Status of the Silurian Zn-Pb Discovery, Northeast Shore of Pemmican Island, Lake Winnipegosis

by

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Introduction

Zn-Pb mineralization was discovered in 2004 in the north basin of Lake Winnipegosis, as depicted in ***Figure 1*** (Bamburak and Klyne, 2004). The discovery was made by drilling below the lake bottom, near the northeast shore of Pemmican Island.

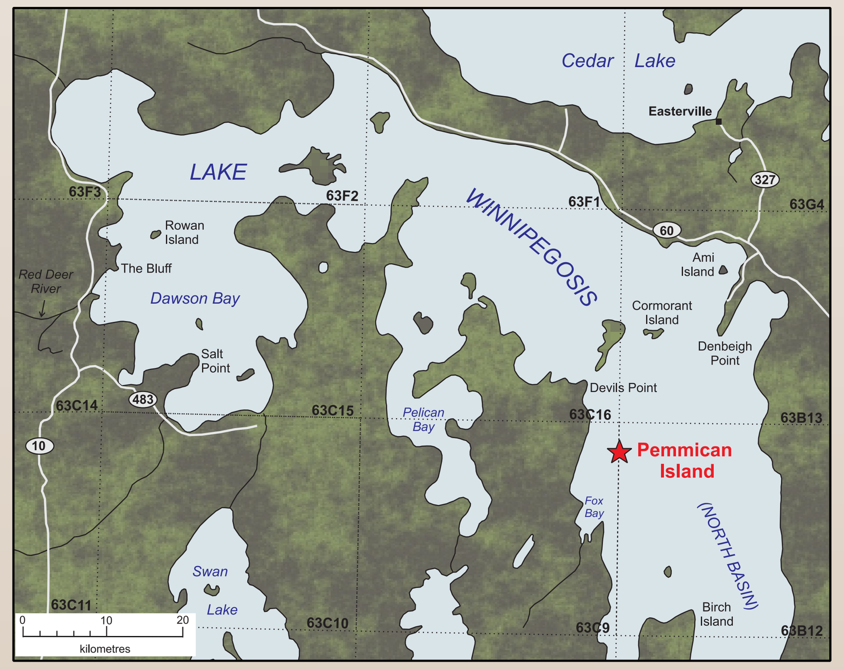


Figure 1: North basin of Lake Winnipegosis, showing location of Pemmican Island (Bamburak and Klyne, 2004).

Geological Setting

The Zn-Pb mineralization is situated:
1. within dolomite of the Cedar Lake Formation of the Silurian Interlake Group (***Table 1***);
2. below the argillaceous Devonian Ashern Formation (***Table 1***) and the pre-Middle Devonian unconformity, with associated karst development;
3. up-dip of the faulted eastern margin of the buried Precambrian Superior Boundary Zone, which cuts two subdomains of the Archean Berens River Domain of the Superior Province as shown in ***Figure 2***;
4. at the northern edge of the Camperville gravity low (***Figure 2***);
5. on the southwest flank of the Precambrian Severn Arch, as shown in ***Figure 3***;
6. near the edge of the composite Elk Point/Williston sedimentary basin (***Figure 3***); and
7. on the southeast limb of the Moose Lake Syncline (***Figure 3***).

