GEOLOGICAL INTERPRETATION OF GRAVITY ANOMALIES IN THE SOUTHWESTERN GRENVILLE PROVINCE, ONTARIO

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Abstract

Regional gravity surveys and geologic mapping in the southwestern Central Gneiss Belt, Ontario, Grenville Province show gravity anomalies associated with the Parry Sound and Kiosk domains. Twenty-five year old two-and-a-half-dimensional (2.5 D) models of the Parry Sound domain gravity anomaly have been revised, incorporating constraints from new geological mapping and seismic reflection profiles. In the revised models the general shape and extent of the Parry Sound domain is essentially unchanged from the original models. The Kiosk domain is a poorly known terrain of granulite facies high strain gneiss separated by a shear zone from underlying amphibolite facies gneiss. 2.5 D models of the Kiosk domain constrained by over 250 density measurements and field mapping indicate that the Kiosk domain is rhomboid shaped and with boundaries dipping to the southeast at about 30 degrees to a depth of about 20 to 25 km where they flatten out. Contrary to suggestions of a proposed Lower Go Home-Lower Rosseau-Kiosk thrust sheet, the Kiosk domain and adjacent McCraney subdomain have been interpreted as large blocks that are separate from the proposed Lower Rosseau-Lower Go Home thrust sheet. From the modeling results it is suggested that the Allochthon Boundary Thrust (ABT) extends to the north of the Bonfield batholith and not along the northern boundary of the Kiosk domain.

Key Words: Grenville Province, Kiosk domain, Parry Sound domain, gravity modeling, Ontario

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CHAPTER I
Introduction

1.1 Introduction

The Grenville Province is interpreted to be a portion of the Grenvillian orogen. This is a Himalayan scale collision (Dewey and Burke 1973) that occurred between 1160 and 970 Ma (Rivers et al. 1989). Located in the Central Gneiss Belt of the Grenville Province in Ontario are high-grade gneisses that have arc-related protoliths, such as continental and island arc to intra-arc and back arc assemblages (Culshaw and Dostal 1997; Rivers 1997; Carr et al. 2000; Slagstad et al. 2000). These rocks have Archean to Late Mesoproterozoic ages (Ketchum and Davidson 2000; Slagstad et al. 2004). In the Central Gneiss Belt granulite facies terrains are separated from amphibolite terrains by tectonite zones, some of these boundaries contain pods of retrogressed eclogite. The constraint of facies changes across tectonite zones provides evidence of tectonic movement within the crust (Davidson et al. 1982). The crust, which is currently about 35 km thick (Mereu and Jobidon 1971) was once roofed by and additional 20 to 25 km of crust, as indicated by the presence of upper amphibolite and granulite facies rocks. This makes it a prime location to examine the interior structure of a major orogen. The Central Gneiss Belt of the Grenville Province has been divided into series of domains and subdomains based on lithological, structural and magnetic trends (Davidson and Morgan 1981). The divisions of the Grenville Province and domains and subdomains of interest to this study are discussed in section 1.2 and shown in Fig. 1.1.

A previous study based on a gravity survey and fieldwork within the Parry Sound domain of the Grenville Province was used to model and determine the likely subsurface extent and shape of the Parry Sound domain (Lindia et al. 1983). Since the completion of this study in 1983, further insight has been gained as a result of seismic surveys, additional field work and research. This study tackles revising Lindia's gravity models by incorporating new data and ideas from the neighbourhood of the Parry Sound domain, as well as modeling an additional area found to the east of the Parry Sound domain, that includes a portion of the Britt and Kiosk domains as well as the McCraney subdomain. The subsurface structure of the Kiosk domain is important because its northern boundary has been identified as a possible location for the Allochthon Boundary Thrust (ABT) (Dickin 2000). The ABT is a significant thrust boundary that marks where allochthonous terrains thrust over parautochthonous material. The exact position of the ABT is unknown, particularly in Western Quebec and Ontario (Rivers et al. 1989). A second possible location for the ABT suggested by Ketchum and Davidson 2000, is along the northern edge of the Bonfield batholith. The subsurface structure of the Kiosk domain may shed some light on the feasibility of this location and nature of the boundary.

1.2 Objective

The objective of this study was to use forward modeling to create a series of cross sections within the Parry Sound domain that best represent the likely subsurface geology and agree with the observed gravity (Fig. 1.1). Five of these cross sections were based on Lindia et al.'s 1983 work, the changes made represent additional information about the area based on geological mapping that has occurred since 1983, such as mapping along the Georgian Bay and the resulting cross sections by Culshaw et al. 1997. These changes have resulted in a different interpretation of the possible subsurface geology. The sixth cross-section was from within the Kiosk domain and is based on past field work by Dr.

Nick Culshaw, department of Earth Sciences, Dalhousie University and Duncan McLeish. Samples collected by them, in addition to samples from the Geological Survey of Canada have been weighed to determine density. These density values and knowledge of the surficial geology have been used to model the observed gravity.

1.3 Study Area

The area of interest is located within the Central Gneiss Belt of the Grenville Province in Ontario (Fig. 1.2). It has an area of about 8100 km^2 and is found to the east of Georgian Bay, Ontario (Fig. 1.1). Within the area of interest are the Shawanaga, Britt, Parry Sound, Ahmic, Moon River, Seguin, Go Home and Kiosk domains and the McCraney subdomain. The Powassan batholith is to the east of the Parry Sound within the Britt domain; to better represent the lithological variances within the Britt, this batholith is modeled as a separate entity. As well, the area to the north of the Kiosk domain has been modeled separately from the rest of the Britt domain. Within this study, it has been informally referred to as the Bonfield terrain after the Bonfield pluton that makes up a large portion of this area (Davidson and Breemen, 2001).

1.4 Geological Setting

The Grenville orogen formed during the collision of the SE facing margin of the Laurentian craton, arc assemblages and continental terrains found to the southeast (Rivers et al. 1989). It is composed of southeast dipping imbricates that are bounded by northwest running ductile thrust zones (Rivers et al. 1989). The Ontario portion of the Grenville orogen has been divided into three parts (Fig. 1.2); from northwest to southeast they are; the Grenville Front Tectonic Zone, the Central Gneiss Belt and the Central Metasedimentary Belt (Easton 1992; Carr et al. 2000; Wodicka et al. 2000).

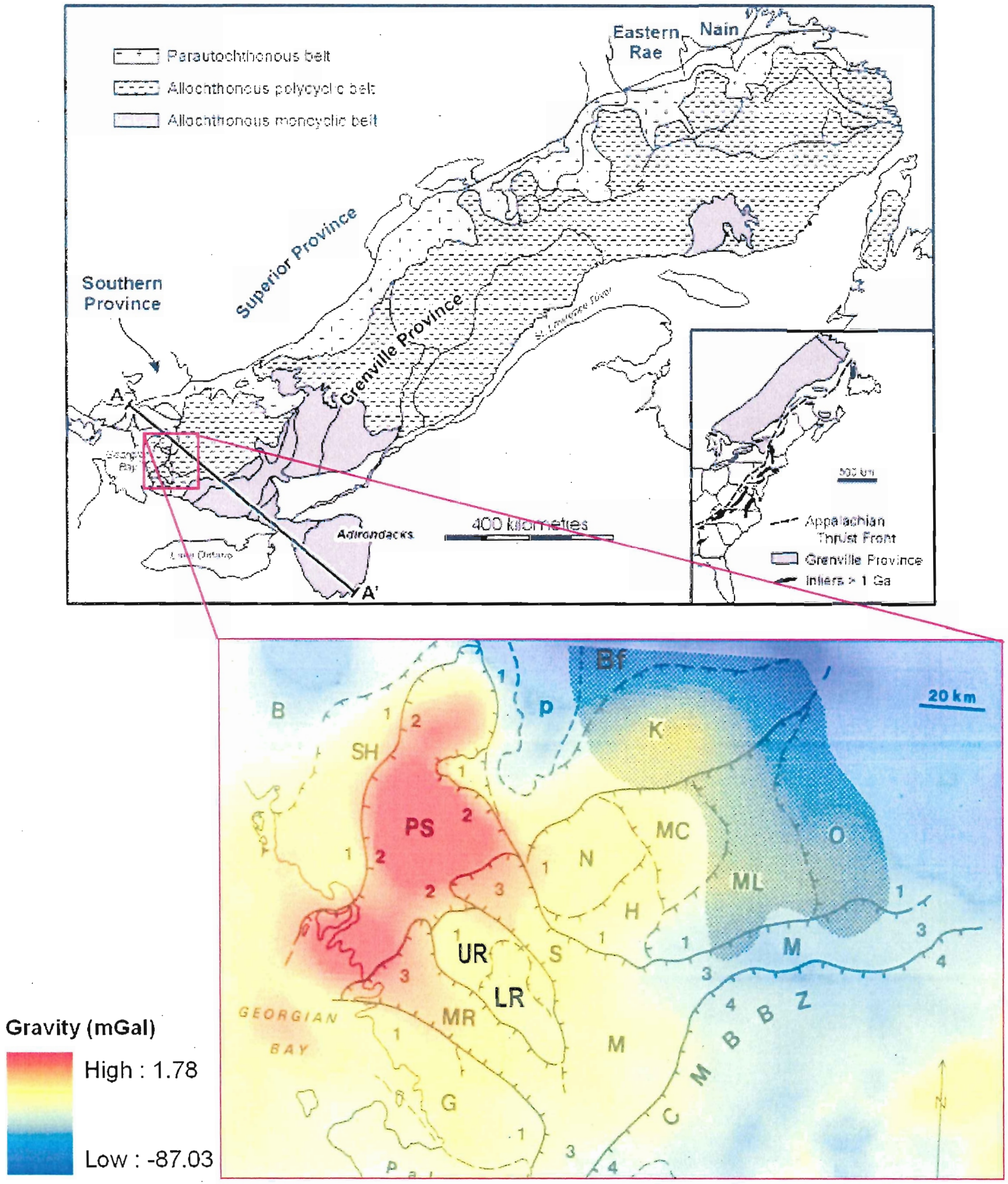

***Figure 1.1**: Location Map: The upper map shows the Canadian extent of the Grenville Province (from Carr et al, 2000). The lower map shows the lithotectonic subdivisions of the Central Gneiss Belt. The lithotectonic divisions are: Bf- Bonfield terrain, B- Britt domain, CMBBZ- Central Metasedimentary Belt boundary zone, G-Go Home domain, H- Huntsville subdomain, K- Kiosk domain, LR- Lower Rosseau domain, MC- McCraney subdomain, ML- McLintock subdomain, MR- Moon River domain, M- Muskoka domain, N-Novar subdomain, O- Openongo subdomain, p- Powassan batholithic complex, PS- Parry Sound domain, S- Seguin domain, SH- Shawanaga domain and UR- Upper Rosseau domain. The numbers refer to the stacking order of the domains, where 1 is the deepest and 3 is the top layer. The image is underlain by a Bouguer gravity map. (Map after Davidson and Grant 1986; Gravity map from the Canadian Geodetic Information System 2008).*

The Central Gneiss Belt (CGB) is predominately composed of reworked high-grade rocks of the Laurentian craton, as well as supracrustal sequences that were deposited along the Laurentian Margin (Carr et al. 2000; Wodicka et al. 2000). The area of the CGB and the Central Metasedimentary Belt (CMB) is also classified as three lithotectonic segments; Laurentia and its margin, the Composite Arc Belt, and the Frontenac-Adirondack belt (Fig. 1.2) (Carr et al. 2000). The domains within these belts are lithotectonic blocks that have boundaries determined by their lithologies, metamorphic histories and geophysical properties (Davidson and Morgan 1981; Slagstad et al. 2004). Between the domains there are zones of ductile shear where crustal blocks were thrust against one another (Davidson and Grant 1986). The area of interest is within the Laurentia and Laurentia Margin segment of the Central Gneiss Belt, composed of 1800-1680 Ma arc granitoids and subordinate supracrustal rocks and ca. 1450 Ma granitoids (Carr et al. 2000) that are thought to have a back-arc origin (Slagstad et al. 2004).

The collision between Laurentia and the Composite Arc Belt to the southeast occurred in two stages. At 1160 Ma, granulite metamorphism occurred in the Parry Sound domain and along the Central Metasedimentary Belt boundary zone (CMBBZ) (McEachern and van Breemen 1993). The CMBBZ is a crustal scale ductile thrust belt located between the CGB and the composite arc belt (Fig. 1.2) (Carlson et al. 1990; Jamieson et al. 2007). This metamorphism was associated with the final stages of what is known as the Elzevirian orogeny (McLelland et al. 1996; Culshaw et al. 1997; Wodicka et al. 2000). The rocks of the Laurentian craton and margin that now underlie the Parry

Sound domain do not have tectonic activity of this age associated with them, suggesting that the metamorphism and deformation of the Parry Sound domain occurred at a distal location (Wodicka et al. 1996). The second stage occurred between 1120 and 1080 Ma, which corresponds to the Ottawan orogeny. During this phase, the rocks within the area of interest, with the exception of the Grenville Front Tectonic zone (GFTZ) and the Parry Sound domain underwent high-grade metamorphism and deformation. The GFTZ is a crustal scale southeast dipping thrust zone located along the northern edge of the Grenville orogen that marks where the orogen is thrust against the Archean foreland (Jamieson et al. 1995; Culshaw et al. 1997). The metamorphism and deformation are thought to be associated with the exhumation and the transport of the Parry Sound domain and other deep rocks over the Laurentian craton that occurred 1080 Ma. As a result of this thrusting 1065-1045 Ma, metamorphism occurred from the Shawanaga domain to the CMBBZ. Sometime after 1065 Ma, but before the Parry Sound domain had cooled, the Moon River domain was thrust over the Parry Sound domain, resulting in deformation of the southeastern Parry Sound domain. Some extension occurred at 1020 Ma in the Shawanaga shear zone prior to the final stage of convergence that occurred from 1000 to 980 Ma (Culshaw et al. 1997).

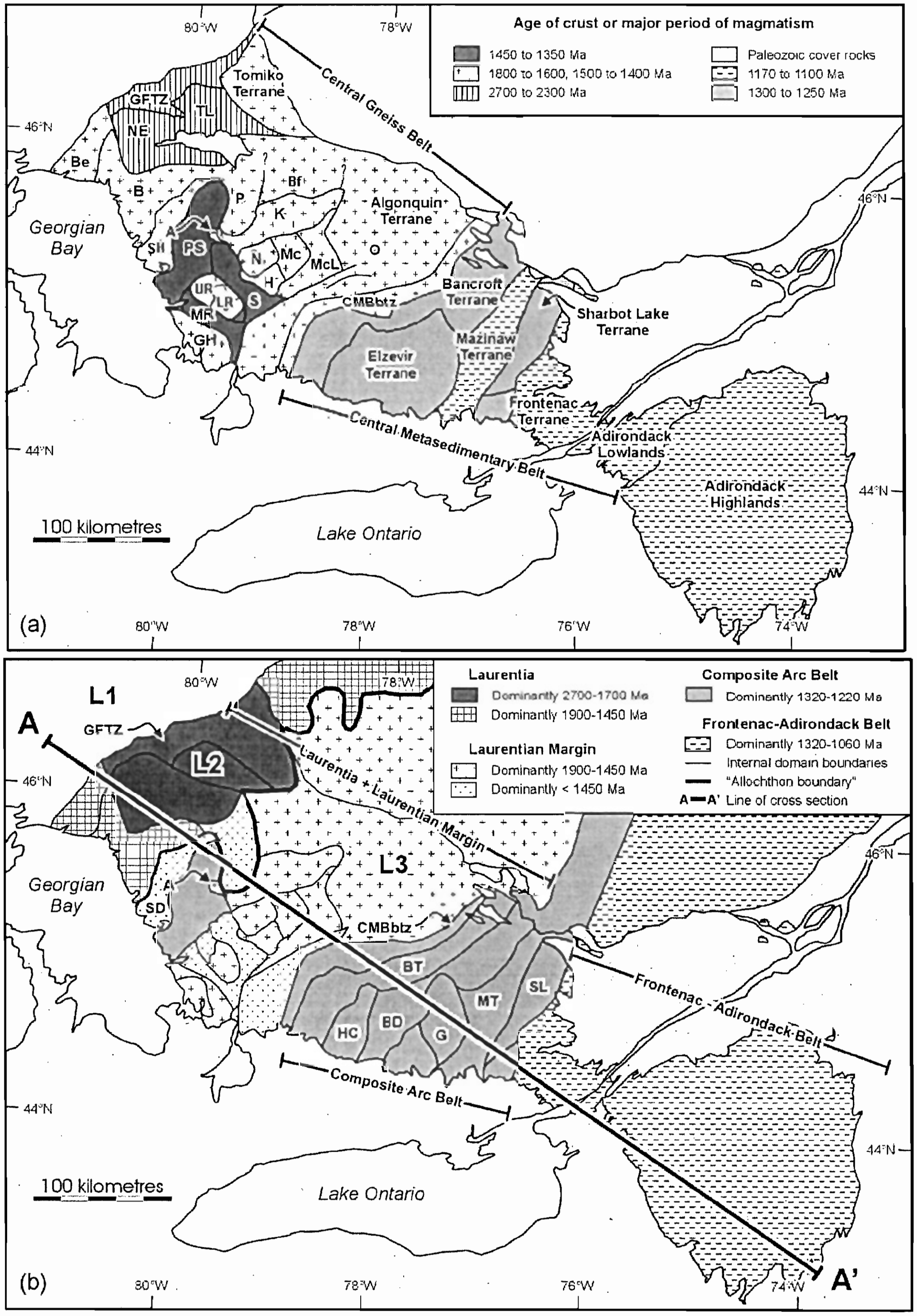

***Figure 1.2**: Divisions of the south western portion of the Grenville Province: **(a)** Lithotectonic terranes: the Grenville Front Tectonic Zone (GFTZ), the Central Gneiss Belt and the Central Metasedimentary Belt. The letters represent the same domains as in Figure 1.1. **(b)** Lithotectonic divisions based on age and lithology are; Composite Arc Belt - <1300 Ma rocks from arcs, rifted arcs and marginal basins; Frontenac- Adirondack Belt –supracrustal rocks and orthogneiss assemblages; Laurentia and Laurentia margin- Archean crust. The letters are not relevant to the area of interest. (From Carr et al. 2000).*

1.5 Regional Geology

The Britt domain is found to the north of the area of interest. It overlays the crustal scale southeast dipping Grenville Front Tectonic Zone (GFTZ) and is bordered to the southeast by the Shawanaga shear zone. The Britt domain consists of granitic to tonalitic orthogneiss, less abundant paragneiss and mafic dykes (Culshaw et al. 1997). These rocks predate the intrusion of ~ 1690 Ma granitoid metaplutonics (Corrigan et al. 1994, Culshaw et al. 1997) and ~1450 megacrystic granitoid plutons (van Breemen et al. 1986; Culshaw et al. 1997). The rocks are strongly deformed and were affected by granulite facies metamorphism (~1450-1430 Ma) (Tuccillo et al. 1992, Culshaw et al. 1997). They are believed to be of Laurentian origin (Culshaw et al. 1997). Within the Britt domain are the Powassan batholith and the area to the north of the Kiosk domain, which as previously explained, within this paper is referred to as the Bonfield terrain after the Bonfield batholith.

