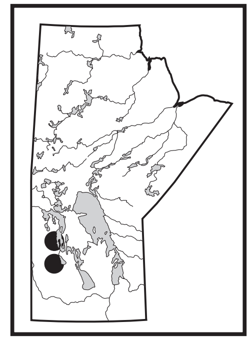
GS-16 Manitoba Geological Survey's Stratigraphic Corehole Drilling Program, 2007 (parts of NTS 62N1, 16, 63C1)

by J.D. Bamburak



Bamburak, J.D. 2007: Manitoba Geological Survey's Stratigraphic Corehole Drilling Program, 2007 (parts of NTS 62N1, 16, 63C1); *in* Report of Activities 2007, Manitoba Science, Technology, Energy and Mines, Manitoba Geological Survey, p. 166–174.

Summary

Under the 2007 Stratigraphic Corehole Drilling Program of the Manitoba Geological Survey (MGS), a total of three coreholes were drilled. Two of the coreholes were drilled west of Lake Winnipegosis and one, west of Dauphin. Corehole M-1-07, completed to a depth of 125.2 m, penetrated possible 'hydrothermally altered dolomite' (or hydrodolomite) within the upper part of the Silurian Interlake Group, beneath the Devonian Ashern Formation. Corehole M-2-07, drilled to 29.7 m, succeeded in obtaining a more complete recovery of sulphide mineralized core from the upper part of the Souris River Formation, than in previous drilling at this site. A third corehole (M-3-07) was drilled west of Dauphin to a depth of 11.2 m within Cretaceous shale of the Favel and upper Ashville formations. The drillcore indicated that altered (burnt) shale, found in outcrop in the bank of the Valley River, does not extend into the subsurface to the east and is probably a localized geological feature.

The recognition of hydrodolomite in the province would provide the incentive for Mississippi Valley-type metallic mineral investigations and for oil and gas exploration in southwestern Manitoba.

Introduction

The Manitoba Geological Survey (MGS) 2007 Stratigraphic Corehole Drilling Program continued investigations in the Duck Bay and Wellburns Creek areas of west-central Manitoba. This complements work originally started in 2006 (Bamburak, 2006). Two coreholes (M-1-07 and M-2-07; Figure GS-16-1) were drilled into Devonian and Silurian dolomite as detailed in Table GS-16-1.

An additional corehole (M-3-07) was drilled to a depth of 11.2 m into Cretaceous shale (Table GS-16-1). This corehole was drilled near the east bank of the Valley River, west of Dauphin (Figure GS-16-1).

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 (Figure GS-16-2). In 2006, corehole M-1-06 was drilled on the southern margin of the community to a depth of 75.4 m, ending in the Devonian Ashern Formation (Figure GS-16-3). The original target of the 2006 drilling was the karstified top of the Silurian Interlake Group but the hole had to be abandoned prematurely due to sand infill. In early August 2007, a second attempt resulted in the successful completion of corehole M-1-07 (Figure GS-16-1, Table-GS-16-1) to a depth of 125.2 m, ending within the Interlake Group.

Examination of core from M-1-07 (Table GS-16-1) reveals contrasting textures. Above the argillaceous Ashern Formation, the core shows typical Winnipegosis Formation dolomite. In contrast, the core below the Ashern Formation and a major unconformity indicates that several of the upper Interlake Group beds have been distinctly altered, in addition to karst development. The alteration consists of abundant dark grey and white mottles with blue-green argillic veinlets, believed to be characteristic of 'hydrothermally altered dolomite' or hydrodolomite. Some of the beds are also vuggy and very soft, and contain very fine grained black sulphides. The core from M-1-07 has been split and half of the core crushed and sent for instrumental neutron activation analysis (INAA) and inductively couple plasma (ICP) analysis.

