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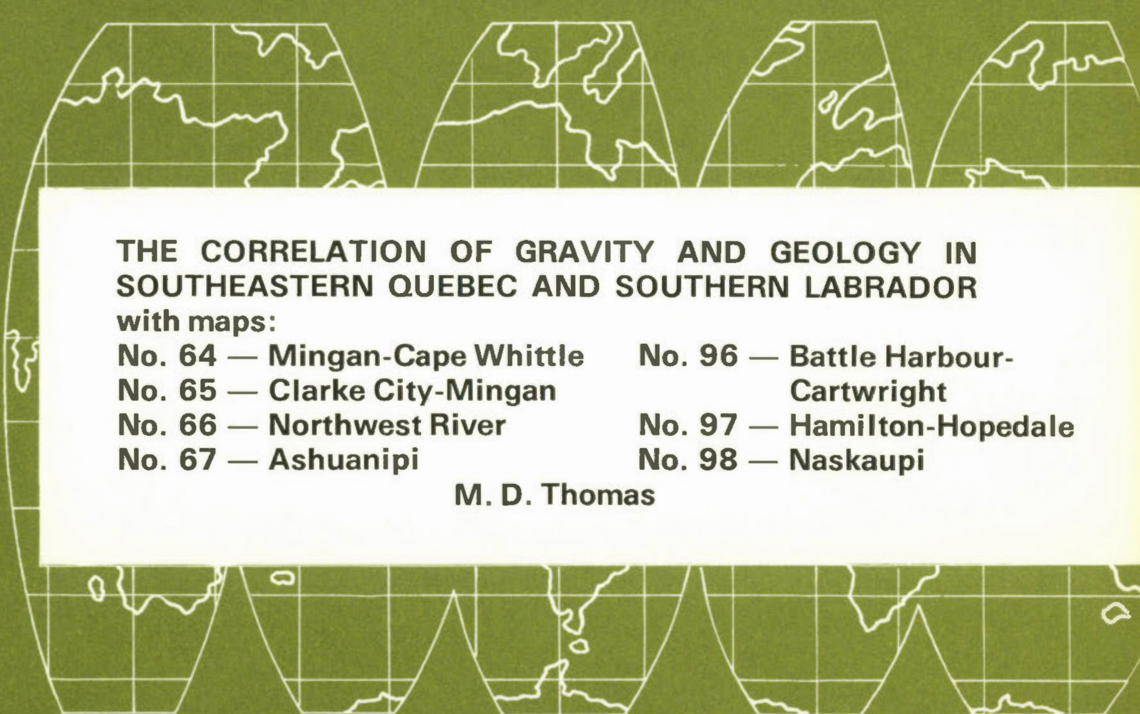

THE CORRELATION OF GRAVITY AND GEOLOGY IN SOUTHEASTERN QUEBEC AND SOUTHERN LABRADOR

with maps:

No. 64 — Mingan-Cape Whittle
No. 65 — Clarke City-Mingan
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M. D. Thomas

DEPARTMENT OF ENERGY, MINES AND RESOURCES
OTTAWA, CANADA 1974

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Contents

Abstract – The results of over 3,000 gravity observations in southeastern Quebec and southern Labrador over mainly the Grenville Structural Province and portions of the adjacent Superior, Churchill and Nain provinces are presented in the form of 1:500,000 contoured Bouguer anomaly maps. The results of almost 1,500 density measurements on rock samples from the area are also given.

The gravity field over the Grenville is characterized by prominent regional and local anomalies, while that over an adjacent area of the Superior is devoid of such anomalies. There is also a significant difference in the background levels of the Bouguer anomalies over the two provinces; the level of the Grenville is about 15 mgal higher than that of the Superior. The latter difference is attributed to a denser Grenville crust.

Three extensive regional anomalies outlined largely by linear belts of steep gradients dominate a broad belt of country along the Grenville Front and the eastern part of the area; these anomalies trend northeasterly parallel to the gross trend of the Grenville. The most spectacular anomaly is the Grenville Front low which parallels closely and straddles the Grenville Front over 900 km. In profile it is asymmetrical with gentle gradients (0.35 mgal/km) defining its northern flank and steep gradients (1.0 mgal/km) defining the southern flank.

There is no obvious correlation between the anomaly and the geology and so large scale crustal variations are interpreted to explain it. The northern flank is interpreted to arise from horizontal density contrasts induced by downflexuring of the Superior, Churchill and Nain crusts towards the axis of the anomaly; the southern flank is thought to be a reflection of denser Grenville crust in steep contact with crust of 'normal' density. A crustal root beneath the axis of the anomaly interpreted from seismic experiments by other workers, contributes to the negative effect. The second anomaly, the Musquaro-St. Lewis high likewise exhibits no apparent correlation with the geology, and a shallowly buried anorthositic complex possibly fault bounded along its northwestern margin is interpreted as a source. The third anomaly, the Minipi-Barron Lakes high correlates extremely well with the anorthositic and related rock-types of the Mealy Mountains which occur over its southern part. The linear belts of steep gradients defining parts of the margin of this anomaly are interpreted to coincide with major faults juxtaposing the denser rocks of the anorthositic complex against lower density quartzo-feldspathic lithologies. The southwestern part of the survey area is largely covered by a large oval negative regional anomaly, the Moisie-Aguanas low, which has a gross east-west axis, and which is attributed to a concentration of granites in the upper crust; 'pure' anorthosites may also contribute to this anomaly.

Prominent gravity highs in the region are interpreted as gabbroic masses, and two-dimensional models having approximately saucer- or funnel-shapes are presented for several of these. All models have upper surfaces coinciding with sea level and extend to depths varying between 6 to 14 km.

Résumé – Les résultats de plus de 3 000 mesures de gravité relevées dans le sud-est du Québec et le sud du Labrador, principalement dans la province structurale de Grenville et dans des parties adjacentes aux provinces du lac Supérieur, de Churchill et de Nain, sont présentés ici sous forme de cartes à courbes de niveau, au 1:500 000, d'une anomalie de Bouguer. Les résultats de près de 1 500 mesures de densité d'échantillons de roche de cette région y figurent également.

Le champ de la gravité dans la province de Grenville est caractérisé par des anomalies régionales et locales marquées, tandis que celui de la région adjacente à la province du lac Supérieur ne présente pas de telles anomalies. Une différence importante existe dans les niveaux de référence des anomalies de Bouguer des deux provinces; le niveau de la province du lac Supérieur est inférieur d'environ 15 mgal. Cette différence est attribuée à une densité plus élevée de la croûte dans la province de Grenville.

Trois anomalies régionales de grande superficie, délimitées en grande partie par des zones rectilignes à gradients élevés, dominent une large zone le long du front de Grenville et de la partie est de la région; la direction nord-est de ces anomalies est sensiblement parallèle à l'orientation générale de la province de Grenville. L'anomalie la plus remarquable est la zone de faible gravité du front de Grenville qui longe ou chevauche ce front sur plus de 900 km. Son profil asymmétrique, et de faibles gradients (0,35 mgal/km), définissent le flanc nord, et des gradients élevés (1,0 mgal/km) définissent le flanc sud.

Aucune corrélation est évidente entre l'anomalie et la géologie, il faut donc pour l'expliquer, l'attribuer à des variations à grande échelle de la croûte. Le flanc nord résulterait de contrastes de densité dans le plan horizontal, causés par un plissement affaissé de la croûte dans les provinces du lac Supérieur, de Churchill et de Nain, et orienté dans l'axe de l'anomalie; dans le flanc sud, l'anomalie résulterait de la croûte de Grenville, de densité supérieure, et en contact direct avec la croûte de densité «normale». La présence d'une racine de croûte sous la partie centrale de l'accident, déduite à partir d'expériences séismiques effectuées par d'autres chercheurs, contribue à un résultat négatif. La seconde anomalie, la zone de forte gravité Musquaro-St. Lewis, ne présente pas de corrélation apparente avec la géologie, et un complexe d'anorthosites peu profond, probablement limité par des failles le long de sa bordure nord-ouest, en est peut-être la cause. La troisième anomalie, la zone de forte gravité des lacs Minipi-Barron, est en excellente corrélation avec les anorthosites et autres roches associées des montagnes Mealy de la partie sud de cette zone. Les zones rectilignes à gradients accusés, qui délimitent les parties de la bordure de cet accident, coïncident, d'après l'interprétation, avec de grandes failles où les roches denses du complexe des anorthosites se juxtaposent aux roches de densité moindre quartzo-feldspathiques. La partie sud-ouest de la région étudiée présente sur une grande superficie une vaste anomalie négative de forme ovale, zone de faible gravité de Moisie-Aguanas, à direction générale axiale est-ouest, et attribuée à une concentration de granites dans la partie supérieure de la croûte; des anorthosites «pures» peuvent également contribuer à cette anomalie négative.

Des zones proéminentes de forte gravité dans cette région, résulteraient, d'après l'interprétation, de masses de gabbros; pour plusieurs, des modèles à deux dimensions sont présentés en forme approximative de soucoupe ou d'entonnoir. Les surfaces supérieures de ces modèles coïncident avec le niveau de la mer, et leurs profondeurs varient de 6 à 14 km.

1 — Introduction

During the period 1954 through 1968 a series of air-transported gravity surveys was carried out by the Gravity Division of the Dominion Observatory (now the Earth Physics Branch) in southeastern Quebec and southern Labrador. The area covered by the surveys is outlined in Figure 1 and includes a large part of the Grenville Structural Province as well as smaller adjacent areas of the Superior, Churchill, and Nain provinces as defined by Stockwell (1964). The results of the surveys are presented on the seven 1:500,000 contoured Bouguer anomaly maps which accompany this report.

An integral part of the gravity surveys was the collection of rock samples for density determinations, since a knowledge of surface densities can be critical in the interpretation of many gravity anomalies. The samples were obtained at gravity stations whenever conditions permitted. Density measurements were also made on a collection of rock samples obtained by the Quebec Department of Natural Resources from the Grenville 1970 area.* The results of these density studies are presented.

The gravity anomalies of the region and their relationship to the geology, and in some cases to topography, are described; qualitative interpretations are presented for most of the anomalies, but two-dimensional models have been computed for several prominent positive anomalies which are thought to be related to gabbroic masses. In most cases the source of the anomalies is evident in one or more of the surface lithologies, but where there is no obvious correlation between anomaly and geology deeper sources have been postulated. The latter are generally interpreted in terms of the end members of the density range for the area, namely gabbros as an explanation of gravity 'highs', and granites for gravity 'lows.' Extensive regional anomalies which do not appear to correlate with the geology are interpreted to result from broad scale structure within the crust, rather than from discrete lithological variations.

2 — Gravity Surveys

The first gravity observations in the region were made in 1954 by M.J.S. Innes, who visited 10 localities using fixed-wing aircraft. In the following years, up to and including 1963, several other small surveys using the same mode of transport realized a further 286 measurements. The first major survey in the area was achieved in 1964, when helicopters were the principal means of conveyance; another large helicopter survey was completed in 1968. Altogether, 3,009 stations have been occupied within the region and air transportation was used for most of them, because road access is extremely limited. Some pertinent information relating to the gravity surveys is listed in Table I.

Survey Procedures

The primary data of a gravity survey on land are the time of observation, the observed gravity value, the elevation and the geographical coordinates of the station.

The gravity observations were tied to control stations which form part of the national gravity network, the primary station of which is the National Reference Pier at Ottawa; this has an adopted value of 980.622 gals. Both the survey stations and control stations are indicated on the gravity maps which accompany this report. The former are normally

*Grenville 1970 area: is used throughout this report as an abbreviation in referring to the Magpie, St. Jean and Romaine Rivers Area (Grenville 1970) mapped by the Quebec Department of Natural Resources (Sharma and Franconi, 1973).

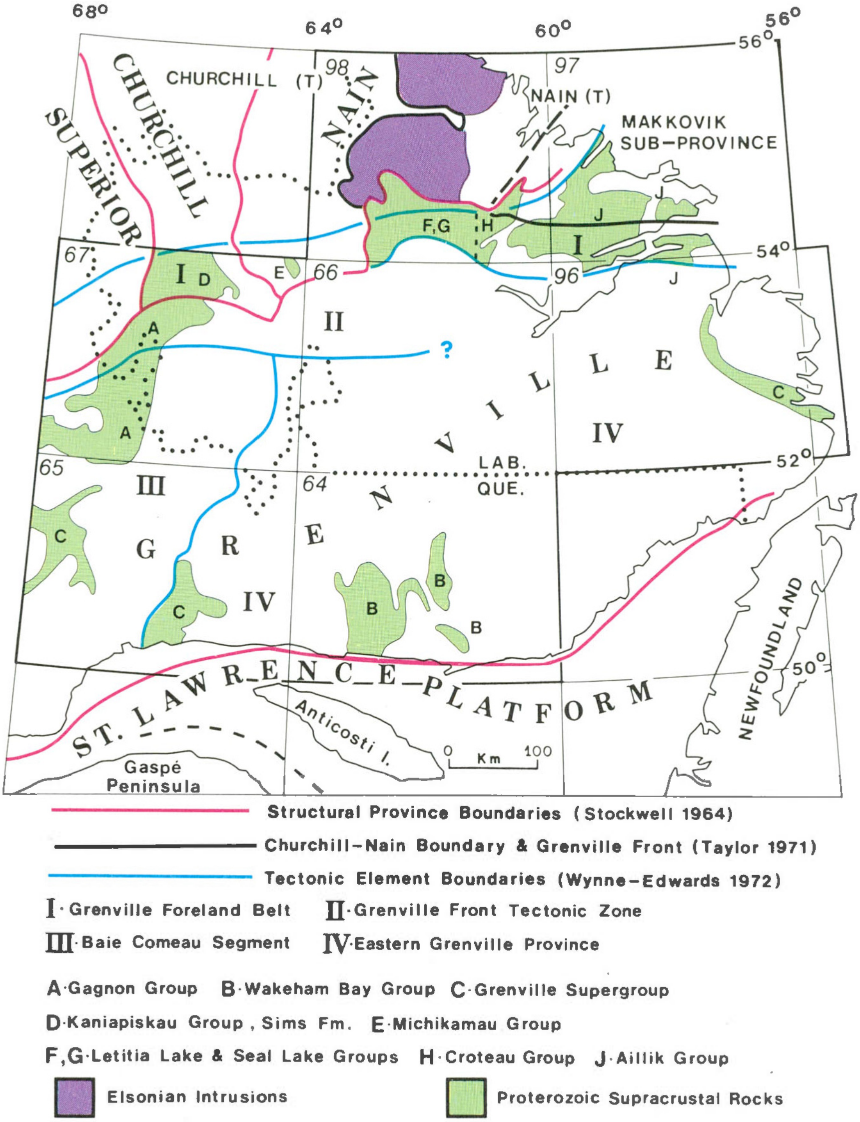

Figure 1. Location map of survey area. Major structural boundaries, Elsonian intrusions along Churchill-Nain boundary (Taylor, 1971), and areas of Proterozoic supracrustal rocks (Wynne-Edwards, 1972) are outlined.

Structural provinces defined by Stockwell (1964) are labelled in large lettering. CHURCHILL (T) and NAIN (T) are labels for the Churchill and Nain provinces as defined by Taylor (1971).

Broken black line marks southern limit of St. Lawrence Platform.

Number in upper left-hand corner of a 2° latitude by 4° longitude area is the number of the gravity map covering the area. Gravity map number 96 is 2° latitude by 4° 30′ longitude and extends as far east as longitude 55° 30′.

Naskaupi Fold Belt corresponds with region of supracrustal rocks F, G.

Elsonian intrusion immediately north of F, G region is Harp Lake Anorthosite.

TABLE I
Summary of Gravity Surveys 1954-68

Year	No. of Stations	Project	Observers	Gravity Meter
1954	10	54-002	Innes	†W192
1956	4	56-001	Tanner	NA137
1959	129	59-003	*Tanner Buck	W433
1960	72	60-004	*McConnell Davidson Vandort	W431 W391
1961	78	61-002	*McConnell Reader Weaver	W433 W391
1963	3	63-023	Winter	G7 G9
1964	1681	64-010	*Weaver D.F. Brulé Dekort Peters Richard Weaver J.	G9 G74 W546 W460 W433 W431 W391
1965	68	65-009	Buchan	G7 G9
		65-010	*Tanner Boyd	G7 W546
		65-013	*Winter Buchan	G9 G75
1968	964	68-106	*Halpenny Burke	G74 W807
Total Stations	3009		*Party Chief	

†Gravity Meter Index

W – Worden
NA – North American
G – LaCoste-Romberg Geodetic Meter

spaced between 10 to 15 km apart, and the latter about 90 km apart. North American and Worden gravity meters were read at a control station about every 4 hours whenever possible, whereas the relatively drift-free LaCoste-Romberg meters were read at control stations approximately every 8 hours.

Elevations were obtained by altimetry in the following fashion. Two altimeters were observed at each station and, whenever feasible, were read at a known elevation approximately every hour, in order to correct elevations of intermediate stations for instrumental drift. At every third station, on the average, the wet and dry bulb temperatures of a psychrometer were recorded to correct the altimetry for varying temperature and humidity. More frequent readings of the psychrometer were made depending on weather conditions and/or the magnitude of elevation changes between successive stations.

Geographical positions were determined primarily from 1:250,000 and 1:500,000 topographic maps.

Errors in the Gravity Anomalies

The gravity data were reduced to the common datum of sea level using a uniform density of 2.67 g/cm^3, and are presented as contoured Bouguer anomaly maps; the contour interval is 5 mgal.* Errors in these maps arise from three sources:

- the gravity meter and gravity control network;
- the reduction of the gravity observations to datum;
- the estimation of theoretical gravity.

Errors: gravity meter and gravity control network

Errors in this category are individually and collectively small, and relatively insignificant taken in the context of air-transported surveys of this type. The standard error in observed gravity is estimated to be ±0.25 mgal with respect to the datum defined by the national gravity network. Individual errors contributing to this value in decreasing order of magnitude are:

- error arising from assumption of linear drift between control readings;
- observational error, i.e. levelling and reading the meter;
- error in the calibration of the meter;
- error due to changes in the calibration factor during the survey.

Errors: reduction of the gravity observations to datum

The largest errors in the Bouguer anomalies due to observational sources are those introduced during the reduction of the gravity data to sea level, and are largely a consequence of obtaining station elevations by altimetry. The standard error in elevation for surveys of this type within the Precambrian Shield regions of Canada is ±4.6 m; the corresponding error (based on an adopted value of 0.1969 mgal per metre for the combined free air and Bouguer correction) in the Bouguer anomaly is ±0.9 mgal.

The use of a uniform density of 2.67 g/cm^3 in the Bouguer correction may also contribute error to the Bouguer anomaly, since any departure of the density of the crust, between sea level and a gravity station, from the 2.67 g/cm^3 value will result in error. The size of the error will vary according to the magnitude and configuration of the density change(s). Such errors are extremely difficult to quantify, but will be largest where the terrain is elevated and of high density. Within the survey area such terrain generally correlates with large positive gravity anomalies so that any error from this source is relatively small compared to the size of the anomaly. Furthermore, since relative differences in the Bouguer anomalies are used for gravity interpretations the magnitude of this type of error is further reduced. Thus the incorporation of the uniform density error into the Bouguer anomaly maps presented with this report is not significant for the geological interpretations.

