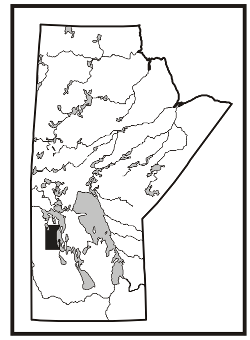
GS-32 INVESTIGATIONS ON THE CAMPERVILLE GRAVITY LOW (PARTS OF NTS 62N/E AND 63C/E)

by J.D. Bamburak, I.T. Hosain, M.A.F. Fedikow and E. Dobrzanski[1]



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SUMMARY

Over many years of documentation by the Manitoba Geological Survey and the Geological Survey of Canada, anomalous features have been found in the vicinity of Camperville, Manitoba. Other recent studies have concluded that the Superior Boundary Zone, lying immediately to the northwest, has been active during the Paleozoic. A major fault appears to separate the Superior Boundary Zone from the Camperville gravity low. Long-term movements along this fault may have produced channelways for deep fluid migration from the buried Precambrian basement. These channelways may have also penetrated the overlying Phanerozoic strata. The fluids may have left their signature by depositing minerals at structural and lithological traps. The purpose of this summer's field work was to determine if unique mineralization is present in the vicinity of the Camperville gravity low, and if this mineralization has economic potential.

INTRODUCTION

The Camperville area contains numerous anomalous features that have been documented by the Manitoba Geological Survey, Geological Survey of Canada and other agencies. The most conspicuous of these is a semicircular (65 km diameter) gravity low of approximately 30 mGal, the most intense low in the province (Fig. GS-32-1). This gravity low was noted in the mid-1960s (Buck, 1968). The Camperville gravity low (CGL) is abruptly truncated on the northwest by the northeast-trending gravity high of the Superior Boundary Zone (SBZ), which roughly parallels the Swan River.

