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GEOSCIENTIFIC REPORT

Bedrock mineral resources of Manitoba's Capital Region

By
R.K. Bezys,
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and G.G. Conley

Manitoba
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Cover photo: Mulder Pit 88 Quarry, East Stonewall, Manitoba. New quarry opening, 1995. Quarry face consists of Gunton Member, Stony Mountain Formation.

ABSTRACT

The distribution of bedrock mineral resources in Manitoba's Capital Region, primarily within Ordovician formations, has been determined from the examination of quarries, outcrops, water-well and corehole data. As a result of the compilation of this data, new depth to bedrock, bedrock topography, geology and mineral potential maps (NTS 62H10, 11, 14 and 15 and 62I2, 3, 6 and 7; scale 1:50 000) are being released in final format, accompanying a geological report. Six areas with high potential for crushed stone were identified in and around the Capital Region, all with less than 5 m of overburden thickness. The sites include the towns of Stonewall (and northeast of the town) and Stony Mountain; the Town of Garson (and Tyndall); the Town of Gunton; east of the Town of East Selkirk; and the Sturgeon Road area (Winnipeg). The City of Winnipeg site was identified after the Manitoba Geological Survey drilled the prospective area. Contour mapping had determined that it was an area of shallow overburden thickness.

The protection of these regions from future land-use pressures will ensure a supply of bedrock resources (either as crushed stone or building stone) for the Capital Region area. These resources provide a tremendous amount of wealth to the economy of Manitoba, and sterilization of these areas will cause considerable expense as other alternatives are sought.

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INTRODUCTION

Objective

The City of Winnipeg is fortunate in having access to ample resources of carbonate bedrock, immediately north of the city in the Rural Municipality of Rockwood. The bedrock is composed primarily of calcium and magnesium carbonate and has many uses in today's economy such as crushed stone aggregates, cement, lime, chemical and metallurgical stone, fillers and extenders, building stone and pulverized stone. Manitoba's construction and transportation infrastructure rely heavily upon these resources and the limestone industry will remain a vital segment of the province's economy well into the new century.

The Capital Region area (Winnipeg and surrounding municipalities) has exerted tremendous pressure on its resources in regard to land-use planning needs. In the Capital Region area, several localities, such as the towns of Stonewall and Stony Mountain, possess areas of shallow bedrock exposures with high potential for bedrock mineral extraction. These sites have been, and continue to be, sources for crushed stone, primarily for use in the City of Winnipeg.

Sand, gravel and crushed stone in the Capital Region are in high demand by the construction industry. Production of these commodities (including dimension stone) in the province was estimated at $44 million in 2001 (Table 1). This extraction forms the largest mining sector by volume produced and land acreage disturbed in Manitoba.

Historically, the population of rural Manitoba has been concentrated in urban centres, such as Winnipeg. However since the early 1970s, there has been a reverse migration from Winnipeg to outlying towns and municipalities. This movement has resulted in land-use patterns within these municipalities changing from rural agricultural to semi-urban and urban. This change has been accompanied by increased pressure by local residents and environmentalists to restrict quarrying of sand, gravel and crushed stone.

Housing subdivisions in the vicinity of active pits and quarries have been a source of public complaints. Quarrying is a heavy industrial land use, which can involve blasting, crushing, screening, operation of heavy equipment and local truck traffic, that may be disruptive to local residents. Rural municipalities are challenged with balancing the pressures for new housing construction and the need to protect both existing quarries and occurrences of near-surface bedrock with industrial mineral potential.

This report will examine many aspects of the bedrock mineral resource potential in the Capital Region area. The first part deals with the geology of limestone and dolomite formations on a regional scale, integrating all recent interpretations of stratigraphy, lithology and nomenclature. This is particularly important as the Capital Region relies heavily on bedrock aggregate because of a shortage of sand and gravel deposits and increasing land-use pressures. The second part deals with the interpretation of the accompanying maps and the economic geology of the region.

The Capital Region Study area (Fig. 1) consists of eight maps from the northern region (bedrock geology, bedrock topography, overburden thickness and mineral potential of NTS 62I2, 3, 6 and 7; scale 1:50 000) and eight maps from the southern region (NTS 62H10, 11, 14 and 15; scale 1:50 000). Preliminary versions of the first eight maps have been released (Bezys et al.,1999a–h). Final versions of all maps accompany this report.

Previous Work

The present study relied predominantly on previous work conducted by Bannatyne and Jones (1979), who produced geology, bedrock topography and overburden thickness maps for NTS 62I2, 3, 6 and 7 (scale 1:50 000). Mineral resource and engineering studies were carried out by Underwood McLellan and Associates Limited (1976) and Kjartanson (1983) for the Winnipeg area, and by James F. MacLaren Limited (1980) for the southern Interlake region. Jones (1986) studied the aggregate potential of bedrock exposures in the Capital Region. A geological and economic investigation was carried out by Bannatyne (1988), who examined the dolomite resources of southern Manitoba.

Table 1: Value of Manitoba stone and sand and gravel production, 1992–2001.[1]

Commodity	1992 ($000s)	1993 ($000s)	1994 ($000s)	1995 ($000s)	1996 ($000s)	1997 ($000s)	1998 ($000s)	1999 ($000s)	2000 ($000s)	2001 ($000s)
Sand and gravel	35,239	33,679	35,486	35,340	26,379	33,283	30,405*	29,989	26,968	26,855p
Stone										
limestone	6,243	8,318	10,170	13,058	11,315	15,487	16,675	15,614	19,688	17,092p
granite	1,510	2,597	1,775	1,851	2,993	3,106	8,196	4,376*		
shale	17	33	87	111	114	123	99	99		
Total	**43,009**	**44,627**	**47,518**	**50,360**	**40,801**	**51,999**	**55,375***	**50,078**	**46,656**	**43,947p**

Notes:
p = preliminary
* = estimated

[1] In Western Canada, the largest use of sand and gravel is for roadbed surfaces, followed by concrete aggregate, asphalt aggregate, and fill. However, production values shown in the table do not include shipments of stone and sand and gravel to Canadian cement and lime plants, but do include natural silica sand and crushed quartz or silica rock.

Source: Canadian Minerals Yearbook, 1992 to 1999 and http://www.nrcan.gc.ca/mms/ms-e.htm for 2000 and 2001.

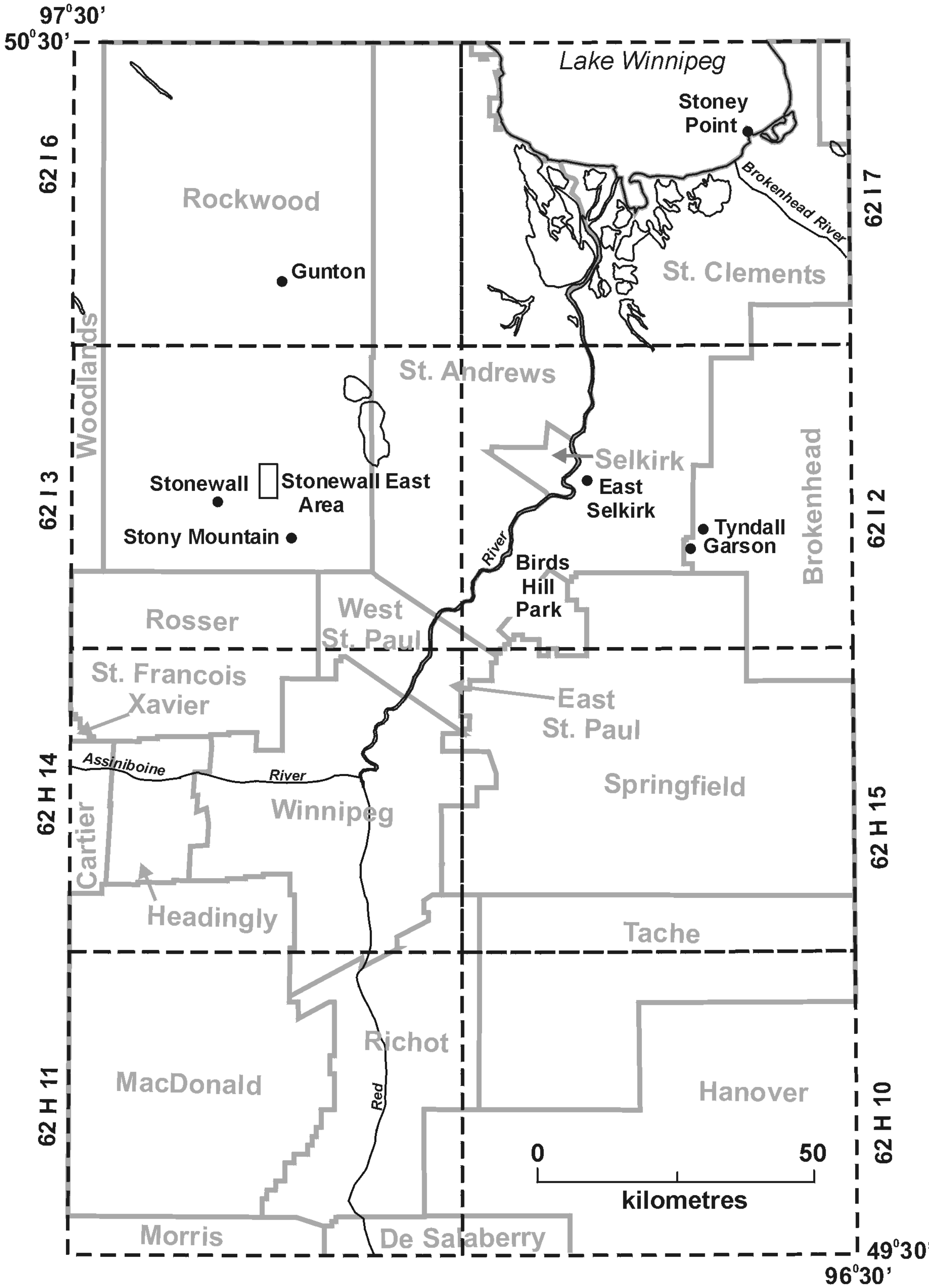


Figure 1: Capital Region area with rural municipality locations.

The glacial geology of the Birds Hill area, northeast of Winnipeg, was studied in detail by Matile (1985). Sand and gravel maps for the following areas have previously been produced: Rural Municipality (R.M.) of Tache (Matile and Conley, 1979); R.M. of St. Clements (Matile and Groom, 1987); R.M. of St. Andrews (Mitchell, 1983); and R.M. of Rosser (Ringrose et al., 1977). Updates to the Capital Region aggregate maps have been done by Groom (1999). A groundwater availability investigation for NTS 62I was conducted by the Water Resources Branch in 1986 (Betcher, 1986) and the resultant maps provided an excellent source of water-well data.

Regional bedrock geological compilations encompassing the area have been carried out by Norford et al. (1994), Bezys and McCabe (1996; 1998), Manitoba Energy and Mines (1997) and Bezys and Conley (1998a–f; 1999).

Present Study

Mandate

The Manitoba Round Table on the Environment and the Economy (established in 1988) initiated a Sustainable Development Strategy for Manitoba's Capital Region in 1993. This is part of a larger strategy to deal with the environment, economy and people of Winnipeg, Selkirk, Stonewall and the surrounding municipalities. This process is outlined in the *Workbook on the Capital Region Strategy* (Manitoba Round Table, 1995) and was used in public open houses and workshops.

Policy 4.3 of the Capital Region Strategy (Manitoba Round Table, 1995) states that "Economically valuable mineral deposits shall be protected from land uses which limit mineral exploration and development. Mitigative action shall be taken to minimize environmental and human health impacts from mining operations. Within the strategy, these mineral deposits will be protected in municipal development plans" (with reviews every 5 years) and in zoning bylaws under the Planning Act. Until the plans or bylaws are in place, Provincial Land Use Policy #9 (Manitoba Round Table, 1995) is used to protect known deposits.

Under Policy 4.3, the identification, evaluation and protection of significant mineral deposits is the responsibility of the Manitoba government. This policy corresponds with Policy 3.1 of the Manitoba Round Table's Minerals Strategy (within its Land and Water Strategy). The Minerals Strategy is documented in *Applying Manitoba's Mineral Policy* (Manitoba Round Table, 1994), which was produced with public consultation in 1991. The process was further refined in *Applying Manitoba's Capital Region Policies* (Manitoba Round Table, 1996), which identified the sectors responsible for implementing the actions listed under Policy 4.3.

To identify and evaluate the bedrock mineral resources in the Capital Region, the Mines Branch of Manitoba Industry, Trade and Mines requested the Manitoba Geological Survey's assistance in the compilation of mineral resources and other geological information. The purpose of this assessment is to provide mineral resource data for use in municipal development plans for the Capital Region that will legally protect high quality quarry minerals.

Initial summaries on the Capital Region Study are presented in Bamburak and Bezys (1995; 1996).

Methodology

The rural municipalities of Rockwood, St. Andrews and St. Clements (Fig. 1) (NTS 62I2, 3, 6 and 7), in the northern part of the Capital Region, were selected as the first municipalities to be assessed and mapped because of the presence of shallow bedrock. To provide the required information in sufficient detail for land-use purposes, it was necessary to produce a computerized subsurface database consisting primarily of water-well records. These water-well records were used to map depth to bedrock, bedrock topography, bedrock geology and mineral potential. Water-well data was augmented with detailed examination of quarries, bedrock exposures and use of corehole information (Table 2) from the Manitoba Stratigraphic Database (MSD) (Bezys and Conley, 1999).

Geological mapping for map sheet NTS 62I3 (containing the Rural Municipality of Rockwood) (Bezys et al., 1999c, d) (Fig. 1), using quarry inventories and water-well records, began in 1995. This map area was selected as the initial target for assessment because of the economically important crushed stone production in the Stonewall East and Stony Mountain areas.

Sixteen quarries were inventoried in the Rural Municipality of Rockwood in 1995 (Bamburak and Bezys, 1995). Data sheets for this project were modelled after Goudge (1944) and Derry Michener Booth and Wahl and Ontario Geological Survey (1989a–c). A stratigraphic section was generated for each quarry (Appendix 1). The areal extent of each quarry was sketched and selected quarry sections were described, sampled and photographed (Appendix 1). All field information was combined with historical descriptions, mineral inventory cards, property ownership maps and mineral disposition maps.

During the 1996 field season, the work was expanded to include the rural municipalities of St. Clements and St. Andrews. Data pertaining to the quarries were entered into a computer database; stratigraphic sections were drafted in final form; and industrial mineral inventory cards were updated (Appendix 1) (Bamburak and Bezys, 1996; Bezys et al., 1999a, b, g, h).

From 1995 to 1997, all water wells within the Capital Region Study area that intersected bedrock and had an accompanying survey location, were downloaded from GWDrill (digital water-well database, Water Branch, Manitoba Conservation). This also included wells within river lots. Using the survey information, wells were plotted onto 1:50 000 scale topographic maps and UTM locations and ground elevations were corrected from a digital elevation model constructed from 1:20 000 contour and spot elevations. Infill data came from water wells whose locations were only accurate to the centre of the nearest legal subdivision (L.S.). This posed a problem because even in lightly populated areas, two or more wells were mapped to the same coordinate. The procedure used to select the infill well was to examine the stratigraphy of each water well at the location and then select the most appropriate ones based on the stratigraphic characteristics of the nearest neighbours. Stratigraphic wells from the Manitoba Stratigraphic Database were used as key reference points.

A three corehole drilling program north of Stonewall was conducted by the Manitoba Geological Survey in 1996 (Table 2: M-04-96, M-05-96 and M-06-96) (Bezys, 1996a) and extended the aggregate resources of the Gunton Member of the Stony Mountain Formation 6 km to the northwest of a hole drilled in 1980 (M-01-80) (McCabe, 1980; Bannatyne, 1980). A subsequent three corehole drilling program in the Garson area (Table 2: M-07-96, M-08-96 and M-09-96) (Bezys, 1996a) confirmed the presence of additional dimension stone (Selkirk Member of the Red River Formation; Tyndall Stone™), 3 km to the southeast of the operating Gillis Quarry.

Table 2: List of coreholes in NTS 62H and 62I.

Unique well identifier	Well name	Easting	Northing	Map (NTS)	Formation at bottom of well	Kelly bushing (m)	Ground elevation (m)	Total depth (m)
100/02-29-003-11E1/00	GSC-O-92	714200	5457750	62H1	Precambrian	350.5	350.5	76.8
100/15-33-002-05E1/00	Dominion City No. 2	655825	5448975	62H2	Winnipeg	281.8	281.8	168.0
100/10-04-003-05E1/00	Dominion City Hole No. 3	656200	5450250	62H2	Precambrian	285.0	285.0	193.9
100/01-28-001-02W1/00	Cego Gretna	597580	5434952	62H4	Precambrian (weathered)	253.0	249.3	367.6
100/14-17-003-01W1/00	ASM-BTO Et Al Plum Prov.	604595	5452631	62H4	Precambrian (weathered)	246.0	242.3	318.5
100/01-28-004-04W1/00	Green Wakeley Roland	577256	5464371	62H5	Precambrian (weathered)	265.2	262.1	444.1
100/03-01-005-02W1/00	Red River Lowe Farm	601049	5467808	62H5	Precambrian (weathered)	242.9	241.1	348.1
100/02-01-005-01W1/00	Red River Lowe Farm	610929	5467981	62H6	Precambrian (weathered)	238.3	238.3	290.8
100/02-13-005-06E1/00	Manitoba Sun Core Hole No. 5	670175	5472800	62H7	Precambrian (weathered)	294.7	292.6	149.7
100/01-05-008-08E1/00	Richer South Water Well	683670	5499350	62H9	Winnipeg	283.5	283.5	57.9
100/08-36-006-07E1/00	La Broquerie Test Water Well	680180	5488200	62H10	Precambrian (weathered)	282.0	282.0	116.1
100/09-10-007-04E1/00	Manitoba Sun Core Hole No. 3	646900	5490850	62H10	Precambrian (weathered)	243.8	241.7	164.0
100/08-10-007-06E1/00	Steinbach Water Well	667005	5491200	62H10	Winnipeg	256.0	256.0	74.7
100/14-11-008-05E1/00	Steinbach Water Well	657900	5501670	62H10	Winnipeg	243.2	243.2	87.2
100/09-15-008-05E1/00	Steinbach Water Well	658600	5502730	62H10	Winnipeg	243.2	243.2	91.4
100/10-12-008-01E1/00	Manitoba Sun Core Hole No. 2	620250	5500000	62H11	Precambrian (weathered)	239.0	236.9	242.9
100/13-06-008-03E1/00	Winnipeg Formation Test	631350	5499350	62H11	Precambrian (weathered)	234.7	234.7	211.7
100/14-20-006-01W1/00	Sun Manitoba Core Hole #1	603973	5484057	62H12	Precambrian (weathered)	239.9	237.7	306.9
100/01-12-007-02W1/00	ASM-BTO Et Al Osborne Prov.	601426	5489209	62H12	Precambrian (weathered)	242.0	238.3	322.5
1W0/04-27-007-04W1/00	Carman Strat. Test No. 10	576930	5493550	62H12	Stony Mountain	254.8	253.3	165.2
1S0/04-32-007-04W1/00	Carman Strat. Test No. 9	573723	5495469	62H12	Stonewall	259.8	258.5	173.7
1S0/04-34-007-04W1/00	Carman Strat. Test No. 8	576937	5495155	62H12	Stonewall	253.1	251.8	154.5
100/07-35-007-04W1/00	B.A. Wiebe	579560	5495752	62H12	Precambrian (weathered)	251.8	248.5	414.5
100/04-06-008-03W1/00	Sun Carman	582015	5497084	62H12	Winnipeg	249.6	247.8	347.2
1W0/12-03-008-04W1/00	Carman Stratigraphic Test No. 7	576864	5497634	62H12	Stonewall	253.3	253.3	154.8
100/16-12-008-04W1/00	Sun Carman	581518	5499888	62H12	Precambrian (weathered)	249.3	247.5	383.4
100/11-04-010-02W1/00	Manitoba Sun Core Hole No. 6	596875	5520925	62H13	Precambrian	237.7	237.7	309.1
100/10-36-010-04W1/00	Kewanee Benard	580687	5525776	62H13	Precambrian	244.9	242.3	363.6
100/10-04-011-01W1/00	Manitoba Sun Core Hole No. 8	604975	5527825	62H13	Precambrian	241.1	241.1	276.8
1S0/04-01-011-04W1/00	S.T.H. #1 GWG Oakville	579570	5526404	62H13	Stony Mountain	244.9	243.5	164.6
100/16-23-009-02E1/00	M-01-85, Brady Road	628721	5514148	62H14	Red River	235.0	235.0	26.6
100/04-24-010-02E1/00	Wpg Supply Hole No. 3 & 4	629450	5522025	62H14	Precambrian	233.5	233.5	243.8
100/13-04-010-03E1/00	HEATFLOW #7 (UOFM)	633850	5519150	62H14	Precambrian	231.6	231.6	609.6
100/11-15-011-01E1/00	Manitoba Sun Core Hole No. 10	616430	5531250	62H14	Precambrian	242.3	240.2	243.8
100/01-21-011-01E1/00	M-03-74, Headingly, N.	615750	5533450	62H14	Red River	240.2	240.2	103.5
100/11-22-011-01E1/00	(ASD) Art Dawson DH #11	616225	5533150	62H14	Red River	240.2	240.2	53.3
100/08-35-011-01E1/00	(ASD) Art Dawson DH No. 5	618500	5535950	62H14	Red River	240.8	240.8	51.5
100/15-04-011-02E1/00	M-13-88, WRB/MP #1	624500	5529000	62H14	Red River	237.7	237.7	69.1

Table 2: List of coreholes in NTS 62H and 62I. (continued)

