GS-16 INTERPRETATION OF THOMPSON-TYPE GEOPHYSICAL SIGNATURES (NTS 63B AND 63F) AND THE POSSIBLE CAUSE OF THE CAMPERVILLE GRAVITY LOW (NTS 62N AND 63C), WEST-CENTRAL MANITOBA

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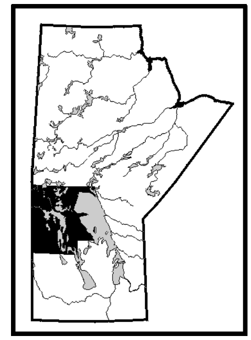

Hosain, I.T. and Bamburak, J.D. 2002: Interpretation of Thompson-type geophysical signatures (NTS 63B and 63F) and the possible cause of the Camperville gravity low (NTS 62N and 63C), west-central Manitoba; *in* Report of Activities 2002; Manitoba Industry, Trade and Mines, Manitoba Geological Survey, p. 117-130.

SUMMARY

Gravity and magnetic surveys were carried out in the summers of 2000 and 2001 over the southern extension of the Superior Boundary Zone. The purpose of the surveys was to delineate the Thompson Nickel Belt below the Paleozoic cover rocks and to determine the cause of a neighbouring gravity low in the Camperville area.

This project outlines the Thompson Nickel Belt within a gravitational low along The Pas Moraine, where there are short-wavelength, low-amplitude magnetic anomalies. This setting is interpreted as the signature that the Thompson deposits would have if they were situated beneath approximately 200 m of cover rocks.

In the Camperville area, a large, ellipsoidal, 35 mGal gravity low, measuring approximately 120 km by 60 km, is interpreted to be a granitic intrusion with a high concentration of magnetite.

INTRODUCTION

Gravity and magnetic surveys were carried out over the southern extension of the Superior Boundary Zone (SBZ) during the summers of 2000 and 2001 (Fig. GS-16-1). The purpose of the surveys was to delineate the southern extension of the Thompson Nickel Belt (TNB) and to determine the cause of the large gravity low in the Camperville area. One 200 km profile along The Pas Moraine (Provincial Highway 60) and several profiles across the Camperville anomaly were carried out with the assistance of students from the University of Manitoba's Earth Science Department. The survey traverses are shown in Figures GS-16-2 and GS-16-3.

GEOLOGICAL SETTING

The southern extension of the Precambrian SBZ in southwestern Manitoba (Fig. GS-16-1) is buried beneath an increasing thickness of Phanerozoic strata towards the southwestern corner of the province. The SBZ is bounded to the east by the Archean craton of the Superior Province, and to the west by the Trans-Hudson Orogen (see Fig. GS-17-1, this volume). The 2000 and 2001 study areas, shown in Figures GS-16-2 and GS-16-3, are situated within the outcrop belts of Paleozoic (Silurian and Devonian) and Mesozoic (Cretaceous) formations. The Ordovician to Devonian and Cretaceous stratigraphy of the study areas is shown in Figure GS-17-2 (this volume).

The Superior Province is divided into various domains and subdomains (Fig. GS-17-1, this volume). The domain and subdomain boundaries form T-intersections with the SBZ. The Camperville gravity low, a major gravity anomaly adjacent to the SBZ within the Berens River Domain, is also shown in Figure GS-17-1 (this volume) and in Figure GS-16-1.

Pleistocene glacial till and lacustrine sediments overlie the Paleozoic and Mesozoic outcrop belts. The Pas Moraine is a major glacial feature that crosses the SBZ (and the 2001 study area) from northwest to southeast.

GEOPHYSICAL SURVEYS

The general description of the surveys and preliminary interpretation are outlined in the 2000 and 2001 Reports of Activities (Bamburak et al., 2000; Surasky and Minkus, 2000; Surasky et al., 2001). The gravity and magnetic surveys were carried out over an eight-day period in 2000 and an eight-day period in 2001. The instruments used were a Worden gravity meter and an MP-3 proton-precession magnetometer. Station spacing was 1 km. The gravity and magnetic readings were recorded simultaneously at stations off the shoulder of the highways. A base station was visited every 2 hours to correct for drift in the gravity meter and for diurnal corrections for the magnetic survey. Because terrain in the area was relatively flat, terrain corrections were not applied to the gravity data.

BACKGROUND

Aeromagnetic anomalies in the SBZ appear to be produced by the upper level of the buried Precambrian rocks. In