ERA	PERIOD	FORMATION	MEMBER	MAXIMUM THICKNESS (m)	BASIC LITHOLOGY
CENOZOIC	QUATERNARY	(Recent)			Top soil, dune sands, lake clays, peat
		Glacial Drift		140 *	Clay, sand, gravel, boulders, till
	TERTIARY				
		Turtle Mountain	Peace Garden Goodlands	160 **	Shale, clay, sand, lignite
MESOZOIC	CRETACEOUS	Boissevain		45	Sand, sandstone, greenish grey
		Pierre Shale (First White Specks)	Coulter Odanah Millwood Pembina Gammon Ferruginous	400 **	Grey shales, non-calcareous, local ironstone, bentonitic, carbonaceous
		Niobrara		75 **	Grey speckled shale, calcareous, bentonitic
		Morden Shale		55 **	Dark grey shale, non-calcareous, concretions, local sand and silt
		Favel (Second White Specks)	Assiniboine Keld	45	Grey shale with calcareous specks, bands of limestone and bentonite
		Ashville	Belle Fourche Shale Westgate Newcastle Skull Creek	80	Dark grey shale, non-calcareous, silty, Newcastle (sand zone)-quartz sandstone
		Swan River		150 *	Sandstone and sand, quartzose, pyritic shale, non-calcareous
	JURASSIC	Waskada		60	Banded green shale and calcareous sandstone, bands of limestone, varicoloured shale
		Melita		145 **	
		Reston		45	Limestone, buff, and grey shales
		Amaranth	Evaporite	55	White anhydrite and/or gypsum and banded dolomite and shale
	TRIASSIC		Red Beds	45 *	Red shale to siltstone, dolomitic
PALEOZOIC	PERMIAN PENNSYLVANIAN	St. Martin Complex		265(+) *	Carbonate breccia, trachyandesite (crypto-explosion structure?)
	MISSISSIPPIAN	Madison Group: Charles		20	Massive anhydrite and dolomite
		Madison Group: Mission Canyon	MC-5 MC-4 MC-3 MC-2 MC-1	120	Light buff limestone, oolitic, fossiliferous, fragmental, cherty, bands of shale and anhydrite
		Madison Group: Lodgepole	Flossie Lake Whitewater Lake Virden Scallion Daly	185	Limestone and argillaceous limestone, light brown and reddish mottled, zones of shaley, oolitic, crinoidal and cherty limestone
		Bakken	Upper Middle Lower	20 **	Two black shale zones separated by siltstone
	DEVONIAN	Qu'Appelle Group: Three Forks		55	Red siltstone and shale, dolomitic
		Sask. Group: Birdbear		40	Limestone and dolomite, yellow-grey, fossiliferous, porous, some anhydrite
		Sask. Group: Duperow		120	Limestone and dolomite, argillaceous and anhydritic in places
		Man. Group: Souris River (First Red)		90	Cyclical shale, limestone and dolomite, anhydritic
		Man. Group: Dawson Bay (Second Red)		50 **	Limestone and dolomite, porous, anhydritic, local red and green shale
		Elk Pt. Group: Prairie Evap.		120	Halite, potash and anhydrite, interbedded dolomite
		Elk Pt. Group: Winnipegosis		75	Dolomite, yellow brown, reefy
		Elk Pt. Group: Elm Point		**	Limestone, fossiliferous, high-calcium
		Elk Pt. Group: Ashern		12 *	Dolomite and shale, brick red
	SILURIAN	Interlake Group	★	110	Dolomite, yellow buff, fossiliferous, several argillaceous marker beds
	ORDOVICIAN	Stonewall	t-marker zone Williams	** 25	Dolomite, sparsely fossiliferous, t-marker defines Ordovician-Silurian boundary
		Stony Mountain	Gunton Penitentiary Gunn	45	Dolomite, yellow buff Dolomite, dusky yellow, fossiliferous, red shale, green fossiliferous limestone bands (Gunn)
		Red River	Fort Garry Selkirk Cat Head Dog Head	170	Dolomitic limestone and dolomite, mottled (Tyndall Stone within Selkirk)
		Winnipeg	Upper Unit Lower Unit	65 *	Green shale, waxy, interbedded sandstone Sand, sandstone and quartzose
	CAMBRIAN	Deadwood		25	Black to green grey sand, waxy, glauconitic siltstone and shale
PRECAMBRIAN					Metamorphic and crystalline rock

* Potential major karst event ** Potential minor karst event

★ Cedar Lake Formation host rock for mineralization

Table 1: Stratigraphic column for Phanerozoic rocks in west-central Manitoba (Bamburak and Klyne, 2004).

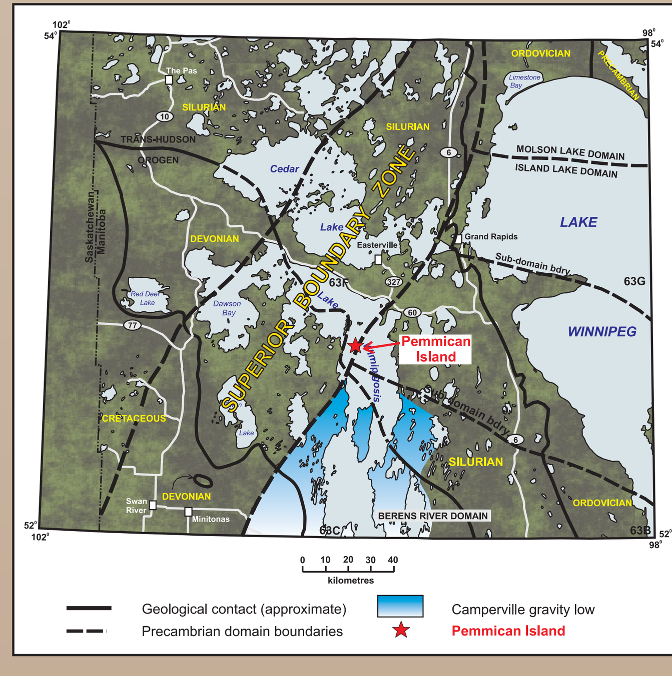


Figure 2: Geological setting of Pemmican Island, related features and immediate vicinity at the north end of Lake Winnipegosis