Unique well identifier	Well name	Easting	Northing	Map (NTS)	Formation at bottom of well	Kelly bushing (m)	Ground elevation (m)	Total depth (m)
100/04-09-011-02E1/00	M-01-83, St. James	623900	5529250	62H14	Red River	239.0	239.0	84.5
100/06-12-011-02E1/00	WEST GYP EMPRESS ST	629450	5529750	62H14	Red River	235.0	235.0	90.5
100/07-18-011-02E1/00	M-01-82, St. James	621525	5531325	62H14	Red River	239.1	239.1	43.2
100/01-20-011-02E1/00	M-01-02 Sturgeon Road	623546	5532402	62H14	Stony Mountain	240.5	240.5	10.0
102/01-20-011-02E1/00	M-02-02 Sturgeon Road	623446	5532403	62H14	Red River	240.4	240.4	32.6
100/05-30-011-02E1/00	(ASD) Art Dawson DH #12	620800	5534425	62H14	Red River	240.2	240.2	42.1
100/01-33-011-02E1/00	ASD #7	625160	5535725	62H14	Red River	243.5	243.5	42.1
100/13-33-011-02E1/00	M-01-79 Moore	623875	5536875	62H14	Red River	242.7	242.7	48.1
100/01-08-012-01E1/00	(ASD) Art Dawson DH No. 2	613625	5538725	62H14	Red River	243.5	243.5	114.0
100/10-13-010-01W1/00	(ASD) Art Dawson DH No. 6	610125	5521275	62H14	Red River	238.3	238.3	70.4
100/11-01-011-01W1/00	Manitoba Sun Core Hole No. 9	609700	5527825	62H14	Precambrian	241.1	239.0	264.0
100/10-13-011-01W1/00	Manitoba Sun Core Hole No. 7	609700	5531050	62H14	Precambrian	241.7	241.7	259.4
100/16-03-010-07E1/00	Manitoba Sun Core Hole No. 4	676775	5520125	62H15	Precambrian (weathered)	270.4	270.4	108.8
100/01-04-011-05E1/00	Dugald Museum Water Well	654900	5528150	62H15	Winnipeg	237.5	237.5	100.0
100/16-22-011-07E1/00	Oakwood Water Well	676150	5534650	62H15	Winnipeg	263.1	263.1	55.0
100/13-32-011-07E1/00	Springfield Water Well	671330	5538070	62H15	Winnipeg	249.9	249.9	62.5
100/07-35-010-10E1/00	GSC-U-92	707400	5528700	62H16	Precambrian	299.9	299.9	62.3
100/13-04-014-08E1/00	M-03-83, Green Oak	682200	5559650	62I1	Precambrian	231.6	231.6	36.3
100/13-05-014-08E1/00	M-02-83, Green Oak	680525	5559675	62I1	Precambrian	233.0	233.0	38.9
100/14-26-012-06E1/00	M-09-96, Tyndall S	666640	5546300	62I2	Red River	248.1	248.1	15.6
100/11-14-013-04E1/00	Terra Test #3	644925	5554250	62I2	Precambrian (weathered)	233.0	233.0	468.1
100/04-16-013-05E1/00	M-02-97, Selkirk	352860	5551275	62I2	Red River	233.2	233.2	30.5
100/14-22-013-05E1/00	M-01-97, Selkirk	354875	5553900	62I2	Precambrian	228.9	228.9	112.8
100/01-26-013-05E1/00	Schaller #1	657425	5554650	62I2	Precambrian	232.4	232.4	449.6
102/01-26-013-05E1/00	Schaller #1A	657425	5554575	62I2	Red River	232.4	232.4	40.5
100/15-03-013-06E1/00	M-03-69, Garson Quarry	665325	5549375	62I2	Red River	249.1	249.1	51.5
100/13-06-013-06E1/00	Red River Garson	659572	5549232	62I2	Precambrian	240.8	236.8	189.6
100/16-14-013-06E1/00	M-07-96 Tyndall N	667480	5552850	62I2	Red River	244.4	244.4	17.5
100/02-22-013-06E1/00	M-08-96 Tyndall NW	665360	5552875	62I2	Winnipeg	240.1	240.1	72.3
100/16-32-013-15E1/00	M-03-97 Selkirk	357425	5557225	62I2	Precambrian	230.1	230.1	115.1
100/16-01-014-07E1/00	M-04-83, Green Oak	678625	5559650	62I2	Red River	235.0	235.0	19.8
100/04-14-012-01E1/00	M-04-77, Gordon	617200	5540400	62I3	glacial drift	241.8	241.8	12.8
100/01-27-012-01E1/00	M-03-77, Gordon	616800	5543675	62I3	glacial drift	242.3	242.3	11.4
100/15-08-012-02E1/00	M-05-77 Winnipeg N.	622975	5540400	62I3	Stony Mountain	242.6	242.6	23.2
100/12-17-012-02E1/00	M-02-79 Lilyfield	622170	5541400	62I3	Red River	243.9	243.9	45.9
100/07-29-012-02E1/00	Stony Mountain No. 1	622700	5544575	62I3	Precambrian (weathered)	243.8	243.8	307.9
100/16-35-012-02E1/00	M-01-78 Stony Mountain	628200	5546850	62I3	Red River	233.8	233.8	48.8
100/08-11-013-01E1/00	M-02-77 Stonewall SW	618225	5549025	62I3	Stony Mountain	246.9	246.9	23.0

Table 2: List of coreholes in NTS 62H and 62I.

Unique well identifier	Well name	Easting	Northing	Map (NTS)	Formation at bottom of well	Kelly bushing (m)	Ground elevation (m)	Total depth (m)
100/01-12-013-01E1/00	B-1A-76, Stonewall South	619880	5548650	62I3	Red River	242.0	242.0	42.2
100/16-08-013-02E1/00	M-01-77 Stony Mountain West	623175	5550000	62I3	Stony Mountain	243.8	243.8	22.0
100/02-14-013-02E1/00	M-02-69, Stony Mountain Quarry	627700	5550500	62I3	Red River	248.4	248.4	30.2
100/12-20-013-02E1/00	B-1E-76 Winnipeg N	621825	5552825	62I3	Stonewall	246.9	246.9	14.3
100/13-30-013-02E1/00	M-01-69 Stonewall Quarry	620400	5554575	62I3	Stonewall	250.2	250.2	27.2
100/13-16-013-03E1/00	B-1D-76 Stony Mountain E	633375	5551925	62I3	Red River	234.7	234.7	13.4
100/13-19-013-03E1/00	B-1B-76 Stony Mountain N	630125	5553425	62I3	Red River	235.5	235.5	43.7
100/10-27-013-03E1/00	M-01-70 Mowatt Quarry	635685	5554825	62I3	Red River	231.3	231.3	61.6
1OC/10-27-013-03E1/00	Quarry Pit #12, Mowatt Farm (Outcrop)	635675	5554825	62I3	Red River	232.6	232.6	4.1
100/04-23-014-01E1/00	M-06-96 Lait NW (Stonewall NW)	616625	5561625	62I3	Stony Mountain	250.5	250.5	19.6
100/01-17-014-02E1/00	M-01-80 Stonewall N	622985	5560225	62I3	Red River	246.9	246.9	81.5
100/04-20-014-02E1/00	M-05-96 Jennifer Creek (Stonewall)	621450	5561725	62I3	Stony Mountain	246.0	246.0	8.1
100/04-29-014-02E1/00	M-04-96 Jackfish Creek (Stonewall)	621475	5563350	62I3	Stony Mountain	245.4	245.4	14.1
100/04-05-014-03E1/00	B-1C-76 Stony Mountain N	631600	5557150	62I3	Red River	234.7	234.7	14.3
100/15-35-014-01W1/00	69-02, Woodroyd	607621	5566250	62I3	Red River	264.6	264.6	153.9
100/13-31-013-01W1/00	M-10-79 Warren	600490	5556075	62I4	Stony Mountain	249.7	249.7	72.4
102/13-31-013-01W1/00	M-01-86 Warren	600485	5555900	62I4	Stony Mountain	249.7	249.7	72.6
100/16-36-013-29W1/00	Wilson Woodlands Prov.	590129	5565791	62I4	Precambrian	272.9	270.4	326.1
100/04-06-015-02W1/00	Chevron Woodlands Prov.	590265	5566167	62I4	Precambrian (weathered)	271.0	267.9	319.7
100/02-28-015-02E1/00	M-18-90, South of Teulon	623750	5573600	62I6	Stony Mountain	261.6	261.6	31.3
100/16-36-015-03E1/00	69-04, Petersfield	638800	5576400	62I6	Winnipeg	229.2	229.2	121.0
100/14-35-016-01E1/00	M-11-79 Teulon	616575	5585850	62I6	Red River	271.3	271.3	112.0
100/03-25-016-03E1/00	M-03-79 Netley	638000	5583600	62I6	Red River	233.2	233.2	60.2
100/04-28-017-01E1/00	69-03, Norris Lake	612685	5592790	62I6	Red River	266.7	266.7	153.3
100/08-29-017-02E1/00	M-19-90, East of Inwood	622050	5593525	62I6	Stony Mountain	262.7	262.7	29.7
100/14-06-018-04E1/00	M-07-80, Winnipeg Beach Quarry	639168	5597872	62I11	Winnipeg	228.6	228.6	93.6
100/04-11-018-01W1/00	M-02-88, Inwood Quarry	606100	5597720	62I11	Red River	273.4	273.4	81.2
100/13-32-017-02W1/00	M-01-88 Inwood W.	591290	5595385	62I12	Stony Mountain	262.0	262.0	93.4
100/13-03-018-01W1/00	M-20-90, West of Inwood	604275	5597375	62I12	Fisher Branch	275.8	275.8	29.7
102/04-11-018-01W1/00	M-04-69, Inwood Quarry	606150	5597775	62I12	Stony Mountain	271.3	271.3	36.6
100/08-14-018-02W1/00	M-05-70 Inwood W	597275	5599400	62I12	Interlake	266.7	266.7	18.3
100/03-03-019-01W1/00	M-31-91, I.M. SANDRIDGE	604880	5605740	62I12	Stonewall	277.9	277.9	20.5
100/05-03-019-01W1/00	M-28-91, I.M. SANDRIDGE	604090	5606300	62I12	Stonewall	277.5	277.5	19.5
100/07-03-019-01W1/00	M-32-91, I.M. SANDRIDGE	604950	5606440	62I12	Stonewall	278.5	278.5	21.2
100/01-04-019-01W1/00	M-29-91, I.M. SANDRIDGE	604060	5605700	62I12	Stonewall	279.3	279.3	22.0
100/02-04-019-01W1/00	M-30-91, I.M. SANDRIDGE	603300	5605700	62I12	Fisher Branch	276.1	276.1	12.8
100/01-10-019-01W1/00	M-18-91, I.M. SANDRIDGE	605670	5607360	62I12	Stonewall	276.8	276.8	15.9
100/02-10-019-01W1/00	M-13-91, I.M. SANDRIDGE	604875	5607350	62I12	Stonewall	276.7	276.7	16.0

Table 2: List of coreholes in NTS 62H and 62I. (continued)

Unique well identifier	Well name	Easting	Northing	Map (NTS)	Formation at bottom of well	Kelly bushing (m)	Ground elevation (m)	Total depth (m)
100/03-10-019-01W1/00	M-14-91, I.M. SANDRIDGE	604475	5607350	62I12	Stonewall	275.4	275.4	15.9
100/04-10-019-01W1/00	M-15-91, I.M. SANDRIDGE	604050	5607350	62I12	Stonewall	276.8	276.8	15.9
100/05-10-019-01W1/00	M-25-91, I.M. SANDRIDGE	604410	5608080	62I12	Stonewall	274.9	274.9	15.8
102/05-10-019-01W1-00	M-16-91, I.M. SANDRIDGE	604050	5607750	62I12	Stonewall	276.2	276.2	14.4
100/07-10-019-01W1/00	M-26-91, I.M. SANDRIDGE	604870	5608100	62I12	Stonewall	275.2	275.2	9.9
102/07-10-019-01W1/00	M-27-91, I.M. SANDRIDGE	604920	5607750	62I12	Stony Mountain	275.8	275.8	46.4
100/08-10-019-01W1/00	M-19-91, I.M. SANDRIDGE	605670	5607750	62I12	Stonewall	276.8	276.8	16.0
102/08-10-019-01W1/00	M-20-91, I.M. SANDRIDGE	605660	5608170	62I12	Stonewall	276.2	276.2	15.8
100/09-10-019-01W1/00	M-21-91, I.M. SANDRIDGE	605560	5608560	62I12	Stonewall	274.9	274.9	15.9
100/12-10-019-01W1/00	M-17-91, I.M. SANDRIDGE	604050	5608000	62I12	Stonewall	275.5	275.5	14.6
100/13-10-019-01W1/00	M-24-91, I.M. SANDRIDGE	604420	5608920	62I12	Stonewall	272.8	272.8	20.8
100/14-10-019-01W1/00	M-23-91, I.M. SANDRIDGE	604830	5608930	62I12	Stonewall	269.4	269.4	15.8
100/15-10-019-01W1/00	M-22-91, I.M. SANDRIDGE	605190	5608870	62I12	Stonewall	274.3	274.3	16.3
100/04-15-019-01W1/00	M-01-84, Narcisse	604215	5609125	62I12	Red River	274.6	274.6	68.7
100/04-21-019-01W1/00	M-40-92, SANDRIDGE NW (I.M.)	602320	5610580	62I12	Stonewall	274.3	274.3	20.3
100/03-20-019-04W1/00	M-39-92, CLARKLEIGH (I.M.)	571570	5610000	62I12	Moose Lake	256.0	256.0	60.0
100/05-04-022-01W1/00	M-35-92, POPLARFIELD (I.M.)	601660	5635840	62I13	Stonewall	272.8	272.8	20.4
102/05-04-022-01W1/00	P-93-01, Poplarfield	601900	5635950	62I13	Fisher Branch	273.0	273.0	15.2
103/05-04-022-01W1/00	P-93-02, Poplarfield	602100	5635750	62I13	Fisher Branch	273.0	273.0	15.2
100/04-05-023-01W1/00	M-21-90, Fisher Branch North	600050	5645025	62I13	Stony Mountain	263.6	263.6	29.5
100/08-14-023-03W1/00	M-03-88, Broad Valley	586375	5648675	62I13	Stony Mountain	275.8	275.8	94.3
100/01-23-023-03W1/00	M-36-92, BROAD VALLEY (I.M)	586510	5649860	62I13	Silurian undifferentiated	281.0	281.0	20.3
100/15-06-022-01E1/00	M-38-92, ARBORG WEST (I.M)	609380	5636870	62I14	Red River	262.1	262.1	99.7
100/08-30-013-04E1/00	ProAm GB-98-2	646105	5554670	62I2	Precambrian (weathered)	231.3	231.3	653.2

In 1997, a three corehole drilling program near Selkirk was conducted as an extension of the sub-Phanerozoic, shield margin studies in NTS 62I2, and to investigate the Paleozoic and Precambrian geology of the Capital Region area (Table 2: M-01-97, M-02-97, M-03-97) (Bezys and Bamburak, 1997). Two of these holes intersected the Precambrian. In coreholes M-01-97 and M-03-97, thicknesses of the Selkirk Member, Red River Formation, ranged from 73.4 to 76.1 m. In corehole M-02-97, 15.5 m of undifferentiated Red River Formation was encountered and the hole had to be abandoned due to karst infill. To test the interpreted bedrock high in the vicinity of Sturgeon Road (in the northwest part of Winnipeg), two coreholes were drilled in 2002 (Table 2: M-01-02, M-02-02) (Bezys and Bamburak, 2002). All new corehole data were added to MSD. All corehole logs in NTS 62H and 62I are presented in Appendix 2.

PALEOZOIC STRATIGRAPHY AND TECTONIC SETTING

The Paleozoic outcrop belt of southern Manitoba occurs within the Manitoba Lowland or First Prairie Level (Fig. 2). The Paleozoic succession dips gently to the southwest at approximately 2.8 m/km. South of the City of Winnipeg, within the Manitoba Lowland, a large area of Jurassic strata (Fig. 3) occurs as infill of a major pre-Mesozoic channel in the Paleozoic erosion surface (Bezys and McCabe, 1996; 1998). Smaller channels and karst sinkholes filled with Jurassic and Cretaceous sediments are also present within the Capital Region (Bannatyne, 1988). The Manitoba Lowland is bounded on the east by the Precambrian Shield, and on the west by the Manitoba Escarpment.

The Manitoba Escarpment forms the eastern edge of the Second Prairie Level, which is composed of Cretaceous strata dipping gently to the southwest at 1.5 to 1.9 m/km (Fig. 2). The actual escarpment is composed of soft, easily eroded sandstones and shales in the lower part of the Cretaceous, underlying a resistant shale cap (Odanah Member of the Pierre Shale).

The Paleozoic outcrop belt in southwestern Manitoba is draped on the much older Precambrian Shield (Fig. 3 to 6). The individual outcrop belts for Ordovician and Silurian formations are shown in Figures 7 to 16. These belts are situated near the northeastern edge of the Western Canada Sedimentary Basin (WCSB) – a composite feature in Manitoba which includes two smaller basins or sub-basins. The Williston Basin, centered in northwestern North Dakota, controlled most Paleozoic deposition (with the exception of the Devonian) and the Elk Point Basin, centered in south-central Saskatchewan, controlled deposition during Devonian time (Fig. 4).

The present erosional edge of the WCSB in Manitoba roughly parallels the regional structure contours on the Precambrian surface (Fig. 5), and those structure contours on the Ordovician and Silurian formations (Fig. 7, 9, 11, 13 and 15). Thus, it would

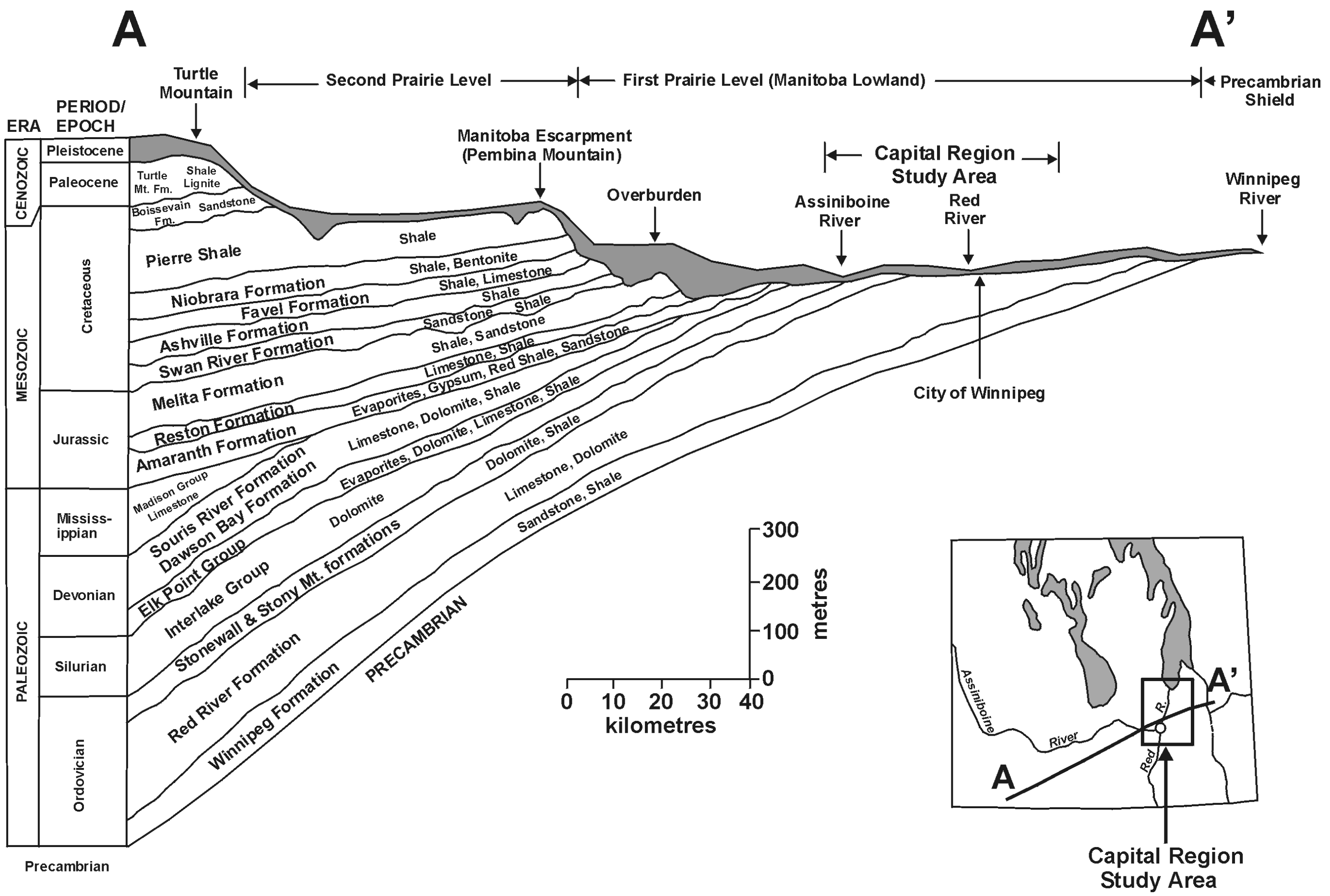


Figure 2: Structural cross-section of southern Manitoba.