Wellburns Creek (formerly Point River)

In August 2006, corehole M-2-06 was completed south of PR 271, immediately east of a tributary to Wellburns Creek (formerly Point River) west of Lake Winnipegosis (Figure GS-16-2). The corehole reached a depth of 90.7 m and ended within the Devonian Upper Member of the Winnipegosis Formation (Figure GS-16-3). Bamburak (2006) reported that a possible sphalerite/galena grain was present within a fracture shear within the Second Red Beds of the Dawson Bay Formation at a depth of about 72.8 m. Scanning electron microscopy (SEM) and energy-dispersive X-ray spectrometry (EDS) analyses of the grain by J. Young of the Department of Geological Sciences at the University of Manitoba confirmed the grain was sphalerite and that there is also abundant sphalerite present on the slickensides of the fracture surface (J. Young, pers. comm., 2007).

The presence of sphalerite crystals in corehole M-5-00, drilled near the east end of PR 271 (Figure GS-16-2), was reported by Bamburak et al. (2000) and Bamburak (2006). X-ray diffraction (XRD) confirmation of this identification was received from J. Young of the Department of Geological Sciences at the University of Manitoba (J. Young, pers. comm., 2007). In addition, the XRD analysis indicated the presence of minrecordite ($CaZn(CO_3)_2$) and stilleite (ZnSe) in the core sample.

