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Metal Contents of Selected Phanerozoic Drill Cores and the Potential for Carbonate-hosted Mississippi Valley-type Deposits in Manitoba

OPEN FILE REPORT

By
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Manitoba
Industry, Trade
and Mines

Cover:
Galena pebble found in the Doan family garden near Balmoral, Manitoba (the pebble measures approximately 2x3x1 cm).

Georeference:
NTS grid: 62I, 62J, 62N, 62O, 62P, 63B, 63C, 63F, 63G

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ABSTRACT

Approximately 6000 drill core samples from Phanerozoic carbonates and shales were analyzed for Cu, Zn, Pb, Mn, Fe and Ni in order to determine the source of a galena pebble found near Balmoral and to assess the potential for Mississippi Valley-type (MVT) deposits to occur in southern Manitoba. Selected samples were analyzed for fluorine. Background values vary from formation to formation, but Pb and Zn values that exceed two standard deviations of the entire data set occur in drill cores over a wide area.

The Ordovician rocks of southeastern Manitoba contain carbonate breccia and altered basal sandstones that are affected by Precambrian basement highs; these features suggest an environment similar to that of the Viburnum Trend. Trace amounts of galena reportedly occur in Winnipeg Formation rocks — a potential source rock — in the Grindstone Point area. Some of the breccia in the High Rock Lake area, previously attributed to impactite activity, may represent solution collapse breccia — a ubiquitous feature of MVT deposits.

Devonian rocks in the Dawson Bay–Winnipegosis area that are equivalent to the host rocks to the Pine Point deposits are notably lacking the ubiquitous coarse grained white sparry dolomite crystals that are widespread in the Pine Point district. The 'prairie-type' mineralization discovered in the Mafeking area has gangue minerals and a mode of occurrence that resembles Upper Mississippi Valley-type deposits. This mineralization occurs above the Precambrian Churchill–Superior Boundary Zone and faults in this basement probably provided channelways for fluid and metal migration into the overlying carbonate rocks.

INTRODUCTION

The recovery of a small egg-sized galena pebble from the Doan family garden in the vicinity of Balmoral, Manitoba (Fig. 1; McCabe, 1969) prompted searches for additional pebbles by several exploration companies (H. R. McCabe, pers. comm., 1980). These investigations included examining fields and rock piles for mineralized boulders, analyses of oil well cuttings by XRF, and geochemical soil sampling programs. These programs did not reveal any new occurrences and interest waned in finding the source of the Balmoral pebble. Till and drill core studies were initiated in 1980 to search for additional galena pebbles, heavy minerals associated with Mississippi Valley-type (MVT) mineralization and diamonds (Gale et al., 1981; Nielsen, 1982).

Results from the initial till investigations determined that the Balmoral pebble had been found in a thick unit of uncompacted till with clay interbeds that had been deposited on top of the basal till in this area. It was concluded that the Balmoral galena pebble was found in waterlain till deposited by icebergs in glacial Lake Agassiz; it was probably deposited as a 'drop stone' from floating ice (Gale et al., 1981; Nielsen, 1989).

A galena pebble was reportedly found by a Mr. Jones of Cominco on July 11, 1968 at Kindersly, in southwestern Saskatchewan (Bill Coombes, Saskatchewan Geological Survey, pers. comm., 1982). Sphalerite and galena were intersected in drill cores of Middle Devonian carbonate rocks of the Lower and Upper Elk Point Subgroups in Saskatchewan (Campeau and Kissen, 1988). Trace amounts of mineralization were intersected in drill cores obtained by Occidental Petroleum in 1976. The mineralization occurs in the Meadow Lake Formation, which occurs above the Basal Red Bed that has been correlated with the Ashern Formation of Manitoba; the Meadow Lake Formation occurs below the Winnipegosis Formation (Kent, 1999). The host rocks are 'quartzose arenaceous' and 'grey argillaceous' beds that consist of dolomitic mudstone and minor wackestone lenses (Campeau and Kissen, 1988). The Basal Red Bed sits unconformably on the Winnipeg Formation quartz sandstones in this area.

Galena was reported from two outcrops of Winnipeg Formation sandstones near Grindstone Point by Genik (1952). His description of the heavy minerals in the Winnipeg Formation includes "Galena – A steel blue cubic fragment may be tarnished pyrite grain. Galena from Grindstone Point reported by F.D. Shepard (personal communication.) Outcrop at Grindstone Point has some steely blue cubic crystal aggregates, may be galena." (Genik, 1952, p. 88).

An occurrence of 'lead-zinc' in a trench on an island on the west side at the Paleozoic/Precambrian contact in the northern half of Lake Winnipeg was examined during the 1960s by a staff geologist for D.S. Robertson Consulting Co. The occurrence was reportedly under claim at that time (J. Brummer, written comm., 1989). It is surmised that the mineralization mentioned by J. Brummer is probably the same as that noted by Mr. Shepard who was employed at that time by the Mines Branch of the Province of Manitoba.

H. Keats (pers. comm., 1982) reported obtaining galena in heavy mineral concentrates of beach sands from the Balmoral area in 1967, but was unable to identify the sites during a field trip to the area in 1980. Nielsen (1990) did not encounter significant trace amounts of lead in Quaternary materials of southern Manitoba.

Several 1 mm long acicular grains of honey-coloured sphalerite were identified in drill core (M-6-80) from the Winnipegosis Formation by the first author in 1980.

A pebble of pure galena, reportedly from the Birch River area (Nielsen and Gale, 1982), was analyzed and found to be isotopically identical to the Pine Point galena. The isotopic data indicate that the sample was definitely derived from Pine Point (G. Cumming, pers. comm., 1983) and was unlikely to have been found in the Birch River area. This is consistent with the absence of any degree of rounding, the absence of a lead carbonate rind and the Quaternary environment where the sample was reportedly found.

Following the discovery of the Balmoral pebble (McCabe, 1969), exploration for MVT Pb-Zn mineralization was undertaken by Cominco, Gulf Minerals and the Exploration and Operations Branch of the Manitoba

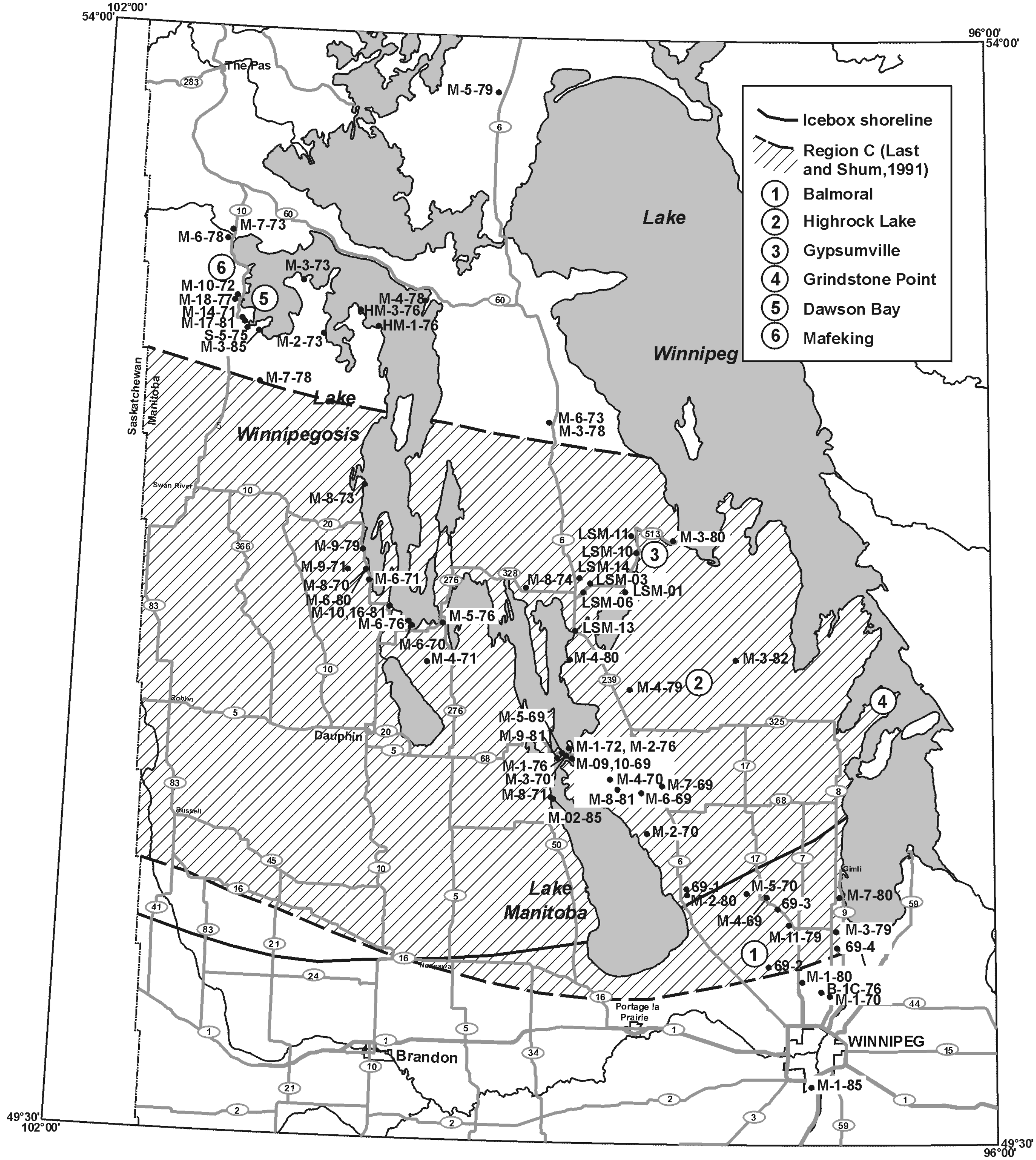


Figure 1: Location of drill cores of Phanerozoic rocks sampled. Shale deposits occur south of the Icebox paleoshoreline (Kessler, 1991).

Mineral Resources Division.

Cominco undertook a reconnaissance study that included analyzing oil well cuttings for Pb and Zn as well as heavy mineral studies of beach sands and tills (W. Wolf, Cominco, pers. comm., 1982). Gulf Minerals sampled oil well cuttings and several drill cores. Their XRF analytical data are included in Manitoba Industry, Trade and Mines assessment files (A.F. 92192). The systematic increase and decrease in reported elemental values suggest that considerable instrument drift occurred during the analysis and elemental data spikes were not obtained. In addition, Gulf Minerals conducted a regional soil survey by collecting a shallow soil sample every ¼ mile along all accessible roads in the area west of Lake Winnipeg and north of the City of Winnipeg. Anomalous values were followed up, but no high values could be repeated. Basal till was not sampled in this study (P. Fisher, Gulf Minerals, pers. comm., 1984). Gulf Minerals drilled four holes in the Minnitonas area before abandoning the project.

Both Cominco and Gulf Minerals used chemical solutions known as "zinc zap" and 'lead zap" to test boulder piles in farmers fields. No mineralized boulders appear to have been identified.

The Exploration and Operations Branch of the Province of Manitoba sampled twigs and soils in the Dawson Bay and Winnipegosis areas. A seismic survey was conducted and four holes were drilled in the Dawson Bay area of Lake Winnipegosis (Stephenson, 1973).

Brine pools, muds and springs in western Manitoba were investigated for base and precious metal contents (Stephenson, 1973; Evans, 1976; Wadien, 1984; Bezys et al., 1997). Unpublished results of analyses of brines performed by the Exploration and Operations Branch are on file in the Manitoba Mines Branch nonconfidential assessment files; anomalous base metal values were obtained from a number of brine pool sediments situated in Devonian rocks. Bezys et al., (1997) found anomalous Au, Pd and Pt; anomalous Zn and Ni were also found at the same brine sites (M. Fedikow, pers. comm., 1999). Brines from springs west of Lake Winnipeg were analyzed by McRitchie and Kaszycki (1997) and Thorleifson et al. (1998).

CURRENT STUDY

The Phanerozoic of Manitoba is extensively covered by variable thicknesses of Quaternary clays and tills. Outcrops are sparse and widely separated. A program of till investigations was undertaken to assess the potential for MVT mineralization in the Phanerozoic of southern Manitoba. The results of the till investigations are summarized in a report by Neilsen (1990). Concurrent studies were conducted on the heavy mineral contents of the tills and the metal contents of selected drill cores. The results of these two investigations are presented here.

Heavy mineral investigation

Portions of the till samples collected were sieved and heavy minerals concentrated on a Wifley shaker table (Nielsen, 1989). Visual examination of the concentrates indicated that the most abundant minerals were magnetite, intergrowths of magnetite and ilmenite and garnet. The heavy separates from the Wifley table were separated with heavy liquids. The heavy mineral portions were separated into strongly- , weakly- , and non-magnetic fractions using a hand magnet and a Franz Isodynamic magnetic separator. The nonmagnetic fractions were mounted on thin section glass and examined under the binocular and polarizing microscopes. Sphalerite and galena were not positively identified in any of these samples.

A portion of the sample concentrates were examined for diamond indicator minerals by Monopros in their laboratories in Canada and South Africa. None of the samples was found to contain kimberlite indicator minerals (Fowler, 1987).

A portion of the heavy mineral separates were leached in acid and analyzed for Pb and Zn. No systematic geochemical anomalies were identified.

Drill core investigation

The Geological Services Branch undertook a systematic diamond drill program throughout southwestern Manitoba to obtain samples for stratigraphic and mapping purposes (e.g. McCabe and Bannatyne, 1969a; Bezys and Conley, 1999). This program resulted in a large repository of well documented drill cores from all Phanerozoic formations in the province. In addition to the examination of available outcrops, drill core from this repository were sampled and analyzed for selected base metals (Gale et al., 1981; Nielsen and Gale, 1982, 1983, 1985) and major elements (Gale, 1991; Bamburak and Gale, 1993).

The objective of the drill core investigation was to determine if one or more of the formations contained evidence that metalliferous fluids percolated through them, and to direct follow-up investigations to those parts of the formations that contain anomalous metal values. Although brief accounts of MVT potential have been presented earlier (Gale et al., 1984, 1987, 1988), this paper presents the analytical data for this project.

Methodology

Drill cores were selected from the repository to provide a composite stratigraphic fence that extends from southeast of Balmoral to the Dawson Bay region (Fig. 1). The cores sampled from this section provide data for most of the formations that are exposed at surface, 'up ice' from the Balmoral pebble site; this presumes that the ice dropped galena pebble was derived from tills deposited in Manitoba.

Approximately 6300 drill core samples were collected. The drill cores sampled are indicated on Figure 1. The number of samples analyzed from each formation are tabulated in Table 1. Drill core logs are presented in Table 2.

Sample preparation

Samples were obtained by cutting an approximately

Table 1: Summary of drill core samples analyzed from each formation and member

Formation						Amaranth Fm.	St. Martin Complex			Souris River Fm.						Dawson Bay Fm.			
BoreHole	Total Depth	Interval Top	Interval Base	Sampled Core	Overburden	Lower Amaranth (Red Beds)	Polymict Breccia	Granite Breccia	Carbonate Breccia	Souris River Formation	Sagemace Member	Point Wilkins Member	middle Point Wilkins	lower Point Wilkins	First Red Beds	Upper Member (Dawson Bay)	Middle Member (Dawson Bay)	Lower Member (Dawson Bay)	Second Red Bed Member
69-01	152.4	4.6	152.1	147.5	18														
69-02	153.9	18.3	153.3	135.0															
69-03	153.3	16.3	149.4	133.1															
69-04	121.0	7.6	105.2	97.6															
B-1C-76	14.3	3.0	14.0	11.0															
HM-01-76	12.5	0.0	12.0	12.0															
HM-03-76	22.6	0.8	16.5	15.7															
LSM-01	89.9	65.2	89.9	24.7				6	29										
LSM-03	91.4	42.1	80.8	38.7		27	17												
LSM-06	70.7	12.8	68.3	55.5															
LSM-10	54.9	25.3	54.9	29.6	2														
LSM-11	153.9	6.4	149.4	143.0															
LSM-13	71.9	2.1	71.3	69.2															
LSM-14	60.7	8.5	58.8	50.3					45										
M-01-70	61.6	7.0	62.2	55.2															
M-01-72	52.0	0.0	46.2	46.2															
M-01-76	34.9	0.0	34.4	34.4															
M-01-80	81.5	0.0	80.9	80.9															
M-01-85	26.6	21.0	26.3	5.3															
M-02-70	17.5	0.0	15.5	15.5															
M-02-73	41.1	0.0	41.0	41.0														15	25
M-02-76	39.1	2.0	38.9	36.9														8	8
M-02-80	287.6	0.0	174.0	174.0															
M-02-85	57.0	30.5	57.0	26.5															
M-03-70	21.0	0.0	21.0	21.0															
M-03-73	61.1	4.6	52.4	47.8														2	9
M-03-79	60.2	3.0	59.8	56.8															
M-03-80	100.0	2.8	55.4	52.6															
M-03-82	246.2	0.0	245.6	245.6															
M-03-85	108.9	3.0	108.7	105.7														5	19
M-04-69	36.6	0.0	30.4	30.4															
M-04-70	16.5	0.9	16.1	15.2															
M-04-71	79.5	0.0	11.5	11.5														20	
M-04-78	93.5	73.9	92.9	19.0															
M-04-79	102.2	0.0	102.2	102.2															
M-04-80	278.6	0.0	278.3	278.3															
M-05-69	41.8	0.0	39.8	39.8															
M-05-70	18.3	0.0	18.0	18.0															
M-05-76	116.7	65.5	107.5	42.0															3
M-05-79	117.9	0.0	119.2	119.2															
M-06-69	29.5	0.0	24.9	24.9															
M-06-70	53.3	0.0	52.4	52.4												11	16	20	13
M-06-71	36.9	1.3	22.1	20.8									31		9				
M-06-73	107.7	0.0	53.4	53.4	4														
M-06-76	138.1	21.9	85.4	63.5															5
M-06-78	74.8	2.8	60.5	57.7														4	10
M-06-80	142.5	2.1	142.0	139.9							114				32	32	40	28	62
M-07-69	41.2	0.0	41.0	41.0															
M-07-73	64.0	1.2	27.4	26.2															
M-07-78	124.2	7.1	123.8	116.7						139									
M-07-80	93.6	0.0	88.8	88.8															
M-08-70	49.7	0.0	51.2	51.2								28			14	6	3		
M-08-71	23.9	5.7	23.0	17.3														16	8
M-08-73	28.9	0.0	27.1	27.1															
M-08-74	16.0	0.0	15.7	15.7															
M-08-81	22.3	0.0	22.0	22.0															
M-09-69	11.9	0.0	10.8	10.8														17	
M-09-71	46.9	0.0	45.6	45.6						21		14							
M-09-79	38.5	5.2	38.4	33.2														19	26
M-10-69	25.4	0.0	25.4	25.4															
M-10-72	21.8	0.0	21.0	21.0														12	7
M-11-79	112.0	4.5	111.5	107.0															
M-14-71	61.8	0.0	36.9	36.9									78	23	27				
M-16-81	139.6	55.3	139.3	84.0												11	19	27	16
M-17-81	85.8	0.0	86.2	86.2	2										8	10	31	11	22
S-05-75	100.9	0.0	100.6	100.6	1													9	15
Grand Total					27	27	17	6	74	160	114	42	109	23	90	70	109	213	248

Formation	Winnipegosis Fm.				Elm Point Fm.	Ashern Fm.	Silurian			Interlake Group					
BoreHole	Winnipegosis Formation	Transitional Beds	Upper Member (Winnipegosis)	Lower Member (Winnipegosis)	Elm Point Formation	Ashern Formation	Silurian (Undifferentiated)	Post Crater Fill	Crater Breccia	Interlake Group	Cedar Lake Formation	East Arm Formation	Atikameg Formation	Moose Lake Formation	Fisher Branch Formation
69-01											55			6	11
69-02															13
69-03															
69-04															
B-1C-76															
HM-01-76	9					5									
HM-03-76	16														
LSM-01															
LSM-03															
LSM-06					50										
LSM-10															
LSM-11															
LSM-13										84					
LSM-14															
M-01-70															
M-01-72	41				34										
M-01-76	46														
M-01-80															
M-01-85															
M-02-70					21	4									
M-02-73	55														
M-02-76	16														
M-02-80				5		8					81			24	19
M-02-85	43														
M-03-70	35														
M-03-73			16	13		15									
M-03-79															
M-03-80															
M-03-82								80	97						
M-03-85		1	107	15		14									
M-04-69														4	30
M-04-70				22		3									
M-04-71															
M-04-78															
M-04-79					3	10	146								
M-04-80				9		14					96	24	14	24	13
M-05-69	64														
M-05-70														19	10
M-05-76			19	28		10				8					
M-05-79														6	18
M-06-69						4					36				
M-06-70	10														
M-06-71															
M-06-73											19	23	11	5	18
M-06-76	104														
M-06-78			45	1											
M-06-80		19	29	38		9									
M-07-69											61				
M-07-73			37												
M-07-78			16	23		7									
M-07-80															
M-08-70															
M-08-71															
M-08-73	40														
M-08-74					16	1					3				
M-08-81				10	11	2									
M-09-69															
M-09-71															
M-09-79	59														
M-10-69			41												
M-10-72		5													
M-11-79															13
M-14-71															
M-16-81			29	26		3									
M-17-81		7	34	12											
S-05-75		15	86	12		5									
Grand Total	538	47	459	214	135	114	146	80	97	92	351	47	25	88	145

Formation	Stonewall Fm.			Stony Mtn. Fm.			Red River Fm.						Winnipeg Fm.		
BoreHole	Stonewall (Upper)	Stonewall (Lower)	Williams Member	Gunton Member	Penitentiary Member	Gunn Member	Red River Formation	lower Red River Formation	Fort Garry Member	Selkirk Member	Cathead Member	Doghead Member	Winnipeg Formation	upper Winnipeg unit	Grand Total
69-01	5	4	4	19	28				2						152
69-02	7	7	8	14	34				62	46					191
69-03		5	4	13	42				46	69	9				188
69-04										50	27	59		8	144
B-1C-76									16						16
HM-01-76															14
HM-03-76															16
LSM-01															35
LSM-03															44
LSM-06															50
LSM-10				4					36						42
LSM-11	8	4	1	29		27			51	20	35	47	1		223
LSM-13															84
LSM-14															45
M-01-70									40	49					89
M-01-72															75
M-01-76															46
M-01-80				5	12	30			55	31					133
M-01-85							8								8
M-02-70															25
M-02-73															95
M-02-76															32
M-02-80	6	10	10	16		36			33						248
M-02-85															43
M-03-70															35
M-03-73															55
M-03-79									7	158	24				189
M-03-80					10				40	20					70
M-03-82								57	66		34		2		336
M-03-85															161
M-04-69	16														50
M-04-70															25
M-04-71															20
M-04-78	15	7	5												27
M-04-79															159
M-04-80	9	12	7	24	28				59	33	37	47		1	451
M-05-69															64
M-05-70															29
M-05-76															68
M-05-79	5	23	6	22	26				18	69					193
M-06-69															40
M-06-70															70
M-06-71															40
M-06-73															80
M-06-76															109
M-06-78															60
M-06-80															403
M-07-69															61
M-07-73															37
M-07-78															185
M-07-80										56	26	61			143
M-08-70															51
M-08-71															24
M-08-73															40
M-08-74															20
M-08-81															23
M-09-69															17
M-09-71															35
M-09-79															104
M-10-69															41
M-10-72															24
M-11-79	10	9	9	18	18	20			57	26					180
M-14-71															128
M-16-81															131
M-17-81															137
S-05-75															143
Grand Total	81	81	54	164	198	113	8	57	588	627	192	214	3	9	6296

Table 2: Location and geological logs for drill cores analyzed

UTM Easting	UTM Northing	Location	Ground Elev. (m)	Well Name	Stratigraphic Unit	Top (m)	Base (m)	Summary Lithology
570300	5600500	100/04-18-018-04W1/00	251	69-01	Overburden	0.0	19.8	
					Interlake Group			
					Cedar Lake Formation	19.8	22.3	Dolostone, sublithographic to finely crystalline
						22.3	32.3	Dolostone, finely crystalline to sublithographic
						32.3	40.2	Dolostone
						40.2	55.5	Dolostone
						55.5	67.4	Dolostone
					Atikameg Formation	67.4	74.1	Dolostone, sublithographic to lithographic, brown
					Moose Lake Formation	74.1	74.7	Dolostone, sublithographic, green, argillaceous
						74.7	79.6	Dolostone, sublithographic to lithographic, light grey, laminar beds
					Fisher Branch Formation	79.6	81.4	Dolostone, sublithographic brownish grey, mottled upper contact marked with red clay, vuggy
						81.4	91.4	Dolostone, sublithographic to lithographic, light grey fossiliferous (brachiopods)
						91.4	99.4	Dolostone
						99.4	101.2	Dolostone
					Stonewall Formation			
					Stonewall Formation - Upper	101.2	101.5	Dolostone
						101.5	106.4	Dolostone
					Stonewall Formation - Lower	106.4	106.7	Dolostone
						106.7	109.4	Dolostone
						109.4	111.2	Dolostone
					Williams Member	111.2	113.1	Dolostone, sublithographic to finely crystalline, red, argillaceous, arenaceous
					Stony Mountain Formation			
					Stony Mountain Formation - Upper			
					Gunton Member	113.1	130.2	Dolostone, sublithographic, light grey, slightly mottled, upper portion vuggy and fossiliferous
					Stony Mountain Formation - Lower			
					Penitentiary Member	130.2	151.5	Dolostone, finely crystalline to sublithographic, light green, grey and red, argillaceous, tubular structures
					Red River Formation			
					Red River Formation - Upper			
					Fort Garry Member	151.5	152.4	Dolostone, finely crystalline to sublithographic, light grey, brachiopods
607500	5566900	100/15-35-014-01W1/00	265	69-02	Interlake Group			
					Fisher Branch Formation	18.3	21.3	Dolostone, finely crystalline, light yellow grey, fossiliferous, brachiopods, crinoid stems
						21.3	26.2	Dolostone, finely crystalline, light yellowish grey, brachiopods, horn corals and tabulate corals, vugular porosity
						26.2	30.5	Dolostone, sublithographic, light grey, beds 1 to 2 inches thick, dense
						30.5	31.1	Dolostone, red, argillaceous, tight
					Stonewall Formation			
					Stonewall Formation - Upper	31.1	34.7	Dolostone, sublithographic to lithographic, light grey, laminar bedding, tight
						34.7	36.6	Dolostone, sublithographic to finely crystalline, light grey and red, argillaceous and arenaceous, bedding 1 to 3 inches thick
					Stonewall Formation - Lower	36.6	38.7	Dolostone, finely crystalline, light yellowish grey, vugular, tabulate corals and brachiopods, interbedded dolostone breccia

Table 2: Location and geological logs for drill cores analyzed *(continued)*

UTM Easting	UTM Northing	Location	Ground Elev. (m)	Well Name	Stratigraphic Unit	Top (m)	Base (m)	Summary Lithology
					Stonewall Formation - Lower (cont.)	38.7	39.9	Dolostone, finely crystalline, light yellowish grey, drop in porosity from the above interval
					Williams Member	39.9	44.5	Dolostone, red, argillaceous, arenaceous, laminar bedding in the beds of greater argillaceous content, beds up to 3 inches thick in less argillaceous beds
						44.5	46.9	Dolostone, sublithographic, light grey to white bedding .25 to 1 inch thick, tight, argillaceous
					Stony Mountain Formation			
					Stony Mountain Formation - Upper			
					Gunton Member	46.9	57.6	Dolostone, sublithographic, light grey, vuggy and fossiliferous at top of interval decreasing to zero near the base where the rock is tight and massive, mottled
					Stony Mountain Formation - Lower			
					Penitentiary Member	57.6	64.0	Dolostone, finely crystalline, red, argillaceous tubular structures, beds 2 inches thick, some beds vuggy and fossiliferous
						64.0	69.3	Dolostone, finely crystalline, red and green argillaceous, tubular structures, intraclasts suspended in dolomite matrix, green shale beds 1 to 3 inches thick, fossiliferous, vuggy
						69.3	75.0	Dolomitic limestone, red, green and light grey, argillaceous, limestone occurs and brachiopod biomicrite and biosparite, thickness of beds 1 to 2 inches, centre of tubular structures is dolomitic
						75.0	77.7	Dolomitic limestone, same as above except less fossiliferous
						77.7	80.2	Limestone, brachiopod biomicrite, grey green and red, argillaceous, bottom 3 feet of interval consists of a calcareous shale
					Red River Formation			
					Red River Formation - Upper			
					Fort Garry Member	80.2	84.7	Limestone, brachiopod biomicrite, white to light grey, bedding 1.5 inches thick, dolomitic matrix approaching base of interval, brachiopods oriented parallel to bedding
						84.7	89.0	Dolostone, finely to medium crystalline, light and dark grey mottled, white chert nodules, brachiopods and tabulate corals, bedding 1 to 6 inches thick, vugular, quartz and pyrite crystals in lining vugs
						89.0	92.1	Dolostone, finely and medium crystalline, light and dark grey, mottled, fossiliferous, no evidence of bedding
						92.1	95.7	Dolostone, finely crystalline, medium grey and light red, cherty, laminar bedded
						95.7	117.0	Dolostone sublithographic to lithographic, laminar bedded, light grey and red
						117.0	122.2	Dolomitic limestone, light grey, laminar bedded, upper potion of the interval has minor interbedded sublithographic dolostone becoming a high calcium limestone towards the bottom
					Red River Formation - Lower			
					Selkirk Member	122.2	153.9	Dolomitic limestone, light grey (limestone) and buff brown (dolomite), mottled, limestone brachiopod crinoid stem horn coral biomicrite, dolomitization radiates from tubular structures and found along bedding planes
611300	5593000	100/04-28-017-01E1/00	262	69-03	Stonewall Formation			
					Stonewall Formation - Lower	14.9	15.8	Dolostone, finely crystalline
					Williams Member	15.8	22.9	Dolostone, sublithographic, red, argillaceous, arenaceous

Table 2: Location and geological logs for drill cores analyzed *(continued)*

UTM Easting	UTM Northing	Location	Ground Elev. (m)	Well Name	Stratigraphic Unit	Top (m)	Base (m)	Summary Lithology
					Stony Mountain Formation			
					Stony Mountain Formation - Upper			
					Gunton Member	22.9	33.5	Dolostone, sublithographic, light grey
					Stony Mountain Formation - Lower			
					Penitentiary Member	33.5	57.9	Dolostone, sublithographic to finely crystalline, red, green and light grey, argillaceous
						57.9	61.0	Dolomitic limestone, light grey, green and red, argillaceous
					Red River Formation			
					Red River Formation - Upper			
					Fort Garry Member	61.0	61.9	Limestone, micrite, light grey, tight
						61.9	65.5	Dolostone, sublithographic, light grey, tight
						65.5	67.4	Dolostone, finely crystalline, light grey, cherty, fossiliferous
						67.4	72.5	Dolomitic limestone, light grey and reddish brown
						72.5	94.5	Dolostone, sublithographic to lithographic, light grey with minor red interbeds
					Red River Formation - Lower			
					Selkirk Member	94.5	102.1	Limestone, micritic, tight, light grey, slightly mottled
						102.1	144.2	Dolomitic limestone, light grey
					Cat Head Member	144.2	153.3	Calcitic dolostone, light grey and buff brown
638300	5576300	100/16-36-015-03E1/00	230	69-04	Red River Formation			
					Red River Formation - Lower			
					Selkirk Member	7.6	46.0	Dolomitic limestone, yellowish grey and light grey and red mottled
					Cat Head Member	46.0	64.3	Calcitic dolostone, yellowish grey and light grey mottled, dolomite finely crystalline, chert nodules, chert pseudomorphic replacement of fossils
					Dog Head Member	64.3	103.0	Dolomitic limestone, light grey and yellowish grey, dolomite accounts for 30 to 40% of the rock, occurs as finely crystalline concentrations
					Winnipeg Formation			
					upper Winnipeg unit	103.0	108.2	Arenaceous shale, greyish green, medium grained, well rounded quartz sand occurs as small lenses, separated by green shale, tight
						108.2	121.0	Shale, green and dark brown, chitonous brachiopods occur in the shale
631800	5557300	100/04-05-014-03E1/00	235	B-1C-76	Overburden	0.0	3.0	
					Red River Formation			
					Red River Formation - Upper			
					Fort Garry Member	3.0	13.4	
						13.4	14.3	
427400	5850500	100/01-24-044-19W1/00	262	HM-01-76	Winnipegosis Formation	0.3	9.1	Dolomite
					Ashern Formation	9.1	12.5	Shale, red, dolomitic
420000	5856500	100/12-05-044-19W1/00	267	HM-03-76	Winnipegosis Formation			
					Lower Member	0.3	17.0	Dolomite
					Ashern Formation	17.0	22.6	Shale, green to red dolomitic
542250	5732500	SE-16-032-07W1	250	LSM-01	St. Martin Complex			
					St. Martin Series - Tachyandesite	0.0	65.2	Tachyandesite, light greenish to purplish grey, becoming darker reddish grey towards base; medium-fine grained at top grading to very fine grained at base; vesicles and granitic inclusions in bottom 12 feet; numerous calcite veinlets at base
					St. Martin Series - Granitic Breccia	65.2	68.6	Breccia; fragments of altered granitic rocks up to 1 foot in diameter in micro breccia matrix; similar to Bralorne breccia

Table 2: Location and geological logs for drill cores analyzed *(continued)*

UTM Easting	UTM Northing	Location	Ground Elev. (m)	Well Name	Stratigraphic Unit	Top (m)	Base (m)	Summary Lithology
					St. Martin Series - Carbonate Breccia	68.6	71.3	Alternating intervals of brecciated carbonate rocks and granitic microbreccia similar to above but highly altered to compact clay-like material; contacts extremely irregular
						71.3	90.2	Carbonate breccia; consists of limestone, argillaceous limestone, calcareous shale and dolomite, all highly brecciated; varying degrees of mixing of lithologic types are noted, from monomict mosaic or 'crackle' breccias to mixed or polymict
525800	5736500	100/06-26-032-09W1/00	256	LSM-03	Amaranth Formation			
					Upper Amaranth (Evaporite) Member	0.0	10.4	Gypsum, thin bedded, clay seams
						10.4	37.8	Anhydrite, minor clay and gypsum with glauberite 109 to 124
						37.8	42.1	Anhydrite, interbedded red dolomitic shale
					Lower Amaranth (Red Bed) Member	42.1	48.8	Red shale silty, dolomitic; abundant satin spar stringers parallel to bedding; becoming sandy in bottom 2 feet
						48.8	55.8	Breccia; sparse to abundant angular to subrounded fragments of dolomite, "granit", and greenish rock closely resembling the St. Martin trachyandesite; matrix is medium to coarse grained dolomitic sandstone; a few thin satin spar stringers
						55.8	57.6	Dolomite, silty, argillaceous; several inclusions of underlying polymict microbreccia near base; sharp horizontal contact
					St. Martin Complex			
					St. Martin Series - Polymict Breccia	57.6	68.6	Polymict breccia; highly altered friable appearance; color is vaguely mottled shades of reddish to greenish grey
						68.6	80.8	Polymict breccia as above but with carbonate fragments rare or absent, red altered aphanitic igneous fragments predominant and of larger size and partly vesicular; granitic fragments to 4" common
					St. Martin Series - Trachyandesite	80.8	91.4	Tachyandesite, medium purplish grey, very fine grained, massive, abundant fine quartz and feldspar inclusions; granitic fragments to 4" common, in part vesiculated
523000	5732000	100/07-16-032-09W1/00	247	LSM-06	Elm Point Formation	12.8	21.3	Limestone, dolomitic limestone, and dolomite, interbedded, fine horizontal laminations
						21.3	46.6	Limestone, mottles pale yellowish to brownish buff, massive; high calcium limestone identical in appearance to Devonian Elm Point Formation
						46.6	47.9	Interbedded dolomite and limestone, fractured with vuggy solution cavities near base
						47.9	70.7	Recovered only 8 feet broken core, mixed limestone, dolomite and red calcareous shale
546800	5750400	100/07-12-034-07W1/00	245	LSM-10	Overburden	25.3	26.2	
					Stony Mountain Formation			
					Stony Mountain Formation - Upper Gunton Member	26.2	29.0	Dolomite, light grey buff, faintly speckled banded and mottled, microcrystalline, slightly granular, abundant fine fossil fragments
					Red River Formation			
					Red River Formation - Upper Fort Garry Member	29.0	54.9	Dolomite, mostly microcrystalline dense to sublithographic, color varies from pale yellowish brown to medium grey and purplish grey, in part shows prominent mottling, minor fine horizontal lamination

Table 2: Location and geological logs for drill cores analyzed *(continued)*

UTM Easting	UTM Northing	Location	Ground Elev. (m)	Well Name	Stratigraphic Unit	Top (m)	Base (m)	Summary Lithology
544800	5758300	100/11-02-035-07W1/00	242	LSM-11	Stonewall Formation			
					Stonewall Formation - Upper	6.4	11.3	Dolomite, pale grey to yellowish buff, in part faintly mottled, microcrystalline, dense to slightly granular, some coarse vuggy porosity near base
					Stonewall Formation - Lower	11.3	14.0	Dolomite, pale grey to yellowish buff, in part faintly mottled, microcrystalline, dense to slightly granular, some coarse vuggy porosity near base
					Williams Member	14.0	14.9	Dolomite, silty and slightly argillaceous, medium light bluish grey, banded
					Stony Mountain Formation			
					Stony Mountain Formation - Upper			
					Gunton Member	14.9	37.2	Dolomite, pale yellowish buff, massive, microcrystalline, dense to slightly granular; becoming denser and showing faint to prominent streaking and mottling in bottom 11 feet
					Stony Mountain Formation - Lower			
					Gunn Member	37.2	53.6	Dolomite, slightly to moderately argillaceous, mottled and streaked shades of medium to light grey and purplish grey mottling shows characteristic vermiform pattern, sparsely fossiliferous
					Red River Formation			
					Red River Formation - Upper			
					Fort Garry Member	53.6	57.6	Dolomite, pale yellowish buff with grey argillaceous streaking, microcrystalline, chert nodules to 4 inches
						57.6	62.5	Interbedded limestone, dolomite, and breccia; limestone mostly brownish buff finely crystalline subsaccharoidal, some fine argillaceous partings; dolomite buff to grey, partly laminated
						62.5	82.9	Dolomite, variable, light grey to yellowish buff, some purplish grey mottling microcrystalline, sublithographic, some argillaceous bands
						82.9	86.4	Dolomite, in part calcareous, becoming more calcareous towards base, microcrystalline, faintly mottled and streaked grey to buff
					Red River Formation - Lower			
					Selkirk Member	86.4	93.6	Limestone, pale grey to greenish grey, microcrystalline dense at top grading downward to coarse crinoidal biospartite (a high calcium limestone)
						93.6	100.6	Limestone, dolomitic, dolomite disseminated in calcareous matrix, microcrystalline to very finely crustalline, moderately granular, irregular streaking and mottling
					Cat Head Member	100.6	121.3	Calcareous dolomite, light grey buff, faintly streaked and mottled, microcrystalline granular, good fine intergranular porosity; white chert nodules to 2 inches common
					Dog Head Member	121.3	150.3	Dolomitic limestone, mottled shades of pale grey to brownish buff, darker patches highly dolomitized, microcrystalline to very finely crystalline, dense, tight, fine fossil debris (biomicrite); becoming reddish towards base
					Winnipeg Formation	150.3	153.9	Shale and sandy shale, mottled shades of purplish red and green
519000	5715000	100/10-24-030-10W1/00	250	LSM-13	Interlake Group	2.1	71.9	Dolomite, fairly uniform, light buff to greyish white, microcrystalline dense to sublithographic, some coarser grained intervals, several thin shaly beds
521500	5738500	100/06-04-033-09W1/00	250	LSM-14	St. Martin Series - Carbonate Breccia	8.5	60.7	Brecciated limestone, dolomite, and shale; interlayered; rusty shades of light grey to buff but some intervals of medium yellow, orange and red; relatively pure limestone, microcrystalline to medium crystalline is most common

Table 2: Location and geological logs for drill cores analyzed *(continued)*

UTM Easting	UTM Northing	Location	Ground Elev. (m)	Well Name	Stratigraphic Unit	Top (m)	Base (m)	Summary Lithology
622800	5560300	100/10-27-013-03E1/00	235	M-01-70	Red River Formation	0.0	6.7	Overburden
					Red River Formation - Upper			
					Fort Garry Member	6.7	32.0	Dolomite sublithographic
					Red River Formation - Lower			
					Selkirk Member	32.0	62.5	Dolomitic limestone
517500	5661800	100/16-26-024-10W1/00	250	M-01-72	Winnipegosis Formation	0.0	26.8	Saccharoidal dolomite
					Elm Point Formation	26.8	46.9	Dolomitic limestone, calcareous dolomite
					Ashern Formation	46.9	52.1	Shale, red and grey
516000	5658600	100/16-15-024-10W1/00	253	M-01-76	Winnipegosis Formation	0.0	34.8	Dolomite
622800	5560500	100/01-17-014-02E1/00	247	M-01-80	Stony Mountain Formation			
					Stony Mountain Formation - Upper			
					Gunton Member	0.0	3.4	Dolomite, mottles
					Stony Mountain Formation - Lower			
					Penitentiary Member	3.4	10.2	Dolomite, argillaceous, burrow mottled
					Gunn Member	10.2	28.6	Dolomitic shale and calcitic dolomite
					Red River Formation			
					Red River Formation - Upper			
					Fort Garry Member	28.6	44.7	- 30.9 Limestone and calcitic dolomite
								- 39.8 Cherty dolomite
								- 43.5 Cherty limestone
								- 44.7 Intraclastic argillaceous dolomite
						44.7	62.7	- 62.7 Dolomite, fine grained, mottled to laminated
					Red River Formation - Lower			
					Selkirk Member	62.7	81.5	Limestone and mottled dolomitic limestone, cherty
625750	5513750	100/16-23-009-02E1/00	233	M-01-85	Overburden	0.0	20.7	Overburden
					Red River Formation	20.7	26.6	Dolomite, dense
552800	5624900	100/01-05-021-06W1/00	255	M-02-70	Elm Point Formation	0.0	12.8	Limestone, high-calcium
					Ashern Formation	12.8	17.5	Argillaceous dolomite
402800	5845300	100/09-33-043-21W1/00	258	M-02-73	Dawson Bay Formation			
					Lower Member	0.0	6.7	Limestone, dolomite
					Second Red Bed Member	6.7	17.4	Shale, red
					Winnipegosis Formation	17.4	23.8	Dolomite, minor limestone
						23.8	41.1	Limestone
518800	5657800	100/07-13-024-10W1/00	255	M-02-76	Dawson Bay Formation			
					Lower Member	1.8	7.1	Limestone, buff, micritic, dense, grading to calcareous dolomite
					Second Red Bed Member	7.1	18.9	Shale, red, dolomitic
					Winnipegosis Formation	18.9	19.5	Dolomite, finely laminated, fissile
						19.5	42.1	Dolomite, buff, faintly mottled, variably porous and fossiliferous
570300	5598900	102/04-18-018-04W1/00	252	M-02-80	Winnipegosis Formation			
					Lower Member	0.0	5.7	Limestone, mottled partly dolomitic
					Ashern Formation	5.7	16.0	Red and grey dolomitic shale, breccia
					Interlake Group			
					Cedar Lake Formation	16.0	100.5	Dolomite, sublithographic to fossil-fragmental
								(17-20) Limestone, partly dolomitic
					Moose Lake Formation	74.0		(71-74) Shaly, V-marker
					Fisher Branch Formation	88.5		(88-90) Argillaceous, U-marker
					Stonewall Formation			
					Stonewall Formation - Upper	100.5	106.1	Dolomite, sublithographic, medial argillaceous sandy marker
					Stonewall Formation - Lower	106.1	111.8	
					Williams Member	111.8	118.6	Dolomite with argillaceous interbeds

Table 2: Location and geological logs for drill cores analyzed *(continued)*

UTM Easting	UTM Northing	Location	Ground Elev. (m)	Well Name	Stratigraphic Unit	Top (m)	Base (m)	Summary Lithology
					Stony Mountain Formation			
					Stony Mountain Formation - Upper			
					Gunton Member	118.6	130.2	Dolomite, mottled, nodular
					Stony Mountain Formation - Lower			
					Gunn Member	130.2	151.2	Argillaceous dolomite
					Red River Formation			
					Red River Formation - Upper			
					Fort Garry Member	151.2	185.7	Dolomite, minor limestone and shaly beds
					Red River Formation - Lower			
					Selkirk Member	185.7	237.2	Dolomite and mottled dolomitic limestone
					Cat Head Member	237.2	243.9	Dolomite, mottled and banded
					Dog Head Member	243.9	286.9	Mottled dolomitic limestone
					Winnipeg Formation			
					upper Winnipeg unit	286.9	287.6	Shale, silty, hematite oolites
508500	5641500	102/06-25-022-11W1/00	251	M-02-85	Dawson Bay Formation			
					Lower Member	1.0	6.2	Limestone, buff, mottled purplish red sublithographic, slightly argillaceous
						6.2	16.9	Dolomite, argillaceous, microgranular, buff to reddish and purplish mottled
					Second Red Bed Member	16.9	25.8	Dolomitic shale, variably mottled buff to red and grey, some breccia
					Winnipegosis Formation			
					Upper Member	25.8	57.0	Dolomite, massive to partly banded, fine to coarsely crystalline, granular, good intergranular porosity, faint relict fossil content (Upper reefal facies)
515600	5658300	16-15-024-10W	250	M-03-70	Winnipegosis Formation	0.0	24.4	Dolomite, reefoid
393500	5869600	100/09-16-046-22W1/00	261	M-03-73	Dawson Bay Formation			
					Lower Member	0.0	7.6	Limestone, dolomite
					Second Red Bed Member	7.6	16.8	Shale, red and grey
					Winnipegosis Formation			
					Upper Member	16.8	18.3	Dolomite and limestone, finely laminated, partly bituminous
						18.3	28.0	Dolomite and limestone, finely laminated, partly bituminous
					Lower Member	28.0	43.0	Dolomite, buff, granular
					Ashern Formation	43.0	55.5	Shale, argillaceous dolomite, red
					Interlake Group			
					Cedar Lake Formation	55.5	61.0	Dolomite
637800	5583800	100/03-25-016-03E1/00	233	M-03-79	Overburden	0.0	3.0	Clay, some till
					Red River Formation			
					Red River Formation - Upper			
					Fort Garry Member	3.0	5.2	Dolomite
					Red River Formation - Lower			
					Selkirk Member	5.2	52.8	Limestone and cherty banded dolomitic limestone to 13.6 m mottled dolomitic limestone
					Cat Head Member	52.8	60.2	Dolomite, mottled
563500	5756000	100/10-27-034-05W1/00	220	M-03-80	Overburden	0.0	2.8	
					Stony Mountain Formation			
					Stony Mountain Formation - Lower			
					Penitentiary Member	2.8	9.3	Dolomite, slightly argillaceous, mottled
					Red River Formation			
					Red River Formation - Upper			
					Fort Garry Member	9.3	42.0	Dolomite, minor chert and shaly beds, mottled to laminated

Table 2: Location and geological logs for drill cores analyzed *(continued)*

UTM Easting	UTM Northing	Location	Ground Elev. (m)	Well Name	Stratigraphic Unit	Top (m)	Base (m)	Summary Lithology
					Red River Formation - Lower			
					Selkirk Member	42.0	62.5	Dolomite, partly calcareous, cherty
					Cat Head Member	62.5	80.5	Dolomite, cherty, banded
					Dog Head Member	80.5	100.0	Mottled dolomitic limestone
					Winnipeg Formation			
					upper Winnipeg unit	105.0		
591500	5703000	100/01-09-029-02W1/00	239	M-03-82	Silurian			
					Post Crater Fill	0.0	14.0	Fossiliferous dolomite calcarenite, porous, massive
						14.0	22.4	Dolomite, buff, dense, argillaceous and silty interbeds (dip approx. 15 degrees)
						22.4	27.0	Sandy argillaceous dolomite, reddish mottled
						27.0	30.7	Dolomite, buff, mottled
						30.7	48.3	Red beds, sandy silty argillaceous dolomite and dolomite shale
						48.3	54.8	Dolomite slightly argillaceous, floating sand grains near base
					Red River Formation - Crater Breccia	54.8	66.3	Microbreccia; mixed dolomite fragments to 4 cm
					Crater Breccia as below	66.3	246.2	Megabreccia; fine to coarse dolomite fragments to 20 m; some fragments sandstone and shale, trace granite
					Winnipeg	73.1		
					Red River Formation - Lower	73.7		
					Winnipeg	81.5		
					Red River Formation - Lower	82.0		
					Fort Garry Member	85.0		
					Cathead Member	106.0		
					Red River Formation - Crater Breccia	122.5		
					Fort Garry Member	171.0		
					Cathead Member	195.4		
					Red River Formation - Lower	201.6		
					Red River Formation - Crater Breccia	208.2		
					Red River Formation - Lower	210.5		
					Fort Garry Member	212.4		
					Red River Formation - Crater Breccia	214.8		
					Red River Formation - Lower	220.6		
					Red River Formation - Crater Breccia	232.2		
					Red River Formation - Lower	237.7		
373500	5845750	102/09-33-043-24W1/00	269	M-03-85	Dawson Bay Formation			
					Lower Member	0.0	4.7	Limestone, brachiopod biomicrite, partly dolomitized towards base
						4.7	5.6	Dolomite, buff to partly grey mottled, massive very finely crystalline, granular, slightly argillaceous
					Second Red Bed Member	5.6	17.2	Argillaceous dolomite to dolomitic shale, massive to partly brecciated, grey to buff and red, some limestone fragments
					Winnipegosis Formation			
					Transitional Beds	17.2	17.5	Limestone, light grey, finely crystalline, dense, fine irregular shaly partings
					Upper Member	17.5	54.2	Dolomite massive, pelletal banded at top, becoming reefal with some coral and stromatoporoid, good porosity
						54.2	89.7	Dolomite, finely crystalline granular, dark brown bituminous partings toward base (inter reef ?)
					Lower Member	89.7	100.3	Dolomite, medium brown, finely crystalline, moderately granular, fossil fragments, argillaceous bands and streaks (platform ?)
					Ashern Formation	100.3	108.9	Argillaceous dolomite to dolomitic shale buff to brownish red, some breccia

Table 2: Location and geological logs for drill cores analyzed *(continued)*

UTM Easting	UTM Northing	Location	Ground Elev. (m)	Well Name	Stratigraphic Unit	Top (m)	Base (m)	Summary Lithology
606300	5598400	102/04-11-018-01W1/00	271	M-04-69	Interlake Group			
					Moose Lake Formation	0.0	2.7	
					Fisher Branch Formation	2.7	21.1	
					Stonewall Formation			
					Stonewall Formation - Upper	21.1	30.8	Dolomite
					Stonewall Formation - Lower			
					Williams Member	30.8	35.4	
					Stony Mountain Formation			
					Stony Mountain Formation - Upper			
					Gunton Member	35.4	36.6	Dolomite, argillaceous, sandy
546000	5648900	100/04-14-023-08W1/00	251	M-04-70	Winnipegosis Formation			
					Lower Member	0.0	14.1	Dolomite and dolomitic limestone, interbedded
					Ashern Formation	14.1	16.5	Red argillaceous dolomite
453000	5696800	100/03-17-028-16W1/00	261	M-04-71	Dawson Bay			
					Lower Member	0.0	15.2	Limestone, dolomite
					Second Red Bed Member	15.2	23.5	Red mottled shale
					Winnipegosis Formation			
					Upper Member	23.5	24.4	Dolomite
447500	5860800	100/12-19-045-16W1/00	254	M-04-78	Interlake Group			
					Cedar Lake Formation	0.0	28.5	Dolomite, sublithographic and fragmental
						28.5	36.9	Dolomite, algal, fragmental
					East Arm Formation	36.9	45.8	Dolomite, algal; breccia, sandy
					Atikameg Formation	45.8	50.5	Dolomite, granular, vuggy
					Moose Lake Formation	50.5	58.9	Dolomite, aphanitic/fragmental
						58.9	60.0	Dolomite, sandy, silty; breccia
						60.0	68.0	Dolomite, earthy, argillaceous
					Fisher Branch Formation	68.0	74.3	Dolomite, fossiliferous
					Stonewall Formation			
					Stonewall Formation - Upper	74.3	74.5	Dolomite, argillaceous, silty
						74.5	79.0	Dolomite, fossiliferous, laminated, conglomeratic
					Stonewall Formation - Lower	79.0	80.9	Argillaceous, sandy breccia at base
						80.9	90.0	Dolomite, nodular
					Williams Member	90.0	90.7	Argillaceous dolomite; breccia
						90.7	93.5	Dolomite, nodular
544800	5698800	100/02-22-027-07W1/00	287	M-04-79	Elm Point Formation	0.0	3.0	Limestone, thin basal dolomite
					Ashern Formation	3.0	10.0	Breccia, shale/dolomite, shades of red and brown
					Silurian (Undifferentiated)	10.0	98.7	Dolomite, variable, aphanite to granular and vuggy, shale-filled cavities upper 70 m
515500	5700500	100/10-03-029-10W1/00	250	M-04-80	Winnipegosis Formation			
					Lower Member	0.0	6.1	Limestone, high-calcium
						6.1	6.4	Dolomite
					Ashern Formation	6.4	16.6	Dolomitic shale, red to grey
					Interlake Group	16.6	121.2	Dolomite, sublithographic to fossiliferous fragmental and intraclastic
					Cedar Lake Formation	16.6	76.3	
					East Arm Formation	76.3	90.7	(89-91) Argillaceous, V-marker
					Atikameg Formation	90.7	99.8	
					Moose Lake Formation	99.8	113.4	(107-109) Argillaceous, U-marker
					Fisher Branch Formation	113.4	121.2	

Table 2: Location and geological logs for drill cores analyzed *(continued)*

UTM Easting	UTM Northing	Location	Ground Elev. (m)	Well Name	Stratigraphic Unit	Top (m)	Base (m)	Summary Lithology
					Stonewall Formation			
					Stonewall Formation - Upper	121.2	126.5	Dolomite, fine grained, minor chert, medial argillaceous marker
					Stonewall Formation - Lower	126.5	138.6	
					Williams Member	133.7	138.6	Dolomite, partly argillaceous, silty
					Stony Mountain Formation			
					Stony Mountain Formation - Upper			
					Gunton Member	138.6	153.9	Dolomite, nodular, mottled
					Stony Mountain Formation - Lower			
					Penitentiary Member	153.9	171.7	Argillaceous dolomite, reddish mottled
					Red River Formation			
					Red River Formation - Upper			
					Fort Garry Member	171.7	208.5	Dolomite, variable, some cherty and argillaceous
					Red River Formation - Lower			
					Selkirk Member	208.5	228.1	Dolomitic limestone, banded to mottled, in part cherty
					Cat Head Member	228.1	250.3	Dolomite, cherty, laminated
					Dog Head Member	250.3	278.3	Mottled dolomitic limestone
					Winnipeg Formation			
					Upper Member	278.3	278.6	
514300	5660200	100/03-21-024-10W1/00	257	M-05-69	Winnipegosis Formation	0.0	2.1	Dolomite, pale yellowish buff
						2.1	32.3	Dolomite, pale yellowish to brownish buff
						32.3	41.8	Dolomite medium light yellow brown, generally coarse grained
597300	5599100	100/08-14-018-02W1/00	267	M-05-70	Interlake Group	0.0	18.3	Dolomite
					Moose Lake Formation	0.0	12.2	
					Fisher Branch Formation	12.2	18.3	
454800	5715300	102/10-22-030-16W1/00	258	M-05-76	Souris River Formation			
					Point Wilkins Member			
					Lower Point Wilkins	0.0	8.8	Limestone and calcareous dolomite, yellow to buff, porous
					First Red Bed Member	8.8	18.9	Shale, red to grey interbeds, limestone, dolomite, breccia
					Dawson Bay Formation			
					Upper Member	18.9	33.5	Dolomite medium brown, saccharoidal, thin limestone at top
					Middle Member	33.5	44.5	Shale, red to grey, calcareous, fossiliferous
					Lower Member	44.5	58.5	Limestone, buff to purplish, micritic, systolitic, grading to argillaceous
					Second Red Bed Member	58.5	67.7	Shale, dolomitic, buff to red
					Winnipegosis Formation			
					Upper Member	67.7	68.3	Limestone breccia (collapse)
						68.3	71.6	Limestone, laminated, bituminous, stylolitic
						71.6	78.6	Limestone, bituminous, banded and streaked
					Lower Member	78.6	95.7	Limestone, mottled, variably dolomitic
					Ashern Formation	95.7	102.4	Shale, red to buff, dolomitic, breccia interbeds
					Interlake Group	102.4	116.7	Dolomite, buff
480100	5955000	100/16-10-055-13W1/00	273	M-05-79	Interlake Formation			
					Moose Lake Member	0.0	4.6	Dolomite, aphanite, stromatolitic
					Fisher Branch Member	4.6	12.7	Dolomite, calcarenitic
						12.7	15.7	Dolomite, fossiliferous
					Stonewall Formation			
					Stonewall Formation - Upper	15.7	18.5	Dolomite
					Stonewall Formation - Lower	18.5	33.5	
					Williams Member	33.5	37.3	Dolomite, dense, slightly argillaceous

Table 2: Location and geological logs for drill cores analyzed *(continued)*

UTM Easting	UTM Northing	Location	Ground Elev. (m)	Well Name	Stratigraphic Unit	Top (m)	Base (m)	Summary Lithology
					Stony Mountain Formation			
					Stony Mountain Formation - Upper			
					Gunton Member	37.3	50.9	Dolomite, nodular bedded
					Stony Mountain Formation - Lower			
					Penitentiary Member	50.9	66.7	Dolomite, slightly argillaceous, fossiliferous
					Red River Formation			
					Red River Formation - Upper			
					Fort Garry Member	66.7	77.5	Dolomite, dense, partly shaly
					Red River Formation - Lower			
					Selkirk Member	77.5	117.9	Dolomite, mottled, sandy at base
					Winnipeg Formation			
					upper Winnipeg unit	117.9		
549800	5644500	100/15-31-022-06W1/00	268	M-06-69	Ashern Formation	0.0	2.1	Dolostone, finely crystalline, red, argillaceous
						2.1	2.3	Dolostone, breccia, clasts .25 to 1 inch across
					Interlake Group			
					Cedar Lake Formation	2.3	3.5	Dolostone, sublithographic, light yellowish grey, tight
						3.5	7.6	Dolostone, sublithographic, light yellowish grey
						7.6	10.1	Dolostone, finely crystalline to sublithographic
						10.1	12.5	Dolostone, finely crystalline to sublithographic
						12.5	14.0	Dolostone, finely crystalline and lithographic
						14.0	15.5	Dolostone, finely crystalline and sublithographic
						15.5	20.4	Dolostone, sublithographic, light grey
						20.4	20.7	Dolostone, powder
						20.7	21.7	Dolostone, sublithographic, light grey
						21.7	25.9	Dolostone, lithographic, light grey
						25.9	27.1	Dolostone, lithographic, laminar bedded, green shaly partings
						27.1	29.1	Dolostone, finely crystalline, light grey
						29.1	29.5	Dolostone, lithographic, light green, green argillaceous dolostone at upper contact
445400	5714000	100/09-16-030-17W1/00	255	M-06-70	Dawson Bay Formation			
					Upper Member	0.0	7.8	Limestone, dolomite, shale
					Middle Member	7.8	20.0	
					Lower Member	20.0	34.6	
					Second Red Bed Member	34.6	45.4	
					Winnipegosis Formation	45.4	46.6	Dolomite (artesian salt water)
						46.6	53.3	
425000	5734100	100/01-21-032-19W1/00	262	M-06-71	Souris River Formation			
					Point Wilkins Member			
					middle Point Wilkins	0.0	20.1	Limestone, partly argillaceous, dolomitic
					First Red Beds	20.1	29.9	Dolomite and dolomitic shale
					Dawson Bay Formation			
					Upper Member	29.9	36.9	Limestone, dolomite
506600	5810000	100/12-18-040-10W1/00	259	M-06-73	Interlake Group			Dolomite, mottled, argillaceous
					Cedar Lake Formation	2.4	14.7	
					East Arm Formation	14.7	29.9	
					Atikameg Formation	29.9	36.0	
					Moose Lake Formation	36.0	39.0	
					Fisher Branch Formation	39.0	61.9	

Table 2: Location and geological logs for drill cores analyzed *(continued)*

UTM Easting	UTM Northing	Location	Ground Elev. (m)	Well Name	Stratigraphic Unit	Top (m)	Base (m)	Summary Lithology
444000	5716000	100/13-21-030-17W1/00	255	M-06-76	Overburden	0.0	2.7	Till
					Dawson Bay Formation			
					Lower Dawson Bay Member	2.7	13.4	Limestone, buff to brown, micritic, fossiliferous at top, becoming bituminous and grading to bituminous dolomite at base
					Second Red Bed Member	13.4	24.4	Shale, red to buff, dolomitic, breccia zones
					Winnipegosis Formation	24.4	25.0	Limestone, partly dolomitic, coarsely crystalline
						25.0	111.9	Dolomite, highly fossiliferous, stromatoporoidal in upper part, becoming finer grained variably fossiliferous towards base
					Ashern Formation	111.9	117.0	Shale, grey to red, breccia fragments common towards base
					Interlake Group	117.0	138.1	Dolomite, buff, dense
359000	5888100	100/05-07-048-25W1/00	259	M-06-78	Overburden	0.0	2.7	Till
					Dawson Bay Formation			
					Lower Member	2.7	4.9	Limestone, biomicrite
					Second Red Bed Member	4.9	14.6	Dolomitic shale, brecciated
					Winnipegosis Formation			
					Transitional Beds	14.6	14.9	Limestone, dense, stylolitic
					Upper Member	14.9	30.2	Dolomite and limestone, massive
						30.2	53.6	Dolomite, massive, vuggy, fossiliferous
						53.6	59.7	Dolomite, interbedded bituminous and fragmental
					Lower Member	59.7	70.4	Dolomite, massive, vuggy
					Ashern Formation	70.4	74.8	Shale, dolomitic, grey-brown
423800	5739100	102/01-05-033-19W1/00	262	M-06-80	Souris River Formation			
					Sagemace Member	0.0	20.4	Dolomite, fine grained, banded
						20.4	33.7	Shale, dolomitic shale, limestone, breccia
						33.7	49.4	Dolomite, vuggy, fossiliferous, cherty, minor breccia
					First Red Beds	49.4	59.6	Shale breccia, limestone, dolomite (First Red Beds)
					Dawson Bay Formation			
					Upper Member	59.6	72.2	Limestone, partly dolomitized, fossiliferous
					Middle Member	72.2	84.4	Calcareous shale, purplish-red, fossiliferous
					Lower Member	84.4	92.5	Limestone, brachipod biomicrite, partly dolomitic
					Second Red Bed Member	92.5	110.8	Polymict collapse breccia Shale, limestone, dolomite includes Second Red Beds
					Winnipegosis Formation			
					Transitional Beds	110.8	113.2	Transition zone, Dolomite breccia, porous, partly laminated, Limestone, fine vuggy, trace sphalerite, pyrite
					Upper Member	113.2	119.6	Upper Member, Dolomite, partly bituminous laminated, partly fine vuggy (birdseye) porosity inter-reef facies
					Lower Member	119.6	138.5	Lower Member, Platform facies, Dolomite, vuggy, mottled, nodular
					Ashern Formation	138.5	142.5	Dolomitic shale, reddish-brown, pyritic
559300	5646900	100/03-07-023-05W1/00	272	M-07-69	Interlake Group	0.0	7.6	Dolostone, finely crystalline and sublithographic
					Cedar Lake Formation	7.6	12.0	Dolostone, lithographic, light brownish grey
						12.0	13.0	Dolostone, lithographic to finely crystalline
						13.0	14.0	Dolostone, sublithographic, light grey
						14.0	14.6	Dolostone
						14.6	16.2	Dolostone
						16.2	17.8	Dolostone
						17.8	19.8	Dolostone
						19.8	21.0	Dolostone
						21.0	29.0	Dolostone