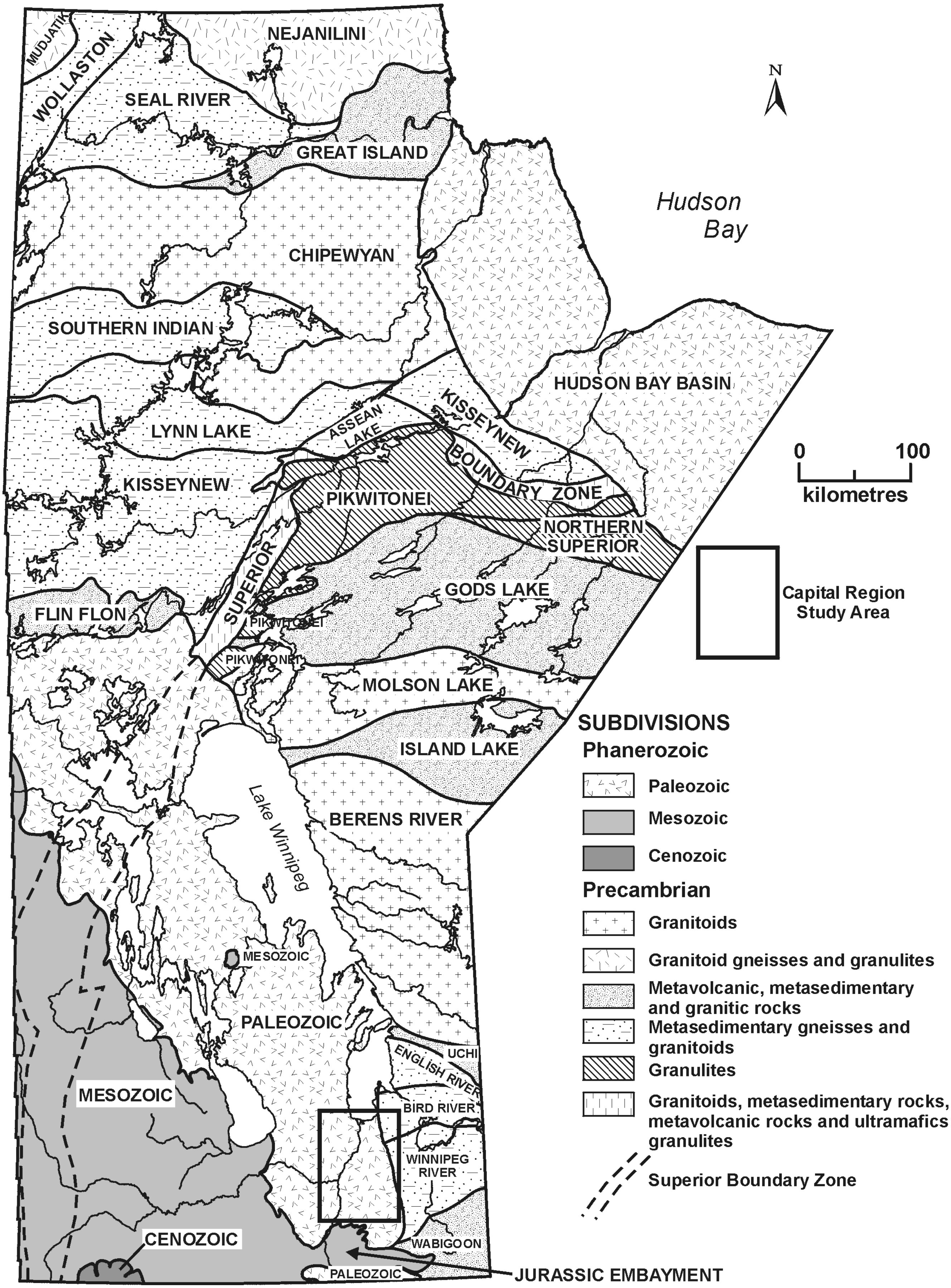


Figure 3: Geological domain map of Manitoba.

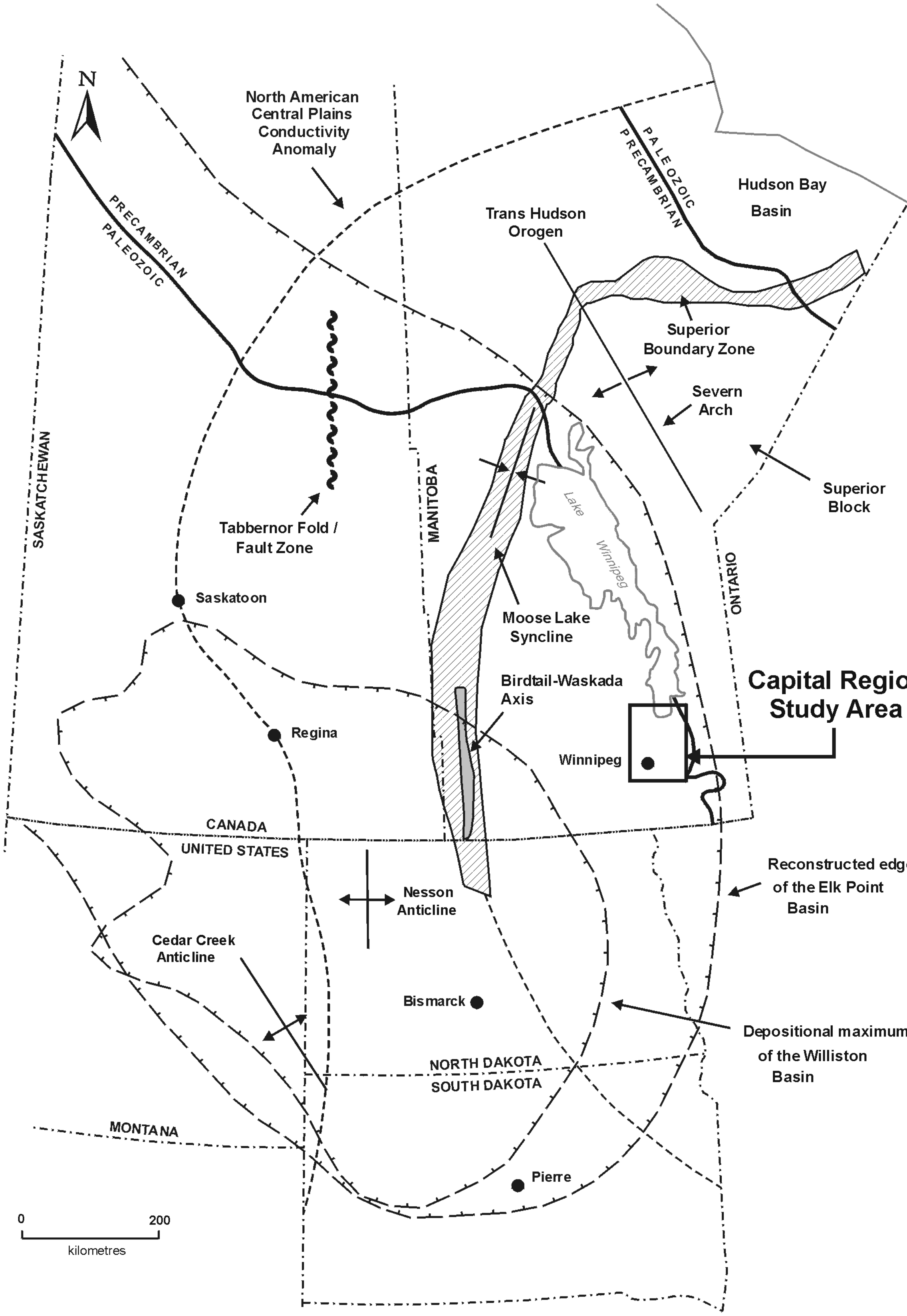


Figure 4: Major structural features of the northeastern Western Canada Sedimentary Basin, including the Williston and Elk Point basins in Manitoba.

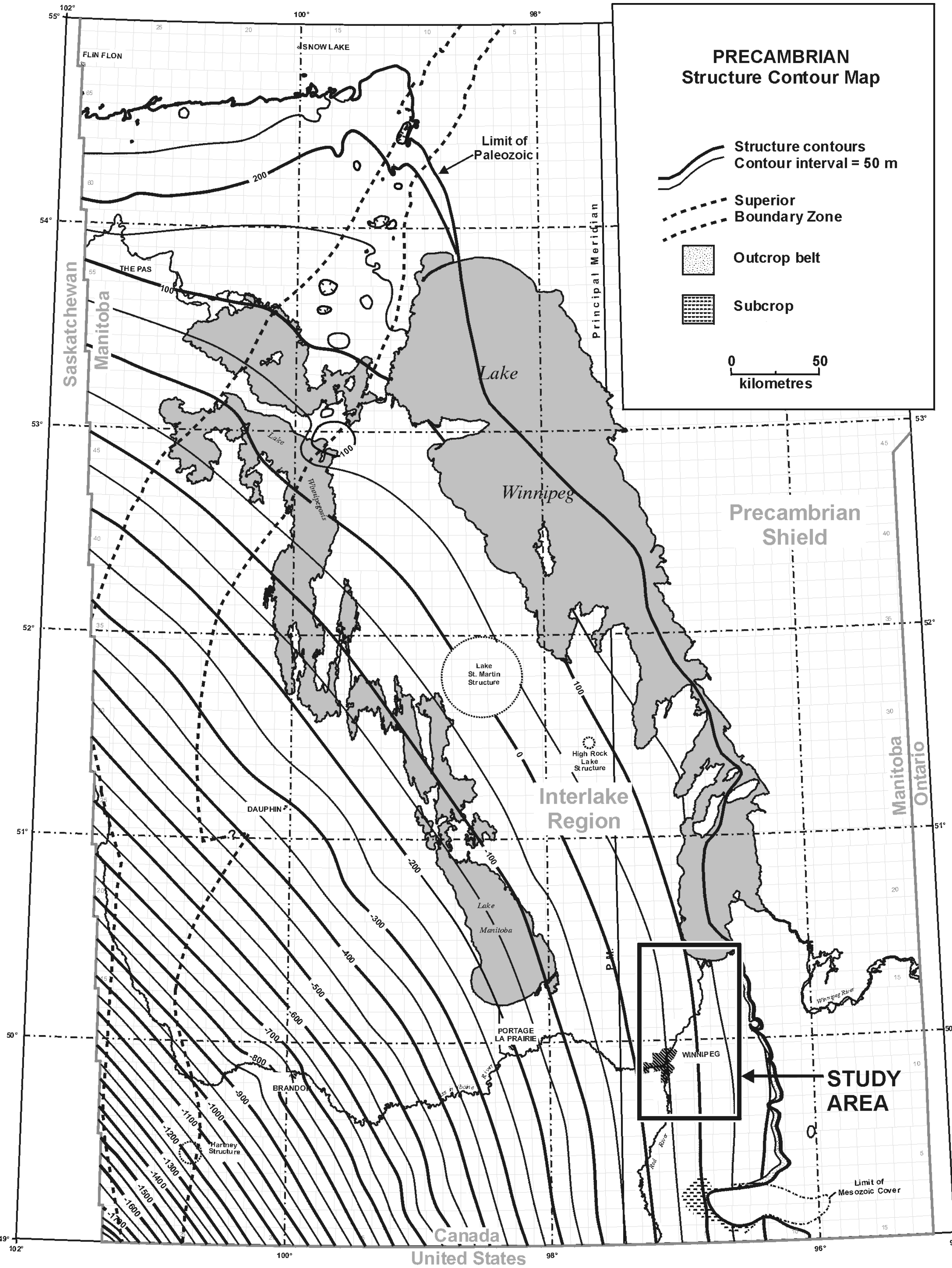


Figure 5: Precambrian structure contour map.

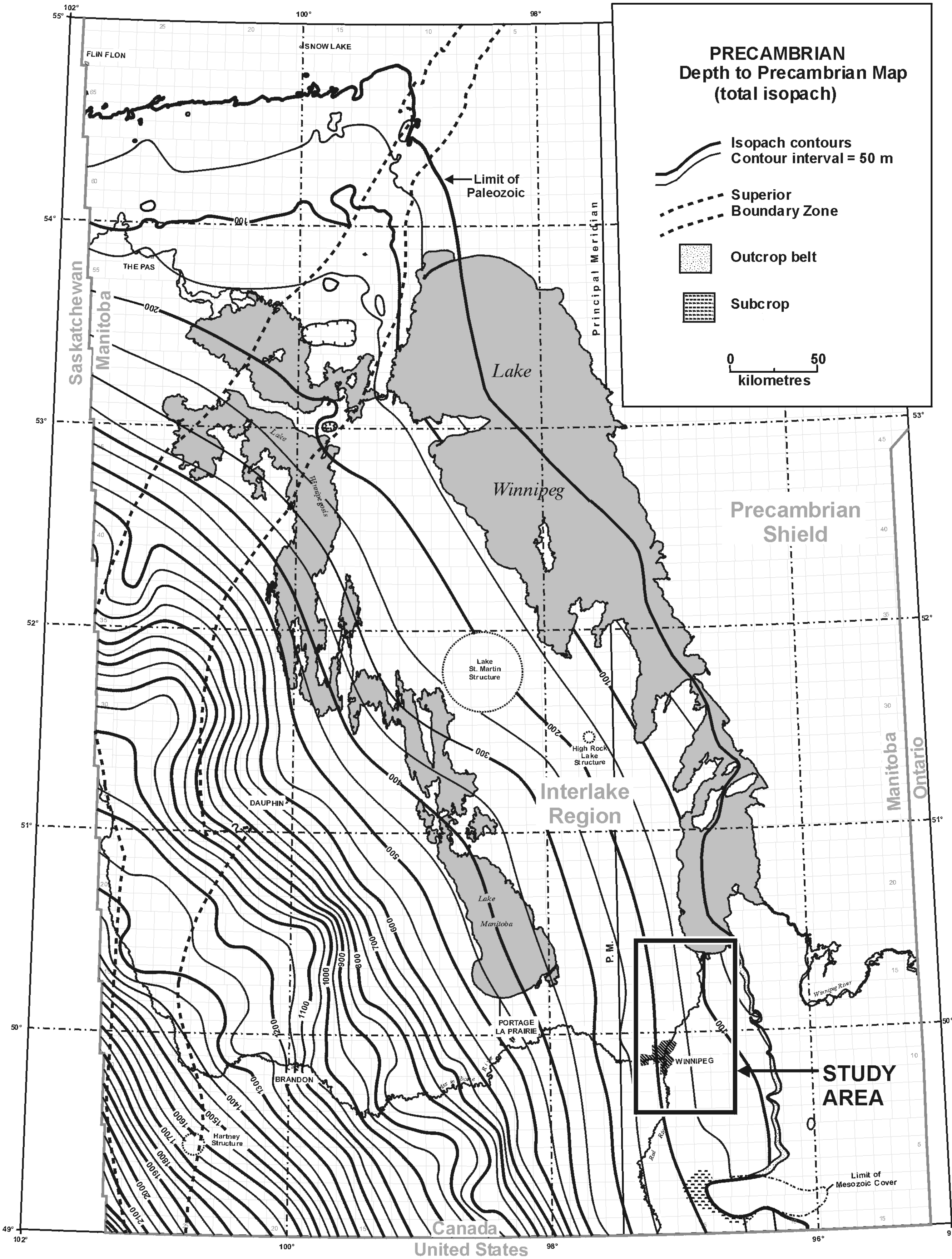


Figure 6: Depth to Precambrian map (total isopach).

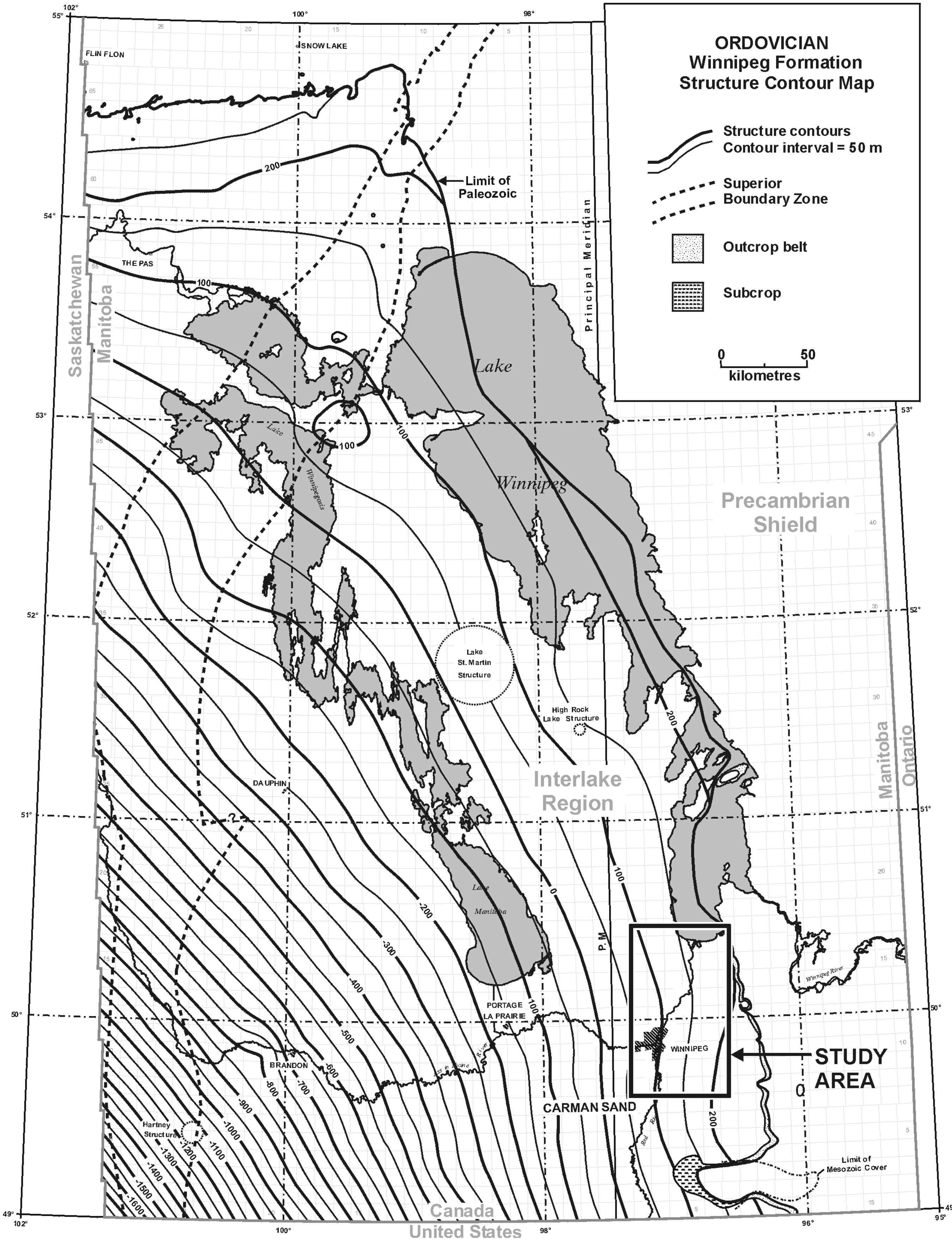


Figure 7: Ordovician Winnipeg Formation structure contour map.

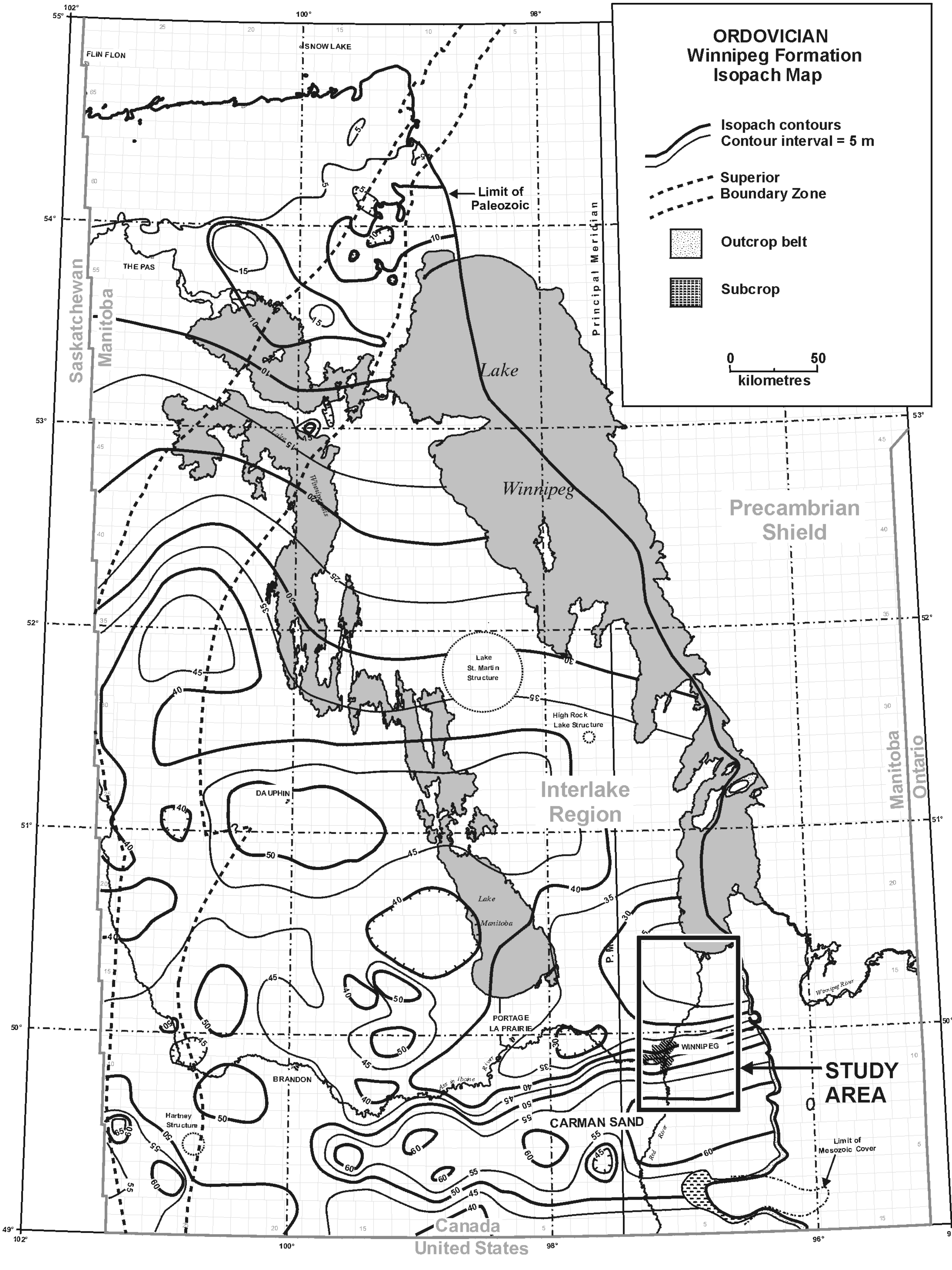


Figure 8: Ordovician Winnipeg Formation isopach map.