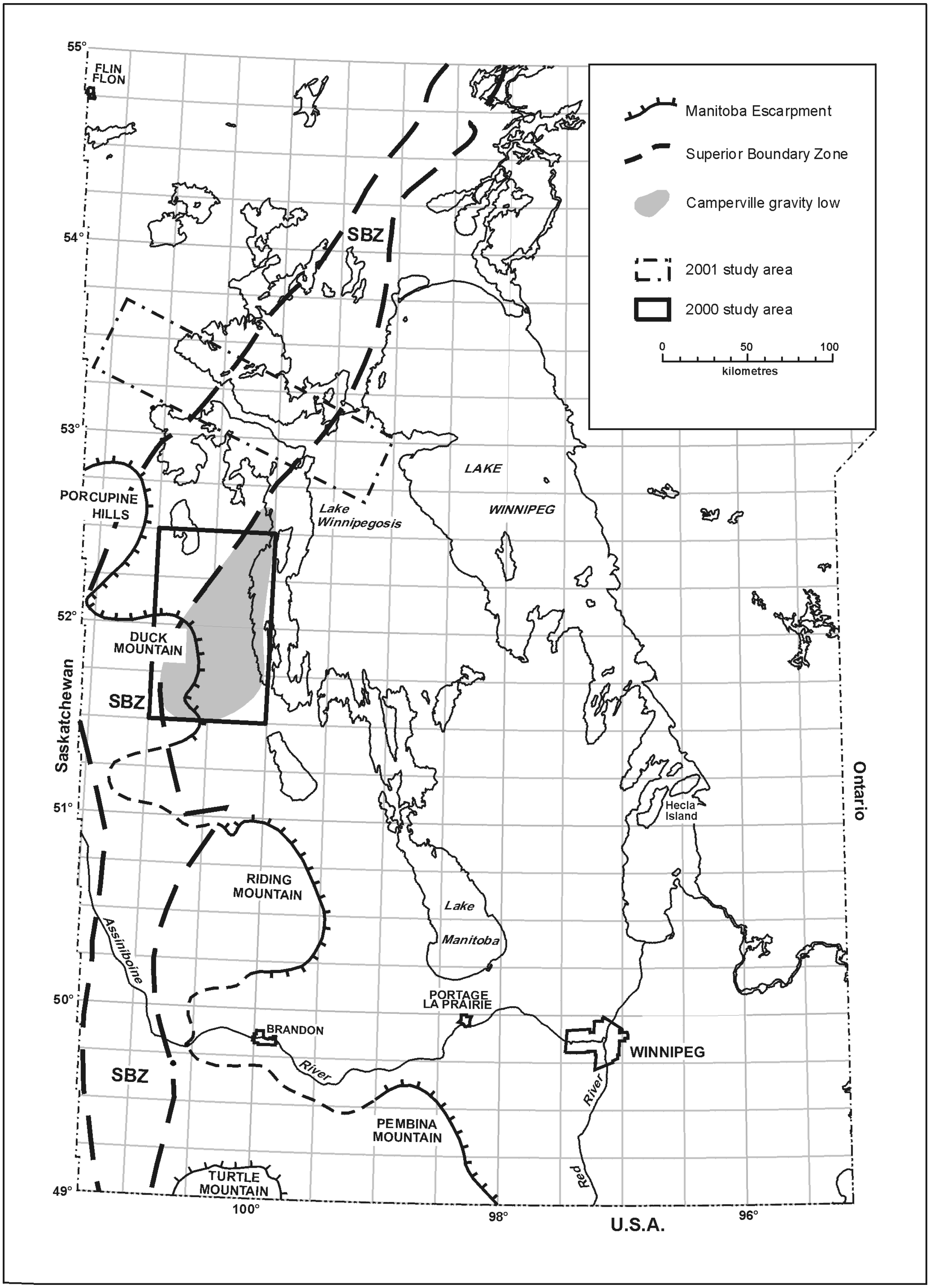

Figure GS-16-1: Location of study areas, showing the Manitoba Escarpment, Superior Boundary Zone and Camperville gravity low.

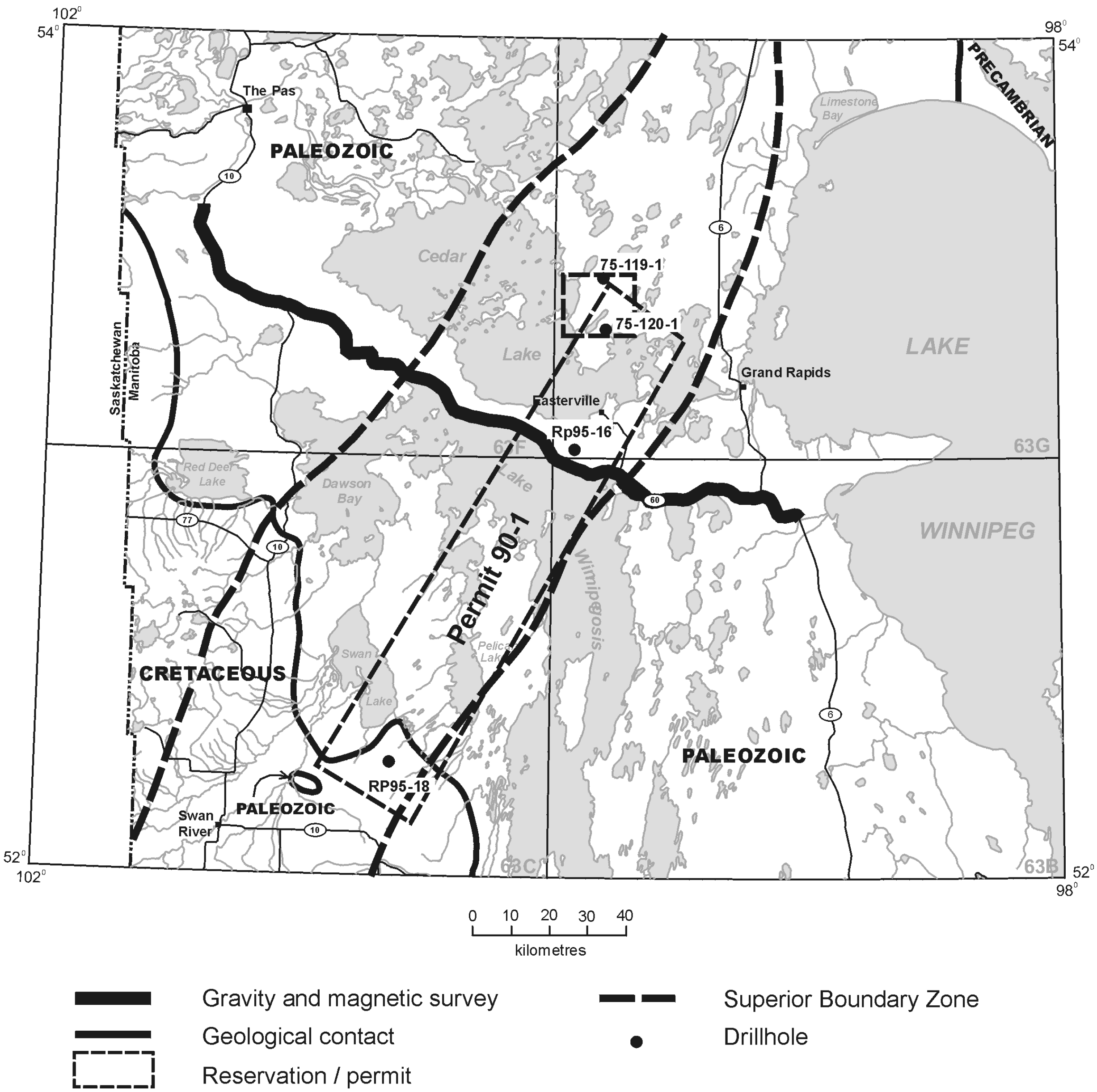

Figure GS-16-2: Location of traverse along The Pas Moraine.

contrast, the gravity patterns appear to be produced by large-scale density contrasts, which are not related to near-surface Precambrian material. The serpentinized peridotite bodies of the TNB, which occur scattered along the axis of a gravity low, are too small to influence the regionally spaced gravity values of the SBZ. It is believed that a deeper crustal source is the cause of the gravity anomalies (Gibb, 1968). If any gravity anomalies were directly caused by the ultramafic rocks, then one would expect to see a correlation with the magnetic peaks. If anything, the opposite seems to be the case. The positive magnetic peaks have shorter wavelengths, reflecting shallow causative bodies.

North of Thompson, within the Hudson Bay Lowlands, the peridotite bodies were drilled by Kennco Explorations (Canada) Limited along the Weir River gravity low, shown in Figure GS-16-4 (Assessment File 91702, Manitoba Industry, Trade and Mines, Winnipeg). The coincidence of a peridotite and a gravity low corresponds to that found at the Thompson-Moak deposits area.

The Setting Lake gravity low, the Mystery Lake low and the Split Lake low (Fig. GS-16-4) outline a belt of amphibolite-facies rocks (Gibb, 1968). The largest area of granite mapped at the surface within the belt, at Split Lake, underlies the most negative gravity values. Measurements show that the granite has a density of 2.60 g/cm^3. The negative anomaly can be explained if it extends to a depth of 7 km (Gibb, 1968).