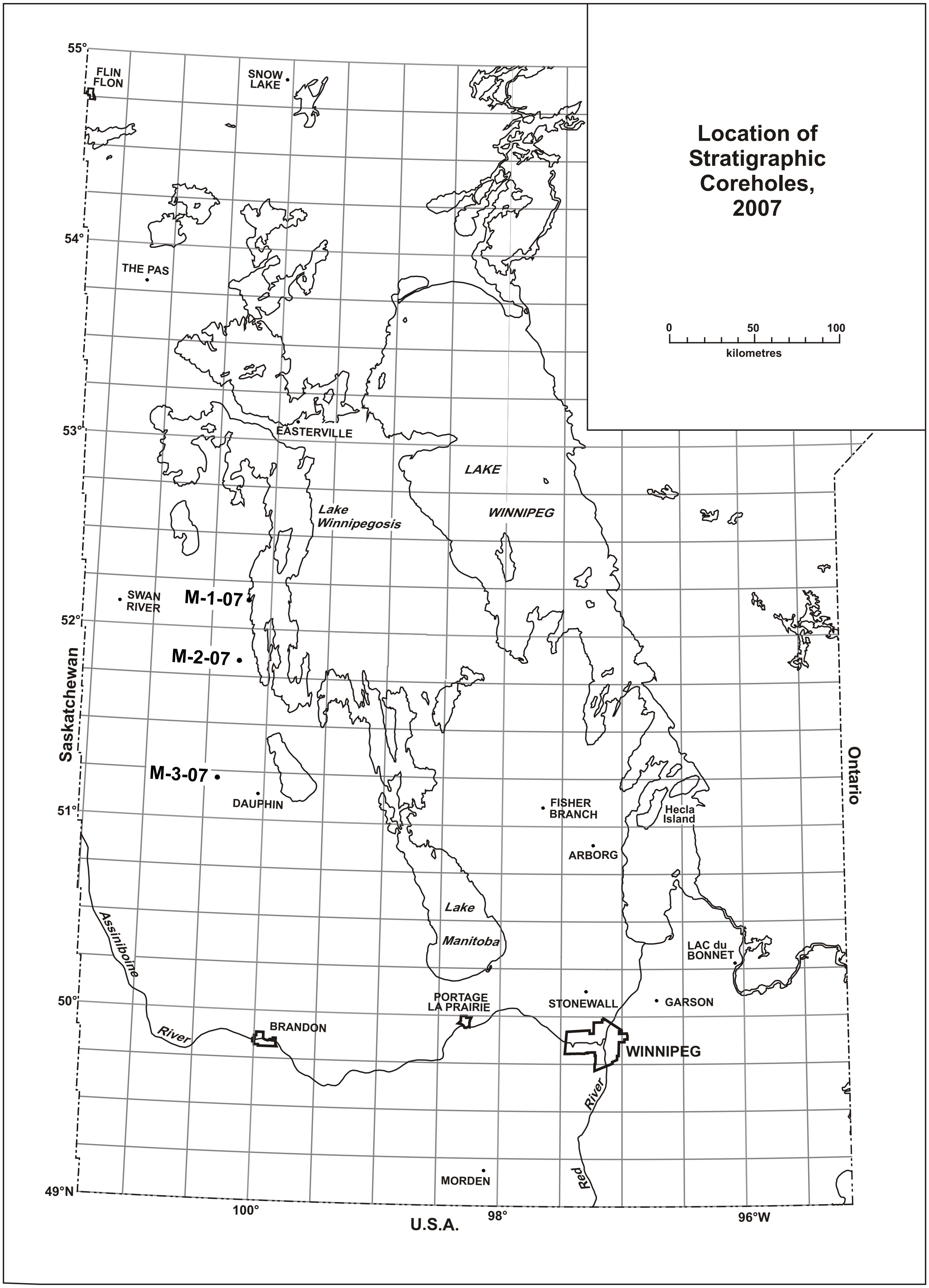


Figure GS-16-1: *Location of Manitoba Geological Survey's stratigraphic coreholes, 2007.*

Table GS-16-1: Summary of Manitoba Geological Survey stratigraphic corehole data, 2007.

Hole no.	Location and elevation (m asl)	SYSTEM/Formation/ (Member)	Interval (m)	Lithology summary
M-1-07	08-30-36-19W	DEVONIAN/ Winnipegosis/ (Upper)	0.0–61.4	Reef facies, dolomite, buff, well defined bedding with numerous horizontal fractures near top, good to excellent fine vuggy (birdseye) porosity with zebra-like textures and specks of black sulphides between 46.5 and 61.0 m
Duck Bay South	5774977N 421088E	(Lower)	61.4–71.7	Platform facies, dolomite, buff, mottled, massive near top, pin-point porosity near base, and sand infill near middle and base
	258	Ashern	71.7–80.1	Dolomite, argillaceous and shale, greenish and red mottled
		SILURIAN/Interlake Group (possibly Cedar Lake Formation at top)	80.1–125.2	Dolomite, buff with beds of porcellaneous, sugary or pinpoint porosity separated by four intervals of hydrothermally altered(?) dolomite with dark grey and white mottles and blue-green argillic veinlets; possible argillaceous marker bed between 122.5 and 123.1 m
M-2-07	02-04-33-20W	DEVONIAN/Souris River/ (Sagemace)	0.0–17.8	Limestone, beige, fine grained with small vugs, calcareous, black to buff limestone (oxidized along fractures) with black sulphides, sand infill at base
Wellburns Creek West	5739363N 415171E	(Point Wilkins)	17.8–26.6	Limestone, yellow and brown, sugary, vuggy, brecciated in part with black sulphide fracture surfaces; becoming argillaceous limestone with calcite-healed fractures at base
	280	(First Red Beds)	26.6–29.7	Shale, dark grey, breccia with disturbed bedding underlain by laminated brown and beige limestone; becoming laminated black and grey shale with polymict breccia and abundant black sulphides downward
M-3-07	13-35-25-21W	Overburden	0.0–3.1	Soil and till
Valley River East	5674213N 408115E	CRETACEOUS/Favel	3.1–7.2	Shale, dark grey to black, speckled, calcareous, horizontally bedded, with a few 2 mm thick gypsum laminae, minor petroleum smell
	335	Ashville (upper)	7.2–11.2	Shale, black, noncalaceous, greasy shale becoming darker downward

According to a University of Arizona webpage, minrecordite has been reported in a dolostone-hosted hydrothermal polymetallic ore deposit in Tsumeb, Namibia and from the wallrock of a carbonate-hosted Pb-Zn orebody in the Navan deposit, Ireland (University of Arizona, 2005).