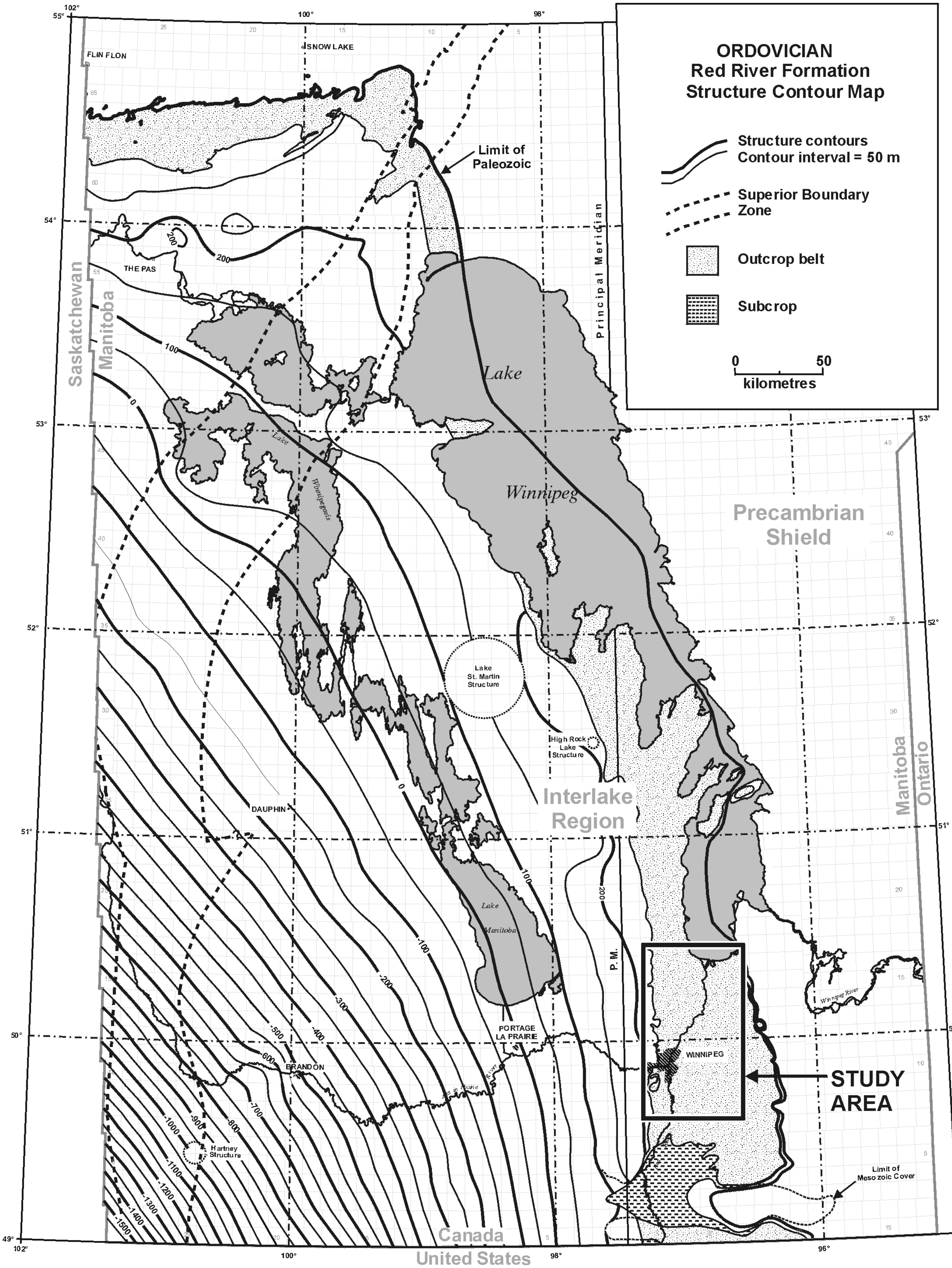


Figure 9: Ordovician Red River Formation structure contour map.

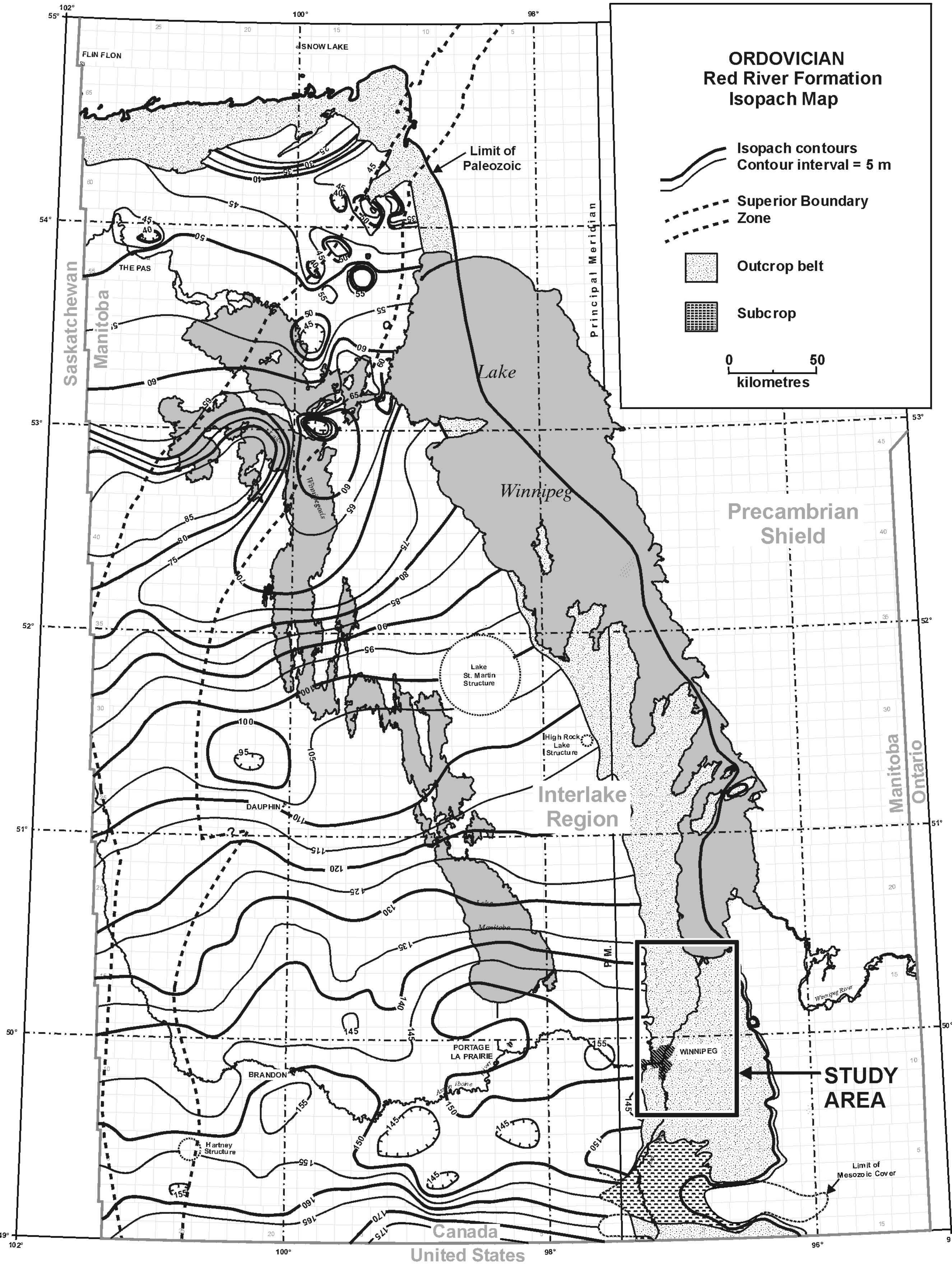


Figure 10: Ordovician Red River Formation isopach map.

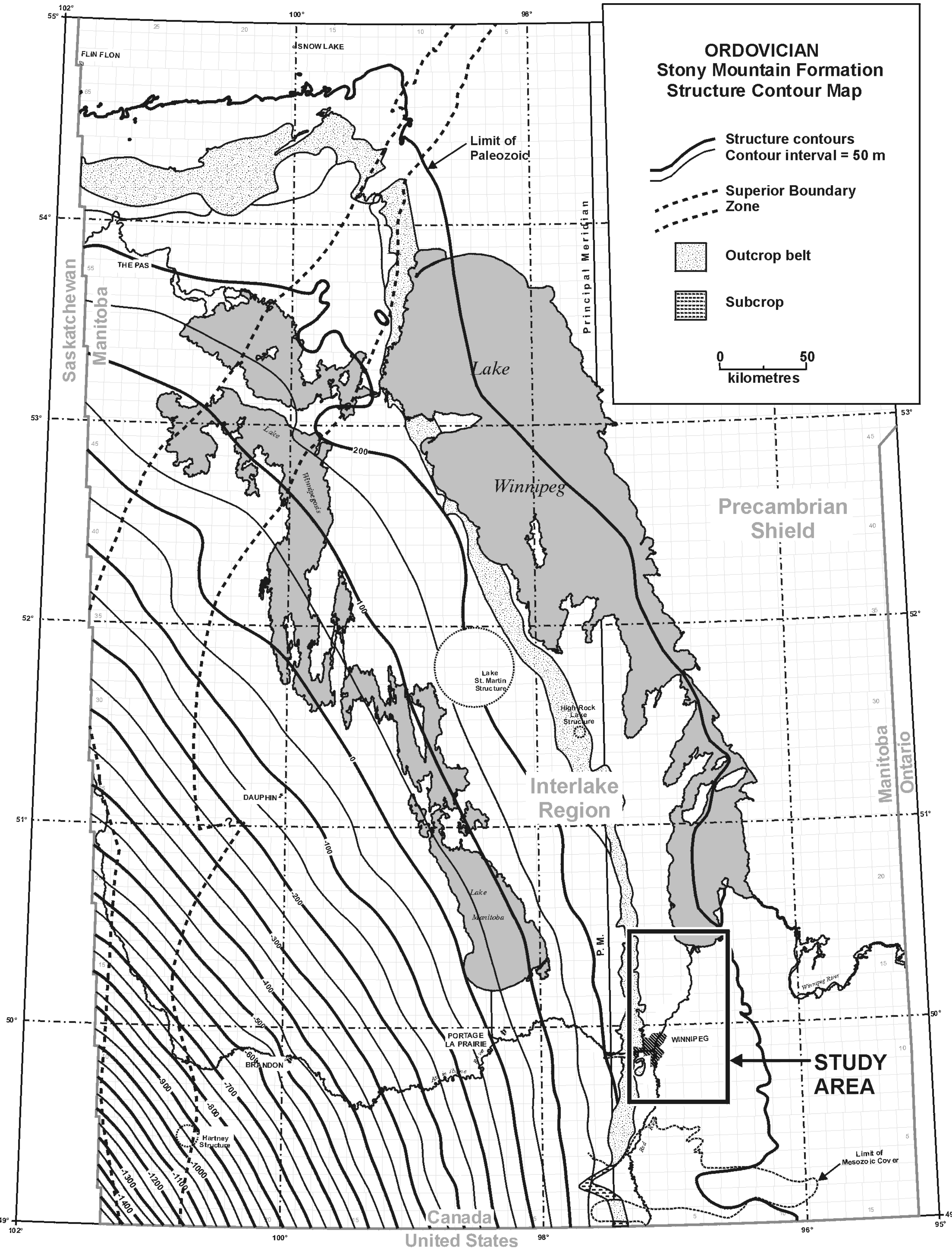


Figure 11: Ordovician Stony Mountain Formation structure contour map.

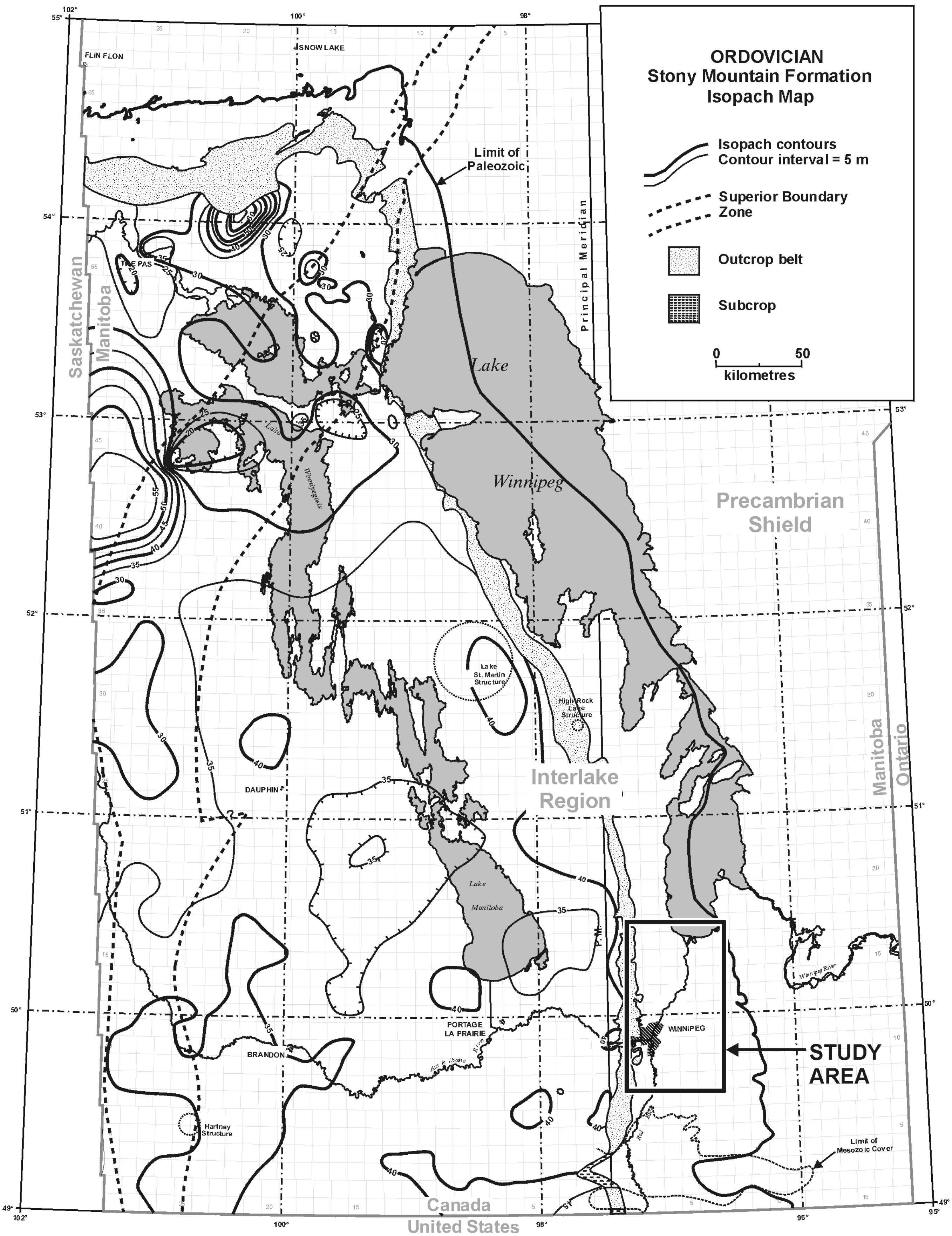


Figure 12: Ordovician Stony Mountain Formation isopach map.

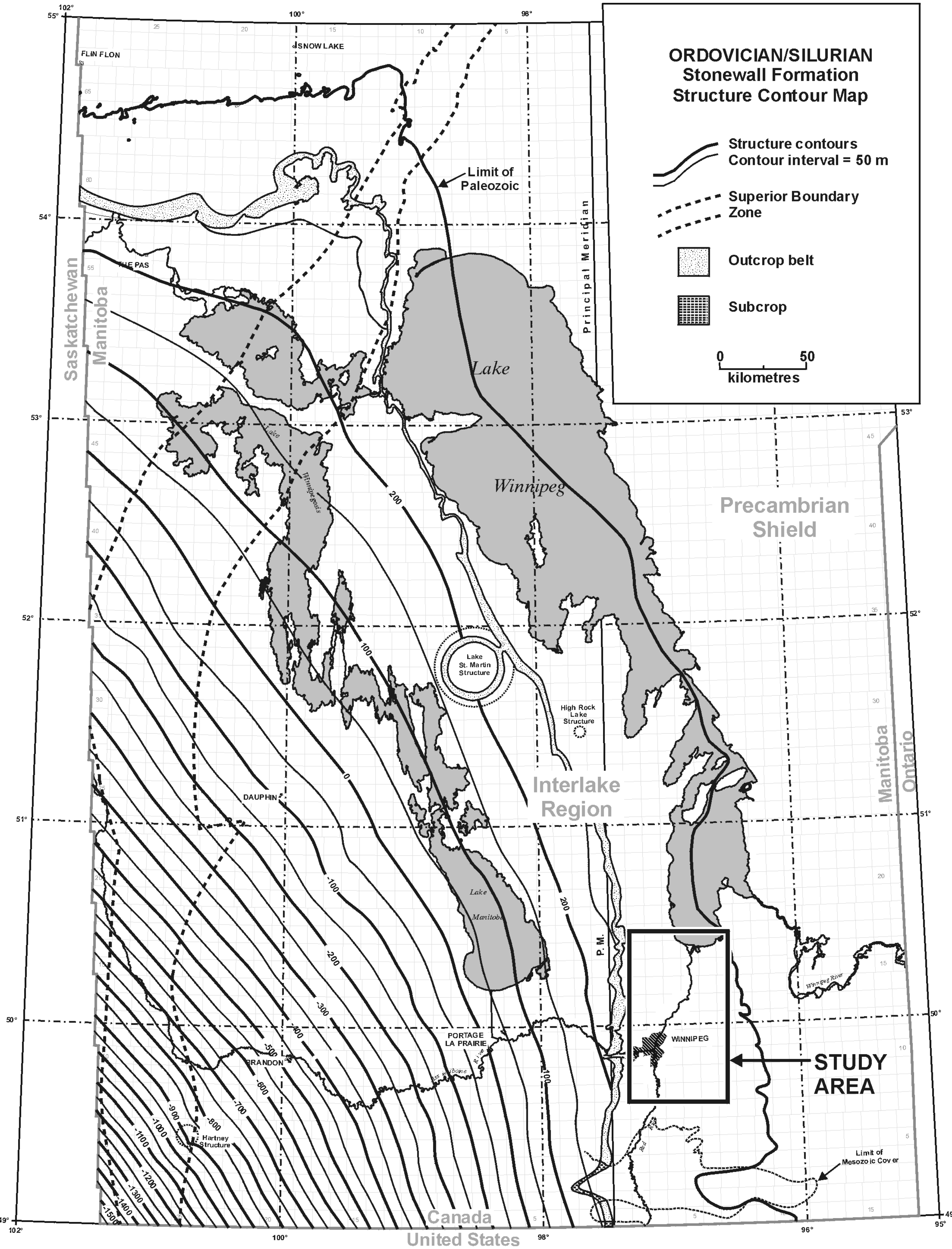


Figure 13: Ordovician/Silurian Stonewall Formation structure contour map.

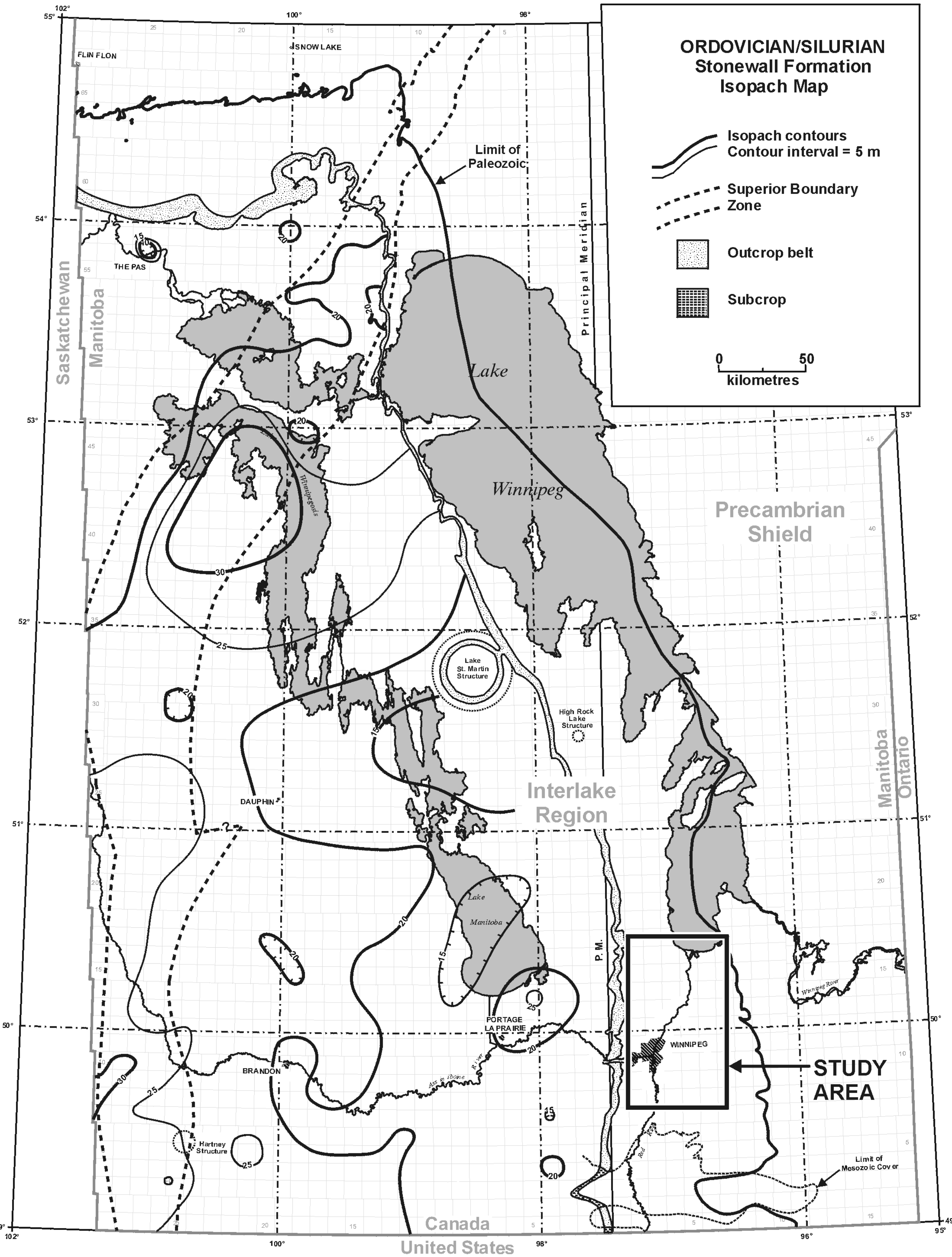


Figure 14: Ordovician/Silurian Stonewall Formation isopach map.