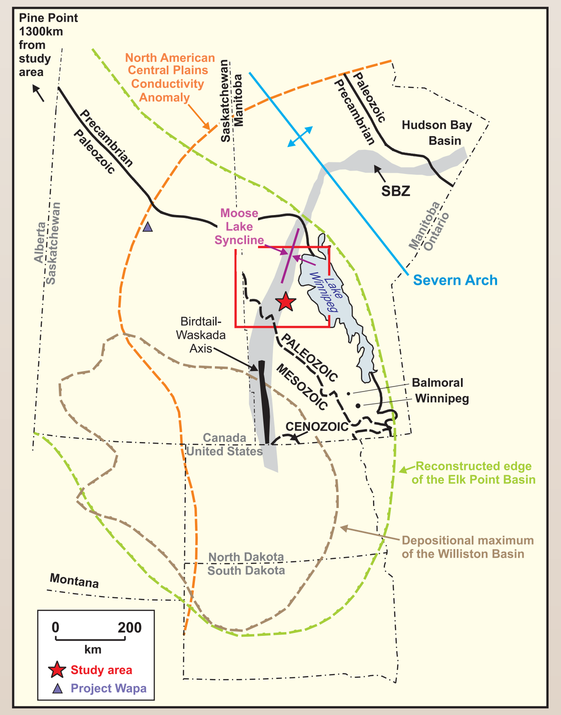


Figure 3: Major structural features and geology of the Williston and Elk Point basins, Manitoba and vicinity (Bamburak and Klyne, 2004).

Geothermal Alteration

Geothermal alteration of the Phanerozoic country rock has been noted at several localities in west-central Manitoba:

M-1-07

As described by Bamburak (2007) stratigraphic corehole M-1-07 was drilled in early August, 2007 by the Manitoba Geological Survey (MGS) south of the community of Duck Bay (***Figure 4***). Examination of core from hole M-1-07 reveals contrasting textures. Above the argillaceous Ashern Formation, the core shows typical buff Winnipegosis Formation dolomite (***Figure 5a***). In contrast, the core below a major unconformity and the Ashern indicates that several of the upper Interlake Group beds have been distinctly altered (***Figures 5b to d***). Some of the alteration consists of abundant dark grey and white mottles with blue-green argillic veinlets, as shown in ***Figures 5b*** and ***5c***. In places, the beds are vuggy, very soft and contain very fine grained black sulphides. Preliminary petrographic examination of thin sections from the core of M-1-07 by the University of Manitoba (pers. comm. 2007-10-29) confirmed the presence of saddle dolomite cement and this indicates that, at a minimum, geothermal alteration has taken place below Duck Bay.

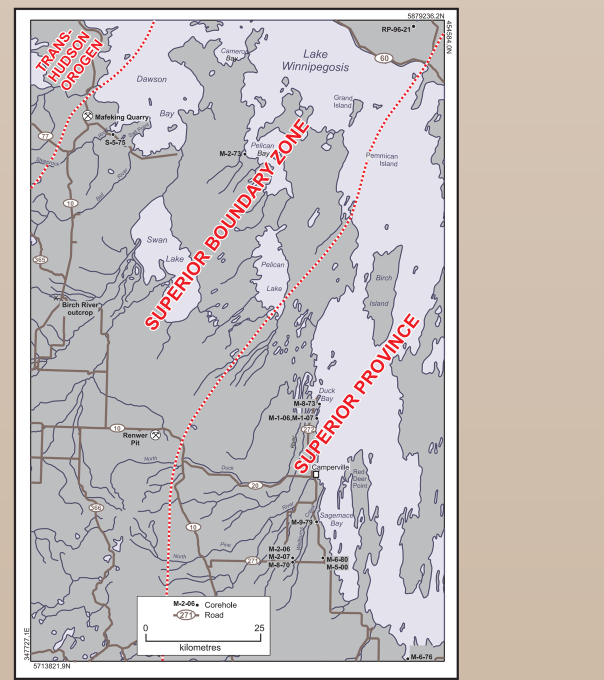


Figure 4: West-central Manitoba study area, showing locations of stratigraphic coreholes, Duck Bay, Pemmican Island, Mafeking Quarry and Birch River outcrop (Bamburak, 2006, 2007).