Both the Powassan and Bonfield batholiths are composed of metamorphosed quartz monzonitic rocks with garnet porphyoblasts in a fine-grained feldspar with minor quartz, biotite and amphibole. They are foliated and in some cases migmatitic. The Bonfield batholith has been dated at 1.5 Ga (L.M. Heaman, personal communication 1993, in Davidson and van Breemen 2001) and the Powassan is dated at ~1250 Ma (Davidson and van Breemen 2001). These mid-Mesoproterozoic plutonic events are thought to be a distal event related to arc or back-arc magmatism along the margin of the Laurentia that occurred prior to continental collision (Davidson and van Breemen 2001). The Bonfield terrain is also composed of interlayered metasedimentary gneiss and granulite. The foliation within the domain is lightly folded and dips east, lineations within the rock plunge east; the rock also contains major recumbent folds with axes parallel to the surrounding lineations (Davidson and Grant 1986).

The Shawanaga domain lies above the Britt domain and below the Parry Sound domain. It consists of quartzofeldspathic paragneiss, amphibolite, and granitoid orthogneiss. The supracrustal rocks are believed to have been deposited on the Laurentian Margin (Culshaw and Dostal 1997). The Parry Sound domain is an allochthonous body that is made up of mafic granulites and high grade granitoid gneisses (Davidson and Morgan 1980; Wodicka et al. 2000). The allochthon is composed of three packages that are separated by ductile shear zones. The base package contains quartzites, anorthosite bodies and large amounts of orthogneiss. The overlying package is composed of granite to gabbro granulite facies metaplutonic rocks and minor amounts of metasedimentary rocks. The top package is similar to the base package; it is composed of minor amounts of supracrustal rocks, granitoid orthogneiss and anorthosite cut by mafic dykes (Culshaw et al. 1997; Wodicka et al. 2000). To the east of the Parry Sound domain is the Ahmic domain that dips below the Parry Sound. Lithologically it is similar to the Shawanaga domain, and it is believed that they either are, or once were connected (White et al. 1994).

The Moon River domain overlies the Parry Sound and Rosseau domains. Its northern portion is composed of retrogressed granulite, pegmatite, and mafic to ultramafic metaplutonic rock and orthogneiss. The southern portion is composed of magmatic granitoid and supracrustal gneisses (Culshaw et al. 1997). The Seguin domain is equivalent to the Moon River domain, and it is hypothesized that they previously formed a continuous body that overlaid the Rosseau domain, and at least part of the Go Home and Algonquin domains (Culshaw et al. 1983). The Rosseau domain is divided into an Upper and a Lower Rosseau. The Upper Rosseau domain is composed of migmatic gneiss of granodioritic composition. There are lithologic similarities between the Upper Rosseau, Upper Go Home and the southern portion of the Shawanaga domains, which support the idea that they could be part of the same thrust sheet (White et al. 1994).

The northern and central portion of the Kiosk domain is composed of highly foliated and lineated quartzofeldspathic gneisses and are characterized by a series of plutons that are tonalitic to granodioritic in composition. Also present are smaller bodies of orthogneiss and metagabbro. The northern boundary of the domain contains a broad zone of highly strained mylonitic gneiss. Further south, metaplutonic rocks are found within a matrix of quartzofeldspathic and pelitic gneisses. The majority of the rocks within the Kiosk domain strike east-northeast, as defined by gneissosity that dips to the southeast, there is also a pronounced mineral lineation that plunges down dip. The lineation is frequently in the form of quartz rods or aggregates of other minerals, formed as a result of ductile stretching. The Kiosk domain is poorly exposed; however, the structural trend is supported by aeromagnetic images of the region (Davidson and Morgan. 1981; Davidson and Grant. 1986). The well defined foliation and lineation in these rocks is thought to be a preserved older fabric (N. Culshaw, personal.

communication, 2008), this and the hypothesized location of the ABT along the northern boundary of the Kiosk domain make it an area of interest. The McCraney subdomain, to the south of the Kiosk domain is composed of abundant quartzofeldspathic gneisses as well as granitoid orthogneiss with some interlayering of biotite-hypersthene gneiss and pelitic gneiss (Culshaw et al. 1983).

1.6 Previous Work

Of particular significance to the profiles 1through 5 in this project is the work done by Lindia et al. 1983, on which many parts of this study were based. Also important are the interpretations of relevant seismic lines done by White et al. 1994, which provided a base for the geometries used in the gravity models. A brief overview of their work is provided.

In 1983, two-and-one-half dimensional models from five gravity profiles across the Parry Sound domain (Fig. 1.3) were created by F.M. Lindia as part of a B.Sc. thesis. She measured densities measured from 772 samples that were collected from within the study area. The densities assigned to each domain in the models were calculated as arithmetic means and the structures were based on interpreted geology as known at the time (Lindia et al. 1983). The resulting models are shown below (Fig. 1.4).

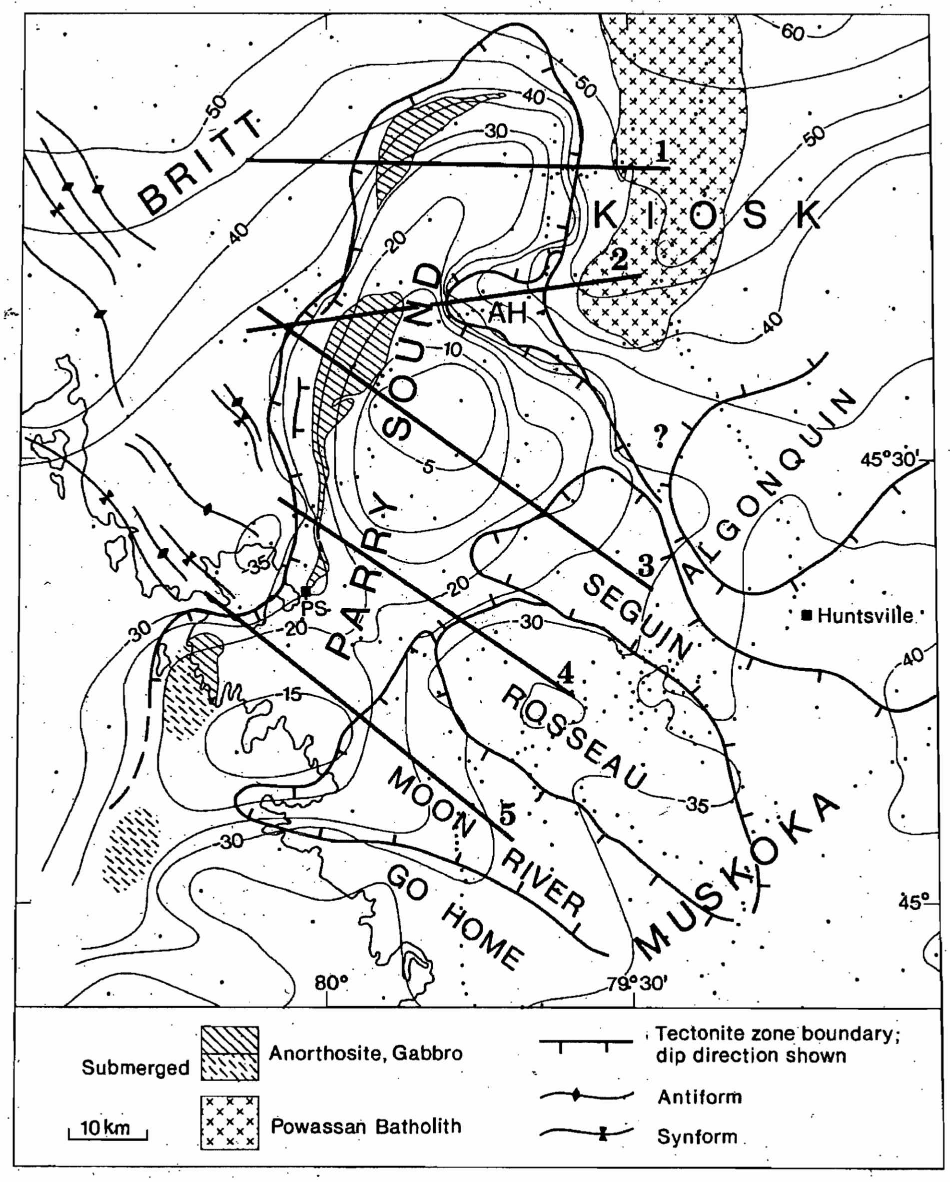

__Figure 1.3:__ Geological map used by Lindia et al. 1983, showing the locations of the five profiles that were created. The dots indicate the location of gravity stations. Contours represent Bouguer gravity (Image from Lindia et al. 1983).

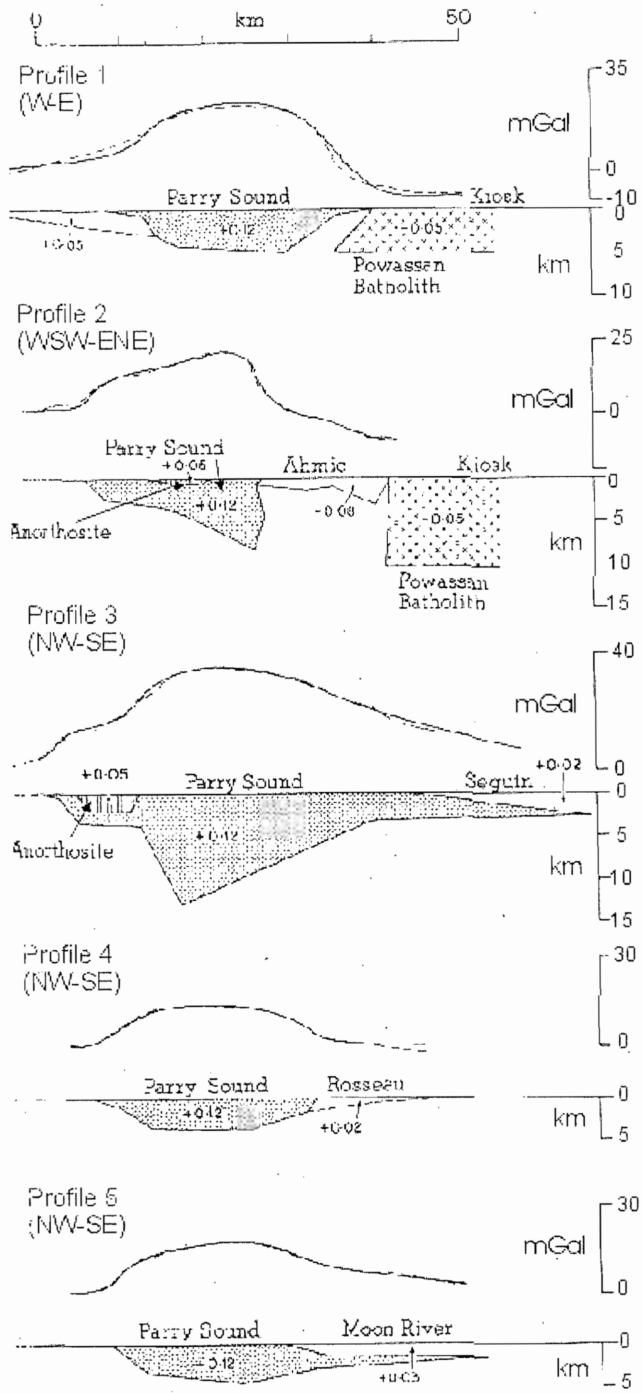

Figure 1.4: *The models that were created by Lindia et al. 1983. The upper portion of each profile shows the gravity profile, and the lower portion shows the interpreted geology. The solid line represents the calculated gravity and the dashed line represents the observed gravity. The density contrasts between bodies in reference to the Britt domain are as follows; Parry Sound: 0.12 mGal, sliver of material to the west of the Parry Sound (Profile 1): 0.05 mGal, Powassan Batholith: -0.05 mGal, Anorthosite: 0.06 mGal, Ahmic: 0.08 mGal, Seguin: 0.02 mGal, Rosseau: 0.02 mGal, and Moon River: 0.03 mGal. Profiles correspond to those shown in Figure 1.3 (from Lindia et al. 1983).*

In 1990 LITHOPROBE completed two seismic lines that cross the Parry Sound domain (Fig. 1.5). The interpretation of these lines by White et al. 1994 has provided a basis for the geometries used in the gravity models (Fig. 1.6). The depth and the typical shape of the bodies provide a good constraint for both the domains that the lines cross, as well as what can be expected for the rest of the region.

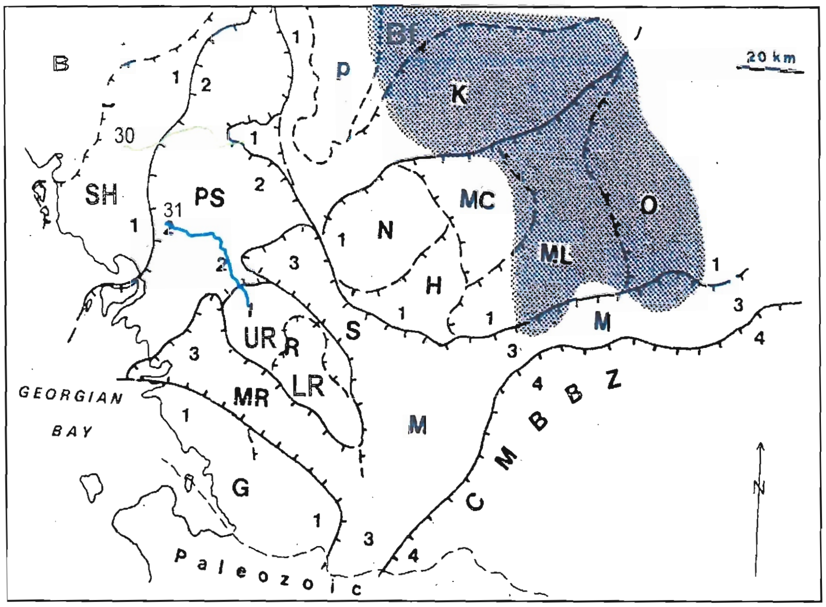

Figure 1.5: *Location of seismic line 30 (green) and 31(blue) relative to the domains and sub domains in the area of interest. Meaning of letters is the same as in Figure 1.1 (Map after Davidson and Grant. 1986).*

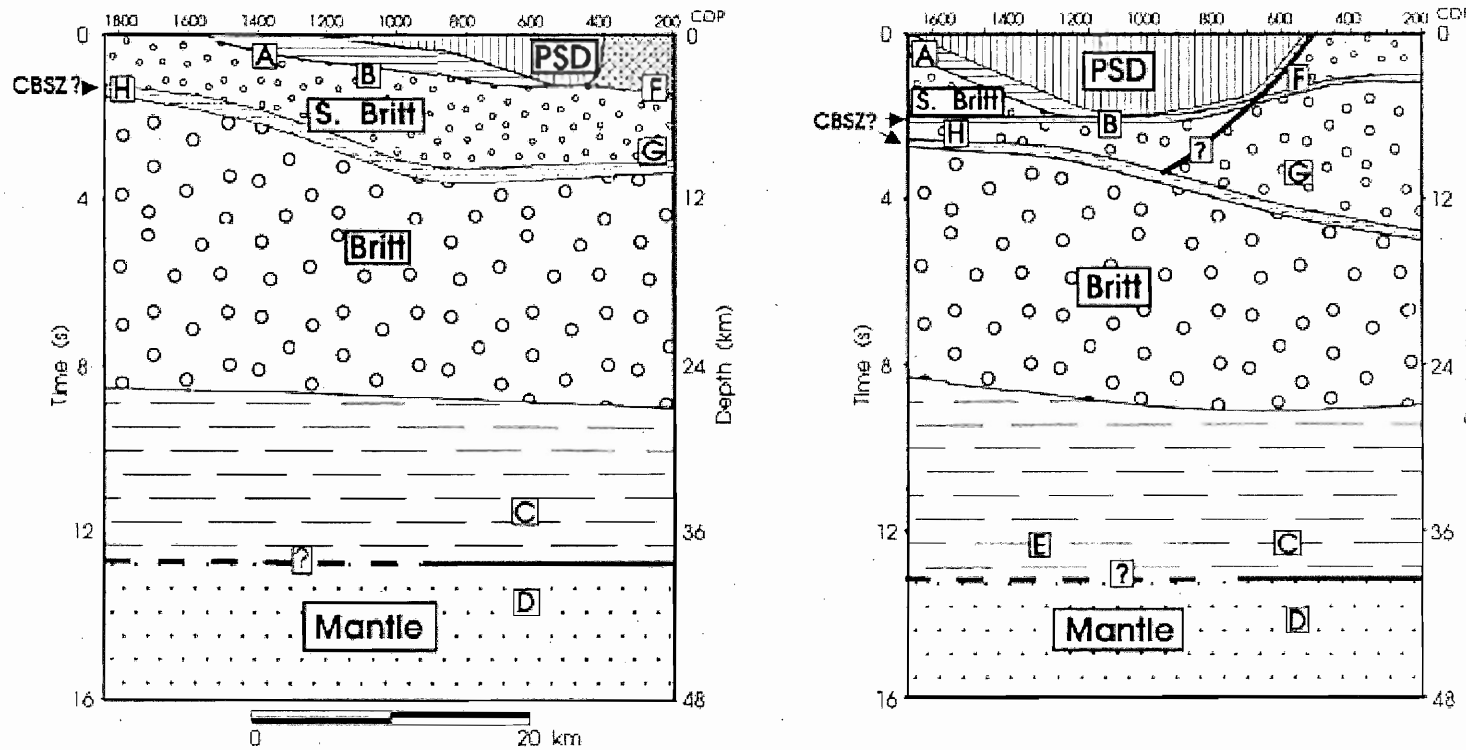

Figure 1.6: *Schematic interpretations of seismic line 30 (left) and 31 (right). Diagrams are vertically exaggerated. PSD refers to the Parry Sound domain and the other letters refer to different boundaries and detachment zones (CBSZ- central Britt shear zone, which is also referred to as the Shawanaga shear zone(Culshaw et al. 1997)) (from White et al. 1994).*

CHAPTER II
Geophysical data

2.1 Introduction

This chapter introduces the gravity, density and field data, as well as the computer software that has been used to model the extent of different geologic bodies within the area of interest.