Table 2: Location and geological logs for drill cores analyzed *(continued)*

UTM Easting	UTM Northing	Location	Ground Elev. (m)	Well Name	Stratigraphic Unit	Top (m)	Base (m)	Summary Lithology
					Interlake Group			
					Cedar Lake Formation *(continued)*	29.0	32.6	Dolostone
						32.6	39.9	Dolostone
						39.9	41.2	Dolostone
361500	5891000	100/08-20-048-25W1/00	271	M-07-73	Winnipegosis Formation			
					Upper Member	0.0	64.0	Dolomite
375900	5822500	100/02-21-041-24W1/00	259	M-07-78	Overburden	0.0	7.1	Till
					Souris River Formation	7.1	96.3	Limestone/shale/dolomite breccia with fragments from Souris River and Dawson Bay (collapse breccia)
					Winnipegosis Formation			
					Upper Member	96.3	97.3	Dolomite, vuggy
						97.3	102.5	Limestone, laminated, breccia
						102.5	106.1	Limestone and dolomite
					Lower Member	106.1	119.9	Limestone, massive, mottled
					Ashern Formation	119.9	124.2	Shale, dolomitic, grey to brown
639000	5598000	100/14-06-018-04E1/00	229	M-07-80	Red River Formation			
					Red River Formation - Lower			
					Selkirk Member	0.0	36.0	Dolomite, yellowish-buff, mottled, chert nodules and silicified fossils
					Cat Head Member	36.0	52.3	Dolomite, slightly darker, streaked and mottled, some chert (possibly Cat Head equivalent but almost indistinguishable from overlying)
					Dog Head Member	52.3	81.0	Mottled dolomitic limestone
						81.0	89.1	As above, increasing argillaceous bands
					Winnipeg Formation			
					Upper Member	89.1	91.2	Shale, dark olive-brown, limonite oolites
						91.2	93.6	Argillaceous sandstone, burrowed texture
415800	5738900	100/13-34-032-20W1/00	280	M-08-70	Souris River Formation			
					Point Wilkins Member	0.0	19.2	Limestone, calcareous shale, breccia
					First Red Beds	19.2	32.9	Limestone, calcareous shale, breccia
					Dawson Bay Formation			
					Upper Member	32.9	46.3	Dolomite, calcareous shale
					Middle Member	46.3	49.7	Dolomite, calcareous shale
508400	5641500	100/06-25-022-11W1/00	251	M-08-71	Dawson Bay Formation			
					Lower Member	0.0	16.8	Limestone, dolomite
					Second Red Bed Member	16.8	24.1	Buff to red dolomitic shale
421400	5779000	100/04-08-037-19W1/00	256	M-08-73	Winnipegosis Formation	0.0	28.0	Dolomite
499000	5732400	100/04-18-032-11W1/00	261	M-08-74	Elm Point Formation	0.0	9.8	Limestone, partly mottled, towards base
					Ashern Formation	9.8	13.1	Dolomitic shale, reddish brown
					Interlake Group			
					Cedar Lake Formation	13.1	15.8	Dolomite
539750	5644500	100/04-06-023-07W1/00	259	M-08-81	Winnipegosis Formation			
					Lower Member	0.0	13.3	Dolomite, vuggy, granular
					Elm Point Formation	13.3	21.0	Dolomitic limestone grading downward to calcareous dolomite and dolomite
					Ashern Formation	21.0	22.3	Dolomitic shale and argillaceous dolomite, buff to reddish grey
516800	3658300	100/08-13-024-10W1/00	258	M-09-69	Dawson Bay Formation			
					Lower Member	0.0	2.8	Limestone, pale yellowish brown
						2.8	11.9	Dolomite, pale yellow buff, faintly mottled
423500	5739300	100/01-05-033-19W1/00	264	M-09-71	Souris River Formation	0.0	16.6	Dolomite, minor shaly dolomite and limestone
						16.6	27.7	Dolomite, minor shaly dolomite and limestone
					Point Wilkins Member	27.7	46.9	Dolomite, minor shaly dolomite and limestone

Table 2: Location and geological logs for drill cores analyzed *(continued)*

UTM Easting	UTM Northing	Location	Ground Elev. (m)	Well Name	Stratigraphic Unit	Top (m)	Base (m)	Summary Lithology
421900	5848500	100/16-31-033-19W1/00	258	M-09-79	Dawson Bay Formation			
					Lower Member	0.0	11.3	Limestone, biomicate; dolomite
					Second Red Bed Member	11.3	21.0	Shale, dolomitic, red
					Winnipegosis Formation	21.0	38.5	Dolomite, excellent porosity, reefoid
530400	5658100	05-17-024-09W	254	M-10-69	Winnipegosis Formation			
					Upper Member	0.0	26.2	Reef - Dolomite
						26.2		Reef - Dolomite
363400	5860900	100/08-17-045-25W1/00	259	M-10-72	Dawson Bay Formation			
					Lower Member	0.0	8.2	Limestone, biomicrite
						8.2	9.1	Dolomite
					Second Red Bed Member	9.4	17.1	Shale, grey and red
					Winnipegosis Formation			
					Transitional Beds	17.1	21.8	Limestone
616400	5586000	100/14-35-016-01E1/00	271	M-11-79	Overburden	0.0	4.5	Clay, till
					Interlake Group			
					Fisher Branch Formation	4.5	12.0	Dolomite, yellowish, fossiliferous
					Stonewall Formation			
					Stonewall Formation - Upper	12.0	18.3	Dolomite, mottled; clayey bands
					Stonewall Formation - Lower	18.3	23.6	
					Williams Member	23.6	29.1	Dolomite, argillaceous, sandy
					Stony Mountain Formation			
					Stony Mountain Formation - Upper			
					Gunton Member	29.1	39.7	Dolomite, mottled
					Stony Mountain Formation - Lower			
					Penitentiary Member	39.7	50.7	Dolomite, argillaceous
					Gunn Member	50.7	62.9	Limestone, argillaceous, fossiliferous
					Red River Formation			
					Red River Formation - Upper			
					Fort Garry Member	62.9	78.2	Limestone; dolomite, cherty and dense; clay at 78.2 m
						78.2	97.2	
					Red River Formation - Lower			
					Selkirk Member	97.2	112.0	Limestone, cherty, mottled dolomitic limestone
365750	5851500	100/04-23-044-25W1/00	280	M-14-71	Souris River Formation			
					Point Wilkins Member			
					middle Point Wilkins	0.0	21.3	Limestone (Pt. Wilkins Member)
					lower Point Wilkins	21.3	29.4	Argillaceous limestone
					First Red Beds	29.4	38.7	Red shale, argillaceous dolomite
					Dawson Bay Formation			
					Upper Member	38.7	46.0	Limestone, dolomitic limestone, calcareous shale
					Middle Member	46.0	61.6	Limestone, dolomitic limestone, calcareous shale
434600	5722300	102/15-09-031-18W1/00	258	M-16-81	Souris River Formation			
					Sagemace Member	0.0	13.6	Limestone, some dolomite, brecciated towards base
						13.6	25.2	Shale and dolomitic shale, brecciated
					Point Wilkins Member	25.2	42.1	Limestone and dolomite
					First Red Beds	42.1	54.2	Shale, grey to red, highly brecciated
					Dawson Bay Formation			
					Upper Member	54.2	64.8	Limestone and dolomite
					Middle Member	64.8	76.5	Grey calcareous shale, fossiliferous
					Lower Member	76.5	92.9	Limestone, fossiliferous; dolomite
					Second Red Bed Member	92.9	102.2	Dolomitic shale, brecciated

Table 2: Location and geological logs for drill cores analyzed *(continued)*

UTM Easting	UTM Northing	Location	Ground Elev. (m)	Well Name	Stratigraphic Unit	Top (m)	Base (m)	Summary Lithology
					Winnipegosis Formation			
					Upper Member	102.2	116.1	Dolomite and limestone, brecciated, shaly laminated at base (inter-reef facies)
						116.1	121.3	Dolomite, bituminous laminate
					Lower Member	121.3	138.0	Dolomite, massive, vuggy (platform)
					Ashern Formation	138.0	139.6	Dolomitic shale
366800	5850300	102/08-14-044-25W1/00	255	M-17-81	Overburden	0.0	1.6	
					Souris River Formation			
					First Red Beds	1.6	7.5	Red dolomitic shale (First Red Beds)
					Dawson Bay Formation			
					Upper Member	7.5	15.0	Limestone and dolomite
					Middle Member	15.0	33.5	Grey calcareous shale, fossiliferous
					Lower Member	33.5	40.2	Limestone, brachiopod biomicrite, grading to argillaceous dolomite
					Second Red Bed Member	40.2	53.4	Red to grey shale, brecciated
					Winnipegosis Formation			
					Transitional Beds	53.4	57.9	Limestone, in part breccia
					Upper Member	57.9	79.3	Dolomite, bituminous laminate with fragmental interbeds (proximal, inter-reef)
					Lower Member	79.3	85.8	Dolomite, vuggy (platform)
368200	5846800	100/03-01-044-25W1/00	255	S-05-75	Overburden	0.0	2.6	
					Dawson Bay Formation			
					Lower Member	2.6	4.0	Limestone, light grey to buff, brachiopod biomicrite
						4.0	6.5	Limestone, micrite, pale buff
						6.5	9.2	Dolomite, medium light brown
					Second Red Bed Member	9.2	18.9	Shale dolomite, shades of brownish to reddish buff at top
					Winnipegosis Formation			
					Transition Beds	18.9	19.1	Limestone, light grey
						19.1	31.0	Limestone, pure high-Ca
					Upper Member	31.0	33.9	Dolomite
						33.9	34.2	Dolomite
						34.2	35.8	Dolomite
						35.8	40.9	Dolomite
						40.9	61.9	Dolomite
						61.9	77.1	Dolomite
						77.1	79.8	Dolomite
						79.8	85.0	Dolomite
					Lower Member	85.0	95.7	Dolomite
					Ashern Formation	95.7	100.8	Dolomite

1 cm slice along the length of each core to provide a continuous sample for each interval sampled. The cut samples were combined over 1 m intervals and bagged in plastic. Samples were crushed in a jaw crusher and pulverized in a tungsten-carbide swing mill. Both jaw crusher and swing mill were thoroughly cleaned between each sample. Pulverized samples were stored in glass bottles.

Analytical procedures

A 0.200 g portion of powder was weighed into a test tube and dissolved in a mixture of 0.5 ml HNO_3 and 1.5 ml HCL (aqua regia). The samples were heated on a steam bath for two hours then diluted to a final volume of 10 ml with distilled/deionized water. The samples were mixed on a vortex mixer and allowed to settle for two hours.

Solutions were analyzed for Cu, Ni, Zn, Pb, Mn and Fe by flame atomic absorption spectrometry (FAAS) using either a Perkin Elmer AA6 or a Varian AA975 with PSC 55 auto sample changer. Background correction was used for all elements and Fe was run on a 10X dilution of the original solution. Standard deviations for the analytical method at various concentrations are presented in Table 3.

Table 3: Standard deviations for aqua regia leach analytical method and elements analyzed

Element	Std. Dev. 0-100 ppm	Std. Dev. 101-500 ppm	Std. Dev. 501-1000 ppm
Cu	3	7	21
Zn	4	9	56
Pb	2	5	45
Mn		23	85
Fe	**		
Ni	3	10	12

** 0.31% for concentrations of 1.0–10.0% Fe

As part of the Quality Assurance process, every batch of 64 samples was run with a BLANK, a duplicate sample and a Certified Reference Material. Statistical analysis of the data for the standard is presented in Table 4. The data are presented in Appendix 1.

Results

Analytical data are presented in Appendix 2. Statistical information is presented for each element for both the entire dataset and each formation in Table 4. Sample concentrations that are ≥ 99 percentile of the entire data set are tabulated and plotted by formation on the figures in Appendix 3. The data are not discussed individually in this report.

DISCUSSION

Significance of the Balmoral pebble

The 'Balmoral pebble' was found in a garden at NE1/4 Sec. 26, Twp. 14, Rge 1 EPM near the town of Balmoral, approximately 35 km north of Winnipeg. The pebble measured approximately 2 x 3 x 1 cm, was well rounded and has an outer thin shell of tan coloured material that resembles Pb carbonate. It consists of almost pure galena and trace carbonate. An assay of a portion of the pebble gave 78% Pb and 8.46 oz./ton Ag.

Pb-isotope determinations were made on a portion of the sample by the Geological Survey of Canada (GSC) in 1969 and are presented below with analyses of galena from Flin Flon (R.M. Farquhar, Supply and Services Canada, written comm., 1979). The obtained values are:

Sample	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$
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

Ratios reported for the Balmoral pebble indicate a non-Precambrian age. The ratios are distinctly different than those obtained for the Pine Point galena (G. Cumming, Univ. Alberta, pers. comm., 1984). The Balmoral pebble appears to have ratios that are different to those of known galena deposits in Manitoba and the Upper Mississippi Valley district of the central United States (Fig. 2). This suggests that it represents an unknown mineralization.

Although it is possible that the source of the Balmoral pebble may represent a unique type of mineralization (e.g. a vein of mobilized Precambrian galena), in the absence of any data to confirm its source this discussion is focused on an evaluation of the potential for the Phanerozoic of Manitoba to contain deposits similar to those of known MVT mineralization such as that present in the Pine Point, Viburnum and Upper Mississippi Valley districts.

Characteristics of Mississippi Valley-type deposits

These deposits have the following characteristics (Brown, 1970):

1. The ores all occur in dolomite.
2. The dominant ore minerals are zinc and lead sulphides.
3. Lead is anomalous J-type; (note: B-type lead occurs at Pine Point and Cornwallis; Kerr, 1977).
4. The ores have low precious metals.
5. Barite and fluorite are associated with some deposits, but absent in others.
6. Sphalerite is low in iron content.
7. Sphalerite, galena and fluorite are characteristically coarse grained.
8. Host rocks are not metamorphosed.
9. The ores are mainly stratabound.
10. Igneous activity is generally absent.
11. Ores formed from low temperature aqueous solutions.

Anderson and McQueen (1982) emphasize that the main characteristic features of MVT deposits are dolomitization, karst development, lithologic and stratigraphic controls and structure. Other notable features of these deposits include: (a) zones of breccia collapse and solution cavities that predate mineralization; and, (b) coarse grained sparry dolomite (e.g. Pine Point) or both dolomite and calcite crystals (Viburnum) occur as gangue minerals. In order to evaluate the MVT potential in Manitoba, brief descriptions of MVT deposits at Viburnum

Table 4: Mean, minimum, maximum and standard deviation for entire data set and for each formation

Entire Data Set

	Cu (ppm)	Zn (ppm)	Pb (ppm)	Mn (ppm)	Fe (ppm)	Ni (ppm)	F (ppm)
No. Samples:	6301	6301	6301	6301	6301	6301	1283
Mean:	5.75	14.49	1.09	142.71	2750.56	4.09	220.27
Minimum:	0.00	0.00	0.00	1.00	0.00	0.00	20.00
Maximum:	710.00	740.00	200.00	2230.00	57000.00	120.00	1100.00
StnDev:	11.33	15.59	4.66	95.75	3108.37	7.19	120.46

Overburden

	Cu (ppm)	Zn (ppm)	Pb (ppm)	Mn (ppm)	Fe (ppm)	Ni (ppm)	F (ppm)
No. Samples:	27	27	27	27	27	27	-
Mean:	4.67	18.41	0.37	122.67	2985.19	7.30	-
Minimum:	0.00	7.00	0.00	36.00	450.00	0.00	-
Maximum:	9.00	27.00	6.00	342.00	6900.00	33.00	-
StnDev:	2.50	5.60	1.24	65.58	2280.81	6.94	-

Amaranth Formation

	Cu (ppm)	Zn (ppm)	Pb (ppm)	Mn (ppm)	Fe (ppm)	Ni (ppm)	F (ppm)
No. Samples:	27	27	27	27	27	27	-
Mean:	8.19	38.52	1.67	603.22	4694.44	5.96	-
Minimum:	1.00	9.00	0.00	101.00	1450.00	1.00	-
Maximum:	30.00	96.00	6.00	2230.00	12150.00	18.00	-
StnDev:	6.20	20.44	1.98	439.62	2149.66	3.26	-

St. Martin Complex

	Cu (ppm)	Zn (ppm)	Pb (ppm)	Mn (ppm)	Fe (ppm)	Ni (ppm)	F (ppm)
No. Samples:	97	97	97	97	97	97	-
Mean:	20.65	27.65	2.84	154.42	7070.10	8.67	-
Minimum:	0.00	3.00	0.00	24.00	300.00	1.00	-
Maximum:	710.00	99.00	47.00	418.00	27500.00	47.00	-
StnDev:	73.42	27.06	6.35	93.91	6957.97	7.78	-

Souris River Formation

	Cu (ppm)	Zn (ppm)	Pb (ppm)	Mn (ppm)	Fe (ppm)	Ni (ppm)	F (ppm)
No. Samples:	538	538	538	538	538	538	1
Mean:	7.89	14.78	1.03	185.13	3400.93	5.28	176.00
Minimum:	3.00	6.00	0.00	54.00	300.00	0.00	176.00
Maximum:	25.00	147.00	25.00	790.00	16200.00	58.00	176.00
StnDev:	2.96	11.17	2.39	104.58	2862.43	8.88	0.00

Dawson Bay Formation

	Cu (ppm)	Zn (ppm)	Pb (ppm)	Mn (ppm)	Fe (ppm)	Ni (ppm)	F (ppm)
No. Samples:	640	640	640	640	640	640	7
Mean:	10.39	25.46	1.60	236.34	5691.33	11.68	338.71
Minimum:	1.00	2.00	0.00	59.00	250.00	0.00	226.00
Maximum:	157.00	259.00	64.00	750.00	57000.00	71.00	398.00
StnDev:	8.31	19.94	4.58	78.69	4251.96	11.46	57.96

Winnipegosis Formation

	Cu (ppm)	Zn (ppm)	Pb (ppm)	Mn (ppm)	Fe (ppm)	Ni (ppm)	F (ppm)
No. Samples:	1258	1258	1258	1258	1258	1258	1171
Mean:	5.58	12.78	0.98	101.53	1384.22	3.04	215.07
Minimum:	187.00	225.00	200.00	831.00	30000.00	108.00	903.00
Maximum:	0.00	0.00	0.00	25.00	200.00	0.00	20.00
StnDev:	9.24	12.71	8.07	52.10	1521.02	5.40	96.49

Elm Point Formation

	Cu (ppm)	Zn (ppm)	Pb (ppm)	Mn (ppm)	Fe (ppm)	Ni (ppm)	F (ppm)
No. Samples:	135	135	135	135	135	135	82
Mean:	9.84	18.09	2.08	142.49	1561.48	5.61	149.43
Minimum:	1.00	5.00	0.00	75.00	100.00	0.00	82.00
Maximum:	53.00	105.00	12.00	266.00	9500.00	35.00	301.00
StnDev:	6.26	9.66	2.52	33.19	1456.98	4.39	42.48

Table 4: Mean, minimum, maximum and standard deviation for entire data set and for each formation *(continued)*

Ashern Formation

	Cu (ppm)	Zn (ppm)	Pb (ppm)	Mn (ppm)	Fe (ppm)	Ni (ppm)	F (ppm)
No. Samples:	114	114	114	114	114	114	22
Mean:	8.65	25.50	0.95	213.72	8274.56	17.68	725.45
Minimum:	0.00	0.00	0.00	78.00	1150.00	0.00	315.00
Maximum:	27.00	72.00	18.00	385.00	33000.00	44.00	1100.00
StnDev:	5.93	13.47	2.44	63.32	4848.48	12.81	257.03

Interlake Group

	Cu (ppm)	Zn (ppm)	Pb (ppm)	Mn (ppm)	Fe (ppm)	Ni (ppm)	F (ppm)
No. Samples:	979	979	979	979	979	979	-
Mean:	2.76	10.75	0.27	69.95	1209.86	2.29	-
Minimum:	0.00	0.00	0.00	1.00	0.00	0.00	-
Maximum:	39.00	44.00	48.00	448.00	15250.00	41.00	-
StnDev:	2.77	7.47	1.77	44.41	1490.58	3.65	-

Stonewall Formation

	Cu (ppm)	Zn (ppm)	Pb (ppm)	Mn (ppm)	Fe (ppm)	Ni (ppm)	F (ppm)
No. Samples:	216	216	216	216	216	216	-
Mean:	3.75	11.32	0.58	79.95	1372.22	1.50	-
Minimum:	0.00	1.00	0.00	29.00	200.00	0.00	-
Maximum:	64.00	35.00	18.00	311.00	7950.00	17.00	-
StnDev:	5.12	6.88	2.06	39.60	1291.60	2.63	-

Stony Mountain Formation

	Cu (ppm)	Zn (ppm)	Pb (ppm)	Mn (ppm)	Fe (ppm)	Ni (ppm)	F (ppm)
No. Samples:	475	475	475	475	475	475	-
Mean:	5.42	14.85	1.01	150.39	4151.05	2.08	-
Minimum:	0.00	1.00	0.00	54.00	600.00	0.00	-
Maximum:	45.00	81.00	17.00	345.00	11150.00	12.00	-
StnDev:	5.05	8.96	1.99	59.47	2765.01	2.87	-

Red River Formation

	Cu (ppm)	Zn (ppm)	Pb (ppm)	Mn (ppm)	Fe (ppm)	Ni (ppm)	F (ppm)
No. Samples:	1783	1783	1783	1783	1783	1783	-
Mean:	4.13	11.74	1.34	157.46	2443.49	2.10	-
Minimum:	0.00	0.00	0.00	5.00	200.00	0.00	-
Maximum:	143.00	740.00	69.00	633.00	26850.00	120.00	-
StnDev:	4.54	18.62	3.67	77.32	1686.27	4.15	-

Winnipeg Formation

	Cu (ppm)	Zn (ppm)	Pb (ppm)	Mn (ppm)	Fe (ppm)	Ni (ppm)	F (ppm)
No. Samples:	12	12	12	12	12	12	-
Mean:	19.58	40.00	6.75	376.25	21762.50	28.42	-
Minimum:	4.00	14.00	0.00	62.00	11350.00	9.00	-
Maximum:	70.00	89.00	33.00	1100.00	36450.00	55.00	-
StnDev:	20.27	23.12	9.87	330.15	9900.00	12.99	-

Note: - indicates that F was not analyzed for this formation.

(Missouri), Pine Point (NWT) and Upper Mississippi Valley (Wisconsin and Illinois) are presented here.

Viburnum Trend deposits

Several papers that describe the geological setting of the galena-rich ores of the Viburnum Trend, southeast Missouri, emphasize the close spatial relationship between the ores in the host Bonneterre Formation and underlying Precambrian basement highs (Paarlberg and Evans, 1977; Mouat and Clendenin, 1977). In most instances the ores occur where the Lamotte sandstones pinch out against the Precambrian basement highs (Evans, 1977). It should be noted (Fig. 3) that the mineralization occurs both on the flanks of, and immediately above, the basement highs (Mouat and Clendenin, 1977). Gerdemann and Myers (1972) emphasize the spatial relationship of the Viburnum ores to algal reefs and a back reef 'white rock' — a light coloured, coarsely

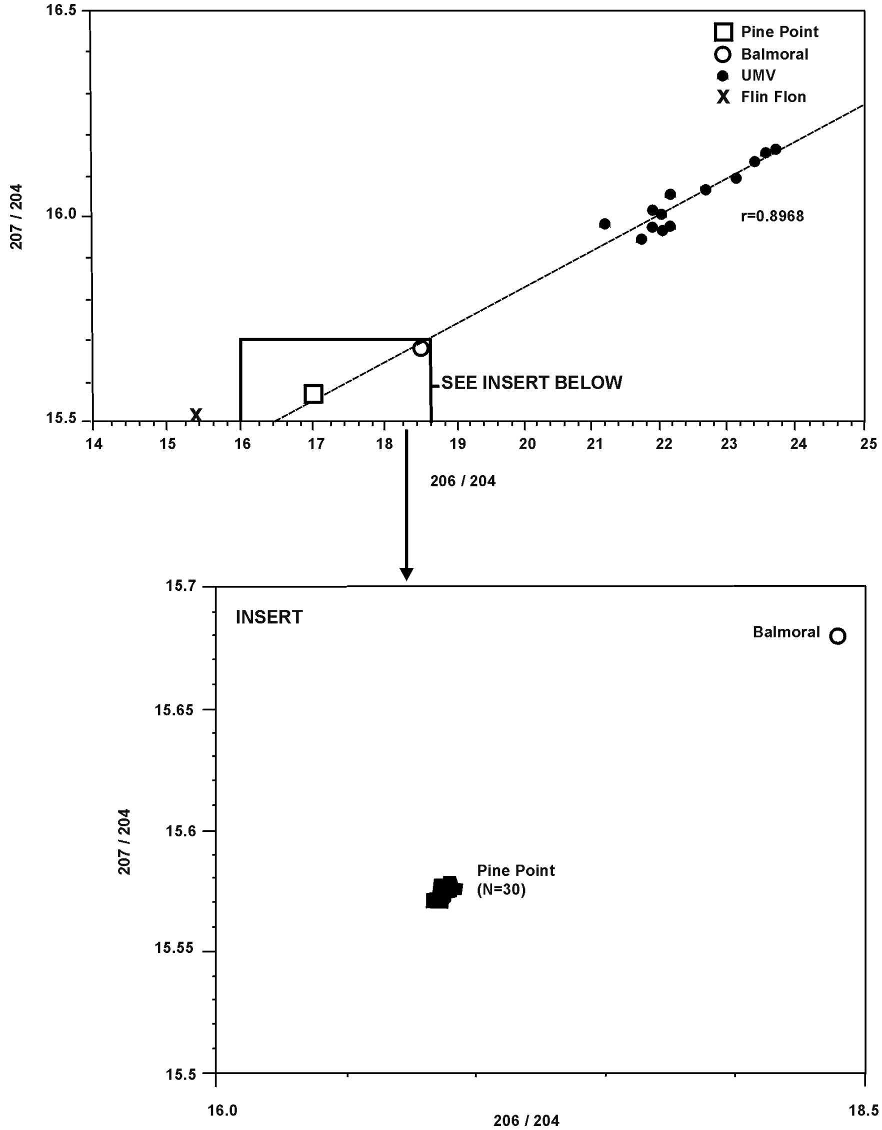


Figure 2: Lead isotope determinations for the Balmoral pebble, Pine Point, Upper Mississippi Valley and Flin Flon galenas (D. Sangster, written comm., 2000).

crystalline, porous dolostone.

The ores are structurally and stratigraphically controlled and occur as bedded and disseminated ore, breccia ore, marginal break ore and as stockwork ore. The breccia appear to be solution collapse features related to dolomitization of the original limestones. Galena and sphalerite are the dominant ore minerals. Chalcopyrite is generally a minor constituent but occurs as discrete bodies of up to several thousand tonnes. Calcite is a common gangue mineral. Dolomite occurs as a gangue mineral and as both brown dolostone and a white crystalline and sugary matrix to breccia and some ores. At the Ozark Lead Company Mine calcite is one of the most common minerals (Mouat and Clendenin, 1977).

Davis (1977) proposed that metals derived during dolomitization of limestones mixed with sulphur ions (H_2S or HS^-) derived from the underlying Lamotte sandstones. The two fluids came into contact with each other along vertical fractures and breccia zones marginal to the Precambrian basement highs.

Pine Point deposits

The zinc-lead deposits of the Pine Point District (Fig. 4) occur in Devonian carbonate rocks that have been extensively dolomitized. The Presqu'ile dolomite is coarse grained and the alteration that produced it generally destroyed the original textures in the rock. Karsting occurred during several cycles of uplift and solution-collapse channels produced in the porous barrier reef served as both conduits for fluids, as well as sites of deposition for mineralization. Coarse grained 'white sparry' dolomite or 'saddle dolomite' (Gibbins, 1988) occurs as cavity fills and is associated with the main mineralization. Faults in the carbonate rocks at Pine Point are subtle representations of regional structures in the Precambrian basement rocks. Middle Devonian aged faults initiated uplift and controlled karsting, dolomitization and mineralization (Gibbins, 1988; Skall, 1975). A detailed analysis of the ore-host rock relationships emphasizes the importance of karstification in controlling ore deposition (Rhodes et al., 1984). The disseminated to massive ores

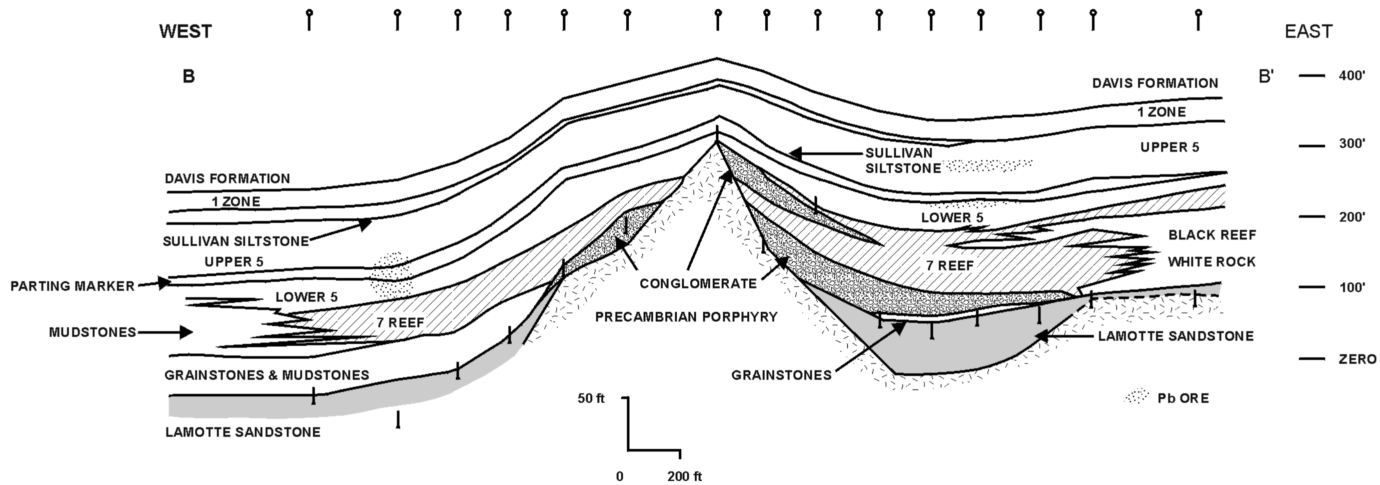


Figure 3a: East-west cross-section of the Bonneterre Formation at the Fletcher Mine, Viburnum Trend (from Paarlberg and Evans, 1977).

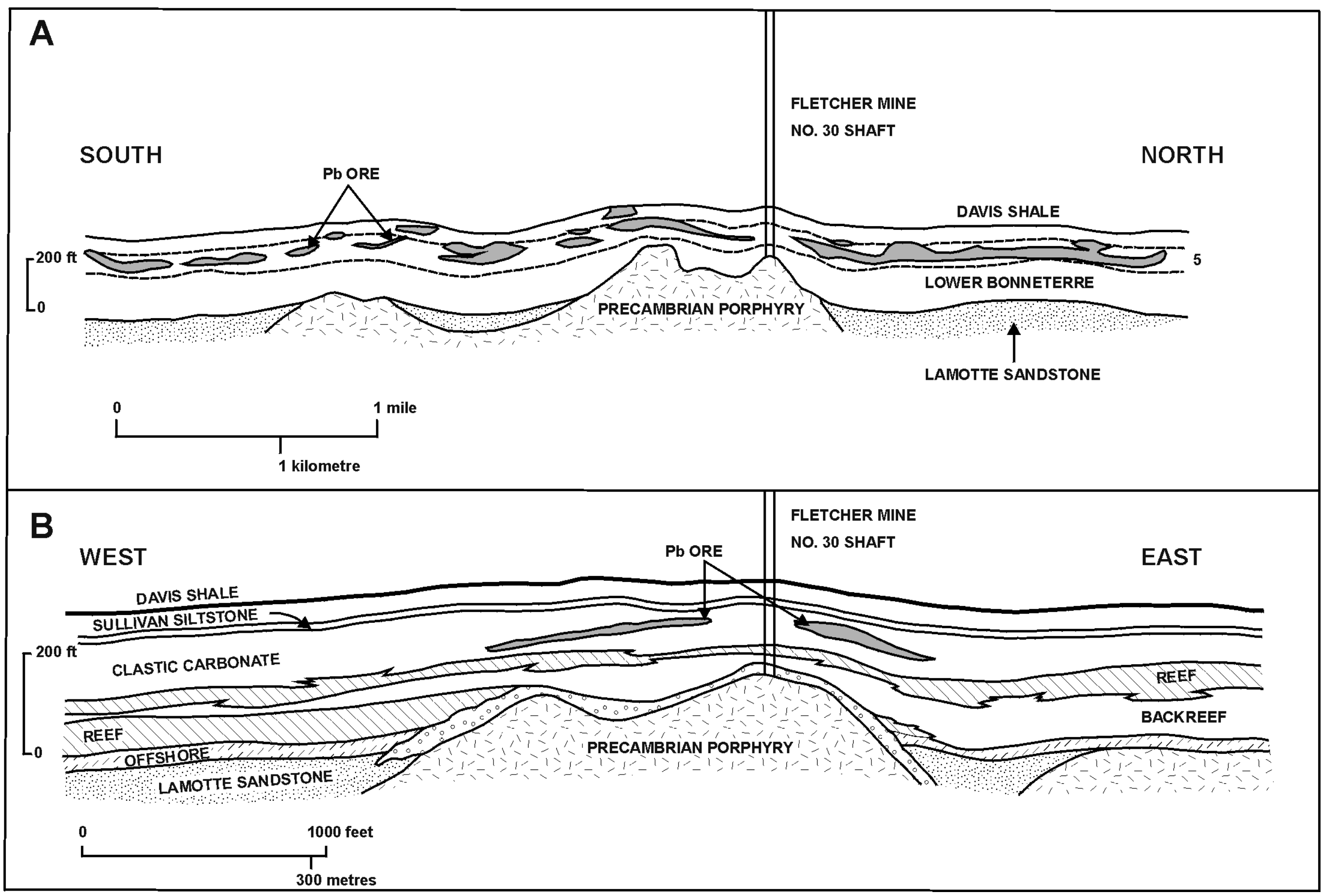


Figure 3b: East-west cross-section at the Brushy Creek Mine, Viburnum Trend (after Evans , 1977).

are classified as 'solution channelway', 'bedding replacement' and 'peripheral' and vary from fine- to coarse-grained (Rhodes et al., 1984).

Upper Mississippi Valley deposits of Wisconsin and Illinois

In this district, folded Cambrian, Ordovician and Silurian dolomite, shale and limestone contain lead, zinc and copper mineralization of Late Paleozoic to Mesozoic age. The ores occur mostly in Middle Ordovician dolomites that are underlain by the St. Peter sandstone, which disconformably overlies Lower Ordovician dolomite that is in turn underlain by Cambrian sandstones and siltstones. Some mineralization occurs in both Lower Ordovician and Cambrian rocks. Typically, the mineralization in this district occurs in steeply dipping veins (pitches) and horizontal lenses (flats) that are controlled in general by small faults with displacements of 0.3 to 3 m, although displacements of up to 300 m occur on some strike-slip shear faults. Some of the ore controlling faults are coincident with and probably related to Precambrian basement features. The ores have been

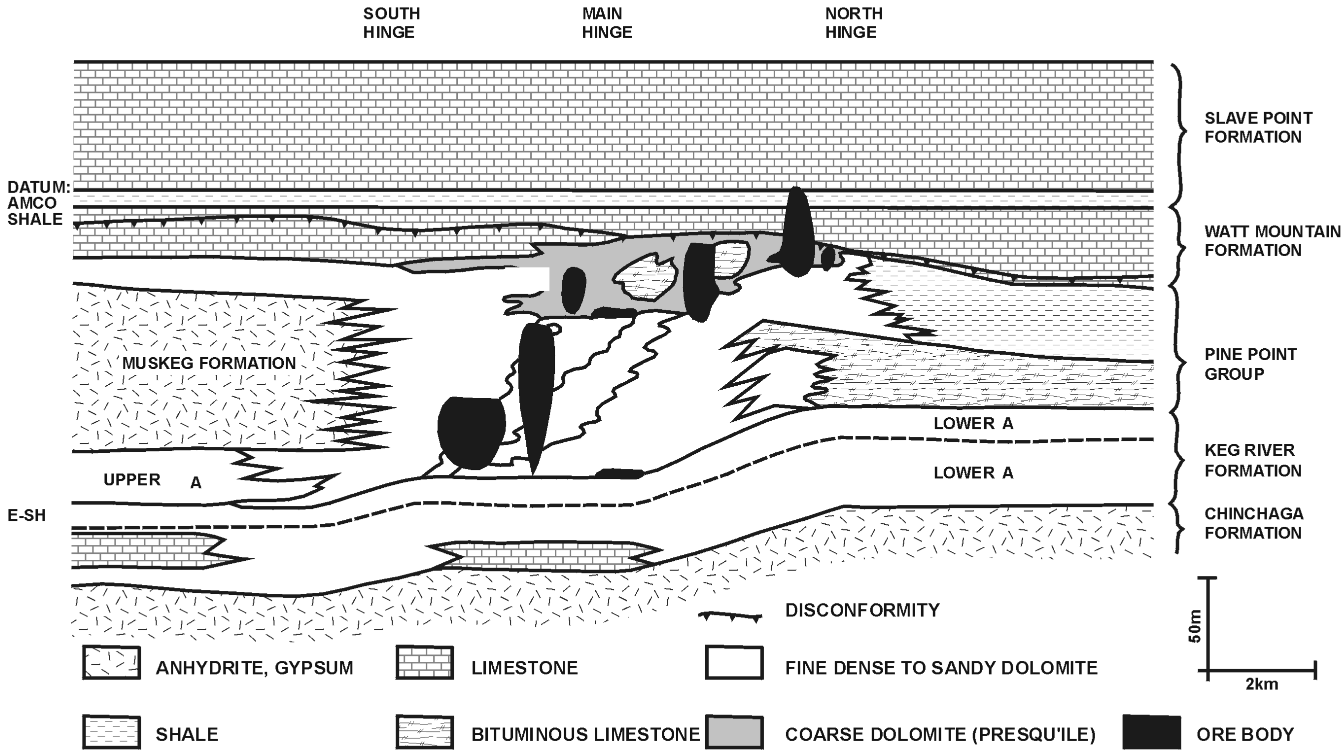


Figure 4: Schematic cross-section through the Pine Point district, NWT. Ore bodies shown in black. Note the district is situated at the junction between an evaporite basin to the south and a shale basin to the north (from Anderson and McQueen, 1982).

deposited in: (1) fracture controlled veins; (2) as cavity fillings in tectonic and solution breccia; and, (3) as disseminations in shale strata. Although many of the ore bodies are linear some are arcuate and represent deposition around synclinal axes. Alteration in this district includes limestone solution, silicification, dolomitization, alteration of clay minerals, pyritization and formation of dolomite sands. Thinning of some beds by dissolution has resulted in the formation of residual shales from some beds; this extensive dissolution of the carbonate beds resulted in the formation of collapse breccia (Heyl et al., 1978).

These deposits differ from other MVT deposits in that quartz is a common gangue mineral, chalcopyrite is a common ore mineral, silver contents of galena, chalcopyrite and some sphalerite exceed 2 oz./ton; minor fluorite is present in some deposits (Heyl et al., 1978). The Northern Arkansas Zinc District also contains quartz and calcite gangue minerals; both Upper Mississippi Valley and northern Arkansas deposits appear, on the basis of fluid inclusion studies, to have formed at higher temperatures than the Viburnum and Pine Point mineralization (Leach et al., 1975; Heyl et al., 1978; Rhodes et al., 1984; Gerdemann and Myers, 1972).

SUMMARY OF GENETIC MODELS FOR MVT DEPOSITS

A succinct summary of genetic ideas on MVT deposits is provided in the following excerpt: "…there is still no single universally accepted model for the genesis of Mississippi Valley-type lead-zinc orebodies … Perhaps the most widely accepted combination of the various theories on genesis is the following: (1) both the metals and the chloride-rich brines thought to transport them derive from basinal rocks, etiher shales or argillaceous carbonates (Jackson and Beales, 1967); (2) the metals and brines are expelled from basinal rocks due to overburden pressures in the basins; (3) metal-bearing brines subsequently migrate toward the edges of the basin; (4) the metallic sulfides precipitate in carbonate basin-margin areas where suitable open spaces exist, through mixing of reduced sulfur species and metallic chloride complexes; and (5) the sulfur is derived either from bacterial reduction of sulfate or from sulfate-H_2S-organic matter interactions close to the site of ore deposition — the latter appears to be the case at Pine Point, …"(Rhodes et al., 1984; p.1053).

Most deposits of MVT mineralization occur at or near the edges of sedimentary basins (Fig. 5; Anderson and McQueen, 1982; Cathles and Smith, 1983). It is generally acknowledged that fluids derived from the adjacent basins dissolved pre-existing limestones to form breccia and cavities, dolomitized the limestones and deposited the metals. A generalized model arising from studies of known districts and individual deposits invokes mixing fluids derived from the basin with sulphur derived from the adjacent evaporites or reefoid facies rocks to permit precipitation of the metals as sulphides (Jackson and Beales, 1967; Gerdemann and Myers, 1972). Other authors envisage the mixing of two fluids derived from different sources (e.g. Brown, 1970; Kerr, 1977; Davis, 1977; Evans, 1977) or the initial entrapment of a single metal- and sulphur-bearing solution against an aquatard and its subsequent release along structural and/or facies breaks into the overlying carbonate rocks; in this model

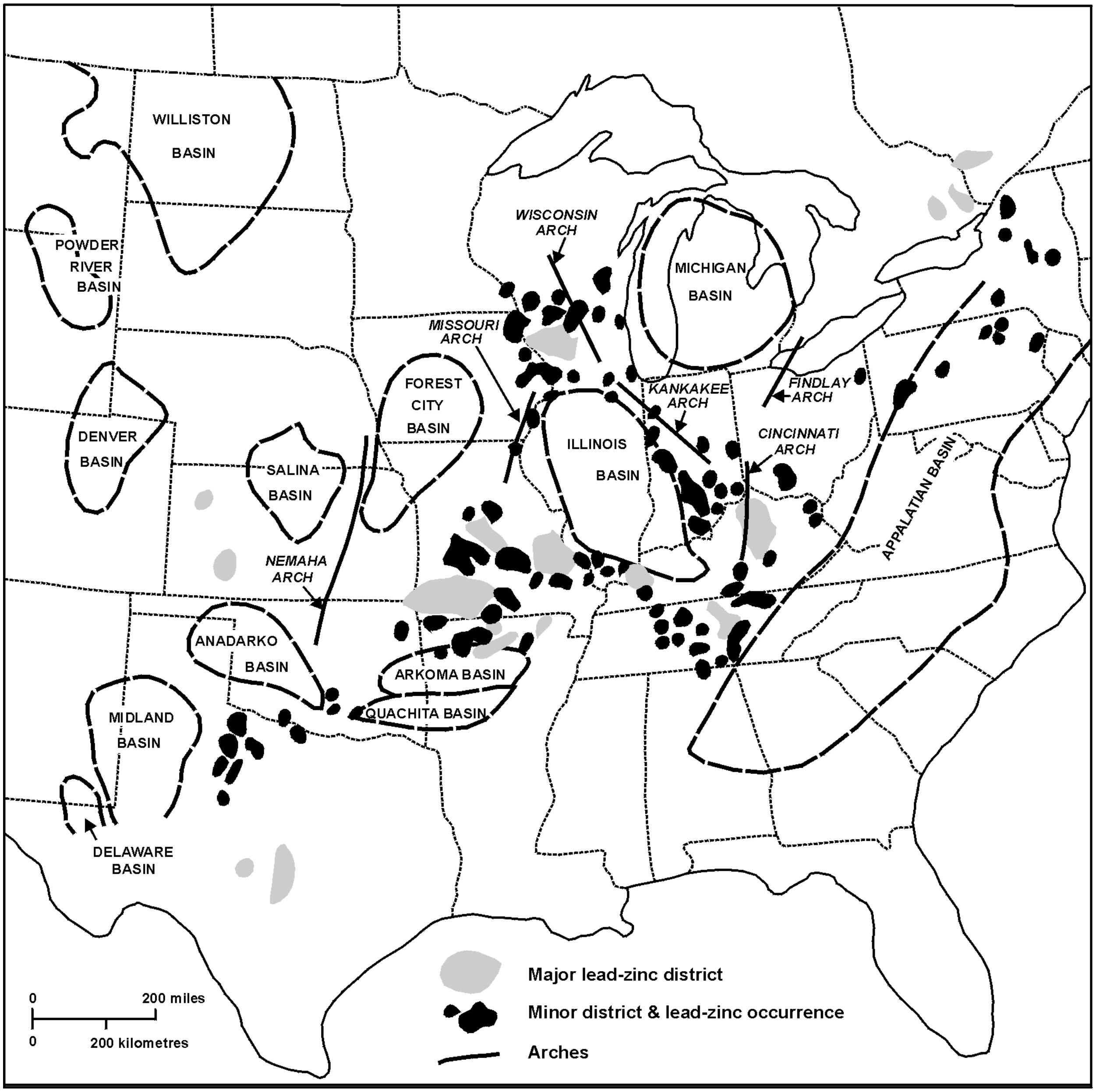


Figure 5: Distribution of Mississippi Valley-type lead-zinc deposits and occurrences around some basins (after Cathles and Smith, 1983).

deposition appears to be favoured by decrease in temperature and change in chemistry (e.g. Cathles and Smith, 1983).

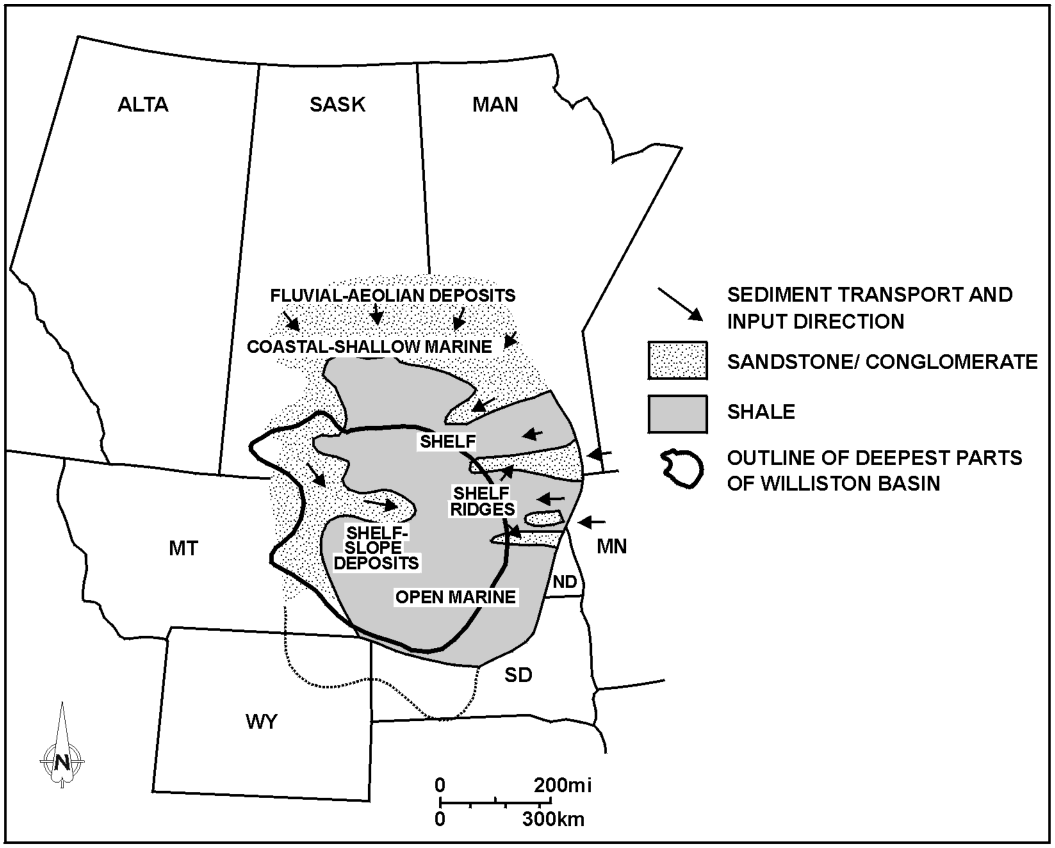
Basins that are potential sources of metals must be deep enough (3-5 km) to increase the temperature of the dewatering brines, dewater in pulses, and contain abundant shale and/or flysch as source materials for the metals (Cathles and Smith, 1983).

MVT DEPOSIT POTENTIAL IN MANITOBA

Williston Basin and Severn Arch

The Phanerozoic rocks of Manitoba lie along the eastern flanks of the Williston depositional basin (Fig. 6) that attained a maximum thickness of 5 km. At 3 to 5 km depths, the strata attain temperatures that are within the range of fluid inclusions in MVT mineralization and are capable of providing ore fluids (Cathles and Smith, 1983). Although dewatering of this basin could have produced metal-bearing brines capable of producing ore deposits, to date there are no known features that could have acted as obvious channelways to focus the fluids into central Manitoba. However, the Devonian reefs of central Manitoba are analogous to the mineralized reefs of the Pine Point District.

Upper Mississippi Valley-type deposits in Wisconsin and Illinois occur on the flank of the Wisconsin Arch. The Severn Arch in northeastern Manitoba may have provided a similar geological environment in post Silurian time for deposition of metals from fluids derived from the Williston Basin. Any deposits that may have formed on the flanks of and near the crest of the Severn Arch would have been lost during the erosions that stripped off the Phanerozoic rocks. However, analogous geological environments and mineralization cannot be ruled out because the location of the apex of the Severn Arch during Devonian time is not known.



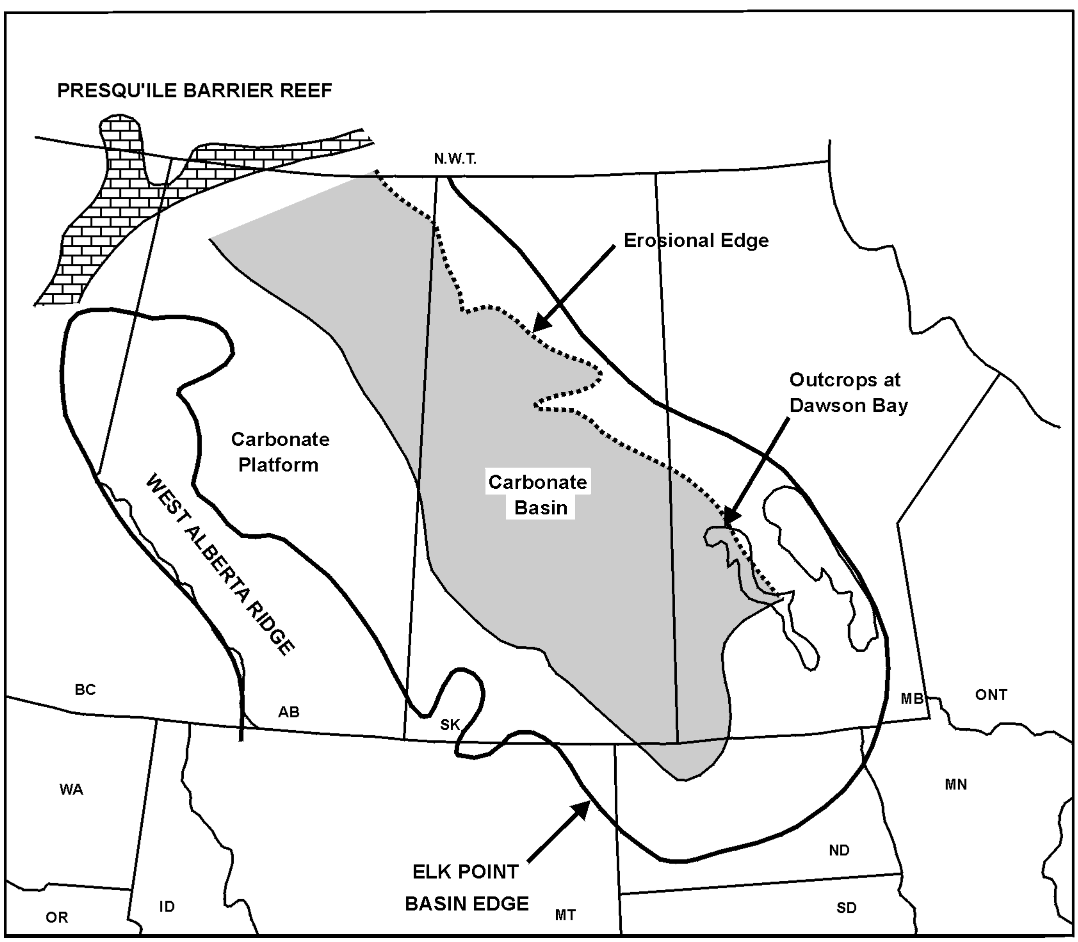


Figure 6: Approximate position of the Williston Basin, extent of the Winnipeg Formation and extent of the Elk Point Basin edge (after Kessler, 1991; Chow, 1991).

Metal sources

Shales and sandstones of the Winnipeg Formation and its stratigraphic equivalents extend into the middle of the Williston Basin (Kessler, 1991) and could have provided metals for MVT mineralizing activity. The Winnipeg Formation sandstone is virtually indistinguishable from the Lamotte sandstone. It is similar in age and occupies a similar position in relationship to the Red River carbonate sequence as the Lamotte does to the Bonneterre carbonate sequence (cf. Table 5, 6). Consequently, the Winnipeg Formation is both a potential aquifer and a source of metals. In addition, studies of the Winnipeg Formation indicate that its mineral content varies regionally from south to north (Last and Shum, 1991). An east-west trending zone referred to as region C (Last and Shum, 1991; see Fig. 1), which extends from just north of Winnipeg to north of Gypsumville, has considerably more quartz and less feldspar components than the other regional subdivisions. In addition, anhydrite is absent in the matrix of this zone. The authigenic clay minerals content of the matrix is considerably higher than the regions to the south, but less than that of the poorly known region to the north. "Although the assemblage is relatively simple, detailed petrographic examination of the Black Island Member in this region reveals a complex sequence of precipitation and dissolution." (Last and Shum, 1991). This can be interpreted as diagenesis or alteration due to fluid movement related to potential mineralizing processes. It is speculated here that the differences in region C of Last and Shum (1991) relative to the other regions, namely, less than 1% feldspar, absence of anhydrite, increased opaque mineral contents (2%) and the wide variety of pyrite crystal morphologies, all support an interpretation of their region C as resulting from regional alteration; albeit by fluids of unsubstantiated origin.

Lead isotope studies of galena ores in the Viburnum deposits indicate that all of the lead could have been derived from the Lamotte sandstone that underlies the host dolomitic limestones of the Bonneterre Formation (Doe and Delevaux, 1972). Trace amounts of galena and sphalerite occur almost everywhere within 30 cm of the Lamotte–Bonneterre contact (Davis, 1977). Locally, adjacent to the ore bodies there is a depletion of lead in the Lamotte sandstone (Gerdemann and Myers, 1972). This suggests that the Lamotte sandstone was probably important as both an aquifer and a source of metals. Davis (1977) envisaged the metals to have been derived from the limestones during dolomitization and mixed with sulphide derived from fluids that passed through the Lamotte sandstones. Gerdemann and Myers (1972) considered the sulphur to have been derived from reef facies rocks.

Ordovician rocks of southeastern Manitoba

In southern Manitoba the Winnipeg Formation unconformably overlies Precambrian rocks and is in turn overlain by carbonates and shales of the Red River Formation (Table 5, Fig. 7). If the reports of galena in the Winnipeg Formation (Genik, 1952) and the authors' interpretation of the galena reported by Shepard from the Grindstone Point area is the same as the trench(es) visited by the D.S. Robertson staff member, then metal-bearing fluids capable of depositing galena and forming ore deposits did circulate through the Winnipeg Formation at some time in its history.

Shale beds that could have acted as suitable aquitards to basin-derived brines are common in both the Winnipeg and Red River formations. In addition, a paleo-shoreline (Fig. 1, 6) for the muddy shale shelf deposits at the top of the Icebox Formation (Kessler, 1991) could have focused fluids upwards into overlying carbonate units of the Red River Formation.

The Ordovician carbonate rocks north and east of Balmoral contain anomalous lead and zinc (Appendix 3). Although the values obtained during this study are low, it is noted here that maximum Zn contents on either side of an ore body at the base of the Davis shale are < 50 ppm Zn and background values of < 20 ppm are attained within 150 m on one side of the deposit and 500 m on the other side (Panno et al., 1988). Although minor subeconomic mineralization can be found outside orebodies in some MVT districts, geochemical dispersion of metals into the dolomitic rocks at the margins of a MVT orebody is notoriously restricted (D. Sangster, pers. comm., 1982). For example, in the Pine Point district the boundary between massive ore and wall rock is typically very sharp even when the host rock is porous (Jackson and Follinsbee, 1969). Consequently, the low values attained do not detract from, but provide additional positive evidence of the MVT potential in this area.

Precambrian basement highs that are an important part of the Viburnum Trend model (Fig. 3) are present in the general vicinity of Gypsumville and High Rock Lake. Pinch-out of the Winnipeg Formation near the northernmost edge of the Paleozoic outcrop belt south of Wekusko Lake is indicated by McCabe (1967) and McCabe and Barchyn (1992). Local pinch-out of the Winnipeg Formation sandstones against the precambrian highs in the Gypsumville and High Rock Lake areas (Fig. 8, 9, 10) have not been recorded, e.g. the Winnipeg Formation at Lake St. Martin appears to have been tilted into place together with the underlying basement by an event that is post Ordovician in age (McCabe and Bannatyne, 1969b; 1970; 1971). The High Rock Lake Precambrian high is also interpreted as a crater structure of Silurian age (McCabe, 1981, 1982), but the Ordovician strata do not appear to be draped over the Precambrian rocks. The presence of 23 m of Winnipeg sandstone in drill core M-5-82 (Fig. 8) at a structurally higher position than seen in drill core M-7-82 does not support a pinch-out interpretation.

Discordancies in depth to the Precambrian surface inferred from drill core data from the William Lake area suggests basement highs and possible faults may be common (Bezys, 1996).

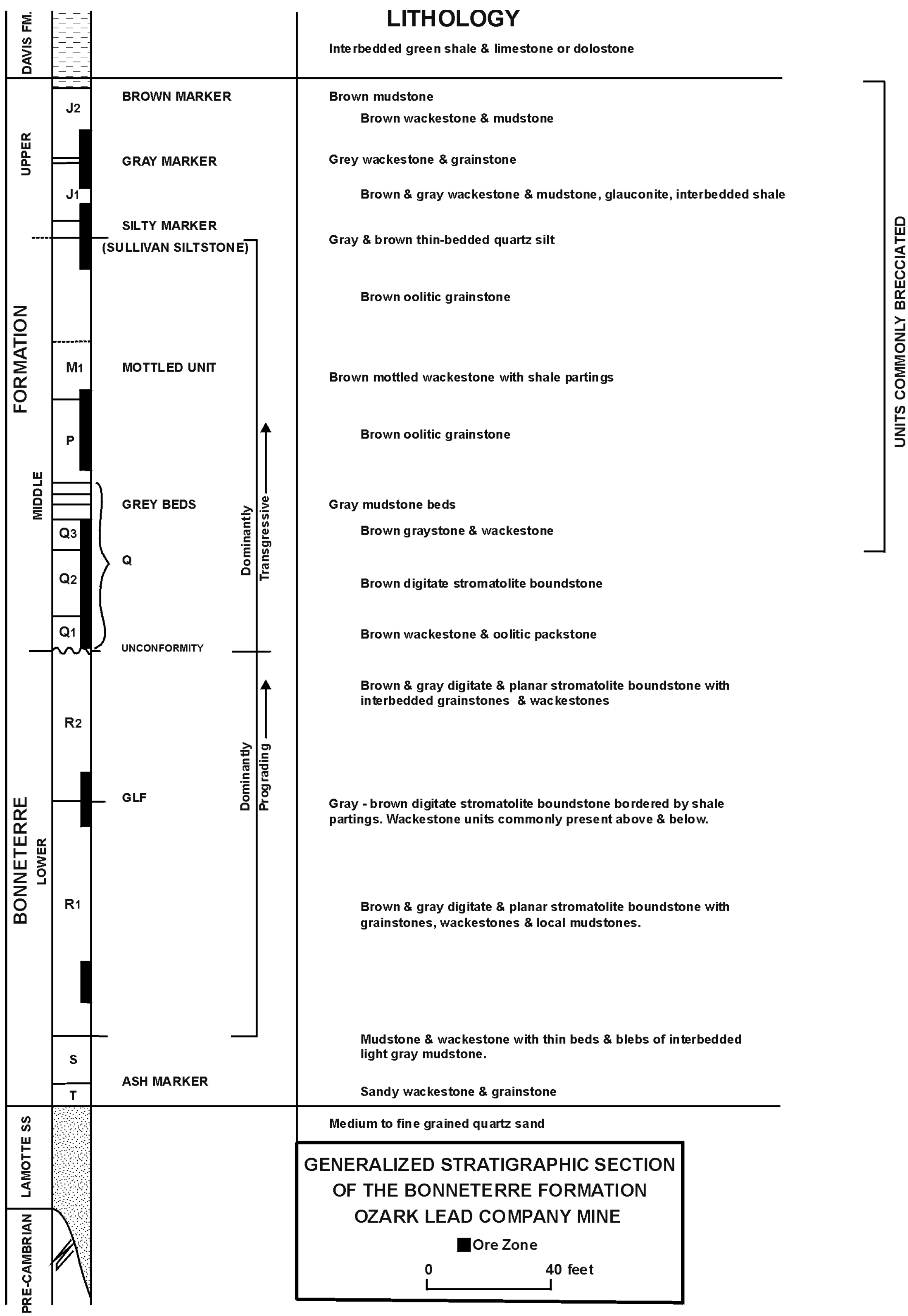
Carbonate breccia, a prerequisite for any of the MVT deposit models, are present in this area. They have been noted in drill cores associated with the High Rock Lake Precambrian high, but have been interpreted as part of, and related to, an impact structure (McCabe, 1981,

Table 5: Stratigraphic column for Phanerozoic rocks in south-central Manitoba (after Bezys and McCabe, 1996).

ERA	PERIOD	FORMATION	MEMBER	MAXIMUM THICKNESS (m)	BASIC LITHOLOGY
CENOZOIC	QUATER-NARY	(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 PENNSYL-VANIAN	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	* * 25	Dolomite, sparsely fossiliferous, t-marker defines Ordovician-Silurian boundary
		Stony Mountain	Williams 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 (after Bamburak, 1999)

Table 6: Generalized stratigraphic section of the Bonneterre Formation at the Ozark Lead Company Mine (after Heyl et al., 1978).