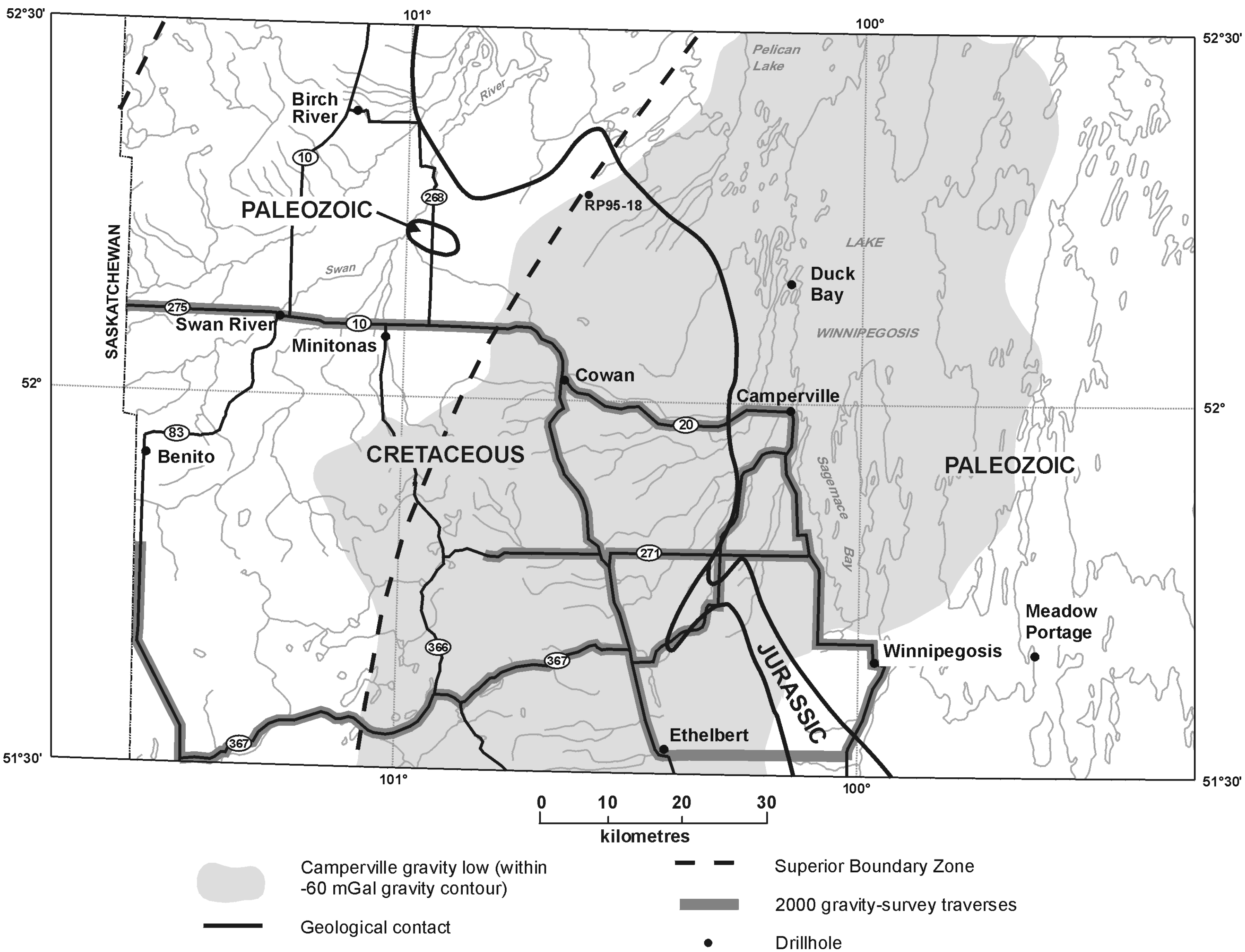

Figure GS-16-3: Location of traverses across the Camperville gravity low.

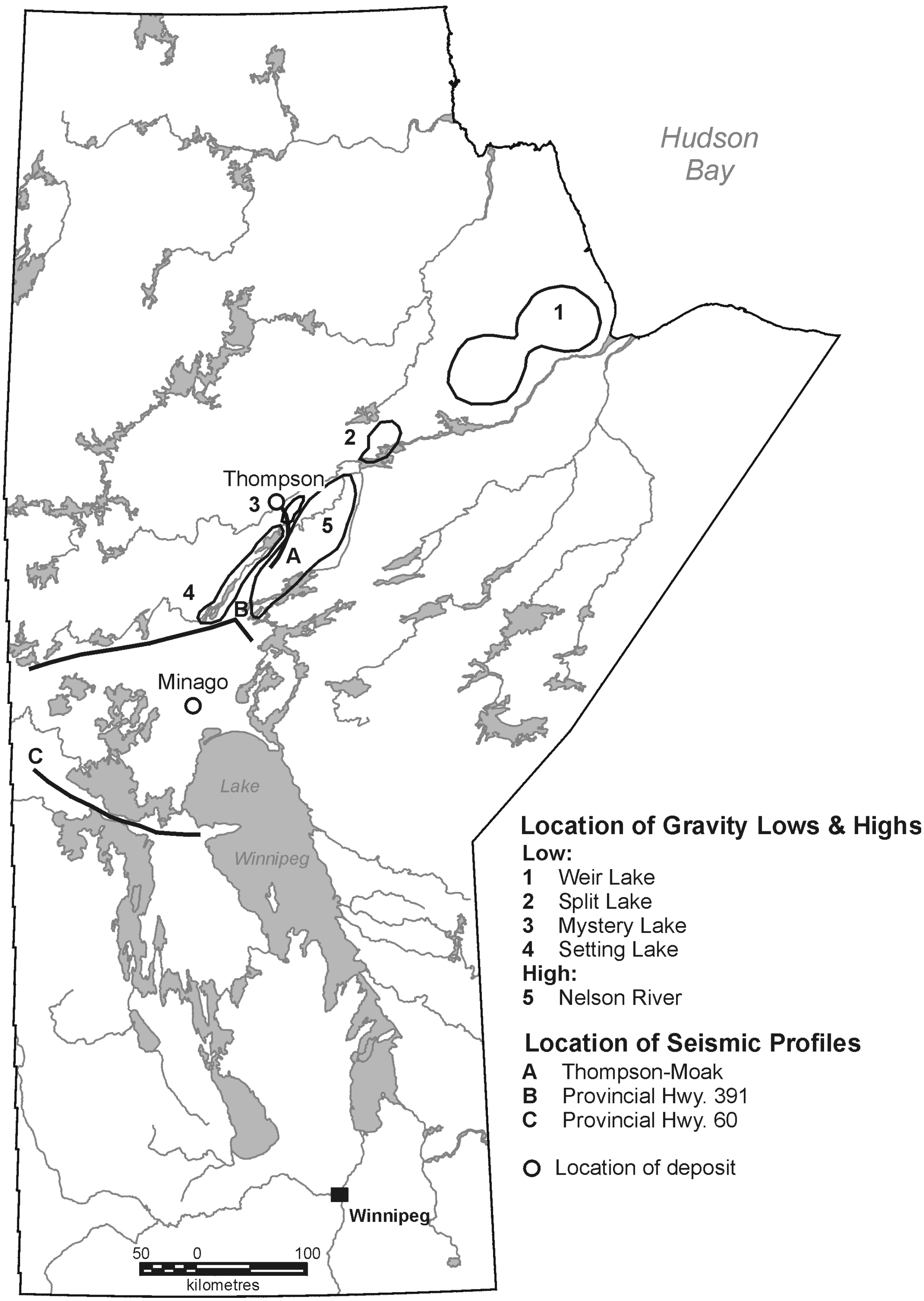

Figure GS-16-4: Location of seismic profiles relative to gravity lows and highs.

The Nelson River gravity high is related to the Archean granulite-facies rocks of the Pikwitonei Subprovince (Fig. GS-16-4). These rocks range in composition from charnockite to metagabbro (Gibb, 1968). To satisfy these geophysical anomalies, the Pikwitonei granulite would have to extend beneath the TNB with a west-dipping boundary separating the two units (Thomas and Tanczyck, 1994).