Because terrain corrections have not been computed, a further error is contained in the anomalies. An idea of the magnitude of this error may be obtained by considering

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* 1 mgal = 10^{-5} m/sec^2.

terrain corrections computed for the Gaspé Peninsula by Tanner and Uffen (1960). Over 60 per cent of the corrections were 1 mgal or less, and since the Gaspé terrain is broadly similar to the more rugged regions of the present area, 1 mgal is likely to be the maximum terrain error for most stations in the area.

Errors: computation of theoretical gravity

The accuracies of the theoretical values of gravity, which were calculated using the International Ellipsoid Formula of 1930, are controlled by the precision with which station positions are located on a base map, and accordingly depend on the scale of the map. The standard error in the gravity anomalies due to errors in positioning for this survey area is ±0.15 mgal.

Summary of Errors

The overall standard error in the Bouguer anomaly arising from the random errors (standard error in observed gravity, standard error in station elevation, standard error in estimation of theoretical gravity) is the square root of the sum of squares of these individual errors and equals ±0.95 mgal. To this error must be added the error due to non-application of the terrain correction, which is a variable error throughout the area, but which has a likely upper limit of 1 mgal for most stations, and the error due to the use of a uniform density of 2.67 g/cm^3 in the Bouguer correction, which qualitative inspection of the area suggests is of sizeable magnitude in relatively local areas which together form only a small percentage of the whole area. It is suggested, therefore, that the error in the large majority of Bouguer anomalies is less than 2.0 mgal.

Presentation of Results

The gravity data are presented on seven Bouguer anomaly maps at a scale of 1:500,000; the contour interval is 5 mgal. The maps and their gravity map series numbers are as follows: Mingan-Cape Whittle (64), Clarke City-Mingan (65), Northwest River (66), Ashuanipi (67), Battle Harbour-Cartwright (96), Hamilton-Hopedale (97), Naskaupi (98). Gravity station locations are shown on all maps, while individual station values are shown on the first four maps. Each map covers an area of 2° latitude by 4° longitude, except the Battle Harbour-Cartwright map which is 4°30′ longitude wide. An index map of gravity maps is superimposed on Figure 1.

3 – Geology of the Area

Apart from small exposures of Palaeozoic sediments along the north shore of the St. Lawrence, the region comprises Precambrian terrain, and covers areas of the Grenville, Superior, Churchill and Nain structural provinces as originally defined by Stockwell (1963). Within the area, slight changes in the boundaries of the provinces were proposed by Stockwell (1964), and major revision by Taylor (1971). On the basis of structural evidence, Taylor suggested that Stockwell's (1964) Eastern Nain Subprovince be regarded as a structural province in its own right, and be renamed Nain Province. He also advocated – on the basis of palaeomagnetic evidence personally communicated to him by W.F. Fahrig (this evidence has since been published (Fahrig and Larochelle, 1972)) – that the Nain Province, as redefined, be extended southward to a new position of the Grenville Front intersecting the coast at Groswater Bay. Fahrig and Larochelle (1972) have but slightly modified the position given by Taylor (1971). Furthermore, on structural considerations, the ground between the Grenville Front and the Kanairiktok River is regarded as a subprovince of the Nain, to which Taylor (1971) gave the name Makkovik. Stockwell's (1964) and Taylor's (1971) boundaries are illustrated in Figure 1. Wynne-Edwards (1972) further defined a Grenville Orogenic Belt which comprises the Grenville Province and a Grenville foreland zone some 80 km wide bordering the Grenville Front to the north. The tectonic elements of Wynne-Edwards' Grenville Orogen are also shown in Figure 1.

The position of the Grenville Front given by Wynne-Edwards is even farther south than that proposed by Taylor. In order to eliminate any confusion arising out of reference to structural provinces and boundaries in the text, the following terminology will be adopted in this report.

Grenville Front: is that structural boundary as defined by Stockwell (1964), which separates the Grenville Province from structural provinces to the north, west of the Naskaupi Fold Belt, and which south of, and east of the fold belt, is positioned as defined by Wynne-Edwards (1972). *Grenville Structural Province:* is that structural province lying south of the Grenville Front as herein defined. *Superior Structural Province:* is that structural province as defined by Stockwell (1964). *Churchill Structural Province:* is that structural province as defined by Taylor (1971). *Nain Structural Province:* is that structural province as defined by Taylor (1971), with the addition of the area between the Grenville Front as defined by Taylor (1971) and Wynne-Edwards (1972), and the Naskaupi Fold Belt as defined by Stockwell (1964). A geological map of the area with the structural boundaries as herein defined superimposed is given in Figure 2.

Grenville Structural Province

The Grenville forms the southeastern segment of the Canadian Shield and in gross form traverses the North American continent from southwest to northeast. It is the youngest structural province in the Shield yielding average K-Ar dates of 950± 150 m y. U-Pb and Rb-Sr determinations indicate an age consistently older than the K-Ar age by about 250 m.y., suggesting that the Grenville orogenic event culminated about 1200 m.y. ago (Wynne-Edwards 1972).

Lithologies

Various quartzofeldspathic gneisses underlie over half of the Grenville, and are thought to represent the reworked equivalents of lithologies comprising older provinces. They are believed to be primarily of Archean age with the possible inclusion of some Aphebian material, and probably constituted the basement upon which the Grenville supracrustal rocks were deposited (Wynne-Edwards, 1972). Large complexes of anorthosite-mangerite and granitic rocks comprise most of the remaining Grenville terrain, and lesser areas of gabbro and supracrustal sediments and metasediments complete the Grenville mosaic.

The anorthosites are of particular interest since they are globally restricted, and according to Wynne-Edwards (1972) the anorthosites of eastern North America probably comprise about 75 per cent of the world's total. The associated mangerites are a subsidiary facies of the anorthositic complexes, and may occur as internal plutons or as partial envelopes around the anorthosites. The gabbroic rocks of the region are also very often associated with, and grade into, the anorthosites.

The Grenville supracrustal rocks belong to three main groups – Grenville Supergroup, Gagnon Group and the Wakeham Bay Group. A tentative correlation within themselves and with supracrustal rocks of the Grenville Foreland Belt is illustrated in Table II. Rocks considered to be Proterozoic supracrustal rocks by Wynne-Edwards (1972), and not indicated in Figure 2 (where they are included with gneisses) are outlined in Figure 1.

Gagnon Group

The Gagnon Group comprises metamorphosed sediments and iron formations, which are thought to represent the southern extension of the Kaniapiskau Supergroup of the Labrador Trough into the Grenville Province.

Wakeham Bay Group

Rocks of the Wakeham Bay Group occupy a north-trending synclinal basin on the north shore of the St. Lawrence between Havre St. Pierre and Natashquan. An estimated 7,620 m of mainly quartzites and calcareous quartzites fill the basin, and these are extensively intruded by sills of gabbro.

Grenville Supergroup

The Grenville Supergroup is distinguished on the basis of three main lithologies – marble, quartzite and aluminous paragneiss occurring in association as scattered remnants throughout the area. Their distribution, according to Wynne-Edwards (1972), is shown in Figure 1.

Structure

Although the gross trend of the Grenville is northeasterly, a well developed structural grain with a similar trend is observed only along the Grenville Front. The absence of apparent northeasterly structural elements elsewhere is a consequence of the basement gneisses, and at least some of the Grenville Supergroup, having experienced multiple deformation as a result of the Kenoran, Hudsonian and Grenville orogenies, and thereby developing complex structure due to the interference of two or more fold sets. The gneisses, therefore, produce a pattern of broad basins and domes having gentle plunges of various orientation. The large anorthosite-mangerite complexes have also exercised a control on the structure, and in their vicinity the structural grain is largely controlled by the shape of the plutons. Despite the paucity of northeast elements on the megascopic scale, fabric analysis of large tracts of the Grenville indicate that linear elements are systematically oriented across the province in a northeasterly direction. These elements are interpreted as a younger set of northeasterly trending and southeasterly dipping axial planes intersecting older S-surfaces in a lineation (Wynne-Edwards 1972).

Three tectonic elements of the Grenville Structural Province as defined by Wynne-Edwards (1972) occur in the area (see Figure 1). The Grenville Front Tectonic Zone comprises mainly quartzofeldspathic gneisses commonly in granulitic facies; these have a well developed northeasterly foliation and contain many parallel zones of cataclasis and mylonitization. Kyanite is the dominant aluminosilicate, in contrast to sillimanite which is prevalent in the rest of the Grenville. The Baie Comeau Segment is differentiated from the Eastern Grenville Province on grounds of contrasting metamorphism. The boundary drawn between the two areas separates anorthosites, supracrustal rocks and basement rocks with contrasting grades of metamorphism within the Eastern Grenville Province from the more homogeneous metamorphism of the Baie Comeau Segment. Amphibolite grade of metamorphism is common in both tectonic elements. In the Eastern Grenville Province the supracrustal rocks are not as strongly metamorphosed as the basement gneisses, and the anorthosites have retained most of their primary features. The latter are closely similar to the anorthosite massifs of the southern Nain and Churchill provinces; the Eastern Grenville Province may therefore represent the reworked extension of the Nain Province (Wynne-Edwards, 1972). The level of crustal deformation in the Eastern Grenville Province is considered to be shallower than in the adjacent region of the Grenville.

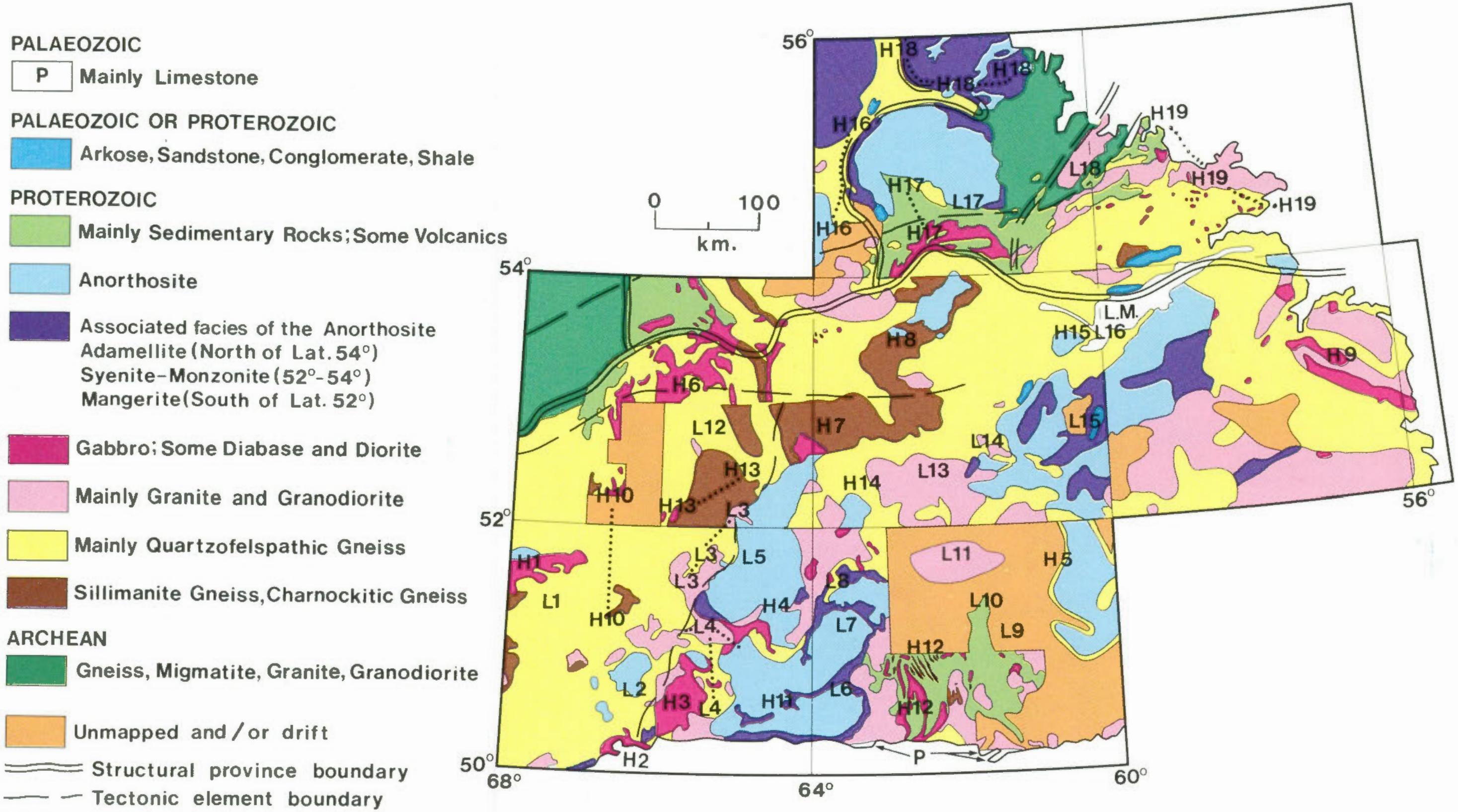


Figure 2. Geological map of survey area. H1 etc., L1 etc. mark positions of positive and negative gravity anomalies respectively. Black dots outline general trend of elongate anomalies (this applies to Figure 3 also) L.M. – Lake Melville.

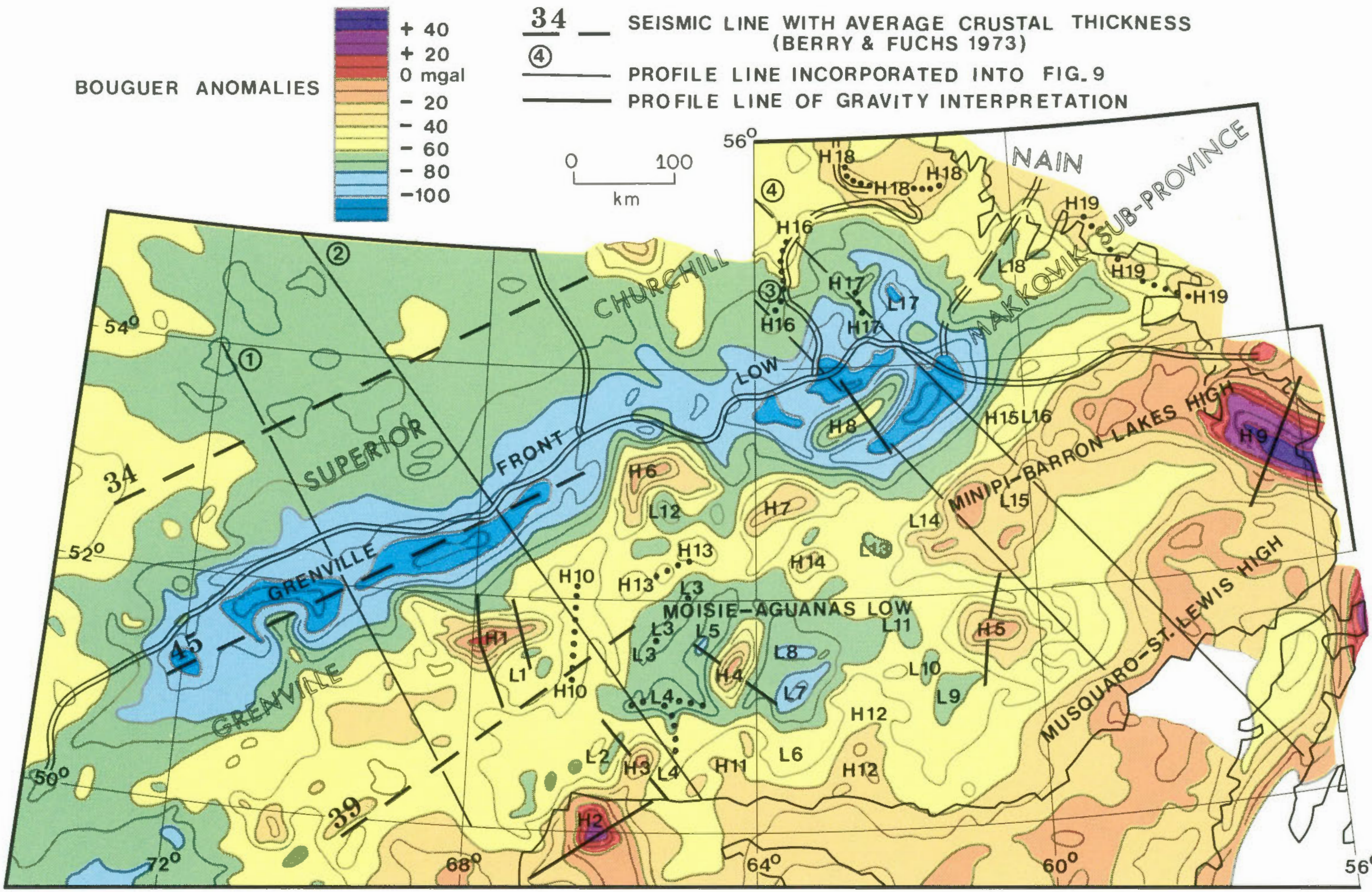
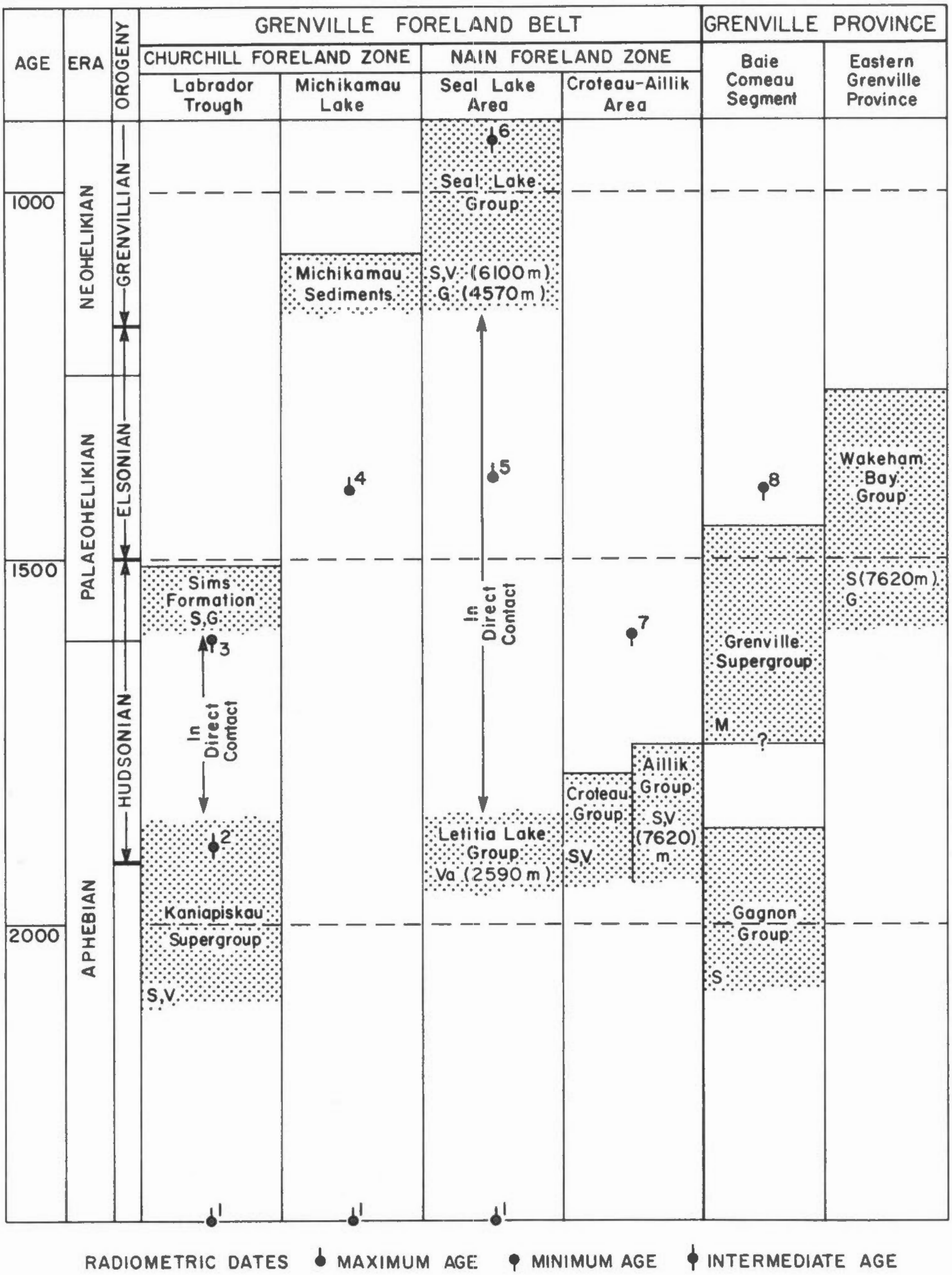


Figure 3. Bouguer anomaly map of survey area, and an adjacent area to the west.