During the drilling of corehole M-2-06 (Figure GS-16-2), core recovery was poor and the drilling mud showed evidence of particles of black mineralization. For these reasons, it was decided to redrill the site of corehole M-2-06 in 2007. Corehole M-2-07 (Figure GS-16-1, Table-GS-16-1) was drilled to a depth of 29.7 m. It had better core recovery with black sulphide mineralization finely disseminated throughout the core, from the Sagemace Member down into the First Red Beds of the Souris River Formation. The mineralization is also concentrated on numerous fracture surfaces. Because the nature of the very fine grained black sulphide mineralization is unknown, the core from M-2-07 has also been sent for INAA and ICP analysis.

Valley River

McCabe and Bannatyne (1970, Stop 13) described an “abnormal” shale outcrop along the Valley River, 18 km west-northwest of Dauphin (near corehole M-3-07, Figure GS-16-1). They described light buff and pink thin-bedded, fissile, speckled calcareous shale of the Cretaceous Favel Formation overlying pink to buff, greyish red, yellow and purplish red noncalcareous slabby to fissile shale of the Ashville Formation. The section was described as having been “highly oxidized” or “burned” relative to a patch of “unoxidized” black shale (of the Ashville Formation, Table GS-16-2), which is present laterally at the south end of the outcrop. McCabe and Bannatyne (1970) did not speculate on the origin of the altered shale but they did mention that the only other known outcrop “of a similar nature” is present on the southeast flank of the Porcupine Hills, where buff and pink weathered Favel Formation can be seen (now referred to as the Digger Don Roadcut, Field Trip Guidebook, Stop 11, McCabe and Bannatyne, 1970).

In June 2006, the Valley River northern outcrop (Table GS-16-3) was sampled by C. Lamb of Husky Energy Inc. during a field trip led by the MGS. Three samples (HE001–003) were collected and standard thin sections were prepared. The slides were double stained for carbonates and impregnated with blue epoxy. After thin-section photomicroscopy, the cover slides from samples HE002 and 003 were removed and the slides submitted for SEM and backscattered electron microscopy. Bulk and clay XRD analyses were conducted on