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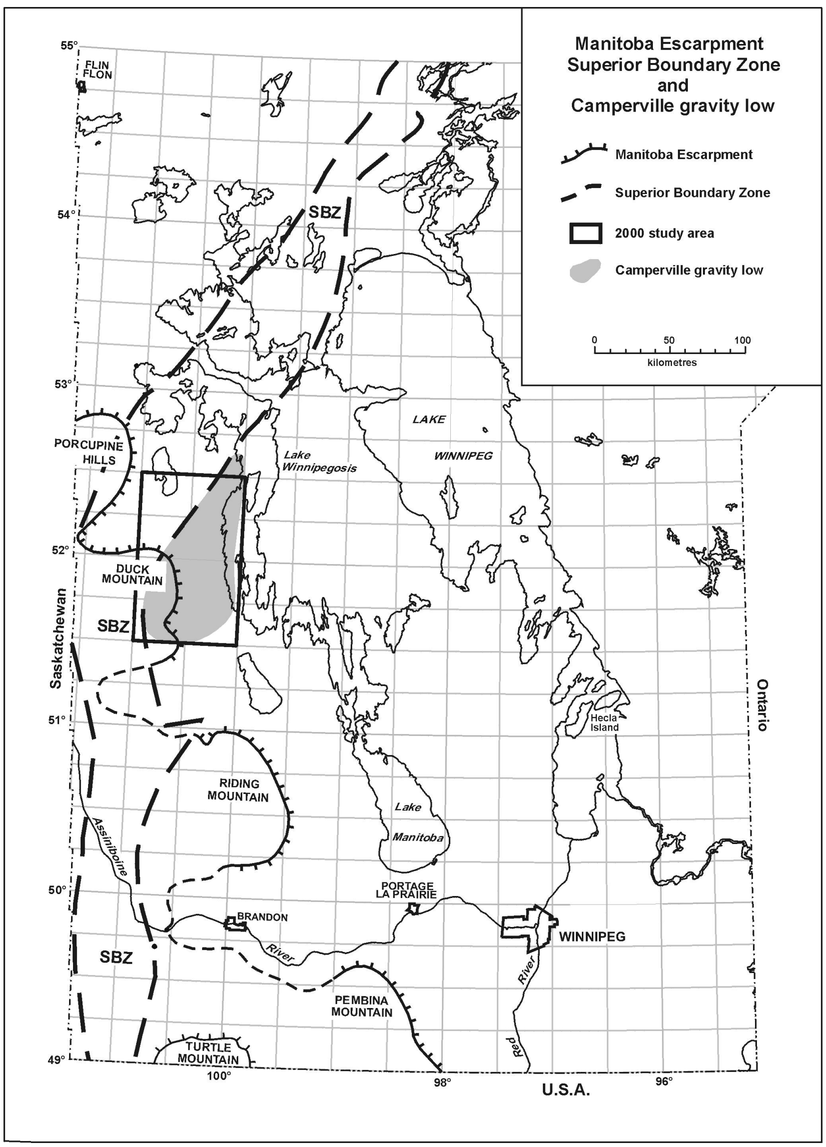
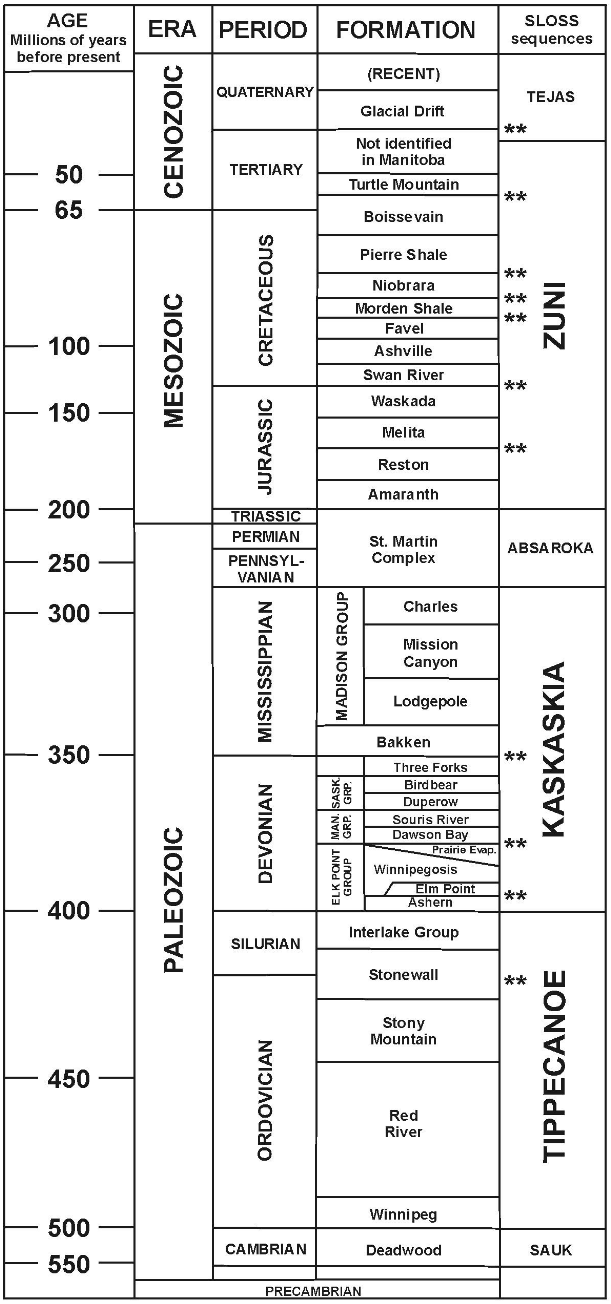


Figure GS-32-1: Location of the Camperville gravity low (CGL) study area, the Manitoba Escarpment and the Superior Boundary Zone (SBZ) in southern Manitoba.

Stratigraphy

The stratigraphic succession of deposition and erosion of formations in southern Manitoba is shown in Figure GS-32-2. The Devonian and Upper Cretaceous stratigraphy of the CGL study area is shown in more detail in Table GS-32-1. For the most part, the Upper Cretaceous marine shale and thin limestone beds were removed by erosion east of the Manitoba Escarpment (Fig. GS-32-1).



Footnote: * Potential major karst events
** Potential minor karst events

Figure GS-32-2: Generalized stratigraphic section for southern Manitoba, with asterisks showing times of karst events (McRitchie, 1991).