TABLE II
Tentative Correlation of Proterozoic Supracrustal Rocks in the Survey Area



S – sediments, M – metasediments, V – volcanics, Va – acid volcanics, G – gabbroic or diabasic intrusions.

Legend for ages: 1 – Archean basement, 2 – Kaniapiskau Supergroup, 3 – Hudsonian Orogeny, 4 – Michikamau anorthosite, 5 – Harp Lake anorthosite, 6 – Seal Lake Group, 7 – Strawberry Lake granite, 8 – Anorthosite intrusive into Grenville Supergroup.

(Note: This table is modified from Wynne-Edwards (1972) Table 2.)

Grenville Front

The Grenville Front trends variably between northeasterly and east-northeasterly across the area and separates the Grenville Province from the older provinces to the north and from the Naskaupi Fold Belt. The criteria for defining the front are variable along its length and may be a fault, mylonite or cataclasite zone, an abrupt change in structural style or metamorphic grade, or a combination of these features. If such criteria are absent, the front is assumed to occupy a position where K-Ar ages become 1000 m.y. or less (Wynne-Edwards, 1972, p. 318); the change from older dates to Grenville dates generally occurs within a distance of less than about 1.5 km.

West of the Labrador Trough the front is delineated by differences in metamorphic grade and structural deformation to either side. To the north charnockitic rocks of the Superior Province are characterized by gently dipping banding and by gently plunging lineations and axes of minor folds. South of the front, biotite-hornblende gneisses of the amphibolite facies have steeply plunging foliation and linear elements. The change in structural style actually develops within the charnockites as they approach the gneisses, with the banding becoming steeper and swinging to a northeast direction (Duffell and Roach, 1959). The front is therefore located within the charnockites a few kilometres north of the boundary with the gneisses; it strikes northeastwards skirting the Gagnon Group and enters the Labrador Trough a few miles south of Sawbill Lake.

Across the trough, as far as the east side of Ossokmanuan Lake, the front separates the relatively unmetamorphosed Kaniapiskau strata from the cataclastic metasedimentary granitoid gneisses thought to be their equivalent to the south; it follows closely the biotite isograd outlined by Fahrig (1967) in the western part of the trough. Near Ossokmanuan Lake, the gneisses are almost uniformly cataclastic, and southward dipping foliation and mylonite layers suggest that the gneisses have been thrust northward (Wynne-Edwards, 1961).

From Ossokmanuan Lake northeastwards to the Naskaupi Fold Belt, the position of the front is not precisely located, and it is inferred largely from the few K-Ar dates available for that area. Stevenson (1969) proposed that the front in this region may be represented by a broad northeast trending zone of cataclasis and shearing along which the rocks immediately west of the Red Wine Mountains* have been thrust northwestwards along a series of northeast trending faults.

The front is well defined south of the Naskaupi Fold Belt. Granite and granitic gneisses have been thrust northwards over the Naskaupi strata to form the overturned synclinorium. The thrusting was accompanied by excessive shearing along the contact between the Seal Lake rocks (Naskaupi Fold Belt) and the granite (Brummer and Mann, 1961).

Eastwards from the Naskaupi Fold Belt to the Labrador Coast, the front is defined on the basis of K-Ar dates (Wynne-Edwards, 1972, p. 287).

Grenville Foreland Belt

The principal criterion for defining the Grenville Foreland Belt is the string of basins comprising supracrustal rocks which occur along the north side of the Grenville Front from Lake Huron to the Labrador Coast. The basins contain largely unmetamorphosed sedimentary and volcanic sequences of Aphebian to Helikian age. The northwestern

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*The name 'Red Wine Mountains' does not appear on the relevant gravity map which accompanies this report. It is a locally used term which has been approved by the Canadian Permanent Committee on Geographical Names, and is applied to the high ground east of Disappointment Lake.

boundary of the foreland is taken at the limit of northeast trending, southeast dipping cleavages, faults and folds which affect the basins. The basement rocks of the foreland belt have radiometric ages which are characteristic of their respective structural provinces. In many places both supracrustal and basement rocks are more highly metamorphosed and deformed towards the Grenville Province. This is interpreted to be the result of uplift of the foreland belt following the Grenville Orogeny, and its subsequent erosion which exposed higher grades of pre-Grenville Orogeny metamorphism. The basement and the supracrustal strata were not metamorphosed or isotopically updated by the Grenville Orogeny (Wynne-Edwards, 1972).

From west to east along the foreland zone, the following supracrustal groups occur within the area; Kaniapiskau Supergroup with unconformably overlying Sims Formation (Churchill Province), Michikamau Group (Churchill Province), Letitia Lake Group with unconformably overlying Seal Lake Group (Nain Province), Croteau Group and Aillik Group (Nain Province). A correlation chart of these groups as well as those supracrustal groups in the Grenville Province is given in Table II.

Superior Structural Province

Rocks belonging to the Superior Province within the study area are mainly pyroxene-bearing gneisses of the granulite facies of metamorphism, together with some granites and granodiorites. A prevailing structural grain is not apparent. A K-Ar age from the area is 2425 m.y. (Fahrig, 1967).

Churchill Structural Province

The Churchill Province includes the strata of the Labrador Trough, and outside the trough mainly paragneisses, granitic gneisses, migmatites, granites and granodiorites. The eastern boundary with the Nain Province is largely obliterated by the large anorthositic and adamellitic intrusions emplaced by the Elsonian Orogeny. Structures within the Churchill are generally north trending and uniform as opposed to north trending but diverse chaotic structures in the Nain (Taylor, 1972). K-Ar dates are variable but average about 1380 m.y. in the portion formerly ascribed to the Western Nain by Stockwell (1964); farther west Churchillian dates are more typical of the Hudsonian Orogeny and are about 275 m.y. older (Taylor, 1971). The younger dates in the area of the Western Nain Subprovince were Stockwell's main reason for erecting a subprovince, and were attributed by him to the Elsonian event.

Nain Structural Province

The Nain basement comprises mainly leucocratic, foliated or banded gneisses of granitic and granodioritic composition; agmatite and migmatite are locally abundant, and diabase dykes are common. The basement is Archean and has an average K-Ar age of 2356 m.y. (Taylor, 1972). Supracrustal rocks of the Croteau and Aillik Groups occur in the Makkovik Subprovince. Structures are generally oriented northerly to northeasterly, except in Makkovik Subprovince where a prevailing northeasterly to easterly grain is developed; age dates in the subprovince are typically Hudsonian (1735 m.y.). Granites occurring mainly in the subprovince have ages which are consistent with an Hudsonian emplacement. Metamorphic grade in the Nain is dominantly almandine-amphibolite.

Elsonian Intrusions

The Churchill-Nain boundary is largely obliterated by large intrusions of anorthosite and adamellite, which occupy a broad northerly belt along the boundary and to which Stockwell (1964) gave the name Elsonian. Strictly speaking they are not to be considered as part of the internal fabric of either the Churchill or Nain provinces, but should be regarded as an entity within themselves i.e. as a petrogenetic province (Davidson, 1972). (Note: on this basis the anorthosite-mangerite complexes of the Grenville Structural Province should be included in the same petrogenetic province; they were described in this report within the context of the Grenville Province since it provided a reference framework.)

The only age available on the anorthosites is that of the Michikamau anorthosite; an age of 1400 m.y. (K-Ar) was obtained (Emslie, 1964). It is likely that other anorthosites would have similar ages. Adamellites have yielded younger K-Ar ages, from 1145 to 1340 m.y. (Taylor, 1972).

4 – Rock Densities

Rock samples for density determinations were collected wherever a gravity station was located near an outcrop; normally a single specimen was obtained. Because large tracts of the region are variously covered by drift, swamp and vegetation, only 377 samples were recovered. A consequence of the sporadic collecting is that over most of the area, density information is extremely thin, and sometimes it is non-existent.

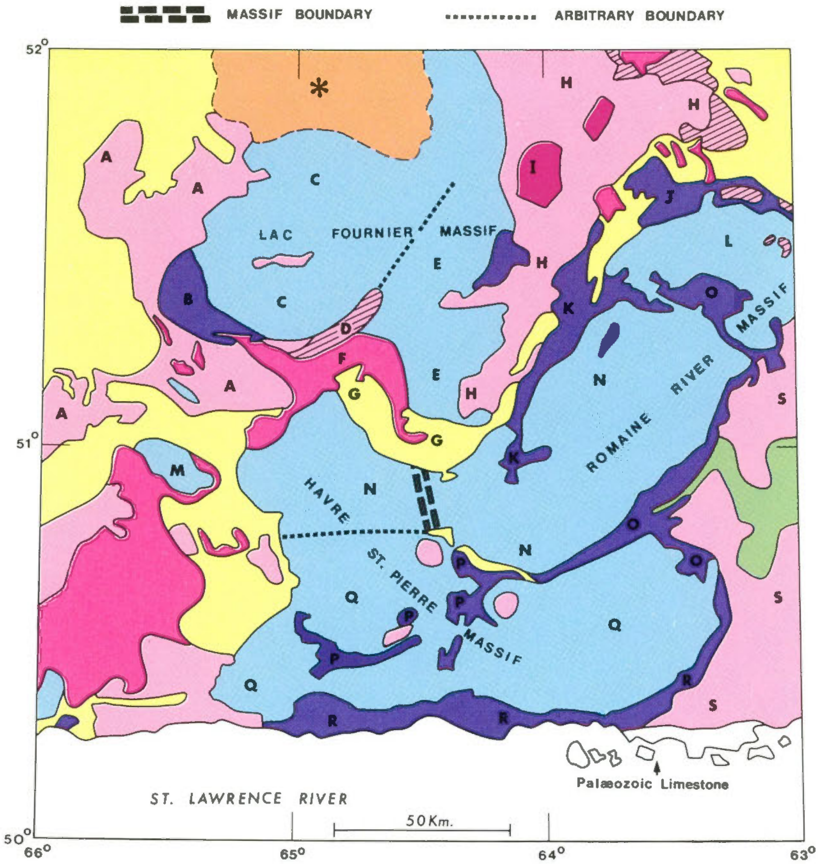
Detailed density information is available for a relatively small part of the region contained between the north shore of the St. Lawrence River and latitude 52°, and between longitudes 63° and 66°. This area was geologically mapped by the Quebec Department of Natural Resources in its 1970 Grenville project. Through the courtesy of Dr. A.F. Laurin director of the Geological Services, and Dr. K.N.M. Sharma one of the participating geologists, samples from the area were made available to the Gravity Division for density measurements; 1,090 measurements were made.

Two weighings were made on each rock sample – the dry weight in air and the unsaturated weight in water. Most of the rocks are crystalline, and accordingly have little or no pore space (usually less than 1 per cent porosity), so that the density obtained with these weighings, which is the dry density, will be very close to the actual grain density of the rock. The densities are accurate to within 0.01 g/cm^3.

Densities of Rocks from the Grenville 1970 Area

The geology of the Grenville 1970 area is illustrated in Figure 4. Because the rock specimens have been collected by a group of geologists working as a team and which is familiar with the Grenville terrain and lithologies, the descriptions and identifications are considered to be reasonably uniform; the precision of the identification therefore presents a good opportunity to compare the densities of the various lithologies in this part of the Grenville. The rock classification used is that widely used by the Geological Survey of Canada (see Wynne-Edwards *et al.* 1970, Figure 4); it is reproduced in this report as Figure 5. Some general remarks (information from Sharma and Franconi, 1973) concerning the mineralogy of some of the lithologies follow.

Granites. Contain up to 80 per cent potash feldspar, up to 20 per cent plagioclase, 10 to 30 per cent quartz, and up to 20 per cent mafics (mainly hornblende and biotite).



GEOLOGICAL UNIT	NAME OF UNIT	NO. OF SAMPLES	AVERAGE DENSITY & STANDARD DEVIATION
A	TREMBLAY LAKE GRANITE	113	2.68 ± 0.13
B	LAC CAMITIT MANGERITE	23	2.81 ± 0.13
C	LAC PIERRES ANORTHOSITE	92	2.77 ± 0.12
D	MAGPIE SYENITE	8	2.72 ± 0.12
E	MAGPIE ANORTHOSITE	54	2.85 ± 0.11
F	MAGPIE GABBRO	75	2.87 ± 0.17
G	MAGPIE GNEISS COMPLEX	52	2.81 ± 0.17
H	TOULADIS GRANITE	103	2.72 ± 0.14
I	SAUTERELLES DIORITE	32	2.80 ± 0.15
J	LAC DUAULT MANGERITE	24	2.75 ± 0.17
K	LAC COUPEAUX MANGERITE	21	2.72 ± 0.08
L	LAC MARTHE ANORTHOSITE	46	2.68 ± 0.03
M	LAC TORTUE ANORTHOSITE	15	2.68 ± 0.04
N	SOUTH MAGPIE ANORTHOSITE	85	2.78 ± 0.15
O	LAC ANDRE MANGERITE	18	2.74 ± 0.13
P	GIRARD LAKE MANGERITE	17	2.73 ± 0.08
Q	EAST CHAMBERS ANORTHOSITE	86	2.73 ± 0.11
R	MINGAN MANGERITE	13	2.81 ± 0.19
S	LAC FORGET PLUTONIC COMPLEX	34	2.69 ± 0.12

Figure 4. Geological map of Grenville 1970 area (after Sharma and Franconi, 1973). Geological legend as for Figure 2 *— unmapped and/or drift; lined areas are syenites.

<table>
<tr><td rowspan="2">Amount of Quartz</td><td rowspan="2">Proportion of Potash Feldspar to total Feldspar</td><td colspan="12">More than 10% Feldspar</td></tr>
<tr><td colspan="12">Composition of Plagioclase</td></tr>
<tr><td></td><td></td><td colspan="3">Albite
An_{0}—An_{10}</td><td colspan="3">Oligoclase
An_{10}—An_{30}</td><td colspan="3">Andesine
An_{30}—An_{50}</td><td colspan="3">Labradorite, etc.
An_{50}—An_{100}</td></tr>
<tr><td rowspan="3">More than 10% Quartz</td><td>More than 2/3</td><td colspan="12">GRANITE
RHYOLITE</td></tr>
<tr><td>1/3-2/3</td><td colspan="12">QUARTZ MONZONITE
QUARTZ LATITE</td></tr>
<tr><td>Less than 1/3</td><td colspan="4">GRANODIORITE
QUARTZ LATITE</td><td colspan="4">QUARTZ DIORITE
DACITE</td><td colspan="4">QUARTZ GABBRO
QUARTZ BASALT</td></tr>
<tr><td rowspan="3">Less than 10% Quartz</td><td>More than 2/3</td><td colspan="12">SYENITE
TRACHYTE</td></tr>
<tr><td>1/3-2/3</td><td colspan="12">MONZONITE
LATITE</td></tr>
<tr><td>Less than 1/3</td><td colspan="6">SYENODIORITE
LATITE</td><td colspan="3">DIORITE
ANDESITE</td><td colspan="3">GABBRO
BASALT</td></tr>
</table>

Figure 5. Classification chart applied to igneous rocks from Grenville 1970 area.

Syenites. Contain 50 to 90 per cent potash feldspar, 5 to 20 per cent plagioclase, 0 to 7 per cent quartz, and 5 to 25 per cent mafics (biotite and hornblende).

Monzonites. Contain 25 to 55 per cent potash feldspar, 25 to 50 per cent plagioclase, up to 25 per cent quartz, and 5 to 20 per cent mafics (mostly biotite and hornblende with minor pyroxene in places). Occasionally the monzonite grades into quartz monzonite.

Mangerites. These are rocks of monzonitic composition with the mafics being mainly pyroxene and amphibole with some biotite. Plagioclase is slightly more abundant than potash feldspar; total feldspar is more than 70 per cent. Mafics vary from 5 to 25 per cent, and quartz may or may not be present.

Diorites. Contain up to 10 per cent potash feldspar, 70 to 90 per cent plagioclase, up to 15 per cent quartz, and 5 to 25 per cent mafics (mostly hornblende and biotite with some pyroxene).

Anorthosites and Gabbros. Rocks mapped as anorthosite include anorthosite (0 to 10 per cent mafics), gabbroic anorthosite (11 to 20 per cent mafics) and anorthositic gabbro (21 to 35 per cent mafics) with only local occurrences of gabbro (>35 per cent mafics). Sharma and Franconi point out (1973, p. 14) that, whenever possible anorthosites containing more than 10 per cent mafics have been identified as such on their map, and gabbro is mapped as a separate unit.

Metamorphic Rocks. Because of the foliated and banded nature of the various gneisses and migmatites, and the consequent rapid compositional changes that may occur from band to band, it is difficult to present even general figures for the mineralogical composition of these rock-types. Most of them, however, are largely quartzofeldspathic containing various amounts of biotite and hornblende as the main mafic minerals.

The results of 1,090 density determinations are summarized in Figure 6; the average and standard deviation are plotted for each lithology, as well as the modal size class (classes). While it is generally true that granites come from areas mapped as granite, and similarly for other lithologies, it is not necessarily inevitable.

It is noticeable that the average value, in most cases, is displaced from the modal value towards the higher densities. This positive skewness is interpreted to result from various degrees of "contamination" of the "typical" rock-type or norm, with mafic minerals. This is demonstrated by considering the anorthosite samples; 222 anorthosites did not carry the qualifier "gabbroic" in their description and yielded an average density of 2.71 ±0.07 g/cm^3, while 72 were described as gabbroic and had an average density of 2.80 ±0.09 g/cm^3. For the gabbros, the average is displaced from the mode towards the lower densities suggesting "contamination" by felsic minerals.