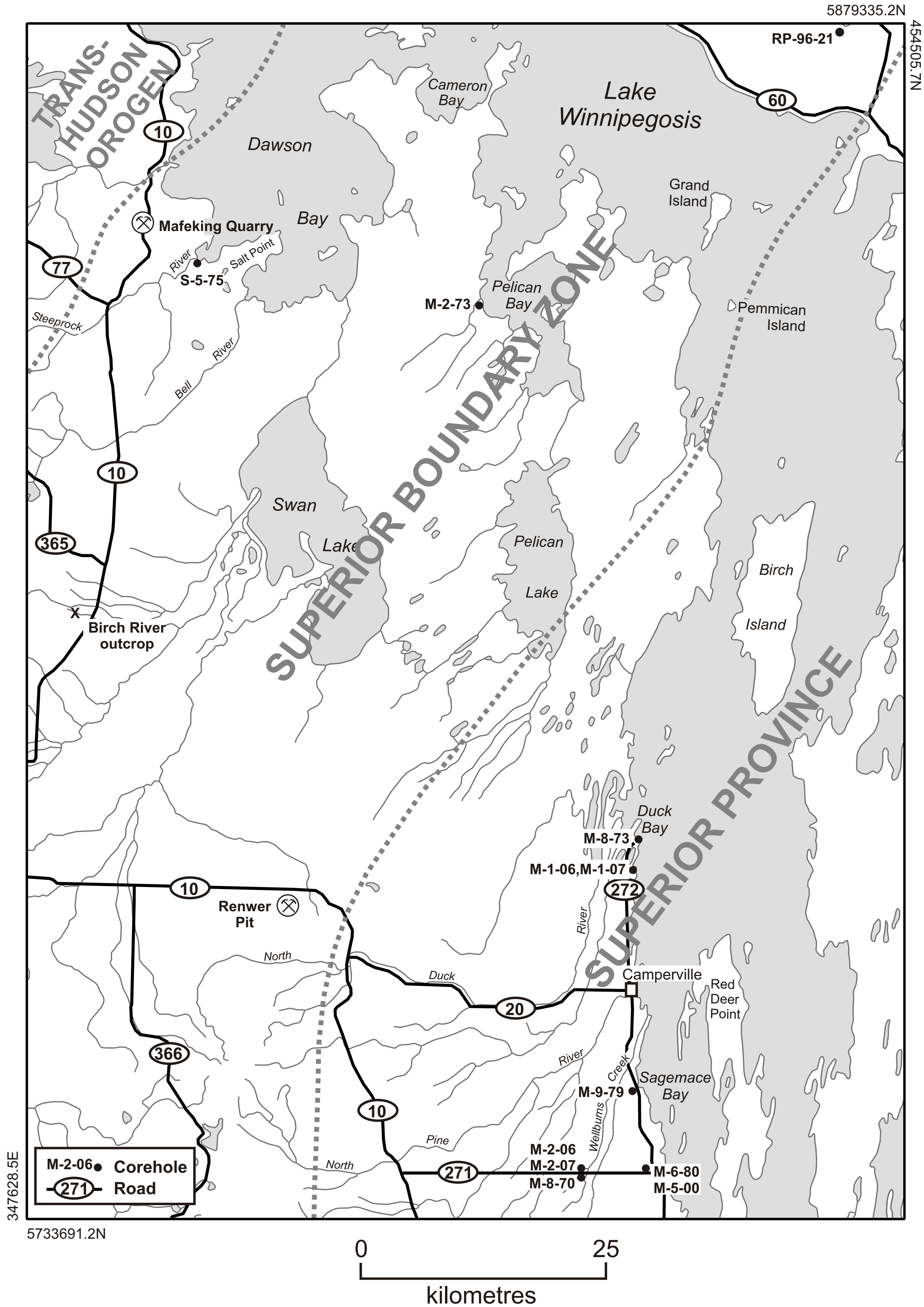


***Figure GS-16-2**: Selected stratigraphic holes west of Lake Winnipegosis, Manitoba, and boundaries of Precambrian domains, including the Superior Boundary Zone (SBZ).*

Period	GROUP/FORMATION	MEMBER	Thickness (m)	DEPOSITIONAL THICKNESS (m) AND SUMMARY LITHOLOGY
CRET. / JUR.				
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 Winnipegosis	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-16-3: *Detailed Devonian stratigraphic succession and lithology (*from *McCabe and Barchyn, 1982; Bezys and McCabe, 1996).*

Table GS-16-2: Mesozoic stratigraphy of the northern part of the Manitoba Escarpment (Bamburak, 1999).

Formation/Member	Maximum thickness (m)	Lithology
Upper Cretaceous		
Pierre Shale		
Odanah Member	150	hard grey siliceous shale
Millwood Member	60	soft bentonitic clay
Pembina Member	7	noncalcareous black shale with numerous bentonite interbeds near base
Gammon Ferruginous Member	5	ferruginous black shale
Carlile Formation		
Boyne Member	30	chalky buff and grey speckled calcareous shale
Morden Member	30	noncalcareous black shale with abundant jarosite
Favel Formation		
Assinniboine Member	17	olive-black speckled calcareous shale with Marco Calcarenite bed near top
Keld Member	17	olive-black speckled calcareous shale with Laurier Limestone bed near top
Ashville Formation	80	noncalcareous black to dark grey shale, silty; Newcastle sand zone, in places
Swan River Formation	150	sandstone, sand and silt, quartzose, pyritic and shale, noncalcareous

Table GS-16-3: Stratigraphy of Valley River northern outcrop, Manitoba, with Husky Energy Inc. samples.