2.2 Gravity Data

The gravity anomalies used in profiles 1 through 5 were taken directly from Lindia et al. 1983 (Fig. 1.4). The gravity data for these anomalies came from their measurements at 125 stations, as well as 60 gravity stations completed by the Earth Physics Branch, Department of Energy, Mines and Resources, Ottawa (Waddington and Dence 1979; Lindia et al. 1983) (locations shown in Fig. 1.3). The gravity data for profile 6 is from the Canadian Gravity Database for which there is approximately 15 km spacing between stations (Fig. 2.1). The data from all sources has undergone Bouguer gravity corrections. The Bouguer correction removes the effect of rock mass and elevation between the survey site and an ellipsoid used as a reference.

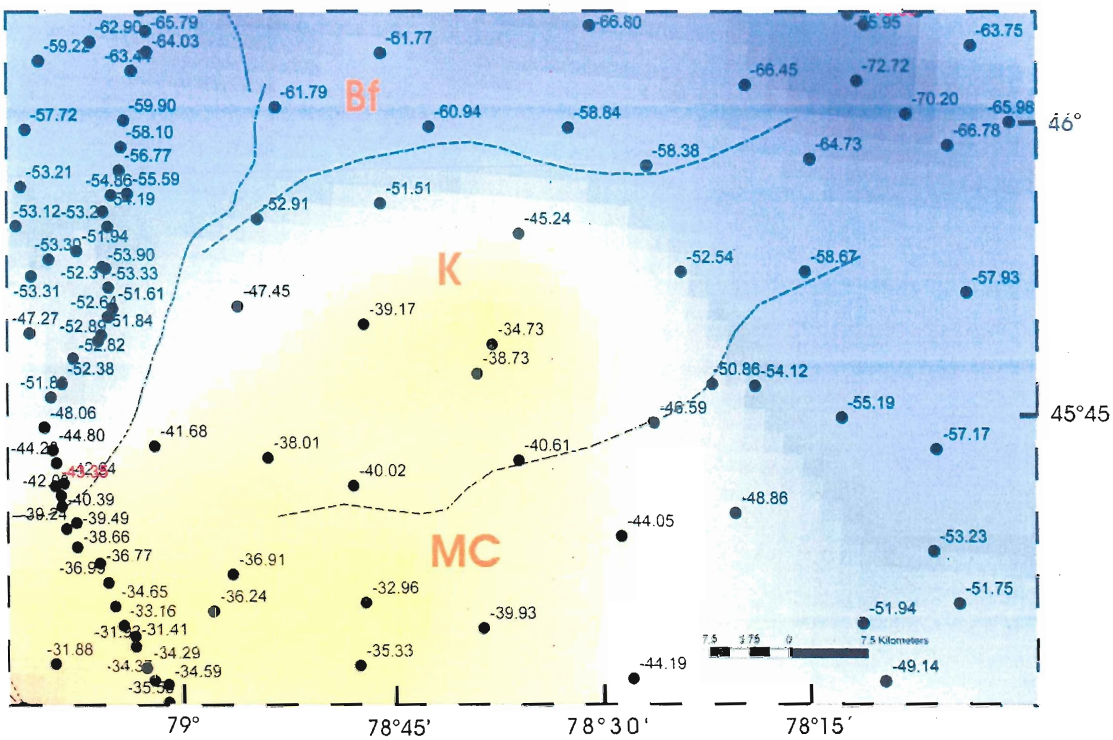

Figure 2.1: *Location map of gravity survey sites within the Kiosk domain. Points show locations and values (mGal) of gravity survey sites from the Canadian Gravity Database. The background colour also corresponds to the Bouguer gravity values; the colour scale is the same as in Figure 2.2a. Letters indicate; Bf- Bonfield terrain, K- Kiosk domain, and MC- McCraney subdomain (Gravity map from the Canadian Geodetic Information System, 2008).*

The gravity set can be used to interpret the subsurface geology from the known densities of surface rocks. There is about a -10 to 35 mGal range in gravity values within the area of interest (Fig. 2.2a). A map of first vertical derivatives enhances near surface features or lateral variations and suppresses anomalies resulting from rocks deeper within the crust (Fig. 2.2b). This map shows the same general trends as the original; however, subsurface features responsible for the anomalies are likely a near surface phenomenon. The gravity data from along six profiles (Fig. 2.3) was input into the program GM-SYS. It was then used together with field data to create models of subsurface geology.

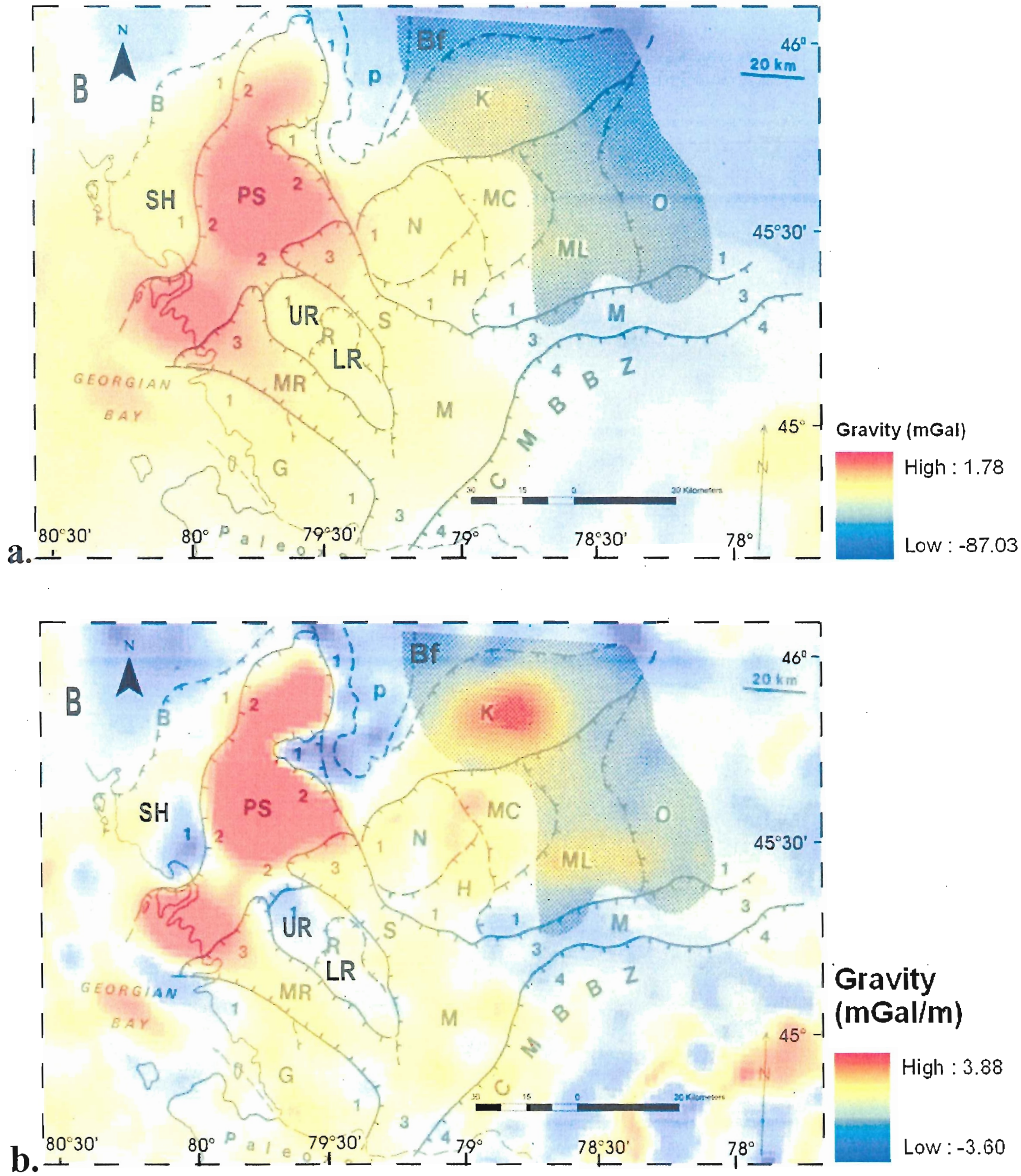

Figure 2.2: **a.** *Bouguer gravity map. The background colour of the map corresponds to the Bouguer gravity values shown in the adjacent legend. The letters in maps a and b identifying the domains are the same as in figure 1.1.* **b.** *First vertical derivative Bouguer gravity map. The background colours, as shown in the adjacent legend correspond to the value of the first vertical derivative of the Bouguer gravity values. This map enhances the effects of near surface geology. (Geological Maps after Davidson and Grant, 1986; Gravity map from the Canadian Geodetic Information System, 2008).*

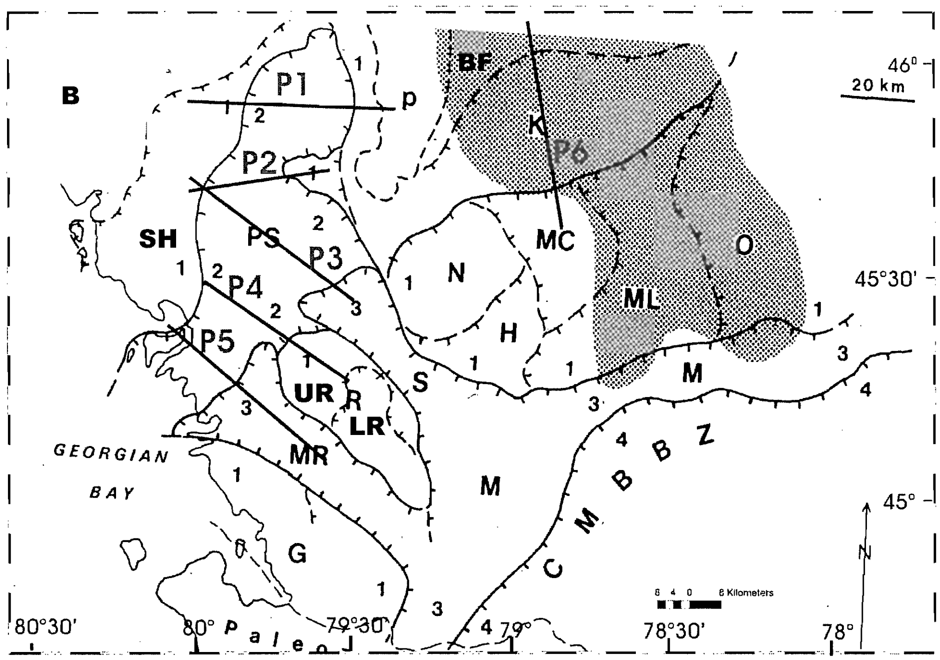

Figure 2.3 *Location map for profiles 1 through 6. The letters in maps a and b identifying the domains are the same as in figure 1.1 (Base map from Davidson and Grant 1986).*

2.3 Density Values

Densities for 307 samples were determined by weighing the samples in air and while suspended in water, these two values were used to calculate the density of the samples. Fifty-six of these samples were collected by Dr. Nick Culshaw and Duncan McLeish from the Bonfield terrain, Kiosk domain and McCraney subdomain. The other 251 samples were on loan from the Geological Survey of Canada (GSC) collection, and are from the Bonfield terrain, Kiosk domain, and McCraney subdomain. One-hundred-twenty-three additional density values and their location were obtained from within the Britt, Shawanaga, and Upper and Lower Rosseau domains from Dr M. Thomas of the Geological Survey of Canada, Earth Physics Branch, Ottawa. These are the same values used by Lindia et al.1983, and allowed the estimation of average densities of domains not recognized at the time of Lindia et al.'s study. Using either an average or a weighted average for these values, (as discussed further in section 3.1.1 and shown in Appendix A) density values for each of the domains with available data was determined.

2.4 GM-SYS

The gravity profiles created for lines 1-6 have been used in the computer program GM-SYS Profile Modeling. GM-SYS is a two and one half dimensional geophysical gravity modeling program. Models are produced by creating blocks that represent different lithological units with assigned density values. The two dimensional shape of these blocks, and their extent perpendicular to the profile (the additional 0.5 dimension) can be controlled. The program calculates the gravity of the models and compares them to the observed gravity profile (GM-SYS 2000).

The decision to use a 2.5 D modeling program rather than a 3 D program was based on the availability of software, time limitations, and because the margin of error associate with using 2.5 D instead of 3 D was determined to be small enough not to significantly alter the results. This was tested by modeling in 3 D a block with a density contrast of 0.5 g/cm^3 that is present at surface to a depth of 3 km (Fig. 2.4). The body had a vertical cross-section of 3X5 km and longitudinal lengths of 3, 5, 7, 9, 15 and 20 km. Profiles were calculated for the resulting gravity anomalies (Fig.2.5). These were chosen to represent going from a 3 D modeled profile, (modeling a body that varies perpendicular to the profile, i.e. the 5X3 body), to an essentially 2D modeled profile (a body that extends to infinity perpendicular to the profile, i.e. the 5X100 body).

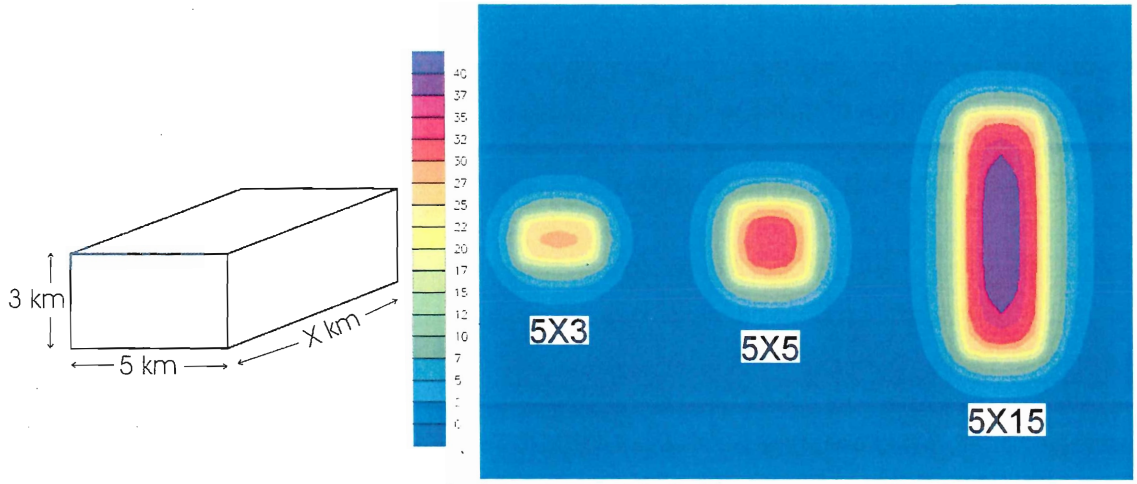

Figure 2.4 *(left) Schematic of the body that was modeled. The 3 and 5 km dimensions remained the same, and X took on the values 3, 5, 7, 9, 15, 25, and 100. (Right) Resulting anomalies of the 3 D modeling, where X was equal to 3, 5 and 15 (aerial view of anomaly). The profiles in Figure 2.5 cut these bodies through their center along the 5 km dimension. (Gravity anomaly figures from Dr. G. Oakey, personal communication, 2008)*

When profiles of the anomalies were compared there were no observable differences between the bodies longer than 5X15 (Fig. 2.5), these would have the same gravity profiles whether modeled in 2 D or 3 D. The differences between these and the 5X3 body were about 10 mGal, about 5 mGal for the 5X5 body and less than 3 mGal for 5X7 and 5X8 bodies. This suggests that for modeling bodies with a high length to width ratio like the Parry Sound, and Kiosk domains 2.5 D modeling is appropriate. Either the Parry Sound domain (profiles 1-5) or the Kiosk domain (profile 6) is the major body in the profile, and as a result, their dimensions and densities have the largest influence on the shape of the gravity profiles. Smaller domains such as the Ahmic, Seguin, Rosseau and Moon River domains are not as ideally suited for 2 D modeling, and some error can be expected from this. However, because 2.5 D is being used and not 2 D the margins of error will be minimized.