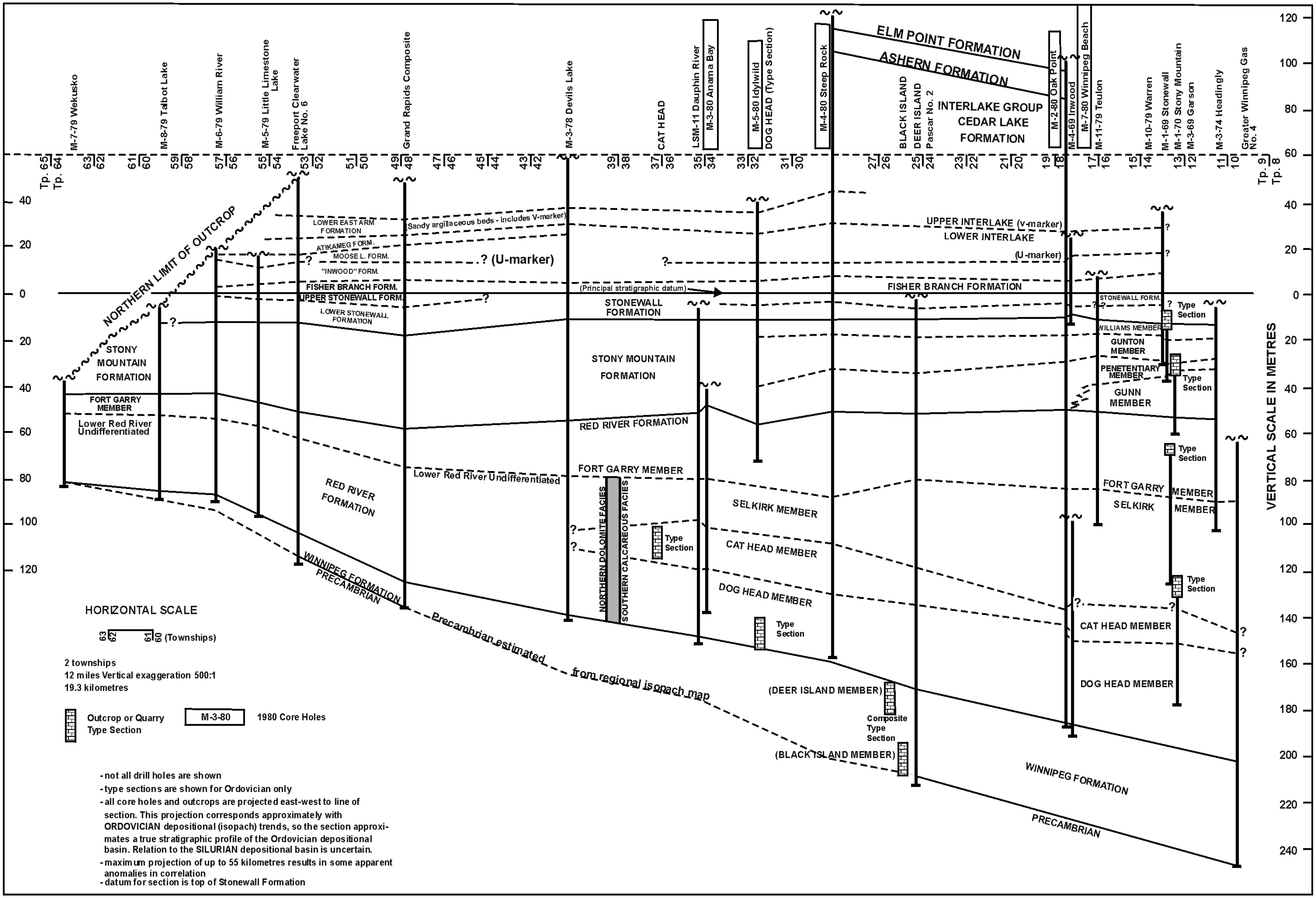


Figure 7: North-south correlation profile of Lower Paleozoic formations in southwestern Manitoba (after, McCabe and Barchyn, 1982).

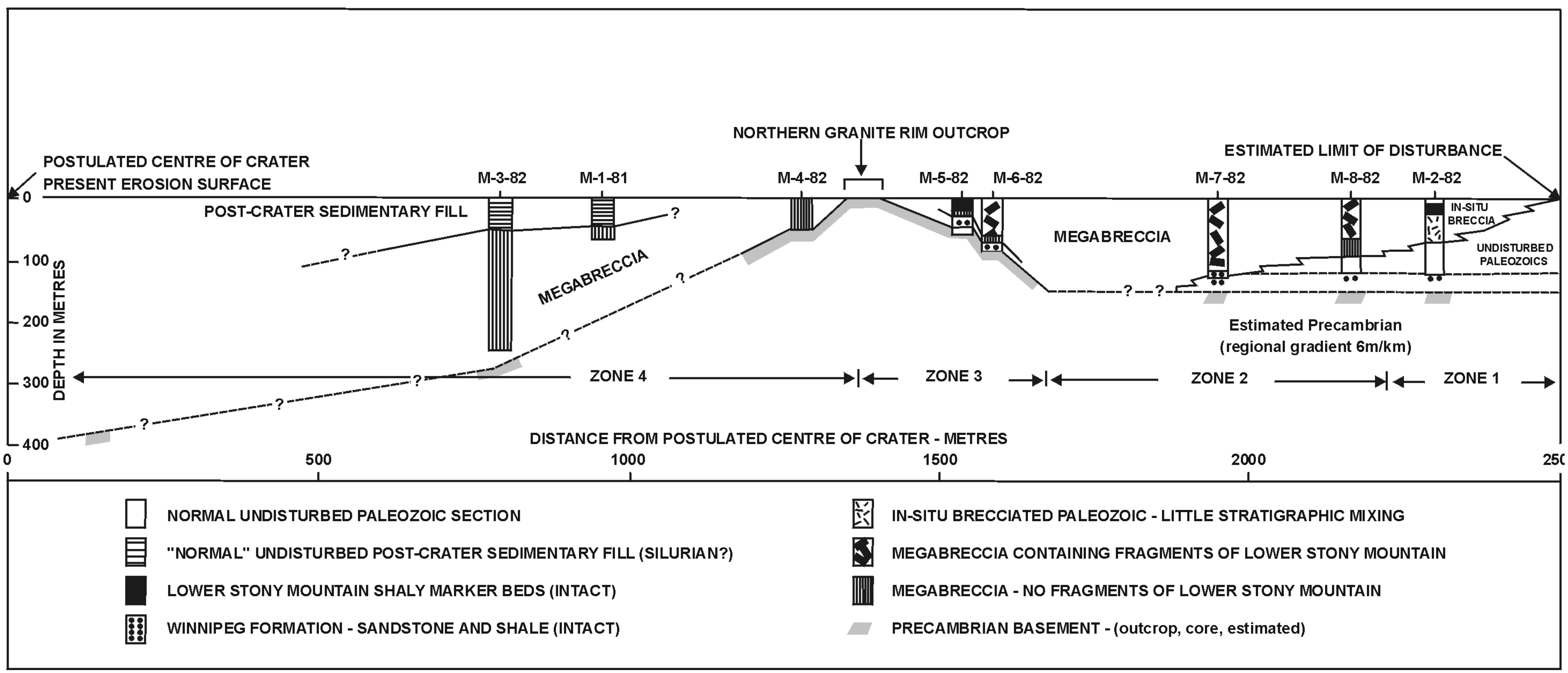


Figure 8: Cross-section of the High Rock Lake structure (after, McCabe, 1982).

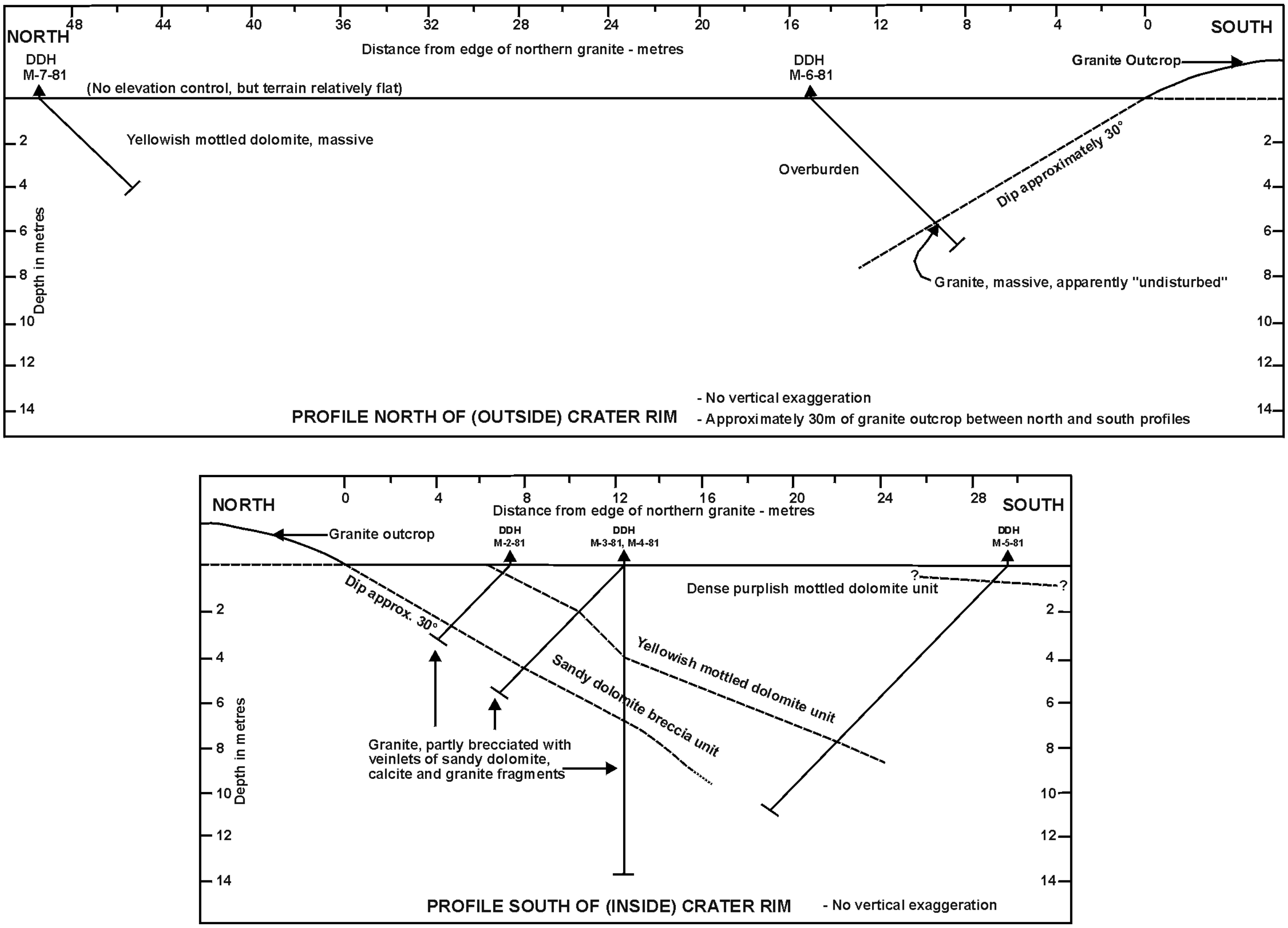


Figure 9: Detailed cross-section of the northern granite outcrop at High Rock Lake (after McCabe, 1981). Note scale different from Figure 8.

1982). These megabreccia and microbreccia appear to be, in part, brecciated Stony Mountain Formation rocks that normally overlie the Red River Formation (Table 5). These megabreccia immediately overlie undisturbed (?) Winnipeg sandstone (Fig. 8) that probably consisted of unconsolidated water-saturated sands in Late Ordovician to Silurian time — the time of the postulated impact. In addition, the sandy dolomite breccia directly on top of Precambrian rocks and beneath undisturbed massive dolomite of unknown age (Fig. 9) may also represent solution breccia material.

An interpretation of the megabreccia (Fig. 8) and the sandy dolomite breccia (Fig. 9) as possible solution collapse features provides an alternative and possibly better (?) explanation of the other observed features in this area. Namely, (1) the presence of intact Lower Stony Mountain Formation shaly marker beds on top of, and separated from, intact Winnipeg Formation sandstones by a thin unit of megabreccia that does not contain fragments of Stony Mountain (drill core M-5-82, Fig. 8; are these megabreccia fragments of Red River ?); (2) undisturbed mottled dolomite overlies sandy dolomite breccia (Fig. 9; McCabe, 1981); (3) the presence of in situ breccia in drill core M-2-82; and, (4) the presence of in situ/undisturbed Stony Mountain Formation shaly marker beds overlying megabreccia. Interpretation of these breccia as solution derived features further enhances the potential for MVT deposits to occur in this area, however, this interpretation does not adequately explain the presence of granite within the breccia in drill cores M-3-82 and M-4-82.

Faults and/or fractures are a common feature in most of the MVT deposit descriptions, as indicated above, and are certainly present in the Viburnum Trend deposits (Mouat and Clendenin 1977; Evans, 1977; Cathles and Smith, 1983). The geology of the Interlake region of southeastern Manitoba is insufficiently known to determine if fracture systems and faults with small vertical displacements occur in the Phanerozoic rocks. For example, the difference in elevation of the Winnipeg sandstone indicated on Figure 8 by drill cores M-5-82 and M-6-82 can be explained by vertical uplift related to faults instead of uplift related to an impactite. It is suggested here that the High Rock Lake feature can be interpreted as a fault controlled uplift.

The postulated fault(s) could be the westward extension of the Wanipigow and Manigotagan faults that are present in Precambrian rocks exposed along the eastern shore of Lake Winnipeg. If movement occurred on these Precambrian basement faults in post Ordovician time, they could have provided pathways for fluid migration from the Winnipeg Formation into the overlying carbonates.

Magnetic shadow maps (Fig. 11) show a magnetic high at the High Rock Lake Precambrian exposures.

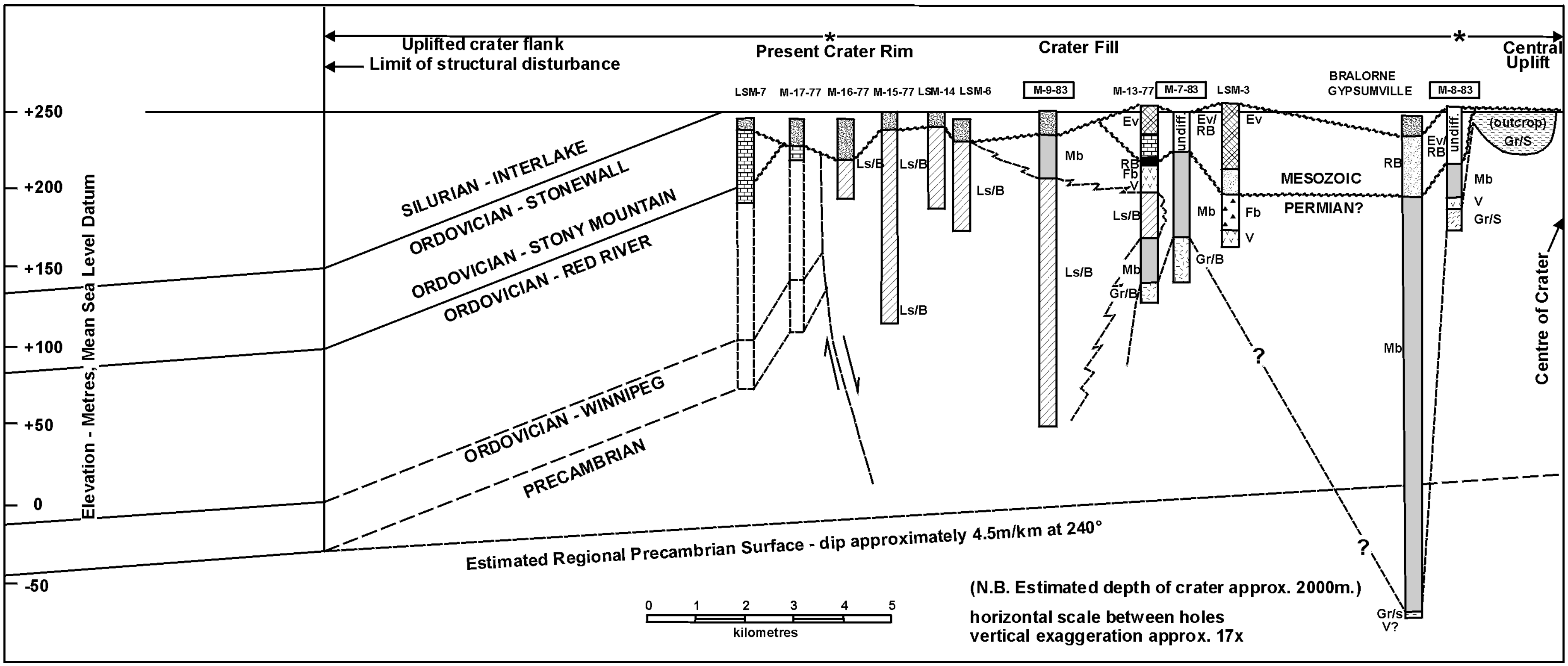


Figure 10: Geological cross-section of the Lake St. Martin crater (after McCabe, 1983).

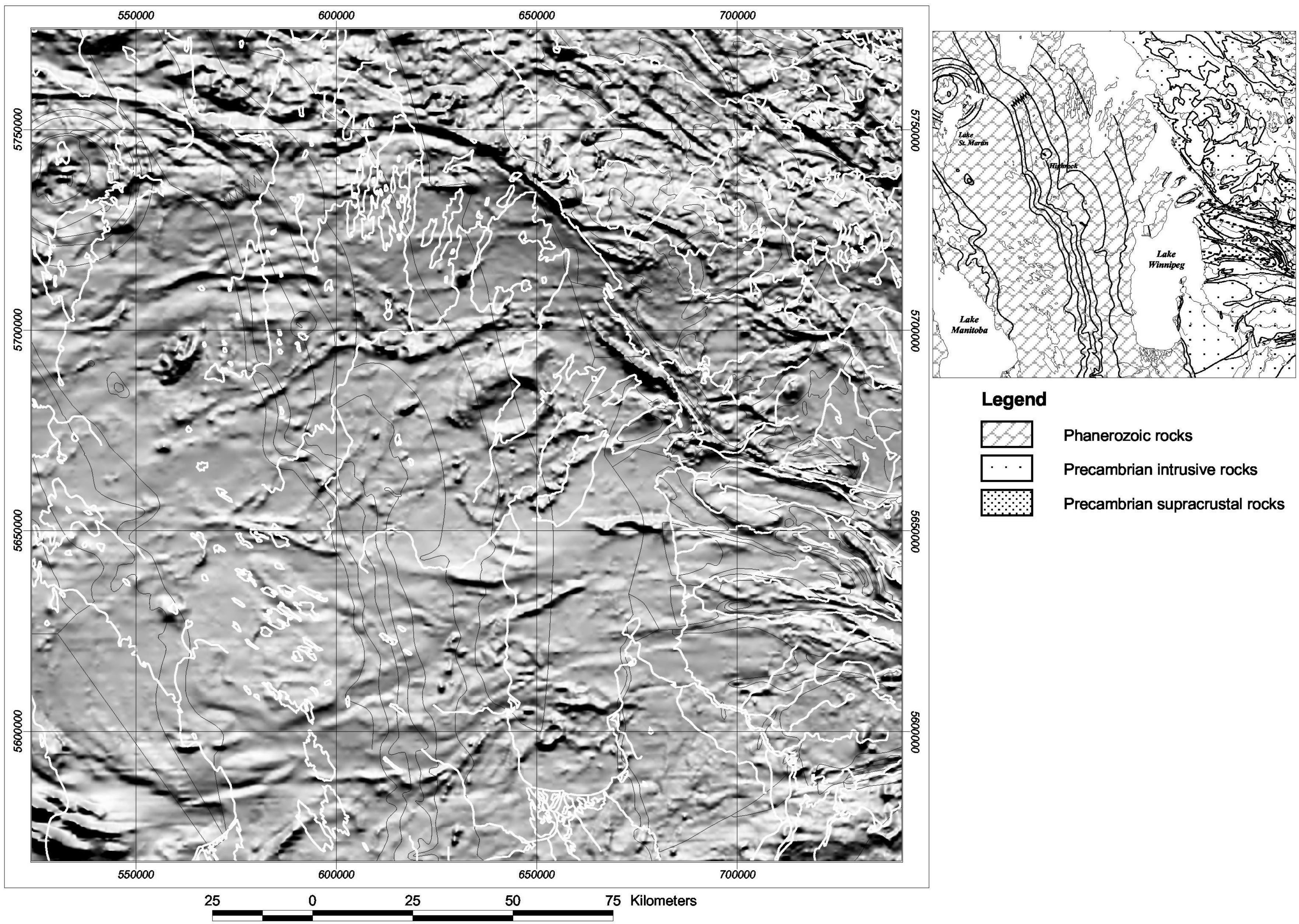


Figure 11: Magnetic shadow map for southeastern Manitoba, general geology and possible basement fault features. (from Viljoen et al., 1999).

Other pinnacle-like magnetic features occur in the vicinity. The shadow maps also show 'straight-line'-type basement features that could represent Phanerozoic faults. Movement on basement structures during Phanerozoic time may have created basement highs that focused fluids during dewatering of the Williston Basin and may have produced MVT deposits in an environment analogous to that of the Viburnum Trend. Apatite fission-track ages from basement rocks at High Rock Lake of approximately 435 +/- 10 Ma indicate that the apatites in the granites were completely annealed during Late Ordovician to Mid-Silurian time (Kohn et al., 1995).

Devonian rocks of central Manitoba

The Devonian reefs present in the Winnipegosis Formation of south-central Manitoba are underlain by the Elm Point Formation. These reefs occur close to the margins of the Elk Point Basin and were probably associated with evaporite deposits that have since been dissolved (McCabe, 1987b). The presence of active base metal-rich brine pools along the western shore of Lake Winnipegosis has focused some attention on this area of the province during the search for Pine Point-type base metal deposits (Stephenson, 1973; Bezys et al., 1997).

Anomalous lead and/or zinc values occur in Winnipegosis Formation rocks in this general area (Appendix 3). Despite a careful search of available core, there is no evidence of white sparry dolomite, which is ubiquitous around and in the Pine Point deposits. The absence of sparry dolomite in or around the reefs of this area does not bode well for the discovery of a Pine Point-type deposit in this area.

Genetic models of the Pine Point mineralization emphasize the importance of Devonian reefs in focusing mineralized fluids (Campbell, 1967; Jackson and Folinsbee, 1969). Skall (1975) presents evidence that the ores are situated in a barrier complex and the vuggy Presqu'ile dolomite is not a formation, but an alteration of several different rock types; most of the altered rocks were deposited in a back reef environment.

Vuggy Devonian reefs, fore reef and back reef environments (Fig. 12, 13) are present in the Winnipegosis Formation in Manitoba and Saskatchewan (McCabe, 1981). The Pine Point barrier complex occurs adjacent to a thick sequence of anhydrite and gypsum (Skall, 1975). Similarly, the Manitoba and Saskatchewan Devonian reefs are adjacent to or covered by thick evaporite sequences that consist mainly of halite, sylvite and minor anhydrite (McCabe, 1981). Drill core of vuggy Devonian dolomite in the Winnipegosis Formation contains crystals of honey-coloured sphalerite and grey pyrite; the clear carbonate crystals lining the vugs have not been identified.

The base- and precious-metal mineralization discovered in the Souris River Formation (Table 5) in western Manitoba and classified as 'prairie-type' by Fedikow et al. (1996) exhibits some similarities to the Upper Mississippi Valley-type deposits. Namely, the mineralization is fracture controlled, contains abundant base metals, quartz and an iron carbonate (siderite/?ferrodolomite) are present as gangue minerals. In addition, the mineralization occurs above basement fractures related to the Churchill–Superior Boundary Zone (Fedikow et al., 1996); it is envisaged that the tectonics are similar to those proposed for the Birdtail–Waskada oilfields to the south (Fig. 14). A comparison of Figures 13 and 14 suggests that some of the stratigraphic relationships in the Devonian rocks may be reinterpreted in light of the Birdtail–Waskada model to provide 'horst and graben structures' in the Dawson Bay area. Confirmation of the presence of vertical fault and fracture systems in the Dawson Bay–The Narrows area or along the western shore of Lake Winnipegosis is needed to further evaluate the base metal potential of the area.

It is possible that the anomalous metal contents obtained from the Winnipegosis and Dawson Bay Formation drill cores in this area (Appendix 3) intersected 'prairie-type'/Upper Mississippi Valley-type mineralization. A correlation with the Carlin-type mineralization cannot be ruled out because gold was not analyzed during this project.

The Upper Mississippi Valley-type deposits appear to be related to basement fractures and faults that focused fluids from a lower statigraphic aquifer upwards into carbonate rocks (Heyl et al., 1978). A similar model is proposed for the 'prairie-type' mineralization in Manitoba (Fedikow et al., 1996). Interpretation of the Birdtail–Waskada oilfield geology (Dietrich et al., 1998) indicates that it is controlled by horst and graben structures and occurs above the subsurface expression of the suture between the Proterozoic rocks on the west and the Archean rocks on the east along the Churchill–Superior Boundary Zone. Although similar detailed seismic studies have not been done in the Dawson Bay–Winnipegosis area, the area sits above the Churchill–Superior Boundary Zone and the emplacement of the base and precious metals is considered to have taken place along basement-related faults and fractures similar to those reported for the Birdtail–Waskada area (Martniuk, 1992; Fedikow et al., 1996). In the absence of drill information on the underlying Ashern Formation, it is possible that some of the relief differential on Devonian rocks in the Dawson Bay area is due to Birdtail–Waskada-type faults (cf. Fig. 13, 14).

Other evidence of Precambrian discontinuities include the east-west trends of Ordovician strata and the approximately northeastward trends of Devonian reefs. Anomalous Paleozoic isopachs along the Churchill–Superior Boundary Zone suggest distortion along this Precambrian suture (McCabe and Barchyn, 1982). These regional features could have provided channelways for fluid migration.

Consequently, the 'prairie-type' mineralization discovered by Fedikow et al. (1996) cannot be discounted as representative of Upper Mississippi Valley-type deposits. Leakage along faults and fractures of material related to deposits of that type formed in stratigraphic and structural traps in carbonate rocks at lower stratigraphic levels (Ordovician?) could account for the mineralization observed in the Mafeking quarry.

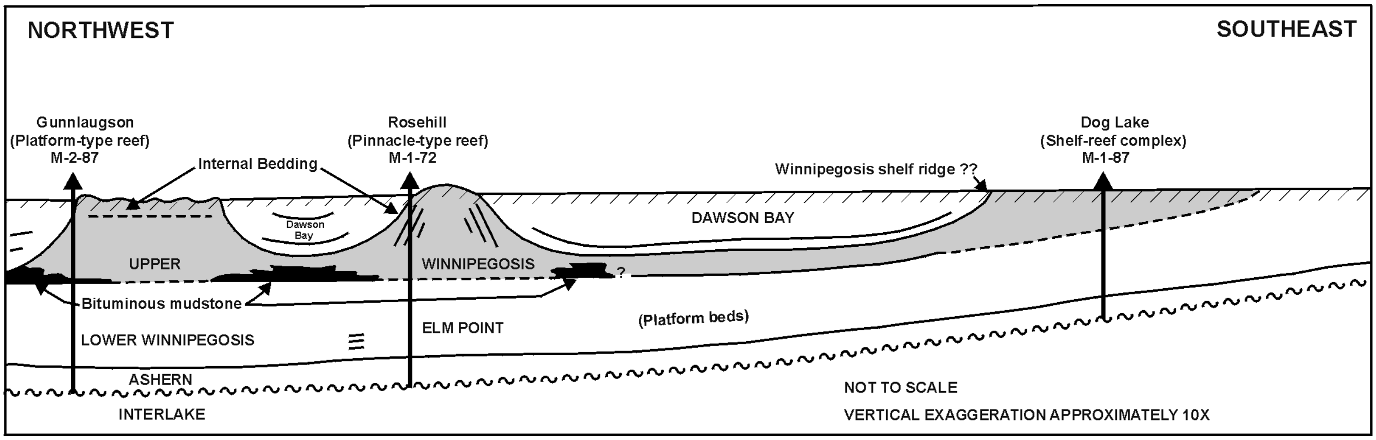


Figure 12: Diagrammatic cross-section of Winnipegosis Formation reefs in the Narrows area (after McCabe, 1987a, b).

Anomalous values in cores from the Winnipegosis Formation are significant. The values are low, but are derived from vuggy dolomitic rocks that in core M-6-80 contains microscopic grains of honey-coloured sphalerite. In comparison to the other formations sampled, the Winnipegosis Formation exhibits evidence that fluids capable of depositing MVT mineralization have percolated through and altered the formation.

The anomalous metal values obtained from cores in the Lake Winnipegosis area must also be evaluated in light of the recognition of the "prairie-type' mineralization in Manitoba (Fedikow et al., 1996). The cores containing anomalous metal values were obtained from an area that is underlain by the extension of the Thompson Nickel Belt — along the suture zone between the Churchill and Superior provinces. It is possible that the anomalous metal values observed in the Devonian and younger rocks are derived by the same mechanism as that producing the 'prairie-type' mineralization, i.e. by fluids derived from the Precambrian basement. Alternatively, the presence of the Churchill–Superior Boundary Zone may have provided the structural disturbance that resulted in fracturing of the Phanerozoic rocks and the pathways for migration of metal-rich fluids through the Winnipegosis Formation during dewatering of the Williston Basin. Fluids that deposited the mineralization in the Devonian Souris River Formation limestones at Mafeking probably transected the Winnipegosis Formation at depth.

Post Devonian breccia

Angular polylithic breccia cemented with calcite outcrops in quarries at several places in the Winnipegosis area and were intersected in cores drilled in and adjacent to quarries. These breccia have been attributed to collapse of overlying formations following solution of salt deposits in the Prairie Evaporite (McCabe and Barchyn, 1982; Bezys and McCabe, 1996). A thick zone of collapse breccia at the top of the Winnipegosis Formation was also intersected in drill hole D-47-76-2 (McCabe, 1976). Samples of this breccia type did not contain anomalous metal values. The formation of the breccia was probably too late to have provided a conduit for any mineralizing activity affecting the area.

FURTHER INVESTIGATIONS

Follow-up studies that should be undertaken during phase II of this project include:

1. Field studies and sampling of Winnipeg Formation sandstones to verify the reported occurrences of galena.
2. Isotopic studies of any galena found in the Winnipeg Formation to permit comparison with the Balmoral pebble.
3. Examination of cores of all Red River Formation rocks that report breccia to determine nature and timing of brecciation relative to dolomitization. Are the breccia a result of impactites or solution collapse?
4. Analyze all cores of breccia in the Ordovician rocks to determine base metal contents.
5. Systematic analysis of shales in the Red River and Winnipeg formations for base metal contents.
6. Obtain drill cores from magnetic highs in the High Rock Lake area to determine if they represent Precambrian basement features that could have focused fluids into overlying carbonate strata.
7. Obtain additional drill cores in the High Rock Lake area to provide a controlled geochemical transect across anomalous basement and breccia features.
8. Drill inclined holes in the vicinity of known base metal anomalies and 'prairie type' mineralization in the Dawson Bay–Winnipegosis area.
9. Re-examine the geology of the Dawson Bay area reefs by drilling a fence of inclined holes to locate possible fault systems and mineralized feeder systems in the vicinity of Devonian reefs or closely spaced vertical holes to establish the position of the Ashern Formation.
10. Analysis of the altered dolomitic limestones in the Mafeking quarry.

SUMMARY

The first phase of the investigation into the source of the Balmoral pebble has established that two areas of the province have the potential to contain MVT deposits. Namely, the Ordovician dolomites between Lake

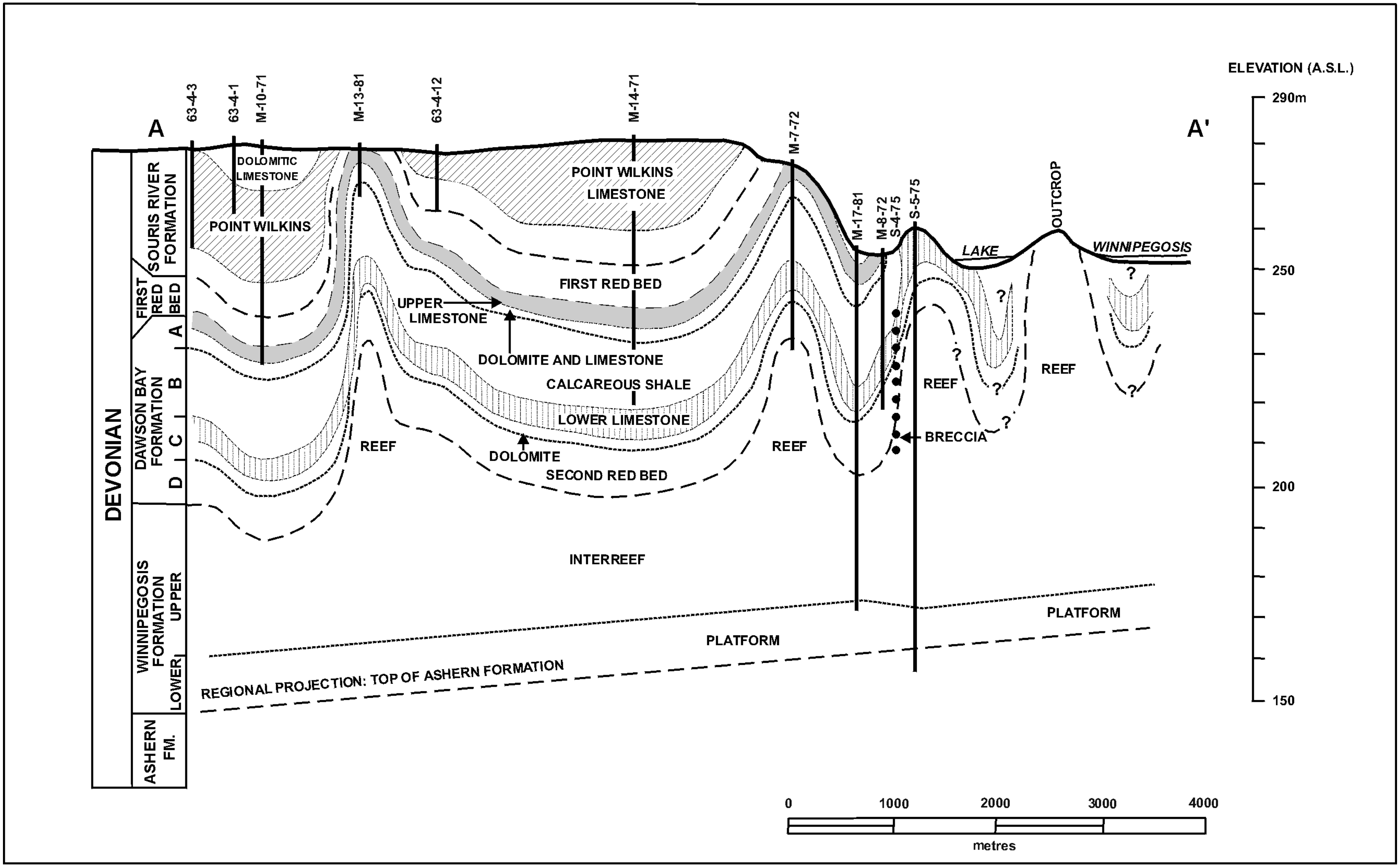


Figure 13: Geological cross-section of the Devonian rocks in the Dawson Bay area (after McCabe, 1987a).

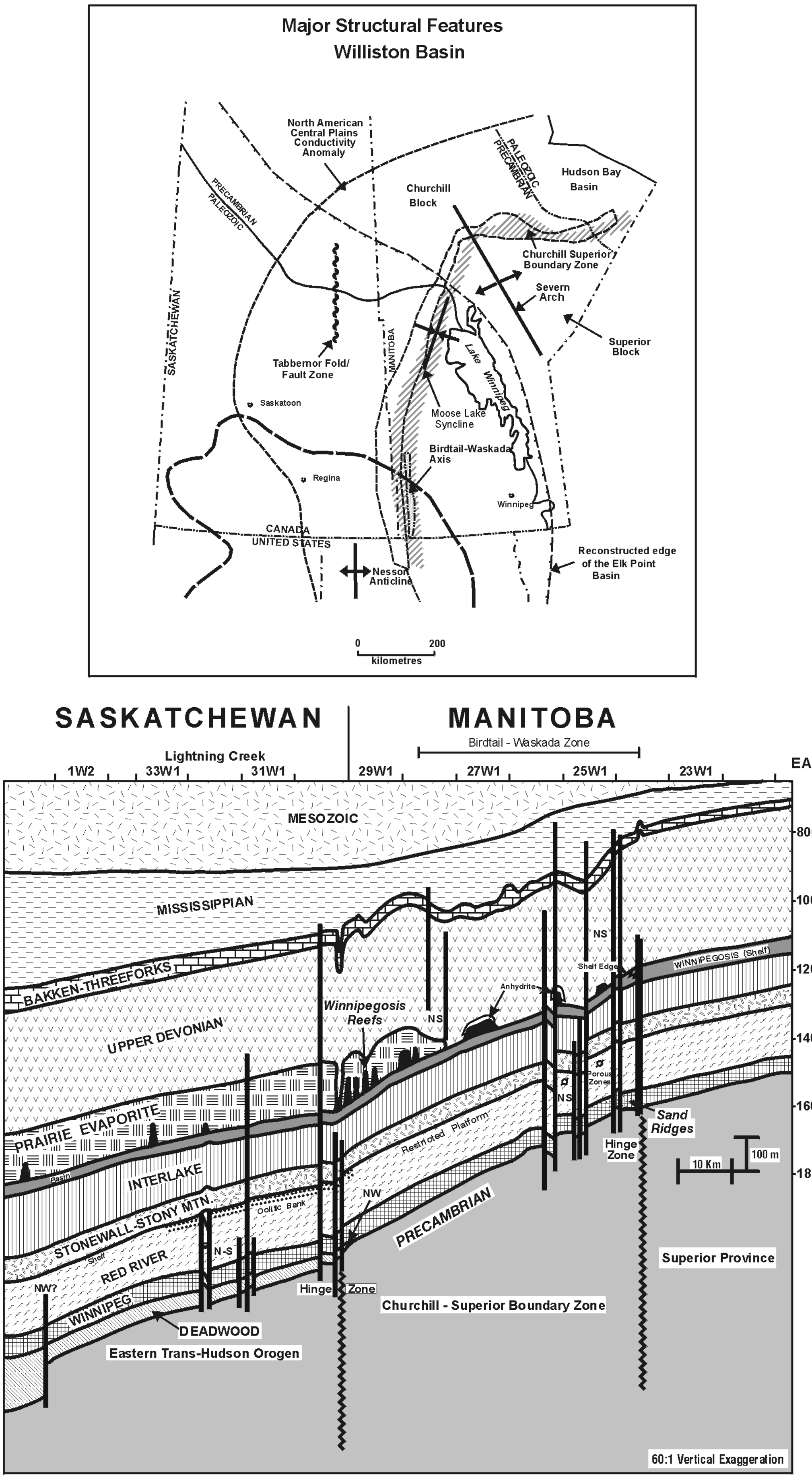


Figure 14: Approximate position of the Churchill –Superior Boundary Zone and cross-section of the Birdtail–Waskada area (after Martniuk, 1992; Dietrich et al., 1998).

Winnipeg and Lake Winnipegosis and the Ordovician to Devonian rocks that overlie the Churchill–Superior Boundary Zone in western Manitoba.

Many of the features associated with Viburnum Trend MVT deposits are present in the Interlake region of southeastern Manitoba, especially in the Ashern–High Rock Lake area. The possible existence of solution-collapse breccia in the High Rock Lake area and the existence of galena in the Grindstone Point area should be investigated.

Solution chimneys that cut Upper Devonian limestones in the Mafeking area have been shown to host 'prairie-type' gold and base metal mineralization (Fedikow et al., 1996). Anomalous base metal values obtained during this geochemical study suggest that 'prairie-type' or Upper Mississippi Valley-type mineralization may be widespread in the area west of Lake Winnipegosis, especially along the Churchill–Superior Boundary Zone.

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REFERENCES

A.F. 92192, Assessment File, Manitoba Industry Trade and Mines, Mines Branch, unpublished data.

Anderson, G.M. and McQueen, R.W. 1982: Ore Deposit Models - 6. Mississippi Valley-Type Lead-Zinc deposits; Geoscience Canada, v. 9, p. 108-117.

Bamburak, J.D. 1999: Cretaceous black shale investigations in the northern part of the Manitoba Escarpment (parts of NTS 62J/W, 62K/N, 62N/E and 63C/W); *in* Manitoba Industry, Trade and Mines, Geological Services, Report of Activities 1999, p. 120-122.

Bamburak, J.D. and Gale, G.H. 1993: Evaluation of magnesium resources in Phanerozoic dolomites of the Interlake area, Manitoba : part 2 - Sandridge area; Manitoba Energy and Mines, Geological Services, Open File Report 92-4, 28 p.

Bezys, R.K. 1996: Sub-Paleozoic structure in Manitoba's northern Interlake along the Churchill Superior boundary zone : a detailed investigation of the Falconbridge William Lake study area; Manitoba Energy and Mines, Geological Services, Open File Report 94-3, 32 p.

Bezys, R.K. and Conley, G.G., 1999: Manitoba Stratigraphic Database and the Manitoba Stratigraphic Map Series; Manitoba Energy and Mines, Geological Services, Open File Report OF98-7, CD-ROM.

Bezys, R.K. and McCabe, H.R. 1996: Lower to middle Paleozoic stratigraphy of southwestern Manitoba; Geological Association of Canada/Mineralogical Association of Canada Annual Meeting, Winnipeg, Manitoba May 27-29, 1996, Field Trip B4 Guidebook, p. 92.

Bezys, R.K., Ducharme, E.B., Bamburak, J.D., and Fedikow, M.A.K. 1997: A geochemical study of saline brine sediments as a guide to Prairie-type microdisseminated mineralization and other precious metals in west central Manitoba (NTS 63C); *in* Manitoba Energy and Mines, Minerals Division, Report of Activities, 1997, p. 118-122.

Brown, J.S. 1970: Mississippi Valley-type lead-zinc ores; Mineralium Deposita, v. 5, p. 103-119.

Campbell, N. 1967: Tectonics, reefs and stratiform lead-zinc deposits of the Pine Point area, Canada; Economic Geology, Monograph 3, p. 59-70.

Campeau, R.M. and Kissin, S.A. 1988: Project WAPA: Evaluation of a lead-zinc occurrence in Middle Devonian carbonates on northern Saskatchewan; Geoscience Canada, v. 15, no. 2, p. 106-108.

Cathles, L.M. and Smith, A.T. 1983: Thermal constraints on the formation of Mississippi Valley-Type Lead-Zinc deposits and their implications for episodic basin dewatering and deposit genesis; Economic Geology, v. 78, p. 983-1002.

Chow, N. 1991: Dolomitization in Middle Devonian platform carbonates, Elm Point Formation, Interlake area, Manitoba; *in* Sixth International Williston Basin Symposium, eds., J.E. Christopher and F.M.Haidl, Saskatchewan Geological Society, Regina, Sask., Special Publication Number 11, p. 34-39.

Davis, J.H. 1977: Genesis of the Southeast Missouri Lead Deposits; Economic Geology, v. 72, p. 443-450.

Dietrich, J., Thomas, M., Hajnal, Z., Redly, P., Zhu, C., and Majorowicz, J. 1998: Basement-sedimentary cover linkages in the Williston Basin, southeastern Saskatchewan and southwestern Manitoba; Geological Survey of Canada, CD-ROM.

Doe, B.R. and Delevaux, M.H. 1972: Source of Lead in Southeast Missouri Galena Ores; Economic Geology, v. 67, p. 409-425.

Evans, D.S. 1976: Dawson Bay (63C/13, 14, 15); *in* Manitoba Department of Mines, Resources and Environmental Management, Minerals Resources Division, Report of Field Activities, 1976, p. 56-57.

Evans, L.L. 1977: Geology of the Brushy Creek Mine, Viburnum Trend, Southeast Missouri; Economic Geology, v. 72, p. 381-390.

Fedikow, M.A.F., Bezys, R.K., Bamburak, J.D., and Abercrombie, H.J. 1996: Prairie-type micro-disseminated Au mineralization — a new deposit type in Manitoba's Phanerozoic rocks (NTS 63C/14); *in* Manitoba Energy and Mines, Minerals Division, Report of Activities 1996, p. 108-121.

Fowler, J.A. 1987: Report on the examination of samples from the Manitoba Department of Energy and Mines Mineral Resources Division, Geological Services Branch, Assessment Files, 14 p.

Gale, G.H. 1991: Evaluation of magnesium resources in Phanerozoic dolomites of the Interlake area, Manitoba: part 1 - reconnaissance; Manitoba Energy and Mines, Geological Services, Open File Report 91-3, 19 p.

Gale, G.H., Nielsen, E., and McCabe, H.R. 1981: Mineral deposit studies in Phanerozoic rocks of southern Manitoba; *in* Manitoba Energy and Mines, Mineral Resources Division, Report of Field Activities 1981, p. 57-62.

1984: Investigations of lead-zinc potential in Paleozoic rocks of southern Manitoba; *in* Manitoba Energy and Mines, Minerals Division, Report of Field Activities 1984, p. 159-163.

Gale, G.H., McCabe, H.R., and Nielsen, E. 1987: Base metal and uranium mineral potential of Paleozoic rocks in Manitoba; Geological Association of Canada, Mineralogical Association of Canada, 1987 Joint Annual Meeting, Program with Abstracts, v. 12, p. 44.

1988: Uranium and base metal potential of the Paleozoic rocks of southern Manitoba; *in* Metallic mineral potential, Western Interior Platform and underlying Precambrian, Geoscience Canada, v. 15, no. 2, p. 101-102.

Genik, G.J. 1952: A regional study of the Winnipeg Formation; M.Sc. thesis, University of Manitoba, 174 p.

Gerdemann, P.E. and Myers, H.E. 1972: Relationships of Carbonate Facies Patterns to Ore Distribution and to Ore Genesis in the Southeast Missouri Lead District; Economic Geology, v. 67, p. 426-433.

Gibbins, W.A. 1988: Metallic mineral potential, Western Interior Platform of the Northwest Territories; Geoscience Canada, v. 15, p.117-119.

Heyl, A.V., Broughton, W.A., and West, W.S. 1978: Geology of the Upper Mississippi Valley base-metal district, third edition; Wisconsin Geological and Natural History Survey, Madison, Wisconsin, 53706, 45 p.

Jackson, S.A. and Beales, F.W. 1967: An aspect of sedimentary basin evolution: The concentration of Mississippi Valley-type ores during late stages of diagenesis; Canadian Petroleum Geology Bulletin, v. 15, p. 383-433.

Jackson, S.A. and Folinsbee, R.E. 1969: The Pine Point lead-zinc deposits, N.W.T., Canada, Introduction and geology of the Presqu'ile reef; Economic Geology, v. 64, p. 711-717.

Kent, D.M. 1999: Mississippi Valley-Type Mineralization in Lower Devonian Lower Elk Point Strata, South La Ronge area, Central Saskatchewan: A case history; *in* MINEXPO'96 SYMPOSIUM — Advances in Saskatchewan Geology and Mineral Exploration, eds. K.E. Ashton and C.T. Harper, Special Publication Number 14, Saskatchewan Geological Society, Regina, Sask., p. 141-151.

Kerr, J. Wm. 1977: Cornwallis Lead-Zinc District; Mississippi Valley-type deposits controlled by stratigraphy and tectonics; Canadian Journal of Earth Sciences, v. 14, p. 1402-1426.

Kessler, II, L.G. 1991: Subsidence controlled stratigraphic sequences and the origin of shelf sand ridges, Winnipeg Group (Middle Ordovician) Manitoba, Saskatchewan, North Dakota; *in* Sixth International Williston Basin Symposium, eds., J.E. Christopher and F.M. Haidl, Saskatchewan Geological Society, Regina, Sask., Special Publication Number 11, p. 1-13.

Kohn, B.P., Osadeta, K.G., and Bezys, R.K. 1995: Apatite fission-tracking dating of two crater structures in the Canadian Williston Basin; Canadian Society of Petroleum Geologists, Bulletin of Canadian Petroleum Geology, v. 43, no. 1, p. 54-64.

Last, W.M. and Shum, W.W. 1991: Diagenesis of the Winnipeg Formation in Manitoba: A regional petrographic study; *in* Sixth International Williston Basin Symposium, eds., J.E. Christopher and F.M. Haidl, Saskatchewan Geological Society, Regina, Sask., Special Publication Number 11, p.14-20.

Leach, D.L., Nelson, R.C., and Williams, D. 1975: Fluid inclusion studies in the northern Arkansas zinc district; Economic Geology, v. 70, p. 1084-1091.

Martiniuk, C.D. 1992: Lower Paleozoic Sequence, Southwestern Manitoba — An Overview; Manitoba Energy and Mines, Petroleum Branch, POF 13-92, 40 p.

McCabe, H.R. 1967: Tectonic framework of Paleozoic formations in Manitoba; Canadian Institute of Mining and Metallurgy, Transactions, v. 70, p. 180-189.

1969: An occurrence of galena in float: Winnipeg area; Manitoba Mines and Natural Resources, Mines Branch, *in* Summary of Geological Fieldwork, 1969, Geological Paper 4/69, p. 125.

1976: Stratigraphic mapping and core hole programs; *in* Manitoba Energy and Mines, Minerals Division, Report of Activities 1976, p. 64-67.

1981: High Rock Lake structure; *in* Manitoba Energy and Mines, Mineral Resources Division, Report of Field Activities 1981, p. 78-82.

1982: Stratigraphic mapping and core hole program; *in* Manitoba Department of Energy and Mines, Mineral Resources Division, Report of Field Activities 1982, p. 75-80.

1983: Stratigraphic mapping and stratigraphic and industrial minerals core hole program; *in* Manitoba Energy and Mines, Mineral Resources Division, Report of Activities 1983, p. 122-130.

1987a: Stratigraphic mapping and stratigraphic and industrial minerals core hole program; *in* Manitoba Energy and Mines, Minerals Division, Report of Activities, p. 151-161.

1987b: A tentative model for Winnipegosis (Middle Devonian) "reefs", Manitoba outcrop belt; Canadian Society of Petroleum Geologists, 1987 Canadian Reef Research Symposium, p. 93.

McCabe, H.R. and Bannatyne, B.B. 1969a: Interlake core hole programs; *in* Manitoba Mines and Natural Resources, Mines Branch, Summary of Geological Fieldwork, 1969, Geological Paper 4/69, p. 119-120.

1969b: Lake St. Martin: A crypto-explosion or crater structure; *in* Manitoba Mines and Natural Resources, Mines Branch, Summary of Geological Fieldwork, 1969, Geological Paper 4/69, p. 115-118.

1970: Lake St. Martin : a crypto-explosion or crater structure; *in* Manitoba Department of Mines and Natural Resources, Geological Survey, Mines Branch, Summary of Geological Field Work, 1970, Geological Paper 4/70, p. 39.

1971: Lake St. Martin and High Rock Lake Precambrian inlier; *in* Manitoba Department of Mines, Resources and Environmental Management, Mines Branch, Summary of Geological Field Work, 1971, Geological Paper 6/71, p. 71.

McCabe, H.R. and Barchyn, D. 1982: Paleozoic Stratigraphy of Southwestern Manitoba; Geological Association of Canada, Field Trip Guidebook, Winnipeg, 1982, 47 p.

McRitchie, W.D. and Kaszycki, C.A. 1997: Tufa Mounds, Upwellings and Gravity Springs in the Central and Northern Interlake Region, Manitoba (parts of NTS Areas 62O, 62P, 63B and 63G); *in* Manitoba Energy and Mines, Geological Services, Report of Activities, 1997, p. 133-146.

Mouat, M.M. and Clendenin, C.W. 1977: Geology of the Ozark Lead Company Mine, Viburnum Trend, Southeast Missouri; Economic Geology, v. 72, p. 398-407.

Nielsen, E. 1982: Ice marginal sedimentation in glacial Lake Agassiz, Manitoba, Canada; International Congress on Sedimentology, v. 11, p. 75.

1989: Quaternary stratigraphy and overburden geochemistry in the Phanerozoic terrane of southern Manitoba; Manitoba Energy and Mines, Geological Services, Geological Paper 87-1, 78 p.

Nielsen, E. and Gale, G.H. 1982: Mineral deposit studies in Phanerozoic rocks of southern Manitoba; *in* Manitoba Department of Energy and Mines, Mineral Resources Division, Report of Field Activities 1982, p. 65-68.

1983: Mineral deposit studies of Phanerozoic rocks in southern Manitoba; *in* Manitoba Department of Energy and Mines, Mineral Resources Division, Report of Field Activities 1983, p. 115-121.

1985: Lead-zinc potential in Paleozoic rocks of southern Manitoba; *in* Manitoba Energy and Mines, Geological Services, Mines Branch, Report of Field Activities 1985, p. 235-236.

Paarlberg, N.L. and Evans, L.L. 1977: Geology of the Fletcher Mine, Viburnum Trend, Southeast Missouri; Economic Geology, v. 72, p. 391-397.

Panno, S.V., Harbottle, G., and Sayre, E.V. 1988: Distribution of selected elements in the shale of the Davis Formation, Buick Mine area, Viburnum Trend, southeast Missouri; Economic Geology, v. 83, p. 140-152.

Rhodes, D., Lantos, E.A., Lantos, J.A., Webb, R.J., and Owens, D.C. 1984: Pine Point Orebodies and Their Relationship to the Stratigraphy, Structure, Dolomitization, and Karstification of the Middle Devonian Barrier Complex; Economic Geology, v. 79, p. 991-1055.

Skall, H. 1975: The paleoenvironment of the Pine Point Lead-Zinc District; Economic Geology, v. 70, p.22-47.

Stephenson, J.F. 1973: Geochemical studies; *in* Summary of Geological Field Work, Department of Mines, Resources and Environmental Management, Manitoba, Geological Paper 2/73, p. 7-8.

Thorleifson, L.H., Betcher, R.N., Birks, J., Boyle, D., Cherry, A., Clark, I., Desbarats, A., Edwards, T., Farrell, D., Grasby, S., Hinton, M., Kaszycki, C.A., Kennedy, P., Leybourne, M., McDougall, W., McRitchie, W.D., Osadetz, K., Remenda, V., Render, F., Ryan, S., and Woodbury, A. 1998: Hydrogeology and hydrogeochemistry of the Red River Valley/Interlake region of Manitoba (NTS 62H, 62I, 62O, 62P and 63B); *in* Manitoba Energy and Mines, Geological Services, Report of Activities 1998, p. 172-185.

Viljoen, D., Chackowsky, L., Lenton, P., and Broome, H.J. 1999: Geology, Magnetic and Gravity Maps of Manitoba: A Digital Perspective; Manitoba Energy and Mines, Geological Services, Open File Report OF99-12, CD-ROM.

Wadien, R. 1984: The geochemistry and hydrogeology of saline spring waters of the Winnipegosis area, south-western Manitoba; B.Sc. Thesis, University of Manitoba, 63 p.

Appendix 1: Replicate analytical data for Certified Reference Material GXR-6. Recommended values (ppm) indicated by *.

Seq. No.	Samp. No.	Cu	Ni	Pb	Zn	Mn	Fe
	GRX-6*	66*	27*	101*	118*	1007*	55850*
1	10-7-82	73	·	102	129	750	47000
2	10-7-82	73	·	104	137	800	47000
3	10-8-82	75	·	100	135	815	51000
4	10-8-82	74	·	102	135	790	52000
5	10-13-82	75	·	100	135	750	50000
6	10-13-82	82	·	106	135	750	50000
7	10-14-82	73	·	99	130	810	51500
8	10-14-82	73	·	98	130	800	52000
9	10-26-82	74	·	102	130	760	51000
10	10-26-82	72	·	102	131	750	51000
11	10-28-82	73	·	100	130	770	49500
12	10-28-82	75	·	103	135	785	50000
13	11-2-82	75	·	102	130	845	51500
14	11-2-82	76	·	104	130	815	51500
15	11-3-82	76	·	104	142	810	51500
16	11-3-82	76	·	102	134	850	54000
17	1-4-83	74	·	99	131	850	50000
18	1-4-83	72	·	99	129	835	50000
19	1-13-83	75	·	101	133	825	50000
20	1-13-83	76	·	103	133	860	49000
21	1-13-83	77	·	102	133	810	50000
22	1-13-83	73	·	102	133	785	51000
23	1-13-83	75	·	101	134	795	50500
24	2-8-83	74	·	100	133	780	52000
25	2-8-83	79	·	110	140	750	48500
26	2-10-83	80	·	110	120	1000	48500
27	2-10-83	82	·	112	137	900	52000
28	2-14-83	74	·	106	130	790	52500
29	2-14-83	74	·	101	130	760	53500
30	2-14-83	79	·	100	131	820	52500
31	2-14-83	77	·	100	125	890	52500
32	3-1-83	75	·	101	132	825	50500
33	3-1-83	75	·	105	132	815	50500
34	3-2-83	76	·	102	134	750	52500
35	3-2-83	74	·	99	133	745	52500
36	3-3-83	75	·	100	132	780	51000
37	3-3-83	74	·	100	132	785	52000
38	3-3-83	73	·	100	130	780	51500
39	5-8-84	75	22	97	134	814	42850
40	5-18-84	75	22	100	135	1120	60000
41	7-18-84	72	21	108	152	990	53500
42	7-12-84	80	25	94	139	1010	53500
43	7-13-84	74	19	94	130	930	51500
44	7-16-84	82	24	103	151	771	56500
45	7-17-84	84	27	107	151	910	54500
46	7-19-84	87	29	116	156	1020	60500
47	6-19-84	87	25	95	139	752	53900
48	6-20-84	79	21	90	126	757	46600
49	6-20-84	89	20	90	148	733	49700
50	11-7-84	74	20	99	133	670	40000
51	11-8-84	79	23	94	138	661	42000
52	11-21-84	75	22	97	133	900	49000
53	11-21-84	76	22	98	134	950	48000
54	11-22-84	73	24	97	128	970	50500
55	11-22-84	75	24	99	133	1010	53000
56	11-27-84	78	23	99	143	990	52500
57	11-27-84	79	23	100	133	950	53500
58	11-27-84	80	23	107	141	950	52500
59	12-4-84	72	23	97	131	950	49000
60	12-4-84	76	25	98	137	950	48000
61	12-6-84	80	24	102	141	800	43000
62	12-6-84	78	23	94	139	850	47000
63	12-10-84	84	24	108	148	910	48500
64	12-11-84	78	24	105	152	890	47000
65	1-30-85	79	23	105	139	910	52000
66	1-31-85	78	24	109	143	960	54500
67	2-21-85	73	21	98	139	643	46500
68	2-21-85	76	21	99	134	659	46500
69	2-22-85	73	·	95	134	661	43000
70	2-26-85	71	20	92	128	840	48500
71	3-5-85	77	24	101	152	1110	49500
72	3-8-85	74	24	97	133	890	49500
73	3-12-85	73	23	100	134	860	44100
74	3-13-85	73	23	102	133	860	47500
75	3-14-85	79	24	96	132	810	48000
76	3-14-85	75	25	99	140	920	48500
77	5-17-85	80	26	98	129	890	51000
78	5-28-85	71	24	97	126	920	53500
79	5-29-85	72	22	98	128	980	57500
80	5-30-85	70	23	101	126	1010	55000
81	5-31-85	76	22	110	136	990	55000
82	6-3-85	74	25	100	131	1030	54000
83	6-10-85	69	23	95	124	810	48000
84	6-11-85	68	21	87	128	860	51500
85	6-12-85	72	22	94	125	860	48000
86	6-13-85	71	23	98	126	840	47500
87	6-14-85	69	23	90	121	800	45000
88	8-21-85	72	25	94	130	950	50500
89	8-22-85	70	24	99	128	690	53000
90	8-22-85	73	28	93	125	900	49500
91	8-23-85	74	25	98	127	673	51000
92	8-26-85	75	23	97	123	653	38400
93	11-6-85	70	23	91	117	870	50500
94	11-7-85	67	23	84	115	850	50500
95	12-11-85	72	22	95	122	790	44000
96	12-16-85	73	23	·	129	·	47000
97	12-18-85	71	21	91	128	790	46000
98	12-19-85	72	22	94	126	830	45500
99	1-7-86	73	22	97	118	840	45000
100	1-8-86	65	21	89	126	950	49500
101	1-8-86	70	23	89	128	820	45500
102	1-9-86	73	22	99	121	870	48500
103	1-10-86	74	21	97	131	810	47500
104	1-13-86	70	21	92	120	790	44000
105	1-14-86	72	23	97	122	810	42500
106	1-15-86	73	22	97	121	800	44000
107	1-20-86	74	24	103	138	900	47000
108	1-22-86	75	22	100	124	820	45000
109	1-29-86	72	24	92	116	870	44000
110	1-30-86	73	23	96	121	850	46500
111	1-31-86	71	23	95	120	850	46000
112	3-3-86	69	22	·	·	726	51000
113	3-5-86	·	28	·	·	·	51000
114	3-5-86	·	21	·	·	·	50500
115	3-7-86	·	24	·	·	·	51000
116	3-7-86	·	24	·	·	·	53000
117	3-7-86	·	24	·	·	·	52500
118	3-11-86	·	23	·	·	·	48500
119	3-11-86	·	22	·	·	·	48000
120	3-12-86	·	23	·	·	·	46150
121	3-12-86	·	23	·	·	·	52500
122	3-12-86	·	24	·	·	·	50000
123	3-12-86	·	23	·	·	·	49000
124	3-20-86	73	23	99	129	940	50000
125	3-26-86	75	22	113	132	1050	51500
126	3-26-86	74	22	99	122	1000	51000
127	4-9-86	76	23	96	127	1010	52500
128	4-9-86	74	24	96	128	1020	51500
129	4-10-86	69	23	101	128	940	50000
130	4-16-86	73	21	98	132	1010	55000
131	4-16-86	72	24	95	128	705	51500

Appendix 2: Geochemical data for drill cores sampled (see diskette in back pocket).

Appendix 3: Tables and maps of data at concentrations ≥ 99 percentile.