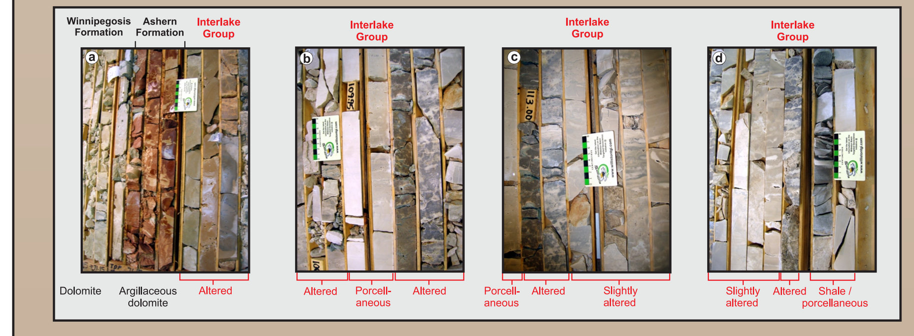


Figure 5: Stratigraphic drillcore from M-1-07 (a) Devonian Winnipegosis Formation (buff) overlying Ashern Formation (red) that overlies altered Silurian Interlake Group (orangey-grey and cream-coloured). (b) Altered Silurian Interlake Group (dark grey with green argillic veinlets), separated by buff porcellaneous dolomite. (c) Downward continuation of ***Figure 5b;*** altered Silurian Interlake Group becoming less altered dolomite downward (light grey and cream-coloured layered mottles). (d) Downward continuation of ***Figure 5c***, to bottom of hole; slightly altered Silurian Interlake Group dolomite becoming more altered downward (dark grey and cream-coloured mottles), overlying shale marker bed (greyish green) that overlies porcellaneous dolomite (buff) with thin sulphide-healed fractures.

M-6-76

The nearest stratigraphic corehole to M-1-07 (which penetrated the same stratigraphic interval) was drilled in 1976 at Paradise Beach (M-6-76, as shown in ***Figure 4***) near the south end of Lake Winnipegosis, approximately 75 km to the southeast. Examination of the core from M-6-76 shows only the uppermost 3.1 m, below the Ashern Formation, is altered over a 16.1 m interval (to bottom of hole); whereas the same interval in M-1-07 is almost completely altered. It should also be noted that corehole M-1-07 is approximately 40 km closer to the vertical faults in the Precambrian basement along the eastern margin of the SBZ (Macek et al., 2006).

Cominco RP-21

Bezys et al. (1996) indicated the possible presence of Cretaceous volcanic vent within the SBZ in Cominco RP-96-21 (***Figure 4***). They stated that non-kimberlitic accretionary lapilli found, within the Swan River Formation (***Figure 2***) likely originated from a volcanic vent within or adjacent to the SBZ, not more than 20 km from the drillhole.

M-5-00

The discovery of the mineral minrecordite in the drillcore of M-5-00 (***Figure 4***) by the Department of Geology, University of Manitoba (J. Young, pers. Comm., 2007). Minrecordite is associated with a dolostone-hosted hydrothermal polymetallic ore deposit in Tsumeb, Namibia (University of Arizona, 2005).

Mafeking Quarry

The identification of hydrothermally-altered conodonts by McCracken (1999) from argillaceous residue contained within chimney structures within the Mafeking Quarry (***Figure 4***). According to Fedikow et al. (2004), the chimney structures in Devonian carbonate host-rock, lined with siderite-rich rind and siliceous sinters, are interpreted to be paleo-brine discharge sites.

Birch River Outcrop

Altered Marco Calarenite, contained within the Assiniboine Member of the Cretaceous Favel Formation, underlain by iron oxide-bearing shale, found along the Birch River (***Figure 4***) by Bamburak (1999).

Other Localities

Mississippi Valley-type (MVT) mineralization found in coreholes (M-2-73, S-5-75, M-9-79, M-6-80 and M-5-00, shown in ***Figure 4***) drilled in the vicinity of the north basin of Lake Winnipegosis as reported by Gale and Conley (2000) and Bamburak (2006). The analytical results of the core show PB-Zn values in Paleozoic carbonate rock several orders of magnitude above those previously obtained in provincial government and mining exploration company investigations (Bamburak, 2006).

Pemmican Island Sulphide Mineralized Zone

J. B. Tyrrell documented the presence of the "marcasite nodules" on the northeast shore of Pemmican Island in 1889. The "nodules" were found within an unconsolidated sandy matrix between typical, well-rounded, Precambrian and Paleozoic cobbles and boulders (***Figure 6***).

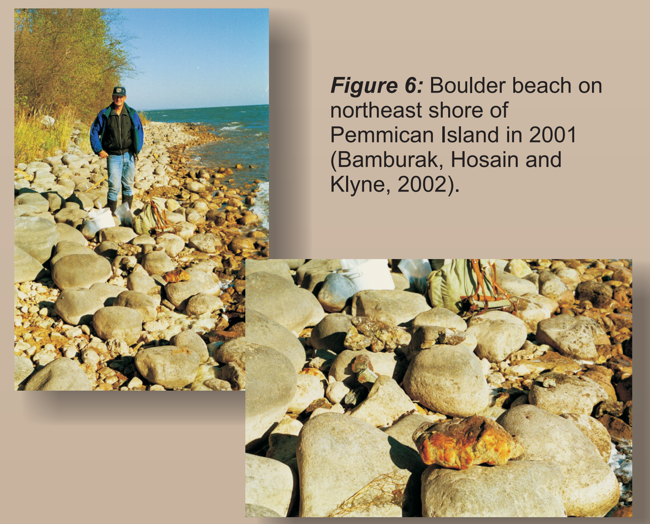


Figure 6: Boulder beach on northeast shore of Pemmican Island in 2001 (Bamburak, Hosain and Klyne, 2002).