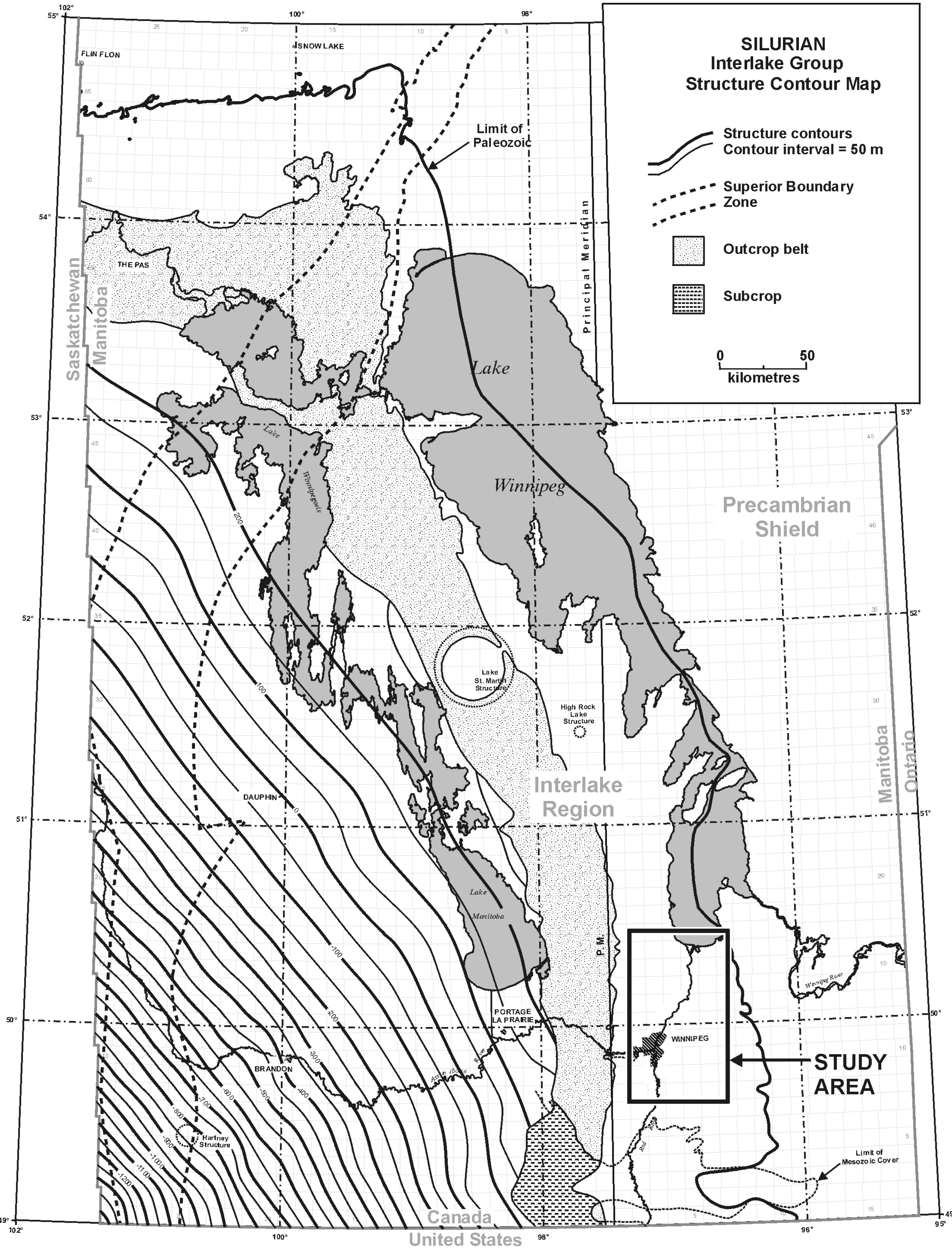


Figure 15: Silurian Interlake Group structure contour map.

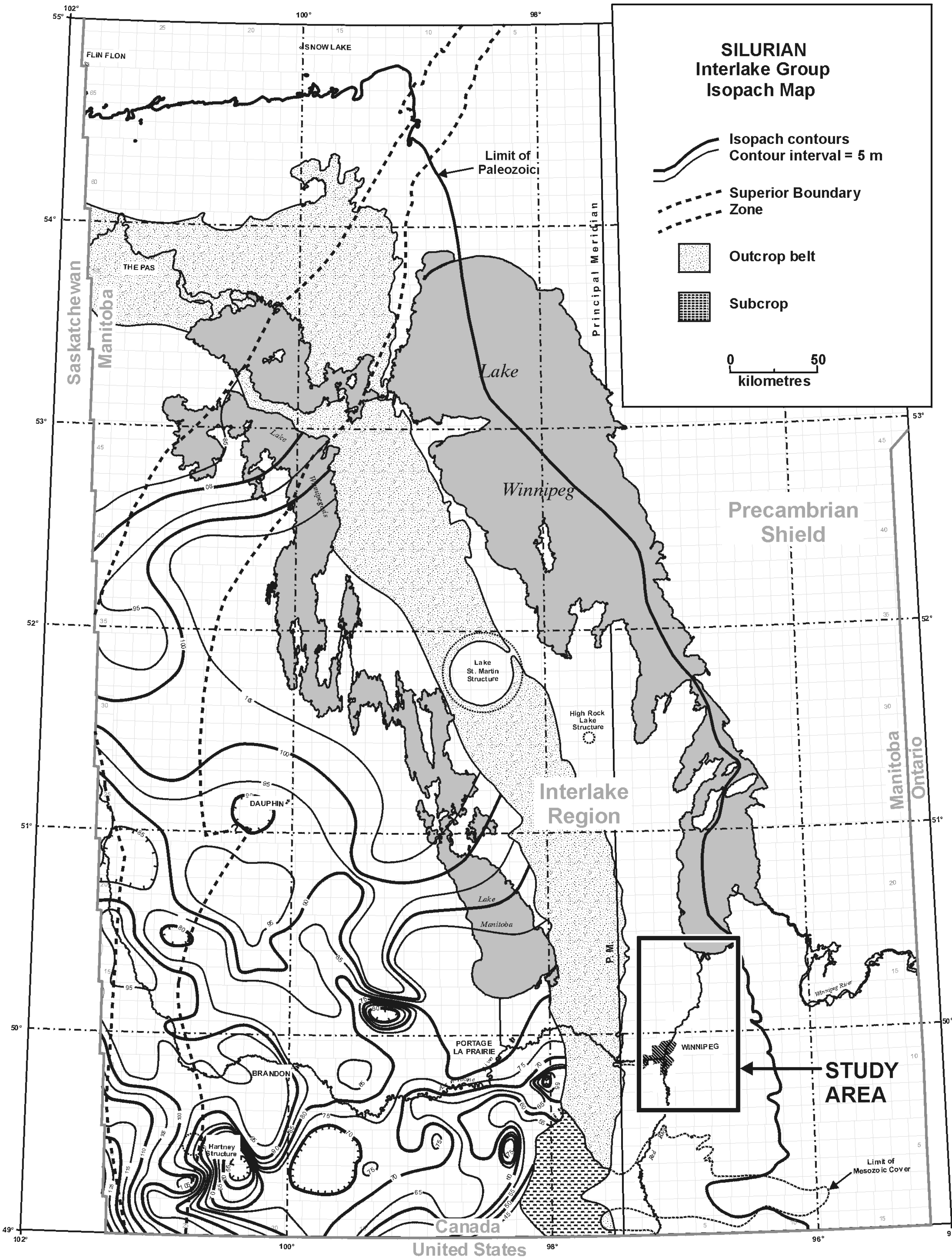


Figure 16: Silurian Interlake Group isopach map.

appear that the original basin depositional edge corresponds to the present edge. If this were true, the strata comprising the Paleozoic outcrop belt would be relatively uniform in lithology and would represent thinner marginal shelf-type deposits compared to a thicker, more basinal sedimentary sequence to the southwest. However, an examination of the isopachs of the Ordovician and Silurian formations (Fig. 8, 10, 12, 14 and 16) (as well as those of Devonian formations - not included) show marked changes in thickness from north to south across southwestern Manitoba. These changes, combined with major variations in lithology, indicate a complex and varied tectonic and depositional framework. For example, the isopachs for the Winnipeg and Red River formations in Figures 8 and 10, respectively, show significant thickening of the formations to the south. McCabe (1967) and Bezys and McCabe (1996; 1998) concluded that the eastern edge of the present-day WCSB has been truncated by uplift and erosion. The Paleozoic outcrop succession is not marginal to the depositional basin but rather exposes a series of dip-sections of the basin, which show the maximum possible isopach and lithofacies variation.

Available data suggest that the tectonic framework was relatively stable during Silurian time (McCabe, 1967), with sparse evidence of basin differentiation in the Manitoba portion of the WCSB (Fig. 15 and 16). This is evidenced also by the relative lithological uniformity of the Silurian strata, which consist almost entirely of micritic to intraclastic and stromatolitic dolomites containing scattered fossil-fragmental interbeds.

The apparently anomalous east-west depositional trend of Ordovician strata, relative to the overall WCSB framework, may be caused by major structural discontinuity in the underlying Precambrian basement. The suggested basement control relates to the Superior Boundary Zone (SBZ), which marks the suture of two major Precambrian cratonic blocks or plates [the Superior Block and the Trans-Hudson Orogen (THO)] (Fig. 3 and 4). The trend of this major Precambrian structure, as it is traced by its associated geophysical anomalies (gravity and magnetic) beneath the Paleozoic cover of western Manitoba, cuts deeply into the eastern flank of the WCSB, and roughly defines the extent of anomalous Ordovician thickening. McCabe (1967) attributed the thickening of the Carman Sand, shown in Figure 8, to slight tectonic movement, as evidenced by the flexure of the Precambrian structure contours, shown in Figure 5. Coincident with the Carman Sand, the overlying Red River Formation is anomalously thin (Fig. 10). These features are parallel to and directly overlie the Precambrian Winnipeg River Domain of Pilkington and Thomas (2001), which suggests relative movement of this orogenic belt during Paleozoic time.

Since the major Paleozoic tectonic element represented by the WCSB straddles the major basement (crustal) discontinuity of the SBZ, it follows that the discontinuity should have had some modifying or distortional effect on the “normal” pattern of basin subsidence (Fig. 4). However, structure contour maps of the individual Paleozoic formations and of the top of the Precambrian show little or no apparent deviation along the boundary zone, except for a synclinal flexure (Moose Lake Syncline) near the northern limit of Paleozoic cover (McCabe, 1967) (Fig. 4).

The Paleozoic depositional framework may have been affected by basement control of the crustal blocks that reacted differently to tectonic forces. The Superior Block, relative to the THO, experienced greater subsidence during depositional episodes, compensated for by greater uplift during erosional episodes. McCabe (1967) proposed that basement tectonic elements in southern Manitoba may have exerted some control over the Paleozoic depositional/tectonic framework. This mechanism controls not only the depositional framework in which the sediments were deposited; but also the distribution of the outcrop belts themselves, and the unusual dip-section configuration relative to the depositional framework. Bezys (1996b) in the Grand Rapids area (NTS 63G) confirmed McCabe’s earlier work that basement tectonic elements influenced the overlying Paleozoic stratigraphy.

Geology

Precambrian

The northeastern edge of the Capital Region consists of near-surface Precambrian Shield rocks of the Archean Superior Block. The Precambrian is overlain to the west by Paleozoic strata and a mantle of Pleistocene glacial sediments and Recent sediments (Fig. 2 and 17). Unconformably overlying Precambrian rocks are basal Paleozoic sandstones and shales of the Middle Ordovician Winnipeg Formation.

Rocks of the Superior Block, underlying the Capital Region, are subdivided into the Bird River Domain and the Winnipeg River Domain (Fig. 3) and both domains are mainly granitoid plutonic rocks and derived gneisses. However, the boundary between the domains coincides with a narrow linear feature and is characterized by relatively subdued and intense magnetic signatures (Pilkington and Thomas, 2001).

Paleozoic

The regional strike of the Paleozoic strata is approximately north, and regional dip increases gradually and uniformly from about 2.6 m/km in the eastern part of the study area to 4.2 m/km in the western part. Despite the regional structural dip to the southwest, isopachs of the Red River and Winnipeg formations all trend east and thicken to the south at up to 0.3 m/km (Fig. 7 to 10). This indicates a major change in the tectonic framework subsequent to early Paleozoic time, as mentioned previously. The present north structural trend probably developed during the late Paleozoic to early Mesozoic, due to uplift with associated erosion and eventual exposure of Precambrian bedrock in southeastern Manitoba.

The predominant outcrops in the Capital Region consist of cyclic carbonates and mudstones of Ordovician age (Fig. 17). The

AGE Millions of years before present	ERA	PERIOD	EPOCH	FORMATION	MEMBER	MAX. THICK (m)	BASIC LITHOLOGY
	CENOZOIC	QUATER-NARY	RECENT				TOP SOIL AND DUNE SANDS.
	CENOZOIC	QUATER-NARY	PLEISTO-CENE	GLACIAL DRIFT		140	CLAY, SAND, GRAVEL, BOULDERS AND PEAT.
	CENOZOIC	TERTIARY	PLIOCENE				
	CENOZOIC	TERTIARY	MIOCENE				
	CENOZOIC	TERTIARY	OLIGOCENE				
50	CENOZOIC	TERTIARY	EOCENE				
65	CENOZOIC	TERTIARY	PALEO-CENE	TURTLE MOUNTAIN	PEACE GARDEN; GOODLANDS	120	SHALE, CLAY, SAND, LIGNITE BEDS. LOCATED ONLY IN TURTLE MOUNTAIN.
	MESOZOIC	CRETACEOUS	UPPER CRETACEOUS	BOISSEVAIN		30	SAND AND SANDSTONE, GREENISH GREY. LOCATED ONLY IN TURTLE MOUNTAIN.
	MESOZOIC	CRETACEOUS	UPPER CRETACEOUS	PIERRE SHALE	COULTER; ODANAH; MILLWOOD; PEMBINA; GAMMON FERRUGINOUS	340	SHALES, GREY, NON-CALCAREOUS, LOCAL IRONSTONE, BENTONITE NEAR BASE, GAS SHOW. / SHALE, DARK GREY, CALCAREOUS, NON-CALCAREOUS, BENTONITIC BANDS.
	MESOZOIC	CRETACEOUS	UPPER CRETACEOUS	NIOBRARA		75	SHALE, GREY SPECKLED, CALCAREOUS, BENTONITIC, SLIGHTLY PETROLIFEROUS.
	MESOZOIC	CRETACEOUS	UPPER CRETACEOUS	MORDEN SHALE		55	SHALE, DARK GREY, NON-CALCAREOUS, RARE IRONSTONE CONCRETIONS, LOCAL SAND AND SILT.
	MESOZOIC	CRETACEOUS	UPPER CRETACEOUS	FAVEL	ASSINIBOINE; KELD	40	SHALE, GREY WITH HEAVY CALCAREOUS SPECKS, LIMESTONE BANDS AND BENTONITE.
100	MESOZOIC	CRETACEOUS	UPPER CRETACEOUS / LOWER CRETACEOUS	ASHVILLE	BELLE FOURCHE; WESTGATE; NEWCASTLE (ASHVILLE); SKULL CREEK	115	SHALE, DARK GREY, NON-CALCAREOUS, FINE-GRAINED QUARTZ SANDSTONE OR SAND "ZONE".
	MESOZOIC	CRETACEOUS	LOWER CRETACEOUS	SWAN RIVER		75	SANDSTONE AND SAND, FINE-GRAINED WITH SILTS AND GREY, NON-CALCAREOUS CLAYS, PYRITIC, GLAUCONITIC.
150	MESOZOIC	JURASSIC	UPPER JURASSIC	WASKADA		200	BANDED, GREEN BENTONITIC SHALE AND CALCAREOUS, GLAUCONITIC SANDSTONE.
	MESOZOIC	JURASSIC	UPPER JURASSIC	MELITA	UPPER; LOWER		BANDS OF SANDY LIMESTONE, VARI-COLOURED SHALE AND SANDSTONE.
	MESOZOIC	JURASSIC	MIDDLE JURASSIC	RESTON		45	LIMESTONE, BUFF AND SHALES, GREY.
	MESOZOIC	JURASSIC	MIDDLE JURASSIC	AMARANTH	UPPER: EVAPORITE	45	ANHYDRITE AND/OR GYPSUM, WHITE AND BANDED DOLOMITE AND SHALE.
200	MESOZOIC	JURASSIC	MIDDLE JURASSIC	AMARANTH	LOWER: REDBEDS	40	SHALE, RED TO SILTSTONE, DOLOMITIC.
	MESOZOIC	TRIASSIC	(?)	ST. MARTIN COMPLEX		300	CARBONATE BRECCIA AND TRACHYANDESITE (CRYPTO-EXPLOSION STRUCTURE).
	PALEOZOIC	PERMIAN	(?)	ST. MARTIN COMPLEX			
250	PALEOZOIC	PENNSYL-VANIAN	(?)	ST. MARTIN COMPLEX			
	PALEOZOIC	MISSISSIPPIAN		MADISON GROUP: CHARLES	DANDO EVAP	20	MASSIVE ANHYDRITE AND DOLOMITE.
300	PALEOZOIC	MISSISSIPPIAN		MADISON GROUP: MISSION CANYON	MC-3 (MC-3b; MC-3a); MC-2; MC-1	120	LIMESTONE, LIGHT BUFF, OOLITIC, FOSSILIFEROUS, FRAGMENTAL, CHERTY, BANDS OF SHALE AND ANHYDRITE.
	PALEOZOIC	MISSISSIPPIAN		MADISON GROUP: LODGEPOLE	FLOSSIE LAKE; WHITEWATER LAKE; VIRDEN; SCALLION; ROUTLEDGE	185	LIMESTONE AND ARGILLACEOUS LIMESTONE, LIGHT BROWN AND REDDISH MOTTLED, SHALEY ZONES, OOLITIC, CRINOIDAL AND CHERTY.
350	PALEOZOIC	MISSISSIPPIAN		BAKKEN	UPPER; MIDDLE; LOWER	20	TWO BLACK SHALE ZONES SEPARATED BY SILTSTONE.
	PALEOZOIC	DEVONIAN		Qu'Appelle Group: THREE FORKS		35	SILTSTONE AND SHALE, RED, DOLOMITIC.
	PALEOZOIC	DEVONIAN		SASK. GROUP: BIRDBEAR		40	LIMESTONE AND DOLOMITE, YELLOW-GREY, FOSSILIFEROUS, POROUS, SOME ANHYDRITE.
	PALEOZOIC	DEVONIAN		SASK. GROUP: DUPEROW		170	LIMESTONE AND DOLOMITE, ARGILLACEOUS AND ANHYDRITIC IN PLACES.
	PALEOZOIC	DEVONIAN		MAN. GROUP: SOURIS RIVER (FIRST RED)		120	CYCLICAL SHALE, LIMESTONE, DOLOMITE AND ANHYDRITE.
	PALEOZOIC	DEVONIAN		MAN. GROUP: DAWSON BAY (SECOND RED)		65	LIMESTONE AND DOLOMITE, ANHYDRITIC. LOCAL RED AND GREEN SHALE.
	PALEOZOIC	DEVONIAN		ELK POINT GROUP: PRAIRIE EVAP.		120	HALITE, POTASH, ANHYDRITE AND DOLOMITE INTERBEDDED.
	PALEOZOIC	DEVONIAN		ELK POINT GROUP: WINNIPEGOSIS	UPPER (REEF)	75	DOLOMITE, LIGHT YELLOWISH BROWN, REEFOID.
	PALEOZOIC	DEVONIAN		ELK POINT GROUP: ELM POINT	LOWER (PLATFORM)		LIMESTONE, FOSSILIFEROUS, HIGH-CALCIUM.
400	PALEOZOIC	DEVONIAN		ELK POINT GROUP: ASHERN		12	DOLOMITE AND SHALE, BRICK RED TO VARIGATED GREEN.
	PALEOZOIC	SILURIAN		INTERLAKE GROUP		135	DOLOMITE, YELLOWISH ORANGE TO GREYISH YELLOW FOSSILIFEROUS, SILTY ZONES.
	PALEOZOIC	ORDOVICIAN		● STONEWALL	UPPER; LOWER; WILLIAMS	20	DOLOMITE, GREYISH YELLOW, BEDDED. / DOLOMITE, YELLOWISH GREY, SHALY. (Upper and Lower separated by the t-marker)
	PALEOZOIC	ORDOVICIAN		● STONY MOUNTAIN	GUNTON; PENITENTIARY	25	DOLOMITE, DUSKY YELLOW, FOSSILIFEROUS.
	PALEOZOIC	ORDOVICIAN		● STONY MOUNTAIN	GUNN	20	SHALE, RED-GREEN, FOSSILIFEROUS LIMESTONE INTERBEDS.
450	PALEOZOIC	ORDOVICIAN		● RED RIVER	FORT GARRY; SELKIRK; CAT HEAD; DOG HEAD	170	DOLOMITIC LIMESTONE, MOTTLED AND MOTTLED DOLOMITE.
	PALEOZOIC	ORDOVICIAN		WINNIPEG	UPPER SHALE	60	SHALE, GREEN, WAXY, AND INTERBEDDED SANDSTONE.
500	PALEOZOIC	ORDOVICIAN		WINNIPEG	LOWER SANDSTONE		SAND AND SANDSTONE, QUARTZOSE.
550	PALEOZOIC	CAMBRIAN		DEADWOOD		60	SAND, BLACK TO GREEN-GREY, WAXY, GLAUCONITIC SILTSTONE AND SHALE, GREEN-GREY TO BLACK. LOCATED ONLY IN EXTREME SOUTHWEST CORNER OF MANITOBA.
	PRECAMBRIAN						ACID AND BASIC CRYSTALLINES AND METAMORPHICS.