The "contamination" poses a serious problem in the selection of a representative density for areas of country mapped as a specific rock-type. While the mode indicates the expected density value it cannot be used as the representative value, since mafic minerals are present to varying degrees and will raise the overall density of the unit. Furthermore,

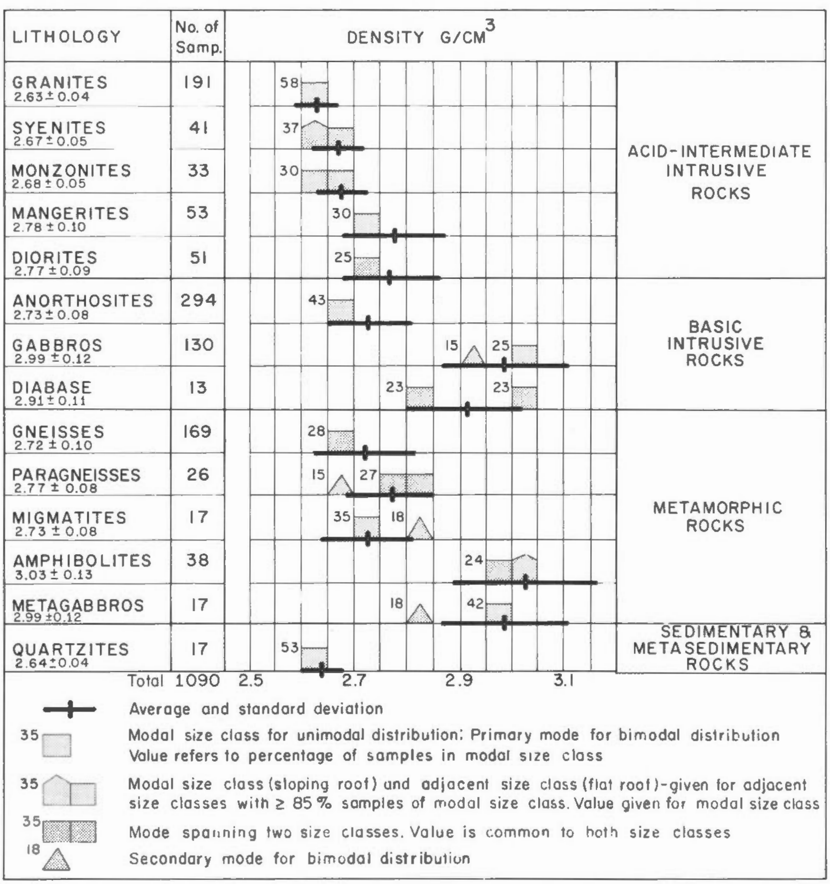


Figure 6. Summary chart of densities of lithologies in Grenville 1970 area. Values of average density and standard deviation are placed beneath the lithology name.

the average density, while allowing for such variations, is only a representative value if the frequency percentages of the sample are indeed representative of the whole body.

For reasonably homogeneous rock units with adequate sampling, the average density is a suitable value to adopt. However, these relatively simple conditions are seldom met with, especially in the case of broad regional studies. Despite the relatively detailed collections made by the Quebec Department of Natural Resources, only 1,090 samples are available for 39,000 square kilometres, and in many parts of the area the sampling has been intensified along certain profiles or in regions of particularly favourable exposure. Sometimes the sampling is not representative on account of an unusual rock-type being more favourably sampled than the prevailing country rock. Also, in regional mapping, large areas are designated to a particular lithology, but may contain pods, xenoliths, dykes and scattered outcrops of other lithologies; all of these serve to influence the overall density of a regional block of the crust. Finally, it must be remembered that surface sampling, at best, gives an idea of the average density in the three-dimensional sense, only for the crust between the lowest and highest elevations of the sampling sites.

In spite of the limitations imposed by the various modifiers, it is felt that the assessment of average densities for large tracts of country is justifiable, in the sense that some sort of guideline is available in the selection of density contrasts for gravity interpretations. The results of averaging densities for some of the igneous and metamorphic tracts of the Grenville 1970 area are shown in Figure 4. Arbitrary names have been given to the geological units for purpose of easy reference. A comparison of the crustal block values of Figure 4 with those for the corresponding lithology of Figure 6 indicates many discrepancies, presumably arising from the foregoing modifiers.

Densities of Rocks Collected by the Gravity Division

Density information obtained by the Gravity Division is very limited for the reasons previously outlined; only 377 samples were measured. Because of the lack of information, it has not been possible to designate average density values to many map units. Where sufficient concentration of determinations are available an average density value is given; these are summarized below:

Rock Group	No. of Samples	Average Density g/cm^3	S.D.
Little Manicouagan Lake Complex (mainly gabbroic rocks)	35	2.95	±0.14
Sept-Iles Complex (mainly anorthosite-gabbro)	17	2.80	±0.13
Anorthosites of Naskaupi map-sheet (G.M.S. 98)	33	2.68	±0.05
Adamellites of Naskaupi map-sheet (G.M.S. 98)	12	2.65	±0.07
Gneisses of Superior Province	9	2.68	±0.09

Besides these smaller areas, the average density of samples (108) collected from the gneissic terrain of the Churchill, Nain and Grenville was calculated: the value is 2.70

±0.11 g/cm³. Since descriptions were not always available for the samples it is possible that non-gneissic lithologies have been included in the average.

5 – Interpretation of Gravity Anomalies

The results of the gravity surveys are presented on the seven gravity maps which accompany this report. In addition, a composite Bouguer anomaly map of the survey area and a contiguous area to the west is given as Figure 3; this diagram faces the geological map (Figure 2) to facilitate comparison of the geology with the Bouguer anomalies. The area to the west was incorporated in Figure 3 to outline the full extent of the regional negative anomaly referred to as the Grenville Front low, and to illustrate the differences in the gravity field over the Superior and Grenville structural provinces. In Figure 3 the broad regional anomalies are labelled in full, while the relatively local anomalies are labelled according to the following code: H indicates a local gravity "high"; L indicates a local gravity "low".

General Description of the Gravity Field

Within the composite* area of Figure 3 the gravity field is dominated by northeasterly trending contours, which are mainly associated with three regional anomalies; the Grenville Front low, the Minipi-Barron Lakes high, and the Musquaro-St. Lewis high. The most extensive of these is the Grenville Front low, which straddles and parallels closely the Grenville Front from Lake Mistassini to the Labrador Coast. The northern margins of the Grenville and the neighbouring margins of the contiguous structural provinces are therefore characterized by a belt of northeasterly contours. Contours with a similar trend predominate in the eastern Grenville, east of the Rivière Natashquan, where the two regional highs occur. A subsidiary west-northwesterly trend is also developed in this region, where contours with such a direction bound portions of the regional highs and the large local anomaly H9. The remainder of the Grenville is largely covered by a broad, roughly oval-shaped regional negative anomaly, the Moisie-Aguanas low; the gross axis of this anomaly is east-west, but within the anomaly northeasterly contours prevail. This regional low is terminated to the west by an extensive low amplitude high (H10) which has a north-south axis, and is one of the few examples of anomalies with such a trend within the area.

Prominent local gravity highs are restricted to the Grenville, and several of these have axes parallel or subparallel to the northeasterly Grenville trend. Many of the highs are peripheral to the Moisie-Aguanas low. In marked contrast to the Grenville, the Superior of Figure 3 has a gravity field which is somewhat featureless and contains no large positive anomalies. The general level of the field over the Superior is also considerably lower than that over the Grenville. In order to quantify the difference, histograms (Figure 7) were compiled of the Bouguer anomalies of the two regions corresponding to the Superior and the Grenville; anomaly values were obtained from a grid of 10 seconds of latitude by 10 seconds of longitude. Both histograms are negatively skewed, mainly because the Grenville Front low lies along the boundary between the two areas. Neglecting the effect of the low, both histograms have distributions approaching normal, and the modal values of the Superior and Grenville are -67.5 and -52.5 mgal respectively. A difference in background anomaly level of about 15 mgal is present across the Grenville Front, on the basis of a comparison of these parts of the structural provinces.

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*Composite area refers to the survey area plus the contiguous area to the west outlined in Figure 3.

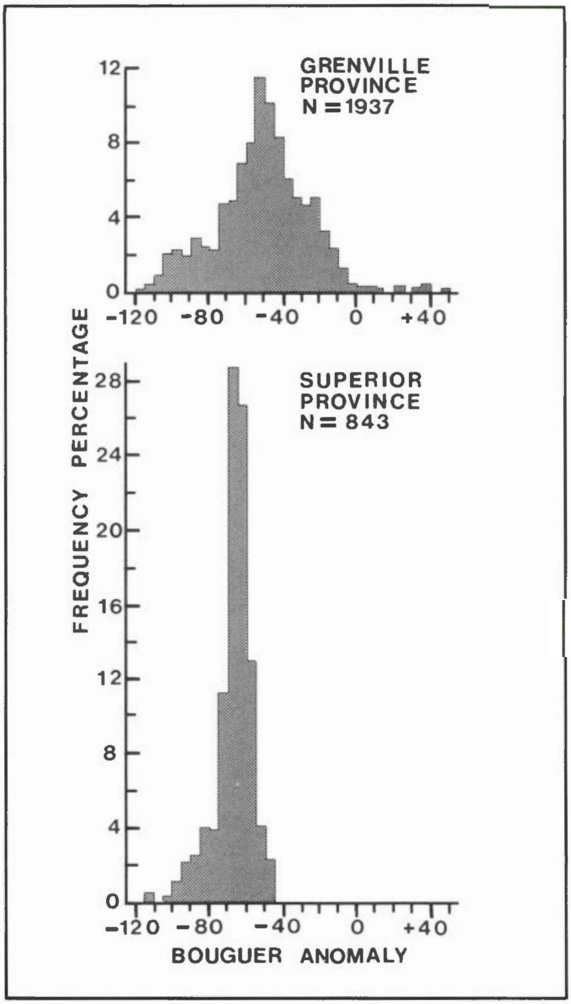

Figure 7. Histograms of Bouguer anomaly values for areas of Superior and Grenville provinces outlined on Figure 3.

Southern limit of Grenville area is defined by latitude 50° and north shore of the St. Lawrence.

N = number of sampling points.

Regional Correlation of Topography and Gravity Field

A comparison of regional Bouguer anomalies with topography (see Figure 8) indicates that changes in elevation do not influence the distribution of anomalies to any great extent; nor are they primarily responsible for the difference in the background levels of the gravity fields over the Superior and Grenville.

Regional Gravity Anomalies

Grenville Front Low

The Grenville Front low is one of the most prominent gravity anomalies in Canada, and extends for almost 1,200 km from Lake Mistassini to the Labrador Coast. It straddles the Grenville Front for the whole of this distance and maintains a close parallelism with it for about 900 km; it has a maximum amplitude of about 45 mgal.

From Lake Mistassini to the Labrador Trough, a distance of some 650 km, the anomaly is linear and trends northeastwards. Local positive anomalies occur on the southern flank of the anomaly over large gabbroic/anorthositic intrusions, but apart from these disturbances, the flank is linear and maintains an average gradient of about 1.0 mgal/km; the northern flank is not as markedly linear, but it maintains an average gradient of about 0.35 mgal/km. The limit of the anomaly to the north is defined approximately by the -70 mgal contour, and to the south by the -55 mgal contour, and between these, the width of the anomaly varies between about 125 to 175 km. The Grenville Front† lies about one-third of the way from the axis of the anomaly to its northern limit.

The northern flank of the anomaly passes uninterrupted from the Superior into the western part of the Labrador Trough, but in the eastern part, the contours are modified locally into northwesterly and north-northwesterly trends paralleling local structure. The southern flank of the anomaly, in the vicinity of the Labrador Trough, is largely controlled by the positive anomaly H6, which faces the trough across the Grenville Front.

East of the Labrador Trough the anomaly appears to be displaced southeastwards along the line of the Churchill River.* The displacement is best displayed by the southern flank, which has shifted an average distance (the average distance is quoted because the strike of the southern flank east of the Labrador Trough does not parallel the strike to the west; it is N 40° E as opposed to N 60°E) of 75 km. The northern flank is more or less continuous along strike with the northern flank observed farther west, and southeastwards displacement is minor, being at most only 25 km. The result of the differential movement of the southern and northern flanks, is that the anomaly has widened to an average width of about 225 km. Gradients of both the northern and southern flanks are closely similar to those on the corresponding flanks to the west. The axial area of the anomaly is largely occupied by the prominent gravity high H8; the Grenville Front lies about halfway between H8 and the northern extremity of the anomaly. The line of displacement is marked by a linear belt of steep gravity gradients (up to 1.7 mgal/km) which is interpreted to be the expression of a major crustal fault, along which the displacement has occurred.

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†Position of Grenville Front in this area (see Figure 3) taken from Geological Survey of Canada Map 1251A (1969) – Tectonic Map of Canada.

*On the 1:500,000 gravity maps accompanying this report, the Churchill River is called the Hamilton River.

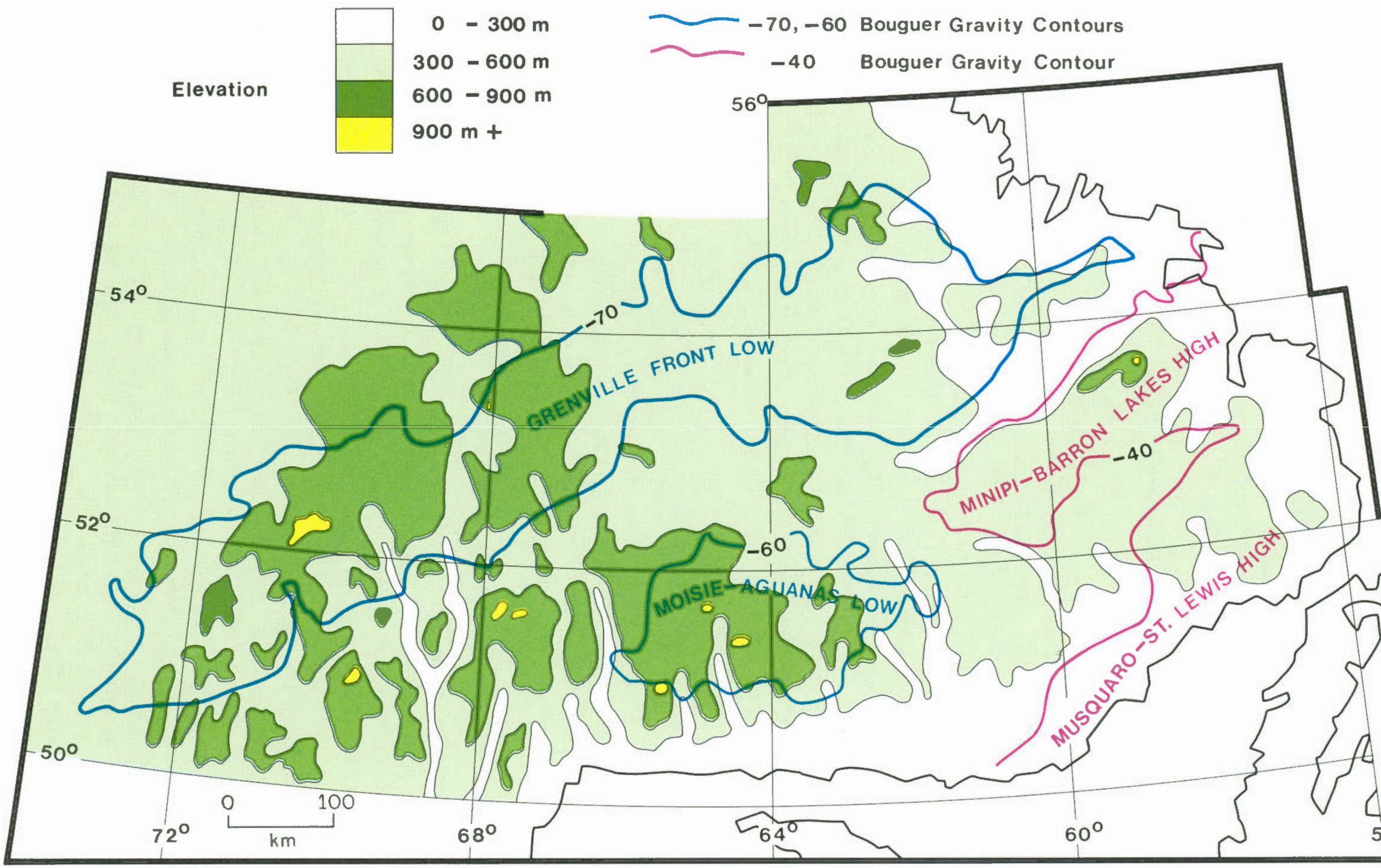

Figure 8. Relief map of region corresponding to Figure 3 with regional Bouguer anomalies superimposed.

The Grenville Front low changes character abruptly near the east end of the Naskaupi Fold Belt across a belt of steep gradients, up to 0.75 mgal/km, trending northwesterly; this belt curves around the northeastern margin of the Harp Lake Anorthosite to link up with the northern flank of the anomaly. Northeastwards from the belt the anomaly continues in modified form as a gently arcuate low across Makkovik Subprovince to the Labrador Coast; its attenuated amplitude is about 20 mgal, and it is about 70 km wide.

A series of profiles across the Grenville Front low is shown in Figure 9a; the lines of these profiles are indicated in Figure 3.

Previous Interpretations of the Grenville Front Low

Attention was first brought to the anomaly by Innes (1957) when it was only partially outlined, and he attributed it to large belt-like masses of granite emplaced during a period of late Precambrian mountain-building.

Later, Grant (1968) established detailed gravity profiles across the anomaly and computed several models to explain it. He divided the anomaly into two components – a negative portion corresponding to the negative axis, and a positive rise corresponding to the higher gravity field over the Grenville Structural Province. The former was explained in terms of a ridge or trough of lighter material, and the rise was attributed to an increase in the average density within the Grenville lower crust.

Tanner (1969) proposed that the anomaly arose from a denser upper crust in the Grenville, causing compensation at the base of the Grenville. The configuration of his model with southward-dipping interface between Superior and Grenville upper crusts, and a vertical face between the sub-Superior mantle and compensated Grenville, explains the anomaly.

Seismic investigations by Berry and Fuchs (1973) provided a new control on the gravity interpretation. Along their seismic profiles (see Figure 3), they interpreted crustal thicknesses of 34, 45 and 39 km, corresponding to the Superior, Grenville Front low area, and the Grenville respectively. They demonstrated that the increased thickness of the crust below the anomalous zone together with the occurrence of low velocity–low density layers in the upper crust, provides an explanation of the anomaly.