The oldest exposed bedrock within the CGL is the Devonian Winnipegosis Formation, located east of the Manitoba Escarpment (Fig. GS-32-1). The Winnipegosis Formation is overlain by the Dawson Bay Formation, which is overlain by the Souris River Formation of the Manitoba Group. Unconformably overlying the Devonian beds is the Upper Cretaceous Swan River Formation. The basal formation of the Manitoba Escarpment is the Ashville Formation, followed in ascending order by the Morden Shale, Niobrara Formation, and the Gammon Ferruginous, Pembina, Millwood and Odanah members of the Pierre Shale (Table GS-32-1).

Pleistocene glacial sediments blanket the Camperville gravity low.

Anomalous Features

Other anomalous features within the Camperville gravity low and/or in its immediate vicinity are:

1) Numerous circular aeromagnetic highs, contained within the -60 mGal contour of the CGL.
2) A residual magnetic high of more than 1000 gammas within the northern part of the CGL, 10 km north of Provincial Trunk Highway (PTH) 20 and northwest of Camperville (Hall et al., 1975).
3) An area of 'magnetic disturbance', situated 2 km northeast of Snake in the south basin of Lake Winnipegosis, 10 km east-northeast of the town of Winnipegosis (Radakir, 1973).
4) A change in orientation of the SBZ from northeast-southwest to north-northwest–south-southeast.
5) The boundary between the sand and shale facies within the Ordovician Winnipeg Formation.
6) The apparent thinning of the Ordovician Red River Formation isopach and a corresponding apparent thickening of the overlying Silurian Interlake/Stonewall isopach.
7) The northern edge of the known Jurassic beds in southern Manitoba.
8) The eastern erosion edge of Mesozoic shale beds of the Manitoba Escarpment.
9) The presence of honey-coloured sphalerite, with minor pyrite, identified in Winnipegosis Transition Zone core between 110.8 and 113.2 m in hole M-6-80, drilled in the vicinity of a quarry on Pine River Road, SE1-5-33-19W (McCabe, 1980).
10) Barite, identified by McCabe (1980), in lower Dawson Bay beds within a quarry in NW16-31-33-19W (10 km north of hole M-6-80).
11) A structurally high, flat-topped, Winnipegosis reef at a depth of 21 m in corehole M-9-79, drilled in the vicinity of the above quarry. With an estimated thickness of 105 m, the reef is the thickest reef known in this portion of the outcrop belt. A strong artesian flow (20 m head) was also encountered (McCabe, 1979, 1980). A value of 200 ppm Pb was obtained from reefoid dolomite (with excellent porosity) of the Winnipegosis Formation at a depth of 30.5 m (Gale and Conley, 2000).
12) A dispersion train of five G10 garnets, trending southeast from the CGL for a distance of 400 km. The nearest G10 garnet to the anomaly was found only 70 km to the southeast (Thorliefson and Garrett, 1993). A sixth G10 garnet was found within the train in a subsequent survey (Matile et al., 1996).

Previous Investigations

The potential for Mississippi Valley–type (MVT) mineral occurrences within Paleozoic carbonate rocks in Manitoba has been suggested by many geologists over the past 30 years (Gale and Conley, 2000). Fedikow (1999) discussed the potential for sediment-hosted disseminated sulphide deposits (Au, platinum-group elements and base metals).

An oil-well testhole was drilled in the area of Paradise Beach, southeast of Winnipegosis (Fig. GS-32-3) in the 1930s or 1940s. The well was on a dome-shaped outcrop of Dawson Bay Formation. The remains of the drill camp can still be seen near the shore of Lake Winnipegosis. Local stories of the drilling project tell of an underground exploration shaft for lignite, base metals or rare elements.

In 1969, a small, well rounded pebble of almost pure galena was found in NE26-14-1E, near the town of Balmoral, 250 km southeast of the CGL and 35 km northeast of Winnipeg. McCabe (1969) suggested that the pebble might have been glacially transported from a site similar to the Phanerozoic Pine Point deposit (NWT).

Table GS-32-1: Table of formations in the vicinity of the Camperville gravity low.