Seismic surveys were carried out under the LITHOPROBE Project (Lucas et al., 1996) along three traverses across the TNB (Fig. GS-16-4). The northernmost traverse was in the vicinity of Thompson, the central one along Provincial Highway 391 (along the Flin Flon–Snow Lake greenstone belt) and the southernmost one along Provincial Highway 60 (approximately 200 m of Paleozoic rocks overlie the Precambrian in the southernmost traverse). Interpretation of the data has been carried out by various scientists. For this project, interpretations of the southernmost two profiles are relevant.

PREVIOUS INTERPRETATION

The LITHOPROBE interpretation of the seismic traverse along Provincial Highway 60 is shown in Figures GS-16-5 and GS-16-6 (Lucas et al., 1996). The geology of the SBZ changes along strike to the south. In the vicinity of line 3SB (Provincial Highway 60), it includes a homoclinal, west-dipping, west-facing succession of subgreenschist metamorphic grade sedimentary and volcanic rocks that unconformably overlies Superior Province basement. The succession comprises a thin interval of discontinuous basal conglomerate and sandstone overlain by tholeiitic basalt (Grand Island and Upper tholeiite units) and komatiite. Age determinations indicate that the mafic-ultramafic volcanic package is significantly younger than the Ospwagan Group. Contacts between the various mafic-ultramafic volcanic sections have been interpreted as thrust faults, although the lower tholeiite-komatiite contact may be stratigraphic (Lucas et al., 1996).

The Muddy Bay metasedimentary unit is of uncertain affinity and may correspond to either the Burntwood Group or the Ospwagan Group of the Reindeer Zone and SBZ, respectively. The granite to the west of the Muddy Bay metasedimentary unit is interpreted as part of the Kisseynew Domain. It is succeeded, to the west, by typical Kisseynew Domain units, Burntwood and Missi Group metasedimentary rocks and, near its termination, by units of the Flin Flon Belt (Lucas et al., 1996).

PRESENT INTERPRETATION

The correlation between the exposed Precambrian rocks and their geophysical signature was determined in various areas by Gibb (1968), Roth (1975) and Thomas and Tanczyck (1994); their results were used to derive the present interpretation of the geology below the Paleozoic rocks. Interpretation of the profile along The Pas Moraine was carried out first, as this was closer to the exposed Precambrian than the Camperville area. The profile also crosses Cominco Limited permit areas, where drillhole information is available (drillhole RP95-16, shown in Fig. GS-16-2, GS-16-7; Assessment File 94638, Manitoba Industry, Trade and Mines, Winnipeg). The LITHOPROBE seismic data interpretation of the traverse along The Pas Moraine (line S3B) was also available and used for correlation purposes (Fig. GS-16-5, GS-16-6).

The published specific gravity and magnetic susceptibility of various rocks are shown in Table GS-16-1.

Modelling of the gravity and magnetic data was carried out using the computer programs GRAV2DC for Windows and MAG2DC for Windows (Cooper, 1998, 2000).

THE PAS MORAINE

The gravity and total-field magnetic profiles, together with the interpreted models, are shown in Figures GS-16-7 and GS-16-8. Some preliminary modelling was carried out by Surasky et al. (2001). Their resulting models are compatible with the present, more detailed interpretation.

In constructing the models, the depth of the Precambrian was set at 200 m, based on drillhole information and the *Stratigraphic Map Series* (Bezys and Conley, 1998). The width, dip, density contrast and susceptibility contrast of lithological units were altered until a reasonable match was obtained between the calculated and observed profiles. The gravity profile was much smoother than the magnetic profile, indicating deep-seated causative bodies. The magnetic profile contained short-wavelength, high-frequency anomalies superimposed on long wavelength anomalies, which reflects more surficial causative bodies superimposed on deeper bodies. Because the program can model a maximum of 16 bodies at a time, the short-wavelength anomalies were not modelled. The interpreted dips of the various lithological units were compatible with the dips of the interpreted seismic reflectors. All available information from

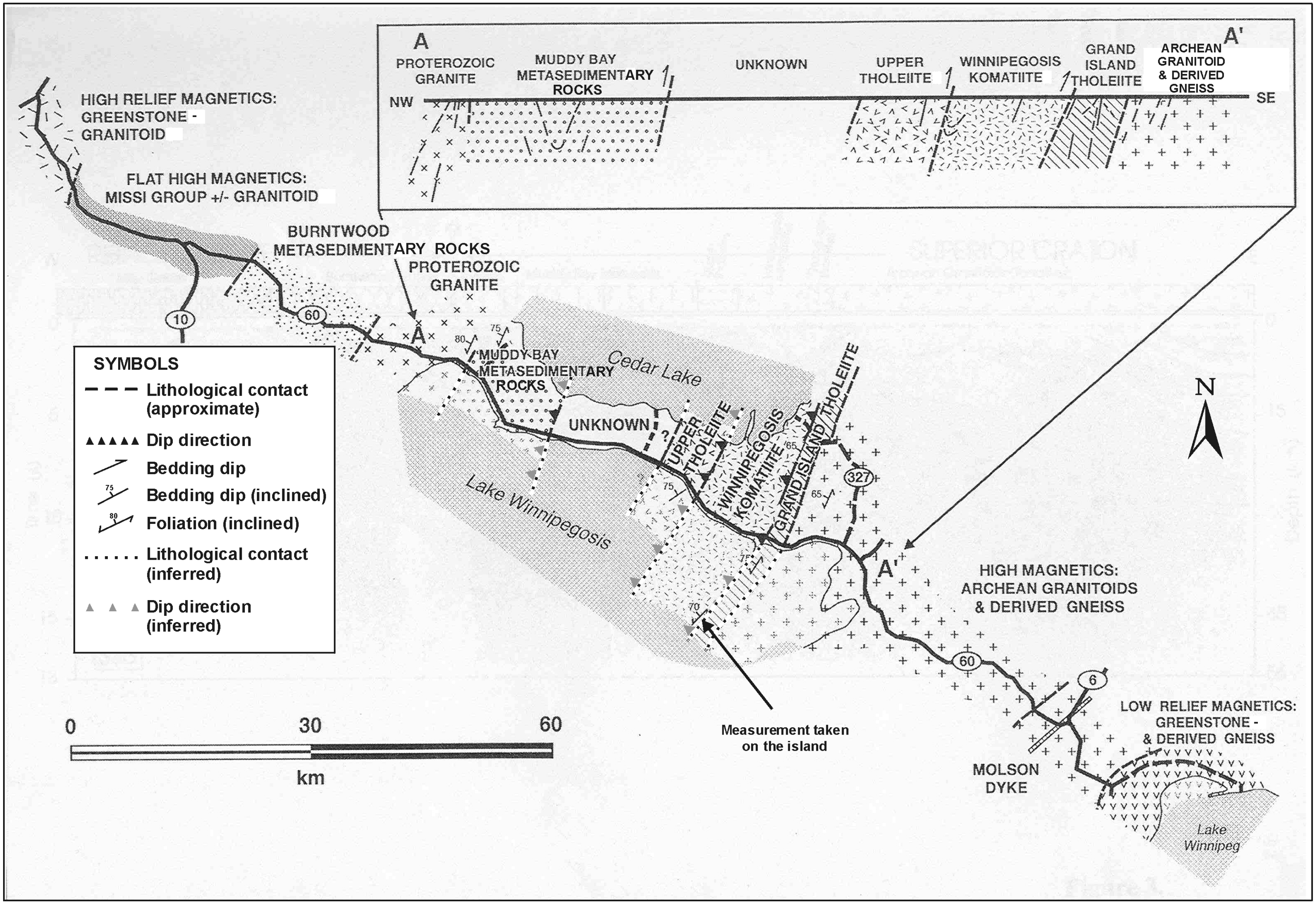

Figure GS-16-5: Map view of lithological units along The Pas Moraine traverse (from Lucas et al., 1996).