A Re-examination of the Grenville Front Low

Geologically the terrain underlying the Grenville Front low is extremely heterogeneous, and an obvious correlation between the anomaly and a particular lithology or lithologies is not apparent. At only one location does there appear to be lithological control on the distribution of the anomaly. This is in the region of the Harp Lake Anorthosite; here a steep gradient partially corresponds with the margin of the anorthosite, which lies essentially on the northern flank of the anomaly (see Figure 9b). Whether this correlation is meaningful, or whether the anorthosite represents a superimposed effect is difficult to ascertain. The densities of the anorthosites average 2.68 g/cm^3 and they would produce a negative effect against the gneisses which partially surround them (the probable upper limit of the average density of gneisses within the survey area is 2.72 g/cm^3 – see previous chapter). However, this effect would seem to be too small to account for the whole anomaly; it is also possible that the gradient at the anorthosite's margin may be largely due to the positive effect of surrounding highs, rather than to a negative effect caused by the anorthosite. An anorthositic source is therefore discounted.

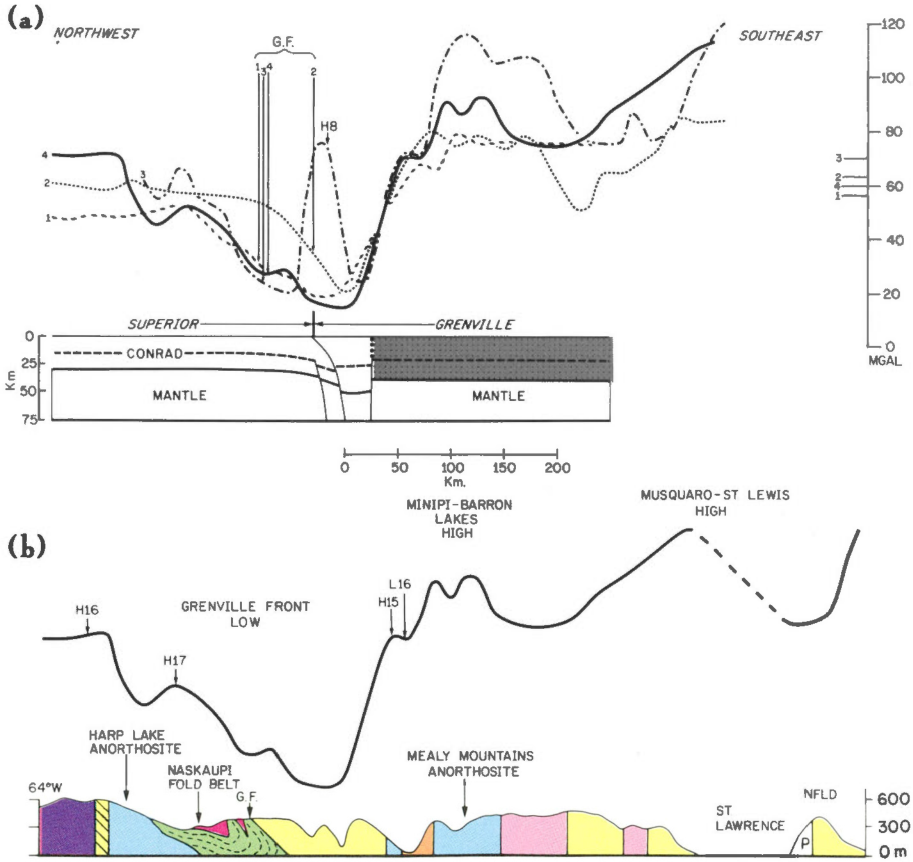

Figure 9. (a) Four superimposed gravity profiles across the Grenville Front low illustrating similarity in profile shape along length of the anomaly. A schematic crustal interpretation of the anomaly is given for profile 2. Shaded area of Grenville crust is interpreted as higher than 'normal' density material.

G.F. indicates position of Grenville Front with respect to each gravity profile.

Mgal scale is arbitrary and does not indicate absolute Bouguer anomaly values. Tick marks on left-hand side of scale indicate relative positions of same absolute Bouguer anomaly value for each profile.

(b) Gravity profile and schematic near-surface geological section along profile 4. Mgal scale is same as that for (a).

Geological legend as for Figure 10; P = Palaeozoic rocks.

The absence of extensive outcrops of low density rock-types in the anomalous terrain does not rule out their existence at shallow depths in the crust. The prevailing lithologies within the composite region of Figure 3 are gneisses, and on this basis, it may be argued that the bulk of the upper crust has a similar composition and hence similar average density. Based mainly on the densities obtained from the Grenville 1970 area, an upper limit for the normal upper crust (gneisses) may be taken as 2.72 g/cm^3, and rock-types which may produce a significant density contrast against a gneissic crust are: granites (2.63 g/cm^3), and quartzites (2.64 g/cm^3). The possibility of such lithologies giving rise to the anomaly is now examined.

Evidence in favour of a granitic source for the anomaly is not strong, and some of it is indirect. Relatively small granites do occur within the anomalous region, but these are few, and are not concentrated in the axial zone where they might be expected. Elsewhere in the Canadian Shield, granites sometimes give rise to large negative anomalies (up to 30 mgal), but these are of relatively limited extent compared to the Grenville Front low. This last observation is perhaps the most convincing piece of evidence against a granitic source for the anomaly; that the granitization process could maintain with such uniformity for such a distance, seems highly improbable. Therefore, while granitic rocks may contribute to the anomaly, they are not considered to be the primary cause, and Innes' (1957) hypothesis is rejected.

Quartzitic rocks have been recognized in a belt of metasedimentary strata, which extends southwestwards from the Kaniapiskau strata of the Labrador Trough along the axis of the anomaly as far as Lake Mushalagan (Dimroth *et al.*, 1970). The quartzites and metasediments are therefore favourably positioned to contribute to the anomaly. However, the possibility of these lithologies being the major source of the anomaly is discounted on the following grounds: similar strata do not occur elsewhere along the axial region of the anomaly; much of the strata is highly metamorphosed thereby eliminating the chances for low density rocks; quartzites are not the prevailing lithology; significant differences in density between the metasediments and the surrounding igneous and metamorphic terrain has so far not been recognized; and finally – and perhaps the most important reason – a similar negative anomaly overlies a part of the Labrador Trough, which contains similar strata in a relatively fresh condition, but the bounding gradients of this anomaly are not always coincident with the Superior/Trough margin, and in places traverses the Superior, suggesting a deeper source than the exposed Kaniapiskau succession. Grant (1968) had proposed that the anomaly might be due to a deep infold of metasedimentary material; this possibility is discounted on the basis of the foregoing evidence.

It is concluded from the available evidence that while anorthosites, granites and some sediments may contribute to the Grenville Front low, they are not the principal source. The great areal extent of the anomaly, and the linearity and consistent gradients of its flanks across a heterogeneity of geology, strongly suggest that the anomaly results from large scale crustal variations involving considerable thicknesses of the crust, rather than from shallow lithological variations. The uniformity of the gravity anomaly along its length is illustrated in Figure 9a, in which four profiles (see Figure 3 for lines of profiles) across the anomaly are superimposed on each other; the profiles were lined up around the southern flank gradient, with the midpoint of each gradient being the reference point. The reason for the superimposition in this manner is an assumption that the southern flank gradient arises along a vertical break in the crust. It may be seen that the profiles are remarkably similar. Since two profiles were taken from each side of the Labrador Trough, the similarity outlined in Figure 9a is also taken as evidence that the portion of the anomaly to the east of the trough is indeed an extension, albeit offset, of the anomaly to the west of the trough.

A model satisfying the anomaly based on large scale crustal variations has already been presented by Tanner (1969). The model comprises a compensated, denser than normal Grenville upper crust in contact with Superior crust of normal density. The compensating base of the thicker Grenville is then the primary cause of the low, and the denser upper crust dipping at about 45° southeastwards from the vicinity of the Grenville Front to a uniform depth of 20 km explains the steep southern flank of the anomaly, and the higher field over the Grenville. Tanner's (1969) model is to a certain extent supported by the seismic results of Berry and Fuchs (1973), who interpreted a thicker Grenville (39 km) than the Superior (35 km). However, under the axis of the low the seismic thickness is increased to 45 km. This crustal root was interpreted by Berry and Fuchs (1973) to partially account for the anomaly, while the rest of the negative effect was attributed to low velocity channels, interpreted as low density (2.43 g/cm^3) layers. The idea of such low density material at depth within a crystalline shield is not supported by surface density measurements, so the interpretation is not fully accepted, though the presence of a crustal root seems reasonable. The interpretation presented herein is a modified compromise of Tanner's (1969) and Berry and Fuchs' (1973) models. Before discussing the details of the proposed model, the evidence for a deep origin of the anomaly is outlined.

The northern limit of the anomaly over the Superior is about 90 km from the Grenville Front, and the northern gradient continues uninterrupted to at least the central part of the Labrador Trough. Therefore it appears that the anomaly is generated at some depth greater than the base of the Labrador Trough. Unfortunately, at the point where the limit of the anomaly traverses the trough, information on the thickness of the trough rocks is incomplete, though Frarey (1961) indicates that at least 4.4 km of strata are present. More complete information is available for Wakuach Lake map-area centred approximately 120 km farther north. About 9.1 km of Kaniapiskau strata and 6.1 km of intrusive sills are described (Baragar, 1967), giving a composite thickness of 15.2 km. Great thicknesses of intrusives are not prevalent in the vicinity of the northern flank, but if the thickness of the Kaniapiskau maintains along the trough, then a depth to the bottom of the trough in the anomalous zone may well be as large as 9 km.

Other evidence for a deep source is based on the prominent highs of the region, which have all been attributed to gabbroic intrusions. The gross similarity of the anomalies both in areal extent and amplitude suggests that the causative bodies are emplaced into an upper crust of fairly uniform density. On this basis, the fact that a few of these highs occur within the region of the Grenville Front low may be taken as evidence that the upper crust underlying the low is of normal density. Since H8 which occurs in the axis of the low has an interpreted maximum depth of 10 km, the source of the anomaly must be deeper.

The following interpretation of the Grenville Front low is proposed on the basis of the foregoing discussions. It is suggested that the northern flank of the anomaly results from the downward bending of the Superior, Churchill and Nain crusts towards the axial region of the anomaly. The effect of the downwarping would be to induce a horizontal density contrast within the crust caused by the lateral passage of one major crustal layer into another (Berry and Fuchs (1973) interpreted a two-layer crust for the Superior), and also a density contrast between the lower crust and the mantle. Supporting evidence for downwarping is available in the form of the string of sedimentary-volcanic basins which lie along the Grenville Foreland Zone; presumably they owe their preservation to downflexuring of this type. The extensive nature and linearity of the southern flank are interpreted in terms of a major fault juxtaposing portions of crust with contrasting density. Unfortunately, a major fault along the southern flank has not been recognized, and the most important tectonic feature of the region, the Grenville Front, lies up to 100 km north of the postulated break, north of the axis of the anomaly. Reconciling the positions of these phenomena in terms of a plausible geodynamic model is therefore difficult, and the problem requires further study. Possibly, the Grenville Front originated as a tensional fracture during the period of downflexuring; it may later have been reactivated during the Grenville Orogeny, which may also have obliterated surface evidence for a major fault underlying the southern flank. A schematic model illustrating the proposed structure corresponding to the gravity profile along line 2 of Figure 3 is given in Figure 9a. The negative portion of the anomaly is attributed to a combined effect of the downwarping, and the crustal root of Berry and Fuchs (1973), while the steep southern flank and the higher field over the Grenville are interpreted to arise from a denser section of the Grenville crust. On the basis of the evidence for a deep source for the anomaly a position within the lower part of the crust is favoured for the denser section, but possibly higher density material is distributed throughout the entire Grenville crust.

East of the Labrador Trough the model requires some modifications, since the anomaly is wider and contains the prominent positive anomaly H8 in the axial region. Part of this widening may be due to the gabbroic body interpreted to generate H8; the width of the anomaly is about 50 km, and if this distance is added to 175 km, the prevailing width of the anomaly west of the Labrador Trough, then the sum is 225 km – the average width of the anomaly east of the trough. On this basis it may be proposed that the increase in width is due to crustal dilation brought about by intrusion of the gabbro; the differential displacement of the northern and southern flanks (25 km and 75 km respectively) of the anomaly could also be explained by this mechanism. There is, however, a major objection to this interpretation, in that the gabbro while it has a surface width of about 50 km does not maintain its width at depth, since it is saucer-shaped with a maximum depth of 10 km (see Figure 10). The problem is therefore more complex than the simple picture obtained from the addition of anomaly widths; detailed model studies are required before an acceptable explanation can be presented.

The steep gradients which separate the main anomaly from the attenuated portion overlying Makkovik Subprovince do not correlate with the geology, but traverse geological boundaries and in places cut across the prevailing structural grain. From this it is considered that the source may be a buried major fault rather similar to that proposed for the southern flank of the anomaly. The attenuated portion, itself, correlates largely with paragneisses, which Stevenson (1970) describes as containing much intrusive pegmatitic material. Possibly the pegmatites originated from a granite at shallow depth, and this may be the cause of the anomaly. If not, then large scale crustal variations would be necessary to account for it. Again, model studies are needed before a more comprehensive treatment can be given.

Moisie-Aguanas Low

A broad regional low occurs in the south-central part of the area. Values in this region are as low as -38 mgal A.G.M.* Tanner (1969) suggested that the anomaly is the result of

*Note: Because it is sometimes difficult to estimate the amplitude of some anomalies, their maximum or minimum values are given relative to the modal Bouguer anomaly of the Grenville histogram (Figure 7). 50 mgal A.G.M. means 50 mgal above Grenville mode.

Density contrast for all models is +0.25 g/cm^3. Small bodies with a negative density contrast (−0.1 g/cm^3) have been included in the interpretations of H8 and H9.

Observed curves for H1 west, H2, H8 and H9 represent residual curves after removal of a regional background. In the H9 residual curve the small positive anomaly immediately southwest of H9 has also been removed.

Values placed on elevation scale for each model correspond to feet (1,000).

Mgal scales are arbitrary and do not correspond to actual Bouguer anomaly values for each anomaly curve.

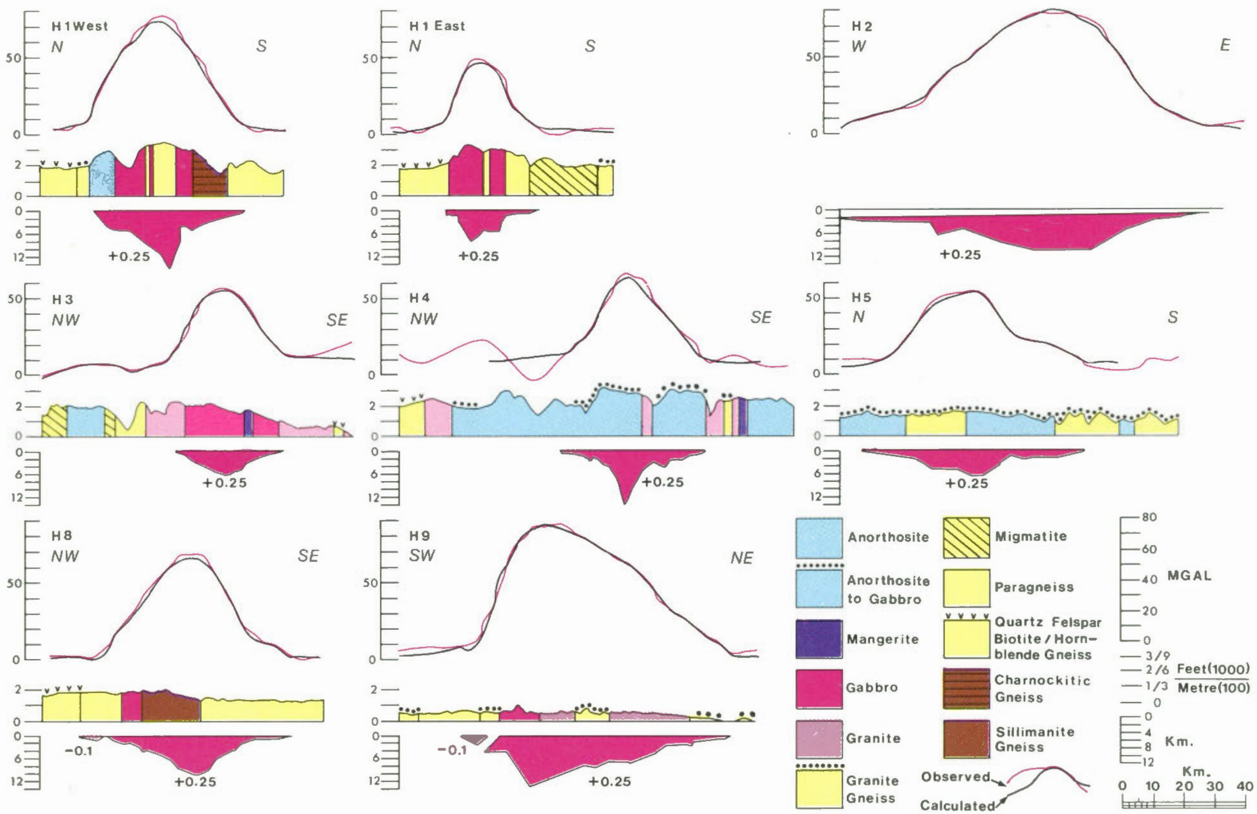

Figure 10. Gravity profiles, interpreted models and near surface geological sections for selected major gravity highs.

compensation at the base of the crust for the high density body interpreted to underlie H4. Tanner's (1969) interpretation is questionable because of the absence of large regional gravity lows (except in the case of H8) being associated with the other prominent highs. The present interpretation favours granites and to a lesser extent anorthosites as the principal cause of the anomaly. Granites in the area have very low densities (average 2.63 ±0.04 g/cm^3), and they are widespread, suggesting that the anomaly may be attributed to a concentration of granites. Some anorthosites in the region which have densities as low as 2.68 g/cm^3 may also contribute to the anomaly.

Minipi-Barron Lakes High

The Minipi-Barron Lakes high parallels closely the Grenville Front low for about 350 km, between the Little Mecatina River and the Labrador Coast. It attains an amplitude of about 50 mgal A.G.M. In large part the two regional anomalies are bounded by steep gradients along their contiguous margin, but it is possible to delineate the anomalies along a belt of gentle gradients and locally negative gravity extending from the lower reaches of the Churchill River through Lake Melville to Double Mer. To the southwest the anomaly is terminated by a west-northwesterly belt of steep gradients which follows the Little Mecatina River. Bounding gradients to the southeast are not as steep, and these separate the anomaly from a broad triangular region which has values close to the Grenville mode; this area separates the anomaly from the Musquaro-St. Lewis high.

The anomaly correlates extremely well with the geology, and there is little doubt that the anomaly is attributable to anorthositic and related rock-types, which contain high density gabbroic material, and which underlie much of the southern and central part of the anomaly. The bounding gradients of the anomaly, in large part, follow closely the boundary between the rocks of the anorthositic series and the lighter surrounding rocks, which are mainly gneisses and granites. The fact that these gradients are distributed in linear belts suggests that they are controlled to a certain degree by faulting. In support of this idea is the proposal by Kranck (1947) that Lake Melville and the Mealy Mountains constitute a graben-horst system, which system coincides with part of the belt of steep gradients defining the northwestern margin of the anomaly. The southwestern margin of the anomaly is also considered to be controlled by similar major faulting, involving much of the crust. The northern ground of the anomaly comprises mainly quartzofeldspathic gneisses, but the continuance of the steep northwestern flank of the anomaly and the anomaly itself, to the Labrador Coast suggests the presence of anorthositic and related rock-types at shallow depths beneath the gneisses. A profile illustrating the relationship of the anomaly to the surface geology is shown in Figure 9b.