● Productive crushed stone intervals within the Capital Region.

Figure 17: Geological formations in Manitoba.

Ordovician/Silurian Stonewall Formation is present in the Stonewall Quarry Park (Appendix 1). Silurian Interlake Group strata are present in the subsurface in the western portion of the Capital Region, but do not outcrop (Fig. 15 and 16).

Ordovician

Winnipeg Formation: The Winnipeg Formation, a quartzose sandstone interbedded by green, waxy shale with sand and silt interbeds, is exposed in outcrop east of the Capital Region.

Red River Formation: The Red River Formation consists of two principal subunits, the lower Red River and upper Red River strata. In the vicinity of the south basin of Lake Winnipeg, the lower Red River can be subdivided into three mappable members: a lower Dog Head Member, a medial Cat Head Member, and a 45 m thick upper Selkirk Member (i.e., Tyndall Stone™) (Fig. 17). Lower Red River strata consist of light grey to yellowish and brownish buff, prominently mottled, fossiliferous, commonly cherty, dolomitic limestones. A thin (8 m thick) limestone is present at or near the top of the Selkirk Member. The upper Red River strata consist of dolomite and argillaceous cherty dolomite, designated as the Fort Garry Member (Fig. 17). Locally, a thin, high calcium limestone bed occurs at the top of the Fort Garry Member. In the Capital Region, the Selkirk Member of the Red River Formation is the only unit exposed in outcrop. The Fort Garry Member is present in quarry exposures.

At Garson (outside the Capital Region, but included in this study), Gillis Quarries Limited is actively quarrying the Red River Formation (Selkirk Member) for its dimension stone (Tyndall Stone™). Scrap bedrock and overburden are presently being crushed by a subcontractor into aggregate.

Stony Mountain Formation: The Stony Mountain Formation is subdivided into three members, in ascending order: the Gunn, Penitentiary and Gunton (Fig. 17). The Williams Member was once included within the Stony Mountain Formation, however, standardized correlations established for the new atlas of the WCSB (Norford et al., 1994) have placed the Williams Member into the overlying Stonewall Formation.

The Gunn Member consists of greyish red to purplish grey, fossiliferous, calcareous shale to argillaceous dolomite with interbeds of relatively clean, fossiliferous limestone. The Penitentiary Member consists of yellowish to reddish grey, fossiliferous, argillaceous dolomite. These two members together comprise the lower Stony Mountain. The upper Stony Mountain (Gunton Member) consists of a buff, finely crystalline, sparsely fossiliferous, nodular-bedded dolomite that is relatively uniform in thickness and lithology.

All three members are exposed in the Mariash Quarry and abandoned City of Winnipeg quarries at Stony Mountain (Appendix 1), an erosional outlier of the Stony Mountain Formation, located 7 km southwest of the town of Stonewall. The Gunton Member acts as a cap rock for a shallowly buried, east-facing, north-trending escarpment (Gunton Escarpment) (Bezys et al., 1999b, d), 4 km east of the town of Stonewall. The Gunton Member is extracted from quarries in the Stony Mountain and Stonewall areas and is used extensively for crushed stone. The stone has also been used to construct buildings in Winnipeg, Stony Mountain (including the federal penitentiary), Stonewall and Gunton.

Ordovician/Silurian

Stonewall Formation: The Williams Member, herein placed as the basal unit of the Stonewall Formation, represents the oldest of a series of so-called “para-time-stratigraphic” markers; thin sandy and/or argillaceous beds that can be traced for many hundreds of kilometres throughout most of the WCSB. These marker beds provide the primary means for stratigraphic subdivision of Upper Ordovician and Silurian strata and probably represent deposits related to brief periods of shoaling or even slight uplift and erosion (i.e., non-sequences) (Porter and Fuller, 1959). The Williams Member consists of buff to grey to red, sublithographic dolomite (Fig. 17).

The lower Stonewall beds, above the Williams Member, consist of pale yellowish grey to yellowish brown, faintly mottled, medium- to thin-bedded, finely crystalline dolomite with sparse, poorly preserved fossils. A sandy argillaceous marker bed, the “t-marker” or “t-zone”, separates the lower Stonewall Formation from the upper Stonewall Formation (Fig. 17). The upper Stonewall Formation consists of light brown to grey, laminated to thin-bedded, sparsely fossiliferous, microcrystalline dolomite, which is capped by a grey to buff dolomudstone marker bed, the Upper Stonewall Marker.

The position of the Ordovician–Silurian boundary in the WCSB has been traditionally placed at the t-marker within the upper part of the Stonewall Formation (Porter and Fuller, 1959; Brindle, 1960; McCabe, 1988) (Fig. 17). Recent biostratigraphic studies confirm this as an approximate placement, both in outcrop in north-central Manitoba (Cormorant Hill roadcut) (Bezys, 1991) and in subsurface coreholes in Saskatchewan (Esterhazy 3SWD well, 16-26-20-33WPM) (Haidl, 1991).

The Stonewall Formation was previously quarried in the town of Stonewall for lime and aggregate production. At present there are no crushed stone producers utilizing this formation in the Capital Region.

Silurian

Interlake Group: The Interlake Group, consisting of the Fisher Branch, Moose Lake, Atikameg, East Arm and Cedar Lake formations (in ascending stratigraphic sequence), is not exposed in the Capital Region and thus is not presently quarried for crushed stone. In the subsurface, the group consists of yellow-orange to grey, fossiliferous, oolitic, stromatolitic dolomite, interrupted by sandy, argillaceous marker beds.

Mesozoic

Triassic/Jurassic/Cretaceous

Amaranth and Swan River formations: The Amaranth and Swan River formations (Fig. 17) are present in pre-Mesozoic karst channels and sinkholes cut into the Paleozoic bedrock. An Amaranth Formation-filled channel is present in the Capital Region southern area (in the Charleswood area of Winnipeg) and another occurrence is located in the Dominion City Channel–Jurassic Embayment (south of the Capital Region) (Fig. 3). The Amaranth Formation consists of gypsum evaporite beds and redbeds. The Swan River Formation is composed of silica sand and carbonaceous and/or kaolinitic clays. Intersections of probable Mesozoic units, determined from water wells, are indicated on the accompanying maps with the symbol K within a green circle.

Cenozoic

Pleistocene and Recent

The present-day landscape of the Capital Region is the result of multiple glacial advances and inundation by glacial Lake Agassiz. For a detailed discussion on the Quaternary geology of the area, refer to Matile (1985) and Manitoba Energy and Mines (1997). Postglacial alluvium of the Assiniboine and Red rivers, organics developed in poorly drained areas, and eolian deposits complete the present-day landscape.

MAP DISCUSSION

The geology, bedrock topography and overburden thickness maps accompanying this report represent the most detailed geological review of the Capital Region in almost 20 years. The maps show many previously unknown geological features that may provide an understanding of the processes that shaped the geological landscape of the Capital Region. In turn, this understanding should aid in future mineral resource identification and exploitation.

The discussion of the maps will move from east to west.

Precambrian

As shown on map sheet NTS 62I7, the Precambrian does exist in the subsurface but the thickness of the Belair Moraine precludes any exposures. Northeast of Beausejour (NTS 62I2) and east of the study area, Precambrian monadnocks are present (Bezys et al., 2001). These outcrops rise 5 to 20 m above the surrounding prairie level and align in a linear pattern (N20°E). The Precambrian/Paleozoic boundary near Green Oak (not in study area), and due east of a Precambrian monadnock, has evidence of faulting.

Winnipeg Formation to the Red River Formation (Selkirk Member)

The anomalous northwest trend of the Winnipeg Formation to Red River Formation (Selkirk Member) outcrop belts (shown on NTS 62H15, 62I2 and 7), relative to the north trend of the Fort Garry Member (Red River Formation) to Silurian Interlake Group outcrop belts (shown on NTS 62H11 and 14, 62I3 and 6) may represent a change in the Paleozoic depositional/tectonic framework. This is indicated by the east trends of the Winnipeg and Red River formations isopachs and corresponding thickening to the south (Fig. 8 and 10). This contrasts with the consistent thickness of the overlying formations.

Red River Formation (upper Fort Garry Member) and Stony Mountain Formation (lower members)

On the west side of the Capital Region (NTS 62H14), the outcrop pattern of the upper Fort Garry Member of the Red River Formation and the overlying lower members of the Stony Mountain Formation are offset. The outcrop belts of these members are displaced 6 km to the west, south of the Assiniboine River, relative to the outcrop belts north of the Assiniboine River. This offset coincides with

1) The generally east-west contact between geological domains in the Precambrian basement. The Bird River Domain is situated on the north and the Winnipeg River Domain is on the south (Fig. 3).
2) A string of Paleozoic bedrock lows that trend east.
3) The location of an east-trending Jurassic outlier between Beaudry Provincial Park and Charleswood (at the west end of the City of Winnipeg).
4) The 30 m deep east-trending bedrock channel occupied by the present Assiniboine River (Kjartanson, 1983).

The coincidence of these features with the offset strongly suggests that, through geological time, periodic reactivation of the

Precambrian basement has possibly occurred along the present trend of the Assiniboine River, and that this reactivation affected the overlying Phanerozoic stratigraphy with both vertical and lateral displacements.

Cretaceous and Jurassic

Numerous karst channels or sinkholes with Cretaceous showings are evident in water wells. These are indicated on the maps (NTS 62H14 and 15, 62I2) as green circles with the symbol K in the middle. Some of these bedrock circular features are aligned in a linear pattern, such as those present along the Assiniboine and Seine rivers (NTS 62H14). The bedrock lows associated with the Assiniboine River and the Jurassic Beaudry–Charleswood outlier may be due to evaporite dissolution within the Jurassic.

Bedrock Features

Bedrock topography in NTS 62I2, 3, 6 and 7 show considerable irregularity with sharply defined highs and lows. These features can be grouped into escarpments, lineaments and outliers.

Escarpments

Lake Winnipeg South Basin Escarpment

North of the study area, Todd et al. (1997; 1998) identified the Lower Paleozoic section (Winnipeg and Red River formations) as a prominent escarpment, approximately 45 m high (G. Matile, pers. comm., 2001), within the middle of the south basin in Lake Winnipeg. The escarpment was defined using seismic reflection data obtained from Todd's Lake Winnipeg Study (Todd et al., 1997; 1998).

Ste. Agathe–St. Norbert (Buried) Escarpment

The Red River coincides with the lower Fort Garry Member outcrop trend and generally parallels the outcrop trend of the overlying upper Fort Garry Member, south of the City of Winnipeg (NTS 62H12 and 14), which is interpreted to be a possible bedrock escarpment cap. Numerous bedrock lows appear to align with the lower Fort Garry Member outcrop belt. The upper unit of the lower Fort Garry Member is a recessive, red, argillaceous, intraformational breccia that is easily eroded.

Gunton Escarpment

The 20 m high north-trending Gunton Escarpment is visible as a topographic high north of the City of Winnipeg. The escarpment, locally breached or notched, extends much of the width of NTS 62I3 and 6 (a distance of 55 km). Its definition is lost south of the Assiniboine River (NTS 62H14).

The escarpment comprises the Gunn, Penitentiary and Gunton members of the Stony Mountain Formation. The Gunn Member is an easily eroded unit that occurs at the base of the Gunton Escarpment. The Gunton Member caps the top of the escarpment and is very resistant. The cap rock parallels the 240 m bedrock contour interval.

The Gunton Member is highly desired by the heavy construction industry as a source of crushed stone, evidenced by the number of quarries northeast of Stonewall (NTS 62I3).

Lineaments

Major fracture orientations in the Capital Region strike northwest and northeast (Render, 1970). An examination of streams on the maps shows a preferred orientation of 120 to 140°. The consistency of the 120 to 140° stream direction implies that glacial ice movement, not bedrock faults, are responsible for the linear trends. According to G. Matile (pers. comm., 2002), the drainage pattern in the Red River valley is controlled by fluted till, with 7 m of relief. However, there are some significant lineaments with different orientations and the possibility of bedrock faulting cannot be ruled out, considering that some of these lineaments are associated with 30 m deep channels in the carbonate bedrock (Kjartanson, 1983).

Red River Lineaments

The Red River flows generally northward across the Capital Region (NTS 62H11 and 14, 62I2, 3 and 7). Kjartanson (1983) indicated that the Red River overlies a 30 m deep channel in the carbonate bedrock. Four lineaments (segments) are discernible along the length of the river, with two orientations:

1) In NTS 62H11, the Red River generally flows northeast (020°) from the bottom of the map to just northeast of Ste. Agathe. The fairly straight riverbed overlies the upper Fort Garry Member cherty dolomite and minor limestone. This lineament agrees with the northeast fracture orientation described by Render (1970) and seems to parallel the west edge of the Jurassic rocks situated 3 km to the east.
2) From northeast of Ste. Agathe to the City of Winnipeg (NTS 62H11 and 14), the tightly meandering riverbed is within the lower

Fort Garry and the upper Selkirk members of the Red River Formation. The general lineament orientation is north (000°), which parallels the Ste. Agathe–St. Norbert Escarpment described earlier. It should be noted that where the river cuts across the Selkirk Member, there are a series of bedrock depressions of 5 to greater than 10 m. These depressions disappear once the river re-enters the lower Fort Garry Member.

3) From the City of Winnipeg to the town of Selkirk (NTS 62H14, 62I2 and 3), the river resumes a northeast (020°) course within the lower Fort Garry and upper to middle Selkirk members of the Red River Formation. The river is again fairly straight with wide meanders similar to the first segment, described above. This segment occurs between the junction with the Seine River Lineament to the south and the northwest projection of the Satans–Cooks Creeks Lineament to the north (*see* description below). This change in the course of the river to 020° may correspond to the change in the Paleozoic deposition/tectonic framework, as described earlier. In this stretch of the river, it passes through several rapids. At Lister Rapids the river flows across an outcrop of resistant carbonate bedrock that controls the base level of the river upstream. The decrease in bed elevation across Lister Rapids is only about 7 m over 15 km, but relative to the gentle gradient of the river (0.0001) this is a significant drop in the profile (Natural Resources Canada, 2002).

4) From the town of Selkirk to Lake Winnipeg (NTS 62I2 and 7), the river trends north (000°) within the lower Selkirk and Cathead members. The meanders are tight at first, then straighten out and the river becomes braided in the Netley Marsh area.

Brokenhead River–Stoney Point Lineament

The Brokenhead River (NTS 62I7), within Brokenhead Indian Reserve 4, trends 135° over a length of 13 km. This direction is parallel to the lower reaches of the Winnipeg River, a major waterway within Precambrian bedrock, approximately 35 km to the northeast. The Brokenhead River course is situated within Lower Paleozoic strata, about 10 m above the Precambrian surface. This could imply that a fault, possibly present in the basement, has affected the overlying Paleozoic strata due to reactivation during Phanerozoic time. Subsequent weathering and erosion along a fault within the Paleozoic strata produced a topographic low that was filled in by younger sediments, and later occupied by the Brokenhead River. This agrees with the processes discussed earlier and described by Kjartanson (1983).

The pronounced lower Red River Formation bedrock high at Stoney Point (NTS 62I7), on the south shore of Lake Winnipeg, also strikes 135°. It is parallel to the Brokenhead River, 4 km to the southwest. Stoney Point is probably associated with a northwest-trending bedrock high north of the Brokenhead River, and is likely the southward continuation of the Lake Winnipeg South Basin Escarpment, described earlier.

Devil's Creek Lineament

A portion of Devil's Creek, which strikes 135°, flows northwest between the towns of Garson and Tyndall (NTS 62I2). The creek occupies a prominent northwest-trending bedrock channel or lineament that is 9 km long and 30 m deep. The strike of this portion of Devil's Creek parallels the strike of the Brokenhead Lineament and Winnipeg River, described above.

All extraction of Tyndall Stone™ from within the Selkirk Member of the Red River Formation, for building or dimension stone, has taken place along the southwest side of the creek channel. Gillis Quarries Limited is currently producing Tyndall Stone™ from quarries located immediately east of the town of Garson. The presence of the channel and the underlying Cat Head Member of the Red River Formation may preclude extraction of Tyndall Stone™ along its length.

Satans–Cooks Creeks Lineament

Satans Creek (a tributary of Cooks Creek) and a downstream portion of Cooks Creek (NTS 62H15, 62I2), also strike 135° over a total length of 11 km. This lineament, situated about 5 km southwest of town of Garson, is roughly on strike with the edge of the Selkirk Member outcrop belt to the southeast (NTS 62 H15).

Seine River Lineament

In southeastern Winnipeg (NTS 62H14), the Seine River trends 155°, which is significantly different from the preferred lineament orientation in this area (135°). Kjartanson (1983) indicated that the river overlies a 30 m deep channel in the carbonate bedrock. The strike direction of the Seine River Lineament may correspond to a change in the Paleozoic deposition/tectonic framework. As described earlier, the northwest trend of the Winnipeg and Red River formation outcrop belts changed direction during Red River Formation deposition to the north trend of the Fort Garry Member (Red River Formation) to Interlake Group outcrop belts. Alternatively, it may reflect the fact that this is the slope in the shallow depression left by glacial Lake Agassiz.

Sturgeon Creek Lineament

In western Winnipeg (NTS 62H14), Sturgeon Creek trends 140° over a distance of 10 km. This lineament, located north of the Assiniboine River, is a northwest-trending bedrock channel that is underlain by the Gunn and Penitentiary members of the Stony Mountain Formation. The southern end of the lineament terminates with the intersection of the Assiniboine River

Lineament, described below.

Numerous minor lineaments with a similar strike are shown on the west side of NTS 62H11 and 14. However, many of these may be the result of fluted tills or artificially created drainage ditches.

Assiniboine River Lineament

The 27 km long Assiniboine River Lineament, shown on the west side of NTS 62H14, is indicated by the generally eastward-flowing Assiniboine River. Although meandering in places, the 088° strike of the river can be seen from the edge of the map sheet to the junction with the Red River. Kjartanson (1983) indicated that the Assiniboine River occupies a 30 m deep bedrock channel.

The Assiniboine Lineament coincides with offset of the upper Fort Garry Member of the Red River Formation and the overlying lower members of the Stony Mountain Formation, described previously. The generally east-west basement contact between Precambrian Bird River Domain (to the north) and the Winnipeg River Domain (to the south) (Fig. 3) underlie the Assiniboine Lineament and it is speculated that reactivation along the basement contact may have produced the offset. The lineament is also parallel to the strike of the Jurassic outlier that lies south of the Assiniboine River. It should also be noted that the basement Precambrian domain contact appears to underlie the apex of the Assiniboine Delta (near Brandon, 180 km west of the study area), which occupies a major re-entrant of the Manitoba Escarpment. This may indicate that reactivation from the basement may have also continued up into Cenozoic strata.

Outliers

Tyndall Outlier

The Tyndall Outlier is a bedrock high, situated northeast of the Devil's Creek Lineament (described above) and the town of Tyndall (NTS 62I2). The outlier comprises the lower beds of the Selkirk Member of the Red River Formation. This outlier contains numerous small quarries that have been used for lime production in the past, some of which are presently used for the production of crushed stone.

Lower Fort Garry Outliers

Numerous outliers of the lower Fort Garry Member (Red River Formation) are present on the east side of the City of Winnipeg (NTS 62H14 and 62I3), east of the Ste. Agathe–St. Norbert Escarpment. The recessive upper unit of the lower Fort Garry Member was easily eroded by the ancestral Red River, leaving the more resistant micritic dolomite, which forms the basal beds, as remnants.

Stony Mountain Outlier

A prominent outlier, the Stony Mountain Outlier, contains the town of Stony Mountain and is located north of the City of Winnipeg (NTS 62I3). The outlier consists of the Gunton Member (Stony Mountain Formation) and has been essentially quarried out. The City of Winnipeg quarried the entire Stony Mountain Formation (Gunton, Penitentiary and Gunn members) at numerous locations. Much of the Penitentiary Member north and east of the townsite has also been removed. At the northeast end of the outlier, the Mariash Quarry extracts some Gunton and Penitentiary formation dolomite as required, but the quarry is limited to the amount of reserves remaining. The old City of Winnipeg quarries have been sold to private interests and may be rehabilitated in the future.

Sturgeon Road Outlier

Based on structure contour data, it appears that a Stonewall Formation outlier should lie coincident with Sturgeon Road, in the western portion of the City of Winnipeg (NTS 62H14). The overburden thickness is 5 m or less. In 2002, two coreholes were drilled to test the depth to bedrock along Sturgeon Road (Fig. 18 and 19; Table 3) (Bezys and Bamburak, 2002). In corehole M-01-02, the overburden thickness was 4.5 m, after which rubble from the Gunton Member (Stony Mountain Formation) was encountered. The corehole eventually became too unconsolidated and had to be abandoned at 10.0 m. In corehole M-02-02, the overburden thickness was 3.5 m and solid Gunton Member dolomite was intersected for the next 5.9 m. The Stonewall Formation was not encountered in either corehole.