Formation/Member		Maximum thickness (m)	Lithology
<u>Upper Cretaceous</u>			
Pierre Shale			
	Odanah Member	150	Hard grey siliceous shale
	Millwood Member	60	Soft bentonitic clay
	Pembina Member	7	Noncalcareous black shale with numerous bentonite interbeds near base
	Gammon Ferruginous Member	30	Ferruginous black shale
Niobrara Formation		30	Chalky buff and grey speckled calcareous shale
Morden Shale		30	Noncalcareous black shale with abundant jarosite
Favel Formation			
	Assiniboine Member	17	Olive-black speckled calcareous shale with Marco Calcarenite beds near top
	Keld Member	17	Olive-black shale, speckled shale, with Laurier limestone beds near top
Ashville Formation		80	Noncalcareous black to dark grey shale, silty; Newcastle sand zone, in places
Swan River Formation		150	Sandstone, sand and silt, quartzose, pyritic shale, noncalcareous
<u>Devonian</u>			
Souris River Formation			
	Sagamace Member	34	Basal, red and orange mottled, calcareous and noncalcareous shale; argillaceous limestone; brecciated dolomite and limestone; aphanitic, partly vuggy limestone with abundant sparry calcite
	Point Wilkins Member	30	Basal red shale; argillaceous and high calcium limestone
Dawson Bay Formation		50	Basal red shale; dolomite; lower limestone, fossiliferous; medial calcareous shale; dolomite; upper stromatoporoidal limestone
Winnipegosis Formation		28 (105)[a]	Dolomite, reefoid; limestone, interreef bituminous laminates
Ashern Formation		26	Dolomite, argillaceous dolomite; dolomitic shale

[a]See item 11 in ‘Anomalous Features’ section of text.

In 1975, Gulf Minerals Canada Ltd. conducted a systematic search for base-metal deposits along the rim of the Western Canada Sedimentary Basin. Ten claim blocks (6752-6761) were staked in August 1975, near the town of Minitonas (Fig. GS-32-3). Gulf Minerals selected the Minitonas area as an exploration target based on:

1) the projected trend (from aeromagnetic data) of the SBZ beneath Paleozoic and Mesozoic cover;
2) the distribution of Winnipegosis reefs;
3) post-Devonian solution of the Prairie Evaporite and probable collapse structures;
4) the Silurian Interlake Group unconformity with the overlying Middle Devonian Ashern Formation and the possible development of karst topography; and
5) the presence of circular structures on the Earth Resources Technology Satellite (ERTS) mosaic.

During November 1975, Gulf Minerals conducted a four-hole drilling program on the claims in accord with Agreement 24 with the Province of Manitoba. The holes drilled in twp. 36, rge. 25 and 26, W1 ranged from 508.4 to 535.5 m in depth, for a total of 2087.6 m. Of this total, 1481.3 m of the core were analyzed, over 3 m lengths, by