Amaranth Formation

Cu >= 20 ppm (99th percentile)

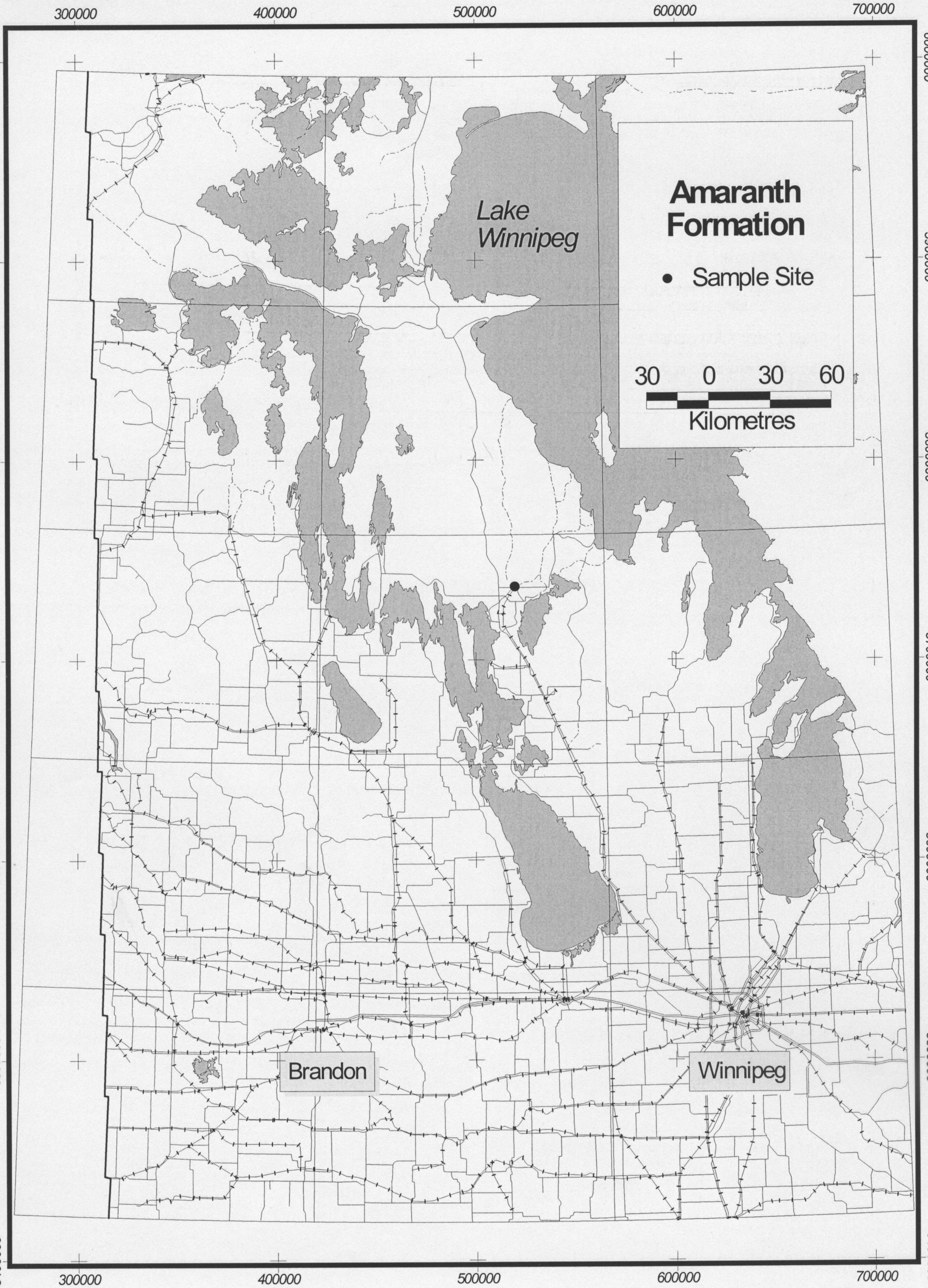
Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/06-26-032-09W1/00	LSM-03	525475	5735850	50.0	21	69	0	519	5400	8	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	57.3	30	96	6	821	12150	18	-	AMARANTH	AMARANTHL

Zn >= 45 ppm (99th percentile)

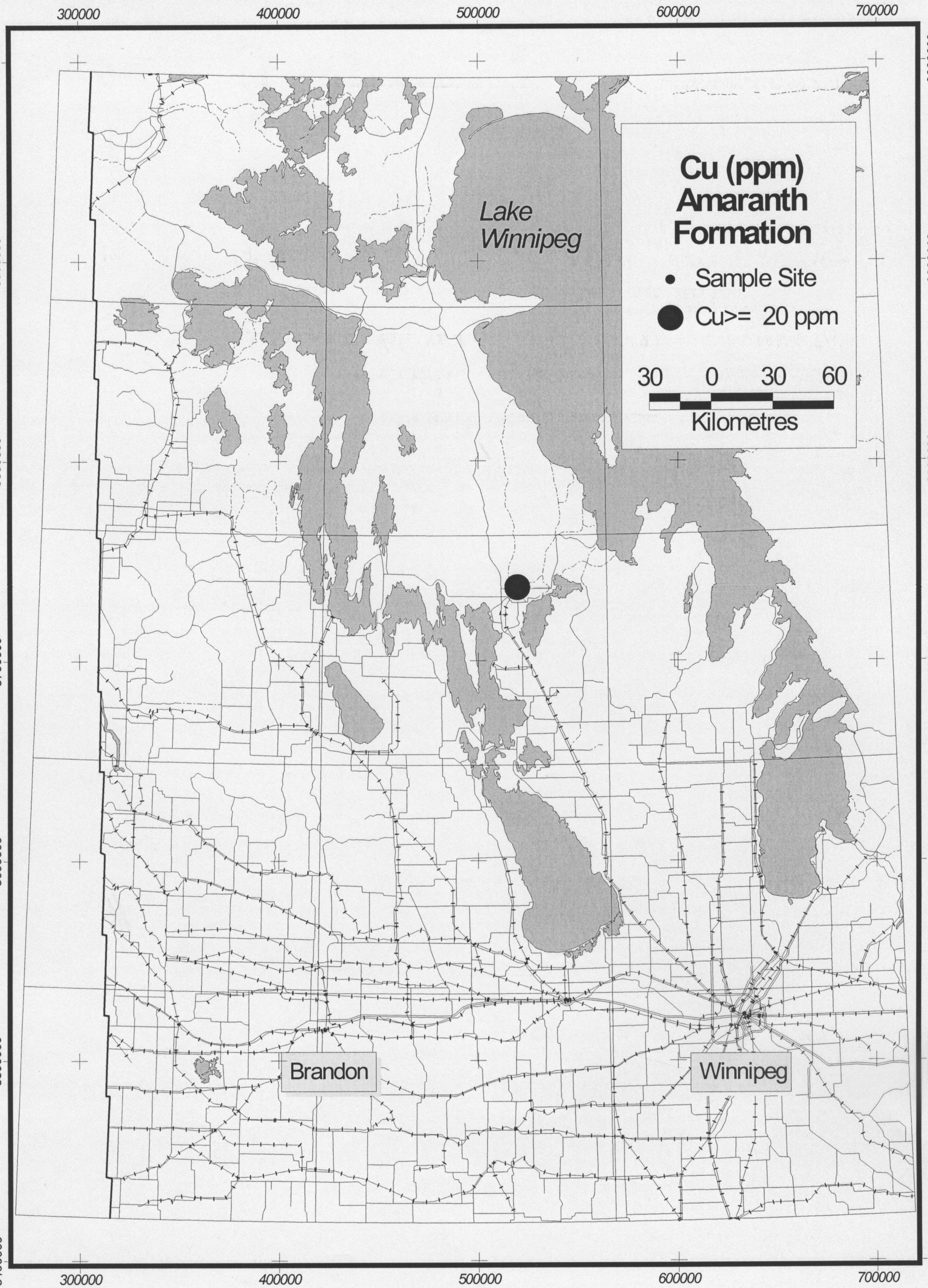
Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/06-26-032-09W1/00	LSM-03	525475	5735850	49.4	14	52	0	483	5900	7	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	50.0	21	69	0	519	5400	8	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	50.6	13	48	0	445	5300	10	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	50.8	11	51	3	435	4950	5	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	51.6	13	61	0	639	5350	6	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	51.9	8	51	0	532	6150	5	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	53.1	6	48	4	628	6550	6	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	53.7	3	45	0	759	5900	5	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	54.3	5	58	4	554	7200	7	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	55.5	2	45	5	870	4850	9	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	56.1	1	52	5	895	6700	7	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	57.3	30	96	6	821	12150	18	-	AMARANTH	AMARANTHL

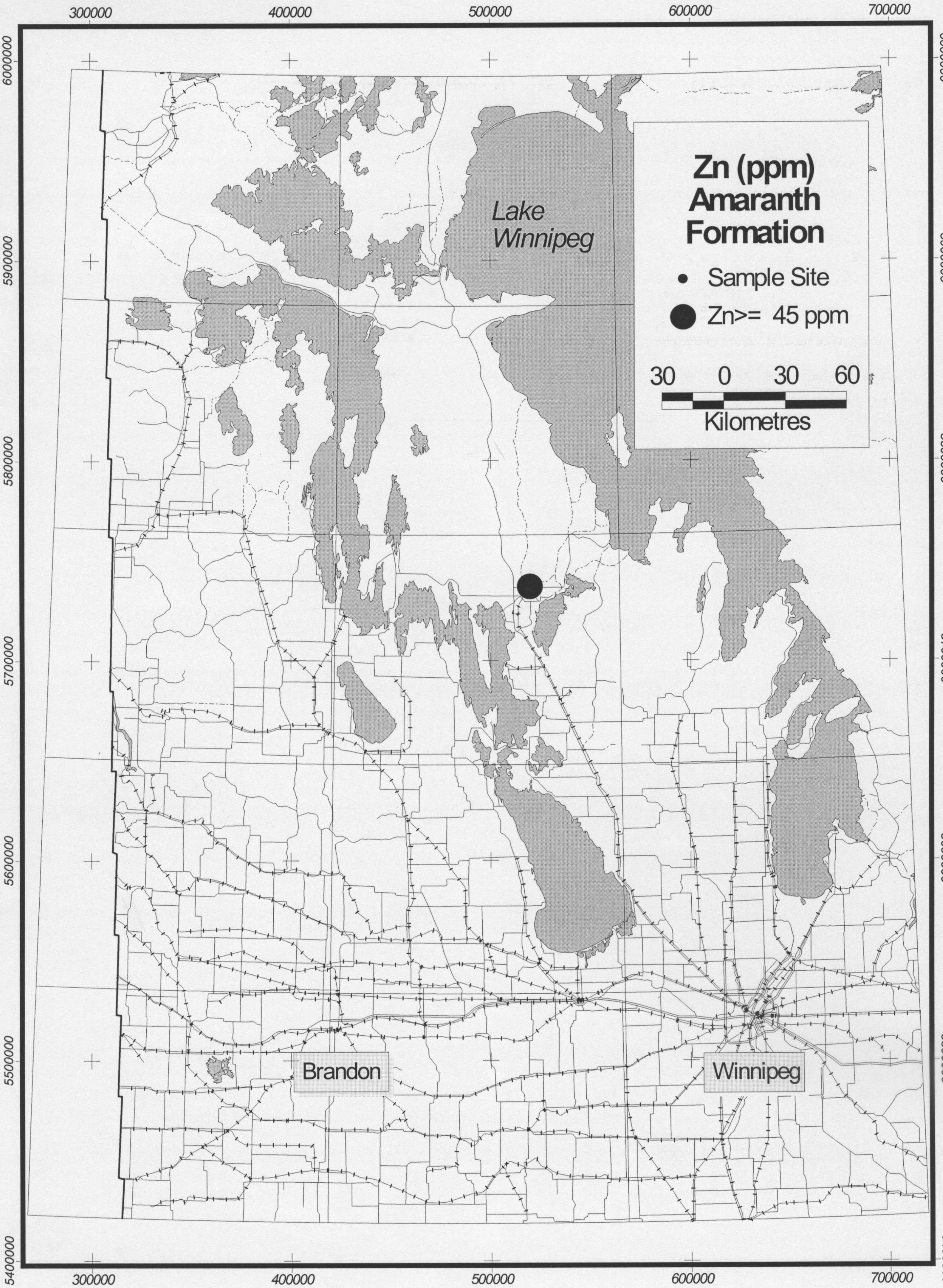
Mn >= 363 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/06-26-032-09W1/00	LSM-03	525475	5735850	44.5	7	22	2	392	3150	4	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	45.1	7	24	2	411	3200	6	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	45.7	8	20	3	398	3050	5	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	46.3	8	18	0	376	2800	5	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	46.9	7	15	0	407	2550	3	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	47.5	6	16	2	437	3000	6	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	48.2	9	28	0	438	4000	8	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	48.8	11	37	0	582	4500	6	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	49.4	14	52	0	483	5900	7	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	50.0	21	69	0	519	5400	8	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	50.6	13	48	0	445	5300	10	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	50.8	11	51	3	435	4950	5	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	51.6	13	61	0	639	5350	6	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	51.9	8	51	0	532	6150	5	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	52.5	5	44	2	591	5550	5	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	53.1	6	48	4	628	6550	6	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	53.7	3	45	0	759	5900	5	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	54.3	5	58	4	554	7200	7	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	54.9	3	44	3	1660	4850	8	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	55.5	2	45	5	870	4850	9	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	56.1	1	52	5	895	6700	7	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	56.7	7	36	4	2230	4600	4	-	AMARANTH	AMARANTHL
100/06-26-032-09W1/00	LSM-03	525475	5735850	57.3	30	96	6	821	12150	18	-	AMARANTH	AMARANTHL

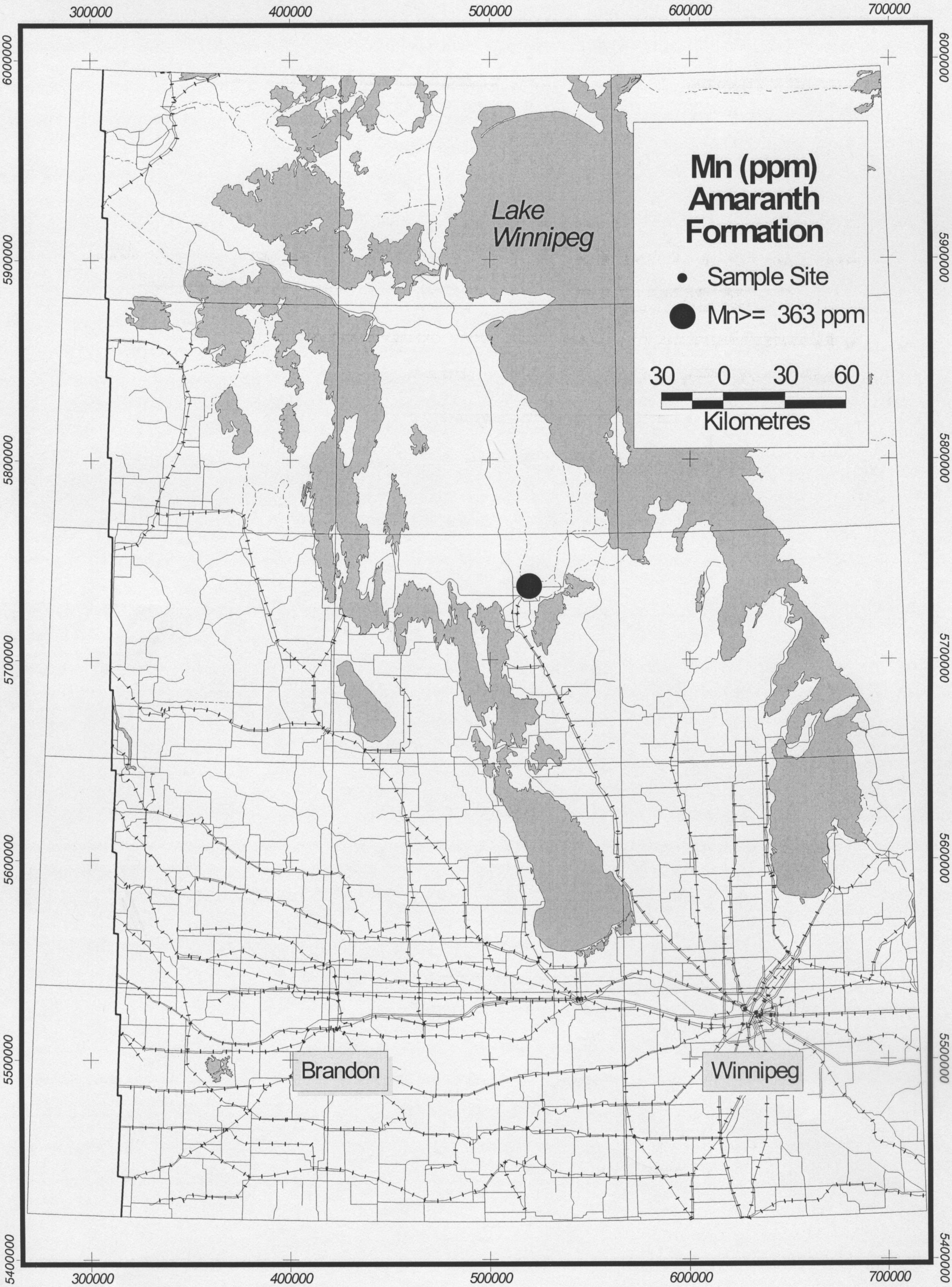


Amaranth Formation
Sample Site
30 0 30 60
Kilometres
Lake Winnipeg
Brandon
Winnipeg
300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000


300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000
Lake Winnipeg
Cu (ppm)
Amaranth
Formation
Sample Site
Cu>= 20 ppm
30 0 30 60
Kilometres
Brandon
Winnipeg



Zn (ppm)
Amaranth
Formation
Sample Site
Zn>= 45 ppm
30 0 30 60
Kilometres
Lake Winnipeg
Brandon
Winnipeg
300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000



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Lake Winnipeg
Mn (ppm) Amaranth Formation
Sample Site
Mn>= 363 ppm
30 0 30 60
Kilometres
Brandon
Winnipeg

St. Martin Complex

Cu >= 20 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
	LSM-01	542250	5732500	65.2	57	73	0	105	17000	11	-	STMARTIN	GRANBRECCIA
	LSM-01	542250	5732500	65.5	70	59	3	107	17500	11	-	STMARTIN	GRANBRECCIA
	LSM-01	542250	5732500	65.8	25	58	0	126	16000	11	-	STMARTIN	GRANBRECCIA
	LSM-01	542250	5732500	66.8	38	54	0	150	14500	15	-	STMARTIN	GRANBRECCIA
	LSM-01	542250	5732500	67.4	29	55	0	177	15500	12	-	STMARTIN	GRANBRECCIA
	LSM-01	542250	5732500	68.0	48	51	0	151	9700	9	-	STMARTIN	GRANBRECCIA
	LSM-01	542250	5732500	69.2	150	70	0	294	16500	9	-	STMARTIN	CARBBRECCIA
	LSM-01	542250	5732500	69.5	710	34	47	159	2500	12	-	STMARTIN	CARBBRECCIA
	LSM-01	542250	5732500	71.3	68	17	0	133	1750	4	-	STMARTIN	CARBBRECCIA
	LSM-01	542250	5732500	82.3	27	71	10	148	12100	28	-	STMARTIN	CARBBRECCIA
	LSM-01	542250	5732500	82.6	35	43	4	148	8900	20	-	STMARTIN	CARBBRECCIA
	LSM-01	542250	5732500	83.5	48	14	0	203	1900	6	-	STMARTIN	CARBBRECCIA
	LSM-01	542250	5732500	83.8	35	26	6	146	5500	47	-	STMARTIN	CARBBRECCIA
100/06-26-032-09W1/00	LSM-03	525475	5735850	57.9	21	99	8	390	17900	16	-	STMARTIN	POLYBRECCIA
100/06-26-032-09W1/00	LSM-03	525475	5735850	63.2	25	76	10	283	17400	16	-	STMARTIN	POLYBRECCIA
100/06-26-032-09W1/00	LSM-03	525475	5735850	63.8	26	56	14	235	17100	14	-	STMARTIN	POLYBRECCIA
100/06-26-032-09W1/00	LSM-03	525475	5735850	68.3	20	94	17	359	20000	12	-	STMARTIN	POLYBRECCIA
100/06-26-032-09W1/00	LSM-03	525475	5735850	68.6	24	84	8	418	27500	23	-	STMARTIN	POLYBRECCIA
100/06-26-032-09W1/00	LSM-03	525475	5735850	69.2	24	75	11	404	25500	10	-	STMARTIN	POLYBRECCIA

Zn >= 45 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
	LSM-01	542250	5732500	65.2	57	73	0	105	17000	11	-	STMARTIN	GRANBRECCIA
	LSM-01	542250	5732500	65.5	70	59	3	107	17500	11	-	STMARTIN	GRANBRECCIA
	LSM-01	542250	5732500	65.8	25	58	0	126	16000	11	-	STMARTIN	GRANBRECCIA
	LSM-01	542250	5732500	66.8	38	54	0	150	14500	15	-	STMARTIN	GRANBRECCIA
	LSM-01	542250	5732500	67.4	29	55	0	177	15500	12	-	STMARTIN	GRANBRECCIA
	LSM-01	542250	5732500	68.0	48	51	0	151	9700	9	-	STMARTIN	GRANBRECCIA
	LSM-01	542250	5732500	69.2	150	70	0	294	16500	9	-	STMARTIN	CARBBRECCIA
	LSM-01	542250	5732500	82.3	27	71	10	148	12100	28	-	STMARTIN	CARBBRECCIA
100/06-26-032-09W1/00	LSM-03	525475	5735850	57.9	21	99	8	390	17900	16	-	STMARTIN	POLYBRECCIA
100/06-26-032-09W1/00	LSM-03	525475	5735850	59.9	15	76	8	272	16600	16	-	STMARTIN	POLYBRECCIA
100/06-26-032-09W1/00	LSM-03	525475	5735850	60.5	7	78	7	255	14750	16	-	STMARTIN	POLYBRECCIA
100/06-26-032-09W1/00	LSM-03	525475	5735850	62.8	17	75	15	266	18050	17	-	STMARTIN	POLYBRECCIA
100/06-26-032-09W1/00	LSM-03	525475	5735850	63.2	25	76	10	283	17400	16	-	STMARTIN	POLYBRECCIA
100/06-26-032-09W1/00	LSM-03	525475	5735850	63.8	26	56	14	235	17100	14	-	STMARTIN	POLYBRECCIA
100/06-26-032-09W1/00	LSM-03	525475	5735850	66.3	12	77	11	274	17450	13	-	STMARTIN	POLYBRECCIA
100/06-26-032-09W1/00	LSM-03	525475	5735850	67.0	19	83	17	343	20950	14	-	STMARTIN	POLYBRECCIA
100/06-26-032-09W1/00	LSM-03	525475	5735850	68.3	20	94	17	359	20000	12	-	STMARTIN	POLYBRECCIA
100/06-26-032-09W1/00	LSM-03	525475	5735850	68.6	24	84	8	418	27500	23	-	STMARTIN	POLYBRECCIA
100/06-26-032-09W1/00	LSM-03	525475	5735850	69.2	24	75	11	404	25500	10	-	STMARTIN	POLYBRECCIA
100/06-26-032-09W1/00	LSM-03	525475	5735850	69.8	19	85	12	353	20050	13	-	STMARTIN	POLYBRECCIA
100/06-26-032-09W1/00	LSM-03	525475	5735850	70.4	15	68	10	330	20650	13	-	STMARTIN	POLYBRECCIA
100/06-26-032-09W1/00	LSM-03	525475	5735850	72.8	18	73	12	336	19500	12	-	STMARTIN	POLYBRECCIA
100/06-26-032-09W1/00	LSM-03	525475	5735850	74.9	12	63	7	311	17350	10	-	STMARTIN	POLYBRECCIA
100/06-26-032-09W1/00	LSM-03	525475	5735850	77.1	9	49	7	373	15350	11	-	STMARTIN	POLYBRECCIA
100/06-26-032-09W1/00	LSM-03	525475	5735850	80.8	16	50	5	383	17000	13	-	STMARTIN	POLYBRECCIA

Pb >= 19 ppm (99th percentile)

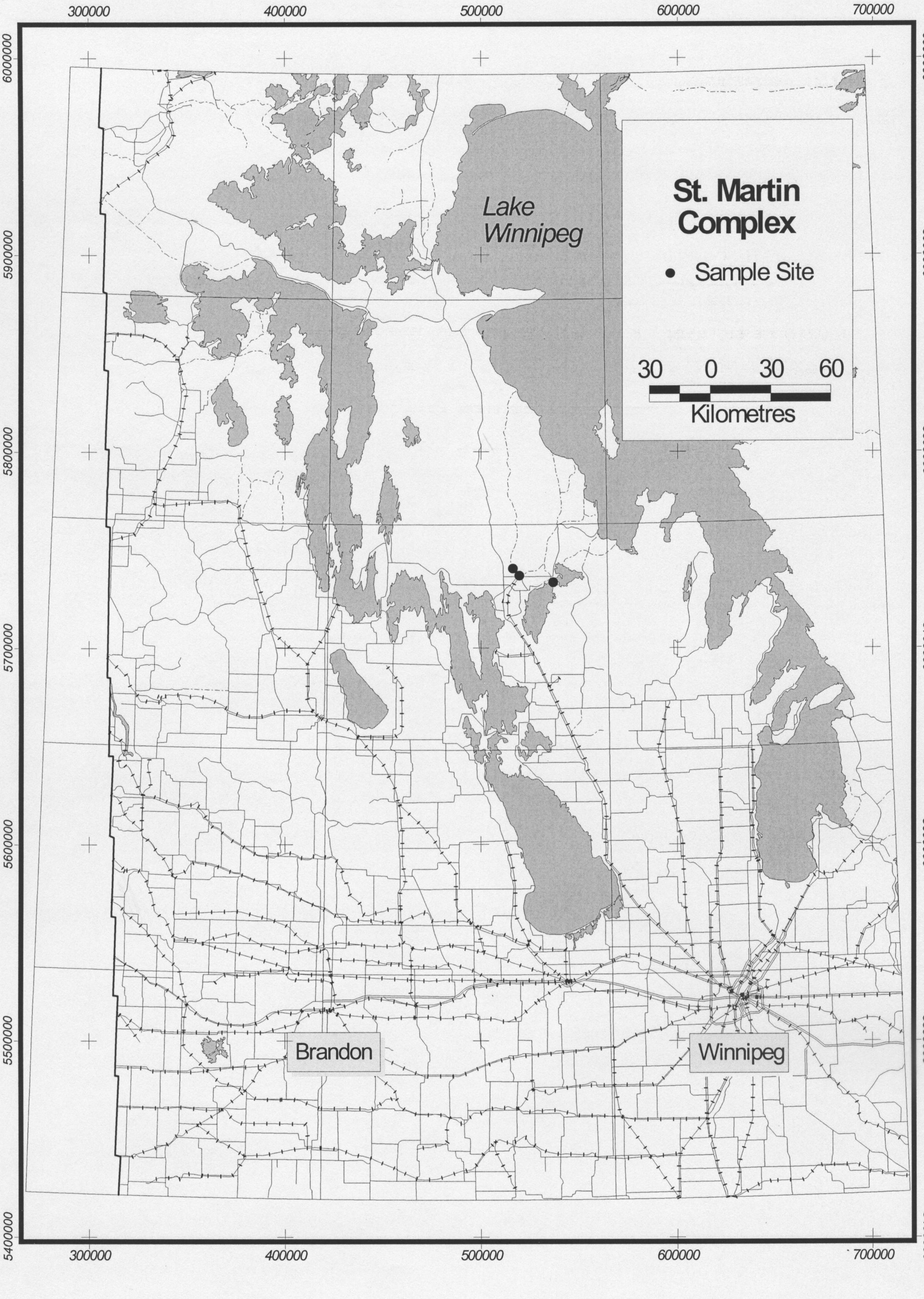
Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
	LSM-01	542250	5732500	69.5	710	34	47	159	2500	12	-	STMARTIN	CARBBRECCIA

Mn >= 363 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/06-26-032-09W1/00	LSM-03	525475	5735850	57.9	21	99	8	390	17900	16	-	STMARTIN	POLYBRECCIA
100/06-26-032-09W1/00	LSM-03	525475	5735850	68.6	24	84	8	418	27500	23	-	STMARTIN	POLYBRECCIA
100/06-26-032-09W1/00	LSM-03	525475	5735850	69.2	24	75	11	404	25500	10	-	STMARTIN	POLYBRECCIA
100/06-26-032-09W1/00	LSM-03	525475	5735850	77.1	9	49	7	373	15350	11	-	STMARTIN	POLYBRECCIA
100/06-26-032-09W1/00	LSM-03	525475	5735850	80.8	16	50	5	383	17000	13	-	STMARTIN	POLYBRECCIA

Ni >= 31 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
	LSM-01	LSM-01	5732500	83.8	35	26	6	146	5500	47	-	STMARTIN	CARBBRECCIA
100/06-04-033-09W1/00	LSM-14	LSM-14	5739275	14.6	3	20	0	135	17300	43	-	STMARTIN	CARBBRECCIA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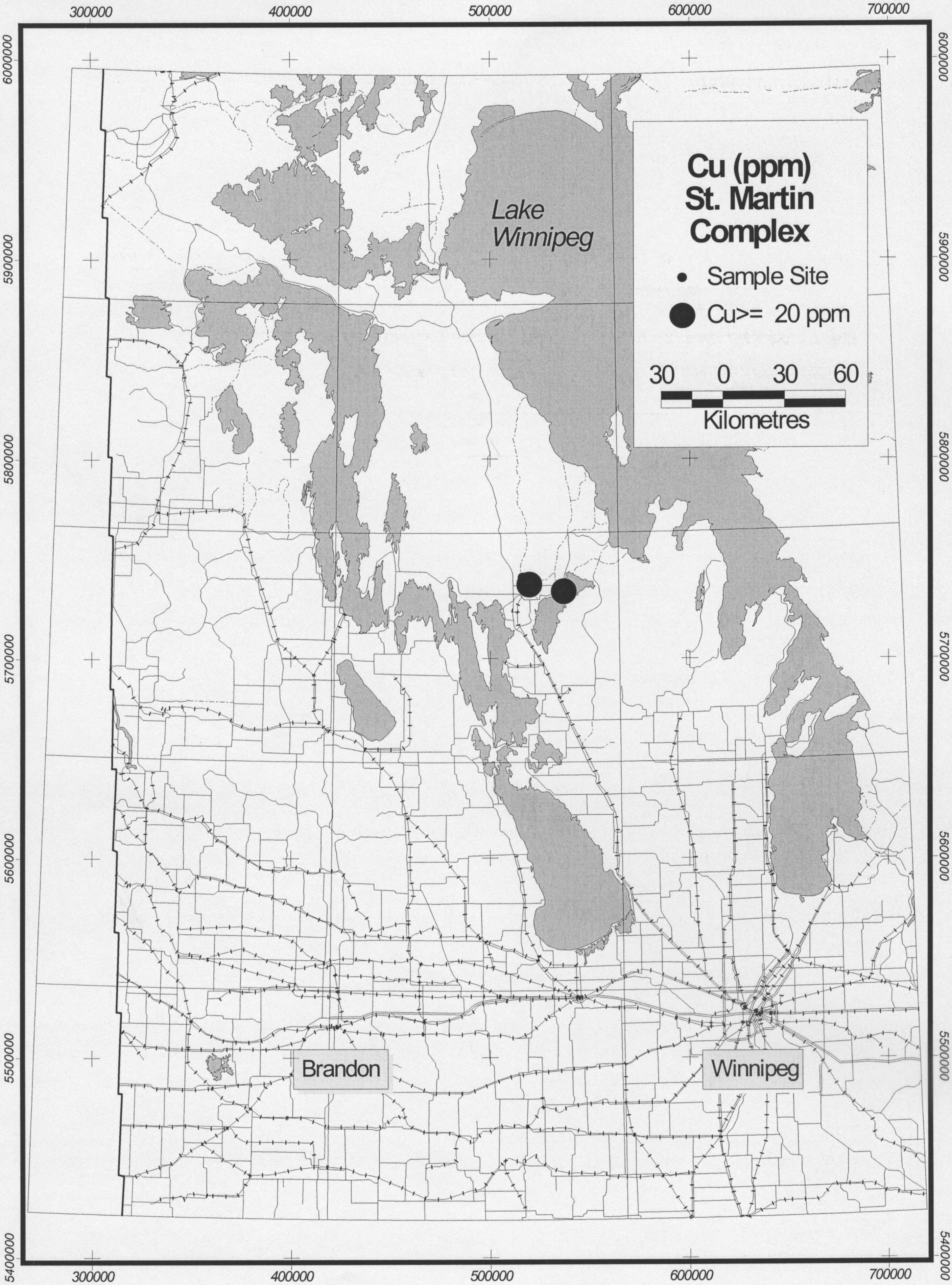
Lake Winnipeg
St. Martin Complex
Sample Site
30 0 30 60
Kilometres
Brandon
Winnipeg



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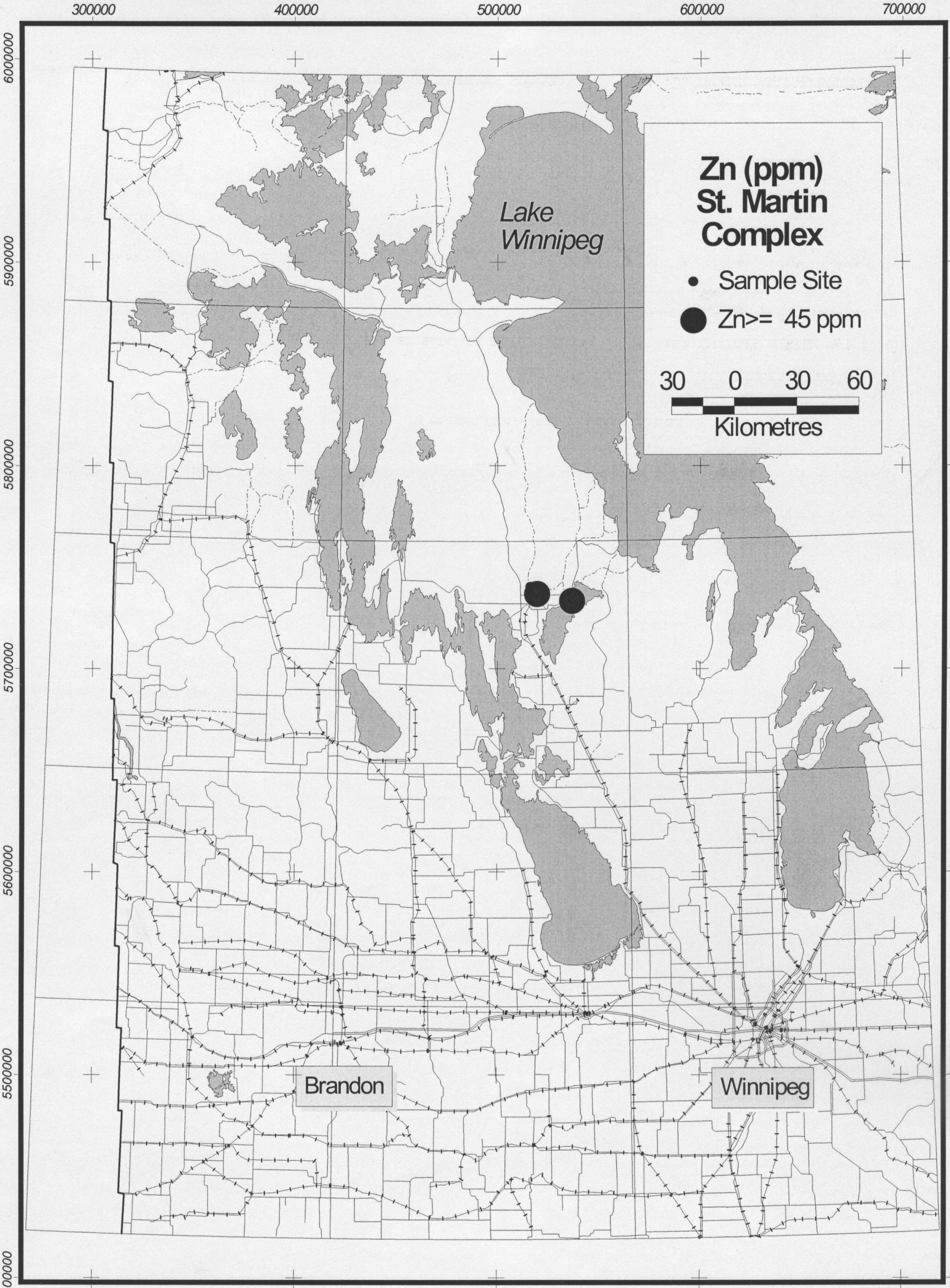
Lake Winnipeg
Cu (ppm)
St. Martin
Complex
Sample Site
Cu>= 20 ppm
30 0 30 60
Kilometres
Brandon
Winnipeg



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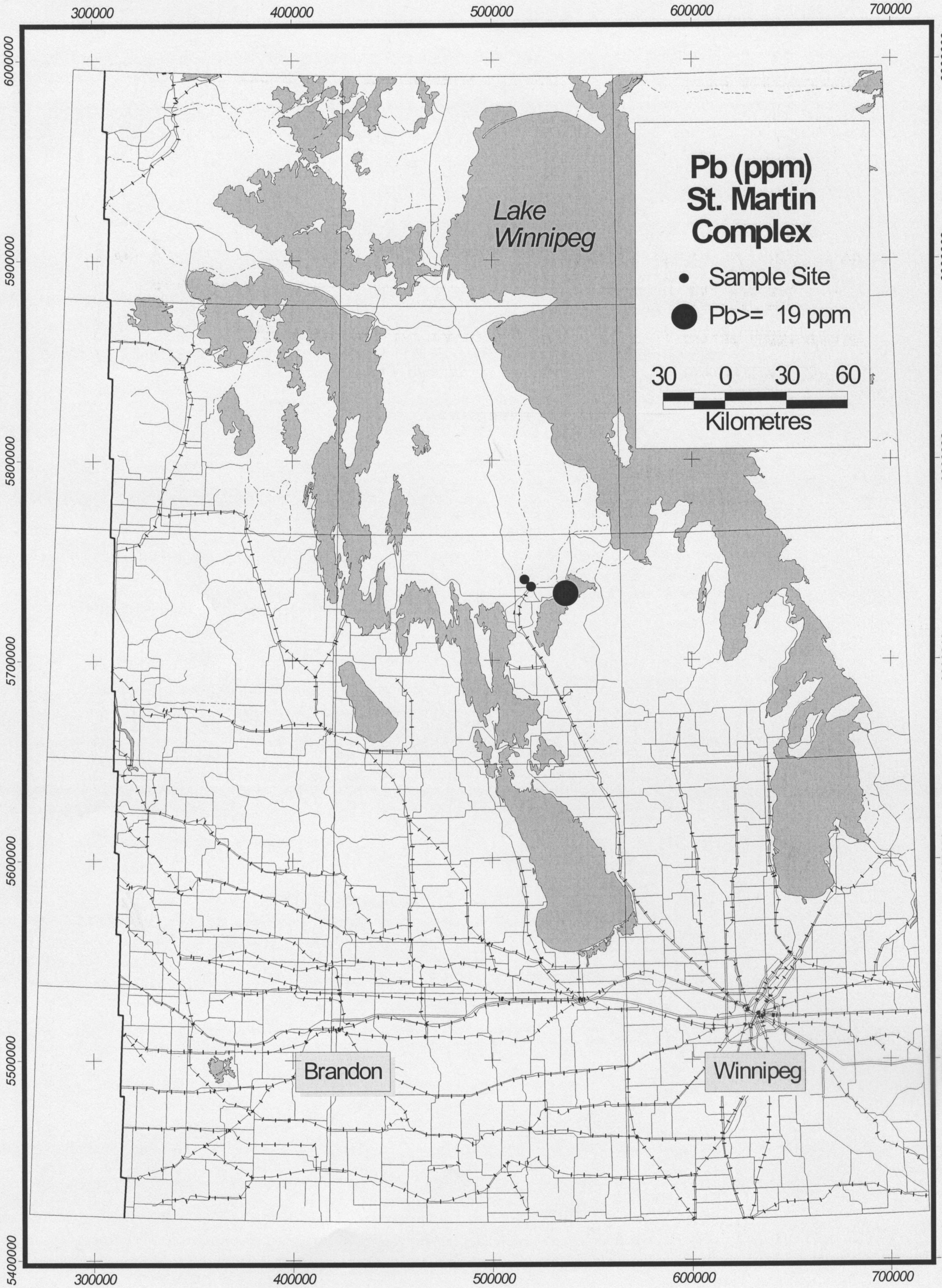
Lake Winnipeg
Zn (ppm)
St. Martin
Complex
Sample Site
Zn>= 45 ppm
30 0 30 60
Kilometres
Brandon
Winnipeg



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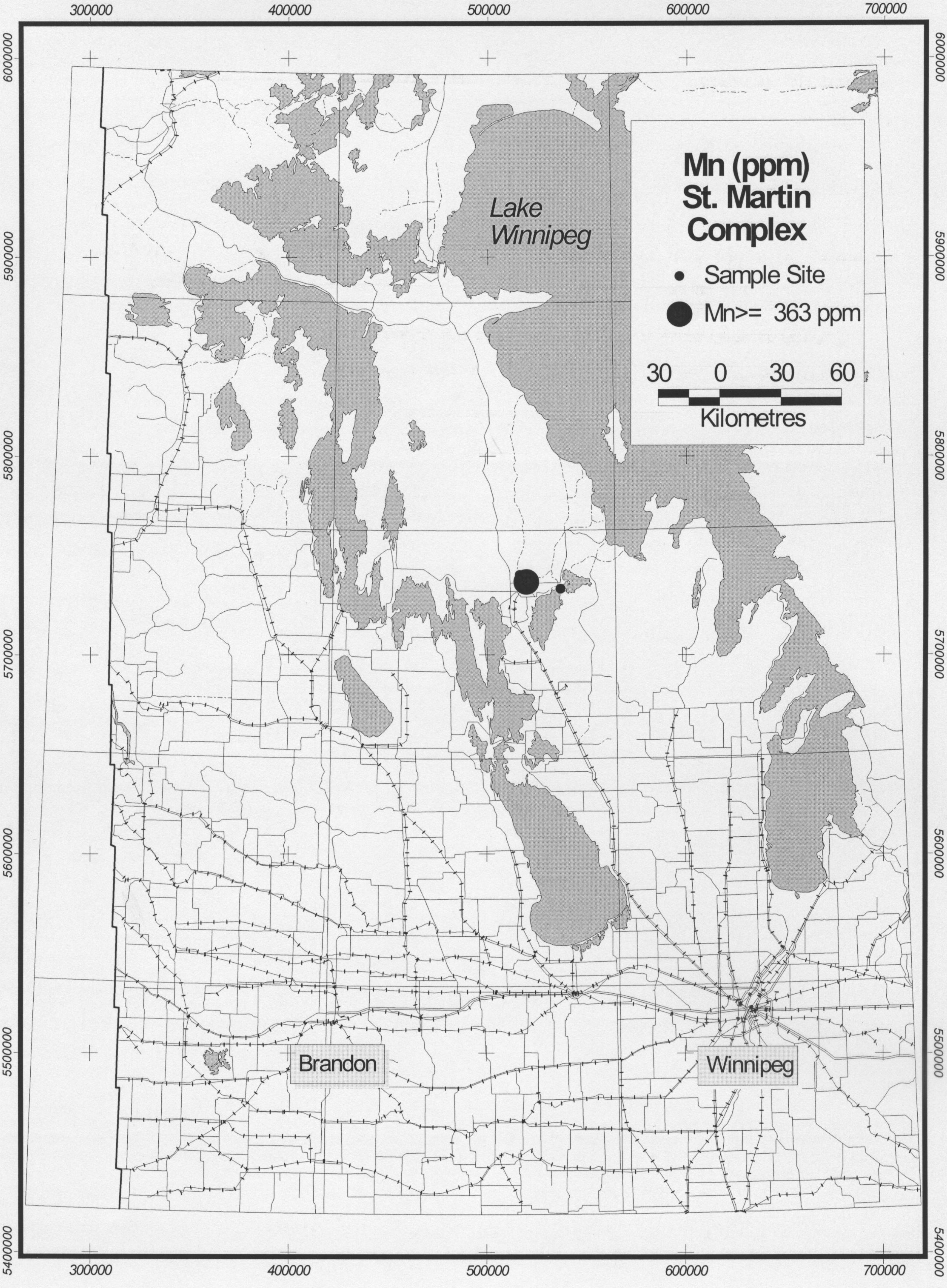
Lake Winnipeg
Pb (ppm) St. Martin Complex
Sample Site
Pb>= 19 ppm
30 0 30 60
Kilometres
Brandon
Winnipeg



Mn (ppm)
St. Martin
Complex
Sample Site
Mn>= 363 ppm
30 0 30 60
Kilometres
Lake Winnipeg
Brandon
Winnipeg
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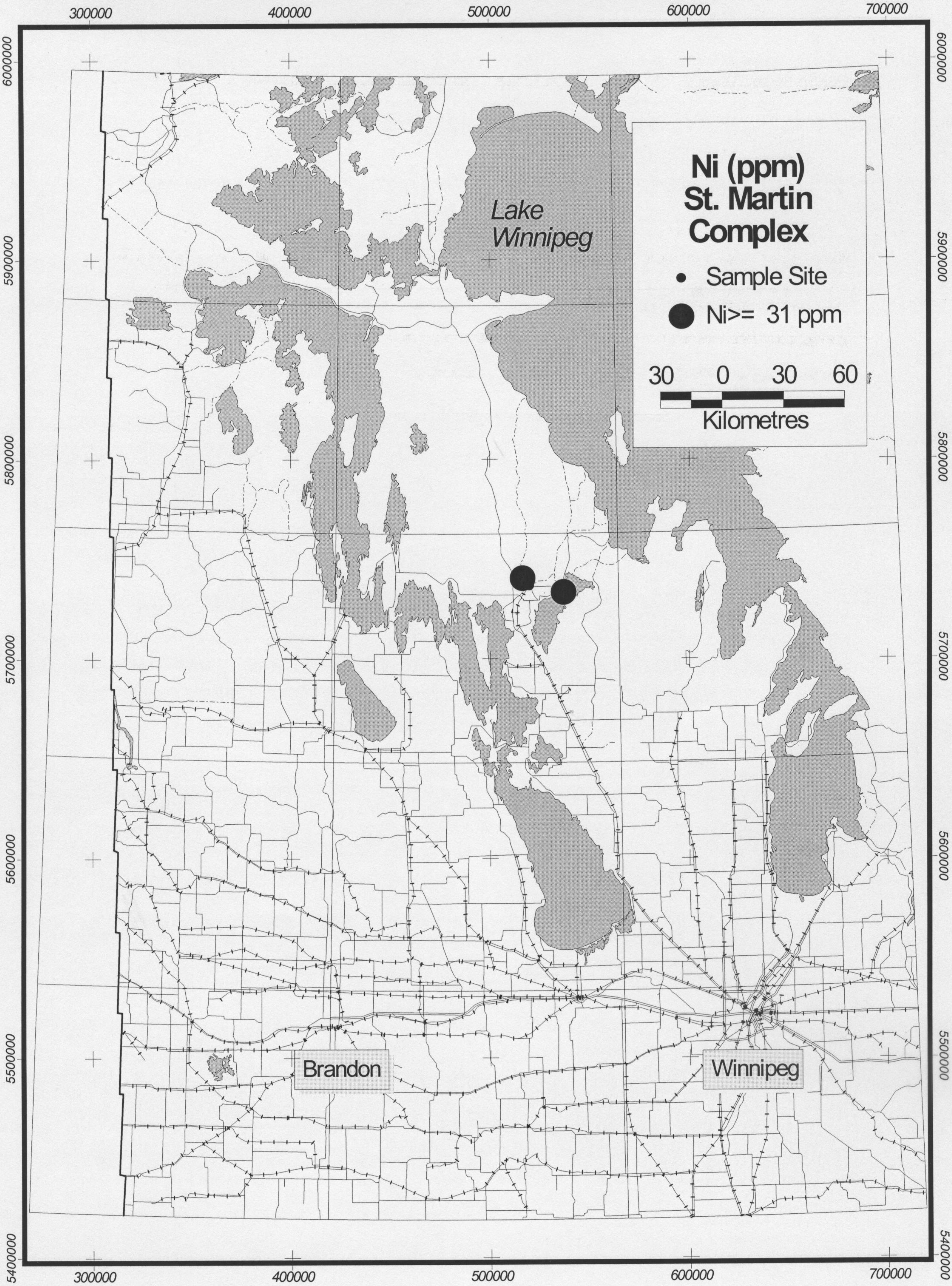

Ni (ppm)
St. Martin
Complex
Sample Site
Ni>= 31 ppm
30 0 30 60
Kilometres
Lake Winnipeg
Brandon
Winnipeg
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Appendix 3: Tables and maps of data at concentrations ≥ 99 percentile. *(continued)*

Souris River Formation

Cu >= 20 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
102/01-05-033-19W1/00	M-06-80	423575	5739040	54.8	20	15	20	172	6350	29	-	SOURISRIVER	REDBED1
102/01-05-033-19W1/00	M-06-80	423575	5739040	57.2	21	12	3	250	4900	28	-	SOURISRIVER	REDBED1
100/13-34-032-20W1/00	M-08-70	415727	5738924	19.2	24	10	2	170	3550	20	-	SOURISRIVER	REDBED1
100/13-34-032-20W1/00	M-08-70	415727	5738924	22.3	20	16	2	181	6400	27	-	SOURISRIVER	REDBED1
100/13-34-032-20W1/00	M-08-70	415727	5738924	29.0	20	14	5	129	3650	23	-	SOURISRIVER	REDBED1
100/04-23-044-25W1/00	M-14-71	365125	5851625	29.5	22	17	0	125	5350	17	-	SOURISRIVER	REDBED1
100/04-23-044-25W1/00	M-14-71	365125	5851625	33.0	25	22	0	166	8600	47	-	SOURISRIVER	REDBED1
100/04-23-044-25W1/00	M-14-71	365125	5851625	33.3	20	25	7	161	4950	41	-	SOURISRIVER	REDBED1

Zn >= 45 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
102/01-05-033-19W1/00	M-06-80	423575	5739040	21.0	7	147	1	201	4200	9	-	SOURISRIVER	SAGEMACE
102/01-05-033-19W1/00	M-06-80	423575	5739040	44.2	4	45	1	120	1400	3	-	SOURISRIVER	SAGEMACE
102/01-05-033-19W1/00	M-06-80	423575	5739040	45.7	4	58	1	196	2650	2	-	SOURISRIVER	SAGEMACE
102/01-05-033-19W1/00	M-06-80	423575	5739040	46.2	4	50	1	202	3300	2	-	SOURISRIVER	SAGEMACE
102/01-05-033-19W1/00	M-06-80	423575	5739040	49.6	10	48	1	250	5500	31	-	SOURISRIVER	REDBED1
100/01-05-033-19W1/00	M-09-71	423475	5739374	28.7	11	96	0	143	1250	2	-	SOURISRIVER	PTWILKINS
100/01-05-033-19W1/00	M-09-71	423475	5739374	43.2	6	84	3	140	2500	3	-	SOURISRIVER	PTWILKINS
100/01-05-033-19W1/00	M-09-71	423475	5739374	44.3	6	79	0	176	3200	4	-	SOURISRIVER	PTWILKINS
100/01-05-033-19W1/00	M-09-71	423475	5739374	45.6	7	53	0	148	3050	4	-	SOURISRIVER	PTWILKINS

Pb >= 19 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
102/01-05-033-19W1/00	M-06-80	423575	5739040	8.6	5	16	20	440	5750	6	-	SOURISRIVER	SAGEMACE
102/01-05-033-19W1/00	M-06-80	423575	5739040	54.8	20	15	20	172	6350	29	-	SOURISRIVER	REDBED1
100/04-23-044-25W1/00	M-14-71	365125	5851625	5.1	9	15	25	92	600	3	-	SOURISRIVER	PTWILKINSM

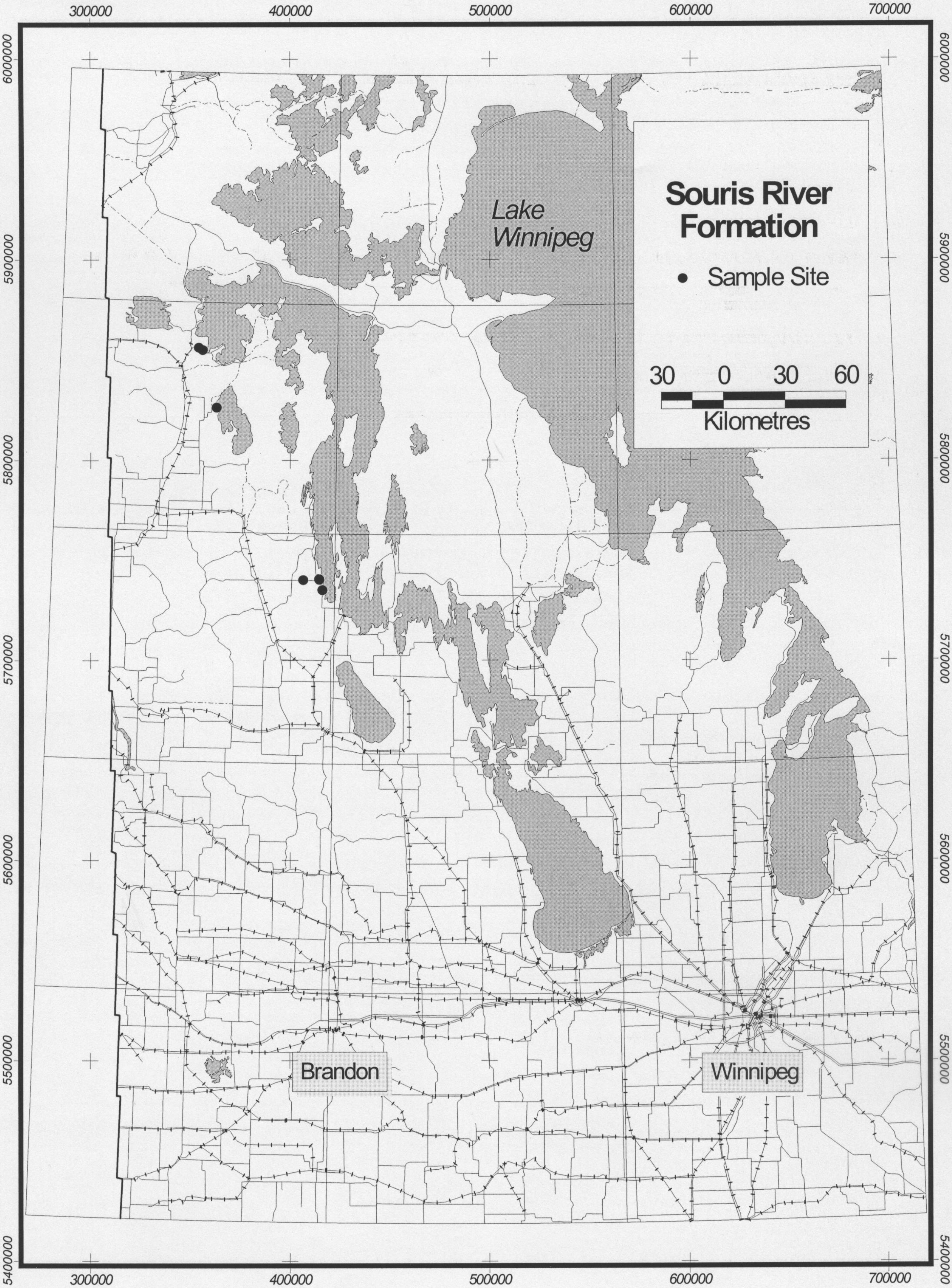
Mn >= 363 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
102/01-05-033-19W1/00	M-06-80	423575	5739040	2.1	7	17	1	440	5600	6	-	SOURISRIVER	SAGEMACE
102/01-05-033-19W1/00	M-06-80	423575	5739040	2.4	6	18	1	540	6850	6	-	SOURISRIVER	SAGEMACE
102/01-05-033-19W1/00	M-06-80	423575	5739040	2.7	7	20	1	590	7500	5	-	SOURISRIVER	SAGEMACE
102/01-05-033-19W1/00	M-06-80	423575	5739040	3.0	9	19	1	500	6150	4	-	SOURISRIVER	SAGEMACE
102/01-05-033-19W1/00	M-06-80	423575	5739040	3.3	9	15	1	470	6450	5	-	SOURISRIVER	SAGEMACE
102/01-05-033-19W1/00	M-06-80	423575	5739040	3.6	12	20	1	450	6450	7	-	SOURISRIVER	SAGEMACE
102/01-05-033-19W1/00	M-06-80	423575	5739040	3.9	11	16	1	530	7600	6	-	SOURISRIVER	SAGEMACE
102/01-05-033-19W1/00	M-06-80	423575	5739040	4.2	9	18	1	510	7450	8	-	SOURISRIVER	SAGEMACE
102/01-05-033-19W1/00	M-06-80	423575	5739040	6.2	5	12	1	460	4950	7	-	SOURISRIVER	SAGEMACE
102/01-05-033-19W1/00	M-06-80	423575	5739040	7.1	5	13	2	470	5550	5	-	SOURISRIVER	SAGEMACE
102/01-05-033-19W1/00	M-06-80	423575	5739040	8.6	5	16	20	440	5750	6	-	SOURISRIVER	SAGEMACE
102/01-05-033-19W1/00	M-06-80	423575	5739040	9.1	6	18	1	420	4950	7	-	SOURISRIVER	SAGEMACE
102/01-05-033-19W1/00	M-06-80	423575	5739040	9.7	7	16	1	680	7900	6	-	SOURISRIVER	SAGEMACE
102/01-05-033-19W1/00	M-06-80	423575	5739040	10.3	6	14	1	600	6950	7	-	SOURISRIVER	SAGEMACE
102/01-05-033-19W1/00	M-06-80	423575	5739040	11.5	8	15	1	430	4650	14	-	SOURISRIVER	SAGEMACE
102/01-05-033-19W1/00	M-06-80	423575	5739040	12.1	8	15	1	450	4450	9	-	SOURISRIVER	SAGEMACE
102/01-05-033-19W1/00	M-06-80	423575	5739040	12.7	7	14	1	460	4600	9	-	SOURISRIVER	SAGEMACE
102/01-05-033-19W1/00	M-06-80	423575	5739040	18.0	4	11	1	370	6500	3	-	SOURISRIVER	SAGEMACE
102/01-05-033-19W1/00	M-06-80	423575	5739040	19.0	5	12	1	450	6400	2	-	SOURISRIVER	SAGEMACE
102/01-05-033-19W1/00	M-06-80	423575	5739040	34.4	5	8	1	410	5550	3	-	SOURISRIVER	SAGEMACE
102/01-05-033-19W1/00	M-06-80	423575	5739040	58.1	5	11	1	447	7400	2	-	SOURISRIVER	REDBED1
102/01-05-033-19W1/00	M-06-80	423575	5739040	59.6	5	15	1	382	6650	4	-	SOURISRIVER	REDBED1
100/02-21-041-24W1/00	M-07-78	373780	5822525	54.6	7	17	0	375	6050	0	-	SOURISRIVER	SOURISRIVER
100/02-21-041-24W1/00	M-07-78	373780	5822525	65.2	7	7	0	385	1500	0	-	SOURISRIVER	SOURISRIVER
100/01-05-033-19W1/00	M-09-71	423475	5739374	0.7	8	37	0	494	10150	13	-	SOURISRIVER	SOURISRIVER
100/01-05-033-19W1/00	M-09-71	423475	5739374	1.6	8	33	0	366	7600	11	-	SOURISRIVER	SOURISRIVER
100/01-05-033-19W1/00	M-09-71	423475	5739374	16.4	6	24	0	415	8400	5	-	SOURISRIVER	SOURISRIVER
102/08-14-044-25W1/00	M-17-81	367000	5850475	4.6	12	21	0	790	11650	32	-	SOURISRIVER	REDBED1
102/08-14-044-25W1/00	M-17-81	367000	5850475	5.1	11	22	0	429	8900	38	-	SOURISRIVER	REDBED1
102/08-14-044-25W1/00	M-17-81	367000	5850475	5.5	10	24	0	670	12000	36	-	SOURISRIVER	REDBED1
102/08-14-044-25W1/00	M-17-81	367000	5850475	6.2	8	19	0	760	10400	29	-	SOURISRIVER	REDBED1

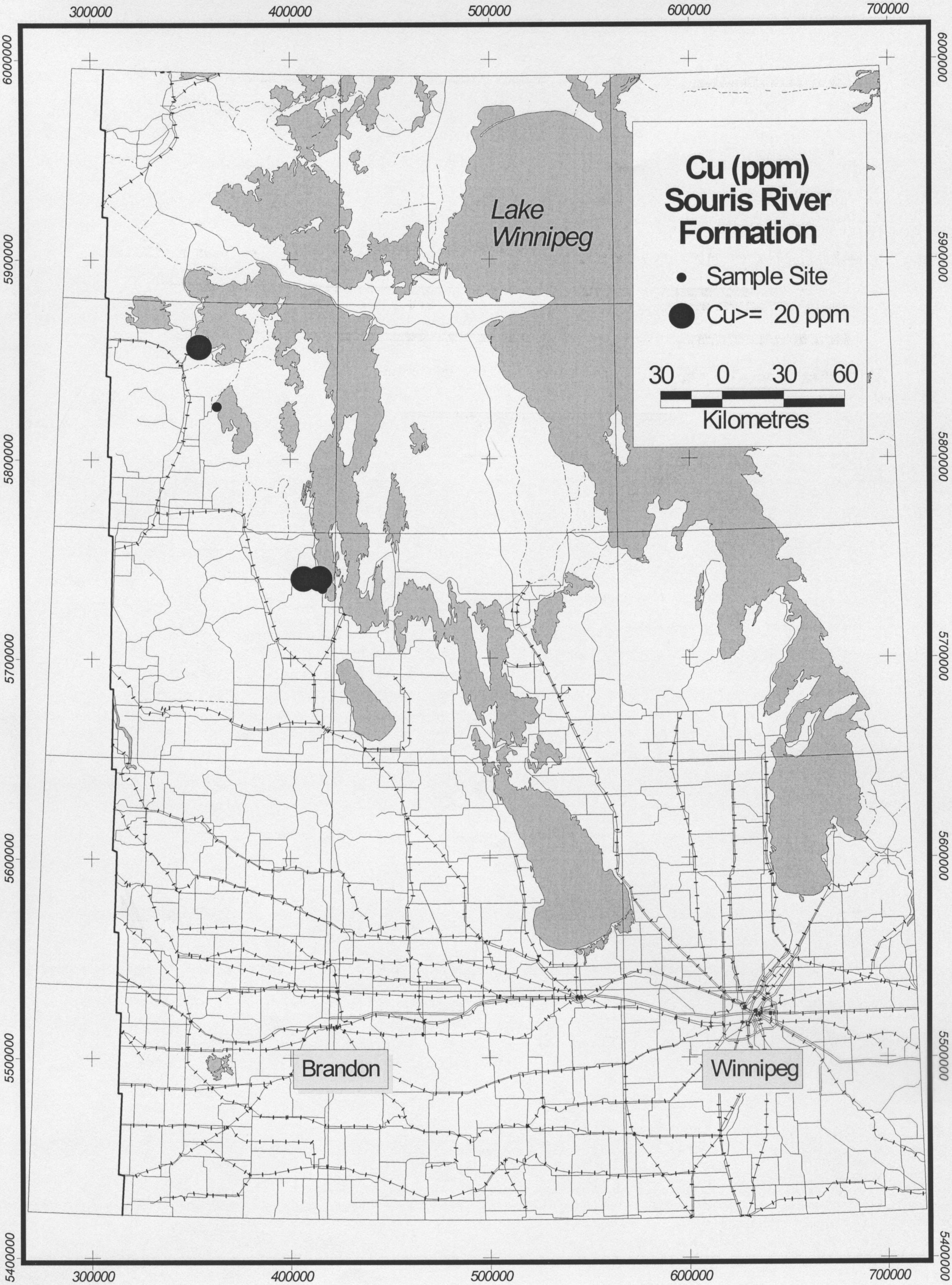
Souris River Formation *(continued)*

Ni >= 31 ppm (99th percentile)