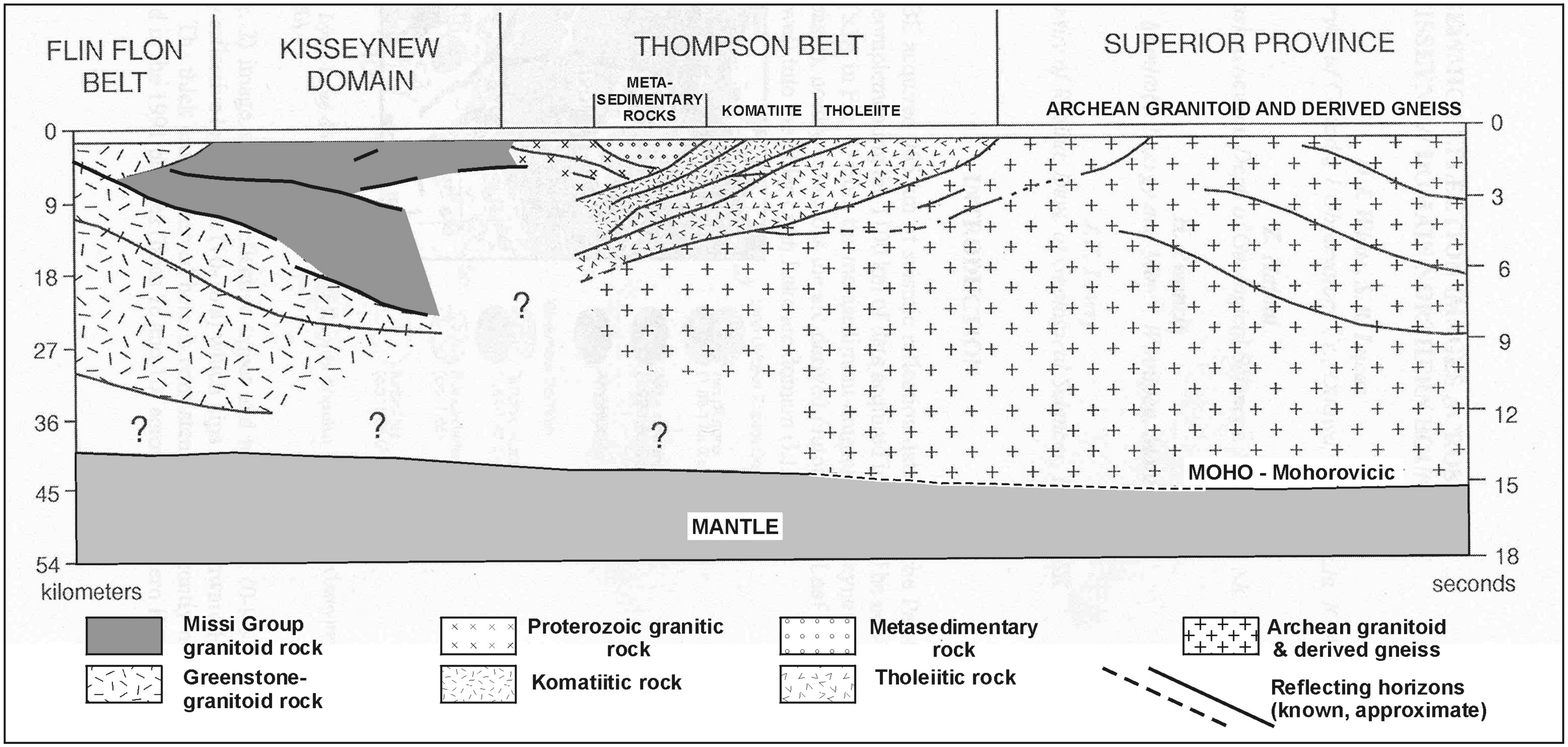

Figure GS-16-6: Seismic model along The Pas Moraine traverse (from Lucas et al., 1996).

Table GS-16-1: Published specific gravity and magnetic susceptibility values (Gibb, 1968; Roth, 1975; Thomas and Tanczyck, 1994).

Rock type	Specific gravity (g/cm^3)	Susceptibility (x 10^{-5} cgs units)
Limestone	2.55	10
Argillite	2.41	
Serpentinite	2.47–2.60	300
Dunite	2.38–2.51	24–400
Granite	2.64	20
Tonalite	2.67	
Gneiss	2.67–2.70	16–25
Metasedimentary rocks	2.62–2.90	
Granulite	2.73–2.84	160–250
Dolomite	2.8	0–7.5
Dolomitic marble	2.85	
Carbonate rich sedimentary rocks	2.91	0.1–1.0
Basalt	3.04	300–600
Gabbro	2.93–3.07	600
Amphibolite	2.89–3.13	
Peridotite	3.15	1300