The presence of the Gunton Member at such shallow depths, within the City of Winnipeg, offers great potential for crushed stone production, especially with the prospective short haulage rates. The bedrock high straddles the boundary between the City of Winnipeg and the Rural Municipality of Rosser, but is mainly within the control of the Winnipeg Airport Lands Corporation.

Beaudry-Charleswood Jurassic Outlier

An outlier of Jurassic Amaranth Formation is situated south of the Assiniboine River (NTS 62H14), stretching from Beaudry Provincial Park to Charleswood (at the west end of the City of Winnipeg). The outlier is parallel to the east-west Jurassic

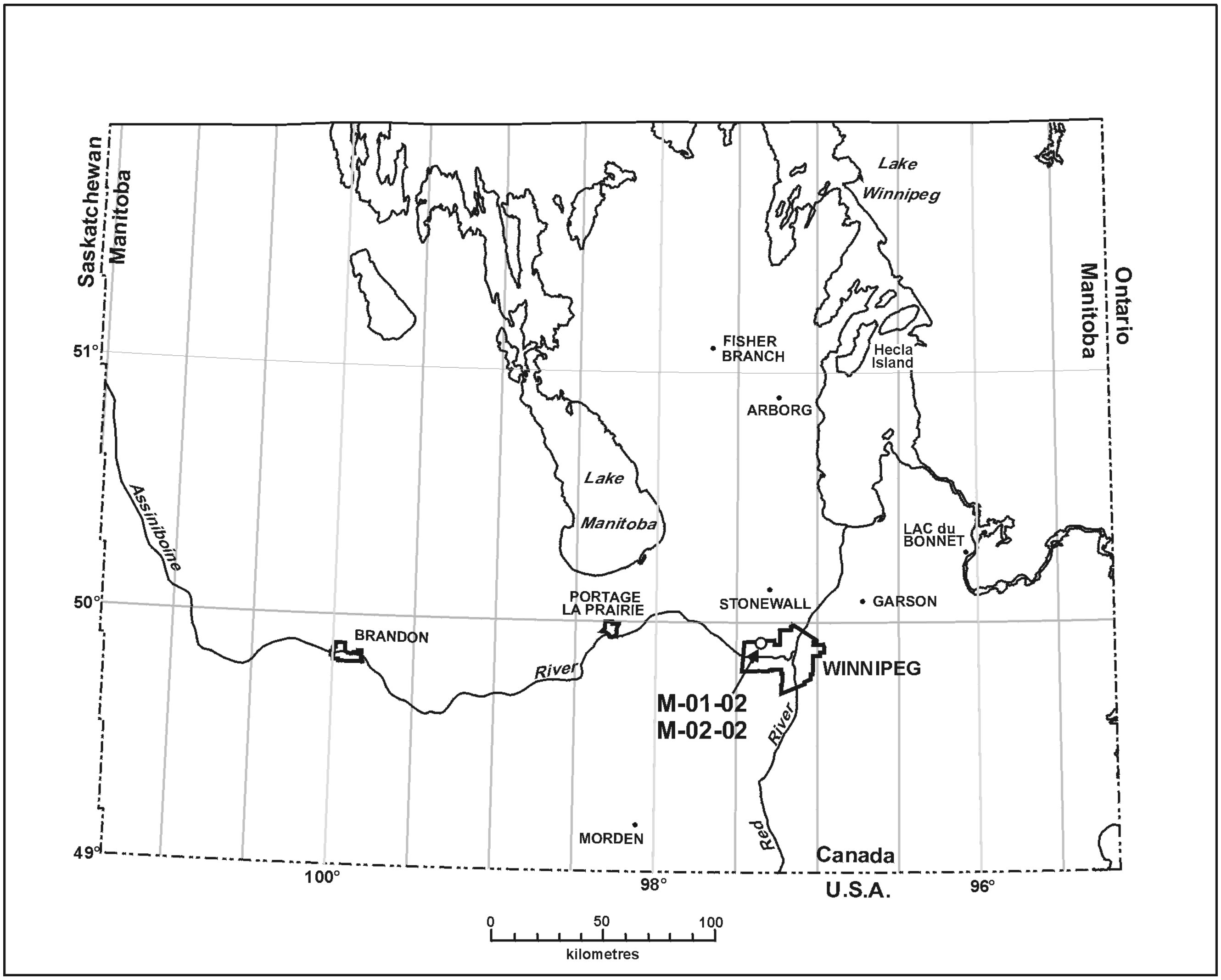


Figure 18: Location of stratigraphic coreholes, 2002.

Embayment or Dominion City Channel (Fig. 3), which has branched off from the main outcrop belt of the Jurassic Amaranth Formation (west of the study area).

Cretaceous Outliers

Many small outliers of Cretaceous Swan River Formation have been intersected in water wells in the Capital Region. These outliers (marked by the symbol K within a green circle), shown on NTS 6214 and 15, 62I2, usually occupy pre-Mesozoic karst channels and sinkholes in the Paleozoic bedrock. Numerous Cretaceous outliers are probably present throughout the Capital Region, but have not been intersected yet.

Bedrock Topography

Bedrock topography in the Capital Region indicates considerable irregularity with sharply defined highs and lows. Using seismic reflection data obtained from the Lake Winnipeg Study, Todd et al. (1997; 1998) identified the Lower Paleozoic section (Winnipeg and Red River formations) within the middle of the south basin in Lake Winnipeg as a prominent escarpment. The escarpment is approximately 45 m high (range of 30–65 m) (G. Matile, pers. comm., 2002). South of Lake Winnipeg, this escarpment becomes buried and is not prominent on the maps. Recent work by G. Matile (pers. comm., 2002) using water wells, indicate the presence of the escarpment (composed of the Red River and Winnipeg formations) along the Precambrian and Paleozoic boundary from Lake Winnipeg to the 49° parallel or United States border. It varies from 20 to 70 m in height.

To the west of Lake Winnipeg, within the Paleozoic outcrop belt, local relief is associated with the soft, easily eroded shales of the Gunn Member of the Stony Mountain Formation (Fig. 17). The overlying Gunton Member forms the Gunton Escarpment and acts as a cap rock that trends approximately north, parallel to the 240 m bedrock contour interval.

The Gunton Escarpment, within the Stony Mountain Formation, appears to be truncated south of the Capital Region study area by a prominent east to southeast bedrock low (Fig. 11 and 12). This bedrock low coincides with the occurrence of the Jurassic

Figure 19: Detailed location map of stratigraphic coreholes, 2002 and nearby water wells (with stratigraphic logs).

Table 3: Summary of stratigraphic corehole data, 2002.

Hole no.	Location and elevation (m)	SYSTEM/Formation/ (Member)	Interval (m)	Lithology summary
M-01-02	01-20-11-2-E1	OVERBURDEN	0.0–4.5	
Sturgeon Rd.	5532402N			
	623546E			
	240.5			
		ORDOVICIAN/Stony Mountain/(Gunton)	4.5–14.8	Tan dolomite, very rubbly
M-02-02	01-20-11-2-E1	OVERBURDEN	0.0–3.5	
Sturgeon Rd.	5532403N			
	623446E			
	240.5			
		ORDOVICIAN/Stony Mountain/(Gunton)	3.5–9.0	Mottled buff and yellow dolomite with pinpoint and vuggy porosity, rubbly in places, poor core
			9.0–9.4	As above, becoming bluish green downward, gradational into below
		(Penitentiary)	9.4–14.2	Mottled blue-green to grey dolomite, argillaceous, yellow in places, minor steel grey sulphides
		(Gunn)	14.2–31.0	Mottled grey, rounded clasts surrounded by red tendrils; limestone interbeds and calcareous shale (3–5 cm thick)
		Red River (Fort Garry)	31.0–32.6	Buff, very fine-grained dolomite

lobe of sediment deposition termed the Jurassic Embayment or Dominion City Channel (Fig. 3) and probably represents a pre-Jurassic bedrock channel. Subsequent overburden thickening coincides with the extent of Jurassic deposition.

A prominent northwest-trending bedrock channel or lineament is evident between the towns of Garson and Tyndall and cuts approximately 30 m into the bedrock and is approximately 6 km long. A bedrock high, also trending northwest, occurs due north of the Brokenhead River and is probably associated with the bedrock exposures of the lower Red River Formation at Stoney Point on Lake Winnipeg. As discussed earlier, circular anomalies are present throughout the map sheet and may reflect local karst topography, such as sinkholes.

Bedrock Fractures

In the Capital Region, the presence of an irregular carbonate bedrock surface, with abundant fractures has been noted in many geological, soils and engineering reports over the past century. The bedrock surface was subjected to numerous erosional events throughout the Phanerozoic, which produced numerous channels and sinkholes that have been masked by glacial sediments (Render, 1970; Barker, 1984)

The construction of the Red River Floodway in 1962 required that a hammer seismic survey be conducted along the centre line of the Floodway for almost 42 km (Hobson et al., 1964). The bedrock surface was test drilled at eight localities and the drilling confirmed the irregular surface shown by the hammer seismic survey. Within 600 m intervals along the profile, the bedrock surface ranged from 6 to 20 m in elevation. According to Render (1970), the major fracture orientations in the Capital Region strike northwest and northeast in the upper 7.5 m of the bedrock surface. The openings vary from hairline fractures to fractures 0.3 m wide, which decrease in size with depth. Large solution cavities were also found.

In the Capital Region, ten stratigraphic cross-sections prepared by Michalyna et al. (1975) also show the surface irregularities in the carbonate bedrock surface. Kjartanson (1983) stated that the bedrock surface in the Capital Region was extensively weathered (karst) in preglacial times and was later modified by glaciation to a depth of approximately 1.0 m. The origin of silica sand, kaolinitic clay, coal particles, and sand and gravel within the disturbed bedrock is believed to be preglacial in origin. Localized depressions (sinkholes) up to 30 m were also mapped. Kjartanson (1983) indicated in cross-sections that the Red, Assiniboine and Seine rivers overlie 30 m deep bedrock channels. This may imply that the present river courses have been partially influenced by pre-existing channels in the carbonate bedrock.

Postglacial movement of the carbonate bedrock in the vicinity of the North Main Sewage Plant is inferred in Plate 5 of Kjartanson (1983). A nearly vertical fault with a 3 m displacement is shown affecting the carbonate bedrock, overlying till, glacial Lake Agassiz sediments, and alluvium. This would indicate that the probable movement took place within the past 8000 years.

McRitchie (1996) began a study of the fracture orientations in Ordovician and Silurian bedrock in the Interlake region and, with new data, compiled a preliminary map the following year (McRitchie and Kaszycki, 1997). Fifteen localities in the Capital Region were examined (Table 4). In the Garson/Tyndall area (outside the Capital Region), 50 fracture orientation measurements were made at more than three sites. Major orientations were centralized around 077° and 180° in the Selkirk Member of the Red

River Formation. This can be compared with major orientations of 040° and 120° determined from approximately 550 measurements from eight localities in the Gunton Member of the Stony Mountain Formation. According to W.D. McRitchie (pers. comm., 1996), the fractures imposed an anisotropy on groundwater movement (particularly along the 120° set). He noted preferred solution fretting, bleaching of redbed phases in the carbonates adjacent to the fractures, phreatic solution cavities filled with friable (Cretaceous?) white silica sand, thinly laminated brown silts and muds in vadose solution pipes and fissures, enhanced precipitation of secondary flowstone on joint faces, and blebby sulphide (pyrite) films.

An examination of stream trends on the study maps, indicate that 120 to 140° is the preferred lineament orientation within the bedrock. A bedrock channel between Garson and Tyndall (NTS 62I2) is suggested by the 135° strike of a small creek, which joins two bedrock lows. The orientation of this creek may have been controlled by a bedrock lineament. The channel is roughly parallel to the orientation of the lower reaches of the Winnipeg and Brokenhead rivers. The Winnipeg River (Fig. 5 and 6) courses entirely within the Precambrian bedrock, whereas the Brokenhead River (NTS 62I7) courses within the Lower Paleozoic strata and is approximately 10 m above the Precambrian contact. This could imply that faulting by basement reactivation may cross-cut overlying Paleozoic strata.

Overburden Thickness

The maximum overburden thickness within the study area is located in the northeast corner of NTS 62I7, where the Belair Moraine is located. The moraine can reach in excess of 100 m, but within NTS 62I7 it is approximately 75 m thick. Another area of thick overburden is associated with the Birds Hill Esker (up to 50 m thick). The Birds Hill area (NTS 62H15, 62I2) has been extensively exploited for sand and gravel (Matile, 1985). Thick overburden (20–35 m) coincides with Jurassic infill of a prominent east-trending pre-Jurassic bedrock channel (south of the Assiniboine River within NTS 62H14). Other areas of thick overburden occur around the town of Teulon, west of the town of Gunton (both on NTS 62I6), and in the southern portion of the Capital Region (NTS 62H10 and 11).

Thin overburden is present within the towns of Stonewall (and northeast of the town) and Stony Mountain (NTS 62I3), and bedrock exposures have been exploited at these sites for crushed stone over the last century. Bedrock beneath shallow overburden around Garson and Tyndall (NTS 62I2) has also been a source of building, dimension and crushed stone. Other areas of near-surface bedrock occur in the town of Gunton (NTS 62I6) and east of the town of East Selkirk (NTS 62I2). Areas of thin overburden (<5 m) occur in the northwest corner of the City of Winnipeg (NTS 62H14). It is reported, although not documented, that shallow bedrock is encountered in some basements in the St. James area of west Winnipeg and in the Red River at Lister Rapids. On all maps, localities indicated by a quarry or an outcrop symbol implies thin or no overburden.

ECONOMIC GEOLOGY

The Capital Region produces primary and secondary industrial mineral products. Primary products are products that have been quarried and processed within the Capital Region, i.e., aggregate, lime and clay. Secondary products are made from materials quarried mainly outside the Capital Region. These materials, transported into the region for processing into finished products, i.e., dimension stone, gypsum wallboard and plaster, lime, cement and brick, are outside the scope of this report. An exception is made for Tyndall Stone™.

Aggregate is a primary product and is the most valuable commodity produced within the Capital Region. Crushed Ordovician

Table 4: Fracture measurements in the Capital Region.

Formation/Member	Quarry name	Fracture orientations	Number of readings
Stonewall	Stonewall	118°-120°	42
Stony Mountain/Gunton	Gillies	120°-125°; 040°-044°	68
Stony Mountain/Gunton	Standard	116°-120°; 040°	64
Stony Mountain/Gunton	White Rock	120°-122°; 024°-035°	50
Stony Mountain/Gunton	Mulder Pit 85	118°-123°; 040° (weak)	55
Stony Mountain/Gunton	Bison	116°-120°; 040°-048° (weak)	62
Stony Mountain/Gunton	Gunton	108°-120°; 040°-044°	111
Stony Mountain/Gunton	Lilyfield	115°-130°; 040°	91
Stony Mountain/Gunton	Stony Mountain	129°; 133°	52
Stony Mountain/Penitentiary	Stony Mountain	140°-150°; 040°	27
Red River/Fort Garry	Oak Hammock	117°-120°; 0°; 60° (weak)	24
Red River/Fort Garry	Riverside	132°	1
Red River/Selkirk	Hadiken	177°-180°; 077°	24
Red River/Selkirk	Garson	070°	18
Red River/Selkirk	Tyndall North	177°-180°	14

Source: W.D. McRitchie, pers. comm., 1997.

dolomitic limestone and dolomite and Pleistocene sand and gravel comprise the aggregate. Ordovician dimension stone (Tyndall Stone™), quarried and processed just east of the Capital Region boundary at Garson, is also an important commodity for decorative and construction purposes. Historically, Ordovician dolomitic lime has also been an important commodity produced in the Capital Region.

Aggregate

Aggregate (sand, gravel and crushed stone) is primarily used by the construction industry. Production of aggregate (including some dimension stone) in the province averaged about $47 million per year from 1992 to 2001 (Table 1). Aggregate extraction forms the largest mining sector by volume produced and land acreage disturbed. Within the Capital Region, 44 producers quarried over 5 million tonnes of aggregate at 67 sites in 2000 (Table 5). These are non-renewable resources that have no suitable, cost-effective engineering substitute for most end uses, such as road construction, concrete and asphalt (Jones, 1986).

Table 5: Capital Region aggregate production, 2000.

	No. of sites	Tonnes produced	No. of producers
Crushed stone	11	3 156 755	8
Sand and gravel	56	2 463 690	36
Total	**67**	**5 620 445**	**44**

Source: Manitoba Industry, Trade and Mines, Mining Recording Office Data, 2001.

Crushed Stone

The Capital Region contains numerous crushed stone quarries and the most abundant source of crushed stone comes from the Stonewall East area (Tables 6 and 7), an area that makes an extremely significant contribution to crushed stone production in the province. The Stonewall East area is underlain by the near-surface Gunton Member of Stony Mountain Formation, which meets most engineering specifications for roadbed aggregate (many bedrock formations in the province do not) (Jones, 1986; Bannatyne, 1988). During the summer months, hundreds of truckloads of crushed stone per hour leave the operating quarries, situated 1 to 4 km northeast of Stonewall. Much of the production is transported south along PTH 7 to construction projects in Winnipeg (Table 8). Details of the amount of crushed stone (Granular Base Course Class "A") in a 1991 tendered project (the last major Highways project in the vicinity of town of Stonewall) is shown in Table 9. It should be noted that the total cost of the project was five times the value of the Granular Base Course Class "A" (this relationship is used to calculate the total value of construction projects in Table 9).

Haulage costs (set in 1985 and in effect in 2001) for aggregate in Manitoba are shown in Table 10. The increase in distance is reflected in increasing costs at the delivery site. Of the ten quarries in the Stonewall East Area, two are almost depleted of the Gunton Member beds but newer quarries have replaced them. Two other quarries in the vicinity with abundant stone are dormant. However, as sites are depleted and/or sterilized from development, there will be a need to produce from more distant localities. The 2000 projected contribution to the Manitoba's gross domestic product (GDP) by crushed stone producers from the Stonewall East area is estimated to be $110 million (Tables 11 and 12).

Sand and Gravel

Sand and gravel comprise more than half of the total value of aggregate production in Manitoba (Table 1). Almost half of this production occurs within the Capital Region (Table 5), and over half of this quantity (over 2 million tonnes) comes from the Birds Hill area. The construction and transportation industries of Winnipeg have benefited from having sand and gravel in close proximity. As reserves in the Birds Hill area are depleted or become unavailable due to land-use pressures, other alternatives will have to be sought at a considerable cost to Winnipeg residents.

Birds Hill is an esker complex deposited at the ice front during the final recession of the Red River Lobe, at an early stage of glacial Lake Agassiz (11,000–12,000 years BP) (Matile, 1985). The northern portion of the Birds Hill area is now sterilized within a provincial park. Current production comes from the southern end of the main esker channel. Because, the objective of this report was not sand and gravel, the reader is urged to see Underwood McLellan and Associates Limited (1976) for further details.

Building Stone/Dimension Stone

Manitoba's limestone and granite production values shown in Table 1 include dimension stone. Both Precambrian and Ordovician dimension stone products are manufactured within or in close proximity to the boundary of the Capital Region. Historically, near Selkirk, building stone slabs and blocks were quarried from Ordovician bedrock exposures within the Red River, and were used to construct Lower Fort Garry. Blocks were also extracted from the lower Stonewall Formation, in quarries near Stonewall. Some of this stone was used locally (Fig. 20 a, b), but some was shipped to Winnipeg for building construction. Similarly, at Stony Mountain, quarried stone from the Gunton Member (Stony Mountain Formation) was used locally, i.e., the Stony Mountain Penitentiary, as well as for churches, homes, stores and other local buildings. Local stone from the Gunton Member (Stony Mountain Formation) was extracted for building stone in the town of Gunton (Fig. 21 a, b).

Table 6: Crushed stone quarries in the Capital Region.