Musquaro-St. Lewis High

The Musquaro-St. Lewis high occupies the coastal region between Musquaro and the Alexis-St. Lewis Inlet area. Its trend is essentially northeasterly, apart from a northerly segment in the vicinity of the Rivière St. Augustin, and its amplitude attains about 50 mgal A.G.M. The trend is outlined essentially by the steep gradients (up to 1.5 mgal/km) trending linearly which bound the northwestern margin of the anomaly. Geological control for the southern part of the anomaly is very poor, and in the northern part (G.M.S. No. 96) where the geology is better known there is no ready correlation between gravity and geology; the gravity gradient often cutting across geological boundaries at high angles. In this northern part the anomaly corresponds areally with mainly granites, granodiorites and granitic gneisses, which are also the main lithologies outside the anomalous terrain. A possible clue to the cause of the anomaly is afforded by relatively small outcrops of gabbro and monzonitic-granodioritic rocks of anorthositic affinity (Eade, 1962), which occur within or close to the main closure of the anomaly. It is suggested, by analogy with the Minipi-Barron Lakes high, that the anomaly is underlain at no great depth by an anorthositic complex of similar nature to that of the Mealy Mountains region, and that the complex is fault bounded along its northwestern margin which accounts for the extensive linear belt of steep gradients.

Description of Gravity Highs

In this section 19 gravity highs and their relationship to geology and topography are described. Wherever possible an estimate of the absolute amplitude of the anomaly is given, but where background effects (e.g. proximal lows) make this difficult, the amplitude is quoted as a value relative to the modal Bouguer value (-52.5 mgal) for the Grenville. The prominent high amplitude (30 mgal A.G.M. to 85 mgal) anomalies (H1 to H9) are described first, and preliminary two-dimensional model interpretations are presented for seven of these. All of the latter are interpreted as gabbroic bodies, and a density contrast of 0.25 g/cm^3 (based on a gabbro-gneiss contrast) has been used in each case. The lines of the gravity profiles used in the interpretations are indicated in Figure 3. The remaining highs (H10 to H18) have amplitudes which are less than 20 mgal or 20 mgal A.G.M., while the coastal anomaly (H19) attains 40 mgal amplitude. It will be useful to refer to the facing diagrams Figures 2 and 3 in following this section, and the succeeding one describing gravity lows. More detail concerning the gravity anomalies is available on the 1:500,000 Bouguer anomaly maps; the relevant map for each anomaly is indicated in the title heading (e.g. G.M.S. No. 67).

H1 – Little Manicouagan Lake Anomaly (G.M.S. No. 65) – Grenville

The Little Manicouagan Lake Anomaly occupies a broad triangular region centred southwest of the lake of that name. The base of the triangle forms the northern limit to the anomaly, and is about 150 km long running east-west; the height is about one-third of the base. The western half of the anomaly is located within the contiguous region of Figure 3 and trends W 28°N producing local perturbation on the southern flank of the Grenville Front low; the eastern half trends E 23°N. An estimate of the maximum amplitude of the anomaly above background is 75 mgal. The terrain in the region is about 500 m higher than the surrounding country, but any terrain effect is insignificant compared to the amplitude of the anomaly.

Geologically the area is complex and comprises a variety of lithologies. Anorthositic rocks occur under the northern extremities of the anomaly, and are bounded to the north by the Harte Jaune Fault, which separates them from amphibolite-grade granitic gneisses; the fault is thought to be an upthrust but the amount of displacement is unknown (Kish, 1968). A shear zone separates the anorthositic rocks from more extensive outcrops of granulitic gabbros farther south, which probably represent recrystallized basic igneous rocks. In places the gabbros are interlayered with granulite-grade paragneisses, which together with some charnockitic gneisses form much of the southern ground of the anomaly. The southern limit of the anomaly follows closely the contact between the granulite-facies varieties and migmatites.

The whole of the anomalous area coincides with an irregular pattern of magnetic anomalies of higher intensity than the surrounding region (G.S.C.* map 7372G), which

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*G.S.C. – Geological Survey of Canada.

suggests that the near surface distribution of anomalous mass covers the same area. This is a control on the gravity interpretation, in that the causative body is likely to extend from near the surface downwards. East of the Manicouagan River the magnetic pattern is less complex and less intense, which considering that the gravity anomaly is also reduced may be indicative of faulting along the course of the river.

The distinctive nature of the anomaly suggests that it is generated by a single lithology having considerable density contrast with the country rocks. Gabbros are prevalent in the anomalous area and are interpreted as the cause of the anomaly. Model interpretations were made along two profiles, one west of the River Manicouagan, and the other east of the river. Inverted approximately triangular cross-sections were interpreted for both profiles (Figure 10); the apex of the triangle attains a depth of 14 km for the west profile, and 8 km for the east profile. Part of this difference may be due to possible faulting along the Manicouagan River, but much of it may be due to gradual thinning of the body towards the east.

H2 – Sept-Iles Anomaly (G.M.S. No. 65) – Grenville

At Sept-Iles a semicircular pattern of steep gravity gradients envelopes the large bay, and correlates closely with anorthositic and gabbroic rocks, which are surrounded by migmatites and gneisses. These gradients are part of a much larger circular anomaly, with a diameter of about 90 km and amplitude 75 mgal, centred in the northern part of the St. Lawrence (Figure 3). The anomaly extends south-southeastwards across the St. Lawrence as a ridge of reduced amplitude. The whole anomaly corresponds closely in distribution with a prominent magnetic anomaly (G.S.C. maps 7353G, 7354G, 7361G and 7362G). The gradients of the gravity anomaly, which are quite steep onshore near the margins of the anorthositic and gabbroic rocks, become relatively gentle across the bay before becoming steeper again across the islands (this feature is more clearly observed on Gravity Map Series No. 86, which accompanies a report by Goodacre *et al.*, 1969).

This concentricity in the anomaly pattern for the northern part of the anomaly may reflect layering within the underlying mass, with lighter material outcropping under the bay. Acidic igneous phases have been mapped in the islands by Faessler (1942) lending support to such a possibility. Concentricity is also apparent in the magnetic pattern in the north, but the magnetic anomalies do not coincide in position with the changes in the gravity gradients; however, the magnetic anomalies possibly result from layering within the basic components of the anomalous mass.

The average density of rocks collected from the Sept-Iles district is 2.80 ±0.13 g/cm^3, but several acidic varieties are included, and this value is probably not representative of the main component of the body, which is interpreted as a gabbro. A model which satisfies the anomaly is shown in Figure 10; it is based on a density contrast of 0.25 g/cm^3. It is a broad basin-like body with a maximum depth of 11 km below sea level. Aeromagnetic depth estimates using the method of Vacquier *et al.* (1951) place the upper surface of the body at about 2 km below sea level at the southwest end of the profile, and 1.2 km at the northeast end. Since the body is exposed on the coast, some faulting along the coastline is probably responsible for the greater depth to the upper surface under the St. Lawrence.

H3 – Lac Travers Anomaly (G.M.S. No. 65) – Grenville

A broad oval-shaped anomaly of about 45 mgal amplitude striking northeasterly is centred on Lac Travers; it parallels and lies immediately east of the boundary between Wynne-Edwards' (1972) Baie Comeau Segment and Eastern Grenville Province. The anomaly has a length of about 50 km and width of 35 km. To the southwest it is connected by a gravity saddle to the Sept-Iles Anomaly. The anomaly coincides with rocks mapped as gabbro, but which may be locally gabbroic anorthosite or anorthositic gabbro (Sharma and Franconi, 1973); mangeritic varieties occupy restricted outcrops within the gabbro. The surrounding terrain comprises mainly granites, migmatites and paragneisses. The gabbro also correlates with an irregular pattern of magnetic anomalies, which are of higher intensity than those of the surrounding border zone (G.S.C. map 7361G). Terrain in the region is fairly rugged and rises from about 460 m in the southwest to over 760 m in the northeast.

A gabbroic model was interpreted for the anomaly with a broad basin-shaped cross-section having a maximum depth of 6 km (Figure 10). The profile used in the interpretation (Figure 3) crosses from granite into gabbro and back to granite, and presumably a higher density contrast than 0.25 g/cm^3 should have been used. However, because of the variable composition of the surrounding terrain, lack of knowledge concerning the depths of the granites, and the preliminary nature of the model interpretations, 0.25 g/cm^3 was considered reasonable.

H4 – Magpie Anomaly (G.M.S. No. 65) – Grenville

Centred about 130 km northeast of the centre of the Lac Travers Anomaly, and lying more or less on the same strike, is a large elongate elliptically-shaped anomaly with an amplitude of about 55 mgal. It has a strike-length of about 80 km and a width of about 45 km, and runs northeastwards from Magpie Lake; it parallels the Baie Comeau Segment-Eastern Grenville Province boundary of Wynne-Edwards (1972), which is about 45 km to the northwest. It overlies the eastern part of the Lac Fournier massif (Sharma and Franconi, 1973), which area corresponds to the Magpie Anorthosite of this report (see Figure 4). The predominating lithologies in the region are gabbroic anorthosite and anorthositic gabbro, but gabbro, syenite, mangerite, and granite also occur in the anomalous zone. The area has considerable relief ranging from 300 m to 900 m above sea level, but any terrain effects are insignificant compared to the size of the anomaly.

The eastern portion of the Lac Fournier massif was mapped by Sharma and Franconi (1973) as containing anorthositic varieties which are relatively enriched in mafic minerals compared to those in the western portion. This difference is reflected in the average densities of the two regions; the Lac Pierres Anorthosite (western portion) has an average density of 2.77 ±0.12 g/cm^3, while the Magpie Anorthosite has an average density of 2.85 ±0.11 g/cm^3. This difference (0.08 g/cm^3) is insufficient to explain the anomaly, but the presence of the gravity high and the fact that the rocks are more mafic suggest the existence of a more basic body beneath the area. It is envisaged that with increasing depth the rocks become progressively enriched in mafic minerals until their composition becomes that of a gabbro. The depth at which the pure gabbro develops is difficult to assess, but a gabbroic model has been interpreted extending from sea level to a maximum depth of about 13 km (Figure 10); the cross-section shape of this model is approximately triangular.

The enrichment of the anorthosite in mafic minerals towards the anomaly, and the great mass of gabbro interpreted to underlie it may have some significance for the development of the anorthosites in the region. It is possible that the gabbro occupies the site of the lower levels of a former magma chamber and has been produced by gravity settling of the mafic minerals while flotation of the lighter plagioclase has given rise to the anorthosites by an adcumulus process similar to that examined by Morse (1968). The area is extremely interesting in this respect, and requires further study before a comprehensive model of anorthosite genesis can be presented.

H5 – Lac Philipot Anomaly (G.M.S. No. 64) – Grenville

A broad oval-shaped anomaly centred close to Lac Philipot has an amplitude of about 45 mgal. Its areal dimensions are about 90 km by 70 km; the long axis strikes between west and west-northwest and parallels the nearby belt of anomalous gradients defining the southwestern margin of the Minipi-Barron Lakes high. The geology of the region is not known in detail, but it appears that granitic gneisses underlie the western part of the anomaly, and gabbroic and anorthositic rocks the eastern part. Unlike the terrain over several of the other high amplitude anomalies, the ground over the anomaly is comparatively flat. The aeromagnetic pattern (G.S.C. map 7369G) does not correlate closely with the anomaly, though narrow positive curvilinear anomalies skirt its eastern extremities, and near the centre positive anomalies strike westerly and northwesterly parallel to the overall trend. The anomaly is interpreted in terms of a gabbroic mass; the depth to the top of the body is questionable but a saucer-shaped model has been derived extending from sea level down to a depth of 6 km (Figure 10).

H6 – Rivière aux Poissons Anomaly (G.M.S. No. 67) – Grenville

A large crescent-shaped anomaly with an amplitude of 35 mgal A.G.M. lies between Ashuanipi and Ossokmanuan Lakes, and faces the Labrador Trough across the Grenville Front. The central linear portion of the axis of the anomaly lies more or less along the strike of the southern flank of the Grenville Front low, with the result that the flank is not discernible as a separate feature, and H6 dominates the gravity field. The linear central axis of the anomaly parallels the Grenville Front low over about 50 km. On the south side of the anomaly, the tails of the crescent enclose a marked negative anomaly L12, which has an amplitude of -25 mgal A.G.M. Most of the northern part of the anomaly is underlain by gabbro altered to pyroxene-gneiss, while the tails are underlain mainly by paragneiss and sillimanite gneiss. The terrain is generally higher over the gabbroic outcrops reaching up to 300 m above the surrounding country.

Because of the position of the anomaly with respect to the Grenville Front low and to L12, selection of a suitable residual anomaly for model interpretation is extremely problematical, and so only a qualitative interpretation is given at this time.

The anomaly is believed to represent the combined effect of two separate geological features. Firstly there is little doubt that the altered gabbros of the area contribute to the anomaly; by analogy with models presented for other prominent gravity highs in this report the gabbros probably extend to a depth of several kilometres. Secondly the unusual shape of the anomaly and its position with respect to the Grenville Front low suggest that a fault-bounded block of denser Grenville crust also contributes to the anomaly. It is thought that this block of crust has been moved northward between faults coinciding in position with the steep gravity gradients bounding the anomaly on the west and the east (see Figure 11). Besides the presumed lateral displacement, there is ample geological evidence in support of vertical displacement; the anomaly in part coincides with cataclastically deformed gabbros, gneisses and metasediments immediately south of the Grenville Front, which are believed to have been thrust northward (Wynne-Edwards, 1961).

H7 – Long Lake Anomaly (G.M.S. Nos. 66 and 67) – Grenville

Located between Atikonak Lake and Fig River, an elongate oval anomaly of amplitude 30 mgal A.G.M. strikes east-northeasterly for 80 km over ground mapped largely as sillimanite gneiss. As for several of the previous H anomalies, the terrain underlying the anomaly is considerably higher (150 to 300 m) than the surrounding land, which in this case is mapped as mainly paragneiss. Gabbroic rocks outcrop in the western portion of the anomaly and are interpreted as the source; they probably form a core to the sillimanite gneisses. The proposed fault zone along the east side of H6 may extend southeastwards along the western margin of the anomaly, while the eastern margin is bordered by the major line of dislocation along the Churchill River which offsets the Grenville Front low. No model interpretation was attempted for this anomaly because of the difficulty in separating local and regional effects.

H8 – Ptarmigan Lake Anomaly (G.M.S. No. 66) – Grenville

The Ptarmigan Lake Anomaly is located completely within the Grenville Front low. It is an elongate oval anomaly with a length of about 130 km and width of 50 km; it trends approximately E 35°N. The amplitude, after removing a regional trend, is about 70 mgal. The anomaly overlies high ground – up to 300 m higher than the surrounding terrain – comprising in the southwest mainly sillimanite gneisses, and in the northeast mainly anorthositic, gabbroic and basic-ultrabasic varieties together with some amphibolites. The surrounding lithologies are largely paragneisses. A gabbroic model has been interpreted for the anomaly, which has a broad basin-like cross-section attaining a maximum depth of 10 km (Figure 10). As for H7 the sillimanite gneisses in the southwest portion of the anomaly probably form a mantle on the gabbros.

H9 – Hawke River Anomaly (G.M.S. No. 96) – Grenville

One of the most remarkable anomalies in the region occupies the coastal region southeast of Sandwich Bay. It is distinctive in two respects; the first is its unusual trend, which is west-northwesterly, and the second is the fact that it is the only area of absolute positive Bouguer anomaly within the study area, and values attain +50 mgal. The high Bouguer values result from the anomaly being superimposed on the regionally high gravity field resulting from the confluence of the Minipi-Barron Lakes high and the Musquaro-St. Lewis high. The strike length of the anomaly is about 120 km and the width is 75 km. Terrain is about 150 m above sea level over most of the region, and is fairly gentle.

After removal of a regional anomaly the residual anomaly has an amplitude of about 85 mgal. The southern flank of the anomaly has the steepest gradients in the study area with gradients locally as steep as 5.7 mgal/km. This flank parallels the contact between granitic gneiss to the south and gabbroic rocks to the north; the latter occur in a broad linear band. Northeastwards the gabbros are succeeded successively by parallel bands of granite-granodiorite, gabbro and granitic gneiss. Northeast of the granitic gneiss the remainder of the anomaly is underlain mainly by a broad crescent-shaped outcrop of granite-granodiorite. Along the northern margins of the anomaly smaller areas of gabbro and intermediate-basic gneiss have been mapped. Granitic gneisses and paragneiss form the main country rock around the anomaly.

A model has been interpreted for the anomaly in terms of a gabbroic mass; an essentially triangular cross-section has been computed with the base lying at sea level and the apex reaching a depth of 13 km (Figure 10) under the southwestern part of the anomaly. The southern contact between the gabbro and granitic gneiss is interpreted to be southerly dipping away from the anomaly; in all other models inward-sloping contacts have been computed. An outward-dipping contact is favoured in H9 because of the association of the very steep gradient with the contact, which traced towards the coast shifts progressively to overlie mainly the granitic gneiss.

The fact that granitic gneisses and granite-granodiorite overlie the central portion of the anomaly, which has produced a model of gabbro with a cross-sectional area of about 500 square kilometres suggests that they are probably very thin. It is likely that the granitic and gneissic rocks form a thin veneer on top of the main gabbro mass, and they may represent an acidic differentiate in a layered complex. The existence of gabbro outcrops around the periphery of the anomaly adds support to such an hypothesis. Allowance for the upper granitic-gneissic layer was not made in the interpretation.

H10 – (G.M.S. Nos. 65 and 67) – Grenville

An extensive positive anomaly runs for about 160 km from Lac Felix southwards to Lac Louis; the width ranges generally from 40 to 50 km. The anomaly is noteworthy, since it is one of the few north-south trending anomalies in the region of any considerable extent. The maximum amplitude is about 10 mgal A.G.M.

Most of the area comprises grey quartz-plagioclase-biotite/hornblende gneisses; migmatites are fairly widespread, and there are smaller areas of charnockitic gneisses; granitic gneisses, paragneisses and gabbro. Density information is practically non-existent for the whole of the anomalous zone so it is difficult to suggest a possible source for the anomaly. Also there is no lithology present which might yield a high density excepting the gabbro which has a limited outcrop. Qualitative inspection of the topography suggests that the anomaly is not terrain-generated. No magnetic anomaly corresponding to the gravity anomaly is apparent (G.S.C. map 7372G).

The source of the anomaly may be a fault-bounded block of denser crust trending in a north-south direction. Some support for such a structure which might control surface structures, is to be found in the work of Franconi *et al.* (1971), who mapped north-south trending elements in the area. Typical Grenvillian structures (northeasterly) are attenuated in rocks thought to be affected by the older north-south deformations; these rocks include the grey gneisses and migmatites, which occur widely in this area.