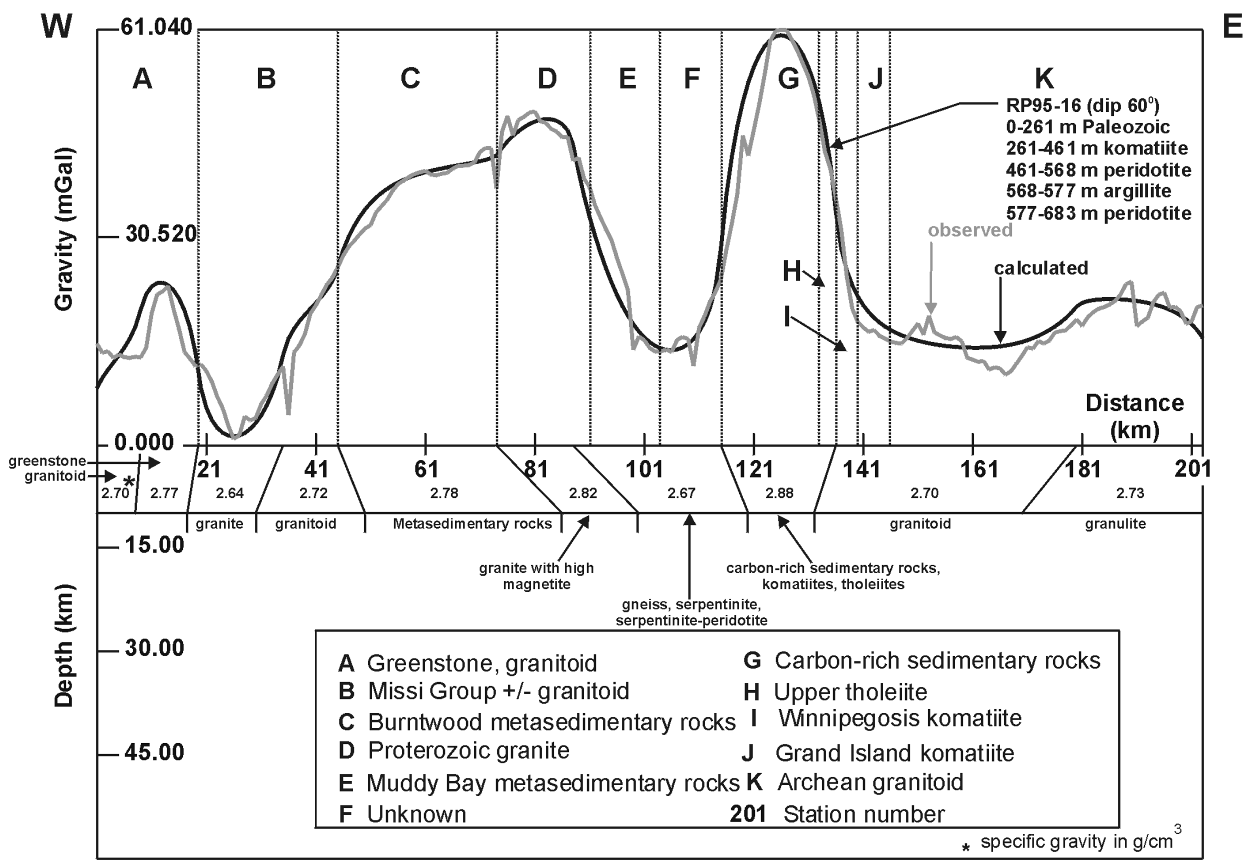

Figure GS-16-7: Gravity profile, with interpreted model, along The Pas Moraine traverse. Upper case letters indicate lithological units interpreted from the seismic survey. Interpreted rock types arrived at using both gravity and magnetic data are shown in small type.

drillholes in the area was utilized. The densities and magnetic susceptibilities are plotted on the models. A background density of 2.67 g/cm^3 was used to determine the densities of the various rock units.

The lithological units interpreted from the seismic survey are indicated by upper case letters on Figures GS-16-7 and GS-16-8. The interpreted rock types arrived at using both the gravity and magnetic data are shown in small type on Figure GS-16-7. There are a few magnetic peaks in the area of the gravity low (between stations 90 and 110).

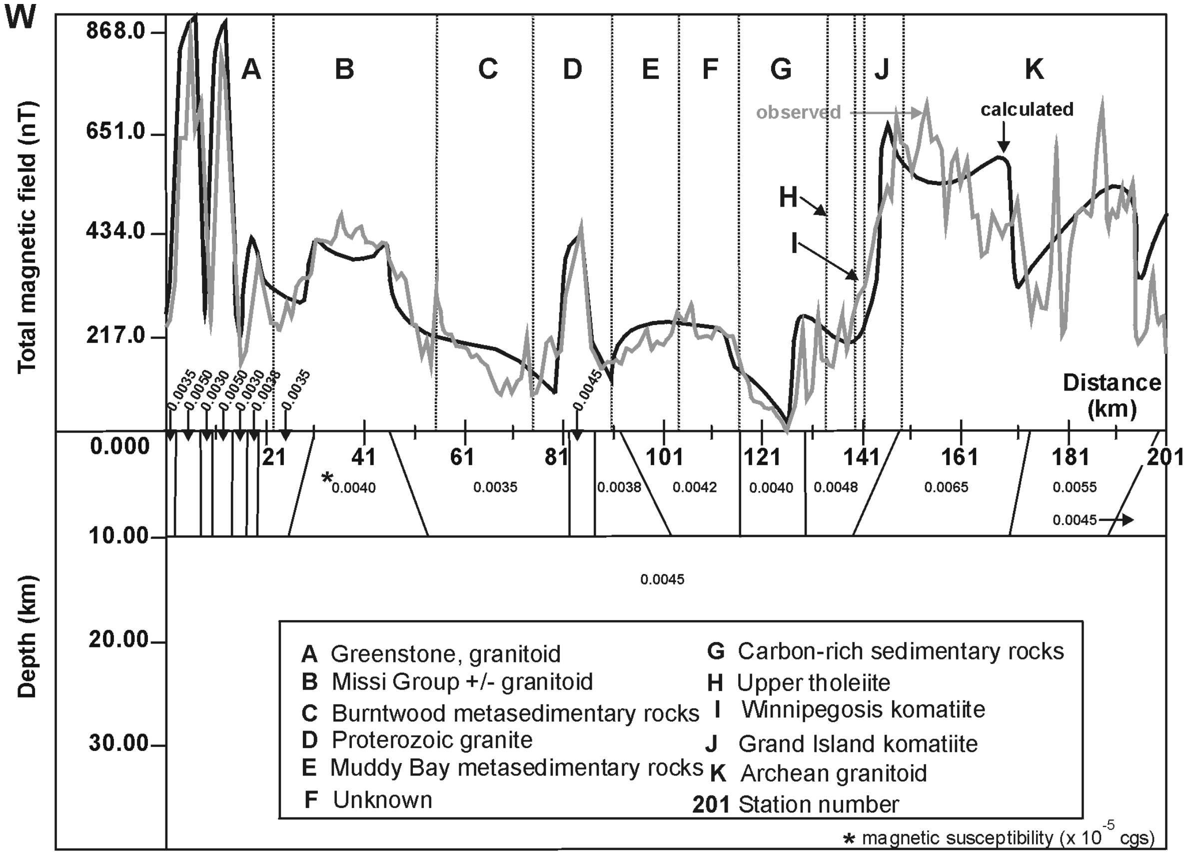

Figure GS-16-8: Magnetic profile, with interpreted model, along The Pas Moraine traverse. Upper case letters indicate lithological units interpreted from the seismic survey.

Detailed interpretation was carried out, as shown in Figures GS-16-9 and GS-16-10, because of the similarity of its gravity and magnetic signatures to those of the Thompson deposits. The interpreted densities and magnetic susceptibilities of the rock units are comparable to those of the TNB (Thomas and Tanczyck, 1994; White et al., 2000). The amplitudes of the magnetic anomalies are smaller than those of the Thompson and Minago River deposits (Fig. GS-16-4), probably due to the greater thickness of cover rocks in this area.

CAMPERVILLE GRAVITY LOW

The gravity and total-field magnetic profiles along Provincial Highways 275, 10 and 20, from Camperville to the Saskatchewan-Manitoba boundary, are shown in Figures GS-16-11 and GS-16-12, together with the interpreted models. This profile was chosen over the other two because it is approximately perpendicular to the strike of the ellipse. Some preliminary modelling was carried out by Surasky and Minkus (2000). Their resulting models are compatible with the present, more detailed interpretation. The modelling was carried out in a manner similar to that of The Pas Moraine traverse, except that the depth to the Precambrian was increased to between 500 and 800 m, going from east to west, in accordance with data on the *Stratigraphic Map Series* (Bezys and Conley, 1998).