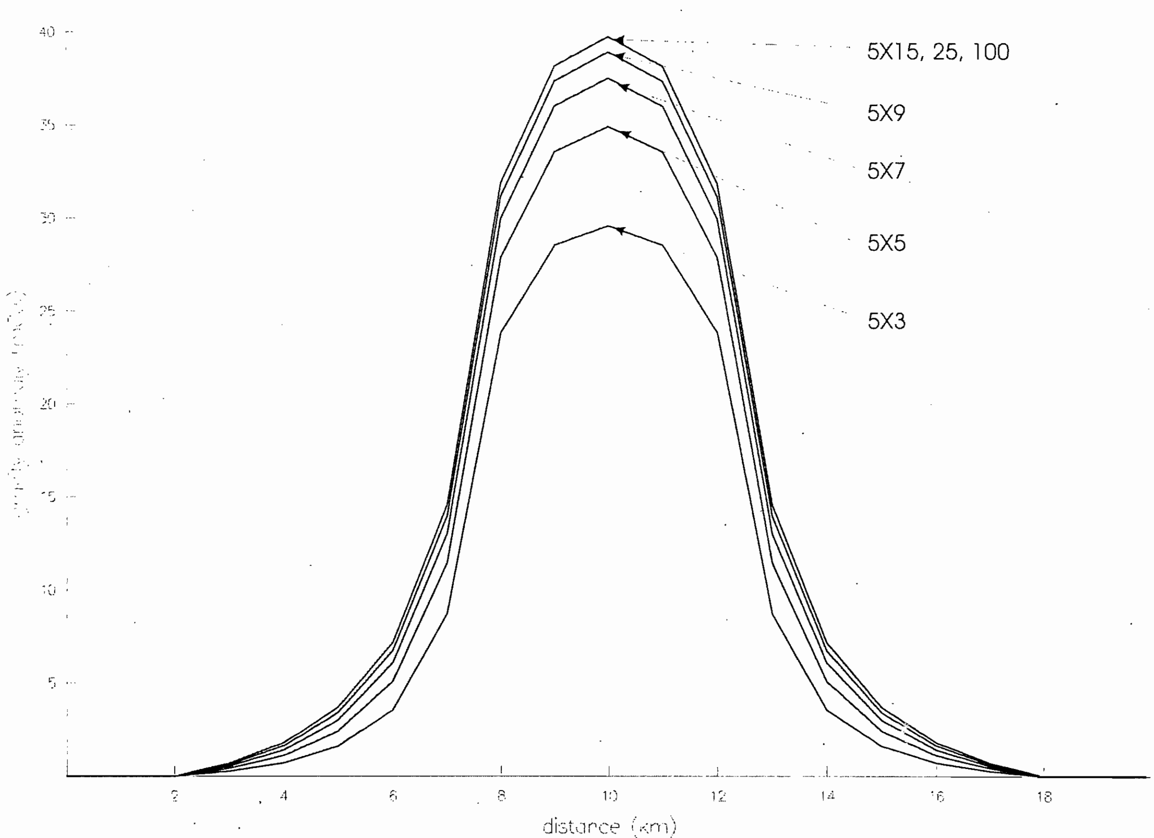

***Figure 2.5**- The gravity profiles of blocks modeled in 3 D. All blocks were present at surface, had a depth of 3 km and a width of 5 km parallel to the profile, the value of the third dimension and which profile it corresponds to is indicated on the graph (NB the top curve was the profile for all block lengths that were greater than 15). (Figure from Dr. G. Oakey, personal communication 2008).*

CHAPTER III
Gravity Modeling

3.1 Introduction

2.5-dimensional models were completed for each of the six cross sections shown in figure 2.3. Multiple models were created for each location in order to determine a variety of possible geologic models that could satisfy the observed gravity anomalies and surficial geology. The variations of each cross section differed in terms of densities, as well as the subsurface shape and depth of different rock bodies. The models that made the most geologic sense are included below. Alternative models for cross-section six are presented in Appendix B.

3.2 Method

The locations of five of the cross sections were chosen to match the gravity models done by Lindia et al. 1983 (Fig. 1.3). The sixth cross-section runs approximately north south through the Kiosk domain; it is an area that was not modeled by Lindia et al. 1983 (Fig. 2.3). Its location and orientation was chosen to be perpendicular to local structural trends and to correspond to the area recently covered during fieldwork by Dr. N. Culshaw and D. McLeish. The models were created in the 2.5-D modeling program GM-SYS.

3.2.1 Density Values

The density values for the different domains and subdomains (Table 3.1) were calculated as weighted averages of the sample densites from each domain, the data and calculations are presented in Appendix A. For the Bonfield terrain, McCraney subdomain and Kiosk domain samples were available for density measurements. Forty-eight of these samples were collected by Dr. N. Culshaw and D. McLeish, the rest were from the GSC collection originally collected as part of research published by Davidson and Grant 1986, as well as Culshaw et al. 1983 and Davidson and Morgan 1981. The sampling of mafic and felsic rocks within these domains was not representative of the distribution observed, therefore a weighted average of the densities based on field estimates made by Dr. N. Culshaw was used for both the McCraney subdomain and the Kiosk domain. The proportions used for the Bonfield terrain was based on estimates from a geologic map (Geologic Survey of Canada, 1996). For the Britt domain, proportions of different lithologies and rock densities were taken from Long (1994). These were used to create a weighted average density. The density value for the Britt domain was also calculated using a weighted average of the density values supplied by Dr. M. Thomas, GSC Ottawa, and resulted in the same average density.

The density values and corresponding locations from Dr. M. Thomas were used to calculate density values for domains defined since the work done by Lindia et al. (1983). Examples include the Shawanaga domain which has been distinguished from the Britt domain and the division of the Rosseau domain into upper and lower domains. These average densities were calculated using a weighted average. For the remaining domains: the Ahmic, Moon River, Seguin, Go Home, the Powassan Batholith complex, and the anorthosite bodies, the density values calculated by Lindia et al. 1983 were used.

			Number of samples and source				
Body	Density	Δ ρ	Total	Field	GSC	Thomas	Lindia et al, 1983
Britt domain	2.68	0	35			35	
Shawanaga domain	2.72	0.04	120			120	
Ahmic domain	2.65	-0.03	27				27
Parry Sound domain	2.85	0.17	305				305
Moon River domain	2.76	0.08	59				59
Lower Rosseau domain	2.72	0.04	39			39	
Upper Rosseau domain	2.71	0.03	46			46	
Seguin domain	2.75	0.07	39				39
Go Home domain	2.75	0.07	17				17
Powassan batholith	2.68	0	NA				NA
Bonfield terrain	2.69	0.01	61	13	48		
Kiosk domain	2.74	0.06	205	23	182		
McCraney subdomain	2.73	0.05	41	12	29		
Anorthosite	2.78	0.1	22				22

Table 3.1*: Table of density values, number of samples, and source of data for each geolgic body included in the models. The difference in density (Δ ρ) is in reference to the Britt domain. Field samples refer to those collected by Dr. N. Culshaw and D. McLeish, GSC samples are from the Geologic Survey of Canada rock depository, Thomas samples are from data supplied by Dr. M. Thomas and the Lindia et al. 1983 density values were taken directly from that work. For the Powassan Batholith, a number of samples was not provided by Lindia et al. 1983.*

GM-SYS 2.5D provides the option for modeled bodies to have a limit in the horizontal plane of the profile (X), perpendicular to the profile (Y), and in the vertical plane (Z). It is also possible to create cross sections that cut geologic bodies at an angle, however, for the purposes of these models all profiles cut the geologic bodies at a 90° angle. The length of bodies in the X and Y direction were estimated from geologic maps showing the extent of the different domains and sub domains, however in most cases the length of the bodies perpendicular to the model was left at infinity. This is discussed further in section 4.3.

3.2 Models

3.3.1 Profile 1:

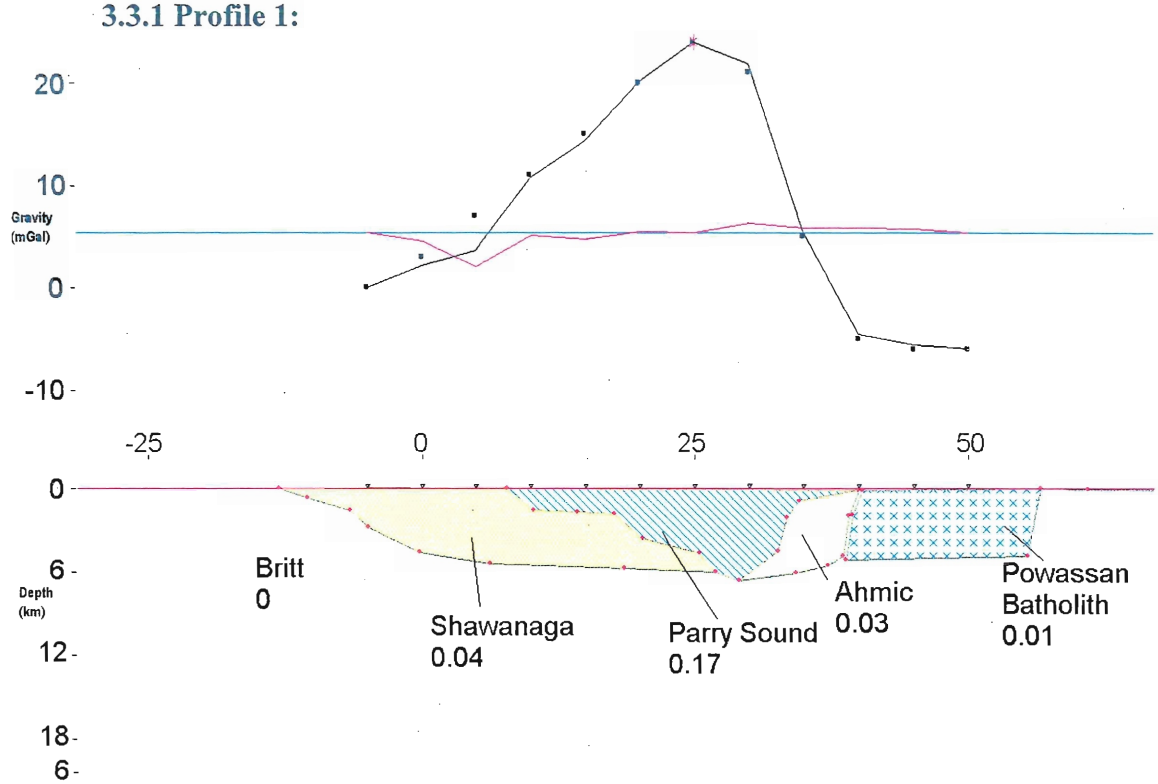

***Figure 3.1**: Profile 1 (see Figure 3.1 for location map) cuts through the Shawanaga domain, Parry Sound domain and the Powassan Batholith. Density contrasts between the domains are shown on the profile. Depth and horizontal distance are in km. The upper portion of the profile shows the gravity anomaly; the dots correspond to observed gravity, the solid black line corresponds to calculated gravity, and the red line shows the difference between the observed and calculated gravity.*

Profile 1 runs west to east across the Britt domain, Shawanaga domain, Parry Sound domain and the Powassan Batholith. Above the Parry Sound domain, there is a gravity anomaly with a maximum of about 25 mGal. The Parry Sound domain has been assigned a 15 km limit in the +X direction (north, perpendicular to the profile) to better represent the body being modeled. The model shows a good fit between the calculated and observed gravity, with the exception of a 5 mGal difference between the calculated and observed gravity near the northwestern end of the profile. This could be fixed by deepening the extent of the Shawanaga domain in this region, however this is not supported by the interpreted structure of the Shawanaga domain in seismic line 30 in which it is modeled to have a smooth gently inclined base that dips beneath the Parry Sound domain (Fig. 1.5 and 1.6). The problem could be attributable to local lithological variations in the Shawanaga domain such as concentrated amphibolites that have been mapped within the domain (Culshaw and Dostal. 1997), or the result of variations within the Britt domain such as the presence of granulites (Culshaw et al. 1997). The Shawanaga domain has been interpreted to extend quite far under the Parry Sound domain before it pinches out. The Ahmic domain on the other side of the Parry Sound domain can be thought of as a continuation of this, as these two are lithologically similar and are thought to be connected beneath the Parry Sound domain (White et al. 1994). In this model, the Ahmic domain is modeled in the subsurface to form a small west-dipping lens on the east side of the Parry Sound domain. The low density of the Ahmic domain, helps to recreate the sharp change in observed gravity to the east of the Parry Sound domain. This profile is very similar to that by Lindia et al. 1983. The major difference is that the Shawanaga and Ahmic domains have been incorporated into the model, and as a result, it was necessary to model the western portion of the Parry Sound domain as a much shallower body.

3.3.2 Profile 2:

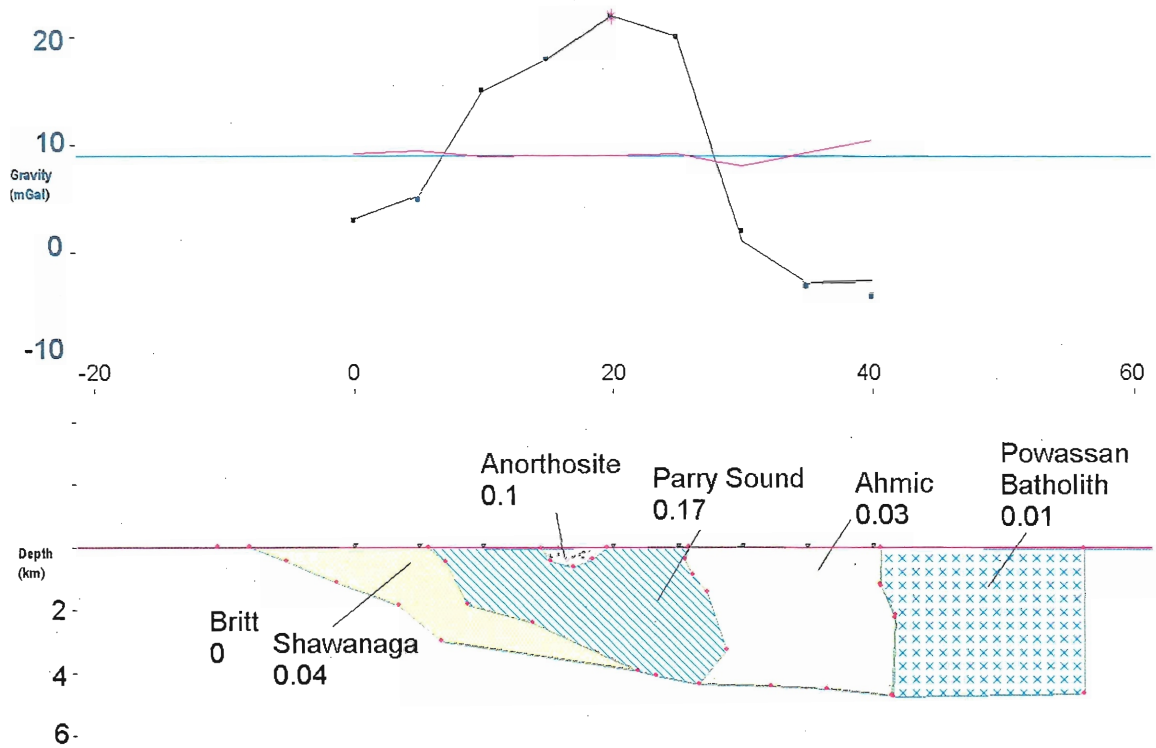

***Figure 3.2**: Profile 2 (see Figure 3.1 for location map) cuts through the Shawanaga domain, Parry Sound domain, an anorthosite body, the Ahmic domain and the Powassan Batholith. Density contrasts between the bodies are shown on the profile. Depth and horizontal distance are in km. The upper portion of the profile shows the gravity anomaly; the dots correspond to observed gravity, the solid black line corresponds to calculated gravity, and the red line shows the difference between the observed and calculated gravity.*

Profile 2 is oriented east northeastward, running from the Britt domain, across the Parry Sound domain, Ahmic domain and ends in the Powassan Batholith. There is a maximum gravity anomaly of about 25 mGal over the Parry Sound domain. The calculated gravity from the model produces a curve that is a good fit to the observed gravity. The eastern end of the model produces a greater calculated gravity than the observed gravity. There are several possible explanations for this, the density value assigned to the Powassan batholith, may not be representative of the entire body or the Ahmic domain could extend quite a bit deeper and more to the southeast. Within the eastern portion of the profile perpendicular to the profile the geology is quite complex. It is possible that geologic bodies adjacent to, but not crossing this cross section are affecting the observed gravity, but are not incorporated into the model. In this case, a 3 dimensional modeling system may be more appropriate than the 2.5 dimensional one that was used. When compared to the same profile modeled by Lindia et al. 1983 there are quite a few differences. Once again, the Shawanaga domain has been incorporated into the model, as well, the Parry Sound domain is more bowl shaped and the Ahmic domain is modeled to extend to a greater depth. The eastern edge of the Parry Sound dips steeply to the west at the surface, but has been modeled to dip east at depth, this was nessecary to support the observed gravity.

This profile has a similar orientation to the seismic line 30 (Fig.1.5). When modeling this profile the interpretation of this line by White et al. 1994 (Fig 1.6) was used as an example of what the structure should look like, while keeping in mind that the profile does not match the seismic line exactly (in particular the seismic line crosses many of the domain boundaries at angles other than 90 degrees, as they do in the profile). The modeled structure is similar to that of the seismic interpretation, however in order to recreate the observed gravity it was necessary to model the Parry Sound domain as quickly increasing its dip in the eastern portion of the model, and adding a subsurface bulge to the east of the Parry Sound body. The depth of the bodies in both the model and seismic interpretation are similar.