Location: 13-35-25-21-W1, 5674326N, 408076E Elevation: 325 m asl at waterline	Thickness (m)
Overburden	
Recent alluvium, soil and vegetation	0.4
Pleistocene boulder pavement	0.1
Favel Formation	
Shale, orange and pink, thin bedded, fissile, calcareous	4.8
Pebble conglomerate, shale clasts, pink and grey, noncalcareous, with gypsum cement	0.14
Shale, yellow, laminated, calcareous **(Sample HE002)**	0.3
Upper Ashville Formation	
Shale, pink-red, slabby to fissile, noncalcareous **(Sample HE003)**	0.75
Shale, greenish buff, slabby to fissile, noncalcareous, with orange fractures (minor grey shale in small 1 m^3 patch near base at south end of outcrop, Sample HE001)	2
Covered interval above waterline	
Rubble	1.5

all three samples using a Phillips XRG-3100 XRD system (Husky Energy Inc., 2007). The sample descriptions and results follow.

Sample HE001 – unaltered grey silty upper Ashville Formation shale

Sample HE001, noncalcareous grey silty shale of the Cretaceous upper Ashville Formation (Table GS-16-3), was collected near the base of the outcrop, at its south end. The 1 m^3 grey shale patch is laterally equivalent to enclosing altered or burnt noncalcareous greenish buff shale.

Thin section petrology, SEM and XRD analyses of Sample HE001 (Husky Energy Inc., 2007) showed that the unaltered silty shale is finely laminated and quartzose (62.0% of the bulk sample is composed of monocrystalline quartz silt grains). Illite comprises the entire clay fraction (13.5%). Also present are K-feldspar silt to sand (5.5%), gypsum (7.8%), anhydrite (4.0%), pyrite (7.2%), sulphate blebs and microscopic reddish iron-oxide particles.

Sample HE002 – altered yellow Favel Formation shale

Calcareous, yellow, laminated shale, from near the base of the Cretaceous Favel Formation, was collected from a conspicuous, and relatively massive, 0.3 m thick bed (Table GS-16-3) situated between thicker overlying and underlying fissile, reddish shale beds, near the centre of the outcrop (Sample HE002). The yellow shale is also found directly below a thin (0.14 m) pink and grey shale pebble conglomerate bed (which probably represents an unconformity). Although the conglomerate is not calcareous, it is still included within the Favel Formation.

According to Husky Energy Inc. (2007), Sample HE002 contains abundant gypsum (forming 31.6% of the bulk sample, as blebs and mineral cement within microscopic pores) and associated calcite (11.0%). Anorthite, in the form of fine laths, and andradite, as rounded crystals with rhombic to trapezoidal faces, constitute 46 and 11%, respectively, of the sample, determined by XRD analysis. Analyses of the yellow shale was performed by GR Petrology Consultants Inc. of Calgary and in their report they stated that "andradite forms as an alteration of siliceous limestone in regional and contact metamorphic environments" (Husky Energy Inc., 2007).

Sample HE003 – altered pink-red upper Ashville Formation shale

Sample HE003 was taken from a 0.75 m thick bed of altered noncalcareous pink-red shale from the Cretaceous upper Ashville Formation (Table GS-16-3), underlying the Favel Formation yellow laminated shale and overlying the upper Ashville Formation greenish buff shale (described above).

The pink-red shale contained in Sample HE003 comprised mainly quartz silt grains and amorphous silica that form 50.5% of the bulk sample. Also present are calcite (6.2%), dolomite (6.0%), anorthite (20.0%), pyrite (3.6%), hematite (6.6%) and ilmenite (2.6%). The clay fraction forms 4.5% of the bulk sample and consists of 87.5% mixed-layer illite-smectite clay and 12.5% illite (Husky Energy Inc., 2007).

Valley River east corehole

In August 2007, corehole M-3-07 (Figure GS-16-1) was drilled into Cretaceous shale of the Favel and upper Ashville formations (Table GS-16-2) to a depth of 11.2 m (Table GS-16-1), near the east bank of the Valley River, 18 km west-northwest of Dauphin. The corehole was designed to test whether alteration noted on the bank of the Valley River (described above) continues within the subsurface to the east.