H11 and H12 – (G.M.S. Nos. 64 and 65) – Grenville

Two triangular areas of positive Bouguer anomalies occur along the north shore of the St. Lawrence. Geologically the two regions are quite different, but the maximum anomaly over both are approximately the same – roughly 20 mgal A.G.M. This suggests that the anomalies are produced by sources at some depth. Portions of the Havre St. Pierre and Romaine River anorthositic massifs underlie H11, while H12 is underlain partially by the Wakeham Bay Group and partially by the surrounding granites, gneisses and quartzites. There is some degree of correlation between the north-northwesterly trend of the Wakeham Bay syncline and the shape of H12. The controlling factor may well be the numerous gabbroic bodies within the Wakeham Bay Group and/or some parent material below.

The height of the area lies mainly between sea level and about 610 m, and while the general lowering of the terrain towards the St. Lawrence may contribute to increases in the Bouguer anomalies in this direction, it is not thought to be the major cause.

H13 – (G.M.S. Nos. 65 and 67) – Grenville

A series of three closures outlines a gravity high running for 110 km from Caopacho Lake northeastwards towards Atikonak Lake; the average width is about 30 km. The amplitude of the anomaly is fairly low being only about 10 mgal A.G.M.

The predominating lithology in the area is sillimanite gneiss; smaller areas of charnockitic gneisses, metasedimentary granitoid gneisses, and minor areas of gabbro, undivided basic to ultrabasic rocks, granitic rocks and crystalline dolomite also occur. The two larger closures overlie areas where gabbroic rocks are concentrated, and it is concluded that these and larger masses of gabbro at depth are responsible for the high gravity values. The anomalous terrain attains up to about 300 m above the surrounding country, which is mainly paragneisses.

H14 – (G.M.S. No. 66) – Grenville

A relatively small broad quadrilateral-shaped anomaly some 30 km wide runs northeastward from Belisle Lake for about 50 km. It has a maximum amplitude of about 15 mgal A.G.M. Lithologically the area is mapped as three broad bands, which, from southwest to northeast, are basic-ultrabasic rocks, quartzofeldspathic gneisses, and granites. The first group continuing at depth below the anomalous zone is interpreted to generate the anomaly.

H15 – (G.M.S. No. 66) – Grenville

A small area of positive anomaly overlies primarily anorthositic rocks immediately northwest of Goose Bay; the maximum amplitude is approximately 15 mgal A.G.M. Although anorthosite is well exposed in this region (Stevenson, 1967a), densities of anorthosites measured from the Grenville 1970 area (see Figure 6) do not appear to be sufficiently high to produce an anomaly of this amplitude. It seems probable that gabbroic phases are present in large volumes, a possibility which was suggested by Stevenson. Magnetically the main part of the gravity anomaly is fairly featureless and of lower intensity than the surrounding country (G.S.C. map 7391G). The anomaly continues as a ridge of subdued amplitude northeastwards to Mulligan River.

H16 – (G.M.S. No. 98) – Churchill

A ridge-like gravity high runs along the western edge of the Harp Lake Anorthosite and then continues southwards through Keep and Fraser Lakes along the eastern margin of the Michikamau Anorthosite. It is difficult to accurately estimate the absolute amplitude because of bordering lows and the proximity of the Grenville Front low to the south. A rough estimate of the amplitude is 15 mgal. The geology is extremely varied along the length of the anomaly; from north to south it passes from adamellite and granitic gneisses to granitic gneisses which are pyroxene-bearing in part and pyroxene-bearing granitic rocks. In the southernmost part of the anomaly anorthositic rocks belonging to the Michikamau intrusion, granites and paragneisses are present. There is no clue in the surface geology as to the cause of the anomaly, and terrain effects are also ruled out since the country is fairly flat. A buried basic source is postulated.

H17 – (G.M.S. No. 98) – Nain

Running north-south from Shipiskan Lake across the western portion of the Naskaupi Fold Belt a ridge-like gravity high appears to terminate in the vicinity of the Grenville Front, where the Grenvillian granitic rocks are thrust northwards over the Seal Lake and Letitia Lake rocks. Estimation of the amplitude is extremely difficult because of proximal anomalies, but it is approximately 15 mgal. There is no apparent correlation between the geology and the anomaly, except perhaps at the southern end near the Grenville-Seal Lake Group contact, where a steeper gravity gradient suggests that the causative body, possibly a gabbro may be truncated by the thrust, and does not continue southwards across the structural boundary, or is perhaps more deeply buried. Terrain effects are not considered to influence the anomaly.

H18 – (G.M.S. No. 98) – Churchill and Nain

Extending from the western headwaters of the Notakwanon River eastwards to the Labrador Coast is a broad region of positive anomaly; the amplitude is difficult to determine because on its southern flanks it shares a common gradient with an area of relatively low Bouguer anomaly overlying the Harp Lake Anorthosite. However, the anomaly is broadly defined by the -40 mgal contour, and an estimate of its amplitude on this basis is 15 mgal. The highest values occur along the southern margin of the anomaly in a broad arc, and locally attain 20 mgal above background (-40 mgal).

The greater part of the anomaly is underlain by adamellite; a variety of gneisses and migmatites together with small areas of anorthosite and granulite constitute the remainder of the region. There appears to be no correlation between the anomaly and the geology. Density information is very limited so it is impossible to determine if there is a density control on the anomaly which is not seen in the surface lithologies. The terrain, which has moderate relief and is considerably dissected, does not appear to have a controlling influence over the anomaly. It is tentatively suggested that a large basic body underlies the area, and gives rise to the anomaly.

H19 – (G.M.S. No. 97) – Nain

A coastal high delineated by a belt of steep gradients running from Hopedale southeastwards towards the mouth of the Big River reaches a maximum amplitude of about 40 mgal over the outer coastal islands. The geology of the area is variable and various gneisses, granitic rocks, sediments and volcanics of the Aillik Group and gabbro are present. The bounding flank of the anomaly is at right-angles to the prevailing structural grain of the area, and therefore a source at depth is favoured as an explanation of the gradient; since the Aillik Group has an estimated thickness of about 7.6 km (Gandhi *et al.*, 1969) the source is at least that deep. The linearity of the flank is interpreted in terms of major block faulting; the source of the high may be a block of crust of higher density than the normal crust, rather than an igneous intrusion.

The anomaly is interrupted by a minor low at Stag Bay and then continues from Burnt Island east-southeasterly for 120 km to the White Bear Islands as a linear gravity high of amplitude 30 mgal. This high terminates the extreme eastern attenuated portion of the Grenville Front low. From north to south three main lithologies underlie the anomaly and parallel its trend; they are successively granitic rocks, granite gneiss and quartzofeldspathic paragneisses. Within the southern two lithologies, pods of gabbro are fairly widespread, as are diabase dykes or sills, but the northern granitic strip contains very few of these types. However, Stevenson (1970) suggests that one of the few gabbroic bodies found within the granites – a curvilinear ridge of gabbro is exposed about 5 km west of Pamiulik Bay – may be part of a laccolith-like sill which has domed up the overlying rocks. Such a body would certainly contribute to the anomaly; its extent – on the basis of the extent of the anomaly – would be much greater than that envisaged by Stevenson.

Terrain in the region is generally gentle and less than 300 m except in the northwest where the Benedict Mountains rise to 740 m. It is not thought to control the anomaly to any large extent.

Description of Gravity Lows

Eighteen gravity lows and their relationship to the geology are described; the relationship to topography is also described where necessary. All amplitudes quoted are relative to local backgrounds. Certain lithological units referred to in discussing some of the anomalies on Gravity Map Series Nos. 64 and 65 are identified in Figure 4. No model interpretations have been done for the gravity lows.

L1 – (G.M.S. No. 65) – Grenville

A circular-shaped anomaly lies between H1 and H10, and is centred on Catouni Lake; it has an amplitude of about 10 mgal. Geologically the area comprises granitic gneisses, migmatites and quartzofeldspathic biotite/hornblende gneisses. The terrain varies mostly between 460 to 910 m, and is very similar to the surrounding country, thereby ruling out topography as a source of the anomaly. A somewhat circular pattern of magnetic anomalies (G.S.C. map 7372G) observed over the northeastern portion of the anomaly suggests the presence of a stock-like intrusion – possibly granite. If a granite is present, and has a greater lateral extension at depth than that suggested by the magnetic anomalies, then it might adequately explain the gravity anomaly.

L2 – (G.M.S. No. 65) – Grenville

A north-northeasterly trending anomaly follows the Nipissis River in the ground immediately west of H3; it has a maximum amplitude of about 15 mgal. The terrain is mapped as comprising mainly migmatite and granite; some mangerite occurs also. It is likely that granitic rocks are mainly responsible for the anomaly; however, the fact that the anomaly follows closely the Nipissis suggests that terrain effects may contribute to it.

L3 and L4 – (G.M.S. Nos. 65 and 67) – Grenville

L3 and L4 are the main closures within a negative region of anomaly which skirts the western margins of the Lac Fournier and Havre St. Pierre massifs. A belt of relatively low gravity extends southwards from the L4 closure along the east side of H3. The maximum amplitude of the anomalous zone is approximately 20 mgal. Most of the country is mapped as granites, granitic gneisses and paragneisses, and the anomaly is attributed to these lithologies. The lithology which probably contributes the greatest negative effect is granite – this is inferred from the spatial relationship between the anomalies and the granites, and from the fact that the granites have the lowest density of any lithological group in the area. The average density is only 2.63 ±0.04 g/cm^3, and therefore the granites are likely to produce a negative effect always. There appears to be no correlation between terrain and gravity anomalies despite the rugged nature of the country.

L5 – (G.M.S. No. 65) – Grenville

Overlying the eastern half of the Lac Pierre Anorthosite is a negative anomaly with a maximum amplitude of about 15 mgal. It runs northeasterly from Lac Go to the Quebec-Newfoundland border, and then north-northeasterly with diminishing amplitude to about latitude 52°. Most of the terrain comprises anorthosite, but centred on Lac Go is an elongate granitic body, which lies partially within the central portion of the anomaly. It is difficult to ascertain whether the anomaly is generated by the granite (density 2.63 g/cm^3) in contact with relatively pure anorthosite (density 2.71 g/cm^3), or due to such anorthosite in contact with gabbroic anorthosite (density 2.80 g/cm^3). Possibly both causes contribute to the anomaly. The contribution of terrain effects to the anomaly is considered to be negligible.

Another possibility for the origin of the low, is that it is an 'apparent' low resulting from its position between H4 and a small high located in the western part of the Lac Pierre Anorthosite; the latter correlates with mangerite, gabbroic anorthosite and anorthositic gabbro.

L6, L7 and L8 – (G.M.S. No. 64) – Grenville

L6, L7 and L8 are negative closures located respectively on the northeastern portion of the East Chambers Anorthosite, east portion of the South Magpie Anorthosite, and western portion of the Lac Marthe Anorthosite. The maximum amplitudes of the anomalies are all tentatively estimated to be about 15 mgal. The closures, themselves, are all located on anorthosites, but the degree to which the latter control the distribution of the anomalies is difficult to assess, since the gravity gradients bounding the lows transgress the boundaries of the anorthosite massifs and continue outside them. The problem is further complicated by the fact that the gradients are common to the highs H11 and H12, and, therefore, positive and negative effects are difficult to separate.

Perhaps some idea of the anorthosite contribution to the gravity anomalies may be obtained by examining L8, which is situated away from the stronger regional gradients. The anomaly has an amplitude of maybe 10 to 15 mgal, and may be due to the density contrast between anorthosite (density of Lac Marthe Anorthosite is 2.68 g/cm^3), and the surrounding mangerite (Lac Duault Mangerite – 2.75 g/cm^3, Lac Andre Mangerite – 2.74 g/cm^3).

The anorthosites would, therefore, appear to play an important role in the development of negative anomalies in this region, however, the transgressive nature of the gradients with respect to the geology suggests other contributory sources. All of the anomalies, as well as L3, L4 and L5, occur within the region designated as the Moisie-Aguanas regional low, and the large number of granites in the region are thought to have a major effect on the development of the low Bouguer anomalies. The problem of the respective contributions of anorthosites and granites needs further study.

The magnetic field over the central parts of all the anomalies is lower and less disturbed than the surrounding field (see G.S.C. maps 7360G, and 7370G), suggesting that the magnetite content of the anorthosites in those areas is lower. Since there is often a correlation between the content of magnetite and mafic minerals in igneous rocks it is reasonable to suppose that the anorthosites in those same areas are relatively pure, which supposition is supported by the low average density (2.68 g/cm^3) of the Lac Marthe Anorthosite.

L9, L10 and L11 – (G.M.S. No. 64) – Grenville

The three anomalies L9, L10 and L11 form a north-northwesterly trending belt of closures following, more or less, the course of the Natashquan River; the maximum amplitude, in all cases is roughly between 5 to 10 mgal. The fact that the anomalies lie along the Natashquan River may indicate some contribution from the terrain, but a geological cause is probably responsible for most of the anomaly in each case. The region is poorly known geologically, but granites are thought to be the source of the lows; L11 is located on granitic terrain. Density information for this region is very poor.

On the G.S.C. aeromagnetic maps 7370G and 7369G, little correspondence between the magnetic and gravity anomalies is seen. However, the magnetic field over L9 is fairly featureless – possibly the result of granitic terrain, and L11 coincides with north-

northwesterly magnetic strikes, which are possibly a smaller-scale reflection of a much larger structure controlling the general trend of the gravity anomalies.

L12 – (G.M.S. No. 67) – Grenville

Forming a large bite on the south side of H6, and centred on Lac Joseph, is a negative closure with maximum amplitude of about 20 mgal. The surface rocks in the area are largely metasedimentary gneisses, and a few gabbroic bodies have been mapped. On the southwest flanks of the anomaly, granitic rocks are exposed, and the anomaly is attributed to a near-surface body of granite.

L13 – (G.M.S. No. 66) – Grenville

A small anomaly located about 50 km southwest of Dominion Lake overlies granitic terrain. It has a maximum amplitude of about 5 to 10 mgal and falls more or less on line with the belt of anomalies formed by L9, L10 and L11. It is thought to be related to the granitic rocks of the area – possibly a more acidic phase. The terrain is relatively flat, and does not appear to control the anomaly.

L14 – (G.M.S. No. 66) – Grenville

A negative bite into the Minipi-Barron Lakes regional high occurs immediately northeast of Dominion Lake. A rough estimate of its amplitude is 20 mgal. Granites-granodiorites and gneisses are mapped in the anomalous region, and the former lithologies, in contact with the basic and ultrabasic rock-types to the south, east and north, are interpreted as the source of the anomaly. There is excellent correlation between the geology, gravity and the magnetic anomalies of the area. The magnetic field is lower and less disturbed over the granites-granodiorites and the gneisses (see G.S.C. map 7379G). Terrain is fairly flat and apparently has little effect on the distribution of the anomaly.

L15 – (G.M.S. No. 66) – Grenville

An anomaly of about 10 mgal maximum amplitude occurs over ground mapped as the Double Mer Formation by Stevenson (1967b). The anomaly extends north-northeasterly along the valley of the Kenamu River from a point near the confluence of this river with the Little Drunken River. The formation consists of conglomerates, sandstones, arkoses and shales of possible Hadrynian age; they are thought to be preserved in a downfaulted block (Stevenson, 1967b). The anomaly is interpreted as resulting from the density contrast formed by the lighter sediments in contact with the surrounding syenite-monzonite series; the latter contain garnets and pyroxenes and are believed to be indicative of the granulite facies of metamorphism by Stevenson. An aeromagnetic low with smooth gradients coincides with most of the sediments (G.S.C. map 7379G).

L16 – (G.M.S. Nos. 66 and 96) – Grenville

A linear negative anomaly runs northeasterly across the western part of Lake Melville from the south end of Goose Bay to Mulligan Bay. It is flanked to the west by H15 and to the east by the steep gradients of the Minipi-Barron Lakes high; west of H15 are the steep gradients associated with the Grenville Front low. Because of the position of the anomaly with respect to the steep gradients of the regional anomalies the selection of a regional background is extremely problematical; consequently only a rough estimate of the amplitude of the anomaly may be given – it is about 10 mgal.

Along the northern shore of Lake Melville, between Mulligan Bay and Lowland Point red arkosic sandstones have been described by Kindle (1924), who, because of their similarity to sedimentary deposits occurring along the north shore of the water body known as Double Mer, named them the Double Mer Sandstone. He regarded them as being earliest Palaeozoic in age and believed they owed their preservation, in what is otherwise Precambrian terrain, to being downfaulted in blocks. Later geologists who have mapped in the eastern Quebec-Labrador region have given similar sedimentary sequences the same name, but have preferred to assign them a Proterozoic age.

A small negative anomaly of a few milligals is associated with the Double Mer region, and it appears likely that it arises from the lighter sediments being in faulted contact with surrounding crystalline basement. The negative anomaly over the western part of Lake Melville is similarly attributed to the proposed downfaulted sedimentary succession.

Evidence for faulting in these areas is to be seen in the steep scarp-like northwestern faces of the Mealy Mountains to the south of Lake Melville, and in similar topography bordering the south side of Double Mer, as well as in the great depths of Lake Melville where depths of over 150 m are common, especially in the eastern part of the lake. Although the Mealy Mountains escarpment is probably the most prominent feature which suggests faulting, it parallels but does not coincide in position with the steepest part of the gradient bounding the Minipi-Barron Lakes high. The latter gradient suggests that a major fault runs northeastwards through the eastern half of Lake Melville. It is possible, therefore, that the Mealy Mountains escarpment represents only one of a series of step-like faults, with the greatest vertical movement occurring along faults underlying the eastern part of the lake.

The contact rocks to the south of Lake Melville are those of the Mealy Mountains which have been mapped as mainly anorthosite by Eade (1962) east of longitude 60°, and as a syenite-monzonite series west of longitude 60° by Stevenson (1967a); the northern contact rocks in the respective areas have been mapped as granitic gneisses and paragneisses, and near Goose Bay is the anorthositic body corresponding to H15.

The available aeromagnetic coverage (G.S.C. map 7391G) shows gentle gradients over the western portion of the gravity anomaly. Using a simple method of estimating depth to magnetic source (Vacquier *et al.*, 1951), a positive magnetic anomaly yielded a depth of 1,450 m below the surface. The anomaly is centred on Happy Valley, and the depth probably represents the thickness of the sedimentary prism at this point.

L17 – (G.M.S. No. 98) – Nain

A north-south trending negative anomaly traverses the central part of the Naskaupi Fold Belt and continues over the southeastern region of the Harp Lake Anorthosite. It is flanked to the west by the parallel high H17, and to the east by a belt of steep gradients associated with the Grenville Front low, and by a small positive anomaly over the southeastern part of the fold belt. Because of these proximal anomalies only a very approximate estimate of the amplitude can be given, this is 10 to 15 mgal.