Owner/operator	Quarry name	Quarry location (L.S./Qtr.Sec.-Sec.-Twp.-Rge.-Mer.)	Easting	Northing	Description	Mineral Inventory Card	Status*
Stonewall East							
Borland Construction (1989) Limited	Borland South	NE-32-13-2-E1	622975	5556475	Appendix 1	Appendix 1	active
	Borland North	SW-5-14-2-E1	622075	5556800	Appendix 1	Appendix 1	active
Inland Aggregates Limited (B-A Materials Limited)	B-A North	SW-4-14-2-E1	623700	5557000	Appendix 1	Appendix 1	active
	B-A South	NE-33-13-2-E1	624050	5556365	Appendix 1	Appendix 1	active
Mulder Construction & Materials Ltd.	Mulder Pit 85	SE-4-14-2-E1	624200	5556700	Appendix 1	Appendix 1	exhausted
	Mulder Pit 88	NE-5-14-2-E1	622900	5557600	Appendix 1	Appendix 1	active
Riverside Gravel (1985) Inc. (Bison Rock and Asphalt Products)	Bison	NW-4-14-2-E1	623800	5558525	Appendix 1	Appendix 1	active
Standard Limestone Quarries	Standard South	SW&NW-33-13-2-E1	623785	5556350	Appendix 1	Appendix 1	active
	Standard North	3&4-4-14-2-E1	623875	5557350	Appendix 1	n/a	exhausted
	Standard West	SE-5-14-2-E1	623100	5556900	n/a	n/a	active
Glacier North Ltd.	Gillies	13-32-13-2-E1	621998	5556900	Appendix 1	Appendix 1	active
Nelson River Construction	Whiterock Quarries Ltd.	07-33-13-2-E1	624175	5555600	Appendix 1	Appendix 1	inactive
Stony Mountain							
Mariash Construction Ltd.	Mariash	SE-14-13-2-E1	628100	5550450	Appendix 1	Appendix 1	active
Dennis Penner	City of Winnipeg West	2-14-13-2-E1	627425	5550475	Appendix 1	Appendix 1	exhausted
	City of Winnipeg East	13-12-13-2-E1	628475	5550250	Appendix 1	Appendix 1	exhausted
Oak Hammock							
Lafarge Canada Inc.	Mowatt Farm (Mulder Pit 12)	10-27-13-03-E1	635675	5554825	Appendix 1	Appendix 1	inactive
Gunton							
CBR Cement Canada Ltd.	Williams or No. 1 Quarry	06-28-15-2-E1	623590	5573625	Appendix 1	Appendix 1	inactive
	Gunn or No. 2 Quarry	07-28-15-2-E1	623750	5573500	Appendix 1	Appendix 1	inactive
	Lime or No. 3 Quarry	14-28-15-2-E1	623575	5574650	Appendix 1	Appendix 1	inactive
R.M. of Rockwood	Gunton Quarry South	15-21-15-2-E1	623685	5572900	Appendix 1	n/a	inactive
Komarno							
Armstrong Construction Limited	Komarno South	NE-20-17-2-E1	622220	5592760	n/a	n/a	active
Mulder Construction & Materials Ltd.	Komarno North	E-29-17-2-E1	621870	5593370	n/a	n/a	inactive
Lilyfield							
Bel Acres Golf & Country Club	Lilyfield NW (Pit 26)	SW-28-12-2-E1	624025	5544325	Appendix 1	Appendix 1	rehabilitated
Libau							
Selkirk Quarries Ltd.	Hadiken	NE-13-14-5-E1	658200	5562400	Appendix 1	n/a	active
Winnipeg							
City of Winnipeg	Little Mountain Quarry Park	14-27-11-2-E1	625972	5535486	Appendix 1	Appendix 1	rehabilitated

*current as of May 1, 2002
n/a - not available

Table 7: Capital Region crushed stone production in tonnes, 1992–2001.

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Area										
Stonewall East[1]	1 419 388	1 575 501	1 885 290	2 104 564	2 486 698	3 393 338	3 702 468	3 295 821	3 001 846	2 776 221
Outside Production[2]	125 639	192 910	173 959	206 245	121 102	151 623	144 682	181 486	154 909	87 400
Total	**1 545 027**	1 768 411	**2 059 249**	**2 310 809**	**2 607 800**	**3 544 961**	**3 847 150**	**3 477 307**	**3 156 755**	**2 863 621**

[1] Stonewall East includes a small amount of production from Stony Mountain (see Table 6).
[2] Outside Production includes Oak Hammock, Gunton, Komarno, Lilyfield, Libau and Winnipeg.

Source: Manitoba Industry, Trade and Mines, Mining Recording Office Data, 2002.

Table 8: Manitoba Transportation and Government Services crushed stone tenders awarded in 2001, Stonewall East.

Product	**Quantity** (tonnes)	**Value** ($)	**Weighted Average** (price per tonne)
Granular Base Course Class "A"	505 000	$4,969,200	$9.84*
Granular Base Course Class "C"	126 000	$1,064,700	$8.45

* includes both production costs in the quarry and delivery costs to the job site.
Source: Manitoba Transportation and Government Services, written communication, 2002.

Table 9: Manitoba Transportation and Government Services project: concrete pavement, PTH 7 Interchange at PTH 101.

Description of work and materials	**Estimated quantities**	**Unit price** ($)	**Total** ($)
Subgrade modification	130 000 m^2	1.50	195,000
Granular Base Course Class "A"	60 000 t	7.35	441,000
Bituminous "A" pavement	16 000 t	16.00	256,000
Concrete pavement (poured)	56 000 m^2	16.22	919,674
Concrete pavement (reinforced)	8 300 m^2	18.22	155,376
Other			349,600
Total cost			**2,316,650**

Source: Manitoba Transportation and Government Services, written communication, 2002.

Table 10: Manitoba Transportation and Government Services minimum truck haul rates.

Hauling distance (km)	**Base rate** ($/t)	**Hauling rate** ($/t/km)	**Cost per tonne** ($)
1-20	0.46	0.09	0.54-2.26
21-40	0.46	0.08	2.34-3.86
41-over	0.46	0.065	3.93

Sample Calculations for 30 tonne Load

Hauling distance (km)	**Base cost** ($)	**Hauling cost** ($)	**Cost per 30 tonne load** ($)
10	13.80	27.00	40.80
20	13.80	54.00	67.80
30	13.80	78.00	91.80
40	13.80	102.00	115.80
50	13.80	121.50	135.30

Note: The haulage cost for a 30 tonne load transported, from the quarry to the job site, over a 30 km distance is approximately $3.00 per tonne.
Source: Manitoba Transportation and Government Services "Provisions for Minimum Truck Haul Rates", November 1985 and in effect as of April 23, 2001.

Table 11: Projected contribution to the 2001 provincial gross domestic product by crushed stone from Stonewall East.

	Quantity (tonnes)	**Value** ($)	**Price/tonne** ($)
Crushed stone tenders for Granular Base Course Class "A" in 2001 (from Table 8, includes production and delivery)	505 000	4,969,200	$9.84
Crushed stone tender for Granular Base Course Class "A" for PTH 7 Interchange at PTH 101 (from Table 9, includes production and delivery)	60 000	441,000	$7.35
Total cost of Interchange (five times the value of Granular Base Course Class "A")		**2,316,650**	
Total crushed stone production in Stonewall East in 2001 (from Table 7) Estimated delivered value of crushed stone to job site	2 776 221	22,000,000	$8.00*
Estimated value of construction projects in 2001 (five times the total estimated cost of delivered crushed stone in 2001 from Stonewall East)		**110,000,000**	

*Production cost – estimated value $5/t; and an average delivery cost of $3/t for a 30 tonne load transported 30 km (from Table 10).

Table 12: Preliminary estimate of quantity and value of dolomite stone resources from the Gunton Member, Stonewall East.

	1980 **Uncrushed stone estimate** (MacLaren 1980)	**2001** **Crushed stone estimate** (this report)	**Potential value***
Thickness	5 m	10 m	
Density	2.30 t/m^3	1.78 t/m^3	
Area	20 km^2	20 km^2?**	
Tonnage	**230 000 000 t**	**356 000 000 t**	**$1.8 billion**

Note:
* The 2001 estimate of potential value of the crushed stone is based on a minimum cost of $5 per tonne.
**No attempt was made to discount stone estimated in the MacLaren report that has subsequently been sterilized by non-mining land-use designation or which may now be known to be overlain by excessive overburden.

Tyndall Stone™

The eastern margin of the Capital Region study area was extended a few kilometres to the east to include the operations of Gillis Quarries Limited at Garson (Fig. 1). Paleozoic mottled dolomitic limestone (Ordovician Selkirk Member of the Red River Formation), often referred to as "tapestry" stone or Tyndall Stone™, has been quarried 50 km northeast of Winnipeg, since 1898. Over the last 100 years, the stone has been used across Canada in building construction (Table 13) worth millions of dollars and has been recognized for its unique mottled appearance (Bannatyne, 1988). An example of its importance is the Manitoba Legislative Building (Fig. 22 a–c), which officially opened in 1920 at a cost of $4.5 million. The replacement cost in 2000 would be over $1 billion, mostly for the elegant stonework.

Tyndall Stone™ has replaced local stone as dimension stone in the Stonewall/Stony Mountain area (Fig. 23). This can be seen in older buildings that have been remodelled or in newer construction, i.e., the new Stonewall and District Health Centre Building. This may be due to several factors:

1) the change in construction methods, from building stone (to support the weight of the structure) to dimension stone (to cover the internal wood and steel support);
2) the lack of skilled artisans to "work" the stone;
3) the bland appearance of the local stone compared to the "tapestry stone"; and
4) the shortage of stone with suitable bedding plane separation (the original Gunton Member cap rock at Stony Mountain has been depleted or sterilized by noncompatible land use, such as housing subdivisions).

In 1993, Gillis Quarries Limited produced 37 000 tonnes of buff, grey or golden finished stone worth $2.5 million. More than 25 000 m^2 were used on the Canadian Museum of Civilization in Hull, Quebec. In 1994, Gillis Quarries Limited employed 35 to 50 permanent staff, with an annual payroll between $1 to 1.5 million (Shetty, 1994).

a)

Figure 20: a), b) Buildings in the Town of Stonewall constructed out of local stone (Stonewall Formation).

b)

Dolomitic Lime

Dolomitic lime or high-magnesia lime (dolime) results when dolomite is calcined. Dolime, used for whitewash, plaster, cement and paper making, was produced from the late 1800s to 1967 in pot and draw kilns, at many localities in the Capital Region.

The largest producer of dolime in the Capital Region was The Winnipeg Supply and Fuel Company Limited in Stonewall (Fig. 1) from 1880 to 1967. Dolomite was quarried from the Stonewall Formation at Stonewall until 1965, when reserves were exhausted. Dolime produced from the Stonewall Formation was known among local masons for its high quality (Bannatyne, 1975). The company's Irwin Quarry and its kilns are preserved as Stonewall Quarry Park (Appendix 1), where an interpretive centre has been built to document Stonewall's lime production history.

Dolime was also produced from dolomite in the Stonewall East area (Fig. 1). From 1957 to 1967, dolomite at the Lillies Farm (Gillies) Quarry (Appendix 1) was extracted from the Ordovician Stony Mountain Formation, which supplemented and then replaced the feed at The Winnipeg Supply and Fuel Company's Stonewall plant. In 1970, the Lillies Farm Quarry supplied the raw material for Steel Brothers Canada Limited's lime plant in Tuxedo, in south Winnipeg.

Potential Mineral Products

Primary

Potential primary mineral production within the Capital Region may come from reactivated quarries and pits. A new type of primary producer would be a base and/or precious metal mine.

a)

Figure 21: a) Kiln remnants at the northeast end of the Gunn or No. 2 Quarry, next to the railway track. The Gunton Member of the Stony Mountain Formation was used to construct the kiln walls. b) Remnants of a structure near the south end of the Williams or No. 1 Quarry, near the railway track. The Gunton Member of the Stony Mountain Formation was used to construct the walls.

b)

Base and Precious Metals

Since the late 1950s, several companies have intermittently explored the buried Precambrian in the Selkirk area for base and precious metals. Drill programs in 1959 and 1960 tested a gravity anomaly and found sporadic pyrrhotite and chalcopyrite. In 1963, a Turam electromagnetic survey was conducted after the release of an aeromagnetic study by the federal government showed a magnetic anomaly roughly coincident with the gravity anomaly. No follow-up work was done.

In the summer of 1995, ProAm Explorations Corporation (ProAm) began the two-year, \$3 million Golden Boy project to investigate a potential nickel deposit within the Red River valley corridor (Redekop, 1997). Phase 1 included detailed magnetic and gravity surveys to identify the most prospective areas for drilling. In February 1996, ProAm conducted a detailed gravity survey based on over 700 specific observations (ProAm Explorations Corporation, 1999). The gravity anomaly indicated by the survey was 15 by 35 km and attained a +38 milligal magnitude (approximately 1/3 greater than that of the Sudbury Basin in Ontario). The anomaly suggested a dense ultramafic-gabbroic lopolith intrusive body in Archean rock, below 150 m of Paleozoic limestone (ProAm Explorations Corporation, 1997a). Claims were staked by Red River Powder and Supply Ltd. in 1996 and 1997, and an option to acquire the claims was taken by ProAm (Assessment File 94270, Manitoba Industry, Trade and Mines, Winnipeg). In April 1997, ProAm conducted a detailed aeromagnetic survey that consisted of over 4000 km of flight line at 200 m intervals. The survey indicated that the gravity anomaly is surrounded by an annular ring of aeromagnetic anomalies covering an area of 20 by 35 km (ProAm Explorations Corporation, 1999).

In 1997, the Manitoba government Geological Services Branch drilled three holes in the Selkirk area as an extension of sub-Phanerozoic, Shield Margin studies (Bezys and Bamburak, 1997). Hole M-01-97 encountered iron formation intruded by gabbro and carried stringers, blebs and disseminated sulphides including chalcopyrite. Hole M-03-97 encountered serpentinized dunite lying below pyrite-enriched Ordovician Winnipeg Formation sandstones. According to ProAm "None of the rock types encountered in the drilling can adequately explain both the profound excess of mass indicated by the gravity anomaly and the

Table 13: Major uses of Tyndall Stone™ in Canada.

Manitoba
Bank of Montreal Buildings, 1913 & 1984, Winnipeg
Canada Post Office, Winnipeg
Canadian Wheat Board, Winnipeg
Castle on the Seine, Winnipeg
Evergreen Place, Winnipeg
Former Air Command Headquarters, Winnipeg
Fort Garry Hotel, Winnipeg
Fort Garry Place, Winnipeg
Fort Whyte Centre, Winnipeg
Great West Life Building, Winnipeg
Hudson's Bay Company Store, Winnipeg
Law Courts Building, Winnipeg
Legislative Building, Winnipeg
Manitoba Medical Association Building, Winnipeg
Manitoba Museum of Man and Nature, Winnipeg
Manitoba Telephone System, Brandon
Manitoba Theatre Centre, Winnipeg
Oak Hammock Marsh Interpretative Centre, near Stonewall
Union Station, Winnipeg
University of Manitoba Buildings, Winnipeg
Winnipeg Art Gallery
Winnipeg City Hall
Winnipeg Convention Centre
Winnipeg International Airport

Saskatchewan
CBC Regina Broadcast Centre, Regina
Cornwall Centre, Regina
Government of Canada Building, Prince Albert
Pollution Control Plant, Saskatoon
Saskatchewan Legislative Building, Regina
Saskatchewan Museum of History, Regina
Sturdy Stone Centre, Saskatoon
T.C. Douglas Building, Regina
University Hospital, Saskatoon
University of Saskatchewan, Saskatoon

Alberta
Banff Springs Hotel, Interior
Calgary Court House
Chateau Lake Louise Hotel
Consulate of Japan, Edmonton
Provincial Museum and Archives of Alberta, Edmonton
Royal Bank of Canada Building, Lethbridge
Shell Canada Limited Office, Calgary

British Columbia
Empress Hotel, Victoria
Hudson's Bay Memorial, Vancouver

Ontario
Canadian Starch Company, Port Colborne
Eaton's College St. Store, Toronto
Parliament Building, Interior, Ottawa
St. Peter's Seminary, London

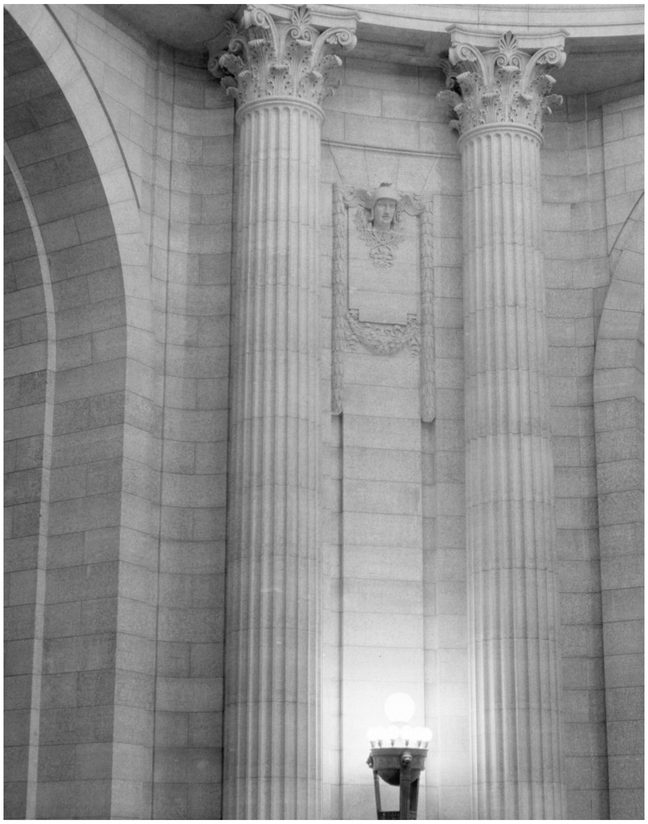
Quebec
Canadian Museum of Civilization, Hull
Chateau Apartments, Montreal
St. Roche's Church, Quebec City

coincident magnetic anomalies" (ProAm Explorations Corporation, 1997b). The scope of the project was also widened to include volcanogenic massive sulphide (VMS) deposits, iron formation-hosted gold deposits, and mineral deposits which may exist in the Phanerozoic cover (ProAm Explorations Corporation, 1997b).

In 1998, ProAm drilled two holes in the Selkirk area. Dr. Jim Franklin, formerly with the Geological Survey of Canada, examined the core from DDH 97-1. He concluded that "The sample of iron formation (97M1-106) has a very low REE (Rare Earth Element) content and exceptionally low Ti (titanium) content, consistent with a rock of dominantly hydrothermal origin. The most remarkable aspect of this sample is its anomalously high Eu (europium) content. It has been pointed out that distal products of high-temperature hydrothermal exhalations produce a chemical precipitate with such an anomalous Eu content may be a prime drill target. The stratigraphic horizon represented by this sample may have high VMS potential" (ProAm Explorations Corporation, 1999). After examining the core from DDH 98-2, he commented that "Alteration, including the high amount of carbonate and the distribution of manganese and barium indicate a VMS (Volcanicogenic Massive Sulphide)-style hydrothermal system operated in the area. The large amount of copper in the basaltic portion of the hole and the anomalous amount of zinc in the sedimentary sequence overlaying the basalt should be pursued, as these are good indications that a focused discharge may have occurred within a kilometre or two of DDH 98-2" (ProAm Explorations Corporation, 1999). As of December, 2000, claims staked by Red River were cancelled and the results of the Golden Boy project released (Assessment files 94270 and 94393, Manitoba Industry, Trade and Mines, Winnipeg).

Figure 22: a), b), c) The use of Tyndall Stone™ in the Manitoba Legislative Building, Winnipeg.

a)



b)

c)

Diamonds

The discovery of diamondiferous kimberlites in Saskatchewan, northwestern Ontario and Wisconsin has encouraged the exploration for similar targets within the Capital Region and in southern Manitoba.

In 1992, John E. Lee recorded claim JEL 45 (SV2232) over a 1500 m wide, 100 nanoTesla "bullseye" aeromagnetic anomaly in Sec. 4, Twp. 17, Rge. 3, E of 1st Mer., 10 km east-northeast of Teulon. The anomaly, shown on a 1960s federal government aeromagnetic map, was similar to the magnetic signature of known kimberlites. The claim was transferred to Indicator Explorations Limited in 1993. In 1994, a ground total field magnetic survey (11.1 line km) was conducted over the anomaly with a Barringer Model GM-122 Proton Magnetometer. The survey resolved the anomaly into a 600 m wide, 800 nanoTesla oval-shaped structure, with a probable mean source diameter in the Precambrian of 350 m. More work was recommended to define the structural configuration before drilling. This work was apparently not done and in November 1995, the claim was cancelled (Assessment File 93658, Manitoba Industry, Trade and Mines, Winnipeg). As of December, 2001, the anomaly was held by Indicator Explorations Limited as Ham 4 (SV9732).

Figure 23: A model lime kiln monument at the south end of the Town of Stonewall on PR 236. The stone used to construct the model was Tyndall Stone™ and not the local stone (Stonewall Formation).

Secondary

A potential secondary product in the Capital Region is magnesium metal extracted from Silurian dolomite. This dolomite outcrops north of the Capital Region at Inwood (and possibly beneath thin cover in the northwest corner of the Capital Region).

SUMMARY AND CONCLUSIONS

The distribution of mineral resources in Manitoba's Capital Region area, primarily within Ordovician formations, has been determined from the examination of quarries, outcrops, water-well and corehole data. As a result of newly acquired data, new depth to bedrock, bedrock topography, geology and mineral potential maps were produced (NTS 62H10, 11, 14 and 15, 62I2, 3, 6 and 7; scale 1:50 000) and accompany this report. All quarries in the study area have been inventoried and are presented in Appendix 1.

Areas of thin overburden (<5 m thick) are areas that should be protected for future bedrock potential and extraction. These include the towns of Stonewall (and northeast of the town) and Stony Mountain; the town of Garson (and Tyndall); the town of Gunton; east of the town of East Selkirk; and the Sturgeon Road area (City of Winnipeg) (Fig. 1) (Table 14). The protection of these regions from future land-use pressure will ensure a supply of bedrock resources (either as crushed stone or building stone) for the Capital Region area. These resources provide a tremendous amount of wealth to the economy of Manitoba, and sterilization of these areas by land-use pressure will cause considerable expense as other alternatives are sought.

To test the interpreted bedrock high (based upon the evaluation of water-well logs in GWDrill) in the vicinity of Sturgeon Road (in the northwest part of Winnipeg), two coreholes were drilled in 2002 (M-01-02 and M-02-02). The Sturgeon Road shallow bedrock area, mostly within the City of Winnipeg and partly in the Rural Municipality of Rosser, offers potential for crushed stone extraction, due to the presence of the highly sought after Gunton Member (Stony Mountain Formation). The overburden thickness was 3.5 to 4.5 m and the Gunton Member thickness was 5.9 to approximately 10.3 m in the two coreholes. With this thickness, the Gunton Member is extractable as a crushed stone resource.

Table 14: Areas with high potential for crushed stone or building stone in the Capital Region.

Location	Formation (Member)
Town of Stonewall (and northeast of town)	Stony Mountain Fm. (Gunton Member)
Town of Stony Mountain	Stony Mountain Fm. (Gunton Member)
Town of Gunton	Stony Mountain Fm. (Gunton Member)
Town of Garson (and Tyndall)	Red River Fm. (Selkirk Member)
Town of East Selkirk (east of town)	Red River Fm. (Selkirk Member)
City of Winnipeg (Sturgeon Road)	Stony Mountain Fm. (Gunton Member)

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