Examination of the M-3-07 core indicates that Favel and upper Ashville formations in the core (Table GS-16-1) are unaltered black to grey, calcareous and noncalcareous shale similar to that seen at the base of the Valley River northern outcrop (Table GS-16-3) and in the eastern half of the Valley River southern outcrop (situated 200 m to the south). This suggests that the altered shale that can be seen in the banks of the Valley River is not widespread and only occurs in the vicinity of the present-day valley walls. It is also very likely that as erosion of the bank continues, a normal 'unaltered' shale bank will be revealed.

The Favel/Ashville formations core from M-3-07 seemed to have a minor petroleum odour that could be detected shortly after drilling (Table GS-16-1), which is consistent with historical studies (Bannatyne, 1970) that indicate the presence of oil shale along the Manitoba Escarpment. However, when the core was viewed under ultraviolet light several days later, no oil fluorescence could be seen. Total organic carbon (TOC) analysis of this core is scheduled for a future project.

Hydrothermal fluids

As indicated earlier, McCabe and Bannatyne (1970) did not indicate how the Valley River outcrop may have been altered, apart from mentioning that it "may represent a 'burned' section of highly oxidized Ashville and Favel beds." However, Bamburak and Nielsen (1996) provided at least five modes of origin for similarly formed scoriaceous clinker from the Cretaceous Favel Formation (Table GS-16-2) found in the Renwer gravel pit (Figure GS-16-2). Autocombustion of oil shale was the most favoured mode of origin by Bamburak and Nielsen (1996); however, in view of the Husky Energy Inc. (2007) suggestion (described above) of "regional and contact metamorphic" alteration possibly due to hydrothermal fluids, volcanic activity cannot be ruled out. It should be noted that Bezys et al. (1996) indicated the possible presence of a Cretaceous volcanic vent near Easterville (Figure GS-16-1) about 200 km to the north of the Valley River outcrop (near M-3-07, Figure GS-16-1) and within the SBZ. They stated that nonkimberlitic accretionary lapilli found, within Swan River Formation (Table GS-16-2) sediment, in Cominco RP-96-21 (Figure GS-16-2) drillcore likely originated from a volcanic vent within or adjacent to the SBZ, not more than 20 km from the drillhole. Gale and Conley (2000) and Bamburak (2006) concluded that basement reactivation within the SBZ likely induced vertical fracturing and faulting of overlying Phanerozoic beds that provided pathways for basement and interformational fluids. Likewise, these vertical fractures and faults may have been utilized as pathways by concurrent volcanic activity.

Hydrothermal fluid activity in southwestern Manitoba is also indicated by

- The possible recognition of hydrodolomite in the drillcore of M-01-07 (as described above).
- The discovery of the mineral minrecordite in the drillcore of M-5-00. As indicated earlier, minrecordite is associated with a dolostone-hosted hydrothermal polymetallic ore deposit in Tsumeb, Namibia (University of Arizona, 2005).

- The identification, by McCracken (1999), of hydrothermally altered conodonts in the argillaceous residue contained within chimney structures found within Devonian carbonate hostrock in the Mafeking Quarry (Figure GS-16-2). According to Fedikow et al. (2004), the chimney structures (which are also lined with siderite-rich rind and siliceous sinter) are interpreted to be paleobrine vents.
- Altered Marco Calcarenite, contained within the Assiniboine Member of the Cretaceous Favel Formation (Table GS-16-2), underlain by iron-oxide–bearing shale, found along the Birch River (Figure GS-16-2) by Bamburak (1999).
- Mississippi Valley-type mineralization found in coreholes (M-2-73, S-5-75, M-9-79, M-6-80 and M-5-00, Figure GS-16-2) drilled in the vicinity of the north basin of Lake Winnipegosis, as reported by Gale and Conley (2000) and Bamburak (2006).
- Mississippi Valley-type mineralization found in a Klyne Exploration drillhole, off the east shore of Pemmican Island in the north basin of Lake Winnipegosis (Figure GS-16-2). Analysis returned values of 4.59% Zn, 0.41% Pb and 0.014% Cu over 15 cm of the Silurian Interlake Group (Bamburak and Klyne, 2004).