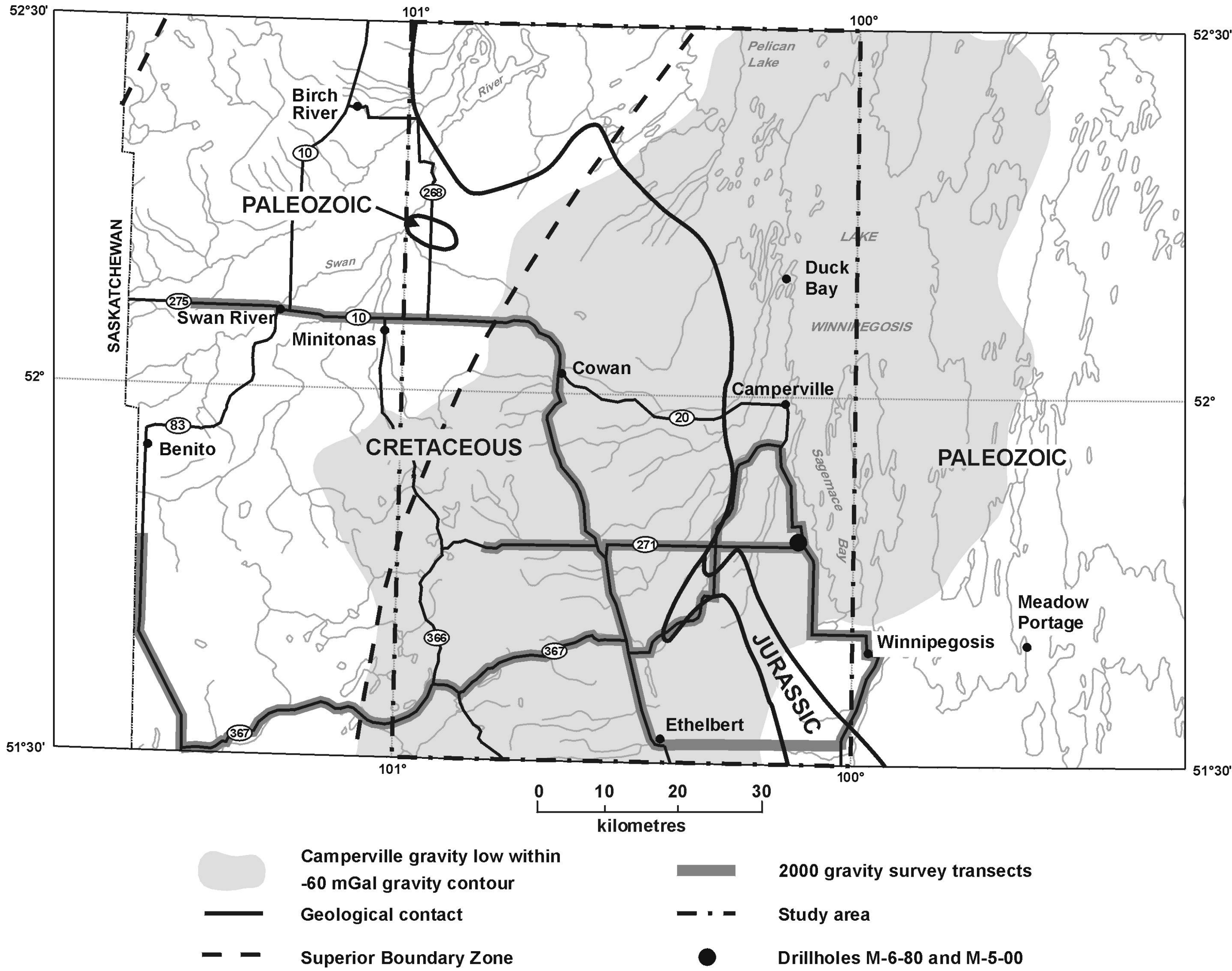


Figure GS-32-3: Camperville gravity low study area.

Technical Services Laboratories, Toronto. The samples were analyzed for Cu, Pb and Zn by the atomic absorption method (Assessment File 92116, Manitoba Industry, Trade and Mines, Winnipeg).

Pyrite was found as fillings in fractures and vugs, as well as being associated with fossils. A small crystal of sphalerite was noted at 429.2 m (1,408 feet) in hole 13-10-36-26W1 (Assessment File 92116). The maximum values for Cu, Pb and Zn occur within a sandy and shaly bed in the Interlake Group. The bed is present in three of the drillholes, and the metal content increases toward the north. The highest Cu value from the Winnipegosis Formation (182 ppm) is from the thickest section in hole 1-28-36-26W1. Another interesting interval is from hole 15-32-36-26W1, where an average of 297 ppm Cu and 294 ppm Zn were obtained from 341.4 to 353.6 m (1,120 to 1,160 feet) in the Interlake Group, with a maximum of 721 ppm Cu and 690 ppm Zn from 347.5 to 350.5 m (1,140 to 1,150 feet). However, Gulf Minerals concluded that there is no significant base-metal content in the sampled intervals and that further work was not warranted (Assessment File 92116).

The results of a detailed geochemical sampling program, carried out from 1980 to 1985 on departmental drill core, was released by Gale and Conley (2000). The utilization of data from this report is described below (*see* 'Geological Investigations' section).

Recent Investigations

Oil-well core and chips, and outcrop samples, from the southern portion of the Manitoba Escarpment were analyzed by Fedikow et al. (1997) to provide new metallogenic concepts relevant to mineral exploration in Phanerozoic sequences. The results of these analyses were published as a series of data files (Fedikow et al., 1998). Additional black-shale samples were collected in the Porcupine Hills area as part of the Prairie-type microdisseminated mineralization study centred on the Mafeking area (Bamburak et al., 1997). In 1999, this work was extended toward the southeast to include the Manitoba Escarpment in the Duck Mountain and Riding Mountain areas (Bamburak, 1999).