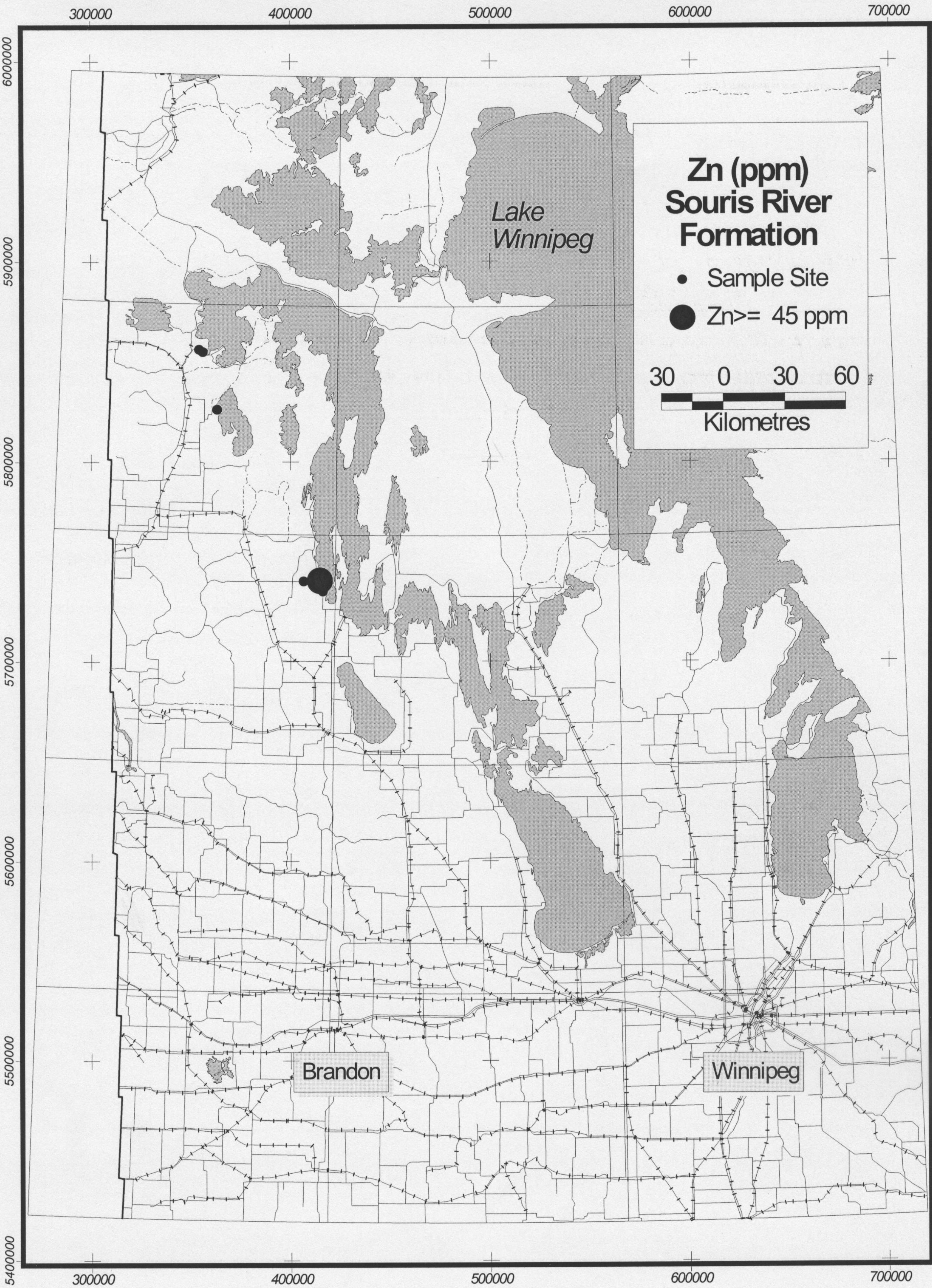
Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
102/01-05-033-19W1/00	M-06-80	423575	5739040	24.1	17	13	1	169	4650	40	-	SOURISRIVER	SAGEMACE
102/01-05-033-19W1/00	M-06-80	423575	5739040	24.8	14	14	1	184	5700	44	-	SOURISRIVER	SAGEMACE
102/01-05-033-19W1/00	M-06-80	423575	5739040	49.6	10	48	1	250	5500	31	-	SOURISRIVER	REDBED1
102/01-05-033-19W1/00	M-06-80	423575	5739040	49.9	14	40	1	248	6500	39	-	SOURISRIVER	REDBED1
102/01-05-033-19W1/00	M-06-80	423575	5739040	52.0	13	14	1	184	2600	35	-	SOURISRIVER	REDBED1
102/01-05-033-19W1/00	M-06-80	423575	5739040	52.4	11	14	1	222	4650	49	-	SOURISRIVER	REDBED1
102/01-05-033-19W1/00	M-06-80	423575	5739040	53.1	15	12	10	167	4550	34	-	SOURISRIVER	REDBED1
102/01-05-033-19W1/00	M-06-80	423575	5739040	58.4	14	12	1	293	5550	38	-	SOURISRIVER	REDBED1
100/13-34-032-20W1/00	M-08-70	415727	5738924	29.4	18	12	6	115	3150	58	-	SOURISRIVER	REDBED1
100/04-23-044-25W1/00	M-14-71	365125	5851625	31.3	6	26	0	195	13900	34	-	SOURISRIVER	REDBED1
100/04-23-044-25W1/00	M-14-71	365125	5851625	33.0	25	22	0	166	8600	47	-	SOURISRIVER	REDBED1
100/04-23-044-25W1/00	M-14-71	365125	5851625	33.3	20	25	7	161	4950	41	-	SOURISRIVER	REDBED1
100/04-23-044-25W1/00	M-14-71	365125	5851625	36.6	8	23	0	145	12900	34	-	SOURISRIVER	REDBED1
100/04-23-044-25W1/00	M-14-71	365125	5851625	36.9	8	22	0	185	11950	32	-	SOURISRIVER	REDBED1
102/08-14-044-25W1/00	M-17-81	367000	5850475	4.6	12	21	0	790	11650	32	-	SOURISRIVER	REDBED1
102/08-14-044-25W1/00	M-17-81	367000	5850475	5.1	11	22	0	429	8900	38	-	SOURISRIVER	REDBED1
102/08-14-044-25W1/00	M-17-81	367000	5850475	5.5	10	24	0	670	12000	36	-	SOURISRIVER	REDBED1



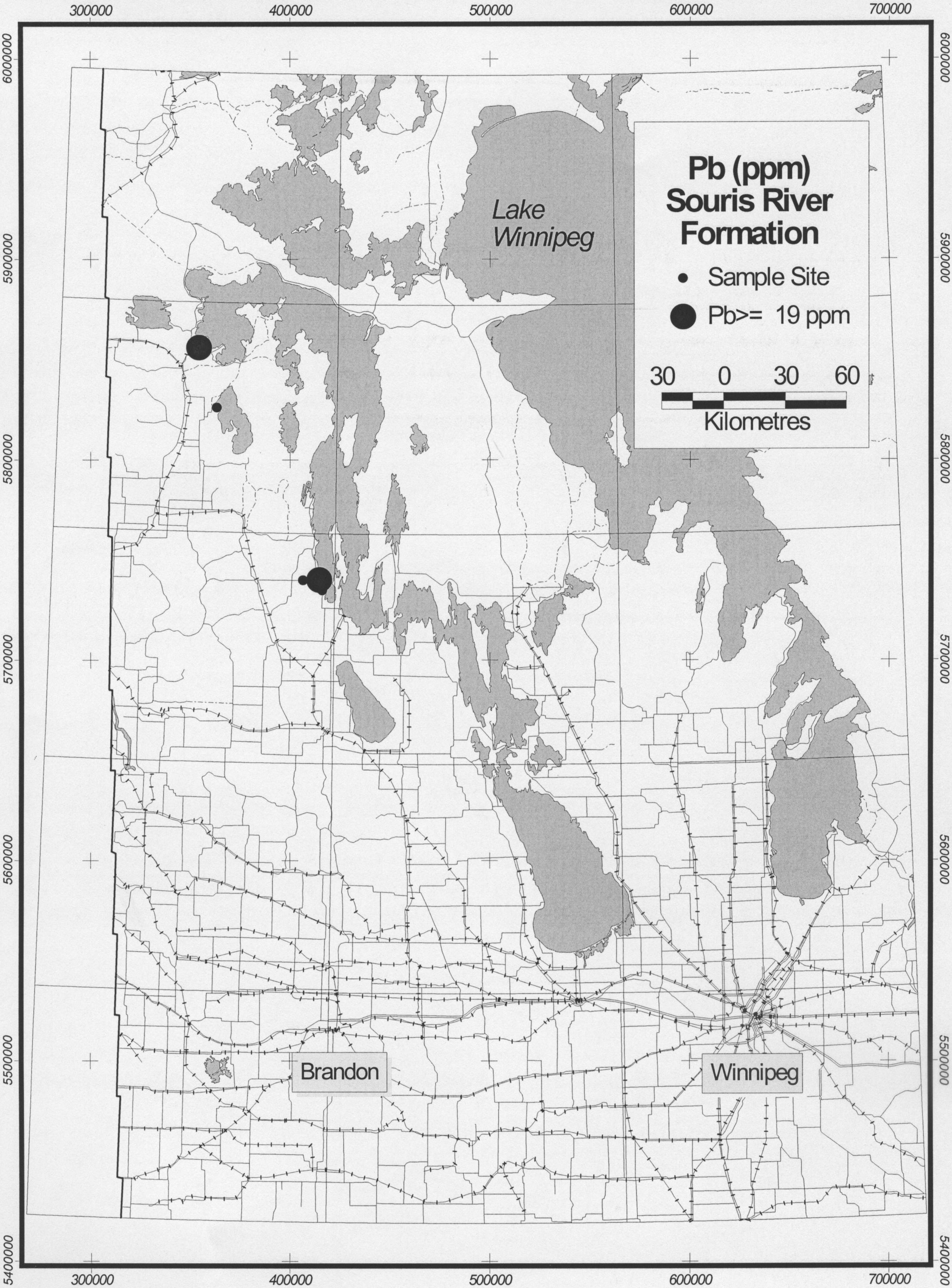
Souris River Formation
Sample Site
30 0 30 60
Kilometres
Lake Winnipeg
Brandon
Winnipeg
300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000



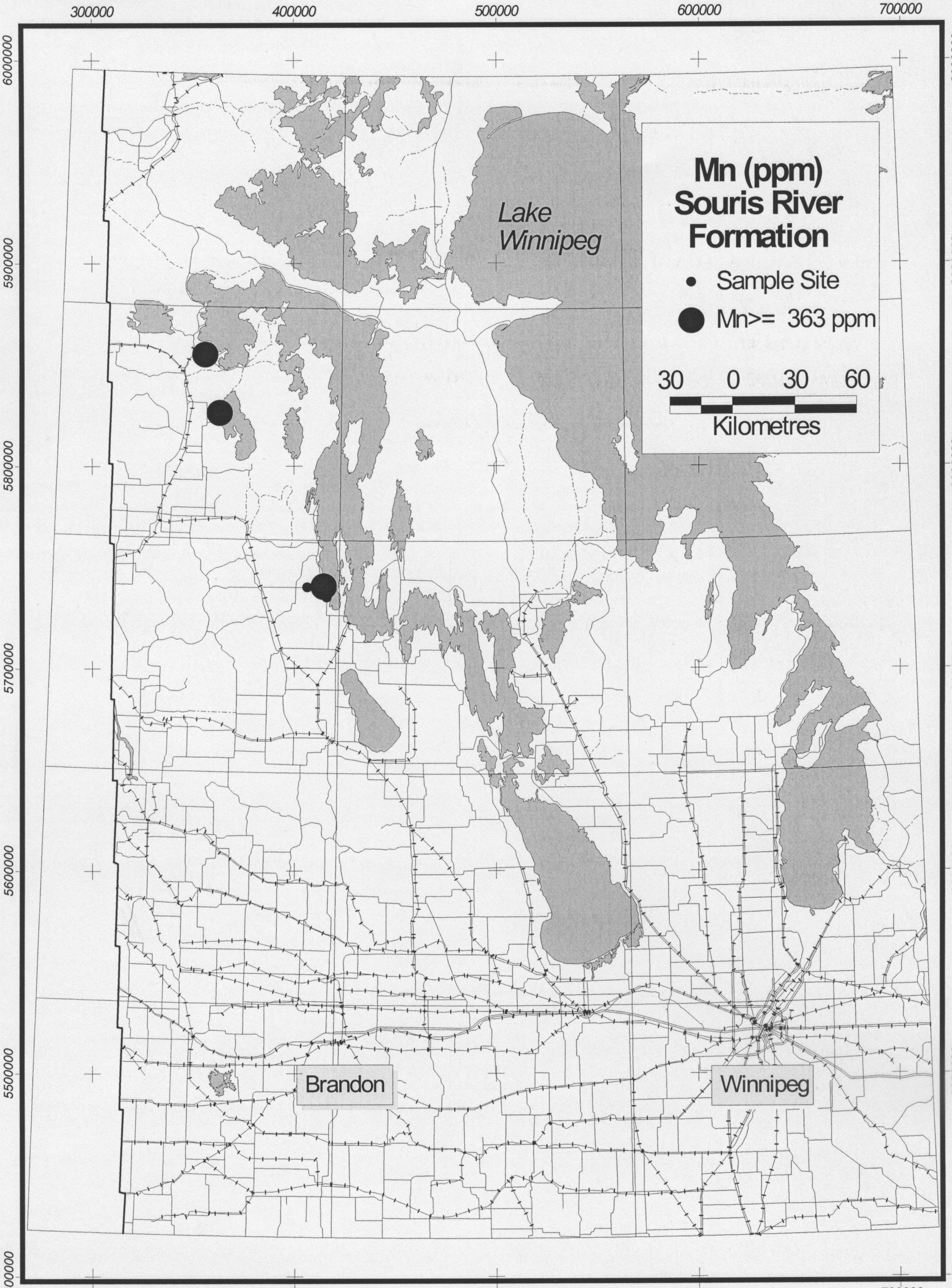
Cu (ppm)
Souris River
Formation
Sample Site
Cu>= 20 ppm
30 0 30 60
Kilometres
Lake Winnipeg
Brandon
Winnipeg
300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000



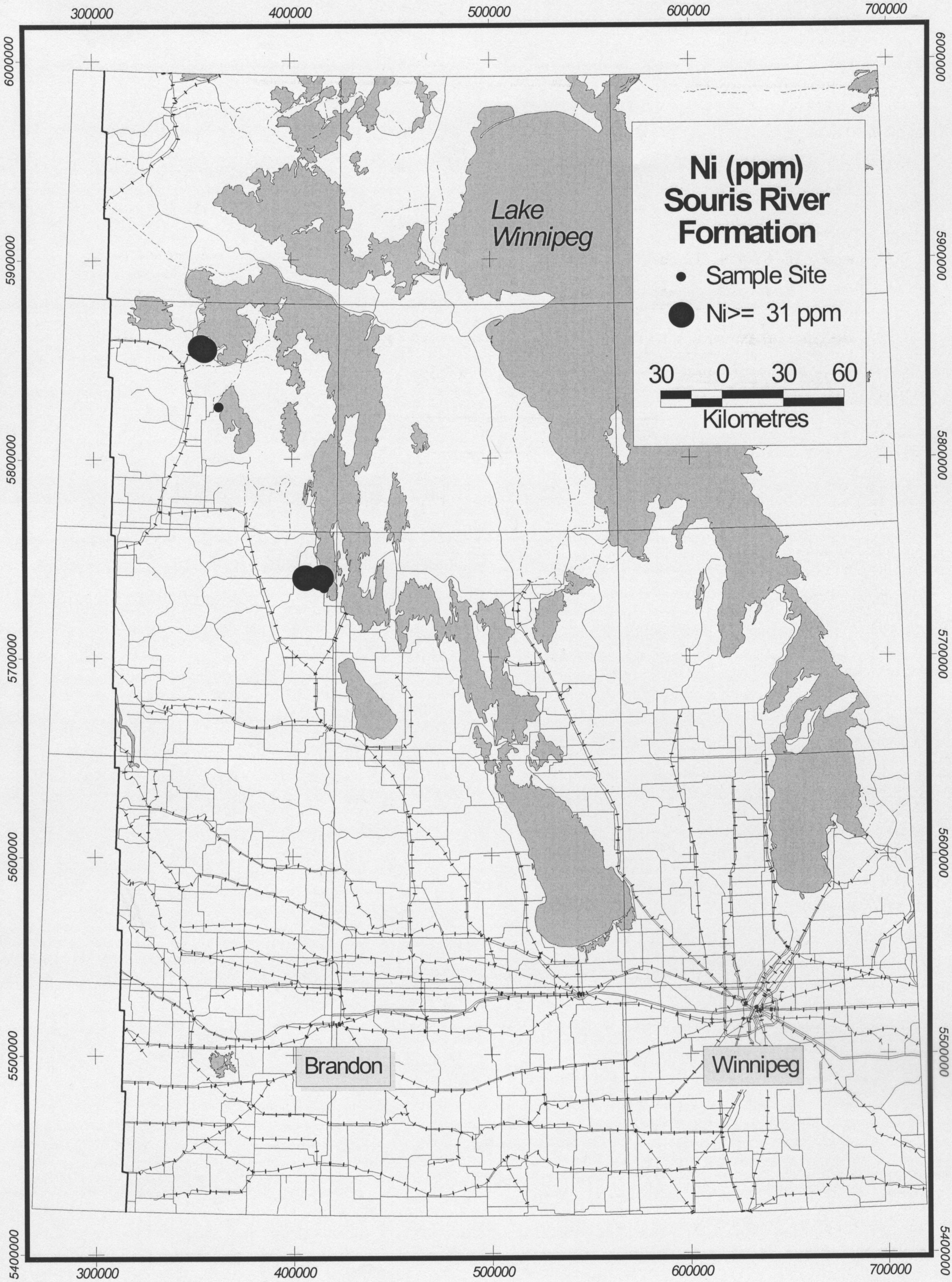
Zn (ppm)
Souris River
Formation
Sample Site
Zn>= 45 ppm
30 0 30 60
Kilometres
Lake Winnipeg
Brandon
Winnipeg
300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000



300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000
Pb (ppm)
Souris River
Formation
Sample Site
Pb>= 19 ppm
30 0 30 60
Kilometres
Lake
Winnipeg
Brandon
Winnipeg



300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000
Lake
Winnipeg
Mn (ppm)
Souris River
Formation
Sample Site
Mn>= 363 ppm
30 0 30 60
Kilometres
Brandon
Winnipeg



Ni (ppm)
Souris River
Formation
Sample Site
Ni>= 31 ppm
30 0 30 60
Kilometres
Lake Winnipeg
Brandon
Winnipeg
300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000

Dawson Bay Formation

Cu >= 20 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/09-33-043-21W1/00	M-02-73	402800	5845100	6.7	24	30	5	330	7500	0	-	DAWSONB	REDBED2
100/09-33-043-21W1/00	M-02-73	402800	5845100	7.2	36	22	22	305	8100	0	-	DAWSONB	REDBED2
100/09-33-043-21W1/00	M-02-73	402800	5845100	8.2	29	30	0	310	7550	0	-	DAWSONB	REDBED2
100/09-33-043-21W1/00	M-02-73	402800	5845100	14.9	22	30	5	240	9150	0	-	DAWSONB	REDBED2
100/07-13-024-10W1/00	M-02-76	518660	5657900	4.9	29	35	3	274	3050	13	-	DAWSONB	DAWSONBL
100/07-13-024-10W1/00	M-02-76	518660	5657900	6.8	23	39	3	296	6950	8	-	DAWSONB	DAWSONBL
100/09-16-046-22W1/00	M-03-73	393539	5869704	7.6	22	23	18	270	3650	0	-	DAWSONB	REDBED2
100/09-16-046-22W1/00	M-03-73	393539	5869704	9.1	22	27	8	230	6900	0	-	DAWSONB	REDBED2
102/09-33-043-24W1/00	M-03-85	373325	5846100	6.9	22	87	15	384	6100	10	-	DAWSONB	REDBED2
102/09-33-043-24W1/00	M-03-85	373325	5846100	13.2	23	34	3	286	10150	30	-	DAWSONB	REDBED2
100/03-17-028-16W1/00	M-04-71	452500	5692400	7.3	38	22	0	178	2700	5	-	DAWSONB	DAWSONBL
100/03-17-028-16W1/00	M-04-71	452500	5692400	9.2	157	59	41	220	1400	36	-	DAWSONB	DAWSONBL
100/09-16-030-17W1/00	M-06-70	445339	5713975	28.0	79	36	0	176	1650	12	-	DAWSONB	DAWSONBL
100/09-16-030-17W1/00	M-06-70	445339	5713975	33.5	36	26	0	198	2900	14	-	DAWSONB	DAWSONBL
100/05-07-048-25W1/00	M-06-78	358950	5888075	7.2	36	141	0	377	15550	26	-	DAWSONB	REDBED2
102/01-05-033-19W1/00	M-06-80	423575	5739040	73.2	23	15	1	293	6900	47	-	DAWSONB	DAWSONBM
102/01-05-033-19W1/00	M-06-80	423575	5739040	92.3	26	17	1	317	6600	30	-	DAWSONB	DAWSONBL
102/01-05-033-19W1/00	M-06-80	423575	5739040	97.9	20	29	1	236	1450	11	-	DAWSONB	REDBED2
102/01-05-033-19W1/00	M-06-80	423575	5739040	98.2	25	42	1	245	1400	15	-	DAWSONB	REDBED2
102/01-05-033-19W1/00	M-06-80	423575	5739040	98.5	34	24	1	255	2100	20	-	DAWSONB	REDBED2
102/01-05-033-19W1/00	M-06-80	423575	5739040	101.3	20	19	1	275	4650	10	-	DAWSONB	REDBED2
102/01-05-033-19W1/00	M-06-80	423575	5739040	102.2	23	15	1	243	6500	13	-	DAWSONB	REDBED2
102/01-05-033-19W1/00	M-06-80	423575	5739040	105.2	20	21	1	253	3850	11	-	DAWSONB	REDBED2
102/01-05-033-19W1/00	M-06-80	423575	5739040	106.8	23	36	1	295	6350	11	-	DAWSONB	REDBED2
102/01-05-033-19W1/00	M-06-80	423575	5739040	107.1	20	28	1	219	5850	9	-	DAWSONB	REDBED2
102/01-05-033-19W1/00	M-06-80	423575	5739040	108.9	20	25	1	250	8450	43	-	DAWSONB	REDBED2
100/06-25-022-11W1/00	M-08-71	508450	5641385	20.3	24	25	0	200	8500	0	-	DAWSONB	REDBED2
100/06-25-022-11W1/00	M-08-71	508450	5641385	23.0	25	23	0	225	9350	0	-	DAWSONB	REDBED2
100/08-17-045-25W1/00	M-10-72	362250	5860300	9.3	21	36	2	285	9750	30	-	DAWSONB	REDBED2
102/15-09-031-18W1/00	M-16-81	434285	5722600	85.9	23	19	4	198	3900	16	-	DAWSONB	DAWSONBL
102/15-09-031-18W1/00	M-16-81	434285	5722600	94.2	31	54	0	214	8700	17	-	DAWSONB	REDBED2
102/08-14-044-25W1/00	M-17-81	367000	5850475	14.0	34	11	0	302	4800	10	-	DAWSONB	DAWSONBU
102/08-14-044-25W1/00	M-17-81	367000	5850475	17.6	35	17	0	310	9050	17	-	DAWSONB	DAWSONBM
102/08-14-044-25W1/00	M-17-81	367000	5850475	41.1	29	27	8	336	7750	71	-	DAWSONB	REDBED2
100/03-01-044-25W1/00	S-05-75	367600	5846630	6.3	20	193	11	710	57000	57	-	DAWSONB	DAWSONBL
100/03-01-044-25W1/00	S-05-75	367600	5846630	9.2	26	36	9	396	10000	33	-	DAWSONB	REDBED2
100/03-01-044-25W1/00	S-05-75	367600	5846630	11.0	20	36	0	300	7900	19	-	DAWSONB	REDBED2

Zn >= 45 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/09-33-043-21W1/00	M-02-73	402800	5845100	14.0	17	47	0	240	14250	0	-	DAWSONB	REDBED2
100/07-13-024-10W1/00	M-02-76	518660	5657900	5.6	11	48	3	246	2900	6	-	DAWSONB	DAWSONBL
100/07-13-024-10W1/00	M-02-76	518660	5657900	6.2	9	47	2	216	3150	4	-	DAWSONB	DAWSONBL
100/09-16-046-22W1/00	M-03-73	393539	5869704	14.9	15	94	4	175	7800	0	-	DAWSONB	REDBED2
100/09-16-046-22W1/00	M-03-73	393539	5869704	16.2	12	147	0	100	6100	0	-	DAWSONB	REDBED2
102/09-33-043-24W1/00	M-03-85	373325	5846100	6.3	6	51	10	381	5000	9	-	DAWSONB	REDBED2
102/09-33-043-24W1/00	M-03-85	373325	5846100	6.9	22	87	15	384	6100	10	-	DAWSONB	REDBED2
100/03-17-028-16W1/00	M-04-71	452500	5692400	9.2	157	59	41	220	1400	36	-	DAWSONB	DAWSONBL
100/09-16-030-17W1/00	M-06-70	445339	5713975	15.5	7	45	3	201	8100	24	-	DAWSONB	DAWSONBM
100/09-16-030-17W1/00	M-06-70	445339	5713975	16.5	6	47	0	200	7700	23	-	DAWSONB	DAWSONBM
100/09-16-030-17W1/00	M-06-70	445339	5713975	17.1	6	45	0	207	8150	28	-	DAWSONB	DAWSONBM
100/09-16-030-17W1/00	M-06-70	445339	5713975	40.2	5	48	0	230	14200	32	-	DAWSONB	REDBED2
100/09-16-030-17W1/00	M-06-70	445339	5713975	41.7	9	50	0	221	14950	33	-	DAWSONB	REDBED2
100/09-16-030-17W1/00	M-06-70	445339	5713975	42.4	11	52	2	219	12550	35	-	DAWSONB	REDBED2
100/09-16-030-17W1/00	M-06-70	445339	5713975	43.0	12	46	0	210	10050	28	-	DAWSONB	REDBED2
100/09-16-030-17W1/00	M-06-70	445339	5713975	43.6	10	47	0	197	10000	32	-	DAWSONB	REDBED2
100/05-07-048-25W1/00	M-06-78	358950	5888075	7.2	36	141	0	377	15550	26	-	DAWSONB	REDBED2
100/05-07-048-25W1/00	M-06-78	358950	5888075	13.7	18	259	0	211	6600	13	-	DAWSONB	REDBED2
102/01-05-033-19W1/00	M-06-80	423575	5739040	109.3	10	45	1	268	6400	22	-	DAWSONB	REDBED2
102/01-05-033-19W1/00	M-06-80	423575	5739040	110.4	6	50	1	59	1600	7	-	DAWSONB	REDBED2
102/01-05-033-19W1/00	M-06-80	423575	5739040	110.5	13	50	1	71	5600	17	360	DAWSONB	REDBED2
100/16-31-033-19W1/00	M-09-79	420799	5748650	11.4	13	55	7	295	6250	0	-	DAWSONB	REDBED2
100/16-31-033-19W1/00	M-09-79	420799	5748650	11.7	16	56	5	270	7650	0	-	DAWSONB	REDBED2
100/16-31-033-19W1/00	M-09-79	420799	5748650	12.6	12	67	0	310	12250	0	-	DAWSONB	REDBED2
100/16-31-033-19W1/00	M-09-79	420799	5748650	16.8	13	53	0	280	8800	0	-	DAWSONB	REDBED2
100/16-31-033-19W1/00	M-09-79	420799	5748650	17.7	10	55	0	260	10600	0	-	DAWSONB	REDBED2
100/08-17-045-25W1/00	M-10-72	362250	5860300	16.3	12	55	0	248	12550	40	-	DAWSONB	REDBED2

Zn >= 45 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
102/15-09-031-18W1/00	M-16-81	434285	5722600	70.1	4	173	3	191	6350	20	-	DAWSONB	DAWSONBM
102/15-09-031-18W1/00	M-16-81	434285	5722600	90.6	8	140	22	251	3550	13	-	DAWSONB	DAWSONBL
102/15-09-031-18W1/00	M-16-81	434285	5722600	91.2	8	62	3	248	3450	12	-	DAWSONB	DAWSONBL
102/15-09-031-18W1/00	M-16-81	434285	5722600	91.9	7	51	5	193	2650	10	-	DAWSONB	DAWSONBL
102/15-09-031-18W1/00	M-16-81	434285	5722600	92.5	7	116	20	210	3650	11	-	DAWSONB	DAWSONBL
102/15-09-031-18W1/00	M-16-81	434285	5722600	94.2	31	54	0	214	8700	17	-	DAWSONB	REDBED2
102/15-09-031-18W1/00	M-16-81	434285	5722600	95.1	7	57	0	212	6800	13	-	DAWSONB	REDBED2
102/15-09-031-18W1/00	M-16-81	434285	5722600	101.5	9	48	0	94	4950	34	398	DAWSONB	REDBED2
102/08-14-044-25W1/00	M-17-81	367000	5850475	47.7	7	47	0	248	20900	40	-	DAWSONB	REDBED2
102/08-14-044-25W1/00	M-17-81	367000	5850475	48.3	7	46	0	215	15150	39	-	DAWSONB	REDBED2
100/03-01-044-25W1/00	S-05-75	367600	5846630	6.3	20	193	11	710	57000	57	-	DAWSONB	DAWSONBL
100/03-01-044-25W1/00	S-05-75	367600	5846630	7.9	12	56	4	388	7850	45	-	DAWSONB	DAWSONBL

Pb >= 19 ppm (99th percentile)

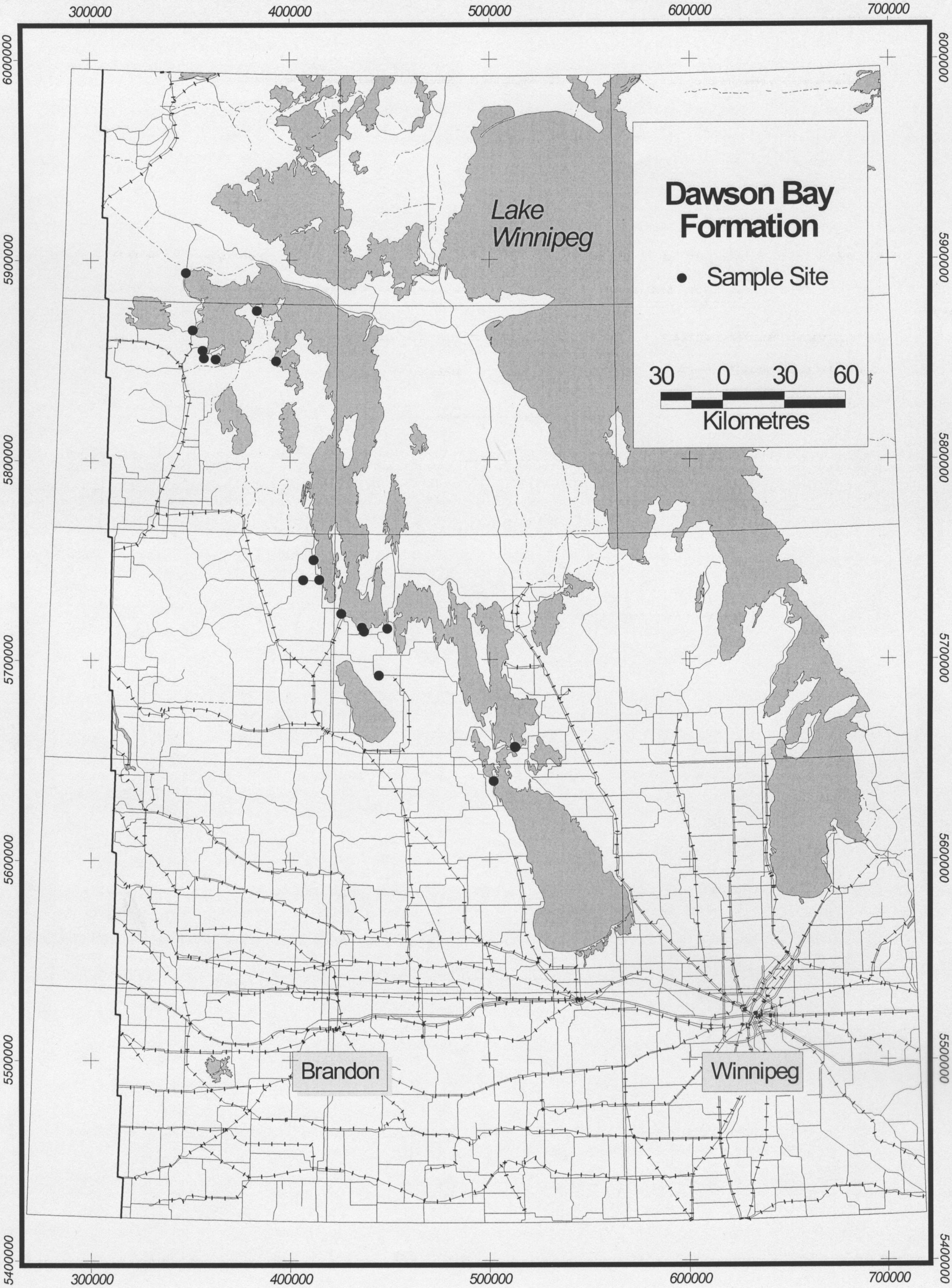
Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/09-33-043-21W1/00	M-02-73	402800	5845100	7.2	36	22	22	305	8100	0	-	DAWSONB	REDBED2
100/09-33-043-21W1/00	M-02-73	402800	5845100	9.8	13	27	64	265	9400	0	-	DAWSONB	REDBED2
100/03-17-028-16W1/00	M-04-71	452500	5692400	9.2	157	59	41	220	1400	36	-	DAWSONB	DAWSONBL
102/01-05-033-19W1/00	M-06-80	423575	5739040	69.3	5	11	19	227	2550	4	-	DAWSONB	DAWSONBU
100/06-25-022-11W1/00	M-08-71	508450	5641385	19.4	7	44	46	195	8900	0	-	DAWSONB	REDBED2
100/16-31-033-19W1/00	M-09-79	420799	5748650	8.3	10	15	22	275	4600	0	-	DAWSONB	DAWSONBL
102/15-09-031-18W1/00	M-16-81	434285	5722600	90.6	8	140	22	251	3550	13	-	DAWSONB	DAWSONBL
102/15-09-031-18W1/00	M-16-81	434285	5722600	92.5	7	116	20	210	3650	11	-	DAWSONB	DAWSONBL

Mn >= 363 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/09-33-043-21W1/00	M-02-73	402800	5845100	2.7	9	8	0	420	4950	0	-	DAWSONB	DAWSONBL
100/09-33-043-21W1/00	M-02-73	402800	5845100	3.0	6	10	0	485	4850	0	-	DAWSONB	DAWSONBL
100/09-33-043-21W1/00	M-02-73	402800	5845100	3.7	4	7	0	410	3050	0	-	DAWSONB	DAWSONBL
100/09-33-043-21W1/00	M-02-73	402800	5845100	4.0	4	8	0	460	3450	0	-	DAWSONB	DAWSONBL
100/09-33-043-21W1/00	M-02-73	402800	5845100	6.1	8	21	0	415	5100	0	-	DAWSONB	DAWSONBL
102/09-33-043-24W1/00	M-03-85	373325	5846100	6.3	6	51	10	381	5000	9	-	DAWSONB	REDBED2
102/09-33-043-24W1/00	M-03-85	373325	5846100	6.9	22	87	15	384	6100	10	-	DAWSONB	REDBED2
102/09-33-043-24W1/00	M-03-85	373325	5846100	7.6	10	37	0	381	7450	21	-	DAWSONB	REDBED2
100/05-07-048-25W1/00	M-06-78	358950	5888075	6.6	16	30	6	422	11300	15	-	DAWSONB	REDBED2
100/05-07-048-25W1/00	M-06-78	358950	5888075	7.2	36	141	0	377	15550	26	-	DAWSONB	REDBED2
102/01-05-033-19W1/00	M-06-80	423575	5739040	89.1	7	10	1	418	5850	4	-	DAWSONB	DAWSONBL
102/01-05-033-19W1/00	M-06-80	423575	5739040	89.4	8	10	1	373	6050	4	-	DAWSONB	DAWSONBL
102/01-05-033-19W1/00	M-06-80	423575	5739040	92.6	9	19	1	380	5900	7	-	DAWSONB	REDBED2
102/01-05-033-19W1/00	M-06-80	423575	5739040	92.9	9	14	1	434	8950	7	-	DAWSONB	REDBED2
100/06-25-022-11W1/00	M-08-71	508450	5641385	14.4	7	25	0	390	4150	0	-	DAWSONB	DAWSONBL
100/08-13-024-10W1/00	M-09-69	519050	5657675	9.8	15	33	5	374	5800	10	-	DAWSONB	DAWSONBL
100/08-13-024-10W1/00	M-09-69	519050	5657675	10.8	10	34	8	406	6850	10	-	DAWSONB	DAWSONBL
100/16-31-033-19W1/00	M-09-79	420799	5748650	9.0	11	31	8	390	7000	0	-	DAWSONB	DAWSONBL
100/16-31-033-19W1/00	M-09-79	420799	5748650	10.0	12	35	5	375	5500	0	-	DAWSONB	DAWSONBL
100/08-17-045-25W1/00	M-10-72	362250	5860300	8.2	10	22	7	365	5400	10	-	DAWSONB	DAWSONBL
102/08-14-044-25W1/00	M-17-81	367000	5850475	11.4	8	7	0	750	5400	5	-	DAWSONB	DAWSONBU
102/08-14-044-25W1/00	M-17-81	367000	5850475	13.7	14	12	0	425	6350	10	-	DAWSONB	DAWSONBU
102/08-14-044-25W1/00	M-17-81	367000	5850475	40.5	15	41	16	427	6100	8	-	DAWSONB	REDBED2
102/08-14-044-25W1/00	M-17-81	367000	5850475	41.7	19	24	5	419	9150	28	-	DAWSONB	REDBED2
102/08-14-044-25W1/00	M-17-81	367000	5850475	42.2	11	26	0	397	10600	22	-	DAWSONB	REDBED2
100/03-01-044-25W1/00	S-05-75	367600	5846630	6.3	20	193	11	710	57000	57	-	DAWSONB	DAWSONBL
100/03-01-044-25W1/00	S-05-75	367600	5846630	7.0	7	26	0	411	4750	9	-	DAWSONB	DAWSONBL
100/03-01-044-25W1/00	S-05-75	367600	5846630	7.3	7	21	0	374	3350	11	-	DAWSONB	DAWSONBL
100/03-01-044-25W1/00	S-05-75	367600	5846630	7.9	12	56	4	388	7850	45	-	DAWSONB	DAWSONBL
100/03-01-044-25W1/00	S-05-75	367600	5846630	9.2	26	36	9	396	10000	33	-	DAWSONB	REDBED2
100/03-01-044-25W1/00	S-05-75	367600	5846630	9.8	15	31	3	700	9750	12	-	DAWSONB	REDBED2
100/03-01-044-25W1/00	S-05-75	367600	5846630	10.4	15	32	4	410	9900	14	-	DAWSONB	REDBED2

Ni >= 31 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
102/09-33-043-24W1/00	M-03-85	373325	5846100	11.6	8	34	0	272	9900	39	-	DAWSONB	REDBED2
102/09-33-043-24W1/00	M-03-85	373325	5846100	12.1	6	35	0	273	10150	66	-	DAWSONB	REDBED2
102/09-33-043-24W1/00	M-03-85	373325	5846100	12.7	8	37	0	278	10350	31	-	DAWSONB	REDBED2
102/09-33-043-24W1/00	M-03-85	373325	5846100	15.6	18	36	0	234	8000	37	-	DAWSONB	REDBED2
100/03-17-028-16W1/00	M-04-71	452500	5692400	9.2	157	59	41	220	1400	36	-	DAWSONB	DAWSONBL
100/09-16-030-17W1/00	M-06-70	445339	5713975	40.2	5	48	0	230	14200	32	-	DAWSONB	REDBED2
100/09-16-030-17W1/00	M-06-70	445339	5713975	41.7	9	50	0	221	14950	33	-	DAWSONB	REDBED2
100/09-16-030-17W1/00	M-06-70	445339	5713975	42.4	11	52	2	219	12550	35	-	DAWSONB	REDBED2
100/09-16-030-17W1/00	M-06-70	445339	5713975	43.6	10	47	0	197	10000	32	-	DAWSONB	REDBED2
100/05-07-048-25W1/00	M-06-78	358950	5888075	6.8	12	37	0	333	14600	46	-	DAWSONB	REDBED2
102/01-05-033-19W1/00	M-06-80	423575	5739040	73.2	23	15	1	293	6900	47	-	DAWSONB	DAWSONBM
102/01-05-033-19W1/00	M-06-80	423575	5739040	95.7	19	15	3	238	4300	33	-	DAWSONB	REDBED2
102/01-05-033-19W1/00	M-06-80	423575	5739040	96.7	8	17	1	207	6100	33	-	DAWSONB	REDBED2
102/01-05-033-19W1/00	M-06-80	423575	5739040	97.3	8	16	1	235	4950	55	-	DAWSONB	REDBED2
102/01-05-033-19W1/00	M-06-80	423575	5739040	103.1	12	21	1	308	8950	42	-	DAWSONB	REDBED2
102/01-05-033-19W1/00	M-06-80	423575	5739040	107.4	11	20	1	265	12950	41	-	DAWSONB	REDBED2
102/01-05-033-19W1/00	M-06-80	423575	5739040	108.9	20	25	1	250	8450	43	-	DAWSONB	REDBED2
100/13-34-032-20W1/00	M-08-70	415727	5738924	47.2	7	12	3	224	6500	33	-	DAWSONB	DAWSONBM
100/08-17-045-25W1/00	M-10-72	362250	5860300	16.3	12	55	0	248	12550	40	-	DAWSONB	REDBED2
102/15-09-031-18W1/00	M-16-81	434285	5722600	64.9	8	12	4	199	5650	32	-	DAWSONB	DAWSONBM
102/15-09-031-18W1/00	M-16-81	434285	5722600	99.9	12	30	11	195	11000	32	-	DAWSONB	REDBED2
102/15-09-031-18W1/00	M-16-81	434285	5722600	101.5	9	48	0	94	4950	34	398	DAWSONB	REDBED2
102/08-14-044-25W1/00	M-17-81	367000	5850475	16.2	14	38	0	264	10700	33	-	DAWSONB	DAWSONBM
102/08-14-044-25W1/00	M-17-81	367000	5850475	21.4	16	36	0	237	8800	32	-	DAWSONB	DAWSONBM
102/08-14-044-25W1/00	M-17-81	367000	5850475	22.6	16	40	0	233	9950	32	-	DAWSONB	DAWSONBM
102/08-14-044-25W1/00	M-17-81	367000	5850475	24.5	12	42	0	239	9350	40	-	DAWSONB	DAWSONBM
102/08-14-044-25W1/00	M-17-81	367000	5850475	41.1	29	27	8	336	7750	71	-	DAWSONB	REDBED2
102/08-14-044-25W1/00	M-17-81	367000	5850475	47.7	7	47	0	248	20900	40	-	DAWSONB	REDBED2
102/08-14-044-25W1/00	M-17-81	367000	5850475	48.3	7	46	0	215	15150	39	-	DAWSONB	REDBED2
102/08-14-044-25W1/00	M-17-81	367000	5850475	48.9	11	42	0	177	10750	37	-	DAWSONB	REDBED2
102/08-14-044-25W1/00	M-17-81	367000	5850475	49.5	15	39	0	152	10200	36	-	DAWSONB	REDBED2
100/03-01-044-25W1/00	S-05-75	367600	5846630	6.3	20	193	11	710	57000	57	-	DAWSONB	DAWSONBL
100/03-01-044-25W1/00	S-05-75	367600	5846630	7.9	12	56	4	388	7850	45	-	DAWSONB	DAWSONBL
100/03-01-044-25W1/00	S-05-75	367600	5846630	9.2	26	36	9	396	10000	33	-	DAWSONB	REDBED2



Dawson Bay
Formation
Sample Site
30 0 30 60
Kilometres
Lake
Winnipeg
Brandon
Winnipeg
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400000
500000
600000
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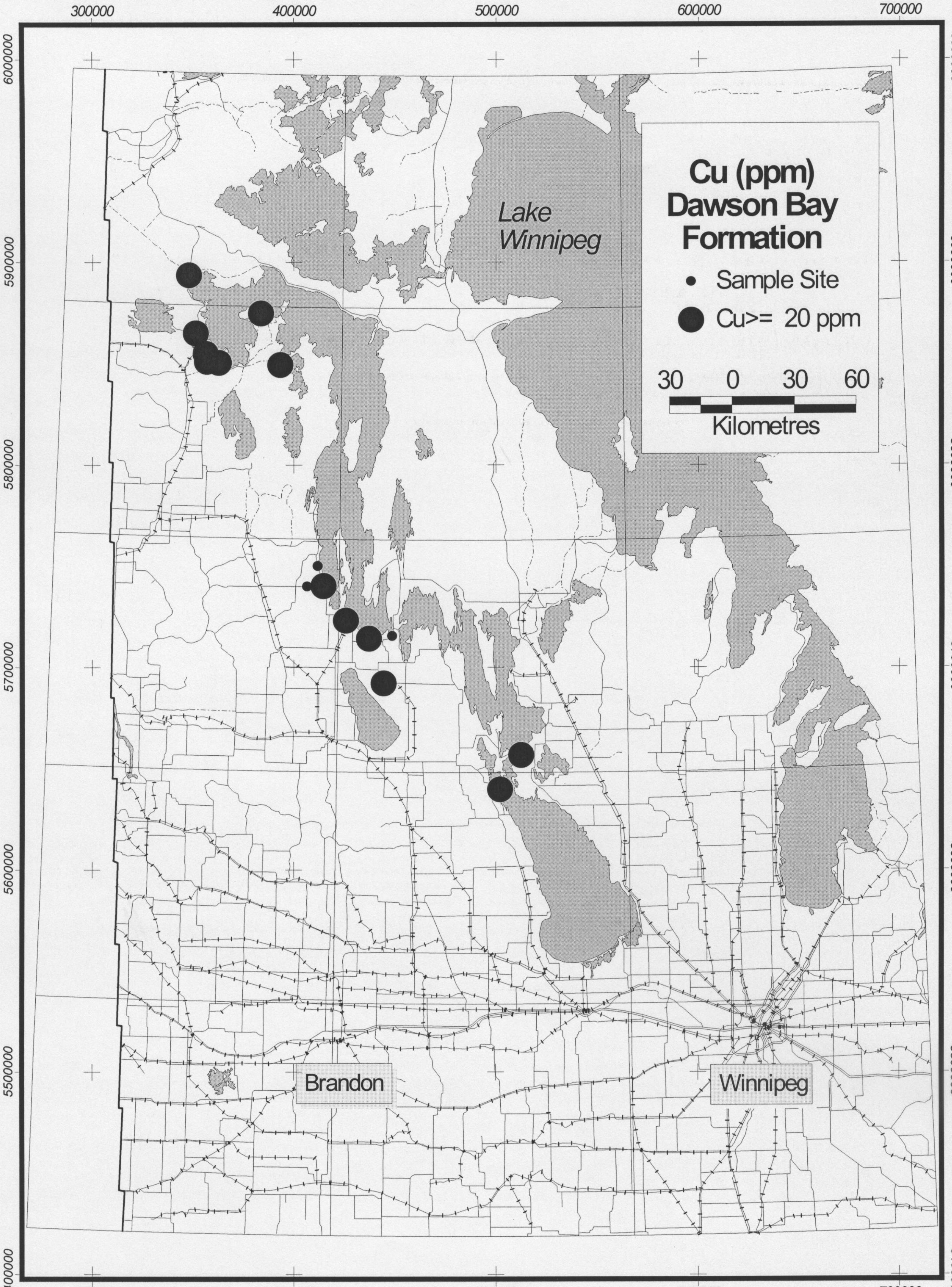
5700000
5600000
5500000
5400000



Cu (ppm)
Dawson Bay
Formation
Sample Site
Cu>= 20 ppm
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Kilometres
Lake Winnipeg
Brandon
Winnipeg
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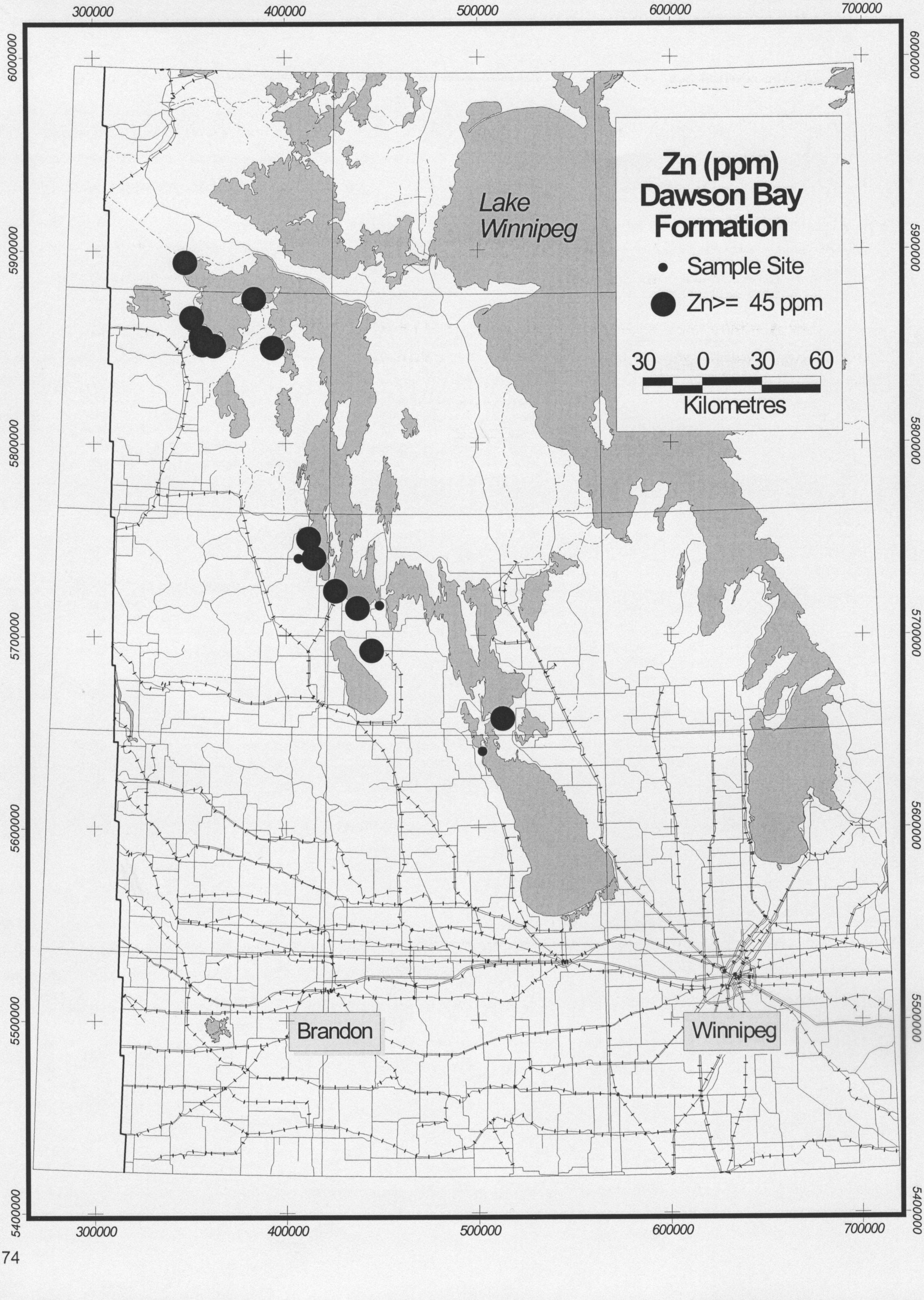
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000


Zn (ppm)
Dawson Bay
Formation
Sample Site
Zn>= 45 ppm
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Kilometres
Lake
Winnipeg
Brandon
Winnipeg
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400000
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700000
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5900000
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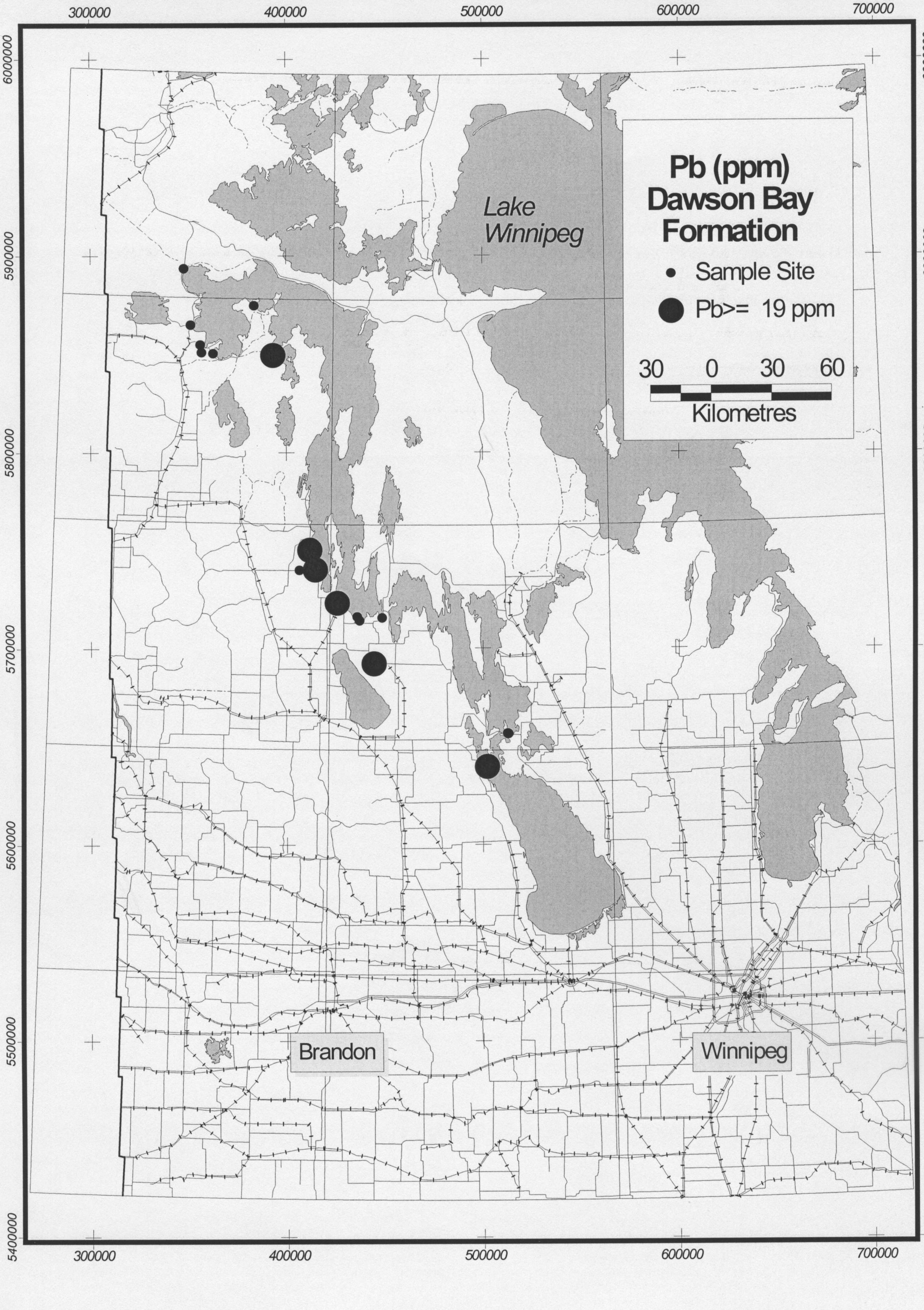
5600000
5500000
5400000


Pb (ppm)
Dawson Bay
Formation
Sample Site
Pb>= 19 ppm
30 0 30 60
Kilometres
Lake
Winnipeg
Brandon
Winnipeg
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5900000
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5600000
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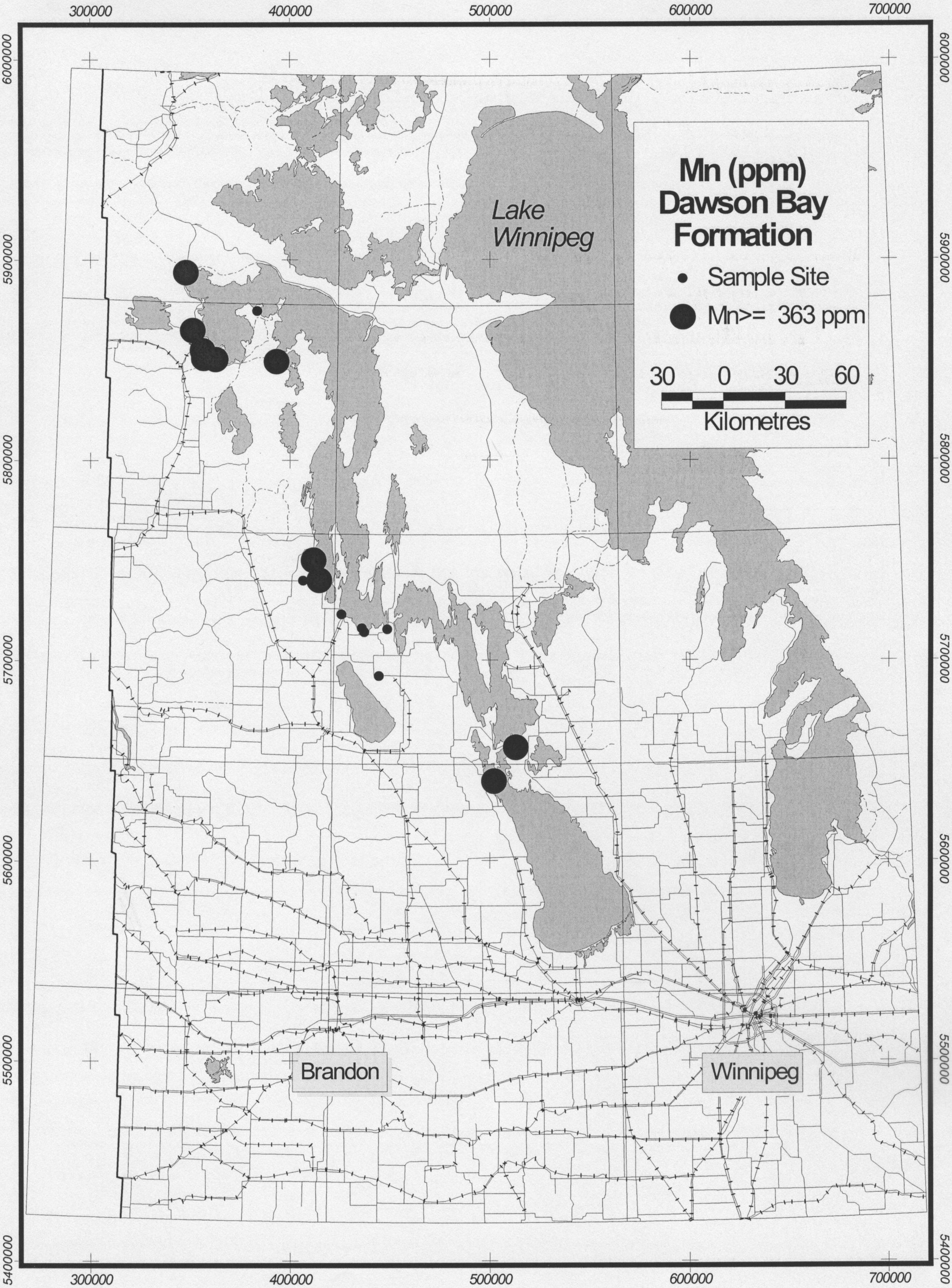
5400000


Mn (ppm)
Dawson Bay
Formation
Sample Site
Mn>= 363 ppm
30 0 30 60
Kilometres
Lake Winnipeg
Brandon
Winnipeg
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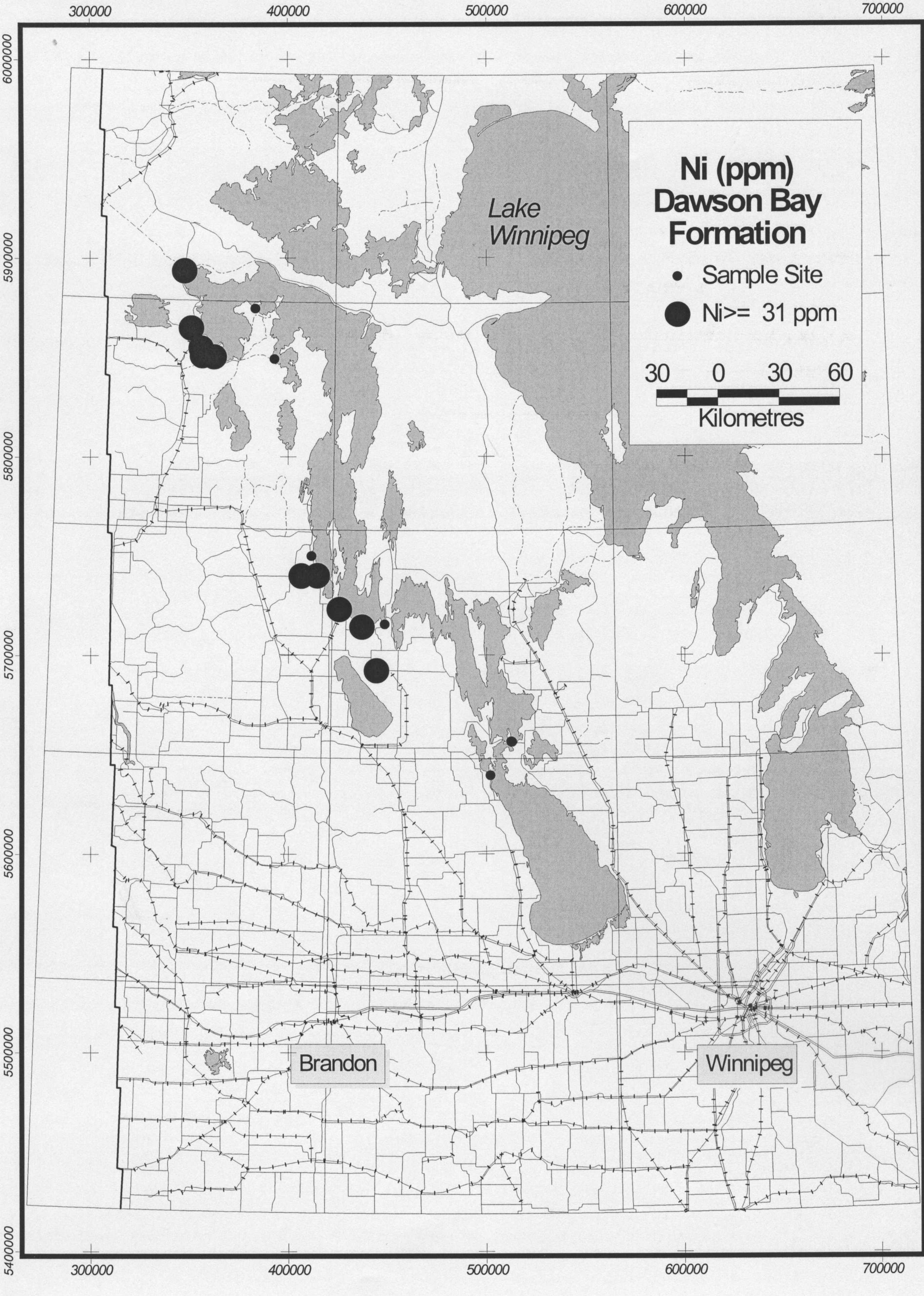
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000