There are similarities between the profiles from the Camperville gravity low and those along The Pas Moraine. The observed Camperville profiles are smoother than those on The Pas Moraine, which is to be expected from causative bodies that are more deeply buried. Also, the western end is smoother than the east, again reflecting thicker cover rocks. The major difference between the two profiles is the 35 mGal gravity low in the southern profile. Modelling interpreted the cause of this to be a higher level structure containing low-density material, probably granite (2.64 g/cm^3). These rocks are interpreted to have high magnetite content, producing the high magnetic anomaly. The underlying rock unit has a calculated density of 2.73 g/cm^3, which would put it in the range of Pikwitonei granulite. At station 50, there are coincident gravity and magnetic highs, which modelling interpreted as being due to a sill with a density of 2.92 g/cm^3 and magnetic susceptibility of 1200 x 10^{-5} cgs units; this would put it in the range of a peridotite. Approximately 20 km northeast of this traverse (along strike with Cominco's southernmost drillhole on their permit 90-1), drillhole RP95-18

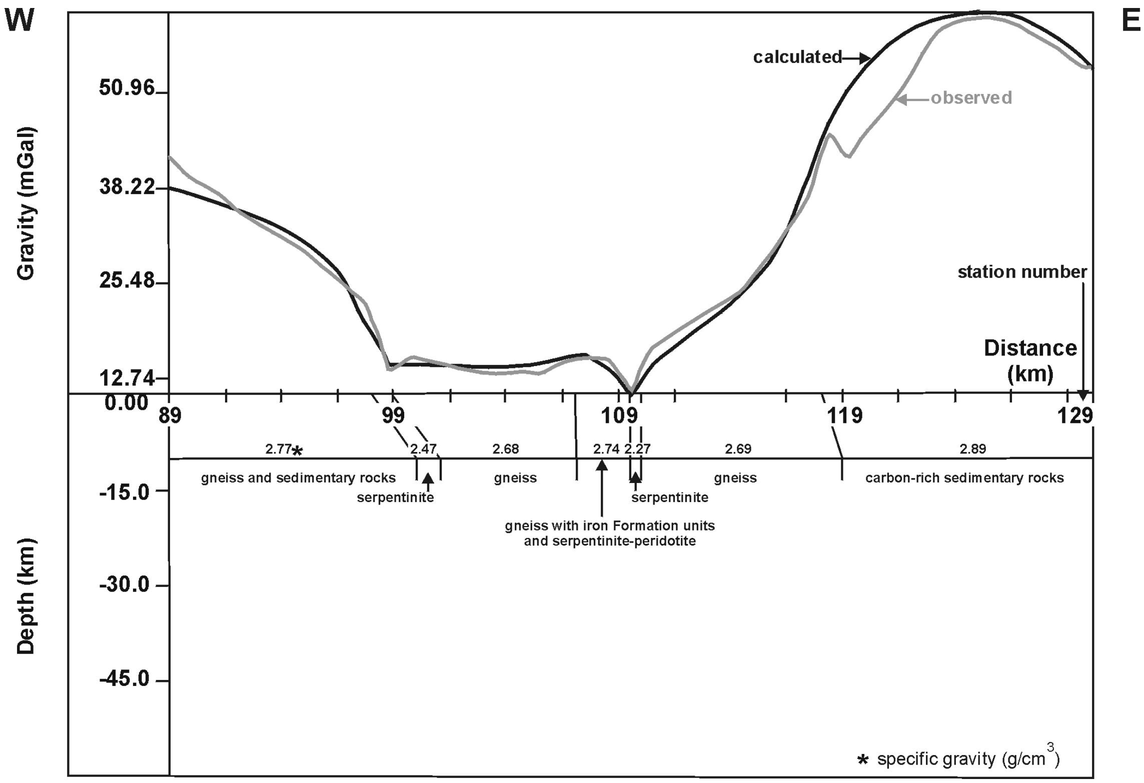

Figure GS-16-9: Detailed gravity profile, with interpreted model, of the area between stations 89 and 129 on The Pas Moraine traverse.

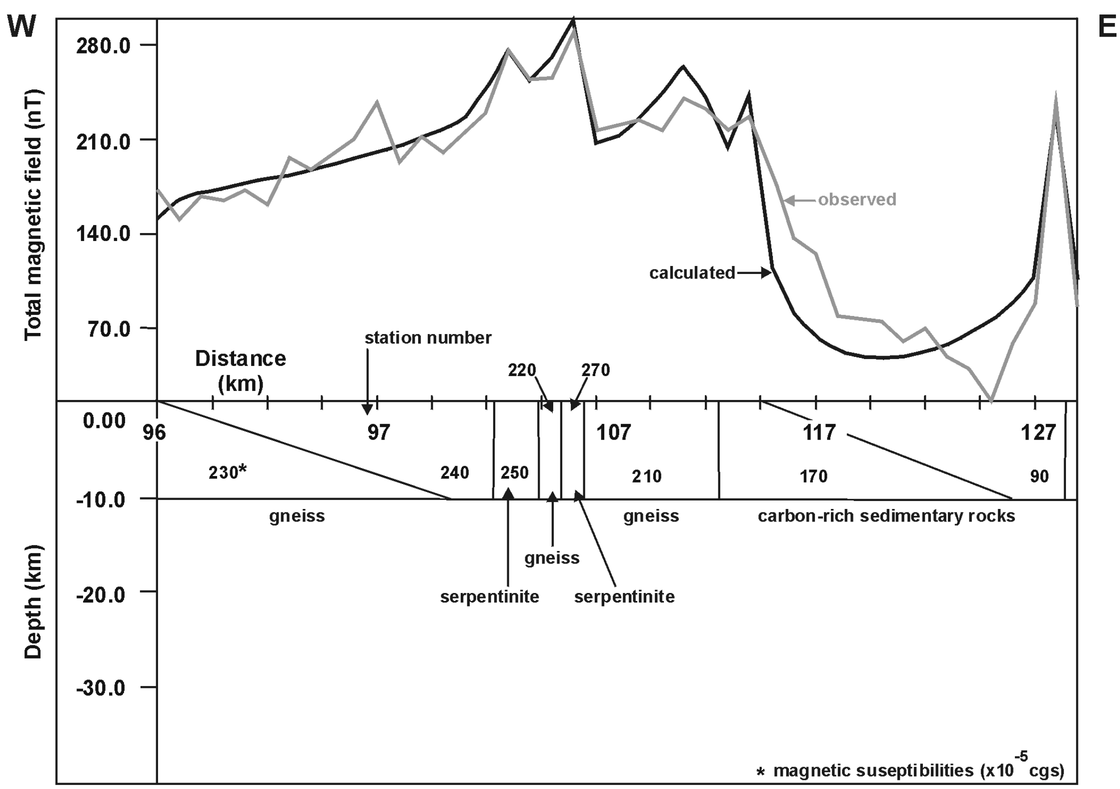

Figure GS-16-10: Detailed magnetic profile, with interpreted model, of the area between stations 96 and 127 on The Pas Moraine traverse.