Tyrrell's "nodules" are actually the aerial part of a mineralized zone (***Figure 7***) that consists of ice-pushed iron sulphide concretions and slabs (within fine silt) that occupy up to 80% of the upper beach slope below the waterline. The mineralized zone measures about 28 m in length along the shoreline, and extends northeast beneath the lake (***Figure 8***). The zone appears to be a continuation of the Pemmican Island karst channel portrayed by Bamburak et al. (2002).

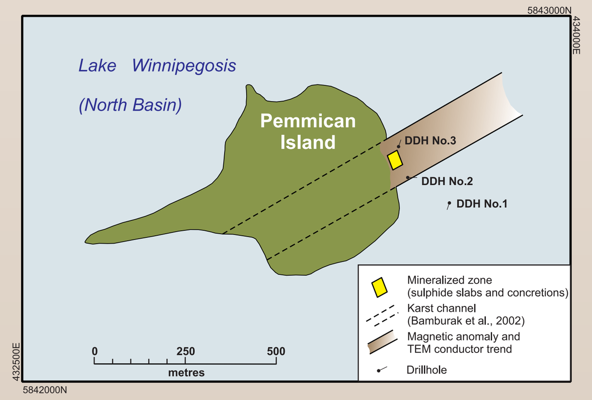


Figure 7: Pemmican Island in the north basin of Lake Winnipegosis showing location of mineralized zone (with solid sulphide slabs and concretions), karst channel, magnetic and conductive trend and drillhole locations (Bamburak and Klyne, 2004).

Figure 8: Ken Klyne checking out magnetism of sulphide slabs and concretions within mineralized zone in 2004.

The concretions and slabs, some of which are oxidized, range in size from pebbles to boulders. Some of the variations in texture, morphology and lithology of the slabs and concretions are depicted in ***Figure 9***. In general, the concretions tend to be ovoid and have fine concentric laminations. The slabs tend to be more massive and fine-grained, but usually have a surface covered with distinct pyrite cubes or have botryoidal and/or tube-like structures. Some of the slabs ranged in size up to 40 cm by 40 cm by 15 cm and weighed 30 to 50 kg. Dolomite breccia, cemented by the iron sulphide, is present in some of the concretions and slabs (***Figure 10***). The sulphide located nearest the dolomite clasts tends to be dark grey and very fine-grained. The sulphide that is furthest from the dolomite tends to be brass-coloured and striated, and is sometimes adjacent to vugs or cavities.

Figure 9: Collage of typical slabs and concretions from the mineralized zone.

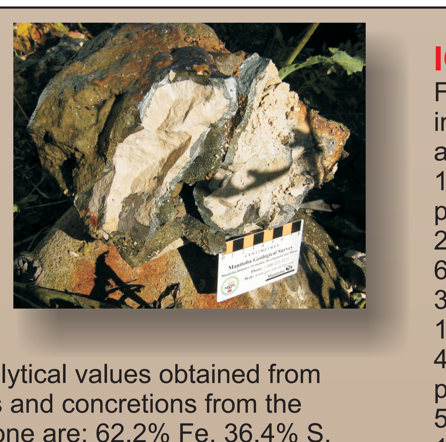


Figure 10: Dolomite breccia cemented by iron sulphide (note: the two types of sulphide cement and vugs/cavities).

Maximum analytical values obtained from sulphide slabs and concretions from the mineralized zone are: 62.2% Fe, 36.4% S, 1.18% Ni, 0.76% Zn, 3670 ppm As, 1100 ppm Pb and 813 ppm Co. It should be noted that the sample with 1100 ppm Pb also contained 1700 ppm Zn.

Zn-Pb Discovery Hole

A broad, but weak magnetic anomaly (***Figure 11***) and a large, high amplitude transient electromagnetic (TEM) response (***Figure 12***) was indicated (in 4 line-km of total field magnetic and 1.7 line-km of TEM surveys) carried out on ice in April 2003 (Bamburak and Klyne, 2004). These coincided with the northeast-trending zone of sulphide slabs and concretions (described above).

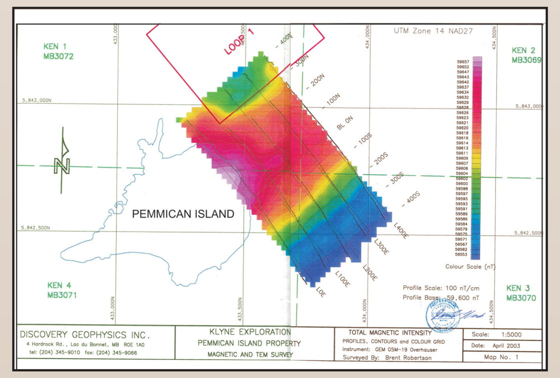


Figure 11: Total field magnetic survey April, 2003.