300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000
Ni (ppm)
Dawson Bay
Formation
Sample Site
Ni>= 31 ppm
30 0 30 60
Kilometres
Lake
Winnipeg
Brandon
Winnipeg

Appendix 3: Tables and maps of data at concentrations ≥ 99 percentile. *(continued)*

Winnipegosis Formation

Cu >= 20 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/01-24-044-19W1/00	HM-01-76	427450	5850250	8.7	50	41	3	304	10900	51	686	WPGOSIS	WPGOSIS
100/09-16-046-22W1/00	M-03-73	393539	5869704	23.8	20	7	3	105	2600	0	480	WPGOSIS	WPGOSISU
100/09-16-046-22W1/00	M-03-73	393539	5869704	24.4	24	7	4	105	6500	0	360	WPGOSIS	WPGOSISU
100/09-16-046-22W1/00	M-03-73	393539	5869704	25.0	30	7	5	105	2350	0	348	WPGOSIS	WPGOSISU
100/09-16-046-22W1/00	M-03-73	393539	5869704	25.6	24	7	5	115	2600	0	348	WPGOSIS	WPGOSISU
100/09-16-046-22W1/00	M-03-73	393539	5869704	26.2	22	7	4	80	3400	0	348	WPGOSIS	WPGOSISU
100/09-16-046-22W1/00	M-03-73	393539	5869704	26.8	35	13	6	90	8400	0	336	WPGOSIS	WPGOSISU
100/09-16-046-22W1/00	M-03-73	393539	5869704	27.7	22	10	3	100	2950	0	420	WPGOSIS	WPGOSISU
100/03-21-024-10W1/00	M-05-69	513100	5659125	7.3	23	37	0	102	2850	5	127	WPGOSIS	WPGOSIS
102/10-22-030-16W1/00	M-05-76	456600	5715375	71.3	49	5	0	80	2150	13	-	WPGOSIS	WPGOSISU
102/10-22-030-16W1/00	M-05-76	456600	5715375	73.7	72	9	0	106	950	28	-	WPGOSIS	WPGOSISU
102/10-22-030-16W1/00	M-05-76	456600	5715375	74.6	187	8	0	157	850	22	-	WPGOSIS	WPGOSISU
102/10-22-030-16W1/00	M-05-76	456600	5715375	75.2	76	7	0	134	550	19	-	WPGOSIS	WPGOSISU
102/10-22-030-16W1/00	M-05-76	456600	5715375	75.8	51	7	0	126	800	17	-	WPGOSIS	WPGOSISU
102/10-22-030-16W1/00	M-05-76	456600	5715375	76.5	77	7	0	193	700	28	-	WPGOSIS	WPGOSISU
102/10-22-030-16W1/00	M-05-76	456600	5715375	77.1	79	6	0	126	1700	39	-	WPGOSIS	WPGOSISU
102/01-05-033-19W1/00	M-06-80	423575	5739040	112.6	21	55	10	57	1050	6	-	WPGOSIS	TRANSITIONAL
102/01-05-033-19W1/00	M-06-80	423575	5739040	115.9	30	10	4	90	750	13	529	WPGOSIS	WPGOSISU
102/01-05-033-19W1/00	M-06-80	423575	5739040	116.6	49	12	8	94	850	24	731	WPGOSIS	WPGOSISU
102/01-05-033-19W1/00	M-06-80	423575	5739040	116.9	160	13	8	91	800	29	529	WPGOSIS	WPGOSISU
102/01-05-033-19W1/00	M-06-80	423575	5739040	118.7	36	32	8	82	1000	13	318	WPGOSIS	WPGOSISU
100/04-06-023-07W1/00	M-08-81	539550	5644450	4.4	24	28	0	229	1500	10	226	WPGOSIS	WPGOSISL
100/04-06-023-07W1/00	M-08-81	539550	5644450	7.5	40	39	22	831	2850	43	291	WPGOSIS	WPGOSISL
100/04-06-023-07W1/00	M-08-81	539550	5644450	9.3	28	32	45	643	4150	23	229	WPGOSIS	WPGOSISL
100/08-17-045-25W1/00	M-10-72	362250	5860300	17.1	25	55	8	155	7200	35		WPGOSIS	TRANSITIONAL
102/15-09-031-18W1/00	M-16-81	434285	5722600	123.5	20	4	0	112	1250	7	168	WPGOSIS	WPGOSISL
102/15-09-031-18W1/00	M-16-81	434285	5722600	124.2	29	8	0	107	950	8	166	WPGOSIS	WPGOSISL

Zn >= 45 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/12-05-044-19W1/00	HM-03-76	419850	5856250	0.8	4	46	7	131	5200	0	257	WPGOSIS	WPGOSIS
100/12-05-044-19W1/00	HM-03-76	419850	5856250	15.2	12	51	2	102	1800	4	183	WPGOSIS	WPGOSIS
102/10-22-030-16W1/00	M-05-76	456600	5715375	68.3	1	79	1	60	500	6		WPGOSIS	WPGOSISU
102/10-22-030-16W1/00	M-05-76	456600	5715375	68.4	2	56	0	79	750	9		WPGOSIS	WPGOSISU
100/13-21-030-17W1/00	M-06-76	444250	5715885	32.7	0	47	0	91	900	1	162	WPGOSIS	WPGOSIS
102/01-05-033-19W1/00	M-06-80	423575	5739040	112.5	9	54	1	88	2300	7	227	WPGOSIS	TRANSITIONAL
102/01-05-033-19W1/00	M-06-80	423575	5739040	112.6	21	55	10	57	1050	6		WPGOSIS	TRANSITIONAL
102/01-05-033-19W1/00	M-06-80	423575	5739040	112.6	5	132	12	67	1050	6		WPGOSIS	TRANSITIONAL
102/01-05-033-19W1/00	M-06-80	423575	5739040	112.8	12	59	1	73	1000	11		WPGOSIS	TRANSITIONAL
102/01-05-033-19W1/00	M-06-80	423575	5739040	113.0	3	225	1	74	6750	21		WPGOSIS	TRANSITIONAL
102/01-05-033-19W1/00	M-06-80	423575	5739040	113.2	8	52	1	87	1200	8	303	WPGOSIS	WPGOSISU
100/04-06-023-07W1/00	M-08-81	539550	5644450	5.7	13	45	0	464	2000	4	200	WPGOSIS	WPGOSISL
100/08-17-045-25W1/00	M-10-72	362250	5860300	17.1	25	55	8	155	7200	35		WPGOSIS	TRANSITIONAL
102/15-09-031-18W1/00	M-16-81	434285	5722600	102.7	0	92	0	103	3700	0	230	WPGOSIS	WPGOSISU
102/15-09-031-18W1/00	M-16-81	434285	5722600	121.0	19	64	21	97	3600	22	180	WPGOSIS	WPGOSISU
100/03-01-044-25W1/00	S-05-75	367600	5846630	38.6	8	45	0	49	550	2	219	WPGOSIS	WPGOSISU
100/03-01-044-25W1/00	S-05-75	367600	5846630	39.2	7	51	0	42	500	1	242	WPGOSIS	WPGOSISU
100/03-01-044-25W1/00	S-05-75	367600	5846630	39.7	6	46	0	42	450	1	233	WPGOSIS	WPGOSISU
100/03-01-044-25W1/00	S-05-75	367600	5846630	48.8	4	162	0	45	450	8	196	WPGOSIS	WPGOSISU
100/03-01-044-25W1/00	S-05-75	367600	5846630	53.3	5	54	0	43	350	2	192	WPGOSIS	WPGOSISU
100/03-01-044-25W1/00	S-05-75	367600	5846630	95.4	12	68	9	198	5300	21	495	WPGOSIS	WPGOSISL

Pb >= 19 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/12-05-044-19W1/00	HM-03-76	419850	5856250	16.5	8	20	48	115	2100	1	223	WPGOSIS	WPGOSIS
100/08-20-048-25W1/00	M-07-73	361500	5890900	13.0	7	31	182	51	800	5	131	WPGOSIS	WPGOSISU
100/04-06-023-07W1/00	M-08-81	539550	5644450	7.5	40	39	22	831	2850	43	291	WPGOSIS	WPGOSISL
100/04-06-023-07W1/00	M-08-81	539550	5644450	9.3	28	32	45	643	4150	23	229	WPGOSIS	WPGOSISL
100/16-31-033-19W1/00	M-09-79	420799	5748650	30.5	6	15	200	75	1150	0	161	WPGOSIS	WPGOSIS
102/15-09-031-18W1/00	M-16-81	434285	5722600	121.0	19	64	21	97	3600	22	180	WPGOSIS	WPGOSISU
102/15-09-031-18W1/00	M-16-81	434285	5722600	122.3	10	20	34	112	2350	14	140	WPGOSIS	WPGOSISL

Mn >= 363 ppm (99th percentile)

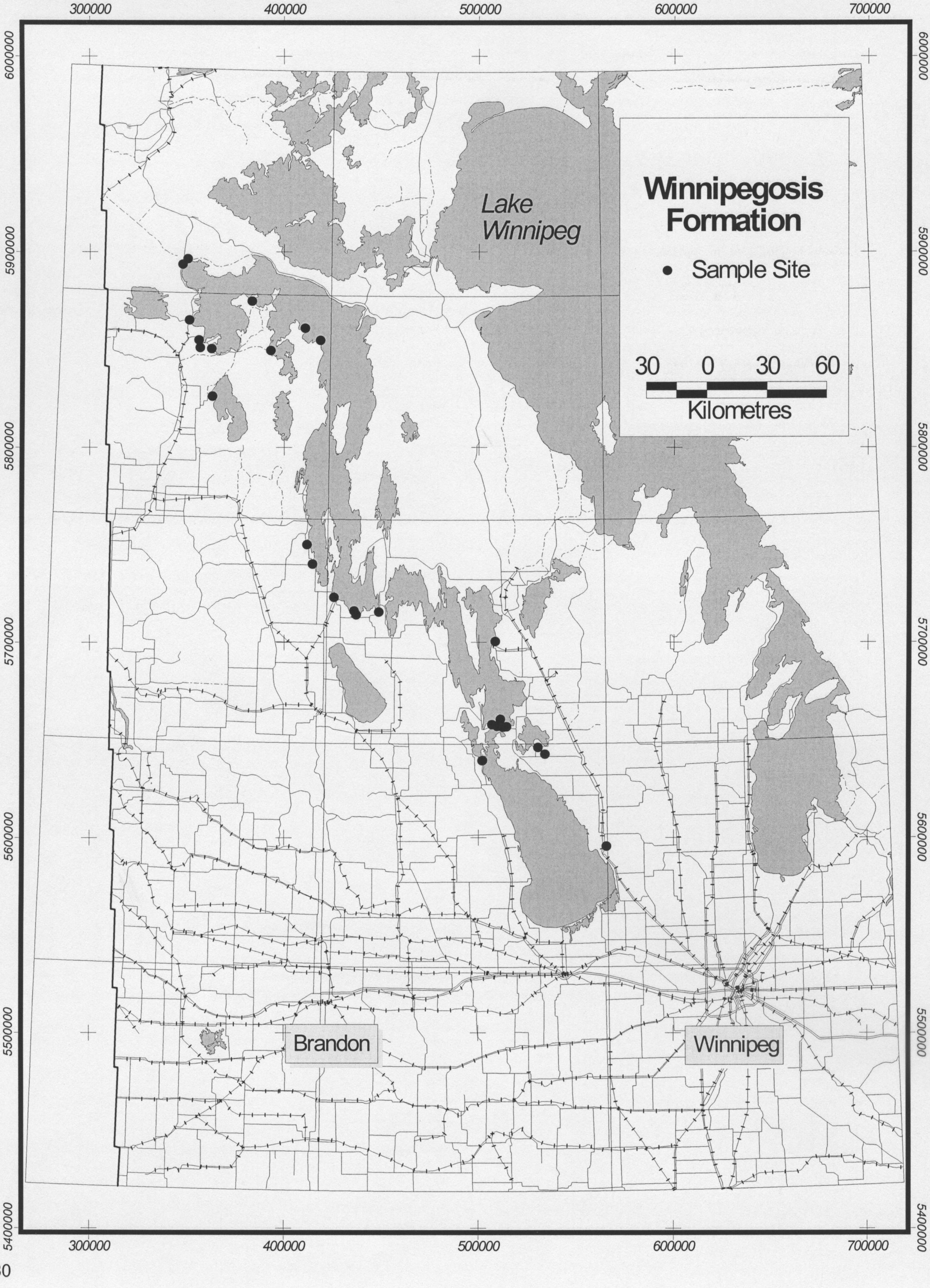
Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/10-03-029-10W1/00	M-04-80	514658	5700545	6.1	6	32	0	404	5550	24	-	WPGOSIS	WPGOSISL
100/04-06-023-07W1/00	M-08-81	539550	5644450	5.7	13	45	0	464	2000	4	200	WPGOSIS	WPGOSISL
100/04-06-023-07W1/00	M-08-81	539550	5644450	7.5	40	39	22	831	2850	43	291	WPGOSIS	WPGOSISL
100/04-06-023-07W1/00	M-08-81	539550	5644450	9.3	28	32	45	643	4150	23	229	WPGOSIS	WPGOSISL

Ni >= 31 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/01-24-044-19W1/00	HM-01-76	427450	5850250	8.7	50	41	3	304	10900	51	686	WPGOSIS	WPGOSIS
102/10-22-030-16W1/00	M-05-76	456600	5715375	69.5	3	5	0	72	1950	108	-	WPGOSIS	WPGOSISU
102/10-22-030-16W1/00	M-05-76	456600	5715375	77.1	79	6	0	126	1700	39	-	WPGOSIS	WPGOSISU
102/01-05-033-19W1/00	M-06-80	423575	5739040	138.4	9	21	1	267	5800	40	500	WPGOSIS	WPGOSISL
100/04-06-023-07W1/00	M-08-81	539550	5644450	7.5	40	39	22	831	2850	43	291	WPGOSIS	WPGOSISL
100/08-17-045-25W1/00	M-10-72	362250	5860300	17.1	25	55	8	155	7200	35	-	WPGOSIS	TRANSITIONAL

F >= 529 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/01-24-044-19W1/00	HM-01-76	427450	5850250	8.7	50	41	3	304	10900	51	686	WPGOSIS	WPGOSIS
100/12-05-044-19W1/00	HM-03-76	419850	5856250	7.7	14	19	8	72	850	6	601	WPGOSIS	WPGOSIS
100/12-05-044-19W1/00	HM-03-76	419850	5856250	8.7	8	18	4	98	1450	6	531	WPGOSIS	WPGOSIS
	M-03-70	515600	5658300	6.6	4	15	0	101	850	0	736	WPGOSIS	WPGOSIS
	M-03-70	515600	5658300	7.3	4	15	0	99	850	2	669	WPGOSIS	WPGOSIS
	M-03-70	515600	5658300	7.9	5	15	0	104	1000	1	568	WPGOSIS	WPGOSIS
100/09-16-046-22W1/00	M-03-73	393539	5869704	21.6	7	7	0	90	3500	0	540	WPGOSIS	WPGOSISU
102/09-33-043-24W1/00	M-03-85	373325	5846100	59.7	1	2	0	43	450	0	532	WPGOSIS	WPGOSISU
100/03-21-024-10W1/00	M-05-69	513100	5659125	21.1	4	17	0	161	2050	0	903	WPGOSIS	WPGOSIS
102/01-05-033-19W1/00	M-06-80	423575	5739040	115.3	13	11	5	90	500	7	630	WPGOSIS	WPGOSISU
102/01-05-033-19W1/00	M-06-80	423575	5739040	115.9	30	10	4	90	750	13	529	WPGOSIS	WPGOSISU
102/01-05-033-19W1/00	M-06-80	423575	5739040	116.6	49	12	8	94	850	24	731	WPGOSIS	WPGOSISU
102/01-05-033-19W1/00	M-06-80	423575	5739040	116.9	160	13	8	91	800	29	529	WPGOSIS	WPGOSISU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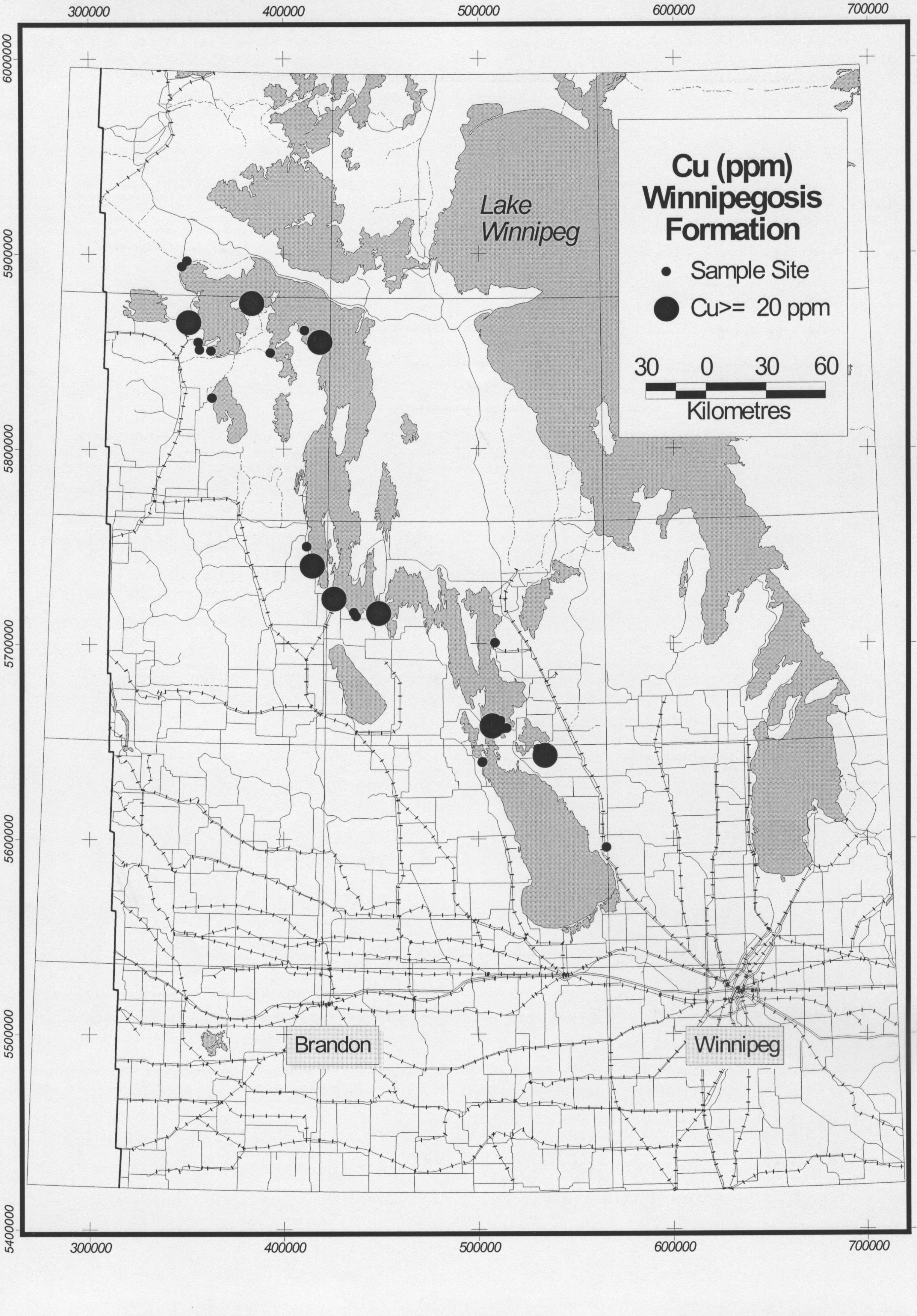
Lake Winnipeg
Winnipegosis Formation
Sample Site
30 0 30 60
Kilometres
Brandon
Winnipeg



Cu (ppm)
Winnipegosis
Formation
Sample Site
Cu>= 20 ppm
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Kilometres
Lake
Winnipeg
Brandon
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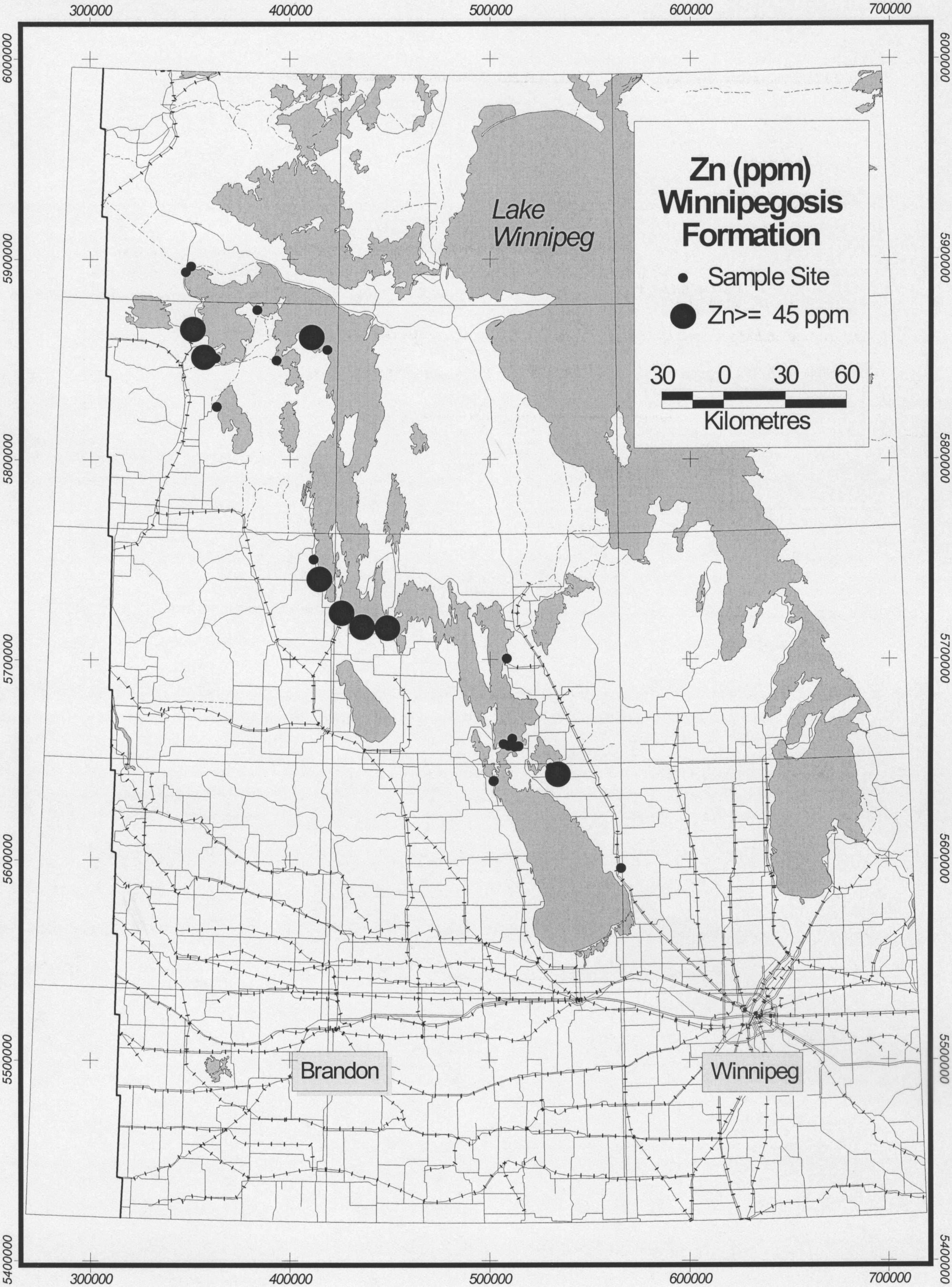

Zn (ppm)
Winnipegosis
Formation
Sample Site
Zn>= 45 ppm
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Kilometres
Lake
Winnipeg
Brandon
Winnipeg
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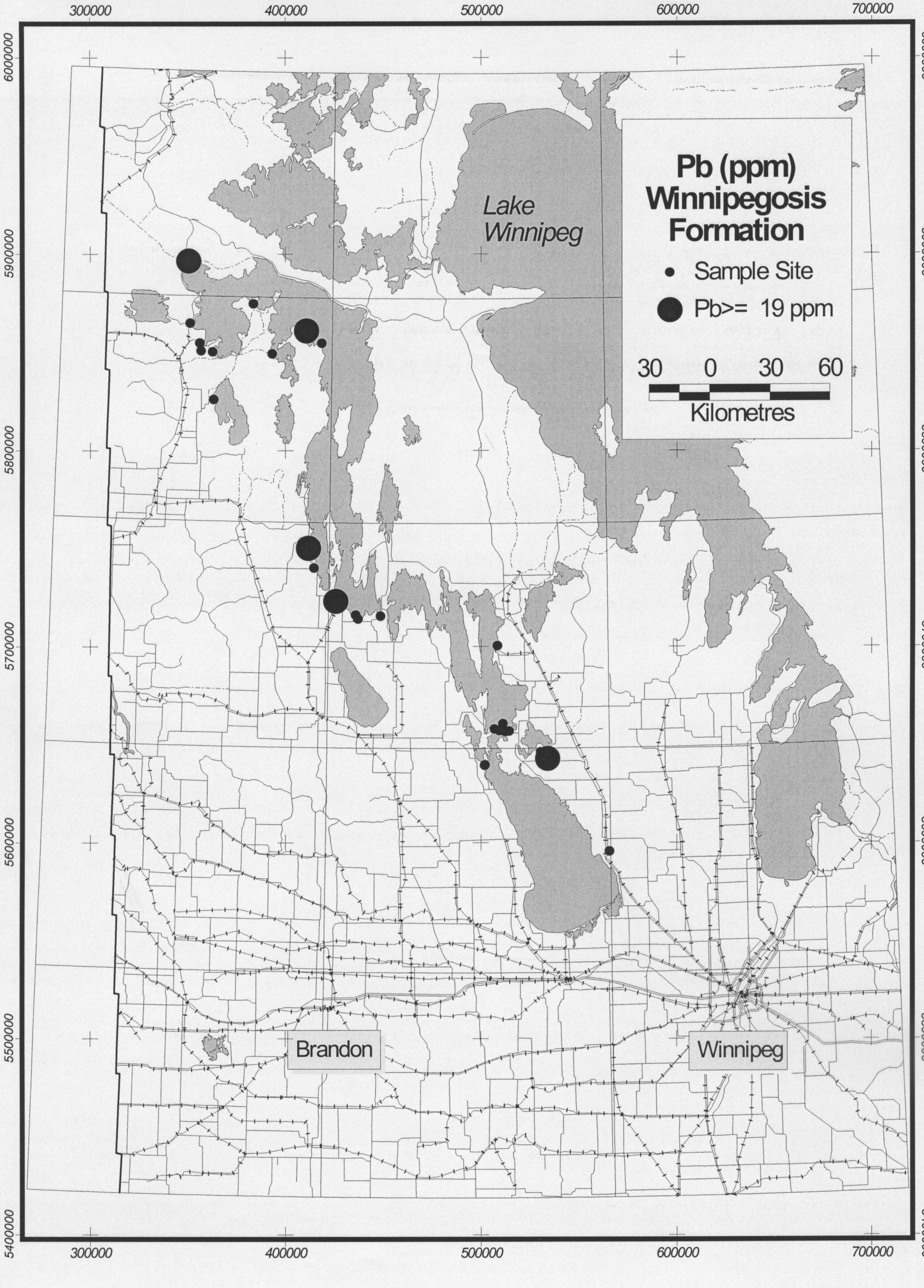

Pb (ppm)
Winnipegosis
Formation
Sample Site
Pb>= 19 ppm
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Kilometres
Lake
Winnipeg
Brandon
Winnipeg
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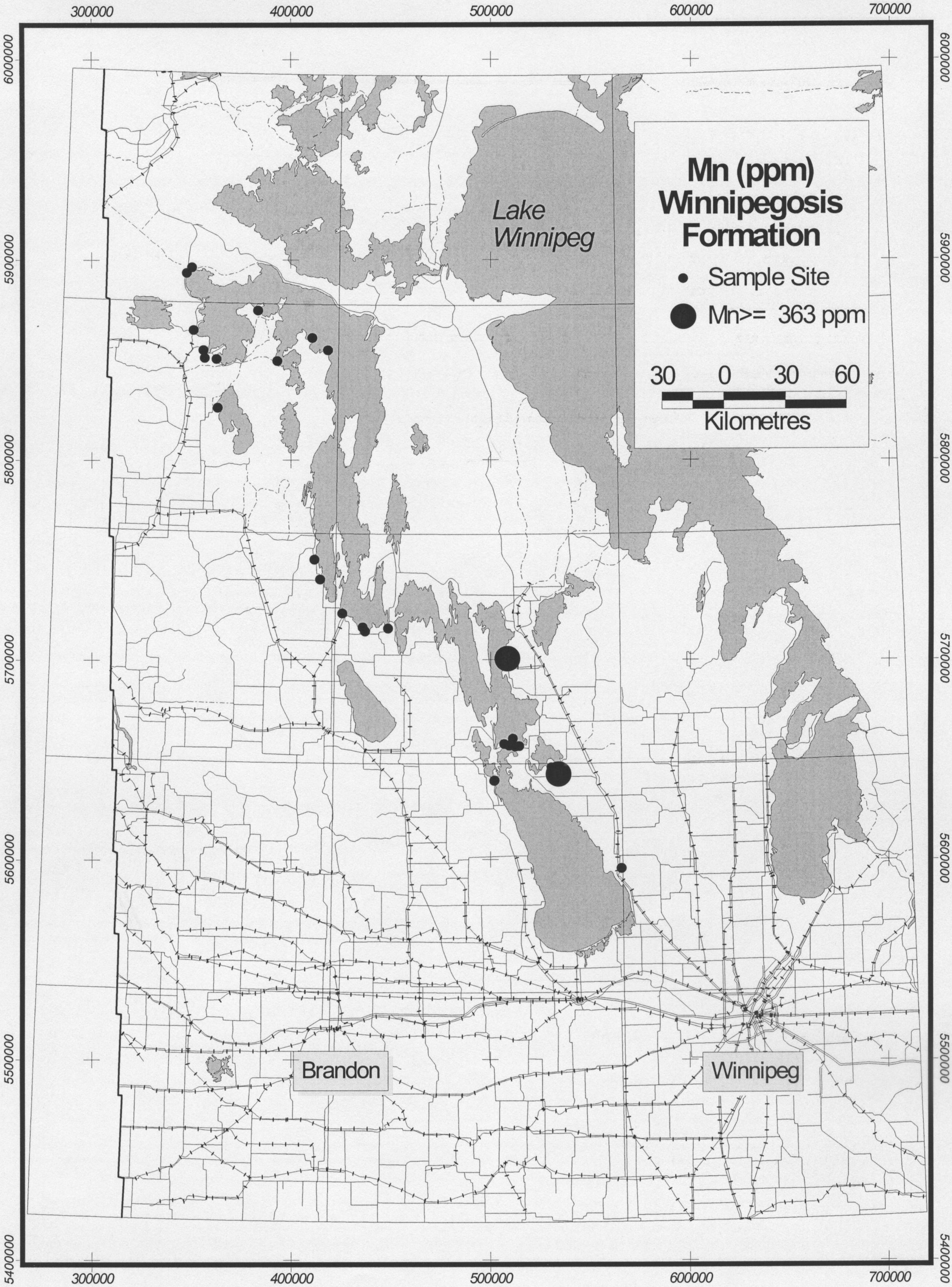
Mn (ppm)
Winnipegosis
Formation
Sample Site
Mn>= 363 ppm
30 0 30 60
Kilometres
Lake
Winnipeg
Brandon
Winnipeg
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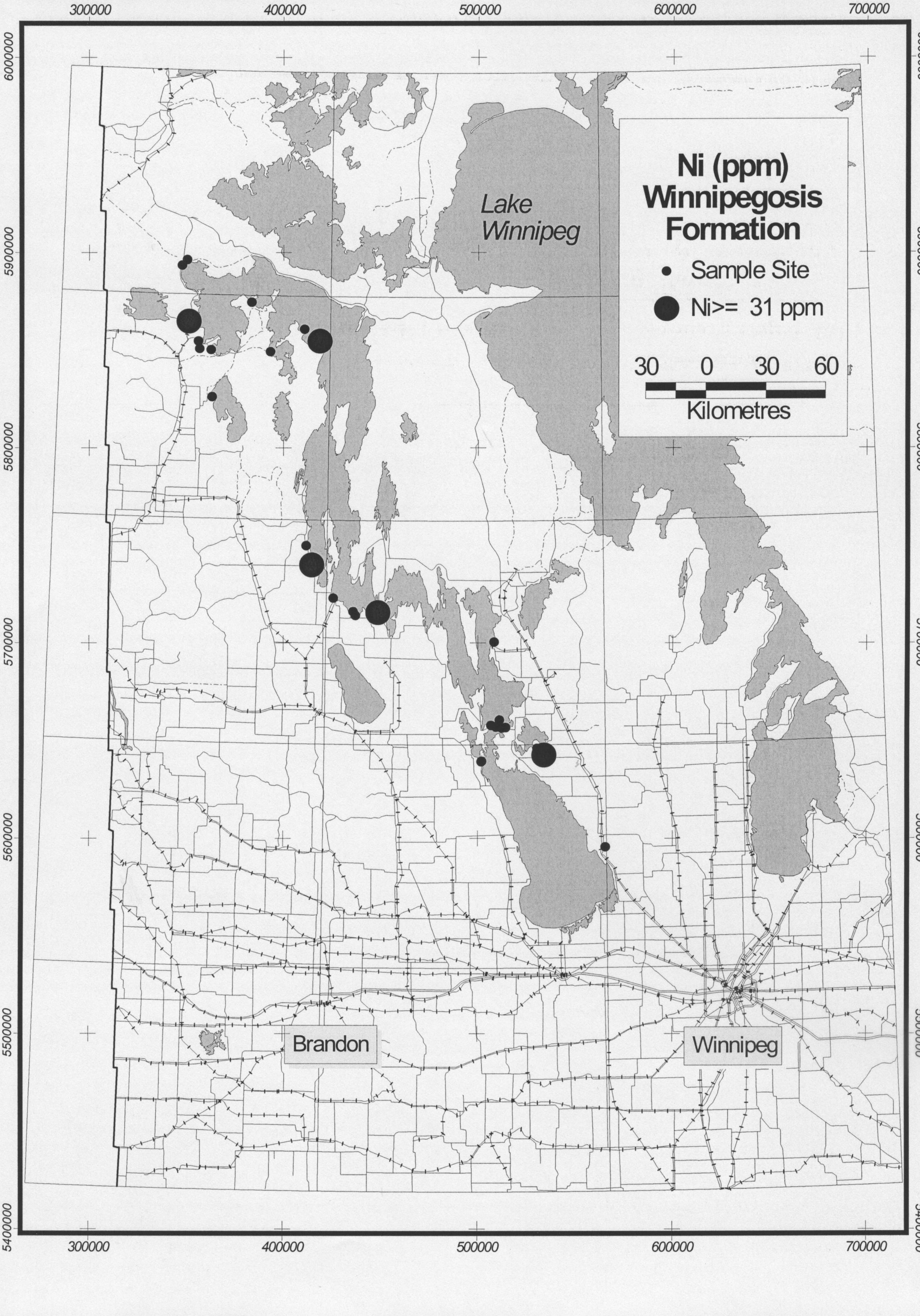

Ni (ppm)
Winnipegosis
Formation
Sample Site
Ni>= 31 ppm
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Kilometres
Lake Winnipeg
Brandon
Winnipeg
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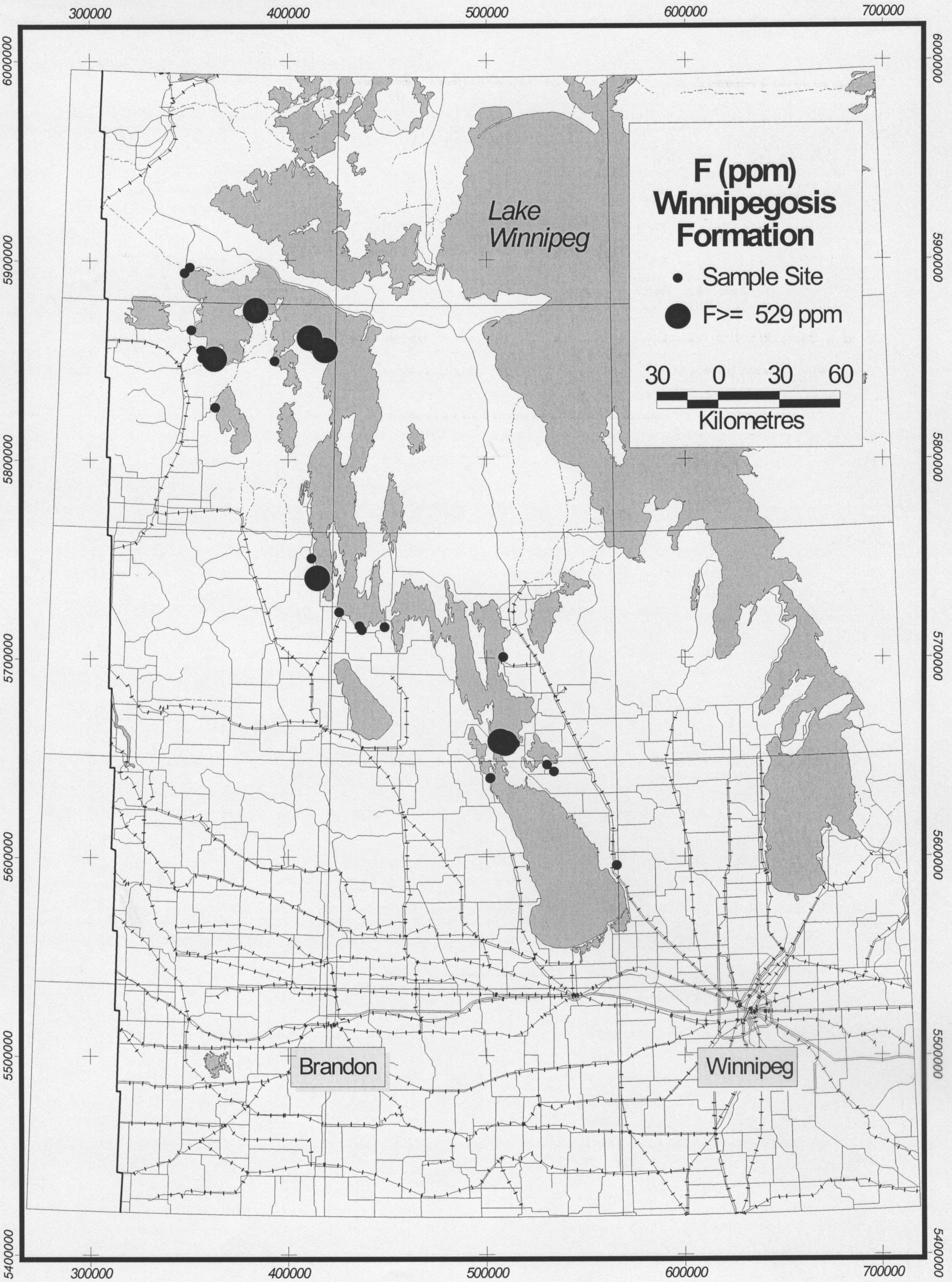

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5400000
Lake Winnipeg
F (ppm)
Winnipegosis
Formation
Sample Site
F>= 529 ppm
30 0 30 60
Kilometres
Brandon
Winnipeg

Appendix 3: Tables and maps of data at concentrations ≥ 99 percentile. *(continued)*

Elm Point Formation

Cu >= 20 ppm (99th percentile)

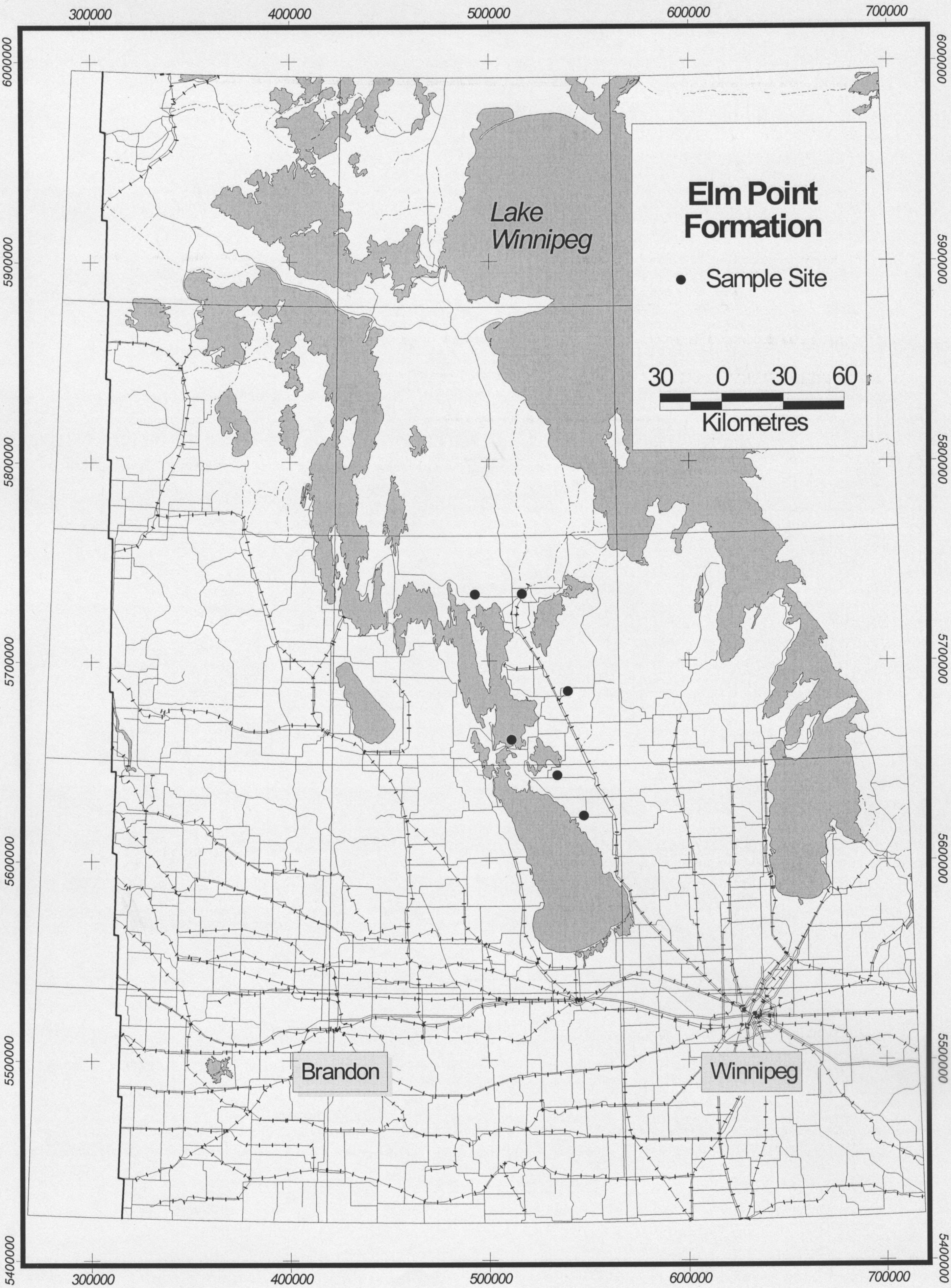
Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/07-16-032-09W1/00	LSM-06	522400	5732625	21.9	53	12	1	164	1050	4	-	ELMPOINT	ELMPOINT
100/07-16-032-09W1/00	LSM-06	522400	5732625	25.6	30	13	8	148	1250	3	-	ELMPOINT	ELMPOINT
100/07-16-032-09W1/00	LSM-06	522400	5732625	28.3	44	11	3	158	1550	3	-	ELMPOINT	ELMPOINT
100/07-16-032-09W1/00	LSM-06	522400	5732625	33.5	20	11	1	161	1550	3	-	ELMPOINT	ELMPOINT
100/01-05-021-06W1/00	M-02-70	552613	5624792	10.9	20	21	0	114	800	9	127	ELMPOINT	ELMPOINT
100/01-05-021-06W1/00	M-02-70	552613	5624792	11.4	24	22	0	105	750	6	121	ELMPOINT	ELMPOINT

Zn >= 45 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/16-26-024-10W1/00	M-01-72	517337	5661775	44.4	12	105	9	128	1250	4	136	ELMPOINT	ELMPOINT
100/04-18-032-11W1/00	M-08-74	499480	5732377	0.7	9	49	0	137	400	5	189	ELMPOINT	ELMPOINT

Ni >= 31 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/02-22-027-07W1/00	M-04-79	544705	5685350	1.3	2	14	0	234	4650	35	-	ELMPOINT	ELMPOINT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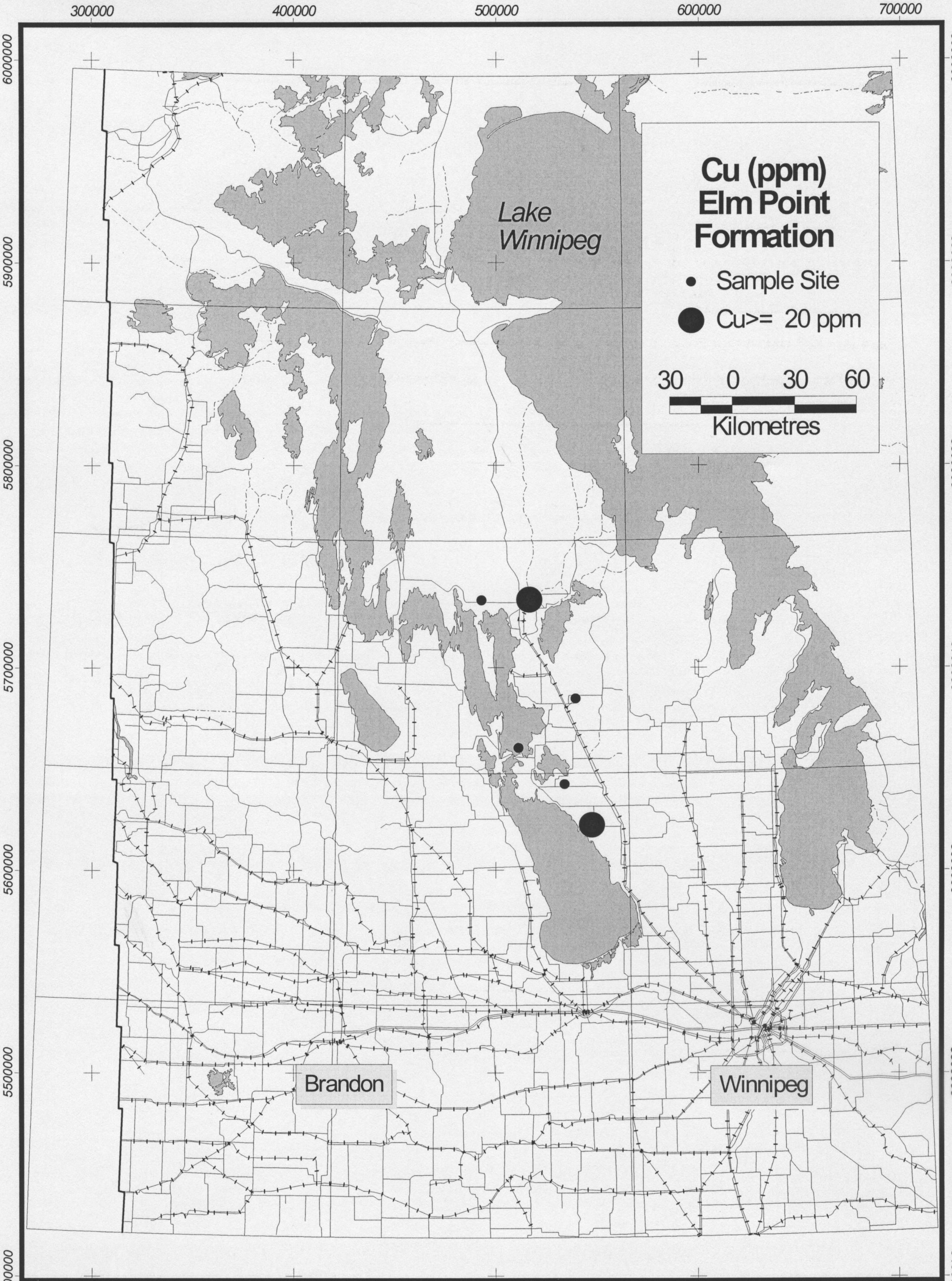
5400000
Lake Winnipeg
Elm Point Formation
Sample Site
30 0 30 60
Kilometres
Brandon
Winnipeg



Cu (ppm)
Elm Point
Formation
Sample Site
Cu>= 20 ppm
30 0 30 60
Kilometres
Lake Winnipeg
Brandon
Winnipeg
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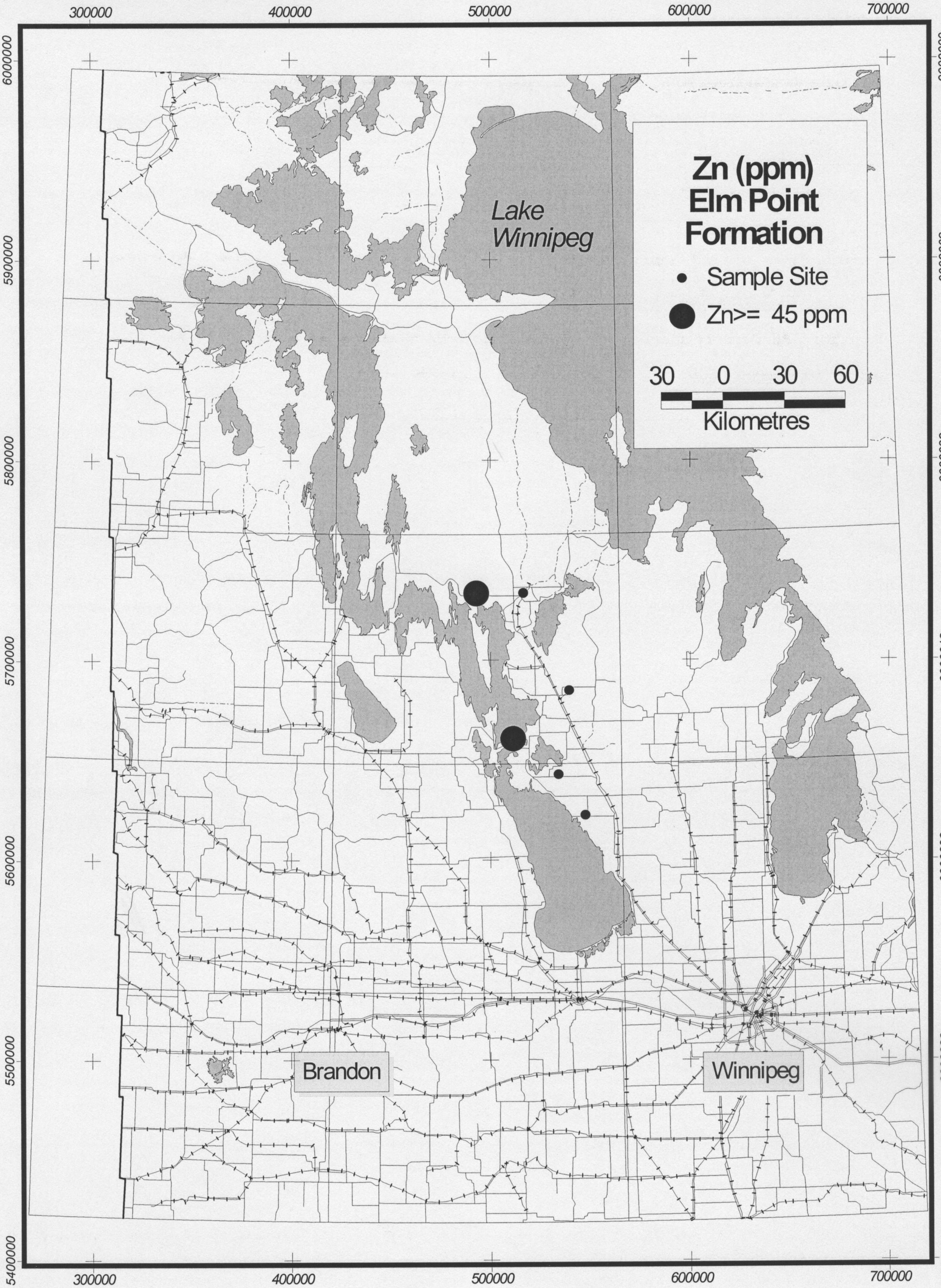

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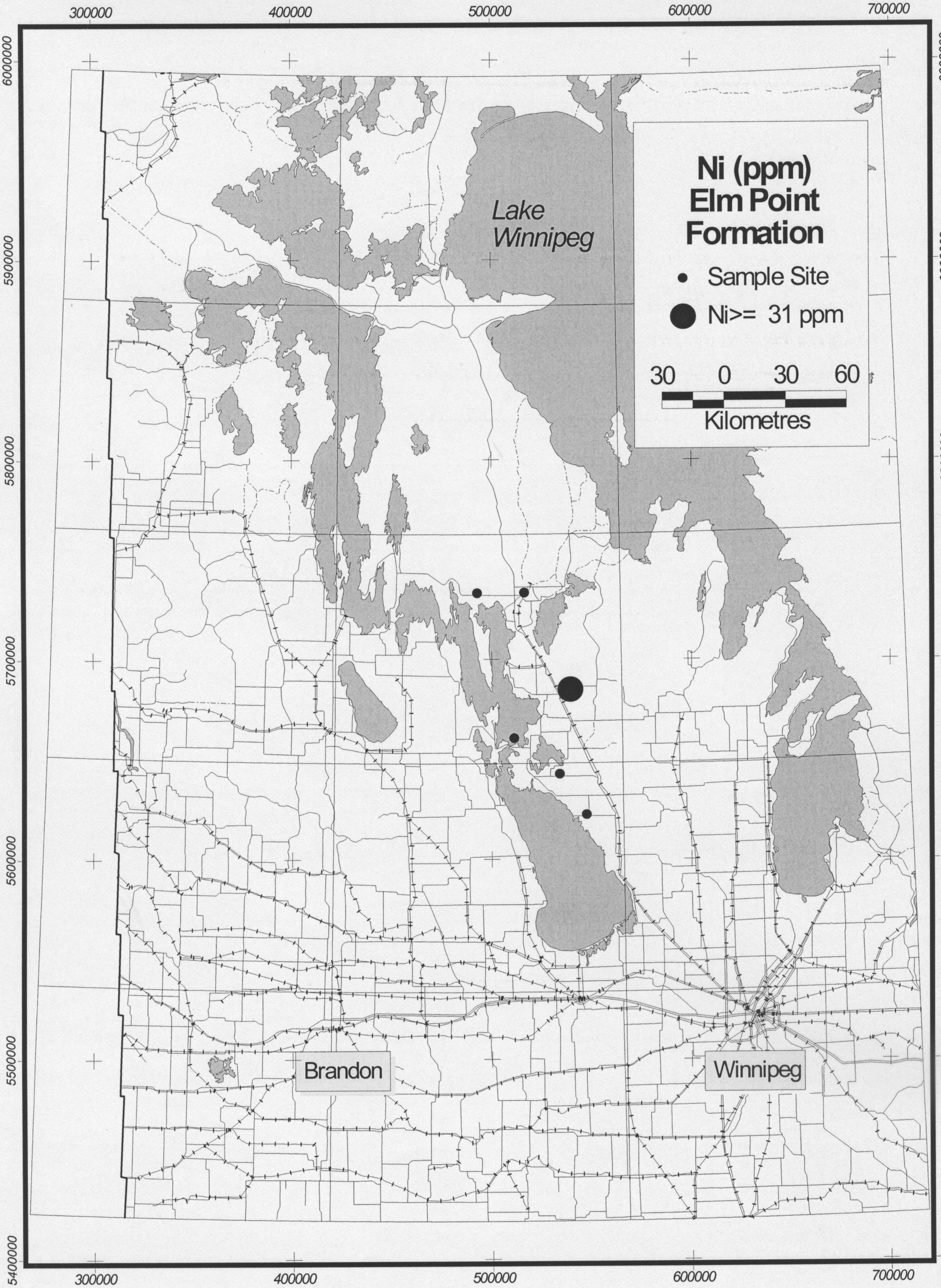
Lake Winnipeg
Zn (ppm)
Elm Point
Formation
Sample Site
Zn>= 45 ppm
30 0 30 60
Kilometres
Brandon
Winnipeg


Ni (ppm)
Elm Point
Formation
Sample Site
Ni>= 31 ppm
30 0 30 60
Kilometres
Lake Winnipeg
Brandon
Winnipeg
300000
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Appendix 3: Tables and maps of data at concentrations ≥ 99 percentile. *(continued)*

Ashern Formation

Cu >= 20 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/01-24-044-19W1/00	HM-01-76	427450	5850250	10.1	20	54	0	241	9150	40	-	ASHERN	ASHERN
100/01-24-044-19W1/00	HM-01-76	427450	5850250	11.0	27	53	2	248	8900	40	-	ASHERN	ASHERN
100/09-16-046-22W1/00	M-03-73	393539	5869704	43.0	23	24	7	220	9700	0	784	ASHERN	ASHERN
100/09-16-046-22W1/00	M-03-73	393539	5869704	43.6	20	37	6	235	8300	0	-	ASHERN	ASHERN
100/10-03-029-10W1/00	M-04-80	514658	5700545	15.8	20	6	0	134	4800	7	-	ASHERN	ASHERN
100/02-21-041-24W1/00	M-07-78	373780	5822525	119.8	24	34	18	345	17000	0	367	ASHERN	ASHERN
100/02-21-041-24W1/00	M-07-78	373780	5822525	120.4	26	39	2	310	15800	0	461	ASHERN	ASHERN

Zn >= 45 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/01-24-044-19W1/00	HM-01-76	427450	5850250	9.5	18	53	2	245	10350	37	832	ASHERN	ASHERN
100/01-24-044-19W1/00	HM-01-76	427450	5850250	10.1	20	54	0	241	9150	40	-	ASHERN	ASHERN
100/01-24-044-19W1/00	HM-01-76	427450	5850250	11.0	27	53	2	248	8900	40	-	ASHERN	ASHERN
100/01-24-044-19W1/00	HM-01-76	427450	5850250	11.7	11	47	0	239	10650	30	-	ASHERN	ASHERN
100/01-24-044-19W1/00	HM-01-76	427450	5850250	12.0	8	72	0	262	10250	30	-	ASHERN	ASHERN
100/09-16-046-22W1/00	M-03-73	393539	5869704	44.2	17	55	0	230	9400	0	-	ASHERN	ASHERN
102/09-33-043-24W1/00	M-03-85	373325	5846100	101.3	17	45	6	221	8850	37	840	ASHERN	ASHERN
102/09-33-043-24W1/00	M-03-85	373325	5846100	101.9	10	48	2	226	9850	37	1100	ASHERN	ASHERN

Mn >= 363 ppm (99th percentile)

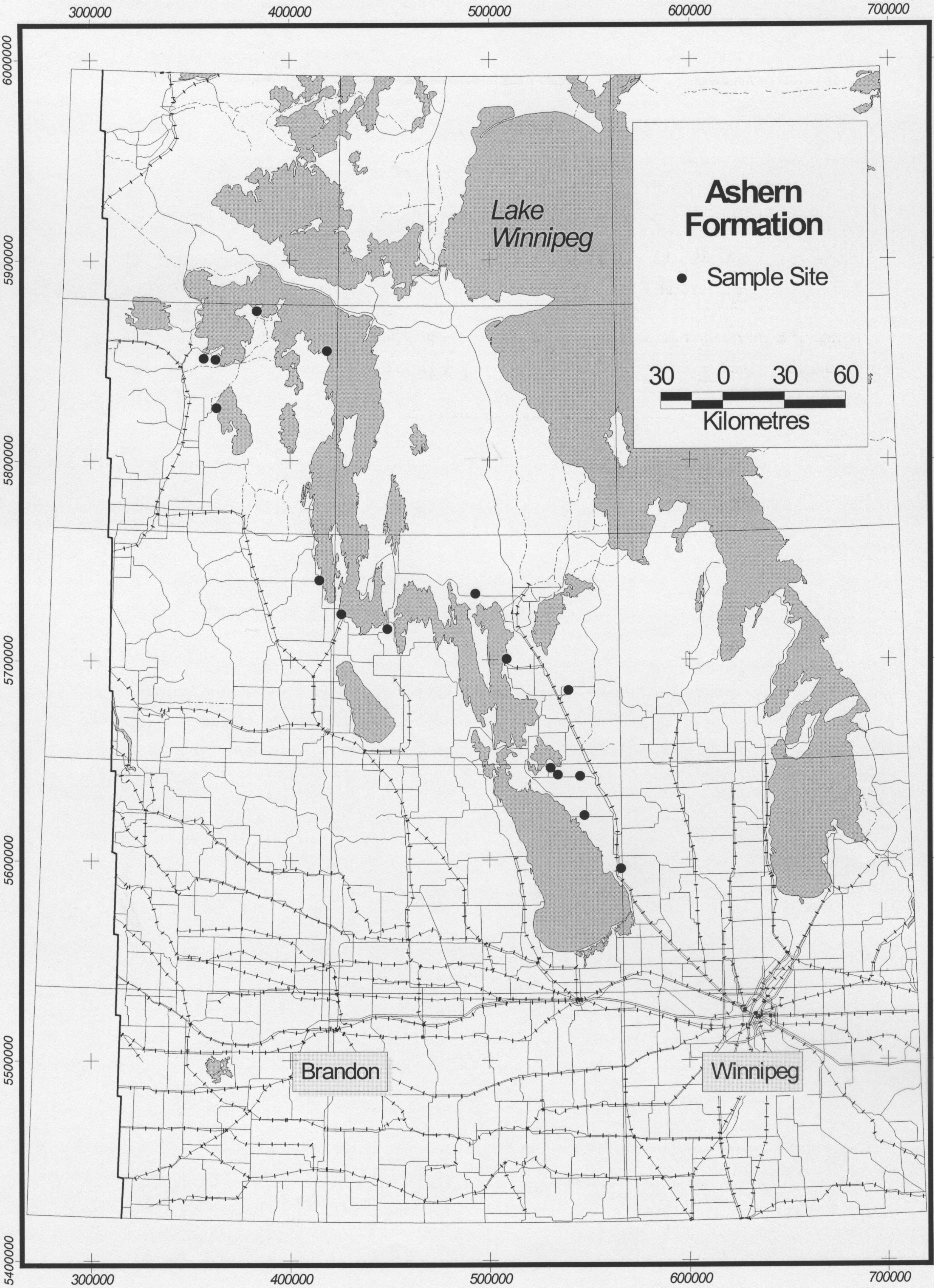
Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/02-21-041-24W1/00	M-07-78	373780	5822525	123.1	14	38	0	385	25000	0	-	ASHERN	ASHERN