Basement Reactivation

Reactivation of the Precambrian basement along the SBZ has been discussed by numerous authors and was reviewed by Bamburak (1999). The main points of the discussion are as follows:

1) Paleozoic strata straddling the SBZ and CGL were probably differentially affected by basin subsidence and uplift during deposition. The Superior craton (and therefore the CGL) underwent greater subsidence during depositional episodes and greater uplift during erosional episodes than the SBZ.
2) Evidence for movement of the SBZ during the Early Paleozoic has been documented in the William Lake area to the northeast and along the Birdtail–Waskada axis to the south. Continuation of these movements during the Mesozoic, along the SBZ, is suggested by the presence of accretionary lapilli in the Easterville area.

3) Penetration of Paleozoic limestone by deep groundwater flow within the outcrop belt is evidenced by solution chimneys in the Mafeking quarry, by the Ochre Lake structure and by modern salt springs. Grasby (GS-34, this volume) describes the latter in further detail.

CURRENT STUDY

Geophysical Surveys

As stated earlier, the presence of the 30 mGal negative anomaly in the Camperville area was documented by the Dominion Observatory in the mid-1960s (Buck, 1968). The gravity low is located immediately east of the SBZ. To test the validity of this low, a series of reconnaissance and detailed transects were conducted during the summer across the low and into the adjacent SBZ. A two-person reconnaissance gravity survey was conducted, from a base in Winnipegosis, over a three-day period in May. The survey was conducted at a 10 km station spacing along three east-west transects across the CGL from Lake Winnipegosis to the Superior Boundary Zone. (Fig. GS-32-3).

The gravity meter used, on loan from the Department of Geological Sciences, University of Manitoba, was a Worden gravity meter with a scale constant of 0.46 mGal/division. The readings could be taken to an accuracy of 0.1 scale division. Elevations were recorded using a GPS unit, but stations were also selected where contour lines on a 1:50 000 scale topographic map crossed the highways. Station spacings for the gravity survey were kept within 10 km. In total, 45 stations were measured along the transects. The station interval of the Dominion Observatory survey was similar to that of the present survey.

The area has little topographic relief except in the vicinity of Duck Mountain. Therefore, only a few stations required topographic corrections. The resulting gravity anomaly of the present survey is identical to that of the 1965 survey.

Two University of Manitoba undergraduate students under our direction carried out a detailed gravity and magnetic transect with 1 km station intervals (*see* Surasky and Minkus, GS-33, this volume). The transect ran from the town of Camperville along PTH 20, PTH 10 and Provincial Road (PR) 275 to the Saskatchewan border (Fig. GS-32-3). Flagged wooden pickets were placed at each station. They used the same gravity meter and, for part of the survey, the University's magnetometer. Unfortunately, their magnetometer malfunctioned midway through the survey and only gravity readings were taken at the remaining stations. We completed the survey in August using the Department's magnetometer, a proton precession MP3 with a sensitivity of 1 nT. The pickets placed by the students enabled us to take measurements at the same locations as the gravity readings. The magnetic readings of the overlapping stations from both surveys were identical.

Gravity readings were also taken along a short transect (8 stations with a 0.5 km spacing) along an east-west township road approximately 5 km north of PTH 10 in the Renwer area (Fig. GS-32-3). This work was carried out to determine the strike of the sharp change in gravity readings along the PTH 10 transect. Interpretation of the data is presently being carried out and will be available at a later date.

Geological Investigations

Devonian and Cretaceous bedrock exposures were sampled to determine if unique mineralization occurs in Paleozoic carbonate rocks and Mesozoic shale within the CGL, and if this mineralization has economic potential. The Devonian outcrops are situated mainly along Lake Winnipegosis and the Cretaceous outcrops are found along the Duck Mountain portion of the Manitoba Escarpment (Fig. GS-32-1). Norris et al. (1982) described most the Devonian exposures and McNeil and Caldwell (1981) have documented many of the Cretaceous sections in detail.