The cause of the anomaly is not readily apparent, since both the topographic and geological grains are perpendicular to the trend of the anomaly. However, a possible clue to the source may be seen in the available aeromagnetic coverage of the area (G.S.C. map 7405G). A broad positive magnetic high running northerly from slightly west of Snegamook Lake corresponds in its southern portion with the most negative area of the gravity low; farther north the axis of the magnetic anomaly is displaced slightly eastwards. The magnetic anomaly also extends farther north than the gravity anomaly and may be related to a particular phase of the Harp Lake Anorthosite. By analogy with the magnetic signatures in the Grenville 1970 area it is possible that this phase is mangeritic. It is tentatively suggested that the gravity low is related to this postulated mangeritic phase, and that the phase decreases in density towards and in the region of the low.

L18 – (G.M.S. Nos. 97 and 98) – Nain

Running northeastwards from just west of West Micmac Lake to the Bay of Islands an area of granodioritic rocks is wedged between Archean migmatites, agmatites, amphibolites and granodiorites, with minor amounts of gneiss to the north, and similar Archean rocks together with metasediments and metavolcanics of the Aillik Group to the south. A negative anomaly of about 10 mgal is associated with the granodiorite, and is attributed to its lower bulk density. Unfortunately, density coverage in the region is meagre, and no conclusive evidence can be given to support this statement.

6 – Synthesis

The main conclusions of the correlation study of the gravity, rock density and geological data of the area are summarized below.

The structural province boundaries and the tectonic boundaries do not appear to coincide with abrupt changes in the pattern or intensity of gravity anomalies, but by considering a contiguous area to the west, together with the survey area, certain gravity characteristics are apparent which are related to particular structural provinces and boundaries. The most remarkable correlation between gravity anomalies and structural boundaries is the parallelism exhibited between the Grenville Front low and the Grenville Front for 900 km. Over this distance the axis of the anomaly lies consistently within the northern margins of the Grenville, but the anomaly straddles the Grenville Front. Considering the structural provinces, there are significant differences in the gravity characteristics of the regions of the Superior and Grenville as outlined in Figure 3. Histograms of Bouguer anomalies of these regions indicate that the modal value for the Grenville is 15 mgal larger than that for the Superior. A further difference is that the Grenville is characterized by several prominent regional and local anomalies, while the gravity field over the Superior is comparatively featureless.

The regional anomalies of the survey area occur completely within the Grenville, except the Grenville Front low which partially overlies the adjacent Superior, Churchill and Nain provinces. Most of these anomalies are outlined largely by northeasterly contours, which are parallel or subparallel to the Grenville trend; the exception is the Moisie-Aguanas low which has a gross east-west axis. In the case of the latter anomaly and of the Minipi-Barron Lakes high, the source of the anomaly is evident in the prevailing geology.

The Moisie-Aguanas low is believed to be related to the low density (2.63 g/cm^3) granites which occur in some areas of the anomalous terrain, and which may be concentrated in the upper crust below this region. 'Pure' anorthosites (density 2.68 g/cm^3) which also occur in the area may contribute to the anomaly.

The southern area of the Minipi-Barron Lakes high correlates closely with the anorthositic and related lithologies, including gabbroic varieties, which comprise the Mealy Mountains massif. The continuity of this anomaly to the Labrador Coast suggests that similar lithologies are present at shallow depth beneath the largely gneissic terrain which coincides with the northern part of the anomaly. The belt of steep gradients delineating the northwestern edge of the anomaly is believed to correlate with a major fault zone, part of which separates downfaulted late Proterozoic or early Palaeozoic sediments of the Lake Melville graben (Kranck, 1947) from the Mealy Mountains horst. The southwestern margin of the anomaly which trends west-northwesterly is also thought to correlate with a major fault.

The extensive Grenville Front low exhibits little correlation with the geology, which is extremely heterogeneous in the anomalous ground, and a source in terms of large scale crustal structure rather than a lithological source is favoured to explain it. It is proposed that the northern flank of the anomaly is generated by downwarping of the Superior, Churchill and Nain crusts towards the axis of the anomaly, thereby inducing horizontal density contrasts between the major crustal layers, and between the crust and mantle. The steep southern flank of the anomaly is interpreted to result from the juxtaposing of denser Grenville crust against crust of normal density; the plane of juxtaposition possibly represents a major fault. The denser crust is probably located mainly within the lower levels of the Grenville, and also explains the higher Bouguer values over the Grenville. The crustal root interpreted from the seismic work of Berry and Fuchs (1973) to underlie the axial region of the anomaly also contributes to the anomaly. East of the Labrador Trough, the anomaly is believed to be displaced southeastwards along a major fault following closely the line of the Churchill River. The greatest displacement is exhibited by the southern flank which appears to have shifted some 75 km. In this area also, the anomaly has increased in width; the increase may be related to the intrusion of the gabbroic body interpreted to underlie H8. The extreme eastern attenuated part of the anomaly may similarly arise from large scale crustal variations, or possibly from a buried granite.

The Musquaro-St. Lewis high does not appear to correlate with the geology, and it is proposed that the anomaly is underlain at shallow depth by an anorthositic complex similar to that comprising the Mealy Mountains massif. This complex is believed to be fault bounded along its northwestern margin.

The major gravity highs (H1 to H9) of the Grenville, which have amplitudes ranging from 30 mgal A.G.M. to 85 mgal, have all been attributed to large gabbroic masses. Most of these have northeasterly axes which are parallel or subparallel to the Grenville; H5 and H9 trend west-northwesterly and H2 trends northwesterly. In all cases gabbroic rocks are mapped at the surface in the anomalous region, though they are not always the prevailing lithology. Two-dimensional model interpretations of some anomalies produced bodies with cross-sections approximating saucer and funnel shapes. The depths of the bodies vary from 6 to 14 km. In containing these highs, which each covers hundreds or thousands of square kilometres, the Grenville Province is unique in the Canadian Shield. This uniqueness in gravity signature is paralleled by the uniqueness of the Grenville in its abundance of anorthositic complexes. The association of the highs with anorthositic complexes suggests that the interpreted gabbro bodies may bear a genetic relationship to the anorthosites. It is thought that they may both have been derived from the same parent magma by some process along the lines of the plagioclase flotation model examined by Morse (1968). Sillimanite gneisses exhibit a remarkable correlation with anomalies H7 and H8 and although they are not interpreted as the cause of the anomalies, which is attributed to gabbroic cores mantled by the gneisses, the relationship is interesting and may be of some value in metamorphic or petrogenetic studies.

The lower amplitude gravity highs (generally less than 20 mgal or 20 mgal A.G.M.) in the area have similarly been attributed to gabbroic or basic sources, though such rocks are not always exposed at the surface or are very limited. Several of these anomalies could therefore only be discussed in general terms.

Gravity lows in the area, which range in amplitude from 5 to 20 mgal, in many cases, have been directly correlated with granitic rocks, late Proterozoic or early Palaeozoic fault-bounded sedimentary basins and to anorthositic rocks.

The regional gravity surveys in southeastern Quebec and southern Labrador have contributed significantly to an understanding of the geological structure of the area. This contribution is illustrated in Figure 11, where interpreted major crustal fractures and axial trends of distinctive gravity anomalies are plotted. The postulated fractures and the anomaly trends impart an internal structural framework to the region, which previously was not widely recognized from geological mapping or aeromagnetic surveys. Most of the deep fractures are interpreted to coincide with bounding gradients of the extensive regional anomalies, but deep fracturing is also probably associated with the gabbroic bodies which give rise to the relatively local gravity highs.

The fractures have two main trends, one is between northeast and east-northeast paralleling the gross trend of the Grenville, and the other is between west-northwest to northwest. Fractures with the latter trend appear to offset or terminate the northeast to east-northeast fractures and are possibly younger. The gross structure outlined by the gravity surveys therefore provides a reference framework for future geophysical and geological studies. The structures themselves are suggested features for detailed study. Deep fractures often provide channelways for ore-bearing solutions, and so the economic importance of the fracture system is also considerable.

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Finally, it must be remembered that the basic data presented in this report result from the efforts of the individuals listed in Table I; they are acknowledged for their contribution.

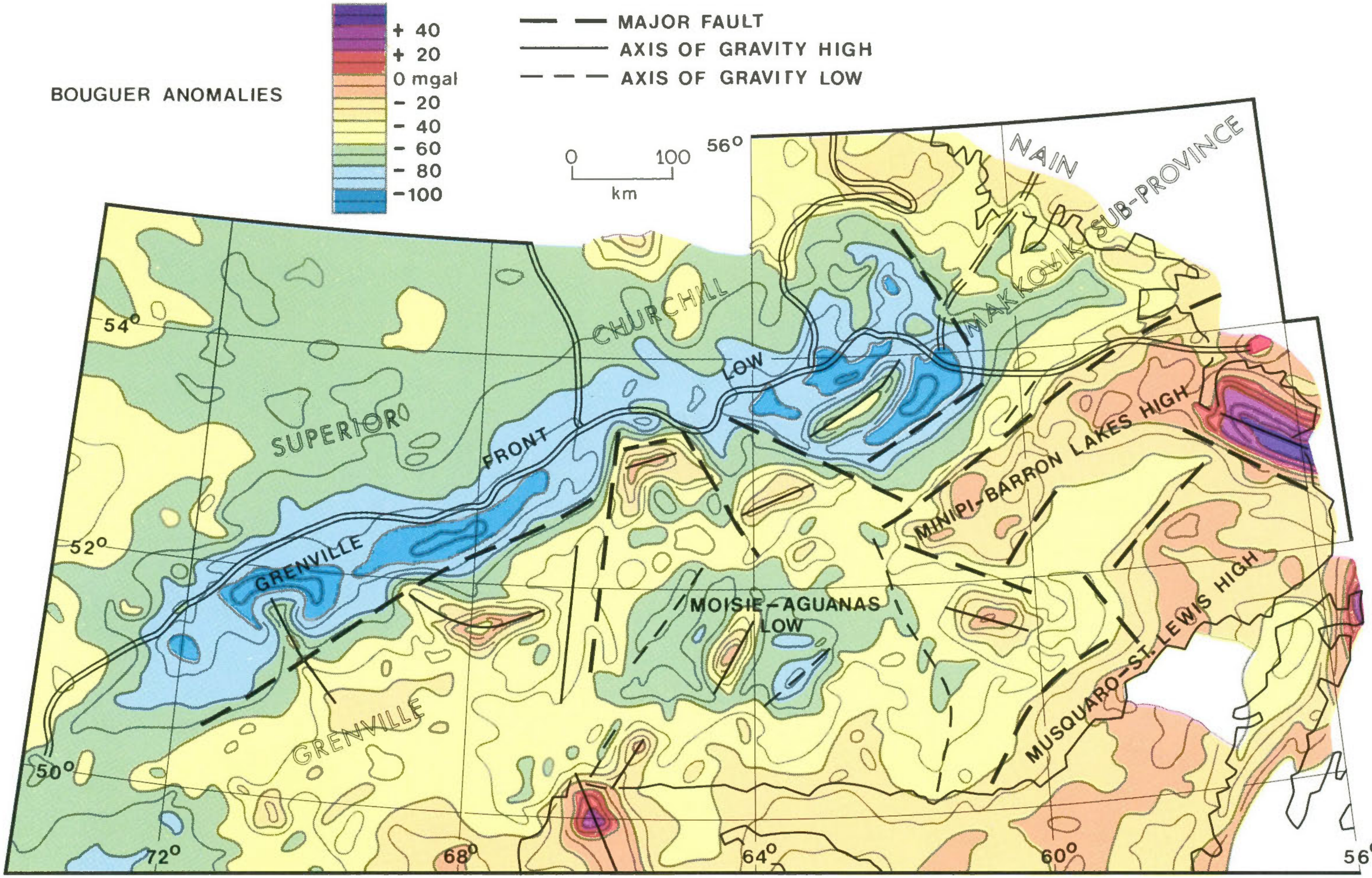

Figure 11. Distribution of major faults interpreted from gravity anomalies within area corresponding to Figure 3.

References

Baragar, W.R.A. 1967. Wakuach Lake map-area, Quebec-Labrador. Geol. Surv. Can., Mem. 344.

Berry, M.J. and Fuchs, K. 1973. Crustal structure of the Superior and Grenville Provinces of the northeastern Canadian Shield. Bull. Seism. Soc. Amer., 63, p. 1393-1432.

Brummer, J.J. and Mann, E.L. 1961. Geology of the Seal Lake area, Labrador. Geol. Soc. Amer. Bull., 72, p. 1361-1382.

Davidson, A. 1972. The Churchill Province. In Variations in tectonic styles in Canada. Geol. Assoc. Can. Spec. Paper 11, p. 381-433.

Dimroth, E., Baragar, W.R.A., Bergeron, R. and Jackson, G.D. 1970. The filling of the Circum-Ungava geosyncline. Geol. Surv. Can., Paper 70-40, p. 45-142.

Duffell, S. and Roach, R.A. 1959. Mount Wright, Quebec-Newfoundland. Geol. Surv. Can., Map 6-1959.

Eade, K.E.1962. Battle Harbour-Cartwright, Coast of Labrador, Newfoundland. Geol. Surv. Can., Map 22-1962.

Emslie, R.F. 1964. Potassium-argon age of the Michikamau anorthositic intrusion. Labrador, Nature, 202, p. 172-173.

Faessler, C. 1942. Sept-Iles area, north shore of St. Lawrence, Saguenay County. Que. Dept. of Mines, Geol. Report 11.

Fahrig, W.F. 1967. Shabogamo Lake map-area, Newfoundland-Labrador and Quebec. Geol. Surv. Can., Mem. 354.

Fahrig, W.F. and Larochelle, A. 1972. Paleomagnetism of the Michael Gabbro and possible evidence of the rotation of Makkovik Subprovince. Can. J. Earth Sci. 9, p. 1287-1296.

Franconi, A., Sharma, K.N.M. and Laurin, A.F. 1971. Géologie de la région des rivières Bersimis, Papinachois, aux Outardes, Manicouagan, Sainte-Marguerite et Moisie, Compté de Saguenay. (Projet Grenville 1968-1969), Que. Dept. Natur. Resour. Open File Report No. 28404.

Frarey, M.J. 1961. Menihek Lakes, Newfoundland and Quebec. Geol. Surv. Can., Map 1087A.

Gandhi, S.S., Grasty, R.L. and Grieve, R.A.F. 1969. The geology and geochronology of the Makkovik Bay area, Labrador. Can. J. Earth Sci. 6, p. 1019-1035.

Geol. Surv. Can. 1969. Map 1251A – Tectonic Map of Canada.

Geol. Surv. Can. 1969. Aeromagnetic Map 7353G – Port-Menier.

Geol. Surv. Can. 1969. Aeromagnetic Map 7354G – Cap-Chat.

Geol. Surv. Can. 1969. Aeromagnetic Map 7360G – Havre-St-Pierre.

Geol. Surv. Can. 1969. Aeromagnetic Map 7361G – Lac Manitou.

Geol. Surv. Can. 1969. Aeromagnetic Map 7362G – Sept-Iles.

Geol. Surv. Can. 1969. Aeromagnetic Map 7369G – Rivière Natashquan.

Geol. Surv. Can. 1969. Aeromagnetic Map 7370G – Lac de Morhiban.

Geol. Surv. Can. 1969. Aeromagnetic Map 7372G – Lac Fouquet.

Geol. Surv. Can. 1971. Aeromagnetic Map 7379G – Minipi Lake.

Geol. Surv. Can. 1971. Aeromagnetic Map 7391G – Goose Bay.

Geol. Surv. Can. 1971. Aeromagnetic Map 7405G – Snegamook Lake.

Goodacre, A.K., Brule, B.G. and Cooper, R.V. 1969. Results of regional underwater gravity surveys in the Gulf of St. Lawrence with map (No. 86 – Gulf of St. Lawrence). Gravity Map Series, Publ. Dom. Obs.

Grant, F.S. 1968. Two gravity profiles in the Manicouagan-Wabush area of west-central Quebec. Can. J. Earth Sci., 5, p. 895-906.

Innes, M.J.S. 1957. Gravity and isostasy in central Quebec. Trans. Amer. Geophys. Union, 38, p. 156-165.

Kindle, E.M. 1924. Geography and geology of Lake Melville District, Labrador Peninsula. Can. Dept. Mines, Mem. 141.

Kish, L. 1968. Hart-Jaune River area, Saguenay County. Que. Dept. Natur. Resour., Geol. Report 132.

Kranck, E.H. 1947. Indications of movements of the earth-crust along the coast of Newfoundland-Labrador. Bull. Comm. Géol. Finl., 140, p. 89-96.

Morse, S.A. 1968. Layered intrusions and anorthosite genesis. In Origin of anorthosite and related rocks. New York State Museum and Science Service – Mem. 18, p. 175-187.

Sharma, K.N.M. and Franconi, A. 1973. Geology of the Rivière Magpie, Rivière St. Jean and Rivière Romaine area, Duplessis County, Quebec. (Grenville Project 1970), Que. Dept. Natur. Resour. Open File Report No. 28405.

Stevenson, I.M. 1967a. Goose Bay map-area, Labrador. Geol. Surv. Can., Paper 67-33.

Stevenson, I.M. 1967b. Minipi Lake. Newfoundland. Geol. Surv. Can., Map 6-1967.

Stevenson, I.M. 1969. Lac Brûlé and Winokapau Lake map-areas, Newfoundland and Quebec. Geol. Surv. Can., Paper 67-69.

Stevenson, I.M. 1970. Rigolet and Groswater Bay map-areas, Newfoundland (Labrador). Geol. Surv. Can., Paper 69-48.

Stockwell, C.H. 1963. Third report on structural provinces, orogenies, and time-classification of rocks of the Canadian Precambrian Shield. Geol. Surv. Can., Paper 63-17, Part II, p. 125-131.

Stockwell, C.H. 1964. Fourth report on structural provinces, orogenies, and time-classification of rocks of the Canadian Precambrian Shield. Geol. Surv. Can., Paper 64-17, Part II, p. 1-21.

Tanner, J.G. 1969. A geophysical interpretation of structural boundaries in the eastern Canadian Shield. Unpublished Ph.D. Thesis, University of Durham, England.

Tanner, J.G. and Uffen, R.J. 1960. Gravity anomalies in the Gaspé Peninsula, Quebec. Publ. Dom. Obs., 21, p. 221-260.

Taylor, F.C. 1971. A revision of Precambrian structural provinces in northeastern Quebec and northern Labrador. Can. J. Earth Sci., 8, p. 579-584.

Taylor, F.C. 1972. The Nain Province. **In** Variations in tectonic styles in Canada. Geol. Assoc. Can. Spec. Paper 11, p. 435-452.

Vacquier, V., Steenland, N.C., Henderson, R.G. and Zietz, I. 1951. Interpretation of aeromagnetic maps. Geol. Soc. Amer. Mem. No. 47.

Wynne-Edwards, H.R. 1961. Ossokmanuan Lake (west half), Newfoundland. Geol. Surv. Can., Map 17-1961.

Wynne-Edwards, H.R. 1972. The Grenville Province. **In** Variations in tectonic styles in Canada. Geol. Assoc. Can. Spec. Paper 11, p. 263-334.

Wynne-Edwards, H.R., Laurin, A.F., Sharma, K.N.M., Nandi, A., Kehlenbeck, M.M. and Franconi, A. 1970. Computerized geological mapping in the Grenville Province, Quebec. Can. J. Earth Sci., 7, p. 1357-1373.