Ni >= 31 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/01-24-044-19W1/00	HM-01-76	427450	5850250	9.5	18	53	2	245	10350	37	832	ASHERN	ASHERN
100/01-24-044-19W1/00	HM-01-76	427450	5850250	10.1	20	54	0	241	9150	40	-	ASHERN	ASHERN
100/01-24-044-19W1/00	HM-01-76	427450	5850250	11.0	27	53	2	248	8900	40	-	ASHERN	ASHERN
102/09-33-043-24W1/00	M-03-85	373325	5846100	100.7	15	41	14	242	11150	35	840	ASHERN	ASHERN
102/09-33-043-24W1/00	M-03-85	373325	5846100	101.3	17	45	6	221	8850	37	840	ASHERN	ASHERN
102/09-33-043-24W1/00	M-03-85	373325	5846100	101.9	10	48	2	226	9850	37	1100	ASHERN	ASHERN
102/09-33-043-24W1/00	M-03-85	373325	5846100	102.5	8	44	0	216	8600	32	940	ASHERN	ASHERN
102/09-33-043-24W1/00	M-03-85	373325	5846100	103.3	13	42	0	222	10000	32	1000	ASHERN	ASHERN
102/09-33-043-24W1/00	M-03-85	373325	5846100	107.5	9	32	2	218	10650	35	-	ASHERN	ASHERN
100/04-14-023-08W1/00	M-04-70	536103	5647857	15.2	6	35	0	162	5700	31	757	ASHERN	ASHERN
100/02-22-027-07W1/00	M-04-79	544705	5685350	7.3	4	17	0	194	6950	36	-	ASHERN	ASHERN
100/02-22-027-07W1/00	M-04-79	544705	5685350	9.1	3	13	2	159	4350	35	-	ASHERN	ASHERN
102/10-22-030-16W1/00	M-05-76	456600	5715375	96.0	5	27	0	237	3300	35	-	ASHERN	ASHERN
102/01-05-033-19W1/00	M-06-80	423575	5739040	138.8	14	20	1	184	3900	35	520	ASHERN	ASHERN
102/01-05-033-19W1/00	M-06-80	423575	5739040	139.2	15	21	1	207	4800	37	-	ASHERN	ASHERN
102/01-05-033-19W1/00	M-06-80	423575	5739040	140.3	12	28	1	180	31000	44	-	ASHERN	ASHERN
102/01-05-033-19W1/00	M-06-80	423575	5739040	141.3	15	27	1	239	33000	39	-	ASHERN	ASHERN
100/04-18-032-11W1/00	M-08-74	499480	5732377	10.3	6	36	0	255	7200	31	1022	ASHERN	ASHERN
102/15-09-031-18W1/00	M-16-81	434285	5722600	138.0	8	19	0	216	11550	34	-	ASHERN	ASHERN
102/15-09-031-18W1/00	M-16-81	434285	5722600	139.3	4	19	0	178	9050	42	-	ASHERN	ASHERN

F >= 529 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/01-24-044-19W1/00	HM-01-76	427450	5850250	9.5	18	53	2	245	10350	37	832	ASHERN	ASHERN
100/01-05-021-06W1/00	M-02-70	552613	5624792	13.3	5	36	0	163	6850	29	752	ASHERN	ASHERN
100/09-16-046-22W1/00	M-03-73	393539	5869704	43.0	23	24	7	220	9700	0	784	ASHERN	ASHERN
102/09-33-043-24W1/00	M-03-85	373325	5846100	100.7	15	41	14	242	11150	35	840	ASHERN	ASHERN
102/09-33-043-24W1/00	M-03-85	373325	5846100	101.3	17	45	6	221	8850	37	840	ASHERN	ASHERN
102/09-33-043-24W1/00	M-03-85	373325	5846100	101.9	10	48	2	226	9850	37	1100	ASHERN	ASHERN
102/09-33-043-24W1/00	M-03-85	373325	5846100	102.5	8	44	0	216	8600	32	940	ASHERN	ASHERN
102/09-33-043-24W1/00	M-03-85	373325	5846100	103.3	13	42	0	222	10000	32	1000	ASHERN	ASHERN
102/09-33-043-24W1/00	M-03-85	373325	5846100	103.9	12	41	0	234	13500	28	1060	ASHERN	ASHERN
102/09-33-043-24W1/00	M-03-85	373325	5846100	104.5	8	40	3	284	11800	27	1060	ASHERN	ASHERN
100/04-14-023-08W1/00	M-04-70	536103	5647857	15.2	6	35	0	162	5700	31	757	ASHERN	ASHERN
100/04-14-023-08W1/00	M-04-70	536103	5647857	16.1	6	33	0	175	5250	23	666	ASHERN	ASHERN
100/04-18-032-11W1/00	M-08-74	499480	5732377	10.3	6	36	0	255	7200	31	1022	ASHERN	ASHERN
100/04-06-023-07W1/00	M-08-81	539550	5644450	21.4	15	31	0	163	6800	28	591	ASHERN	ASHERN
100/03-01-044-25W1/00	S-05-75	367600	5846630	97.9	13	42	3	207	11050	30	840	ASHERN	ASHERN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Lake Winnipeg
Ashern Formation
Sample Site
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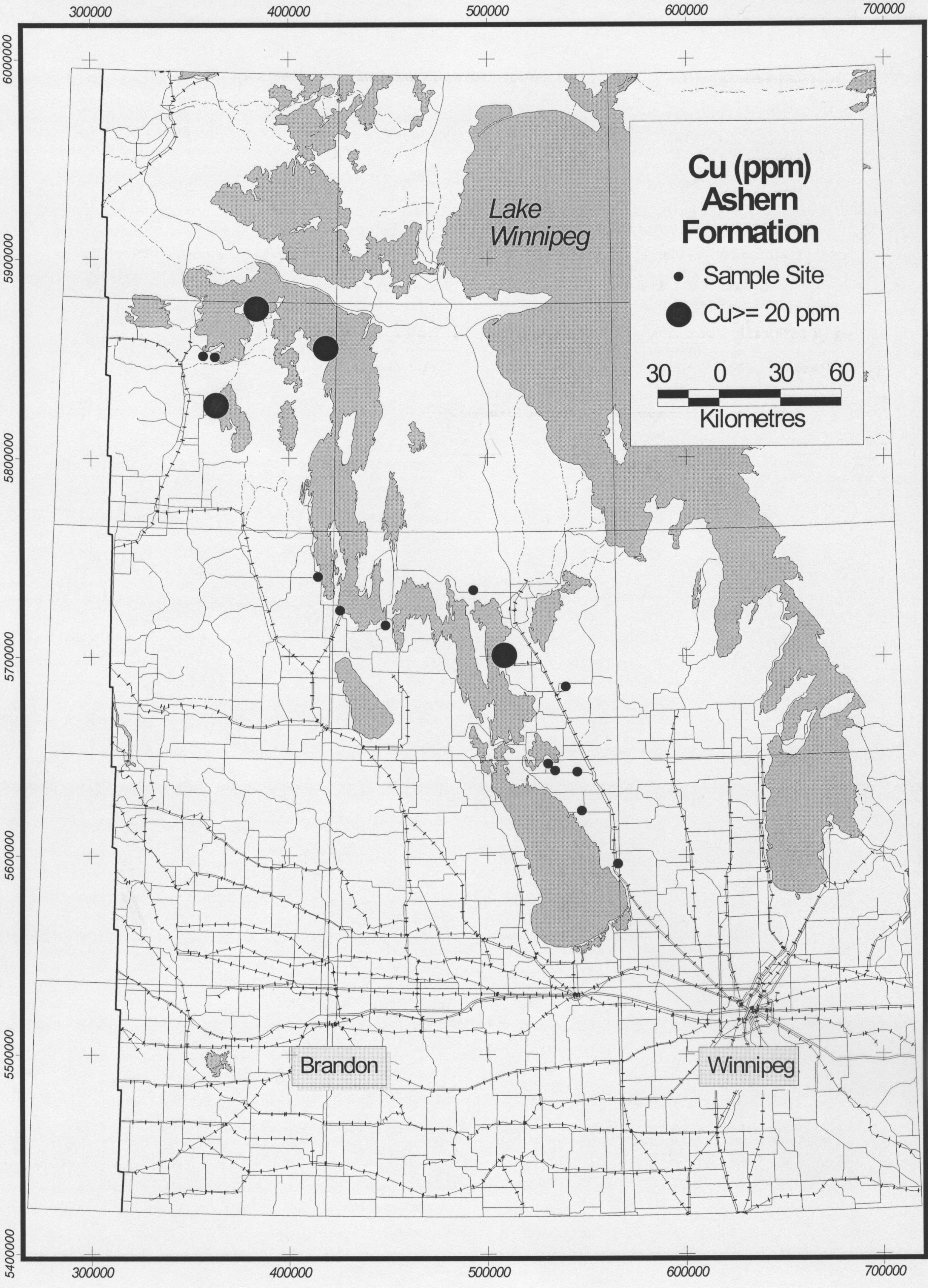
Kilometres
Brandon
Winnipeg



Cu (ppm)
Ashern
Formation
Sample Site
Cu>= 20 ppm
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Kilometres
Lake
Winnipeg
Brandon
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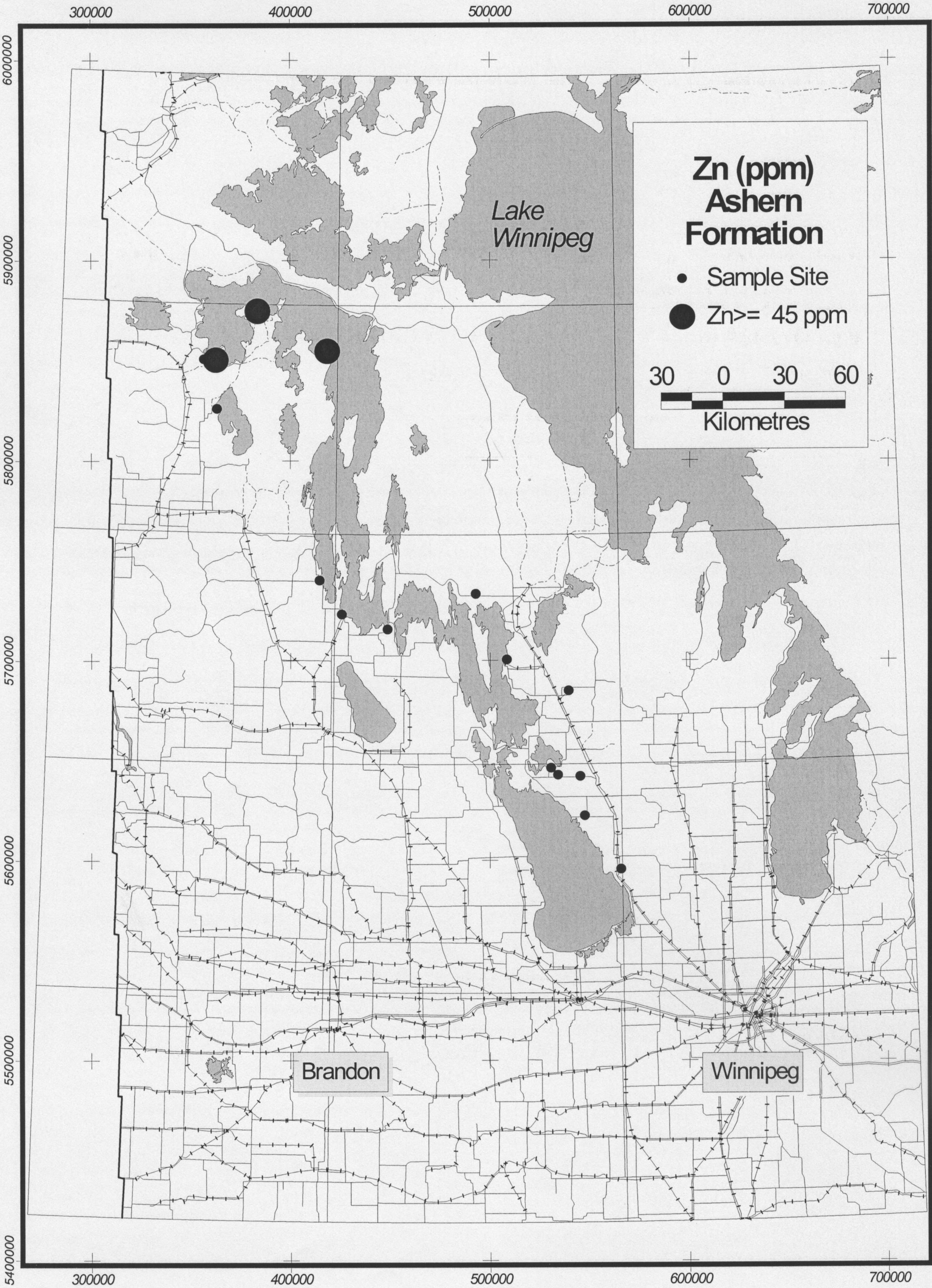

Zn (ppm)
Ashern
Formation
Sample Site
Zn>= 45 ppm
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Kilometres
Lake Winnipeg
Brandon
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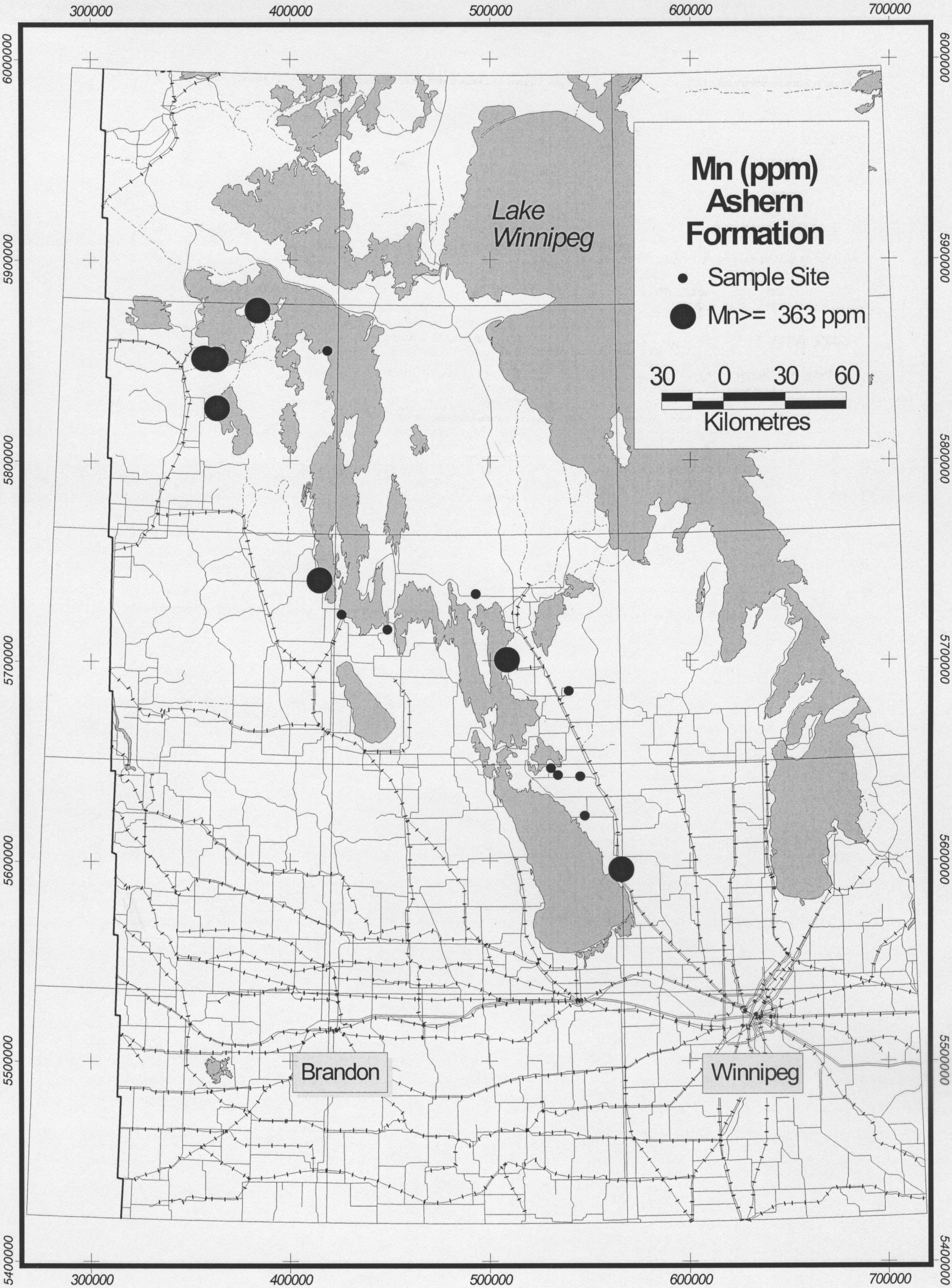
Mn (ppm)
Ashern
Formation
Sample Site
Mn>= 363 ppm
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Kilometres
Lake
Winnipeg
Brandon
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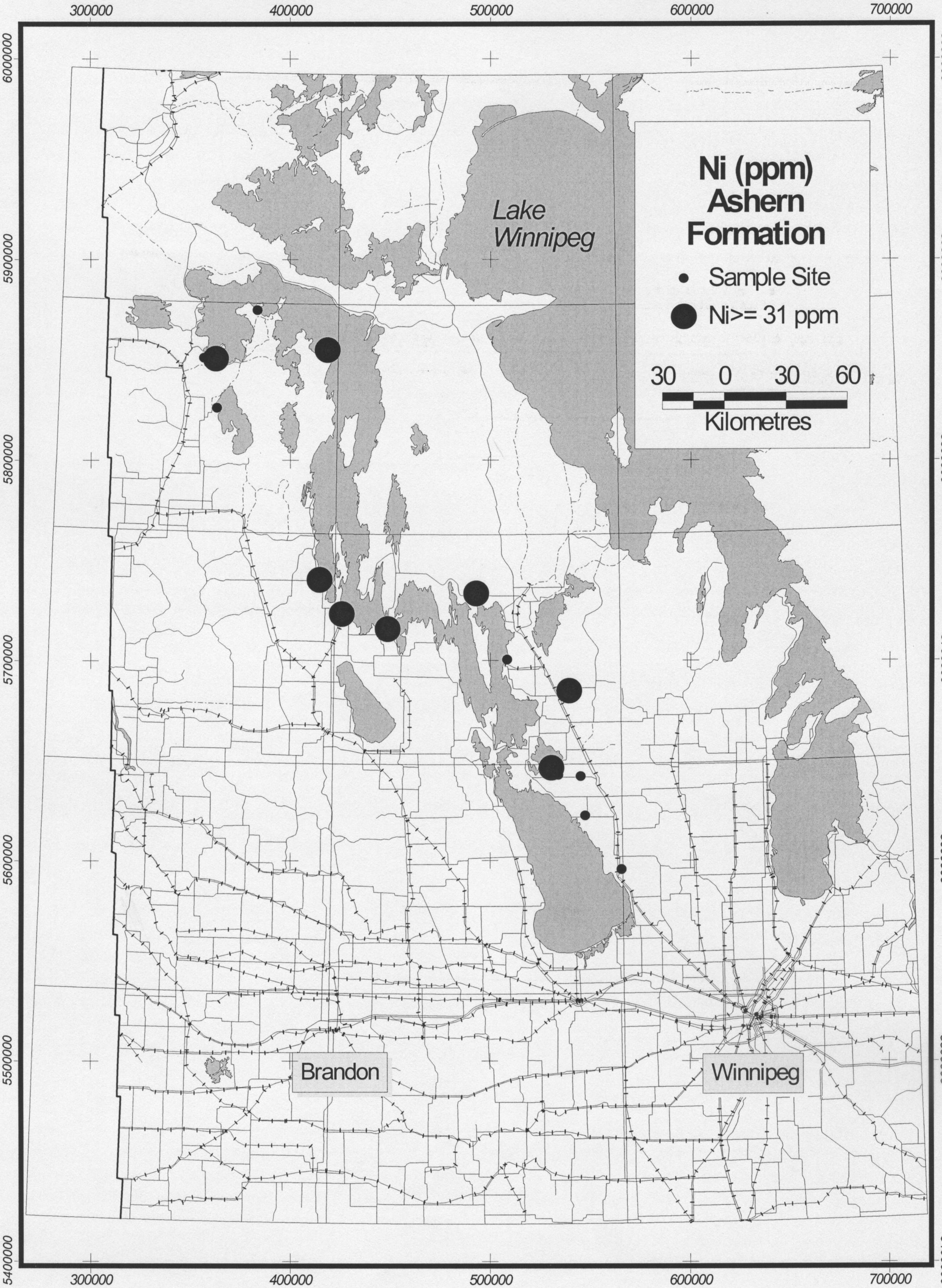

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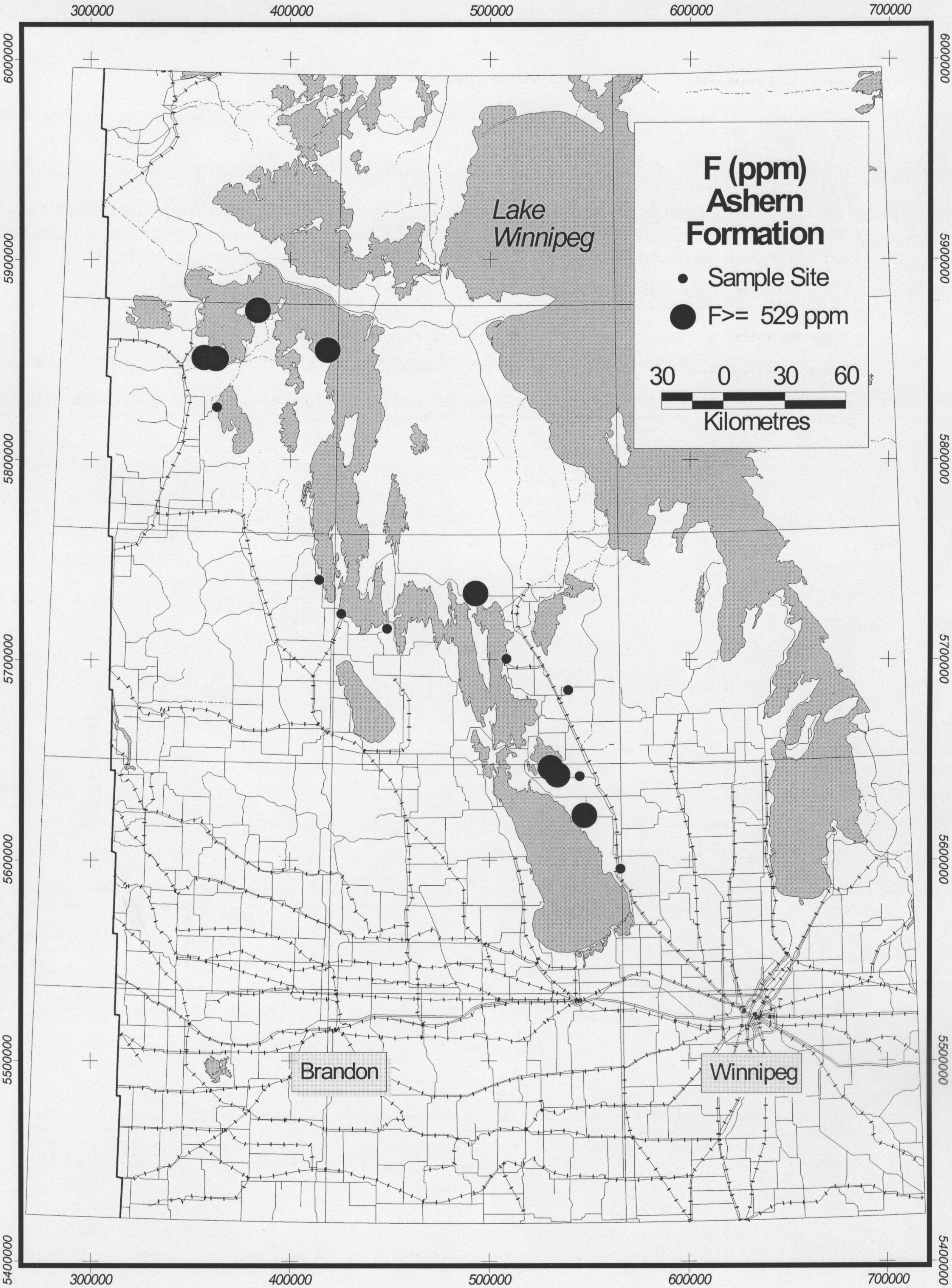
Lake
Winnipeg
Ni (ppm)
Ashern
Formation
Sample Site
Ni>= 31 ppm
30
0
30
60
Kilometres
Brandon
Winnipeg


F (ppm)
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Formation
Sample Site
F>= 529 ppm
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Kilometres
Lake Winnipeg
Brandon
Winnipeg
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Appendix 3: Tables and maps of data at concentrations ≥ 99 percentile. *(continued)*

Interlake Group (including Silurian and Silurian Undifferentiated)

Cu >= 20 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
102/04-18-018-04W1/00	M-02-80	570264	5598817	17.5	39	36	11	315	1500	21	-	INTERLAKE	CEDARLAKE
100/02-22-027-07W1/00	M-04-79	544705	5685350	37.0	27	21	0	90	7800	41	-	SILURIANUND	SILURIANUND

Pb >= 19 ppm (99th percentile)

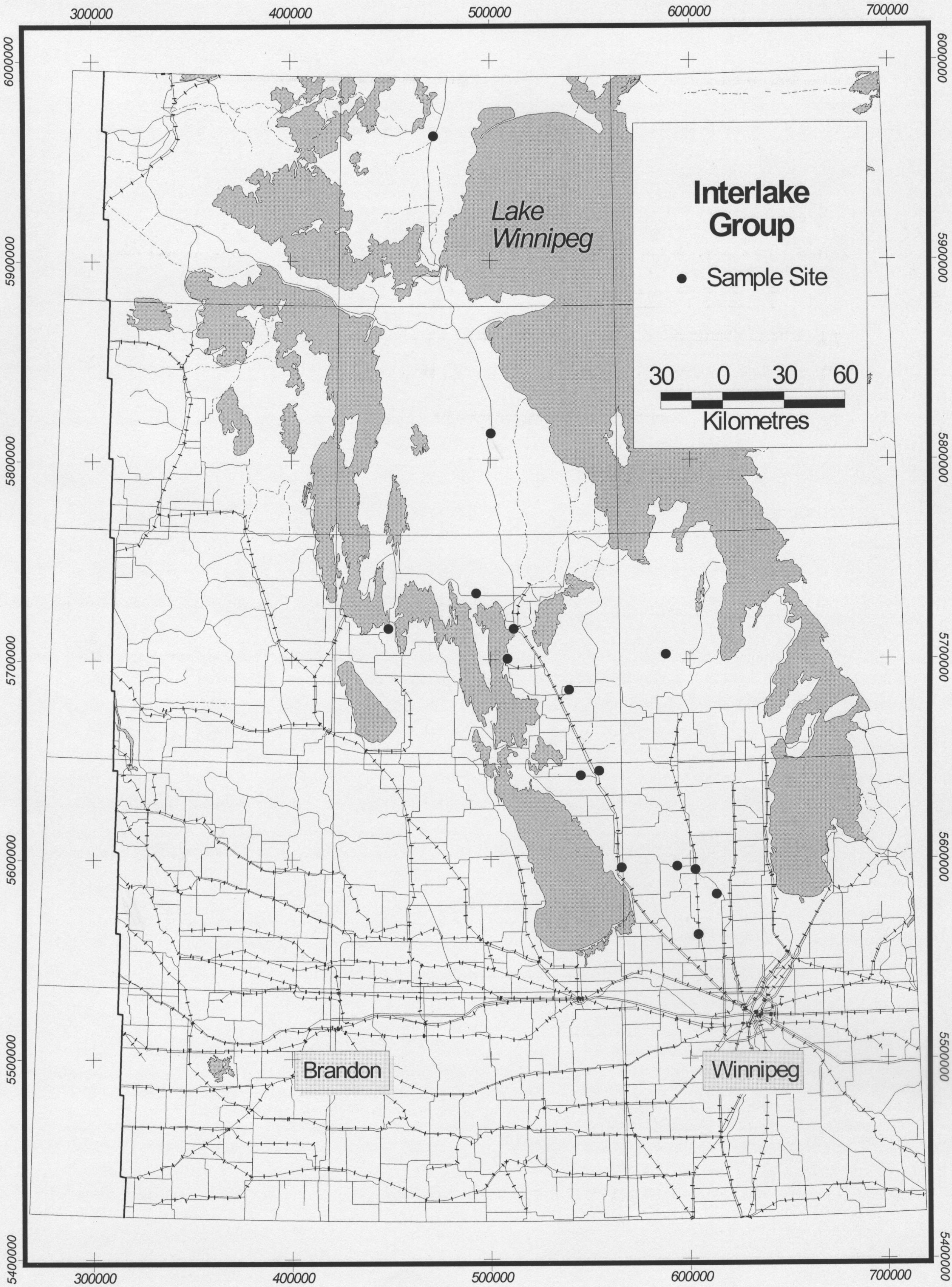
Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/01-09-029-02W1/00	M-03-82	591775	5702500	49.2	6	27	48	151	50	7	-	SILURIAN	POST-CRATERFILL

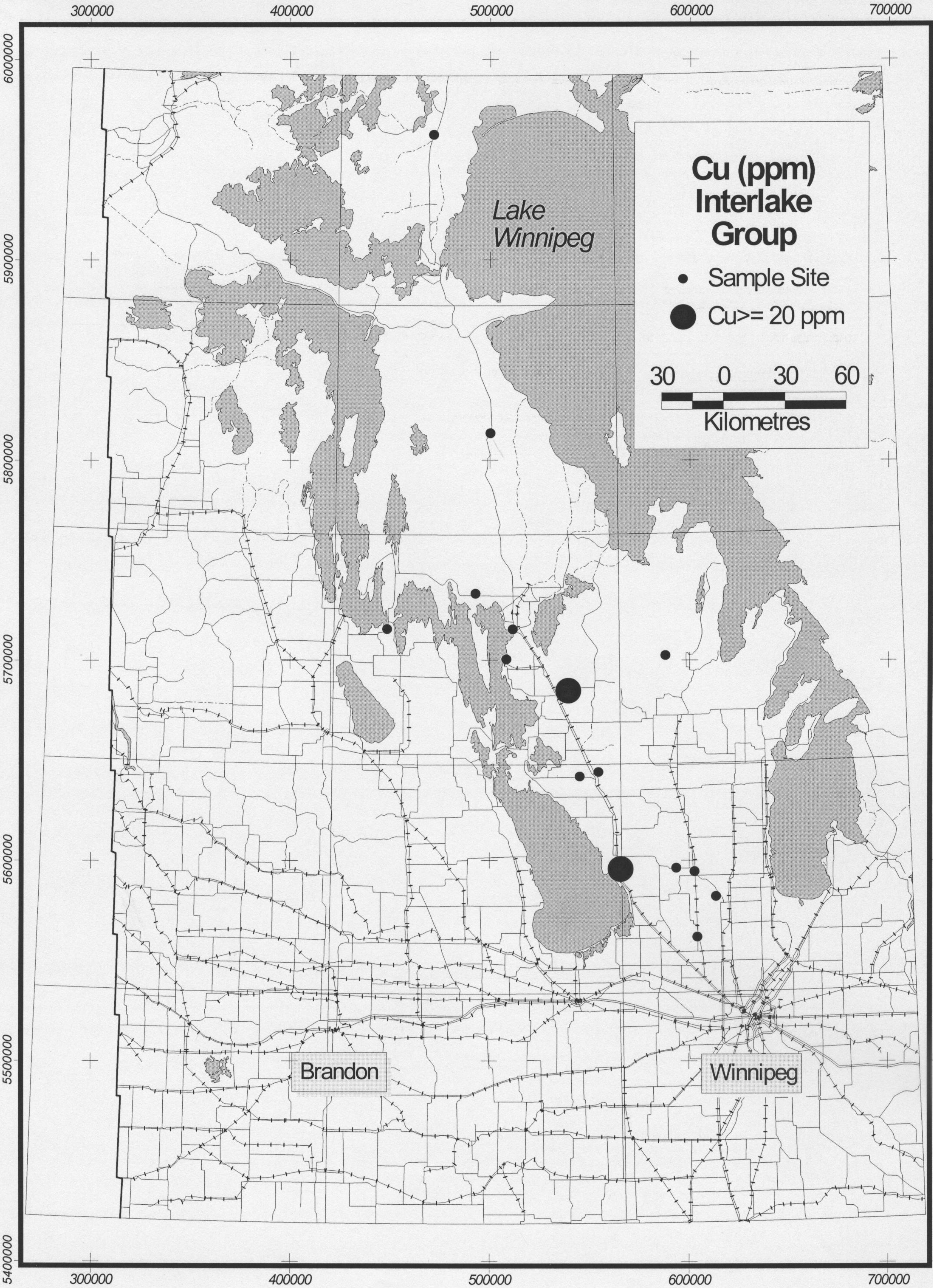
Mn >= 363 ppm (99th percentile)

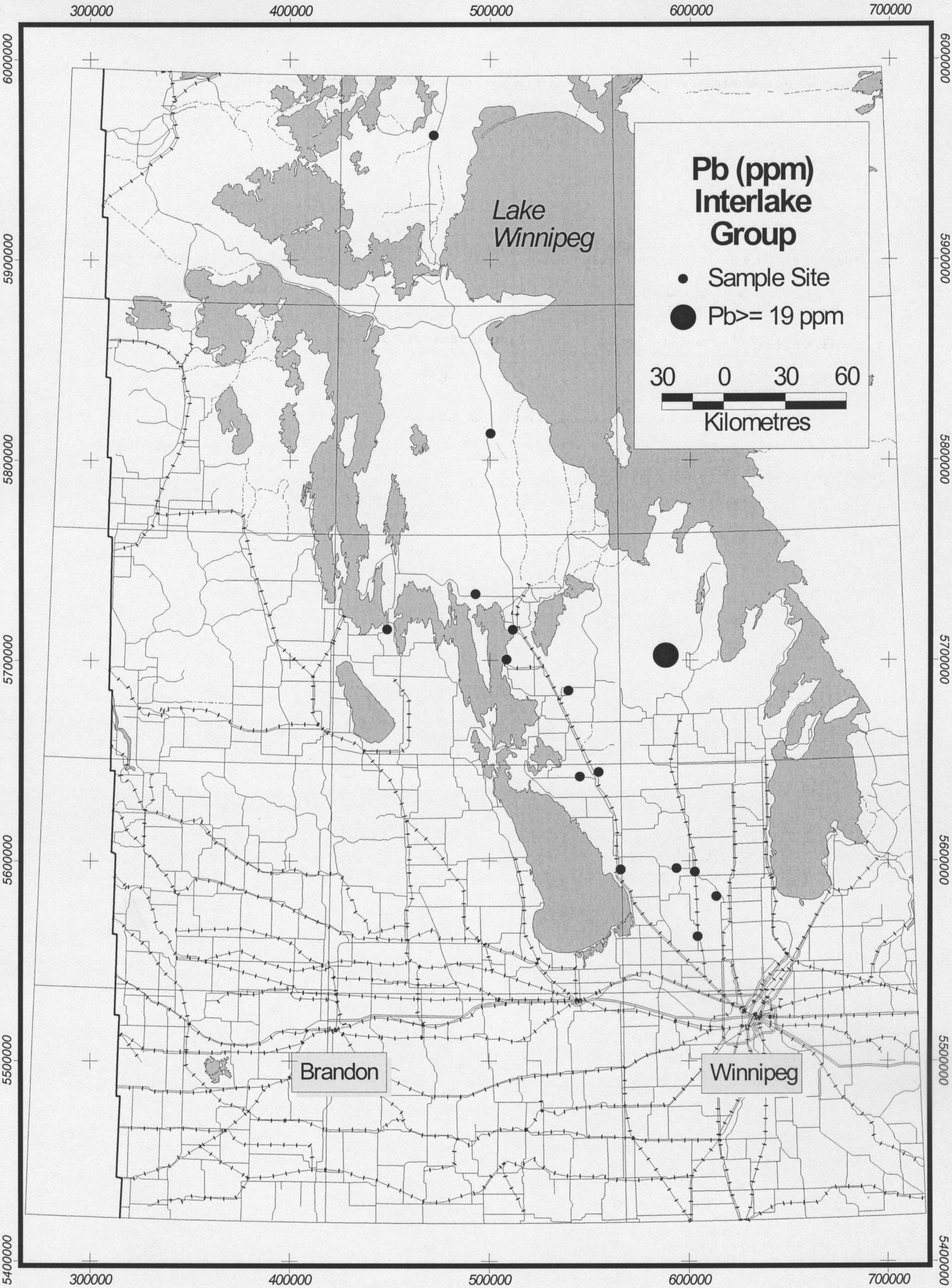
Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
102/04-18-018-04W1/00	M-02-80	570264	5598817	16.0	6	18	0	448	1600	2	-	INTERLAKE	CEDARLAKE

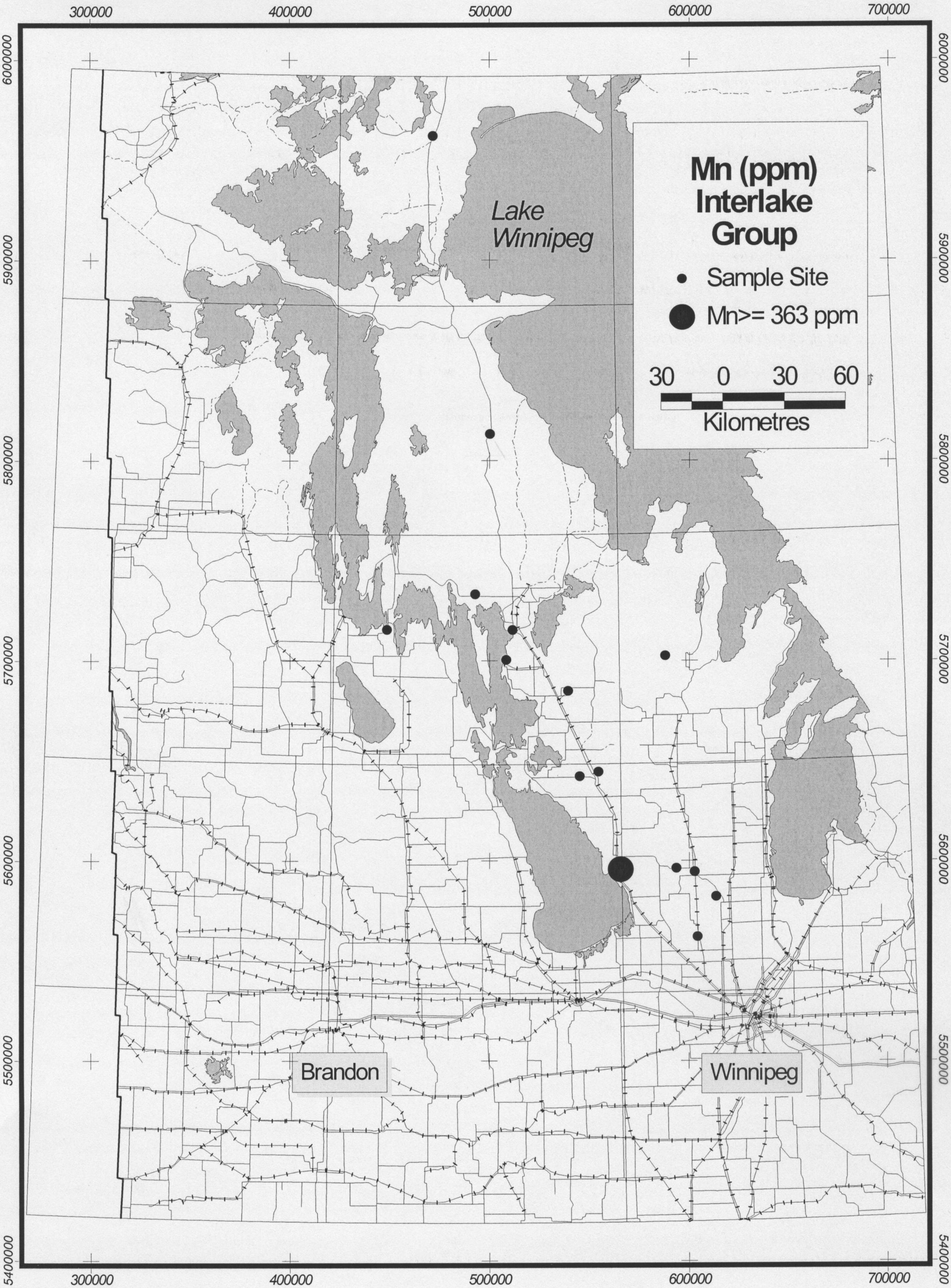
Ni >= 31 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/02-22-027-07W1/00	M-04-79	544705	5685350	37.0	27	21	0	90	7800	41	-	SILURIANUND	SILURIANUND

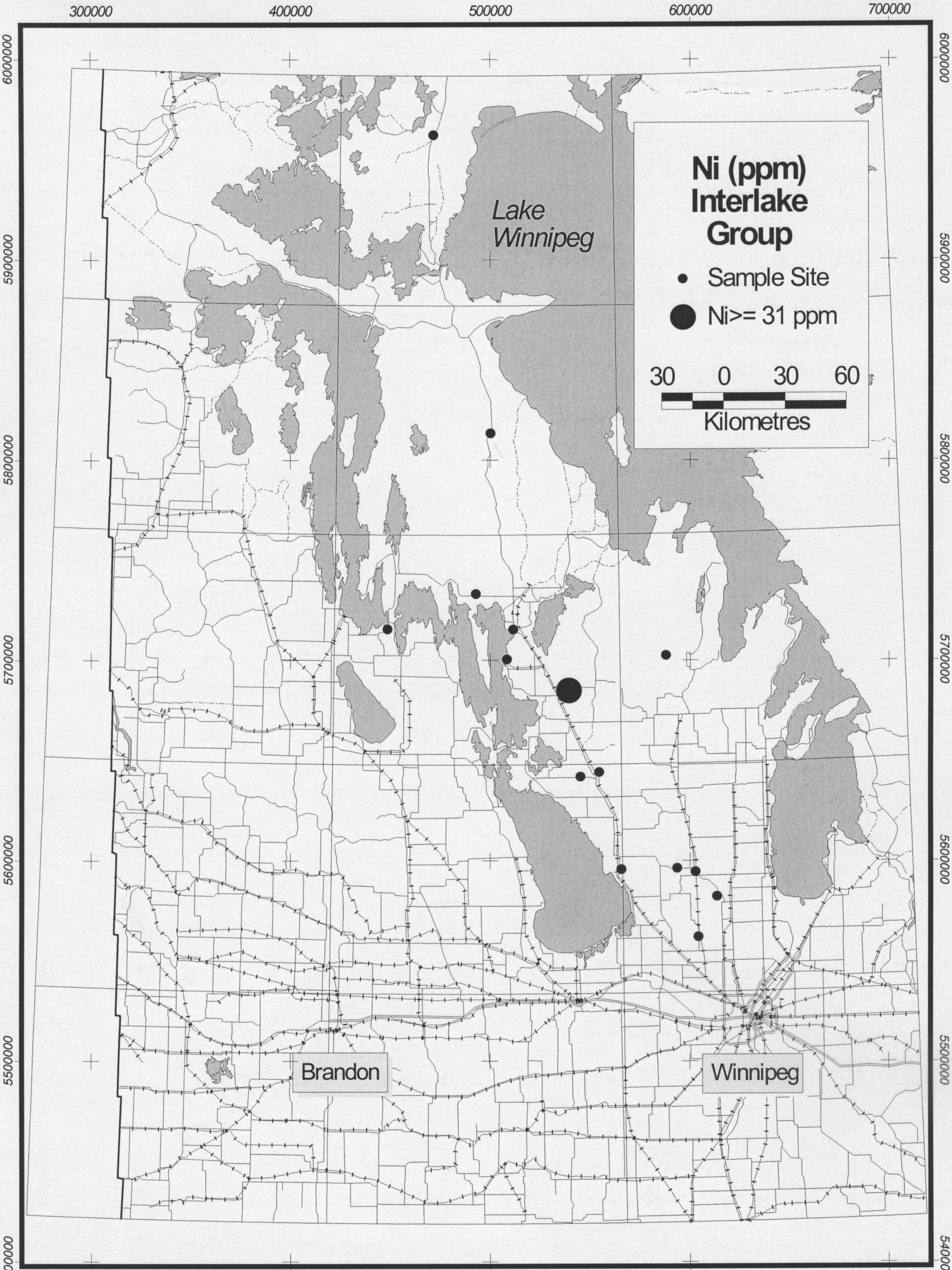

Interlake Group
Sample Site
30 0 30 60
Kilometres
Lake Winnipeg
Brandon
Winnipeg
300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000


Cu (ppm)
Interlake
Group
Sample Site
Cu>= 20 ppm
30 0 30 60
Kilometres
Lake
Winnipeg
Brandon
Winnipeg
300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000


300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000
Lake Winnipeg
Pb (ppm)
Interlake
Group
Sample Site
Pb>= 19 ppm
30 0 30 60
Kilometres
Brandon
Winnipeg



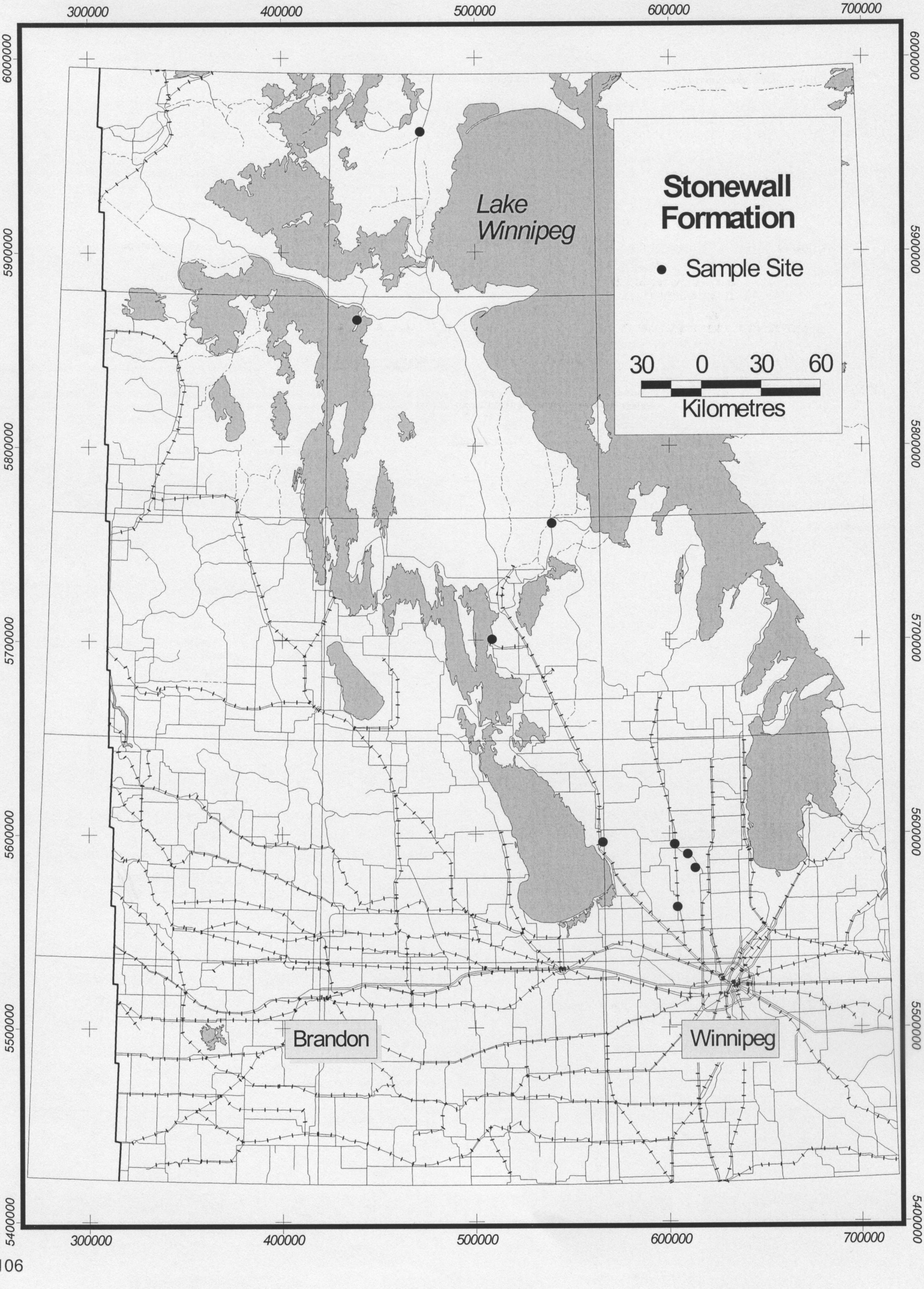
300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000
Lake Winnipeg
Mn (ppm) Interlake Group
Sample Site
Mn>= 363 ppm
30 0 30 60
Kilometres
Brandon
Winnipeg


Ni (ppm)
Interlake
Group
Sample Site
Ni>= 31 ppm
30 0 30 60
Kilometres
Lake
Winnipeg
Brandon
Winnipeg
300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000

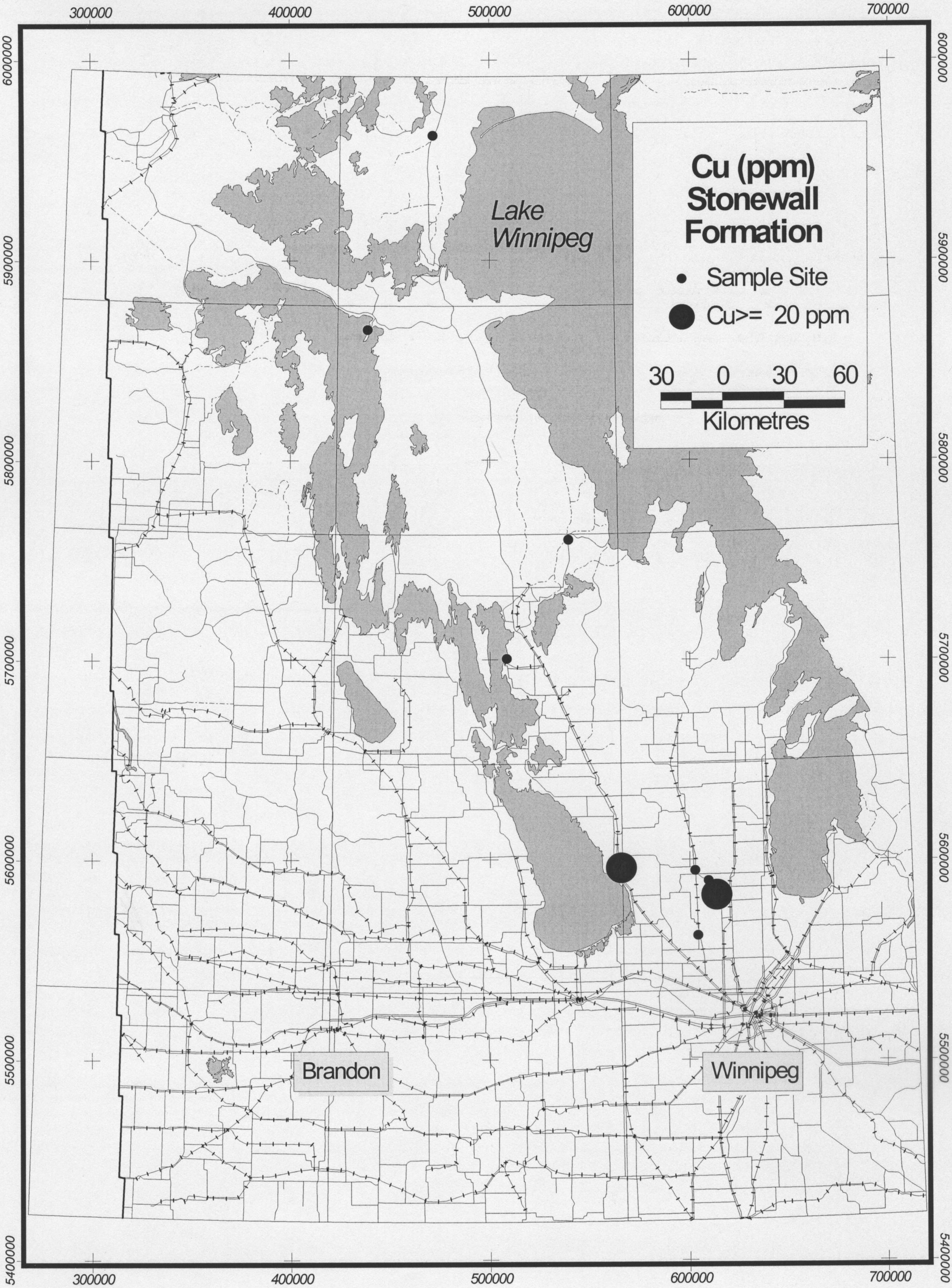
Stonewall Formation

Cu >= 20 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/04-18-018-04W1/00	69-01	570285	5598850	112.8	22	18	0	82	3900	4	-	STONEWALL	WILLIAMS
100/14-35-016-01E1/00	M-11-79	616575	5585850	13.6	64	14	0	65	650	0	-	STONEWALL	STONEWALLU



300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000
Lake Winnipeg
Stonewall Formation
Sample Site
30 0 30 60
Kilometres
Brandon
Winnipeg



Cu (ppm)
Stonewall
Formation
Sample Site
Cu>= 20 ppm
30 0 30 60
Kilometres
Lake Winnipeg
Brandon
Winnipeg
300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000

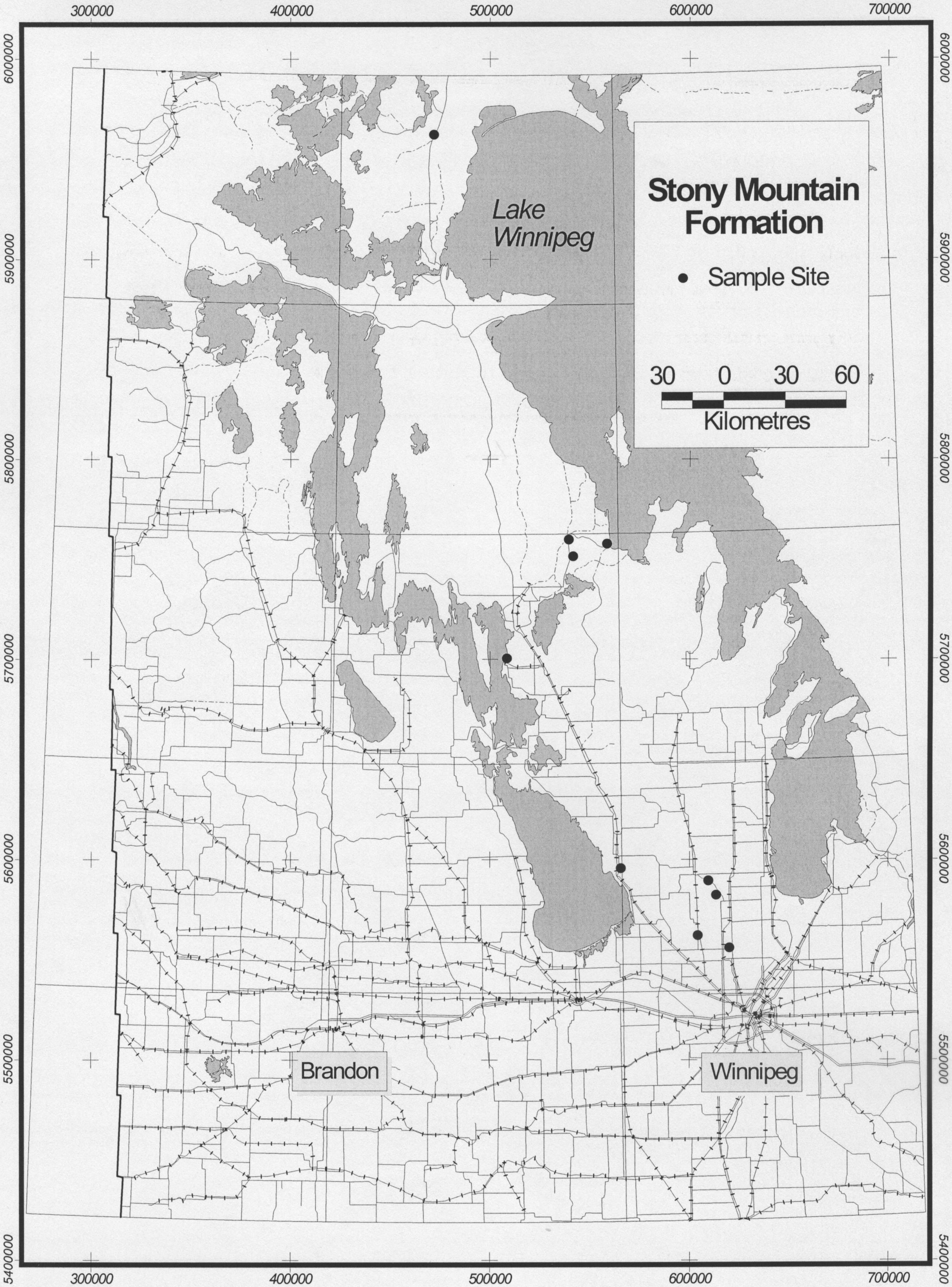
Stony Mountain Formation

Cu >= 20 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/15-35-014-01W1/00	69-02	607621	5566250	73.2	35	24	4	205	5550	0	-	STONYMTN	PENITENTIARY
100/15-35-014-01W1/00	69-02	607621	5566250	73.6	44	20	0	220	6550	0	-	STONYMTN	PENITENTIARY
100/15-35-014-01W1/00	69-02	607621	5566250	75.1	45	27	3	260	6600	0	-	STONYMTN	PENITENTIARY
100/15-35-014-01W1/00	69-02	607621	5566250	76.3	29	34	0	225	7750	0	-	STONYMTN	PENITENTIARY
100/15-35-014-01W1/00	69-02	607621	5566250	80.2	42	27	17	245	5250	0	-	STONYMTN	PENITENTIARY
100/01-17-014-02E1/00	M-01-80	622985	5560225	28.4	34	30	5	200	6000	0	-	STONYMTN	GUNN

Zn >= 45 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/11-02-035-07W1/00	LSM-11	544740	5758240	39.0	5	81	5	105	4500	6	-	STONYMTN	GUNN


Stony Mountain Formation
Sample Site
30 0 30 60
Kilometres
Lake Winnipeg
Brandon
Winnipeg
300000
400000
500000
600000
700000
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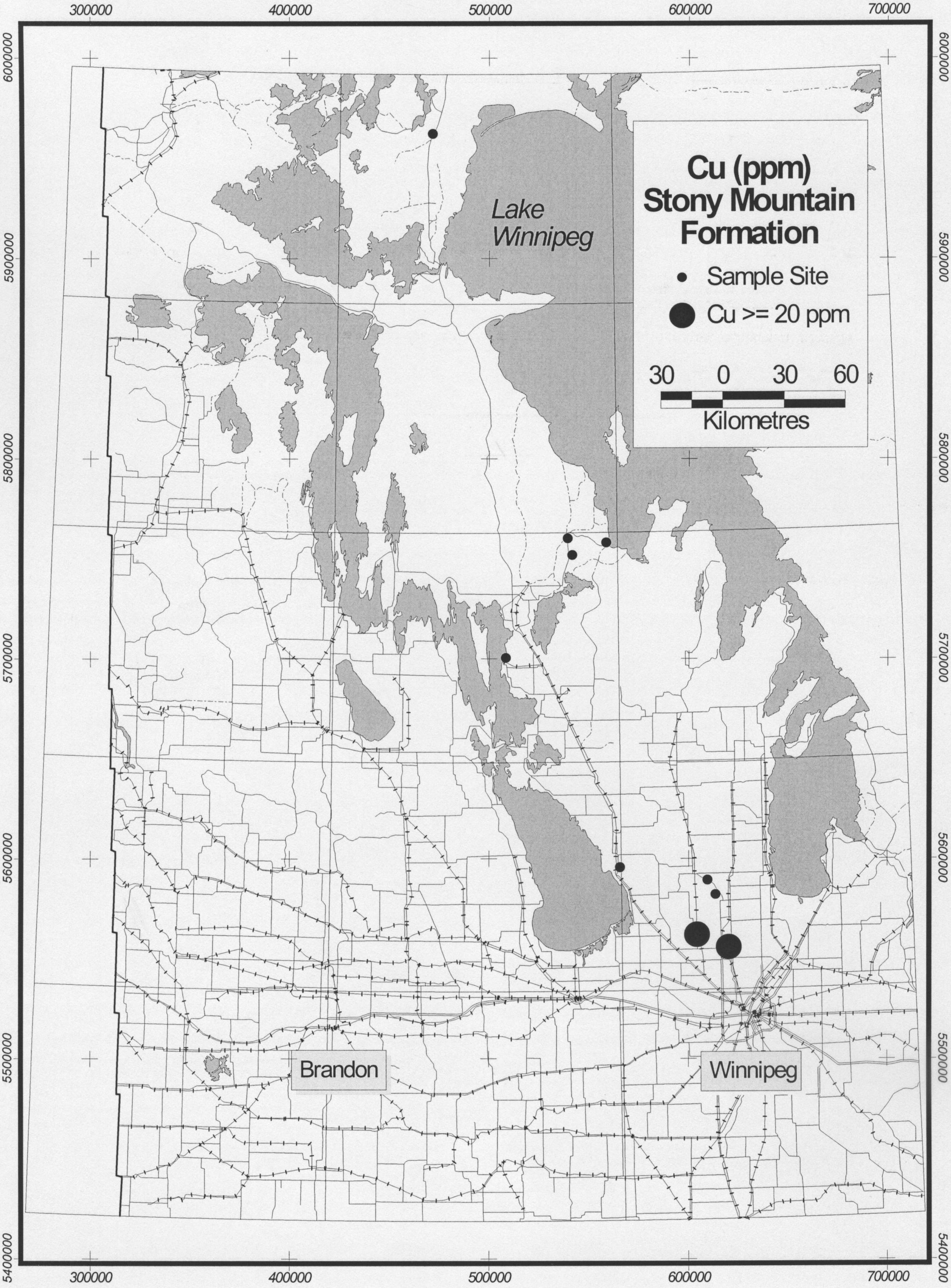
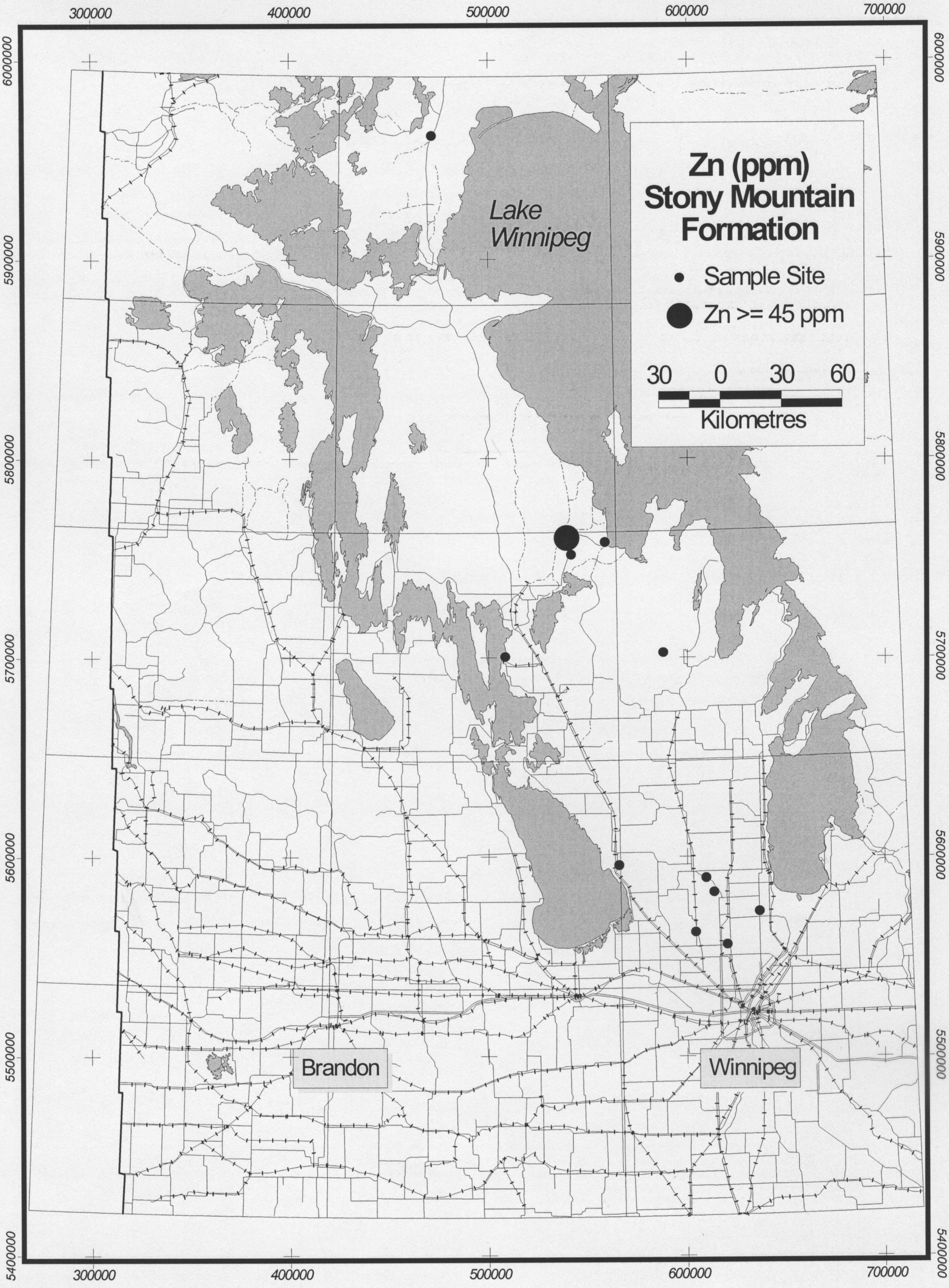
5900000
5800000
5700000
5600000
5500000
5400000