Figure GS-32-4 shows the values of Cu, Zn, Pb, Mn and Fe from hole M-6-80, drilled at a quarry on Pine River Road, SE1-5-33-19W (McCabe, 1980). As described above, honey-coloured sphalerite, with minor pyrite, was identified between 110.8 and 113.2 m (Gale and Conley, 2000), in the Winnipegosis Formation transition zone. Immediately above this zone, polymict collapse breccia was identified at the base of the Dawson Bay Formation. Partly bituminous laminated dolomite was found immediately below the zone. Examination of Figure GS-32-4 indicates that, in hole M-6-80:

1) The Ashern Formation is enriched in nickel and iron relative to the overlying Winnipegosis Formation.
2) The uppermost beds of the Winnipegosis Formation are enriched in Cu, Zn, Pb and Ni, but show a reduction in Fe and Mn relative to the underlying beds. This is also true, with the exception of Ni, for the overlying Dawson Bay Formation.
3) Values for Pb, Ni, Fe and Mn are generally high throughout the Dawson Bay Formation, relative the other formations.
4) Values for Pb, Ni, Fe and Mn seem to be slightly higher near the base of the Point Wilkins Member of the Souris River Formation.
5) There are solitary peaks for Zn, Pb and Ni in the upper portion of the Sagamace Member of the Souris River Formation. The values for Mn seem to be increasing upward through the sequence.
6) Plots of Ni and Fe show similar trends throughout the core, although the relative magnitudes are significantly different. Plots of Pb and Mn also show some similarity to those of Ni and Fe, and the Cu and Zn plots also show some correspondence.

The Pine River Junction corehole M-5-00 (Table GS-32-2) was drilled through 121.0 m of Devonian stratigraphy to verify the presence of sphalerite originally encountered in M-6-80. In corehole M-5-00, black mineralization was encountered at almost the same stratigraphic level as in corehole M-6-80, and appears to be the 'blackjack' form of sphalerite. No honey-coloured sphalerite was found in M-5-00.

B-Horizon Soil Sampling

In October, b-horizon soil samples were collected for enzyme leach and geochemical analysis along PTH 10, in the vicinity of the SBZ and CGL boundary (Fig. GS-32-3).

ACKNOWLEDGMENTS

Ian Ferguson of the Department of Geological Sciences at the University of Manitoba is gratefully acknowledged for facilitating the detailed gravity-magnetometer survey, partially funded under a Natural Sciences and Engineering Research Council of Canada (NSERC) grant. Thanks are also extended to Doug Berk and staff of the Midland Core Facility for drilling M-5-00 during the summer of 2000, and for preparing outcrop and core samples for chemical analysis.

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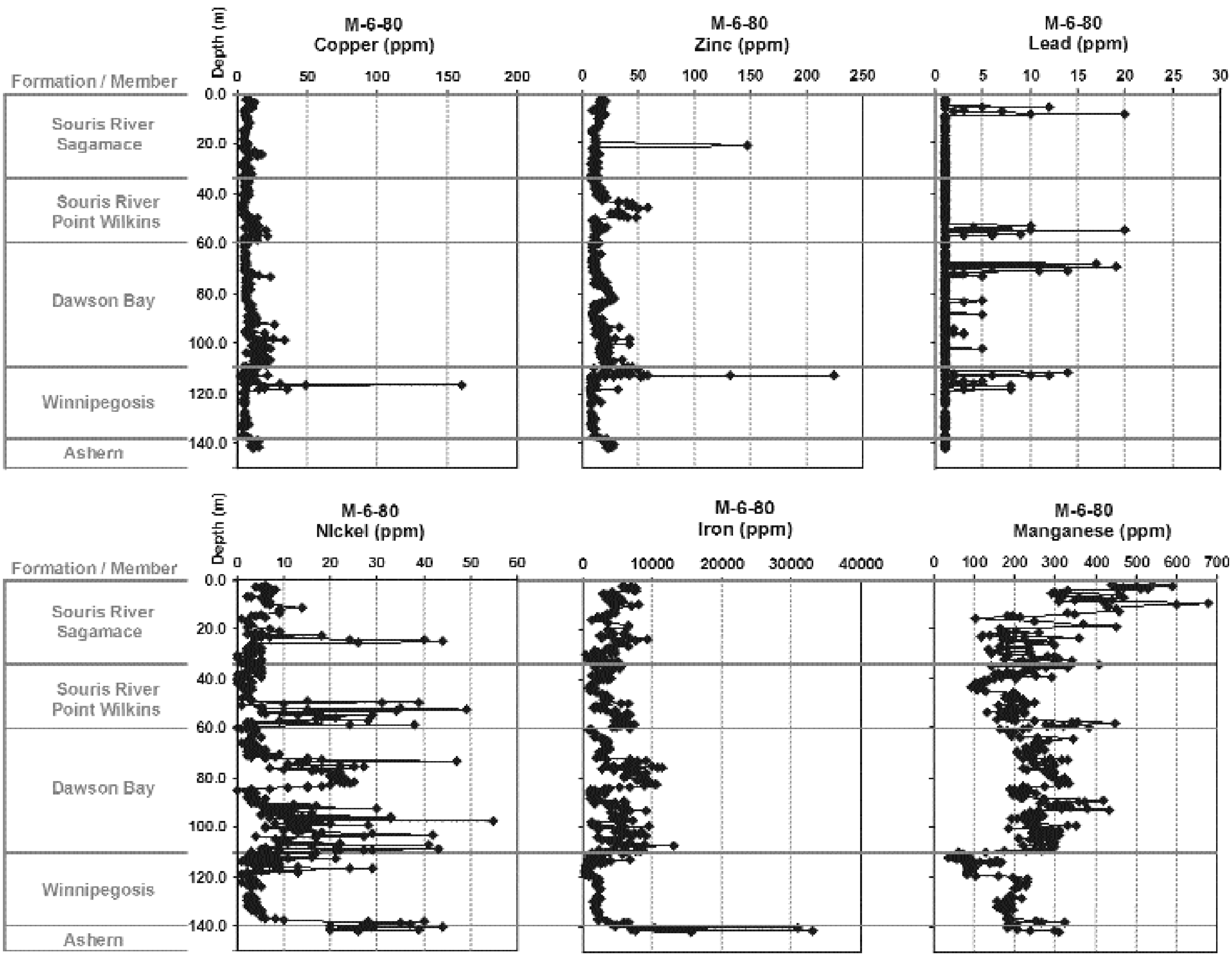