As stated above, hydrodolomite is believed to be present in the karstified Silurian Interlake Group core from M-1-2007, below a major unconformity and the argillaceous Devonian Ashern Formation (Table GS-16-1) that formed a tight cap preventing upward movement of hydrothermal fluids. It should be noted that according to Campeau and Kissin (1988) and Kent (1999), hydrodolomite has been recognized in carbonate rock within the Meadow Lake Formation (equivalent to the Ashern Formation) in Saskatchewan, approximately 500 km northwest of M-1-2007. The hydrodolomite was found during an extensive drilling program carried out by Canadian Occidental Petroleum Limited (now Nexen Inc.) and Saskatchewan Mining Development Corporation, 24 km south of La Ronge.

Further, Christopher (1996) suggested that hydrothermal fluids, which may have altered the carbonate rock within the Meadow Lake Formation, could have increased the grade of the coals in the Lower Cretaceous Manville Group in Saskatchewan to sub-bituminous grade. The Manville Group is equivalent to the Swan River Formation (Table GS-16-2), which underlies the altered or burnt Ashville and Favel formations found in the Valley River outcrop (described above). A similar upward movement of hydrothermal fluids from the underlying Paleozoic beds along faults beneath the Valley River might account for the andradite mineralization, which was indicated in the Husky Energy Inc. (2007) study. Although the drilling of M-3-07 indicated that the burnt shale is probably a local feature, additional drilling is required before alteration by hydrothermal fluids can be completely discounted.

Economic considerations

The possible recognition of hydrodolomite in a MGS corehole drilled near Duck Bay would mark the first time that this rock type has been found in Manitoba. This discovery, if confirmed, is of major significance because it would indicate that warm to hot saline fluids have flowed through the Paleozoic stratigraphic sequence in southwestern Manitoba and had the ability to alter the country rock by increasing porosity and permeability. The leached limestone and dolomite could host metallic mineralization in fractures and voids, precipitated from the brines. These processes could explain the Mississippi Valley-type mineralization found offshore of Pemmican Island in the north basin of Lake Winnipegosis and other similar mineralization present at other sites in west-central Manitoba (Bamburak, 2006).

There is also the potential for the discovery of oil and gas reservoirs in Silurian and possibly older beds in southwestern Manitoba, due to the increased porosity and permeability that was induced by the hydrothermal fluids. Oil and gas migration may have occurred simultaneously with the movement of these hydrothermal fluids through the karstified Silurian Interlake Group, below the Devonian Ashern Formation argillaceous caprock. The best potential for oil and gas traps would be within fractures and faults induced by basement reactivation along the trend of the SBZ, or possibly up dip of the SBZ, within capped karst structures. The relationship between fault-related hydrodolomite and the formation of oil and gas reservoirs in the Ordovician Trenton-Black River carbonate of Michigan, U.S.A., is described by Smith (2003). It may also be of interest to note that according to Eaton (2004), Hydro-Québec committed $330 million, in 2002, to an oil and gas exploration program in eastern Québec focused on hydrodolomite and faulting.

Acknowledgments

J. Young of the Department of Geological Sciences at the University of Manitoba is acknowledged for providing complimentary analytical support and digital copies of the results of drillcore analyses from stratigraphic coreholes drilled near the east end of PR 271. C. Lamb of Husky Energy Inc. is thanked for providing the results of the sample analyses from the Valley River northern outcrop. B. Lenton is gratefully acknowledged for preparing the figures in this report. M. Nicolas and R. Bezys provided many useful suggestions in their review of the manuscript.

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