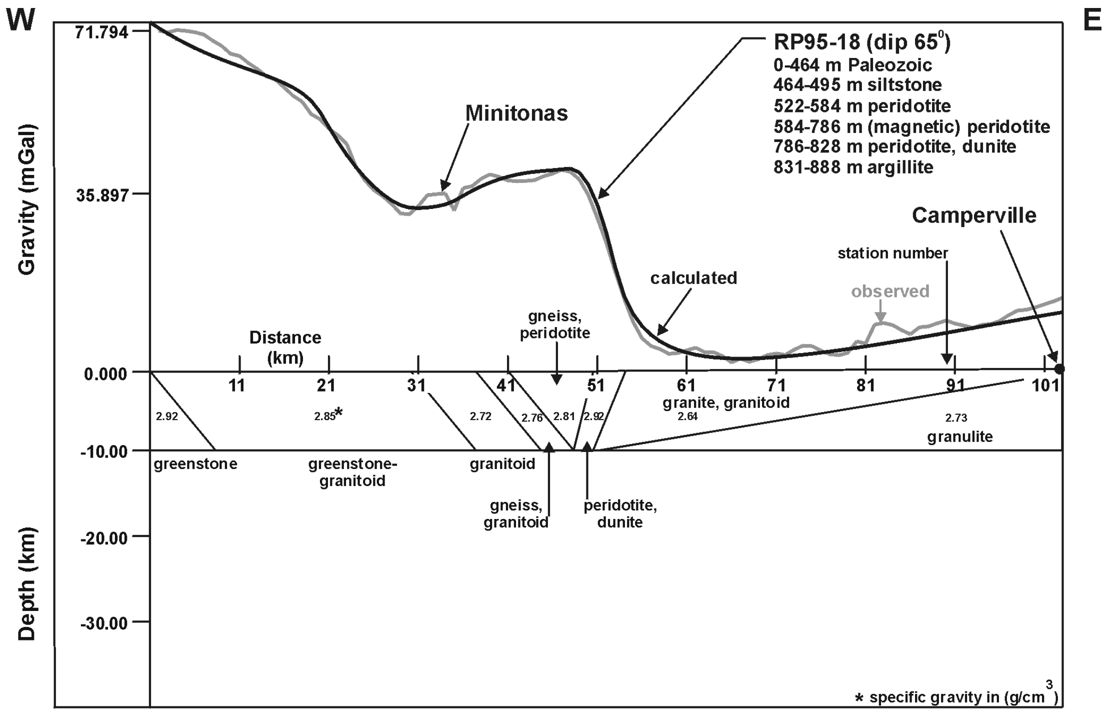

Figure GS-16-11: Gravity profile, with interpreted model, across the Camperville gravity low.

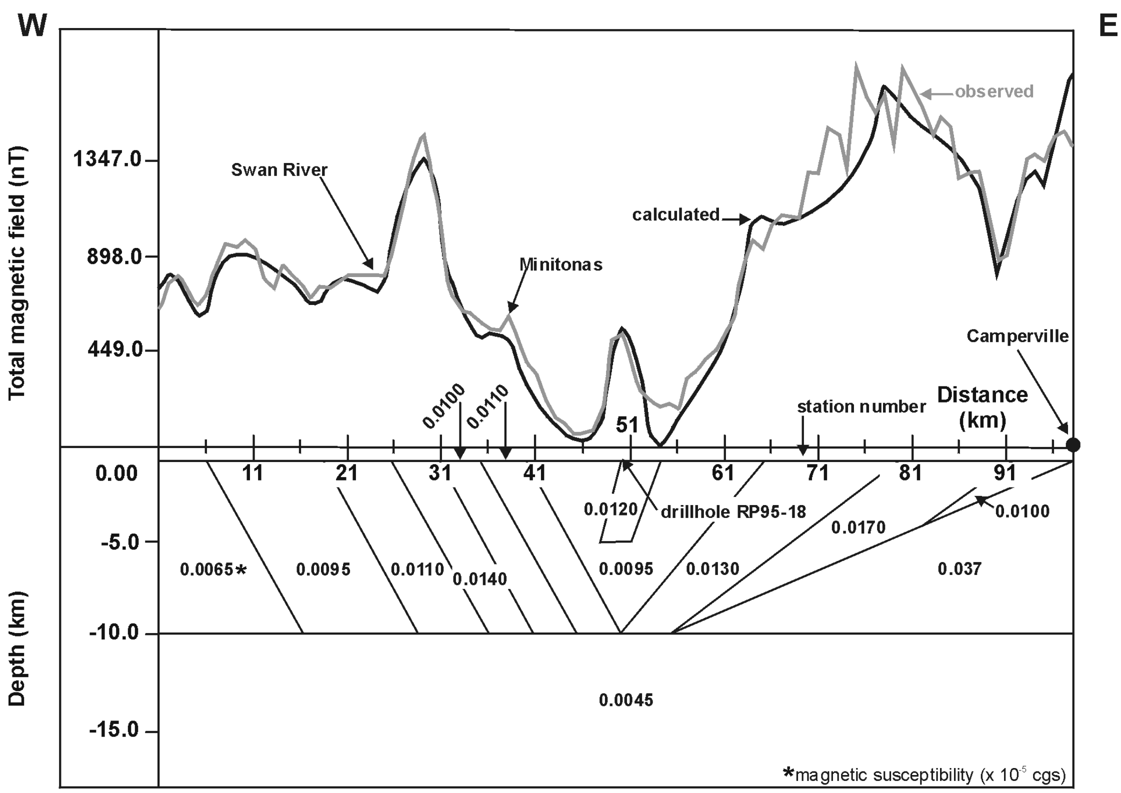

Figure GS-16-12: Magnetic profile, with interpreted model, across the Camperville gravity low.

(Fig. GS-16-2, GS-16-3) intersected a massive peridotite sill, as shown on Figure GS-16-11 (Assessment File 94638, Manitoba Industry, Trade and Mines, Winnipeg).

RECOMMENDATIONS AND CONCLUSIONS

There are similarities between the geophysical anomalies across the Thompson Nickel Belt and the data along The Pas Moraine traverse. The gravity trough, with coincident magnetic anomalies, presents the same model and therefore should be investigated. Deep penetrating electromagnetic surveys and ground magnetic surveys are recommended on strike (northeast) of the gravity low on The Pas Moraine. Flexures in the anomalies are areas for further investigation. Granges Exploration and Amax Exploration carried out Input™, Turam™ and ground magnetometer surveys on mineral reservations 119 and 120, which are on strike, toward the northeast, with the low gravity area of The Pas Moraine profile (Assessment File 92034, Manitoba Industry, Trade and Mines, Winnipeg). Two holes were drilled (Fig. GS-16-2) to test Turam™ conductors and intersected serpentinized peridotite. The remainder of the Turam™ conductors require further investigation. Preliminary Maps 2001FS-1 and 2001FS-2 (Thompson Nickel Belt Geology Working Group, 2001a, b), which encompass mineral reservations 119 and 120, show the principal rock types to be Archean basement migmatite gneiss and Pipe Formation ultramafic rocks with occasional iron formation.

The possible cause of the Camperville gravity low is a granitic intrusion with a high concentration of magnetite. The Pikwitonei granulite of the Superior Province forms a west–dipping, highly magnetic unit below the granitic intrusion.

ACKNOWLEDGMENTS

The authors would like to thank Alan Surasky for assisting in the gravity and magnetic surveys in 2000 and 2001. The Department of Geological Sciences at the University of Manitoba provided the gravity meter for both summers, and supported Alan’s employment during the first summer.

Bonnie Lenton is gratefully acknowledged for preparing the figures used in this report, and Ruth Bezys and Herman Zwanzig are thanked for reviewing the manuscript.

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