Figure GS-32-4: Concentrations of Cu, Zn, Pb, Ni, Fe and Mn (ppm) in corehole M-6-80.

Table GS-32-2: Detailed log of corehole M-5-00

Hole no.	Location and elevation (m)	SYSTEM/Formation/ (Member)	Interval (m)	Lithology summary
M-05-00 Pine River Junction quarry	SE1-5-33-19W 423445N 5739324E 262m	DEVONIAN/Souris River (Sagamace)	0.0–20.2	Dolomite, fine grained becoming brecciated downward
			20.2–27.1	Shale, dolomitic shale, limestone, breccia, short intervals of blue clay infill
		(Point Wilkins)	27.1–45.9	Dolomite, breccia, calcite-filled vugs and healed fractures, becoming vuggy below 36.5 m
			45.9–56.6	Shale breccia with disturbed bedding, limestone, dolomite (First Red Beds)
		DEVONIAN/Dawson Bay	56.6–69.8	Limestone, partly dolomitized, fossiliferous, calcite-filled vugs and healed fractures
			69.8–82.8	Calcareous shale, greenish grey becoming purplish red below 71.6 m, mottled
			82.8–94.8	Limestone, brachiopod, calcite-healed fractures, minor pyrite
			94.8–106.7	Polymict collapse breccia; shale, limestone, dolomite; includes Second Red Beds; below 103.0 m, clasts are beige, grey, pink and brown; below 105.0 m, argillaceous greyish green soft clay; at base are carbonaceous stylolites
		DEVONIAN/Winnipegosis (Transition zone)	106.7–112.7	Upper 2.2 m white, ?kaolinitic clay; dolomite breccia, porous, fossiliferous, partly laminated; limestone, fine vuggy, trace pyrite; lowest 0.5 m dark clay laminae with increase in sulphide banding and clots
		(Upper Member)	112.7–117.1	Dolomite, partly bituminous; minor shiny black mineralization (?sphalerite) in fractures at 114.2 m, minor pyrite; below 114.6 m, nine 3 cm thick sulphide-rich laminae and numerous thinner laminae, partly fine vuggy (birdseye) porosity, inter-reef facies
		(Lower Member)	117.1–121.1	Platform facies; dolomite, vuggy, mottled, nodular; massive near top, pinhole porosity near middle and cavernous porosity near base

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