3.3.3 Profile 3:

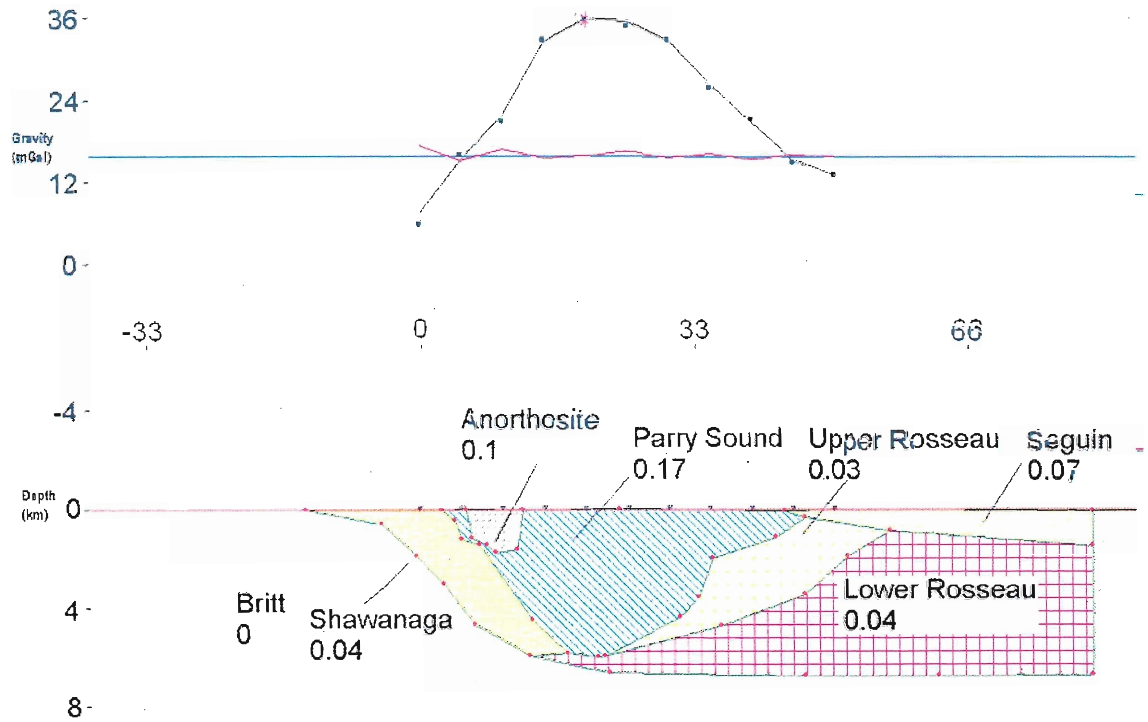

***Figure 3.3**: Profile 3 (see Figure 3.1 for location map) cuts through the Shawanaga domain, Parry Sound domain, an anorthosite body, the Upper and Lower Rosseau domains and the Seguin domain. Density contrasts between the domains are shown on the profile. Depth and horizontal distance are in km. The upper portion of the profile shows the gravity anomaly; the dots correspond to observed gravity, the solid black line corresponds to calculated gravity, and the red line shows the difference between the observed and calculated gravity.*

Profile 3 runs from the northwest to the southeast across the Britt, Shawanaga, Parry Sound, and Seguin domains. The maximum observed gravity anomaly is approximately 35 mGal. There is a good match between the observed and calculated gravity. Within this model, the Shawanaga domain has been interpreted to pinch out under the Parry Sound domain, the Upper Rosseau domain, to which it is thought to be related (White et al. 1994), continues on the other side of the Parry Sound domain where it subcrops against the Seguin domain. The Lower Rosseau domain extends from below the Parry Sound domain and thickens to the southeast. The general shape of the Parry Sound domain is similar to that in the model by Lindia et al. 1983, however because of the addition of the Upper and Lower Rosseau domains below the Parry Sound and the Seguin domains the observed gravity could be modeled without greatly extending the root of the Parry Sound domain beneath the Seguin domain and the Parry Sound domain could be modeled as a thinner body.

3.3.4 Profile 4:

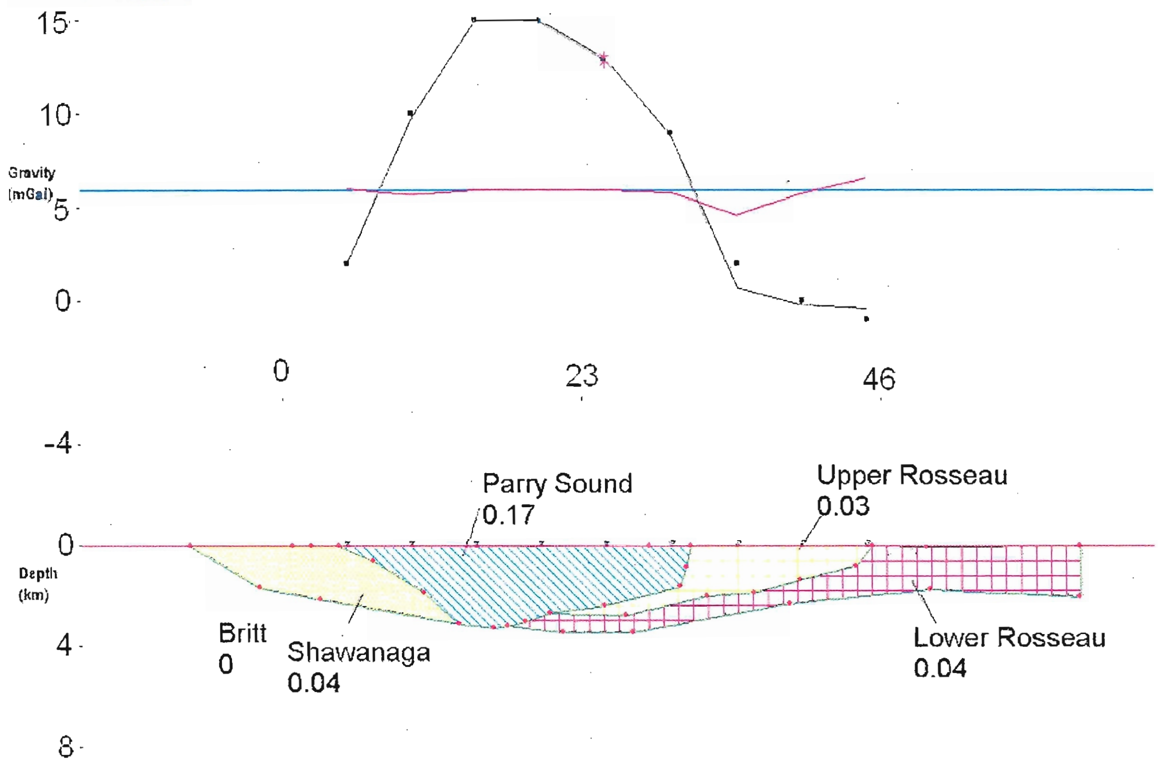

***Figure 3.3**: Profile 4 (see Figure 3.1 for location map) cuts through the Shawanaga, Parry Sound, and the Upper and Lower Rosseau domains. Density contrasts between the domains are shown on the profile. Depth and horizontal distance are in km. The upper portion of the profile shows the gravity anomaly; the dots correspond to observed gravity, the solid black line corresponds to calculated gravity, and the red line shows the difference between the observed and calculated gravity.*

Profile 4 runs from the north-west to the south-east across the Britt, Shawanaga, Parry Sound, and Upper and Lower Rosseau domains. The maximum observed gravity anomaly is approximately 15 mGal. There is a good fit between the observed and calculated gravity with the exception of a smaller than observed gravity in the southeastern portion of the model. Within this model, the Shawanaga domain has been interpreted to pinch out under the Parry Sound domain. The related Upper Rosseau domain does the same on the southeastern side. The Lower Rosseau domain extends from beneath the Parry Sound domain to the southeast where it has been interpreted to thin slightly before thickening. This profile is supported by seismic line 31 (Fig. 1.5) that has a similar orientation to the profile (White et al. 1994). The interpretation of this seismic line (Fig. 1.6) shows the Parry Sound domain extending to a depth of about 5 km whereas in the above model it bottoms out at about 3.5 km. This difference could be related to either a Parry Sound domain density value that is slightly too high, or ambiguities associated with the interpretation of the seismic data. Because of the addition of the Shawanaga, and Upper and Lower Rosseau domains, this model is much more complex than that completed by Lindia et al. 1983. However, the general shape of the Parry Sound domain in both models is very similar.

3.3.5 Profile 5:

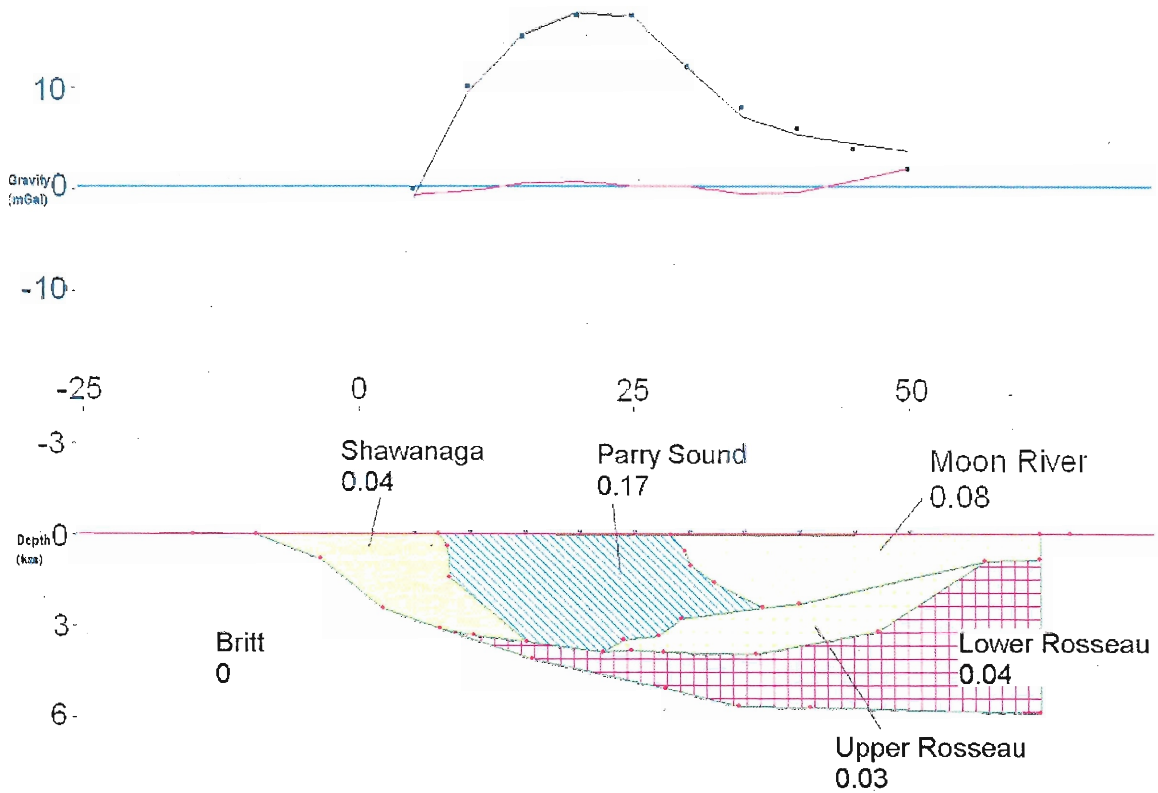

***Figure 3.5**: Profile 5 (see Figure 3.1 for location map) cuts through the Shawanaga, Parry Sound, the Upper and Lower Rosseau and the Moon River domains. Density contrasts between the domains are shown on the profile. Depth and horizontal distance are in km. The upper portion of the profile shows the gravity anomaly; the dots correspond to observed gravity, the solid black line corresponds to calculated gravity, and the red line shows the difference between the observed and calculated gravity.*

Profile 5 runs from the northwest to the southeast across the Shawanaga, Parry Sound, and Moon River domains. The maximum observed gravity anomaly is approximately 15 mGal. There is a good fit between the observed and calculated gravity. Within this model, the Shawanaga domain is interpreted to dip under, and pinch out beneath the Parry Sound domain. The Upper Rosseau domain is interpreted to be an extension of this and thickens from beneath the Parry Sound domain to where it subcrops against the Moon River domain. The Lower Rosseau domain is modeled as first appearing beneath the Parry Sound domain and thickening to the southeast. As in profile

4, the incorporation of the Shawanaga, Upper and Lower Rosseau, and Moon River domains result in a much more complex model than that of Lindia et al. 1983. Despite this, the general shape of the Parry Sound domain remains the same; only it does not extend quite as far to the east. This profile as well as profile 3 is particularly useful for showing the stacking order and the relationship between the different domains.

3.3.6 Profile 6:

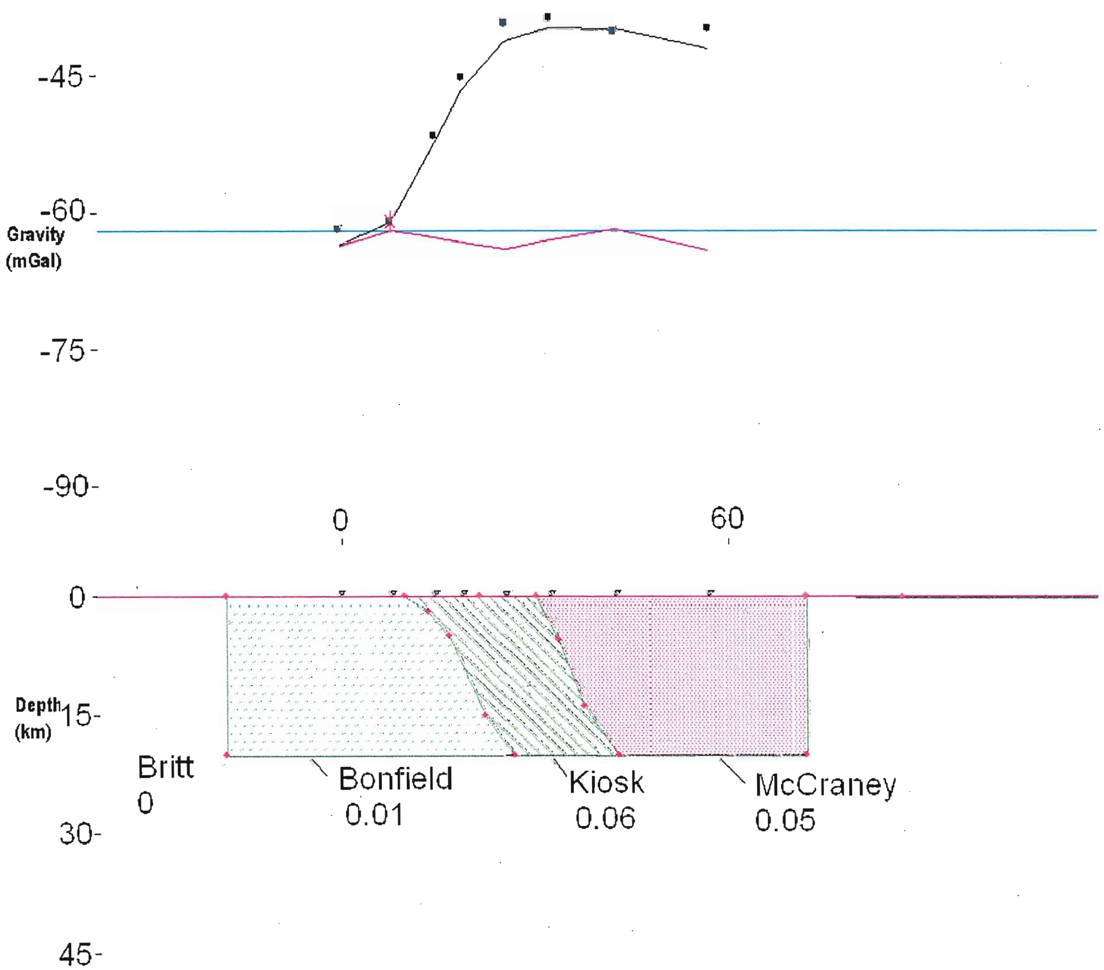

***Figure 3.6**: Profile 6 (see Figure 3.1 for location map) cuts through the Bonfield terrain, Kiosk domain and McCraney subdomain. Density contrasts between the bodies are shown on the profile. Depth and horizontal distance are in km. The upper portion of the profile shows the gravity anomaly; the dots correspond to observed gravity, the solid black line corresponds to calculated gravity, and the red line shows the difference between the observed and calculated gravity.*

Profile 6 runs approximately north south across the Bonfield terrain, Kiosk domain, and McCraney subdomain. The range of gravity values is 23 mGal. There is a good fit between the observed and calculated gravity. The model shows the Bonfield terrain, Kiosk domain, and McCraney subdomain all dipping to the south, which is consistent with structural trends in the rocks (Davidson and Grant 1980). The Bonfield-Kiosk boundary was modeled to increase in dip to satisfy the observed gravity. The Kiosk-McCraney boundary was also modeled to do the same, although due to their similarities in density there is not much gravitational control on this portion of the model. The base of the Kiosk domain and McCraney subdomain are modeled to be flat. It should be noted that in reality these bodies likely are not completely flat, but because experimenting with different dip directions in the base did not result in significantly better result they were left flat. The Bonfield terrain is also shown as having a flat base that stops at a depth of about 20 km, however as explained in chapter 1, the Bonfield terrain is a portion of the Britt domain that only varies slightly litholigically and in density. Thus in reality the Bonfield/Britt terrain/domain can be thought as extending beneath both the Kiosk domain and McCaney subdomain. Depths of 20 to 25 km for the Kiosk domain and McCraney subdomain had their own minor 'problem' areas, but did a good job of satisfing the observed gravity. Examples of four different depths (15, 20, 25 and 30 km) that were tried for profile 6 are presented in Appendix B.

Chapter IV
Discussion

4.1 Geologic Significance

The geometry of the cross sections shown in profiles 1 through 5 are based on earlier cross sections drawn from reflection seismic data (White et al. 1994), and the regional geologic cross section from Culshaw et al. (1997). They compare favorably with those produced by gravity modeling based on a smaller geologic data base (Lindia et al. 1983). The model cross sections of this study are significant because they show that the new geometries are supported by the observed gravity data and are therefore geophysically feasible. The changes in the geometries of the models created by Lindia et al.1983 have been minor. This is because most of the changes in the geologic understanding of the area that affect the models involve the distinction of separate domains from within previously defined domains; for example, identifying the Shawanaga as a separate domain from the Britt domain. These changes and the associated recalculation of average densities involved making changes in the details of the models, but not in the general shape of the bodies within the models.

Profile 6 is of particular interest because the Kiosk domain is relatively unknown geologically compared to domains in the west. The geometry that was best able to satisfy the observed gravity was a rhombus shape with northwest and southeast boundaries that dip to the southeast at an angle of about 30 degrees, then steepen slightly and extend to a depth that could vary from 19 to 20 km where they flatten out. The northwest and southeast boundaries are parallel and dip at the same angle as foliation observed at the surface. From the model it is suggested that the structural trends expressed at the surface in the Kiosk continue into the subsurface; the resulting structure is typically associated with thrust stacks. However it is important to note that the dominant northeast-southwest structures are overprint by northwest trending structures which suggests that the northeast-southwest structures are a relict fabric that has been preserved (Culshaw, personal communication 2008). These domains were at a depth of 25-35 km during the orogeny and would have been hot and ductile (Jamieson et al. 2007), a possible explanation for the preserved fabric is that the Kiosk domain was transported as an intact block and thrust over the Bonfield terrain in a ductile flow regime as discussed by Jamieson et al. (2007) and Culshaw et al. (2006).