Cu (ppm)
Stony Mountain
Formation
Sample Site
Cu >= 20 ppm
30 0 30 60
Kilometres
Lake
Winnipeg
Brandon
Winnipeg
300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000


Zn (ppm)
Stony Mountain
Formation
Sample Site
Zn >= 45 ppm
30 0 30 60
Kilometres
Lake
Winnipeg
Brandon
Winnipeg
300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000

Red River Formation

Cu >= 20 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/04-28-017-01E1/00	69-03	612685	5592790	109.7	26	8	1	80	1350	0	-	REDRIVER	SELKIRK
100/01-17-014-02E1/00	M-01-80	622985	5560225	29.0	21	34	8	195	4850	0	-	REDRIVER	FORTGARRY
100/03-25-016-03E1/00	M-03-79	638000	5583600	18.8	25	10	0	105	1250	0	-	REDRIVER	SELKIRK
100/01-09-029-02W1/00	M-03-82	591775	5702500	151.2	49	17	2	182	4250	5	-	REDRIVER	CRATERBRECCIA
100/01-09-029-02W1/00	M-03-82	591775	5702500	158.2	34	16	4	188	6150	16	-	REDRIVER	CRATERBRECCIA
100/10-03-029-10W1/00	M-04-80	514658	5700545	268.7	143	3	0	175	2850	2	-	REDRIVER	DOGHEAD
100/14-35-016-01E1/00	M-11-79	616575	5585850	74.3	48	31	11	290	3200	0	-	REDRIVER	FORTGARRY

Zn >= 45 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/16-36-015-03E1/00	69-04	638800	5576400	91.7	3	67	0	345	5200	8	-	REDRIVER	DOGHEAD
100/16-36-015-03E1/00	69-04	638800	5576400	92.4	4	122	0	292	12800	17	-	REDRIVER	DOGHEAD
100/07-12-034-07W1/00	LSM-10	546900	5750300	41.8	2	45	4	85	1450	4	-	REDRIVER	FORTGARRY
100/11-02-035-07W1/00	LSM-11	544740	5758240	58.2	3	740	0	126	2350	4	-	REDRIVER	FORTGARRY
100/11-02-035-07W1/00	LSM-11	544740	5758240	69.8	1	52	6	89	1900	1	-	REDRIVER	FORTGARRY
100/11-02-035-07W1/00	LSM-11	544740	5758240	73.2	1	45	3	88	2950	4	-	REDRIVER	FORTGARRY
100/01-09-029-02W1/00	M-03-82	591775	5702500	226.7	2	65	4	263	6200	5	-	REDRIVER	REDRIVERL
100/10-03-029-10W1/00	M-04-80	514658	5700545	183.6	1	76	2	65	1200	3	-	REDRIVER	FORTGARRY

Pb >= 19 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/04-28-017-01E1/00	69-03	612685	5592790	113.1	6	8	42	85	1050	0	-	REDRIVER	SELKIRK
100/07-12-034-07W1/00	LSM-10	546900	5750300	34.1	18	10	19	169	3150	49	-	REDRIVER	FORTGARRY
100/11-02-035-07W1/00	LSM-11	544740	5758240	125.0	0	8	23	82	1000	1	-	REDRIVER	DOGHEAD
100/10-27-013-03E1/00	M-01-70	635685	5554825	13.7	2	25	22	97	1900	7	-	REDRIVER	FORTGARRY
100/10-27-013-03E1/00	M-01-70	635685	5554825	31.4	4	27	35	175	2500	2	-	REDRIVER	FORTGARRY
100/03-25-016-03E1/00	M-03-79	638000	5583600	20.1	4	10	32	130	1650	0	-	REDRIVER	SELKIRK
100/03-25-016-03E1/00	M-03-79	638000	5583600	23.1	5	11	27	135	1900	0	-	REDRIVER	SELKIRK
100/03-25-016-03E1/00	M-03-79	638000	5583600	23.5	5	13	19	140	1750	0	-	REDRIVER	SELKIRK
100/03-25-016-03E1/00	M-03-79	638000	5583600	23.8	5	10	69	130	1500	0	-	REDRIVER	SELKIRK
100/03-25-016-03E1/00	M-03-79	638000	5583600	25.2	5	10	36	115	1350	0	-	REDRIVER	SELKIRK
100/03-25-016-03E1/00	M-03-79	638000	5583600	25.8	5	11	23	95	1150	0	-	REDRIVER	SELKIRK
100/03-25-016-03E1/00	M-03-79	638000	5583600	42.3	5	15	22	115	1050	0	-	REDRIVER	SELKIRK
100/03-25-016-03E1/00	M-03-79	638000	5583600	46.4	5	8	24	125	1300	0	-	REDRIVER	SELKIRK

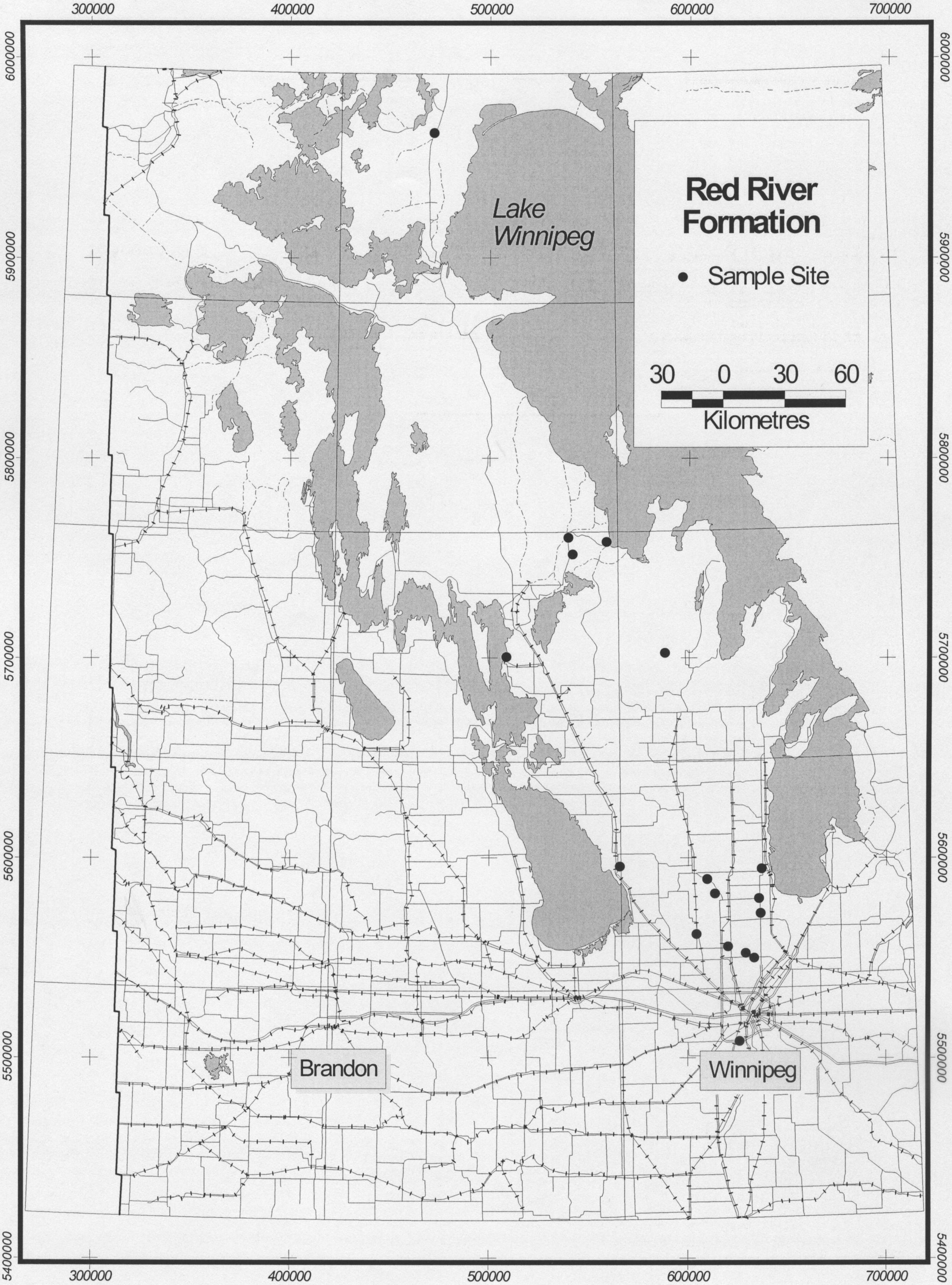
Mn >= 363 ppm (99th percentile)

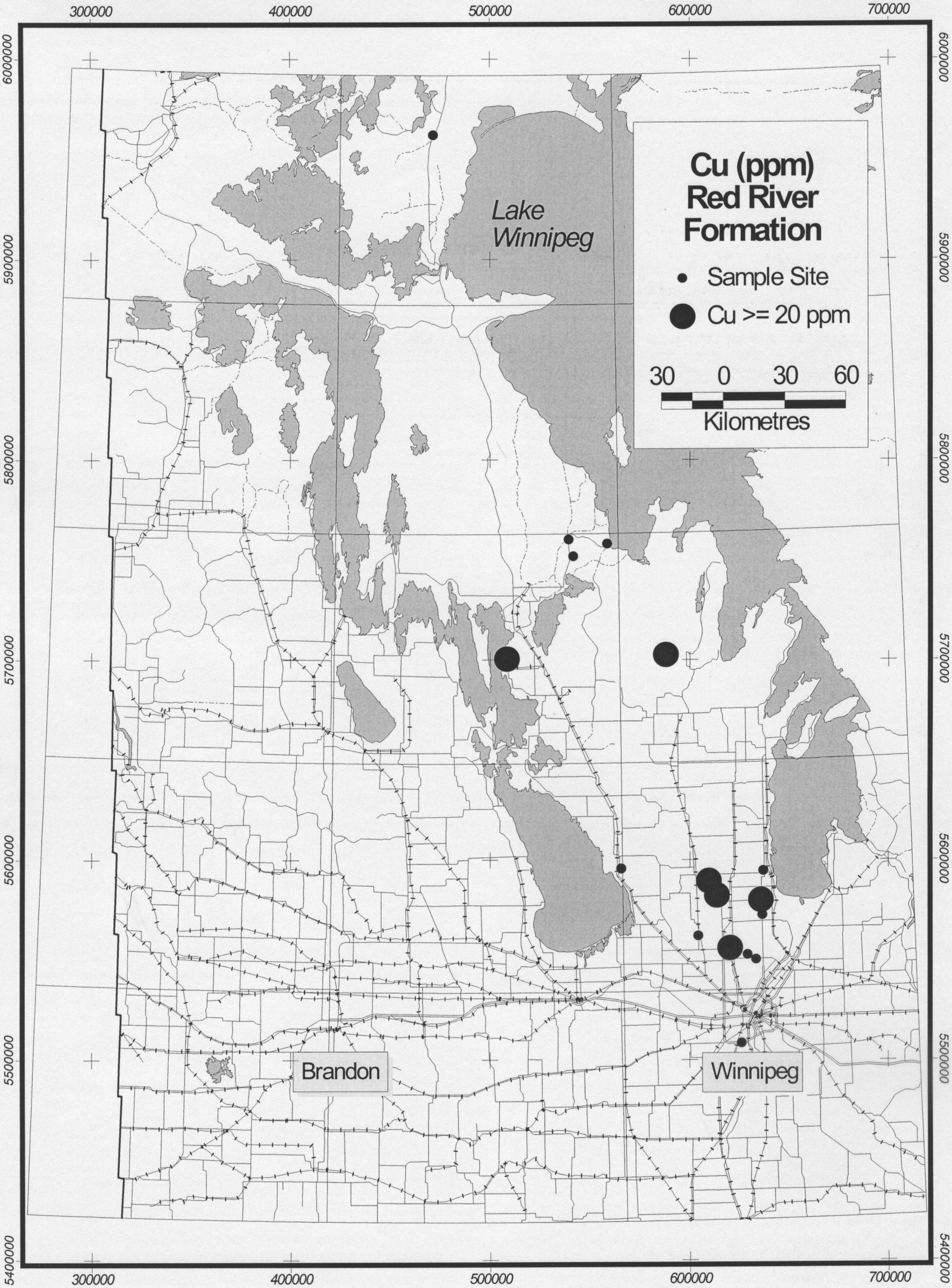
Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/16-36-015-03E1/00	69-04	638800	5576400	97.8	2	18	0	389	6750	9	-	REDRIVER	DOGHEAD
100/16-36-015-03E1/00	69-04	638800	5576400	98.5	4	19	0	405	8650	12	-	REDRIVER	DOGHEAD
100/16-36-015-03E1/00	69-04	638800	5576400	99.1	3	18	0	442	7450	10	-	REDRIVER	DOGHEAD
100/16-36-015-03E1/00	69-04	638800	5576400	99.7	3	19	0	477	10400	13	-	REDRIVER	DOGHEAD
100/16-36-015-03E1/00	69-04	638800	5576400	100.3	3	19	0	519	11100	12	-	REDRIVER	DOGHEAD
100/11-02-035-07W1/00	LSM-11	544740	5758240	148.4	0	6	0	363	6350	4	-	REDRIVER	DOGHEAD
100/01-09-029-02W1/00	M-03-82	591775	5702500	188.5	7	19	0	381	7100	5	-	REDRIVER	FORTGARRY
100/10-03-029-10W1/00	M-04-80	514658	5700545	277.7	1	7	0	380	10450	5	-	REDRIVER	DOGHEAD
100/16-10-055-13W1/00	M-05-79	479050	5954750	108.9	1	3	0	373	4000	1	-	REDRIVER	SELKIRK
100/16-10-055-13W1/00	M-05-79	479050	5954750	111.3	1	3	0	374	4100	1	-	REDRIVER	SELKIRK
100/16-10-055-13W1/00	M-05-79	479050	5954750	111.9	1	3	0	368	3650	0	-	REDRIVER	SELKIRK
100/16-10-055-13W1/00	M-05-79	479050	5954750	112.5	1	3	2	394	4150	1	-	REDRIVER	SELKIRK
100/16-10-055-13W1/00	M-05-79	479050	5954750	113.1	1	3	2	390	4300	1	-	REDRIVER	SELKIRK
100/16-10-055-13W1/00	M-05-79	479050	5954750	113.7	2	3	0	560	4250	2	-	REDRIVER	SELKIRK
100/16-10-055-13W1/00	M-05-79	479050	5954750	114.3	2	3	0	550	4300	1	-	REDRIVER	SELKIRK
100/16-10-055-13W1/00	M-05-79	479050	5954750	115.0	1	7	0	580	5000	1	-	REDRIVER	SELKIRK
100/16-10-055-13W1/00	M-05-79	479050	5954750	115.6	2	3	0	590	5050	1	-	REDRIVER	SELKIRK
100/16-10-055-13W1/00	M-05-79	479050	5954750	116.2	2	3	0	590	5500	1	-	REDRIVER	SELKIRK
100/16-10-055-13W1/00	M-05-79	479050	5954750	116.8	1	2	0	580	5100	1	-	REDRIVER	SELKIRK
100/16-10-055-13W1/00	M-05-79	479050	5954750	117.4	3	2	0	610	5550	2	-	REDRIVER	SELKIRK
100/14-06-018-04E1/00	M-07-80	639168	5597872	79.6	5	15	5	380	4950	1	-	REDRIVER	DOGHEAD
100/14-06-018-04E1/00	M-07-80	639168	5597872	86.3	11	25	0	376	9000	8	-	REDRIVER	DOGHEAD
100/14-06-018-04E1/00	M-07-80	639168	5597872	86.9	9	21	0	397	10050	7	-	REDRIVER	DOGHEAD
100/14-06-018-04E1/00	M-07-80	639168	5597872	87.5	9	29	0	427	10550	9	-	REDRIVER	DOGHEAD
100/14-06-018-04E1/00	M-07-80	639168	5597872	88.2	11	26	3	551	11150	6	-	REDRIVER	DOGHEAD
100/14-06-018-04E1/00	M-07-80	639168	5597872	88.8	13	28	4	633	12550	13	-	REDRIVER	DOGHEAD

Appendix 3: Tables and maps of data at concentrations ≥ 99 percentile. *(continued)*

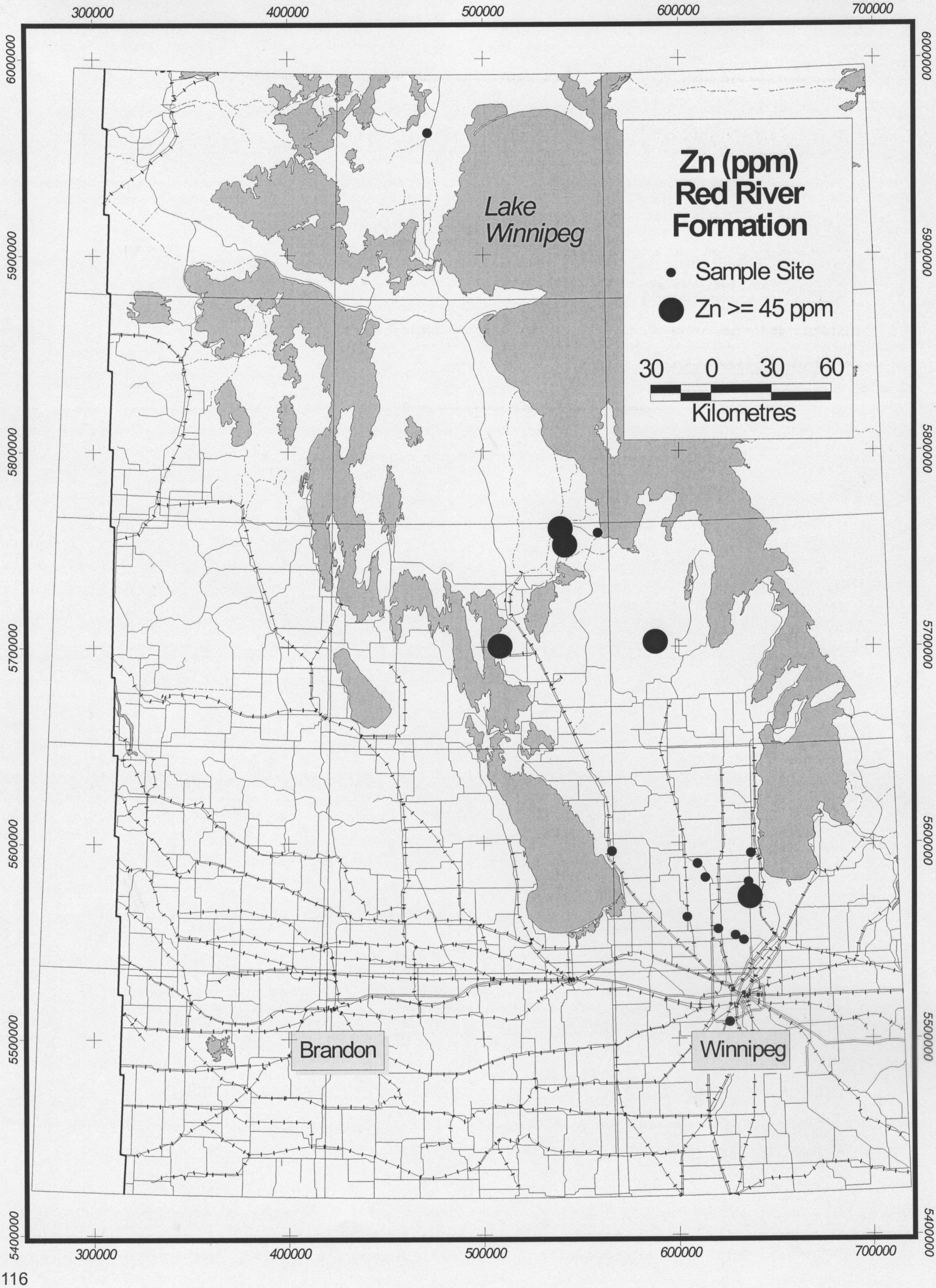
Ni >= 31 ppm (99th percentile)

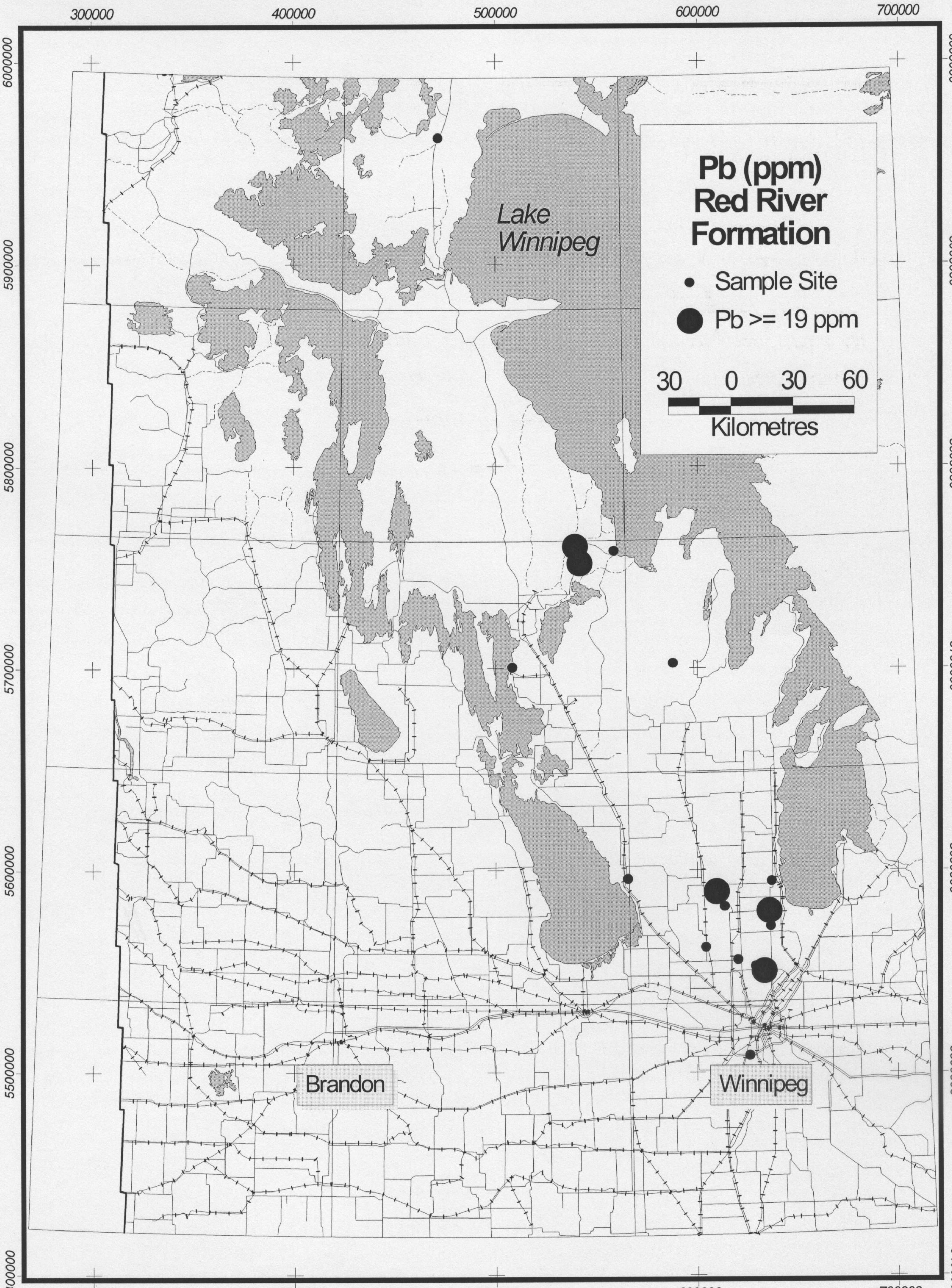
Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/07-12-034-07W1/00	LSM-10	546900	5750300	34.1	18	10	19	169	3150	49	-	REDRIVER	FORTGARRY
100/07-12-034-07W1/00	LSM-10	546900	5750300	41.1	2	6	0	86	1900	31	-	REDRIVER	FORTGARRY
100/10-27-034-05W1/00	M-03-80	563348	5756228	11.4	3	4	0	256	4650	120	-	REDRIVER	FORTGARRY


Red River Formation
Sample Site
30 0 30 60
Kilometres
Lake Winnipeg
Brandon
Winnipeg
300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000

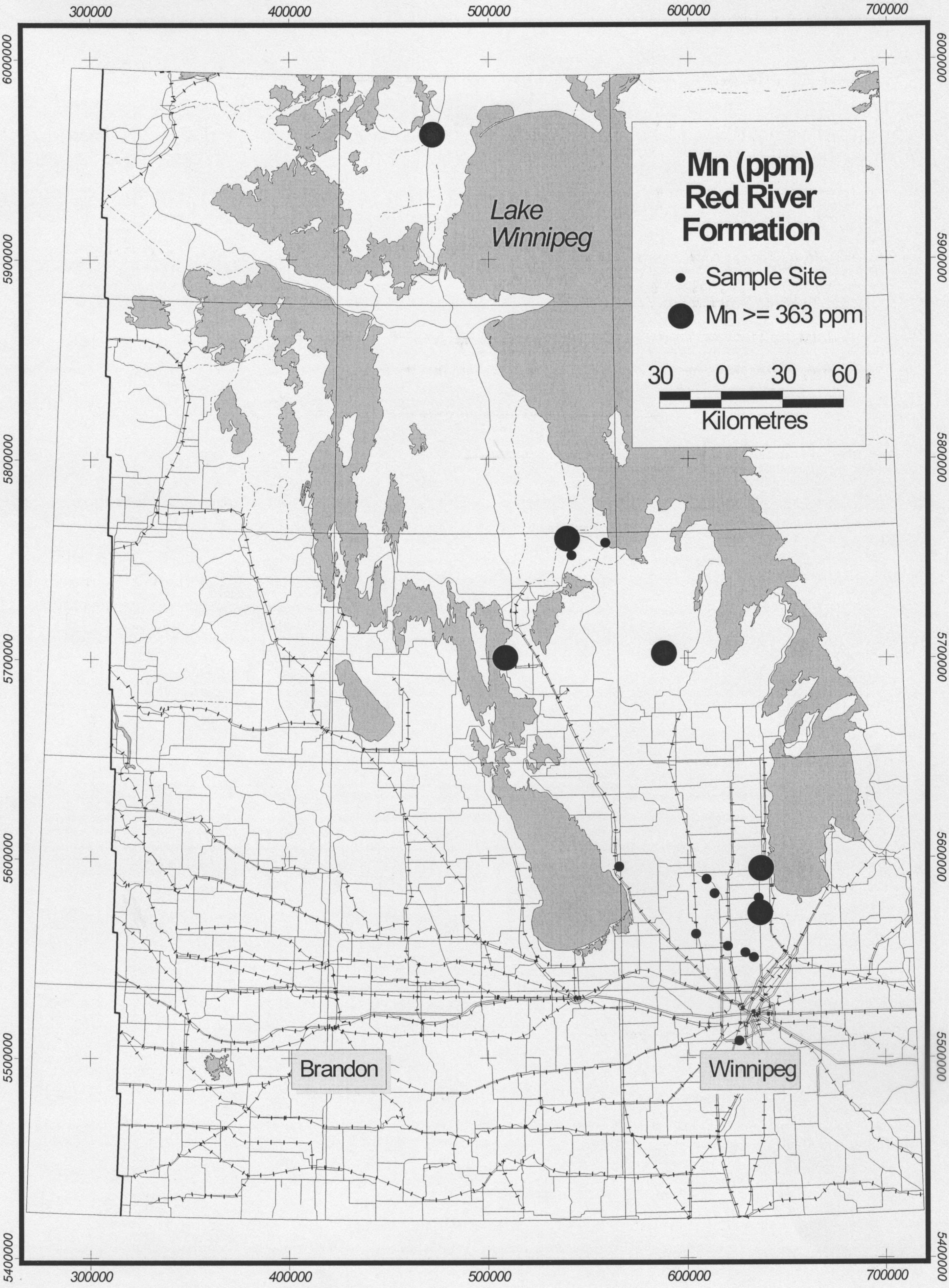


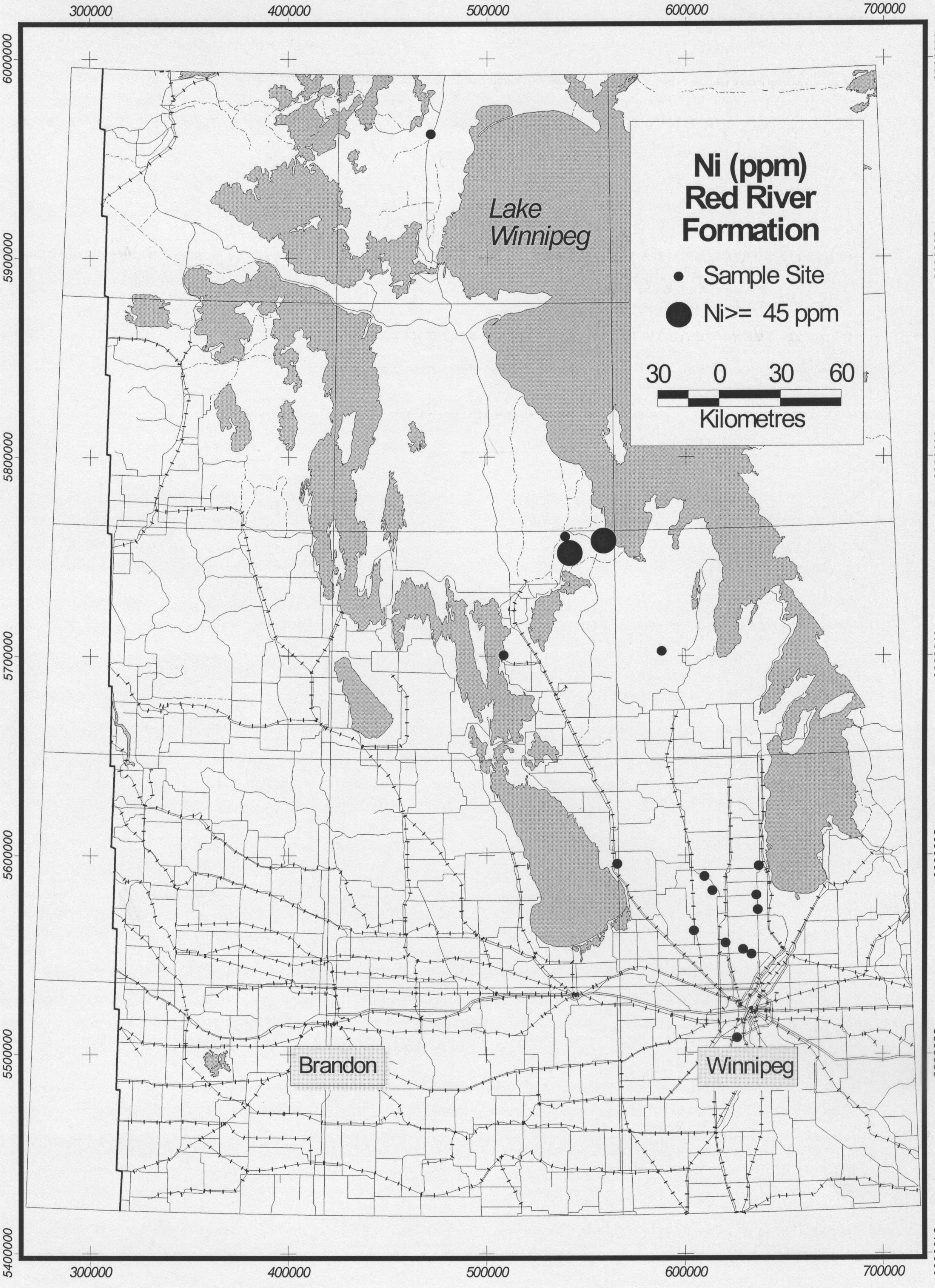
300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000
Lake Winnipeg
Cu (ppm)
Red River
Formation
Sample Site
Cu >= 20 ppm
30 0 30 60
Kilometres
Brandon
Winnipeg


Zn (ppm)
Red River
Formation
Sample Site
Zn >= 45 ppm
30 0 30 60
Kilometres
Lake
Winnipeg
Brandon
Winnipeg
300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000



Pb (ppm)
Red River
Formation
Sample Site
Pb >= 19 ppm
30 0 30 60
Kilometres
Lake Winnipeg
Brandon
Winnipeg
300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000


Mn (ppm)
Red River
Formation
Sample Site
Mn >= 363 ppm
30 0 30 60
Kilometres
Lake
Winnipeg
Brandon
Winnipeg
300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000


300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000
Lake Winnipeg
Ni (ppm)
Red River
Formation
Sample Site
Ni>= 45 ppm
30 0 30 60
Kilometres
Brandon
Winnipeg

Appendix 3: Tables and maps of data at concentrations ≥ 99 percentile. *(continued)*

Winnipeg Formation

Cu >= 20 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/16-36-015-03E1/00	69-04	638800	5576400	102.7	22	57	0	220	31500	31	-	WINNIPEG	WINNIPEGU
100/16-36-015-03E1/00	69-04	638800	5576400	103.9	28	58	3	191	30650	32	-	WINNIPEG	WINNIPEGU
100/16-36-015-03E1/00	69-04	638800	5576400	104.5	70	89	20	234	36450	55	-	WINNIPEG	WINNIPEGU
100/11-02-035-07W1/00	LSM-11	544740	5758240	149.4	46	36	4	62	25500	45	-	WINNIPEG	WINNIPEG
100/10-03-029-10W1/00	M-04-80	514658	5700545	278.3	20	14	0	1100	12650	9	-	WINNIPEG	WINNIPEGU

Zn >= 45 ppm (99th percentile)

Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/16-36-015-03E1/00	69-04	638800	5576400	102.7	22	57	0	220	31500	31	-	WINNIPEG	WINNIPEGU
100/16-36-015-03E1/00	69-04	638800	5576400	103.3	14	64	2	242	36300	35	-	WINNIPEG	WINNIPEGU
100/16-36-015-03E1/00	69-04	638800	5576400	103.9	28	58	3	191	30650	32	-	WINNIPEG	WINNIPEGU
100/16-36-015-03E1/00	69-04	638800	5576400	104.5	70	89	20	234	36450	55	-	WINNIPEG	WINNIPEGU
100/16-36-015-03E1/00	69-04	638800	5576400	105.2	5	46	33	129	22150	32	-	WINNIPEG	WINNIPEGU

Pb >= 19 ppm (99th percentile)

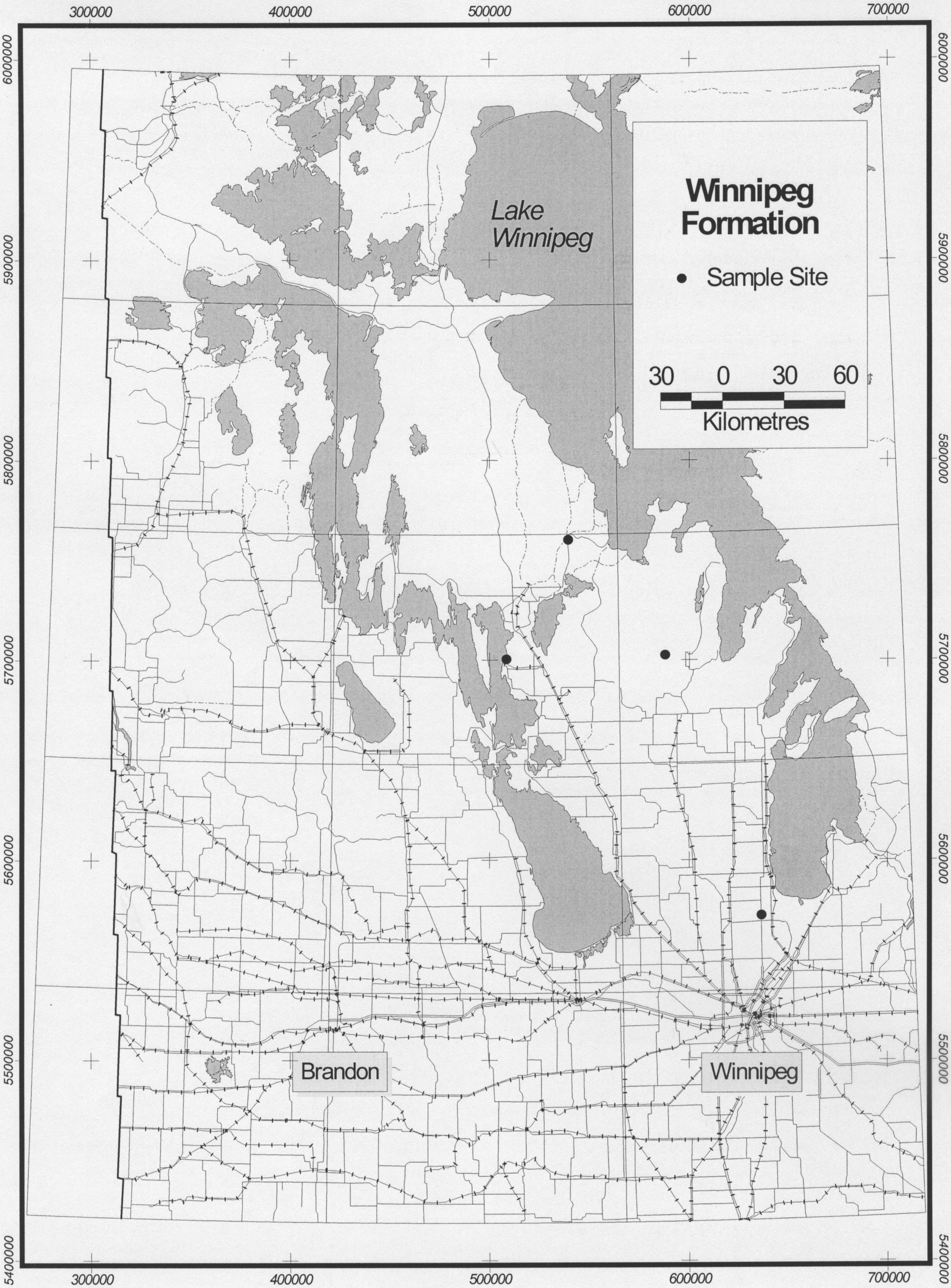
Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/16-36-015-03E1/00	69-04	638800	5576400	104.5	70	89	20	234	36450	55	-	WINNIPEG	WINNIPEGU
100/16-36-015-03E1/00	69-04	638800	5576400	105.2	5	46	33	129	22150	32	-	WINNIPEG	WINNIPEGU

Mn >= 363 ppm (99th percentile)

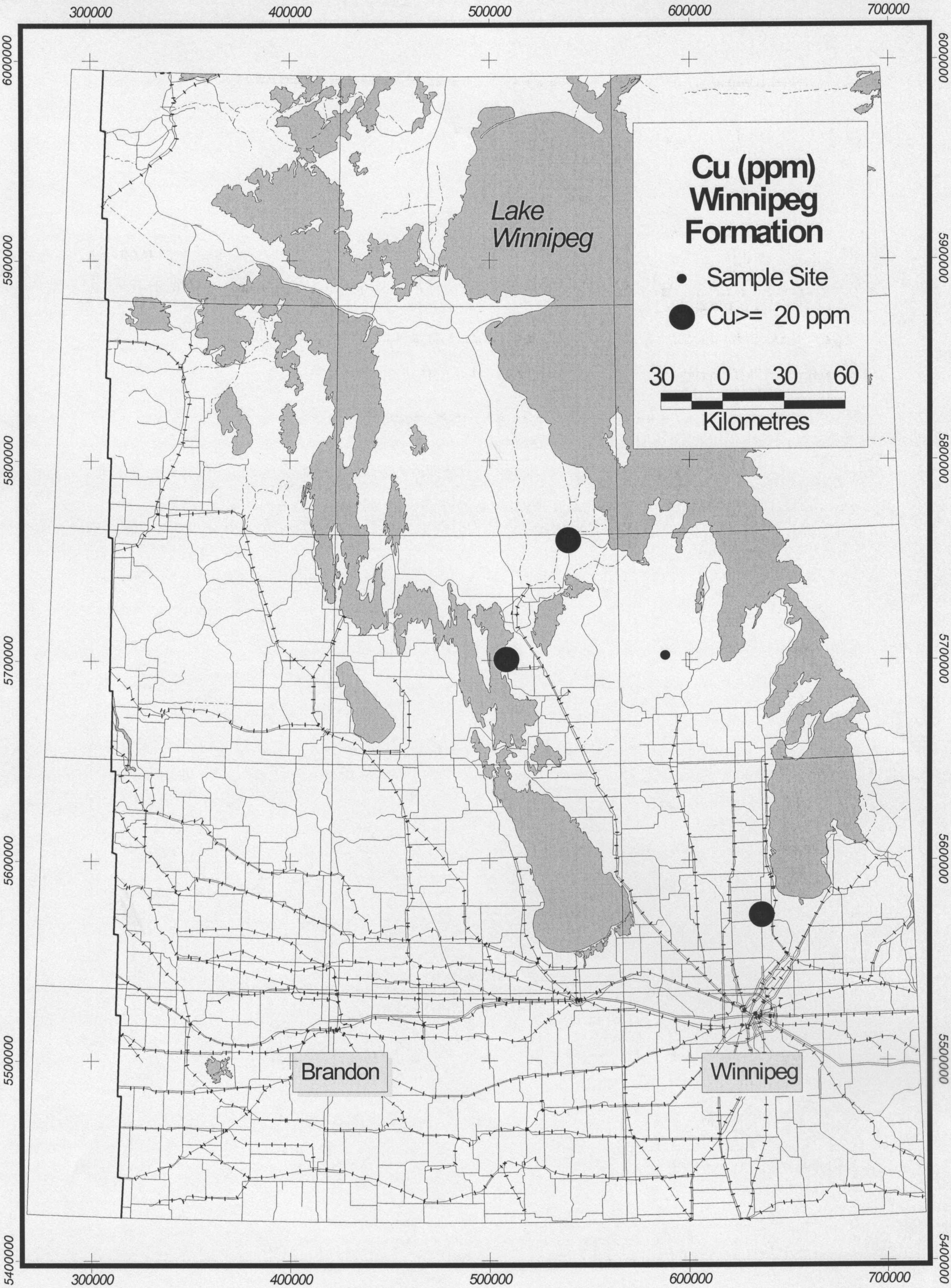
Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/16-36-015-03E1/00	69-04	638800	5576400	100.9	4	21	2	568	12050	14	-	WINNIPEG	WINNIPEGU
100/16-36-015-03E1/00	69-04	638800	5576400	101.5	4	27	6	616	12900	20	-	WINNIPEG	WINNIPEGU
100/16-36-015-03E1/00	69-04	638800	5576400	102.1	11	32	0	849	13700	21	-	WINNIPEG	WINNIPEGU
100/10-03-029-10W1/00	M-04-80	514658	5700545	278.3	20	14	0	1100	12650	9	-	WINNIPEG	WINNIPEGU

Ni >= 31 ppm (99th percentile)

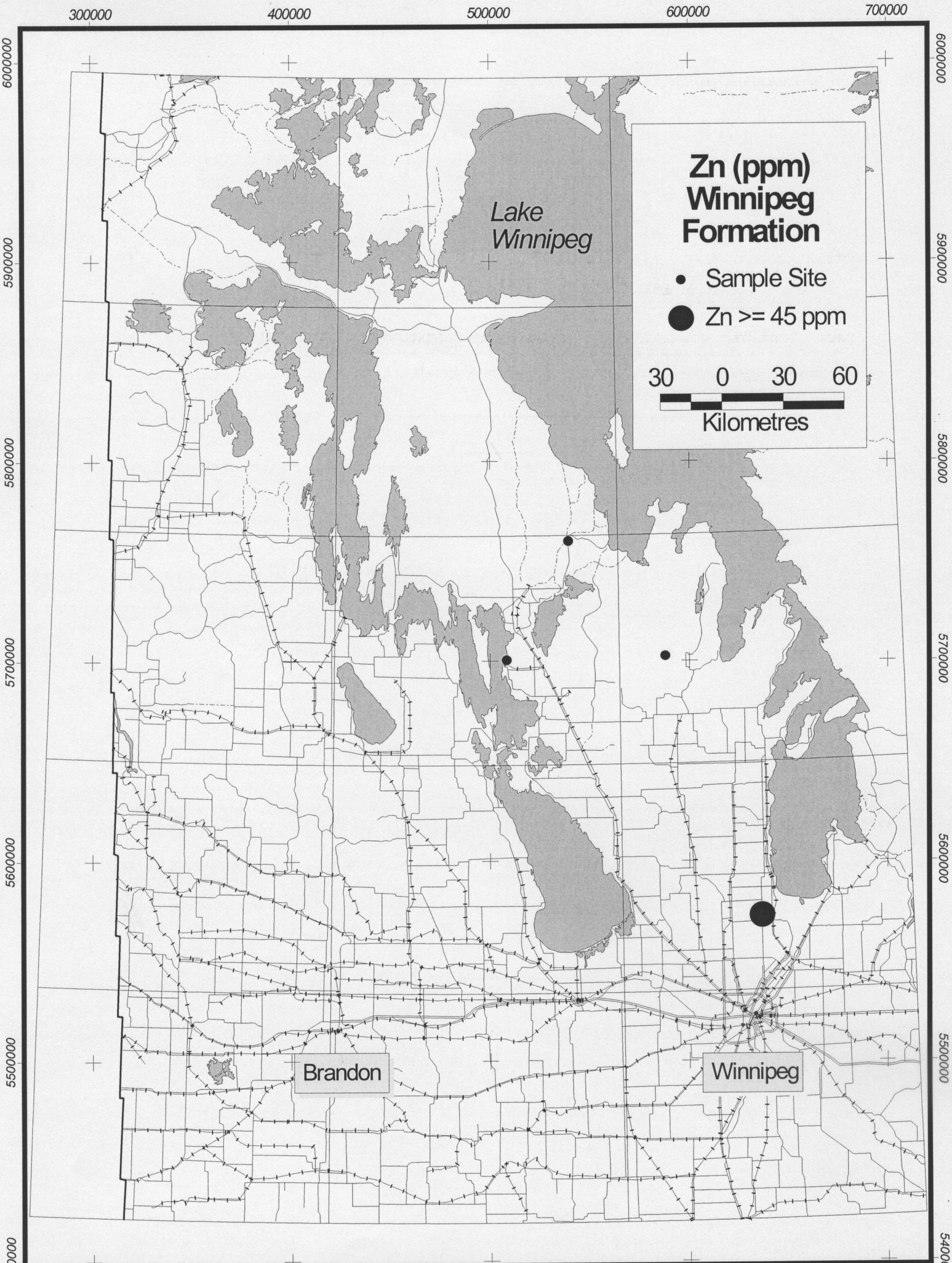
Uwi	Well Name	Easting	Northing	Depth	Cu	Zn	Pb	Mn	Fe	Ni	F	Formation	Subunit
100/16-36-015-03E1/00	69-04	638800	5576400	102.7	22	57	0	220	31500	31	-	WINNIPEG	WINNIPEGU
100/16-36-015-03E1/00	69-04	638800	5576400	103.3	14	64	2	242	36300	35	-	WINNIPEG	WINNIPEGU
100/16-36-015-03E1/00	69-04	638800	5576400	103.9	28	58	3	191	30650	32	-	WINNIPEG	WINNIPEGU
100/16-36-015-03E1/00	69-04	638800	5576400	104.5	70	89	20	234	36450	55	-	WINNIPEG	WINNIPEGU
100/16-36-015-03E1/00	69-04	638800	5576400	105.2	5	46	33	129	22150	32	-	WINNIPEG	WINNIPEGU
100/11-02-035-07W1/00	LSM-11	544740	5758240	149.4	46	36	4	62	25500	45	-	WINNIPEG	WINNIPEG

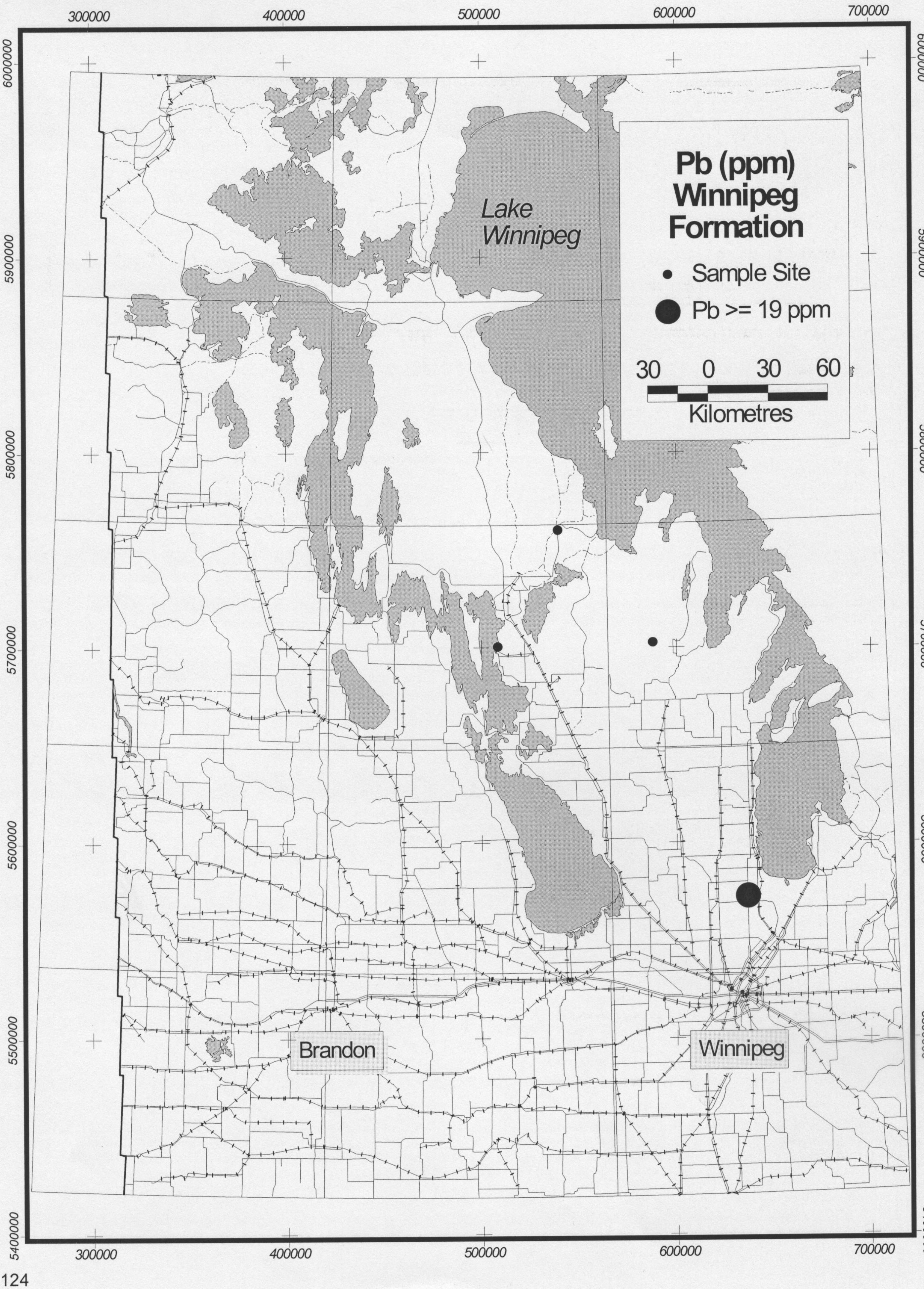


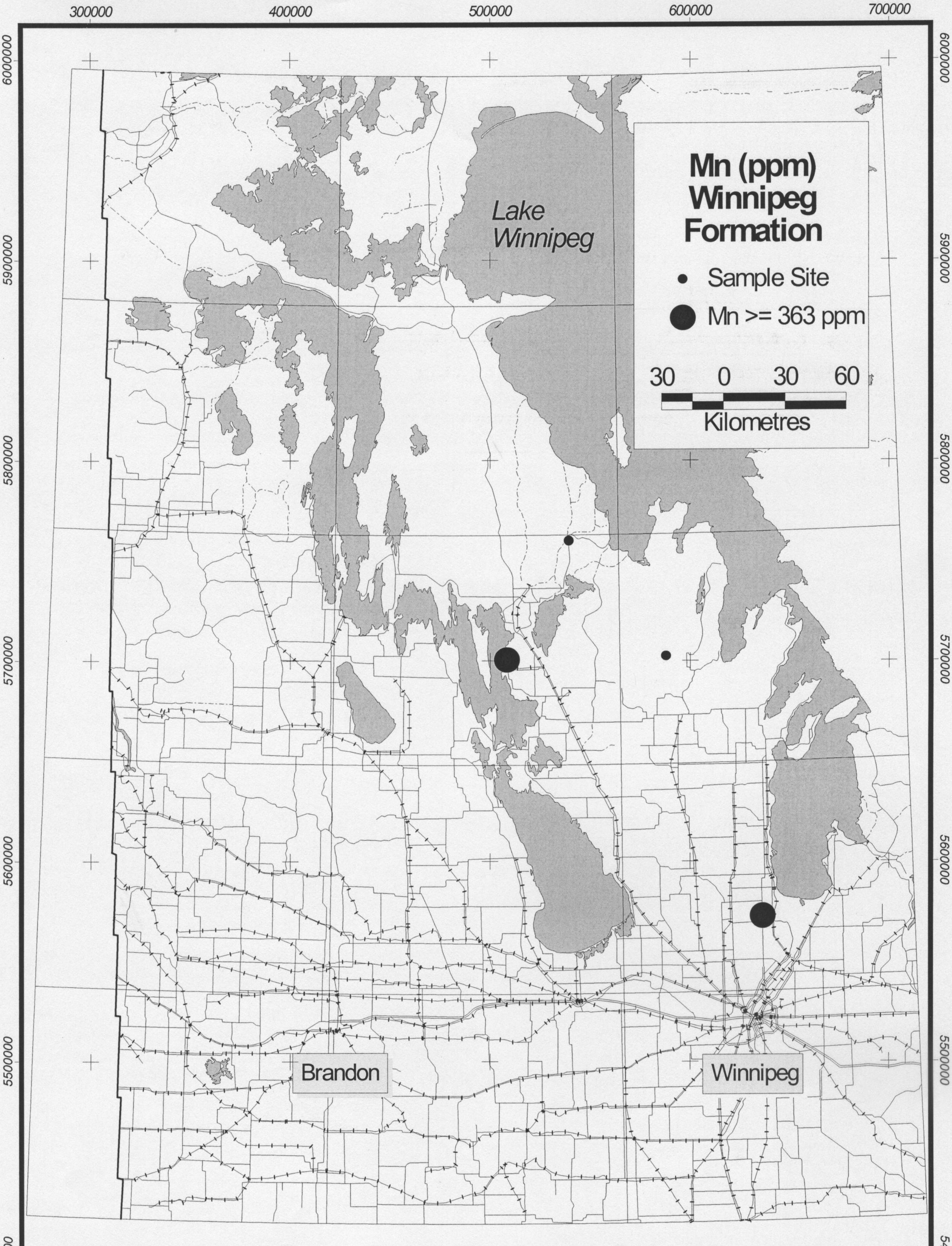
Winnipeg Formation
Sample Site
30
0
30
60
Kilometres
Lake Winnipeg
Brandon
Winnipeg
300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000



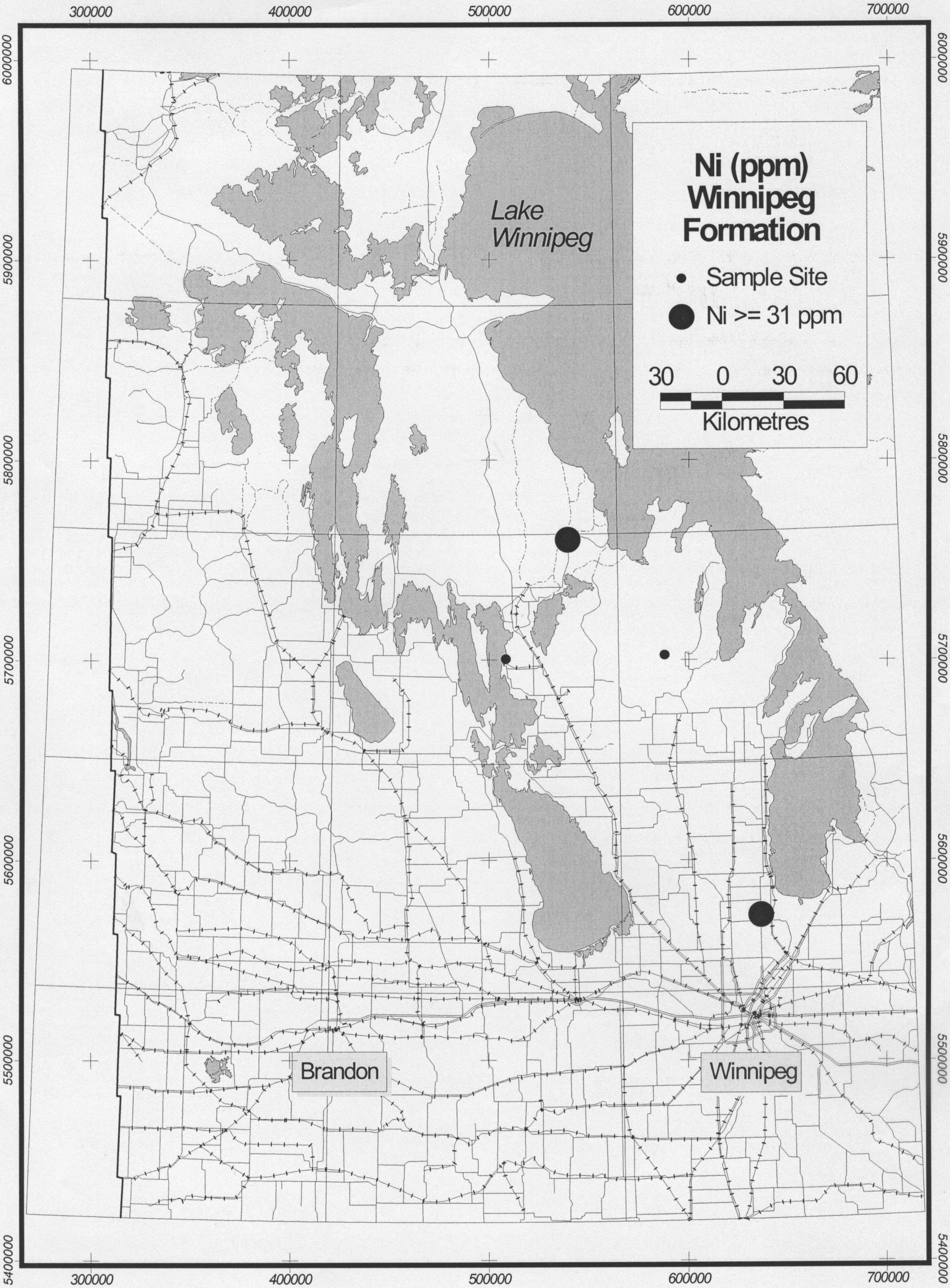
300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000
Lake Winnipeg
Cu (ppm) Winnipeg Formation
Sample Site
Cu>= 20 ppm
30 0 30 60
Kilometres
Brandon
Winnipeg


Zn (ppm)
Winnipeg
Formation
Sample Site
Zn >= 45 ppm
30 0 30 60
Kilometres
Lake
Winnipeg
Brandon
Winnipeg
300000
400000
500000
600000
700000
5400000
5500000
5600000
5700000
5800000
5900000
6000000


300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000
Lake Winnipeg
Pb (ppm) Winnipeg Formation
Sample Site
Pb >= 19 ppm
30 0 30 60
Kilometres
Brandon
Winnipeg



Mn (ppm)
Winnipeg
Formation
Sample Site
Mn >= 363 ppm
30 0 30 60
Kilometres
Lake Winnipeg
Brandon
Winnipeg
300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000


Ni (ppm)
Winnipeg
Formation
Sample Site
Ni >= 31 ppm
30 0 30 60
Kilometres
Lake
Winnipeg
Brandon
Winnipeg
300000
400000
500000
600000
700000
6000000
5900000
5800000
5700000
5600000
5500000
5400000