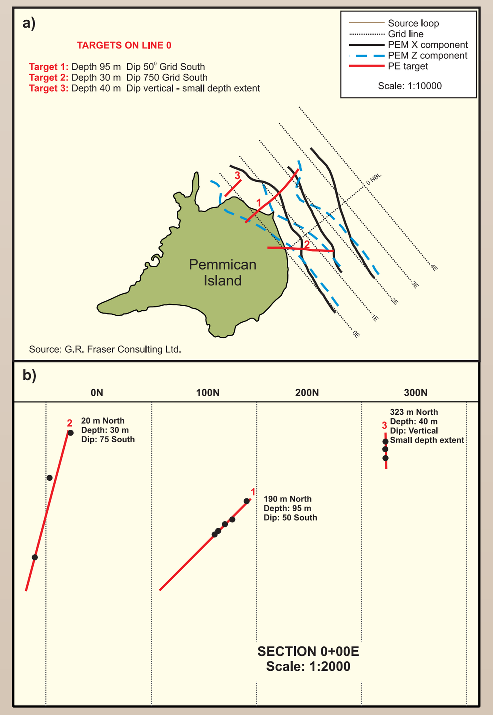


Figure 12a and b: Transient electromagnetic survey April, 2003.

Three 60° angled holes (***Figure 7***) were drilled from the ice near the northeast shore of Pemmican Island in 2004 by Klyne Exploration. DDH Klyne No. 1 confirmed the presence of Ashern Formation below waterline near Pemmican Island. Only a few grains of sulphides were found near the base of the hole. Core from DDH Klyne No. 2 and 3 (***Figure 7***) are partly mineralized with specks, clots and fracture-filled stringers of sulphides within dolomite. ***Figure 13*** shows a fracture-filled stringer within dolomite recovered between 17.7 to 17.8 m from DDH Klyne No. 3, the Discovery Hole.

ICP Analyses

Five small loose chip samples from the mineralized interval from DDH Klyne No. 3, sent for ICP-MS analysis, returned the following:
1. 95% dolomite and 5% sulphide - 6.04% Zn, 8585.9 ppm Pb.
2. 80% dolomite and 20% sulphide - 31.2% Zn, 6882.6 ppm Pb and 62 ppm Ag.
3. 75% dolomite and 25% sulphide - 5.66% Zn and 1.04%Pb.
4. 100% sulphide - 7.48% Zn, 2753.6 ppm Pb and 23 ppm Ag.
5. 95% dolomite and 5% sulphide - 0.98% Zn and 1605.7 ppm Pb.

The mineralized core interval from Klyne DDH No. 3 (sent for ICP analysis by Inco Limited) showed:
1. A 15 cm intersection of solid sulphide in Silurian dolomite host rock (at an approximate depth of 15 m below the ice) graded 4.59% Zn, 0.41% Pb, 0.014% Cu, 10.4% Fe and 14.05% S;
2. A 6.5 m intersection averaging 0.61% Zn, over a drilled interval from 17.5 m to 23.9 m (includes the above intersection).

Lead Isotope Analysis

Analysis of Pb isotopes from known MVT and other massive sulphide deposits have proven useful in determining the genesis of these deposits. ***Figure 14*** shows the plot of the Pb 206/204 vs 207/204 values for Upper Mississippi Valley-type (UMV), and, Pine Point and Flin Flon deposits from Gale and Conley (2000). The purpose of the plot was to determine the possible origin of the Balmoral glacially-transported pebble, which triggered MVT investigations throughout southern Manitoba in the 1970s and 1980s.

Four small core samples from the mineralized interval from DDH Klyne No. 3 were selected for Pb isotope analysis.
1. 50% dolomite and 50% sulphide - 3.146% Pb
2. 75% dolomite and 25% sulphide - 0.335% Pb
3. 40% dolomite and 60% sulphide - 2.417% Pb
4. 70% dolomite and 30% sulphide - 2.927% Pb

Sample 1 was selected for Pb isotope analysis and the result is shown below, with those of the Balmoral pebble and Flin Flon from Gale and Conley (2000) and in ***Figure 14:***

SAMPLE:	$206_{Pb}/204_{Pb}$	$207_{Pb}/204_{Pb}$	$208_{Pb}/204_{Pb}$
Pemmican Island	23.3	16.3	46.0
Balmoral pebble	18.48	15.68	39.03
NREP 1 Flin Flon	15.404	15.217	34.983
NREP 2 Flin Flon	15.417	15.210	34.983

Figure 13: Fracture-filled sulphide stringer within dolomite drillcore from the MVT Discovery Hole, DDH Klyne No. 3 (Bamburak and Klyne, 2004).

