence of Pb-Zn mineralization, if confirmed by INAA/ICP analysis, in corehole M-2-06 would mark the third time that MVT mineralization has been found in drillcore recovered along the eastern end PR 271.

Table GS-24-1: Summary of stratigraphic corehole data, 2006.

Hole no.	Location and elevation (m asl)	SYSTEM/Formation/ (Member)	Interval (m)	Lithology summary
M-1-06 Duck Bay South	12-29-36-19W 5775207N 421140E 258	DEVONIAN/Winnipegosis/ (Upper)	0.0-53.0	Reef facies, dolomite, buff, well defined bedding with massive stromatolites, good to excellent fine vuggy (birdseye) porosity
		(Lower)	53.0-68.0	Platform facies, dolomite, buff, mottled, massive near top, pinpoint porosity near middle, and sand infill near base in caves and vugs
		Ashern	68.0-75.4	Dolomite, argillaceous and shale, greenish and red mottled
M-2-06 Wellburns Creek West	02-04-33-20W 5739363N 415171E 280	DEVONIAN/Souris River/ (Sagemace)	0.0-17.7	Limestone, brown, fine grained with small vugs and shale, calcareous, grey to buff limestone and breccia with black sulphides
		(Point Wilkins)	17.7-26.0	Limestone, yellow and brown, sugary, vuggy
		(First Red Beds)	26.0-35.8	Shale, breccia with disturbed bedding, limestone and dolomite
		Dawson Bay/(Upper)	35.8-51.1	Dolomite, white and brown with shale and limestone
		(Middle)	51.1-63.5	Shale, buff to grey, calcareous shale with brachiopods
		(Lower)	63.5-66.7	Limestone, grey to buff, mottled, brachiopods, calcite filled vugs with fine pyrite
		(Second Red Beds)	66.7-85.1	Polymict collapse breccia, limestone, dolomite with fine pyrite, 72.7 to 72.9 subvertical fracture with 2 mm metallic grain with pryite and sphalerite/galena?
		Winnipegosis/(Transition Zone)	85.1-85.3	Dolomite, buff to grey, massive with stylolites and pyrite blebs
		(Upper)	85.3-90.7	Dolomite, buff, pinpoint porosity and larger in layers, stromatolith banding

Table GS-24-2: Selected copper, zinc, lead and nickel analyses from coreholes drilled in the vicinity of the north basin of Lake Winnipegosis and mean values from 6301 core samples (from Gale and Conley, 2000).

Corehole	Interval (m)	Cu (ppm)	Rank	Zn (ppm)	Rank	Pb (ppm)	Rank	Ni (ppm)	Rank	Formation
M-2-73	9.8–10.2	13	not ranked	27	not ranked	**64**	**4th**	0	not ranked	Dawson Bay
S-5-75	6.3–7.0	20	not ranked	**193**	**4th**	11	not ranked	**57**	**6th**	Dawson Bay
	48.8–49.4	4	not ranked	**162**	**6th**	0	not ranked	8	not ranked	Winnipegosis
M-9-79	30.5–30.8	6	not ranked	15	not ranked	**200**	**1st**	0	not ranked	Winnipegosis
M-6-80	21.0–21.3	7	not ranked	**147**	**7th**	1	not ranked	9	not ranked	Souris River
	52.4–53.1	11	not ranked	14	not ranked	1	not ranked	**49**	**10th**	Souris River
	97.3–97.6	8	not ranked	16	not ranked	1	not ranked	**55**	**7th**	Dawson Bay
	113.0–113.1	3	not ranked	**225**	**3rd**	1	not ranked	21	not ranked	Winnipegosis
	116.9–117.3	**160**	**3rd**	13	not ranked	8	not ranked	29	not ranked	Winnipegosis
Mean of 6301 samples		5.75±7		14.49±4		1.09±5		4.09±3		All
M-5-00*	115.0–116.0	156	n/a	65	n/a	6	n/a	19	n/a	Winnipegosis
	116.0–117.0	410	n/a	38	n/a	5	n/a	32	n/a	Winnipegosis

Notes:

Anomalous geochemical values and their rank within 6301 corehole samples of Gale and Conley (2000) are shown in bold for contrast with typical background and mean values.

* values from M-5-00 postdated the Gale and Conley study

n/a = not applicable

It should also be noted that Gale and Conley (2000) found evidence of MVT mineralization in the 6301 corehole samples they analyzed. The most significant occurrences are discussed below:

- approximately 30 km to the north-northwest of coreholes M-6-80 and M-5-00, the highest Pb value (200 ppm over 0.3 m) was found in corehole M-9-79 within the Winnipegosis Formation (Figure GS-24-3; Table GS-24-2);
- within the SBZ near Pelican Bay and 110 km north-northwest of corehole M-1-06, the fourth highest Pb value (64 ppm over 0.4 m) was found in corehole M-2-73 within the Dawson Bay Formation (Figure GS-24-3; Table GS-24-2); and
- on the western margin of the SBZ and 110 km north-west of corehole M-1-06, the fourth and sixth highest Zn values (193 ppm over 0.7 m and 162 ppm over 0.6 m, respectively) were found in corehole S-5-75 within the Dawson Bay and Winnipegosis formations, respectively (Figure GS-24-3; Table GS-24-2).

Evidence of MVT mineralization was also found by Bamburak and Klyne (2004). A hole drilled off the east shore of Pemmican Island (Figure GS-24-3) in the north basin of Lake Winnipegosis returned values of 4.59% Zn, 0.41% Pb and 0.014% Cu over 15 cm of the Silurian Interlake Group.

The regional dip of Devonian and older Paleozoic formations located between Dawson Bay and Sagemace Bay (Figure GS-24-3) is about 2 m/km to the south-south-west. The anomalous mineralization, described above, is found in Devonian and Silurian formations that are situated within or updip of the SBZ. This may indicate that there is a potential for MVT mineralization, which could extend for over 100 km along and parallel to the trend of the SBZ, in west-central Manitoba.

Pine Point Model

Gale and Conley (2000) suggested that the Pine Point mining district, in the Northwest Territories, could be a possible model for potential MVT mineralization in Manitoba. Pine Point is situated 1300 km northwest of corehole M-1-06, on the south side of the Great Slave Lake Shear Zone (and McDonald Fault). Over 87 Pb-Zn deposits, within karst structures, were defined within a 24 by 65 km area. From these deposits, at least 36 orebodies were mined by Pine Point Mines Ltd. (controlled and operated by Cominco Ltd.). Total production was 64.3 million tonnes averaging 3.4% Pb and 7.0% Zn (Symons et al., 1993). According to Wright et al. (1994), karst development in the Pine Point area was related to basement re-activation that induced fracturing in the dolomite overlying the Great Slave Lake Shear Zone. Deposition of most Pine Point orebodies occurred within a single interconnected paleokarst network where metallic sulphides precipitated from chloride-rich brines (Rhodes et al., 1984).

Economic considerations

Devonian stratigraphic studies not only help to resolve stratigraphic problems, but may also provide a further understanding of metal migration/emplacement in an area where anomalous sequences do exist. It is important that this information is studied and documented to enable the investigation of Manitoba's MVT mineral potential.

Acknowledgments

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