The Kiosk domain has been suggested by Culshaw et al. (1983) to be related to the Lower Rosseau and Lower Go Home domains and potentially forms a continuous thrust sheet (Culshaw et al. 1983). The Lower Rosseau domain is modeled at a depth of about 6 km. This implies that a Kiosk-Lower Rosseau- Lower Go Home thrust sheet would thicken significantly (~ 15km) to the east and thus, that the underlying Britt domain thins to the east (Fig 4.1b). A thickness increase on this scale over a relatively short lateral distance within a single thrust sheet is unlikely, and thus discredits the idea that the Kiosk domain would be a part of a Lower Rosseau-Lower Go Home thrust sheet. An alternative geometry is that a Lower Rosseau-Lower Go Home thrust sheet pinches out against a Novar and McCraney body (Fig. 4.1c).

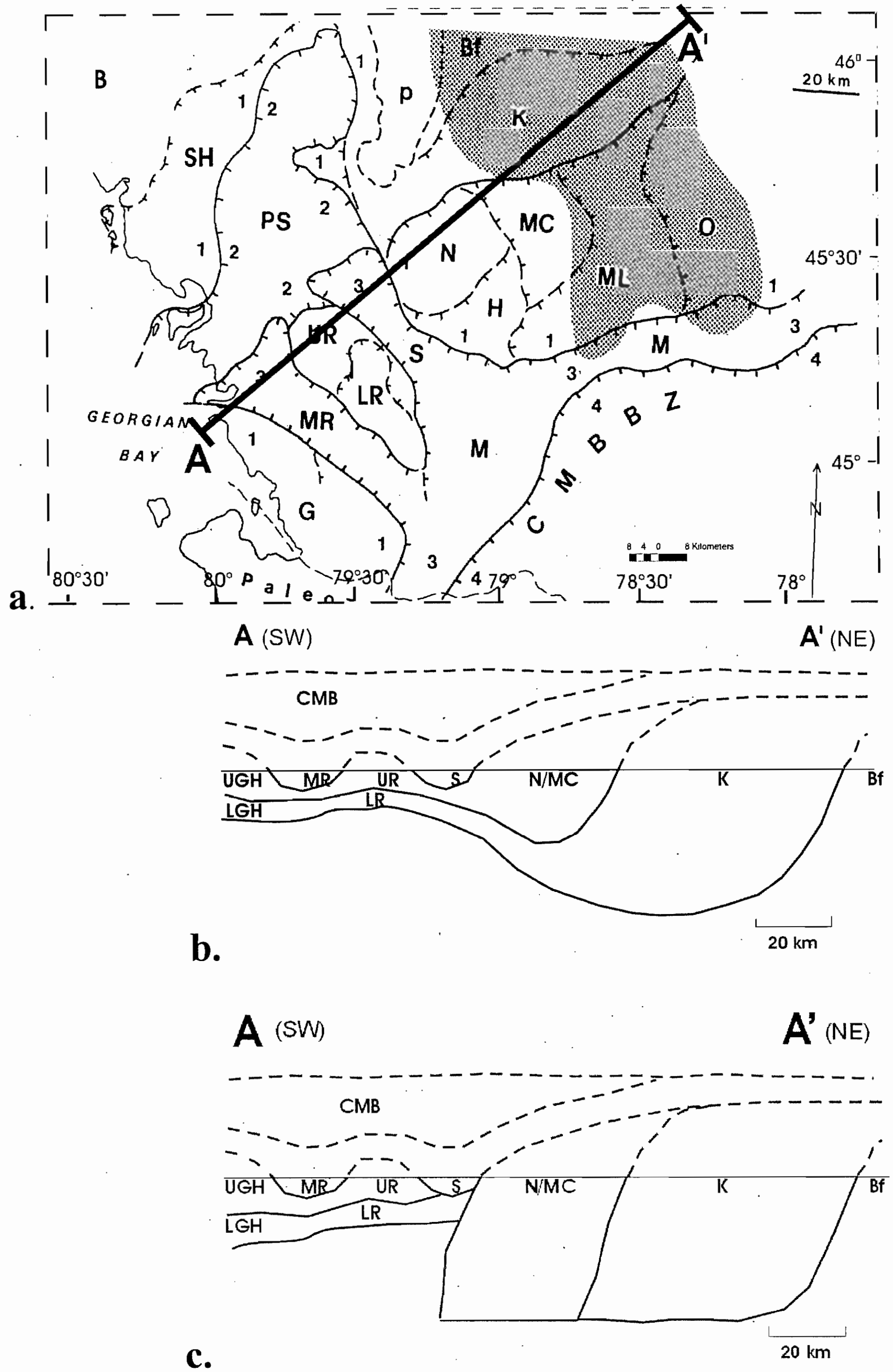

Figure 4.1: ***(a)*** *Cross section location map (after Davidson and Grant 1986).* ***(b)*** *Schematic southwest-northeast cross section from Georgian Bay to the Kiosk domain. This schematic shows the extreme thickening of the proposed Go Home-Lower Rosseau-Kiosk thrust sheet to the east, as well as southwest-northeast folding.* ***(c)*** *Alternative schematic southwest-northeast cross section. This schematic shows theKiosk domain as separate from a Go Home-Lower Rosseau thrust sheet. This thrust sheet is shown to pinch out against the Novar subdomain. For both sections vertical exaggeration is an approximate two times the horizontal. Letters have the same meaning as in figure 1.1.*

As discussed in chapter 1 the depth of the Kiosk domain is significant because the Kiosk –Bonfield contact is a possible location for the ABT. The ABT is thought to run along the SSZ that, from the models and the seismic interpretation completed by White et al. 1994 is thought to be a relatively shallow, gently inclined, feature that is underlain by the Britt domain. If the ABT is located along the north of the Kiosk domain, then the models suggest that in this area it steepens from gently inclined at the surface to moderately inclined before it flattens out below the Kiosk domain. As well it suggests that the extent of the ABT deepens about 10-15 km between the SSZ and the Bonfield-Kiosk contact. This would indicate a steep slope, and may suggest that this is not the location of the ABT. The alternative location of the ABT is along the northern edge of the Bonfield batholith (Ketchum and Davidson 2000). If this were the location of the ABT then the thrust zone would still deepen to 10-15 km, but the gradient would be less steep, and closer to that modeled for the SSZ.

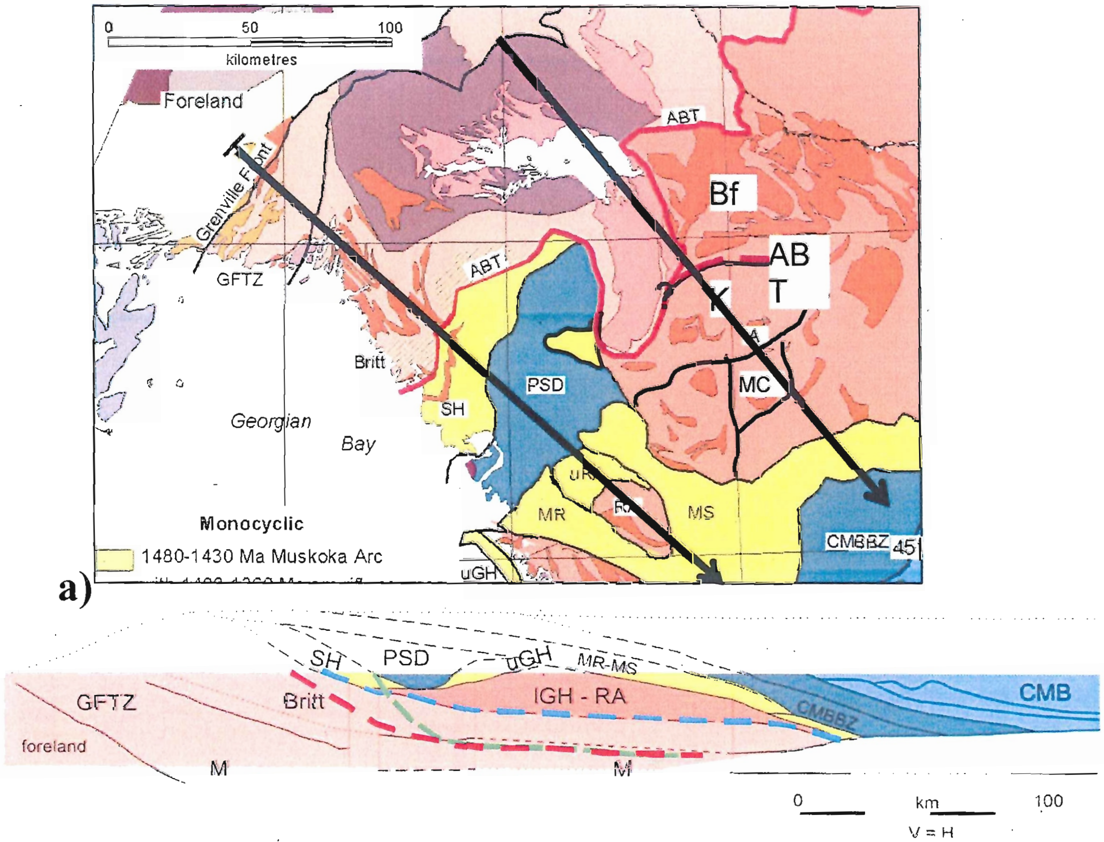

Figure 4.2: ***(a)*** *Cross section location map.* ***(b)*** *Possible locations for the ABT. The cross section runs northwest-southeast across the Grenville province (bottom line). The dashed blue line shows the location of the SSZ, which also corresponds to the ABT. The green and red dashed lines correspond to two proposed locations of the ABT further east (upper line), these have been superimposed on the lower cross section line for comparison. The green line corresponds to the ABT if it were located along the northern edge of the Kiosk domain, this creates a much steeper slope that that of the SSZ. The red line corresponds to the ABT if it were located along the northern edge of the Bonfield batholith, this creates a gentler slope, closer to that of the SSZ/ ABT to the west.*

4.2 Comparisons

The models presented in chapter 3 are more detailed than those completed by Lindia et al. 1983, but for the most part the units retain the same general shape (Fig. 1.3). Important differences to note are that in these models the Shawanaga domain could be modeled to extend beneath the Parry Sound domain and still respect the observed gravity. As well the Shawanaga was modeled to extend as a thinning wedge beneath the Parry

Sound domain that either is continuous with related domains (profiles 3 and 5) or, thins out at the base of the Parry Sound domain before appearing as a similar domain on the other side of the Parry Sound domain (profiles 1, 2 and 4). These changes were made to better represent the ideas of Culshaw et al. 1997 that the Shawanaga, Ahmic, Upper Rosseau, and Go Home domains are lithologically similar, and likely are, or once were connected at depth.

The average densities assigned to the domains were different than those assigned by Lindia et al. 1983 due to the use of weighted means when calculating the averages, and the reassigning of densities within new domains that were not known to Lindia et al. 1983. These differences resulted in changes in the volume of the units that were required to recreate the observed gravity. In particular the density value used for the Britt domain was 0.05 g cm^{-3} less than that used by Lindia et al. 1983. Because the Britt domain was used as the background rock density to which all others were compared, the density contrasts for these models are for the most part greater than those used by Lindia et al 1983. This means that the Parry Sound domain was often interpreted as not extending to the same depth as in the Lindia et al.'s 1983 models, or that a portion of the area below the Parry Sound domain was interpreted to be an extension of the Shawanaga domain or similar domains (profiles 2, 3 and 5).

The orientation of seismic lines 30 and 31 are similar to the orientation of profiles 2 and 4 (Fig. 1.5). Both models for profile 2 and 4 matched the seismic interpretation (Fig. 1.6) fairly well with only minor differences discussed in sections 3.2.2 and 3.2.3.

Profile 2 matched well with the interpretation of the seismic line 30 and profile 4 had a fair match with the interpretation of seismic line 31. The model for profile 4 supports the lower pick for the central Britt shear zone (Fig. 1.6). The good match of the models with the seismic interpretation suggests that the assigned densities are representative of the domains that they were assigned to, and gives confidence to the accuracy of the models without comparable seismic lines.

4.3 Constraints

It is important to note that there are an infinite number of models that could satisfy each one of these gravity curves. However, each constraint applied to the models such as the observed surficial geology, calculated densities, information from seismic profiles, and the geological understanding of the area eliminates numerous, but not all of these possibilities. The models presented within this paper represent what has been determined to be the model that best represents the most likely subsurface geology.

Some of the possible sources of error that need to be taken into consideration are the accuracy of the density values. It is possible that because the samples are from the surface, some weathering of the rocks may have occurred affecting their densities. This problem was minimized by using samples with fresh surfaces when possible. The error within these models associated with surficial weathering is likely small as it would affect all the samples and thus would not have much of an effect on their relative densities which is what is used in the models.

One of the major challenges to the study was the designation of average density values to each domain. The distribution of the samples collected was not uniform; their locations were limited by where there was road access, or where outcrops are present along lakes and rivers. Also, because samples were collected for this project as well as for other work, it is known that the ratio of mafic to felsic samples collected is not representative of the area. To correct for these sources of error it was necessary to weight the proportion of samples of different lithologies as described in section 3.1. As can be expected there is some error associated with these weighting methods, and as a result the actual density values for the different domains could deviate slightly from those used. However as long as they were not large they would only result in minor modifications of the models. For example if the assigned density value of a particular domain was too small, that domain is likely modeled slightly larger than it is in reality. The overall shape of the models would not significantly change. These errors could be improved by more intensive field mapping, and sample collection.

As addressed in section 2.4 the decision to use two and a half dimensional modeling software was determined to be justified. However it is important to consider the effects that the use of 2.5D software instead of 3-D might have had on the models. Bodies such as the Parry Sound and Kiosk domains have an ideal shape for 2.5 D modeling; however the Ahmic, Seguin, Rosseau and Moon River domains which do not extend very far perpendicular to the profile may have more error associated with them. This error can be limited in some cases by setting a limit to the extent of the bodies perpendicular to the profile, however because any empty space in the model is considered to be the Britt domain (which has a low density) this is only helpful if the density change in the direction perpendicular to the model is from high to low (which does not occur within any of the profiles). The Seguin, Lower Rosseau and Moon River domains all have similar densities, and thus in profiles 3, 4 and 5 it is more accurate to leave these bodies as extending to infinity. In profile 2, perpendicular to the profile the Ahmic domain (low density) runs into the Parry Sound domain (high density), and as a result the Ahmic domain may be modeled smaller than it is in reality. In this particular case a 3 D model is more appropriate. The use of a 2.5 D rather than a 3 D program is adequate in most circumstances, especially with large scale of the structures within these models.

4.3 Conclusion

The Bonfield terrain, Kiosk domain and McCraney subdomain were modeled for the first time; the Kiosk domain was modeled to be a rhomboid shaped block that has a depth of approximately 19 to 25 km and overlays the Britt domain. The northwest and southeast boundaries are modeled to dip at about 30 degrees to the south. To the northwest the Kiosk domain overlays the Bonfield terrain (which is a portion of the Britt domain) and to the southeast it is overlain by the McCraney subdomain which is modeled to the same depth as the Kiosk domain. The depth of the Kiosk domain indicates that a Kiosk-Lower Rosseau-Go Home thrust sheet would thicken significantly to the east, and is thus unlikely and that alternatively a lower Rosseau-Go Home thrust sheet may pinch out against the Novar subdomain at depth. It is also indicated that the underlying Britt domain thins to the east. If the Bonfield-Kiosk domain boundary is the location of the ABT then it has been modeled to be steeper along this portion of the thrust zone than along the SSZ portion of the thrust zone. The alternative location to the north of the Bonfield batholith, which would suggest a gentler slope that is more similar to the SSZ is thus more likely. The profiles modeled by Lindia et al. 1983 were revised, incorporating new information and data relevant to the models. The general structure of the Parry Sound domain, which was the main body modeled by Lindia et al.1983, did not differ much between the different generations of models. However, it was shown that the new density values and geometries that better represent the current understanding of the region also satisfy the observed gravity.