Discussion

1. A fault, reactivated during the Phanerozoic, along the eastern boundary of the buried SBZ in the vicinity of Pemmican Island, would have provided avenues for mineralized fluid migration from basement into the overlying sedimentary rock, where the right conditions of pressure and temperature would have resulted in deposition of metallic minerals, such as Cu, Pb and Zn.
2. A widespread and extensive pre-Middle Devonian unconformity provided a truncation-type stratigraphic trap within the porous and karsted upper Interlake carbonate rock and the overlying Ashern Formation redbeds. This formed a secondary caprock or seal to prevent upward movement of (hydrocarbon and/or hydrothermal?) fluids along the unconformity. ***Figure 16*** depicts a cross-section across west-central Manitoba with hypothetical MVT orebodies in paleokarst.
3. At least two phases of mineralization are recognizable in hand samples by the colour of the sulphides changing from brown to grey. These phases were confirmed by the different Ni and As contents as disclosed by electron microprobe analysis, as discussed above. This may indicate that mineralization at Pemmican Island is polymetallic.

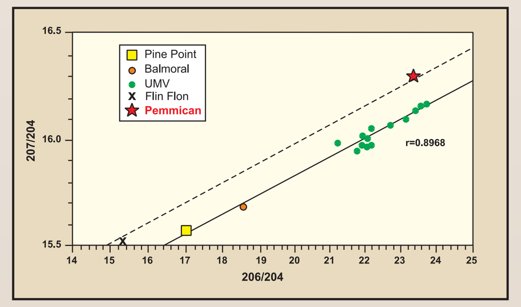


Figure 14: Pb isotope determinations for a Pemmican Island corehole sample, the Balmoral pebble, Pine Point, Upper Mississippi Valley (UMV) and Flin Flon galenas (modified from Gale and Conley, 2000; Bamburak and Klyne, 2004).

Electron Microprobe Analysis

Two electron microprobe transects were carried out on a single sulphide concretion sample from Pemmican Island in 2008. Both transects crossed several grey and brown-coloured mineralized bands. A plot of Ni vs As, shown in Figure 15, from the data shows a distinct grouping of the points along two trend lines for the grey and brown mineralization. In general, Ni>As in the brown bands, but As>Ni in the grey bands. The values for Co are greater than the level of detection for the brown bands, but less than the level of detection for the grey bands. This indicates that the chemistry of solutions that carried the sulphides was variable and that several mineralizing events occurred through time. The sample is essentially marcasite with highly anomalous values of Ni and As.

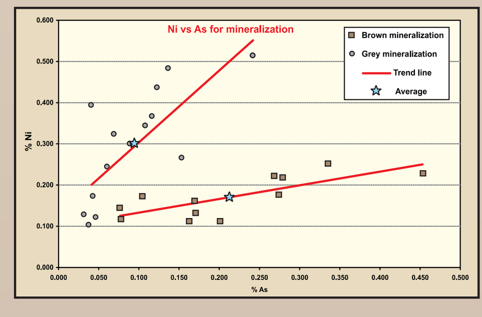


Figure 15: Plot of Ni vs As from electron microprobe data of two transects across a single sulphide concretion collected below the water line on the northeast shore of Pemmican Island.

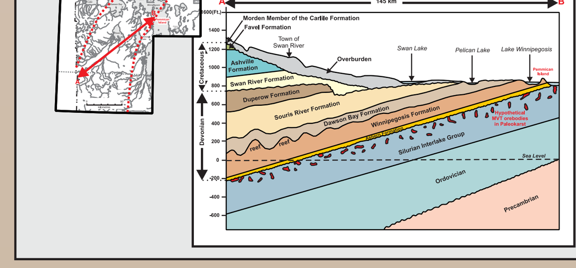
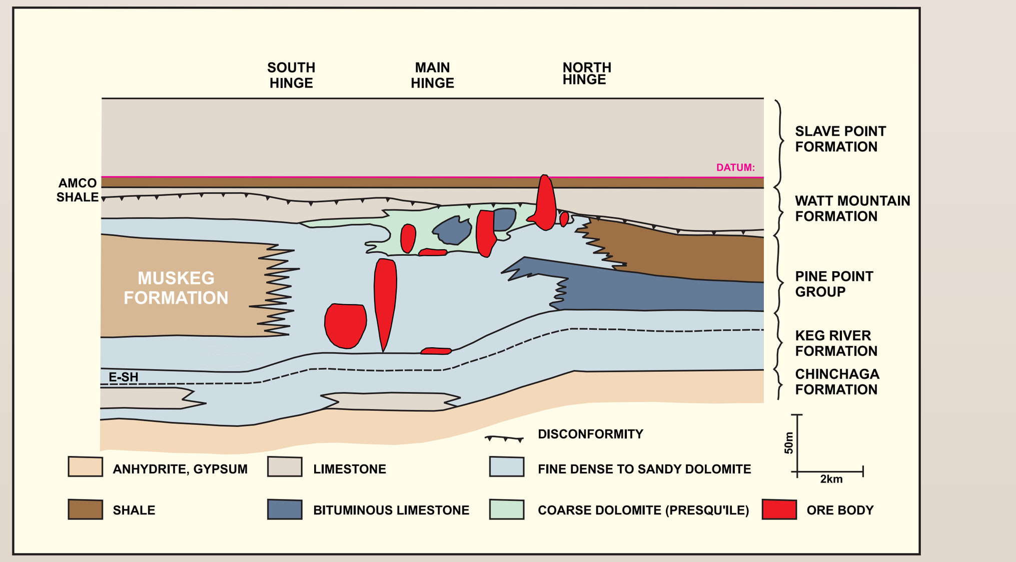


Figure 16: Cross-section across west-central Manitoba showing hypothetical MVT orebodies in Paleokarst.

Theiede and Cameron (1978) showed that the highest concentrations of Cu, Pb and Zn within the Elk Point Evaporite sequence occurred in the green shale and red dolomitic shale of the Ashern Formation, below the massive nodular dolomite of the Winnipegosis Formation. They also concluded that large tonnages of copper, Pb and Zn may be present within the Elk Point Group. The former Pine Point mine in the Northwest Territories and the former Project Wapa in Saskatchewan are situated in approximately the same setting, at the edge of the Elk Point sedimentary basin in Canada.



Pine Point Mining District, N.W.T.
Upper and Middle Devonian Watt Mountain Formation and Pine Point Group
Appears to be associated with Precambrian McDonald Fault and Great Slave Shear Zone
Over 87 Pb-Zn deposits, within interconnected paleokarst network
24 by 65 km area
Total Production - 64.3 million tonnes averaging 3.4% Pb and 7.0% Zn

Figure 17: Schematic cross-section through the Pine Point mining district, N.W.T. from Gale and Conley, 2000; Anderson and McQueen, 1982).

Pine Point, NWT

The Pine Point mining district is located 800 km north of Edmonton (1300 km northwest of north basin of Lake Winnipegosis, ***Figures 1*** and ***3***) on the south side of Great Slave Lake in the Northwest Territories. Within the district, over 87 deposits were defined within a 65 by 24 km area. From these deposits, at least 36 orebodies were mined by Pine Point Mines Ltd. (controlled and operated by Cominco Ltd.) from late 1964 until June 1987 (Rhodes et al., 1984). Total production was 64.3 million tonnes averaging 3.4% Pb and 7.0% Zn (Symons et al., 1993).

At Pine Point, the MVT mineralization is situated within Devonian Pine Point Group and Watt Mountain Formation beds that lie beneath the Amco Shale (***Figure 17***). According to Wright et al. (1994), karst development in the Pine Point area was related to basement re-activation that induced fracturing in the Devonian dolomite overlying the Great Slave Lake Shear Zone (and McDonald Fault). Deposition of most Pine Point orebodies occurred within a single interconnected paleokarst network within bedrock (***Figure 17***) where metallic sulphides precipitated from chloride-rich brines (Rhodes et al., 1984).

Project Wapa, Saskatchewan

Canadian Occidental Petroleum Ltd. and Saskatchewan Mining Development Corporation carried out Project Wapa (***Figure 3***), 24 km south of La Ronge, and 450 km northwest of the north basin of Lake Winnipegosis, from 1976 to 1981. Geochemical analyses of 1600 core samples from 49 drillholes within Middle Devonian hydrothermal dolomite showed values as high as 2850 ppm Pb, but usually ranged from 100 to 600 ppm. These Pb values were accompanied by up to 355 ppm Zn and 3900 ppm F. Visible galena, was noted to occupy a zone (10 km long by 5 km in width), which coincided with the Precambrian Stanley Fault. The project was abandoned in 1981, after shallow drilling (<100 m) failed to locate ore (Campeau and Kissin, 1988 and Kent, 1996).

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Conclusions

1. The Pemmican Island Zn-Pb Discovery has characteristics common with Upper Mississippi Valley-type mineralization, such as a comparable lead isotope ratio. But, the discovery also possesses many features that are similar to Pine Point mining district, deposited in hydrothermally-altered karst within dolomite above a major reactivated Precambrian basement structure and below argillaceous secondary caprock at the edge of the Western Canada Sedimentary Basin.
2. The marcasite mineralization within the discovery, lining the walls of cavities within brecciated Cedar Lake Formation of the Silurian Interlake Group dolomite is polymetallic. This conclusion is indicated by visual examination and by electron microprobe analysis of sulphide and dolomite-bearing concretions and slabs.

The mineralization was deposited during several mineralizing events as euhedral crystals, botryoidal masses, snake-like tube structures, or within fine-grained veinlets within the altered dolomite host-rock.
3. Additional drilling of transient electromagnetic conductors, within a broad weak magnetic anomaly, northeast of Pemmican Island is required to locate the source of mineralization (4.59% Zn, 0.41% Pb) found in the 2004 Discovery Hole; and to demonstrate the potential for a new MVT mining district to be present in the vicinity of Lake Winnipegosis in west-central Manitoba.