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APPENDIX A

Sample	Density	Felsic(1) or mafic(2)
NA011B	2.61	1
NA017	2.64	1
NA020A	2.64	1
NA006A	2.65	1
NA014A	2.66	1
NA011A	2.66	1
NA016	2.68	1
NA017B	2.70	1
NA011C	2.72	1
NA014B	2.75	1
NA005A	2.76	1
NA008A	2.77	1
NA008b	2.78	1
85DM C125-10	2.56	1
80DM M191B	2.58	1
85DM C129-7	2.58	1
85DM C123-7D	2.58	1
85DM C126-4	2.59	1
85DM C123-6	2.59	1
85DM P232A	2.60	1
80DM M187A	2.61	1
80DM M186A	2.62	1
85DM P230-1A	2.62	1
85DM C129-5B	2.62	1
80DM M190A	2.63	1
85DM P225-2A	2.63	1
85DM P225A	2.63	1
85DM W12-1C	2.64	1
80DM M188A	2.64	1
85DM C137-1	2.65	1
80DM M188B	2.66	1
80DM M185A	2.68	1
85DM W12-1A	2.68	1
85DM W13-1	2.68	1
80DM M189A	2.69	1
85DM W12-1B	2.69	1
85DM P219A	2.69	1
85DM P225-4A	2.69	1
80DM M191A	2.70	1
85DM P229-1A	2.71	1
85DM C124-2	2.71	1
85DM P219-2A	2.71	1
85DM C129-2	2.74	1
85DM C123-7A	2.75	1
85DM C154-1	2.75	1
85DM P231B	2.76	1
NA014C	2.83	1
80DM M192A	2.80	1
85DM C123-2	2.82	1
85DM C123-7C	2.84	1
85DM C123-9	2.84	1
NA005B	2.91	2
NA009	2.94	2
NA020B	3.08	2
80DM M193A	2.89	2
85DM P228A	2.89	2
85DM P233A	2.91	2
85DM P231-1A	2.93	2
85DM C125-3	2.93	2
85DM C123-7B	2.93	2
85DM C126	2.94	2
85DM C126-5	2.97	2
85DM C125-9	3.01	2
85DM W13	3.04	2
85DM C137-2	3.18	2
85DM W12	3.19	2

average felsic density: 2.67 average mafic density: 2.95

Observed proportion of felsic and mafic:
Felsic: 0.95 Mafic 0.05

Average Bonfield density: 2.69

Table A-1: *Bonfield terrain density values and average density calculation.*

sample	density	felsic(1) or mafic(2)
NA026A	2.58	1
NA029A	2.59	1
NA060	2.60	1
NA023B	2.61	1
NA024B	2.62	1
NA024A	2.64	1
NA030	2.65	1
NA031B	2.65	1
NA032B	2.68	1
NA059	2.68	1
NA061F	2.69	1
NA034	2.70	1
NA061g	2.71	1
NA031A	2.72	1
NA044	2.75	1
NA032A	2.75	1
NA035	2.78	1
80DM M229A	2.12	1
82DM G195-1	2.41	1
85DM P276-1A	2.54	1
85DM W21	2.54	1
80DM M222A	2.54	1
85DM C152	2.55	1
82DM P204A	2.56	1
85DM C135	2.56	1
85DM C128-9	2.56	1
85DM P214A	2.57	1
82DM P208B	2.57	1
85DM C153-4	2.57	1
80DM M224B	2.57	1
81DM A280A	2.57	1
80DM M210A	2.58	1
80DM M205A	2.58	1
85DM C153	2.58	1
80DM M221A	2.58	1
81DM N263-3A	2.58	1
80DM M224A	2.58	1
85DM C147	2.58	1
85DM W16-1	2.58	1
85DM P212-6A	2.58	1
85DM W21-2A	2.59	1
85DM W18	2.59	1
82DM G196	2.59	1
81DM A281A	2.59	1
82DM G208-1	2.59	1
82DM G206B	2.59	1
85DM C127	2.59	1
85DM C146-7	2.59	1
80DM M209A	2.59	1
85DM C098B	2.59	1
85DM P214E	2.59	1
85DM C153-2	2.60	1
85DM C098A	2.60	1
85DM C128	2.60	1
82DM P208A	2.60	1
85DM P275A	2.60	1
85DM W15A	2.61	1
80DM M204A	2.61	1
80DM M207A	2.61	1
85DM G7A	2.61	1
85DM C128-4	2.61	1
85DM P251-1A	2.61	1
85DM C132-2	2.61	1
85DM P189A	2.61	1
85DM P212A	2.61	1
85DM P276-4A	2.61	1
82DM P197C	2.62	1
81DM N263-5A	2.62	1
80DM M208B	2.62	1
85DM P214D	2.62	1
80DM M208A	2.62	1
85DM C098-5	2.62	1
85DM C098-8	2.62	1
82DM G197	2.62	1
85DM C131-5	2.63	1
82DM P208C	2.63	1
85DM C128-7	2.63	1
82DM G203	2.63	1
82DM P206A	2.63	1
85DM G1	2.63	1
85DM P276-8A	2.63	1
85DM C132-1	2.63	1
80DM M226A	2.64	1
81DM A289A	2.64	1
85DM P216A	2.64	1
80DM M222B	2.64	1

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***Table A-2**: Kiosk domain density values and average density calculation (continued on next 2 pages)..*

Continued from previous page

85DM P212-5A	2.64	1
81DM A289-1A	2.64	1
85DM W19	2.64	1
85DM P191A	2.65	1
85DM C098-4	2.65	1
85DM W21-2B	2.65	1
81DM A289B	2.65	1
82DM P205A	2.65	1
82DM G206A	2.65	1
85DM P212-3A	2.65	1
85DM P276-1B	2.65	1
85DM P261-1A	2.66	1
85DM C146-4	2.66	1
85DM C111-2	2.66	1
82DM G195A	2.66	1
85DM P214C	2.66	1
85DM C128-11	2.66	1
85DM P217C	2.66	1
85DM C153-3B	2.67	1
82DM P206B	2.67	1
85DM P213A	2.67	1
81DM A291A	2.67	1
85DM P176A	2.68	1
85DM P278A	2.68	1
82DM G205-1	2.68	1
85DM C133-4	2.68	1
85DM P217B	2.68	1
85DM P277A	2.69	1
85DM P276-2B	2.69	1
85DM P214B	2.69	1
85DM C128-3	2.69	1
82DM G196-1	2.70	1
82DM G204	2.70	1
82DM P207A	2.70	1
85DM C111	2.70	1
85DM P217A	2.70	1
85DM C098-2	2.71	1
85DM W17-7	2.71	1
85DM C149C	2.72	1
85DM P188A	2.72	1
82DM P197A	2.72	1
85DM W21-2C	2.72	1
82DM G205	2.72	1
85DM C132-4	2.72	1
85DM C153-3A	2.73	1
85DM W17-4	2.74	1
85DM C132-12	2.74	1
81DM A279A	2.74	1
85DM P177-1A	2.75	1
85DM W17-3	2.75	1
81DM N263-4A	2.75	1
82DM G208-3	2.75	1
85DM C133-1	2.75	1
85DM W21-1	2.76	1
85DM P261A	2.76	1
82DM P204B	2.76	1
82DM G207	2.77	1
82DM G195B	2.77	1
85DM C111-1	2.78	1
85DM C146-8	2.78	1
85DM P278-1A	2.78	1
82DM G208-4	2.78	1
85DM C146-3	2.79	1
85DM P175A	2.79	1
85DM P215B	2.81	1
85DM P177-4A	2.81	1
85DM P279A	2.81	1
82DM P204C	2.81	1
85DM P276-3A	2.81	1
85DM G3	2.81	1
85DM P278-1B	2.81	1
85DM W17-1	2.82	1
85DM P276-5A	2.83	1
85DM P276A	2.83	1
85DM P215C	2.83	1
80DM M226B	2.84	1
85DM P251A	2.84	1
81DM A290A	2.84	1
85DM C098-6	2.84	1
NA027B	3.04	2
032C	2.90	2
NA056	2.92	2
NA060B	2.96	2
NA061B	2.97	2
NA061H	2.98	2
NA061E	2.98	2
NA027A	2.99	2
NA024C	3.01	2
NA061D	3.05	2
NA023A	3.10	2
NA061A	3.15	2
NA022	3.15	2

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Table A-2 *Continued*

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NA023C	3.16	2
82DM G209	2.85	2
85DM P215A	2.85	2
85DM P278-1C	2.87	2
85DM P190A	2.88	2
82DM P197B	2.89	2
85DM G4	2.89	2
85DM P263A	2.93	2
85DM C149-2	2.95	2
85DM W20-2	2.96	2
85DM P262A	2.99	2
80DM M228A	2.99	2
85DM C128-1	3.00	2
81DM A290B	3.00	2
80DM M207B	3.00	2
85DM P267-3A	3.01	2
80DM M223A	3.02	2
85DM P192A	3.03	2
85DM P214-2A	3.05	2
82DM P208D	3.06	2
85DM C149-4	3.06	2
82DM P210A	3.06	2
85DM W20-1	3.07	2
85DM P276-7A	3.11	2
85DM P177-2A	3.12	2
85DM W20	3.13	2
85DM P263B	3.14	2
85DM P276-2A	3.14	2
85DM W14B	3.15	2
85DM C113B	3.16	2
85DM W17B	3.22	2
85DM W17A	3.24	2
85DM W14A	3.25	2
85DM P192-1A	3.25	2

average felsic density: 2.64

average mafic density: 3.04

Observed proportion of felsic and mafic:
Felsic:0.92 Mafic: 0.08

average density: 2.74

Table A-2: *Kiosk density values and average density calculation.*

sample	density	felsic(1) or mafic(2)
NA054A	2.58	1
NA050	2.67	1
NA049	2.74	1
NA051	2.80	1
82DM G199	2.57	1
82DM G284	2.57	1
82DM G286A	2.57	1
82DM G286B	2.58	1
82DM G283A	2.59	1
85DM P241-2A	2.60	1
82DM G198	2.62	1
85DM P306-1B	2.63	1
85DM P253B	2.64	1
85DM P255B	2.64	1
85DM P304-2	2.65	1
85DM P305B	2.65	1
82DM G198-1	2.66	1
85DM P305-3A	2.67	1
85DM P305A	2.67	1
85DM P253A	2.67	1
85DM P241A	2.68	1
81DM C309B	2.68	1
85DM P255C	2.68	1
85DM P304A	2.71	1
85DM P306-1A	2.71	1
82DM G200	2.71	1
82DM G201	2.73	1
85DM P240A	2.73	1
85DM P309A	2.76	1
85DM P306-3A	2.80	1
NA055	2.85	2
NA0054B	2.98	2
NA046	3.02	2
85DM P305-1A	2.85	2
85DM P308	2.86	2
85DM P307A	2.99	2
85DM P241-1A	3.00	2

average felsic density 2.67

average mafic density 2.95

Observed proportion of felsic and mafic
felsic: 0.79   mafic: 0.21

Average McCaney density: 2.73

Table A-3*: McCraney subdomain density values and average density calculation.*

thickness	lithology
249	1
4.5	1
145	1
73	1
2.4	1
0.4	1
5	1
1.6	1
2	1
20	1
0.3	1
0.2	1
0.3	1
0.2	1
0.2	1
215	1
3.2	1
0.1	1
0.1	1
0.2	1
0.1	1
0.2	1
0.4	1
0.8	1
0.7	1
1.3	1
1.1	1
0.9	1
1.5	1
3.7	1
0.9	1
0.3	1
0.3	1
0.4	1
0.3	1
0.3	1
1	1
0.5	1
0.4	1
0.5	1
0.3	1
0.4	1
0.3	1
0.3	1
0.5	1
0.4	1
2.6	1
0.5	1
0.9	1
0.4	1
0.3	1
0.4	1
5.1	1
0.3	1
4.9	1
1.5	1
2	1
1.5	1
2.1	1
1.9	1
1.1	1
105	1
30	1
90	1
15	1
1	1
1.2	1
1	1
95	1
1.2	1
0.5	1
0.8	1
0.7	1
0.8	1
1.5	1
0.9	1
1.2	1
0.6	1
0.7	1
1.8	1
0.3	1
1.3	1
0.8	1
0.5	1
10.2	1
1.3	1
0.3	1
1	1
0.8	1
0.5	1
1	1
0.7	1
199	1
120	1
30	1
0.8	1
0.4	1
1.2	1
19	1
15.5	1
0.6	1
0.3	1
0.7	1
1.5	1
0.4	1
20	1
12.8	1
5	1
2.5	1
3.5	1
5.1	1
2.1	1
3	1
0.8	1
2.2	1
2.5	1
2.2	1
1.8	1
3.1	1
4	1
16.5	1
59	1
3	1
2.2	1
2.5	1
0.8	1
0.5	1
4.2	1
5.4	1
4.5	1
2.7	1

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***Table A-4**: Britt domain density values and average density calculations (at end of data) (from Long). The thicknesses of granitic gneiss (1), mafic dikes (2) and granodiorite gneiss (3) layers used in the density calculations are shown in table.*

Continued from previous page

5.5	1
4.9	1
6.6	1
9.2	1
5.8	1
3.9	1
4.2	1
3.8	1
7.2	1
4.4	1
3.5	1
1.9	1
5.6	1
4.7	1
3.6	1
4.1	1
750	1
375	1
205	1
20	1
5.5	1
6.4	1
8.5	1
255	1
600	1
300	1
50	1
200	1
250	1
205	1
1500	1
1	2
0.1	2
3.5	2
0.2	2
0.3	2
1.4	2
20	2
0.4	2
6.7	2
0.3	2
0.3	2
0.2	2
2.5	2
0.4	2
1.2	2
0.4	2
1.2	2
0.8	2
0.7	2
1.7	2
0.1	2
1	2
2.3	2
0.3	2
3.5	2
0.3	2
3.2	2
0.2	2
0.3	2
0.3	2
0.1	2
3.5	2
0.9	2
0.1	2
0.1	2
0.2	2
0.1	2
0.1	2
0.2	2
0.1	2
0.2	2
0.1	2
0.2	2
0.1	2
0.2	2
0.1	2
0.2	2
0.2	2
0.1	2
0.2	2
0.1	2
0.2	2
0.1	2
0.2	2
0.2	2
0.2	2
0.3	2
0.2	2
0.3	2
0.2	2
0.2	2
0.3	2
0.2	2
0.2	2
0.5	2
0.8	2
0.8	2
2.1	2
0.6	2
0.3	2
2.9	2
0.8	2
1.2	2
0.1	2
0.4	2
0.5	2
0.9	2
0.3	2
0.5	2
1.3	2
0.1	2
0.3	2
0.5	2
0.4	2
1	2
0.6	2
0.3	2
0.5	2
0.8	2
0.5	2
0.7	2
0.6	2
0.2	2
0.3	2
0.2	2
3	2
3.1	2
2.5	2
1.5	2
0.5	2
2.1	2
0.8	2
1.1	2
0.8	2
0.9	2
2.1	2
0.8	2
1.9	2
0.5	2
0.4	2
4.5	2

Table A-4 Continued

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1.7	2	2.5	2	0.2	3
2.2	2	1.1	2	0.5	3
0.2	2	2.3	2	0.2	3
0.1	2	0.8	2	0.5	3
0.2	2	2.6	2	0.3	3
1.2	2	1.4	2	0.5	3
2.5	2	2.8	2	7.2	3
0.1	2	1.5	2	0.9	3
0.2	2	2.3	2	0.8	3
0.1	2	3.1	2	8.9	3
0.2	2	1.1	2	15	3
0.2	2	0.8	2	2.5	3
3.6	2	1.2	2	2.1	3
0.5	2	0.1	2	1	3
0.3	2	0.1	2	0.3	3
0.3	2	0.1	2	0.3	3
0.2	2	0.1	2	0.1	3
0.3	2	0.1	2	0.2	3
0.2	2	20	2	0.1	3
3.6	2	1	2	115	3
2.5	2	20	2	120	3
1.5	2	3.5	2	870	3
2.5	2	1.5	2	180	3
1.8	2	1	2	150	3
5.4	2	1	2	305	3
3.8	2	950	3	380	3
3.1	2	625	3	950	3
2.5	2	1	3		
1.6	2	0.5	3		

Total thicknesses	granitic gneiss	mafic dike	granodiorite gneiss	total
	6504.2 m	226.8 m	4688.1 m	11419.1 m
Proportions	57%	1.99%	41.10%	
Average densities	2.651 g/cm³	3.148 g/cm³	2.707 g/cm³	

Average density of Britt domain: 2.68

***Table A-4**: Britt domain density values and average density calculations (from Long 1994). The thicknesses of granitic gneiss (1), mafic dikes (2) and granodiorite gneiss (3) layers in the Britt domain were used to calculate the proportion of each lithology. These proportions were then used in conjunction with the average density values for these lithologies to calculate an average density for the entire Britt domain (thicknesses and density values from Long, 1994).*

density	felsic(1) or mafic(2)
2.59	1
2.59	1
2.6	1
2.6	1
2.61	1
2.61	1
2.62	1
2.62	1
2.63	1
2.63	1
2.64	1
2.64	1
2.64	1
2.65	1
2.65	1
2.65	1
2.66	1
2.66	1
2.66	1
2.66	1
2.67	1
2.67	1
2.68	1
2.68	1
2.69	1
2.71	1
2.71	1
2.71	1
2.72	1
2.72	1
2.75	1
2.77	1
2.82	1
2.84	1
2.89	2
3.06	2

average felsic density:2.67 average mafic density” 2.98

Proportion of felsic and mafic
felsic 0.95 mafic:0.05

Average Britt density: 2.68

***Table A-5**: Britt domain densities and average density calculation (from Dr. M. Thomas's data).*

density	felsic(1) or mafic(2)
2.59	1
2.61	1
2.61	1
2.62	1
2.62	1
2.63	1
2.63	1
2.64	1
2.64	1
2.64	1
2.64	1
2.64	1
2.64	1
2.65	1
2.65	1
2.65	1
2.65	1
2.65	1
2.66	1
2.66	1
2.67	1
2.67	1
2.67	1
2.67	1
2.69	1
2.69	1
2.69	1
2.7	1
2.7	1
2.72	1
2.72	1
2.76	1
2.78	1
2.79	1
2.79	1
2.79	1
2.79	1
2.81	1
2.82	1
2.85	2
2.89	2
2.92	2
2.97	2
3.02	2
3.04	2
3.05	2
3.08	2

average felsic density:2.68

average mafic density:2.98

Proportion of felsic and mafic

felsic: 0.90 mafic: 0.10

Average Upper Rosseau density: 2.71

Table A-6: *Upper Rosseau densities and average density calculation.*

density	felsic(1) or mafic(2)
2.58	1
2.6	1
2.61	1
2.63	1
2.63	1
2.64	1
2.65	1
2.65	1
2.66	1
2.66	1
2.67	1
2.67	1
2.67	1
2.67	1
2.68	1
2.68	1
2.68	1
2.69	1
2.7	1
2.7	1
2.71	1
2.72	1
2.72	1
2.72	1
2.73	1
2.74	1
2.75	1
2.75	1
2.81	1
2.83	1
2.88	2
2.89	2
2.93	2
3.02	2
3.02	2
3.04	2
3.05	2
3.09	2
3.09	2
3.13	2

average felsic density	average mafic density
2.69	3.01

Proportion of felsic and mafic

felsic	mafic
0.9	0.1

Average Lower Rosseau density: 2.72

Table A-7*: Lower Rosseau densities and average density calculation (from Dr. M. Thomas's data).*

density	felsic(1) or mafic(2)
2.59	1
2.59	1
2.59	1
2.6	1
2.6	1
2.6	1
2.61	1
2.61	1
2.61	1
2.61	1
2.62	1
2.62	1
2.62	1
2.62	1
2.63	1
2.63	1
2.63	1
2.63	1
2.63	1
2.63	1
2.63	1
2.64	1
2.64	1
2.64	1
2.64	1
2.64	1
2.64	1
2.64	1
2.64	1
2.64	1
2.64	1
2.64	1
2.64	1
2.65	1
2.65	1
2.65	1
2.65	1
2.65	1
2.65	1
2.66	1
2.66	1
2.66	1
2.66	1
2.66	1
2.67	1
2.67	1
2.67	1
2.67	1
2.68	1
2.68	1
2.68	1
2.68	1
2.68	1
2.68	1
2.68	1
2.68	1
2.69	1
2.69	1
2.69	1
2.69	1
2.69	1
2.69	1
2.69	1
2.7	1
2.7	1
2.7	1
2.7	1
2.71	1
2.71	1
2.72	1
2.72	1
2.72	1
2.72	1
2.72	1
2.72	1
2.73	1
2.73	1
2.73	1
2.74	1
2.74	1
2.74	1
2.74	1
2.75	1
2.75	1
2.75	1
2.75	1
2.76	1
2.76	1
2.76	1
2.77	1
2.77	1
2.77	1
2.77	1
2.77	1
2.77	1
2.78	1
2.78	1
2.79	1
2.79	1
2.79	1
2.79	1
2.8	1
2.8	1
2.8	1
2.81	1
2.81	1
2.83	1
2.84	1
2.84	1
2.84	1
2.85	2
2.9	2
2.9	2
2.92	2
2.94	2
2.94	2
2.94	2
2.96	2
2.98	2
3.01	2
3.16	2

average felsic density	average mafic density
2.69	2.95

Proportion of felsic and mafic
felsic: 0.9 mafic: 0.1

Average Shawanaga domain density
2.72

***Table A-8**: Shawanaga domain densities and average density calculation (from Dr. M. Thomas's data).*

APPENDIX B

One of the variables that was experimented with when modeling the Bonfield terrain, Kiosk domain and McCraney subdomain was depth. The depth of the Kiosk domain has important implications for the geology of the area, as discussed briefly in section 1.0 and more in depth in section 4.1. To try and constrain the depth of these bodies different depths were used while keeping the general geometries and densities of the bodies the same. Four of these are shown below (15, 20, 25 and 30 km) (Fig. B-1 through 4). A depth of 15 km (Fig. B-1) was not sufficient to produce the observed gravity. A depth of 20 km (Fig. B-2) created a calculated gravity that best matched the observed gravity. However, the calculated gravity was slightly less than the maximum observed gravity. To achieve the observed gravity, the depth was modeled at 25 km (Fig. B-3). The observed and calculated gravity above the Bonfield terrain–Kiosk domain contact matched very well, however the McCraney subdomain had a greater calculated gravity than observed gravity. The problems within the McCraney subdomain portion of the model could be due to lithological variations. The fourth depth that was tried was 30 km. The calculated gravity for this model was greater than the observed gravity. This depth is therefore too deep to satisfy the observed gravity. From these models the Kiosk domain and McCraney subdomain can be estimated to extend to a depth on the order of 20 to 25 km.

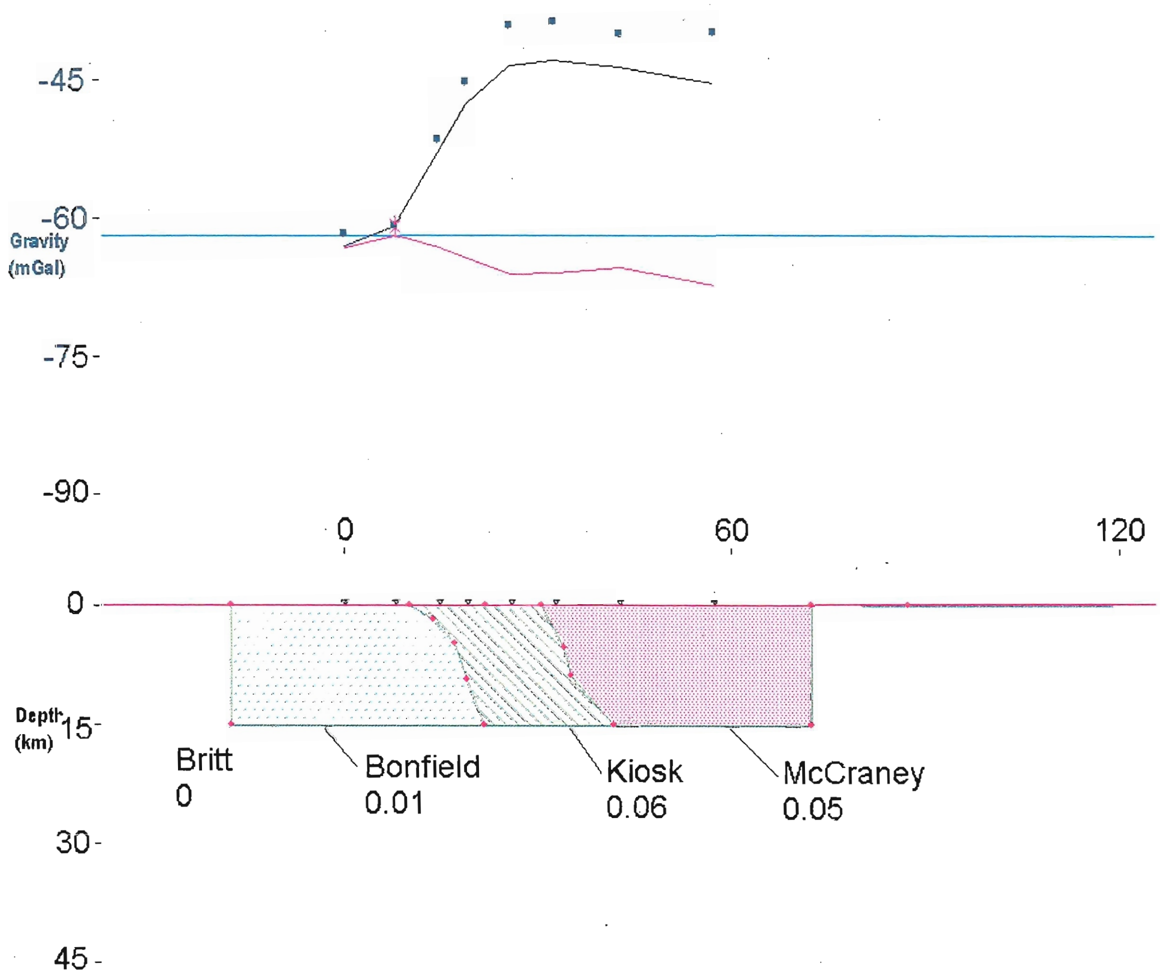

Figure B-1 *Profile 6 modeled with a depth of 15 km. Profile 6 (see Figure 3.1 for location map) cuts through the Bonfield terrain, Kiosk domain and McCraney subdomain. Density contrasts between the bodies are shown on the profile. Depth and horizontal distance are in km. The upper portion of the profile shows the gravity anomaly; the dots correspond to observed gravity, the solid black line corresponds to calculated gravity, and the red line shows the difference between the observed and calculated gravity.*

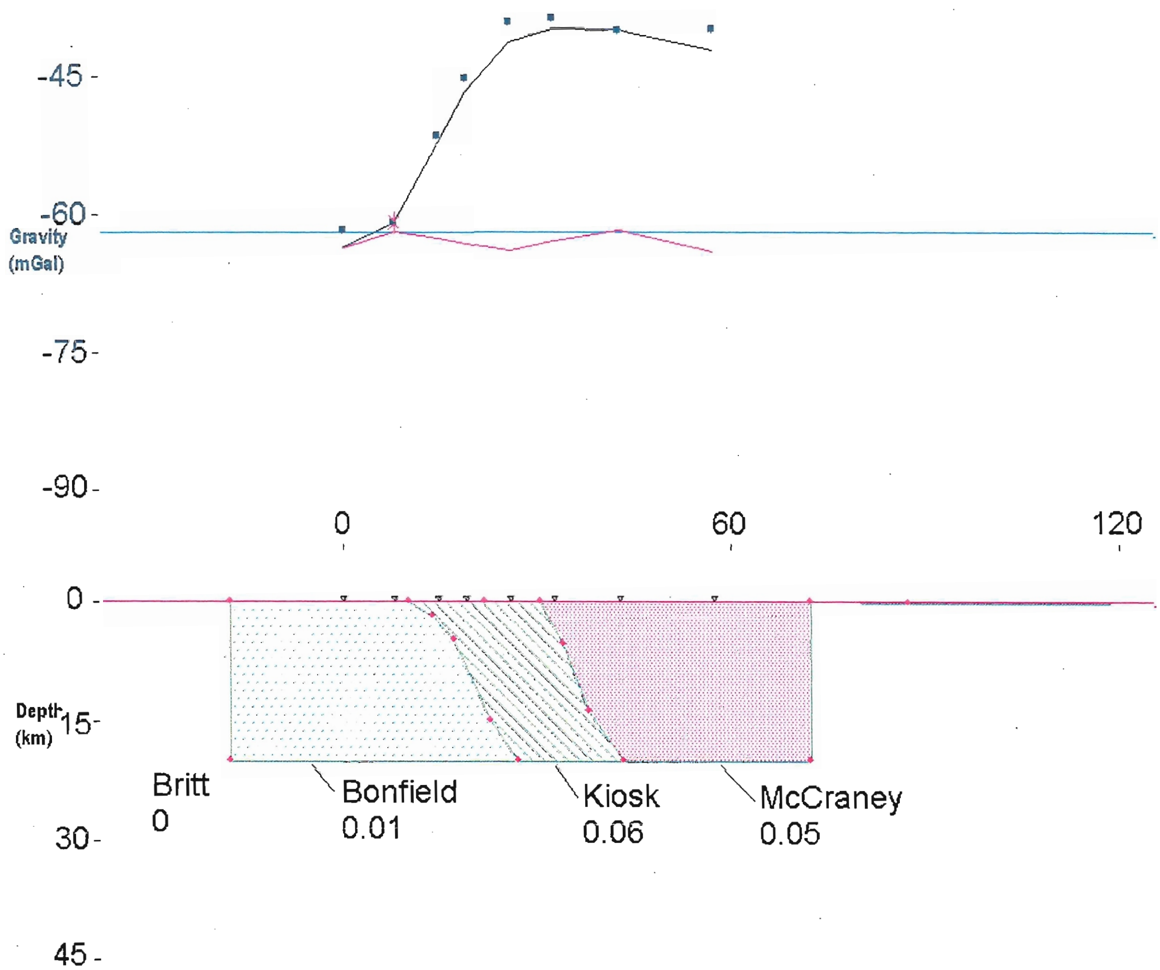

Figure B-2 *Profile 6 modeled with a depth of 20 km. Profile 6 (see Figure 3.1 for location map) cuts through the Bonfield terrain, Kiosk domain and McCraney subdomain. Density contrasts between the bodies are shown on the profile. Depth and horizontal distance are in km. The upper portion of the profile shows the gravity anomaly; the dots correspond to observed gravity, the solid black line corresponds to calculated gravity, and the red line shows the difference between the observed and calculated gravity.*

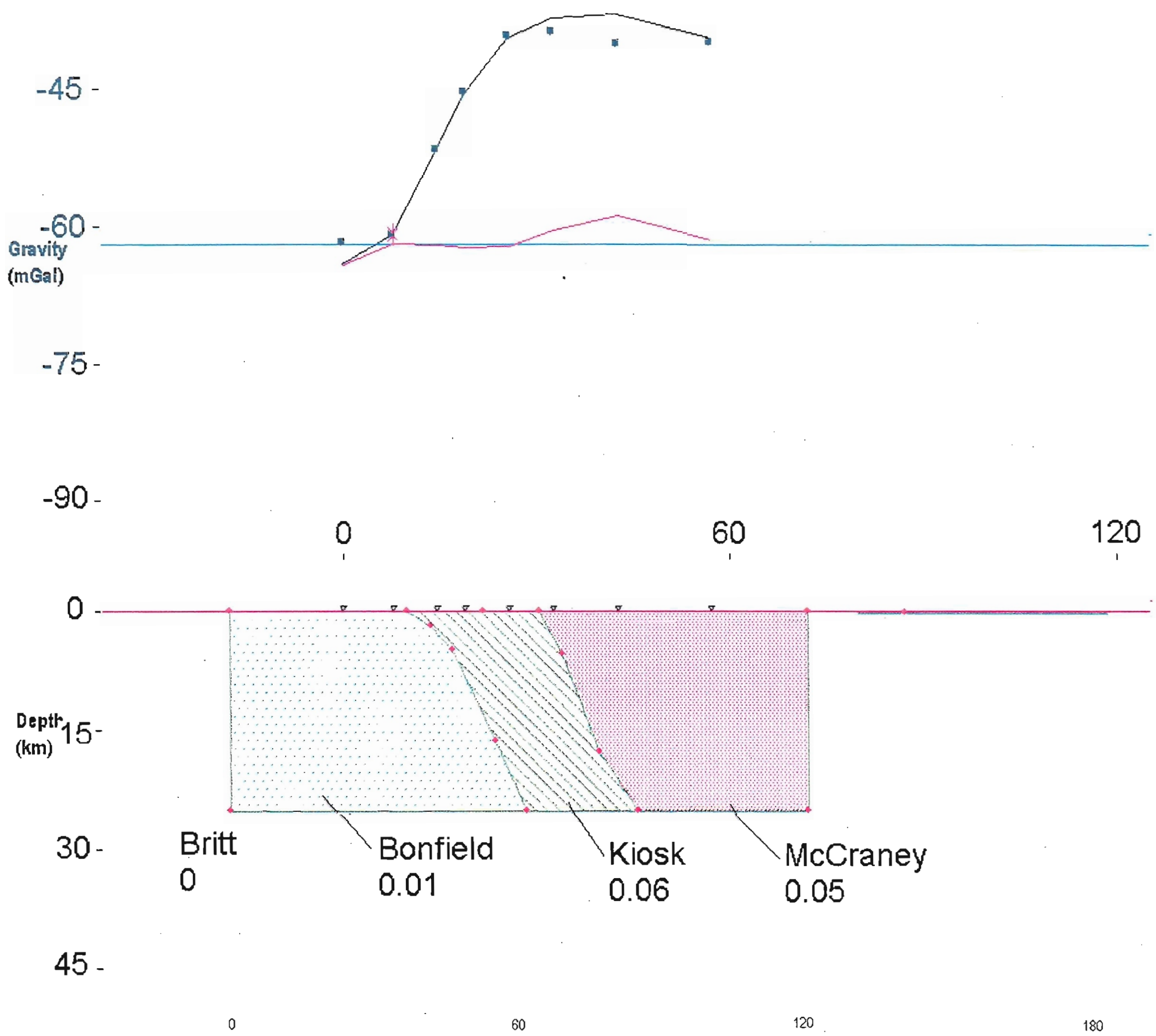

Figure B-3 *Profile 6 modeled with a depth of 25 km. Profile 6 (see Figure 3.1 for location map) cuts through the Bonfield terrain, Kiosk domain and McCraney subdomain. Density contrasts between the bodies are shown on the profile. Depth and horizontal distance are in km. The upper portion of the profile shows the gravity anomaly; the dots correspond to observed gravity, the solid black line corresponds to calculated gravity, and the red line shows the difference between the observed and calculated gravity.*

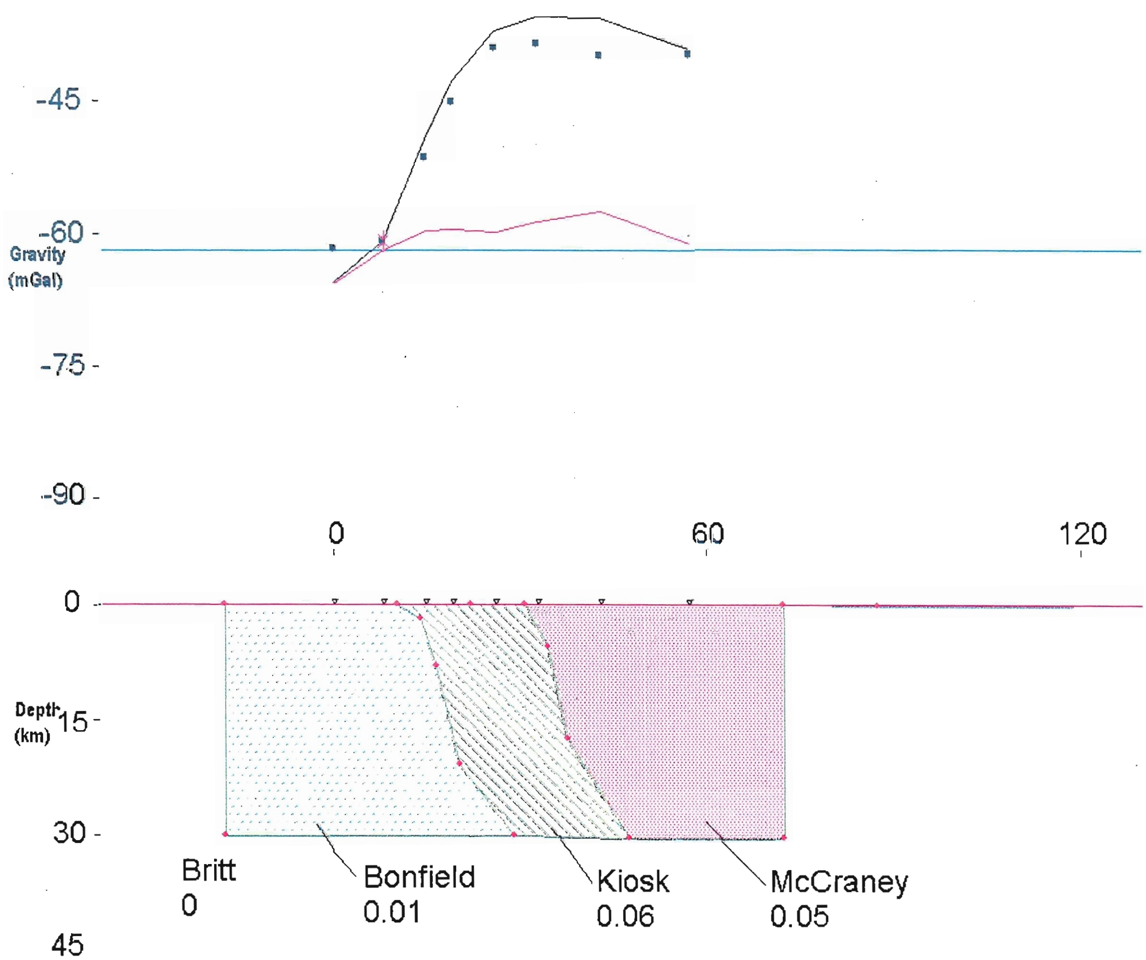

Figure B-4 *Profile 6 modeled with a depth of 30 km. Profile 6 (see Figure 3.1 for location map) cuts through the Bonfield terrain, Kiosk domain and McCraney subdomain. Density contrasts between the bodies are shown on the profile. Depth and horizontal distance are in km. The upper portion of the profile shows the gravity anomaly; the dots correspond to observed gravity, the solid black line corresponds to calculated gravity, and the red line shows the difference between the observed and calculated gravity.*