Geoscience Canada

Gravimetric transect of eastern Ungava Bay, northern Torngat Orogen.

Maurice K. Seguin and Normand Goulet

Volume 17, Number 4, December 1990

URI: https://id.erudit.org/iderudit/geocan17_4art13

See table of contents

Publisher(s)

The Geological Association of Canada

ISSN

0315-0941 (print)
1911-4850 (digital)

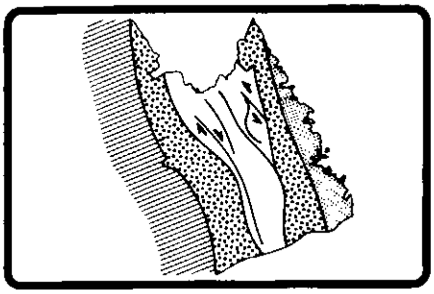
Explore this journal

Cite this article

Seguin, M. K. & Goulet, N. (1990). Gravimetric transect of eastern Ungava Bay, northern Torngat Orogen. *Geoscience Canada*, *17*(4), 273–275.

Article abstract

Detailed gravity data, collected in the northern part of Québec along a SW-NE transectacross the northern Torngat Orogen, provide constraints on the deep structure of this segment of the orogen. The section, located inthe Rae Province east of Ungava Bay, traverses the Archean gneissic terrane of theGeorge River segment, the Early Proterozoic metasedimentary rocks of the Lake Har-bour Group, the Abloviak shear zone and thegranullte-facies migmatttlc complex of the Burwell terrane. The Bouguer gravity profile indicates four distinct zones: (1) in the SW, a low density zone from George River to theeast of Keglo Bay; (2) a zone of intermediate density further to the NE from the Lake Harbour Group extending to Abloviak Fiord; (3) a steep, narrow, Bouguer gravity gradient {positive to the N) which is prominent along the Abloviak shear zone; and (4) a high density zone in the extreme NE of the area. The gravity trend on the contoured Bouguer gravity map is NE in zones 1 and 2, where as it is E-W in zones 3 and 4 and could be correlated with a similar trend in the northern part of the Superior Province west of Ungava Bay. Short wavelength anomalies in zone 1indicate the presence of basin-and-domestructures in the gneissic terrane.



Gravimetric transect of eastern Ungava Bay, northern Torngat Orogen

Maurice K. Seguin
Département de Géologie
Université Laval
Ste-Foy, Québec G1K 7P4

Normand Goulet
Département des Sciences de la Terre
Université du Québec à Montréal
C.P. 8888
Montréal, Québec H3C 3P8

Abstract
Detailed gravity data, collected in the northern part of Québec along a SW-NE transect across the northern Torngat Orogen, provide constraints on the deep structure of this segment of the orogen. The section, located in the Rae Province east of Ungava Bay, traverses the Archean gneissic terrane of the George River segment, the Early Proterozoic metasedimentary rocks of the Lake Harbour Group, the Abloviak shear zone and the granulite-facies migmatitic complex of the Burwell terrane. The Bouguer gravity profile indicates four distinct zones: (1) in the SW, a low density zone from George River to the east of Keglo Bay; (2) a zone of intermediate density further to the NE from the Lake Harbour Group extending to Abloviak Fiord; (3) a steep, narrow, Bouguer gravity gradient (positive to the N) which is prominent along the Abloviak shear zone; and (4) a high density zone in the extreme NE of the area. The gravity trend on the contoured Bouguer gravity map is NE in zones 1 and 2, whereas it is E-W in zones 3 and 4 and could be correlated with a similar trend in the northern part of the Superior Province west of Ungava Bay. Short wavelength anomalies in zone 1 indicate the presence of basin-and-dome structures in the gneissic terrane.

Résumé
La structure interne de l'orogène Torngat nous est dévoilée à partir de données gravimétriques obtenues dans la partie septentrionale du Québec et du Labrador, le long d'une section orientée SO-NE. Le cheminement situé sur la côte orientale de la baie d'Ungava recoupe le terrane de gneiss archéens du segment de la rivière George, les métasédiments du Groupe de Lake Harbour (Protérozoïque inférieur), la zone de cisaillement Abloviak et le terrane de Burwell, un complexe migmatitique au facies granulite. Le profil gravimétrique de Bouguer indique quatre zones distinctes : (1) dans le SO, une zone à faible densité à partir de la Rivière George jusqu'à l'est de Keglo Bay; (2) une zone de densité intermédiaire plus loin vers le NE, soit à partir du groupe de Lake Harbour jusqu'au fiord Abloviak; (3) une zone étroite et montrant une pente abrupte du gradient gravimétrique de Bouguer (positif vers le N) qui prédomine le long de la zone de cisaillement d'Abloviak; et (4) une zone à très haute densité à l'extrémité NE de la région. L'orientation du patron gravimétrique est NE dans les zones 1 et 2 alors qu'elle est E-O dans les zones 3 et 4 et as dernières zones pourraient se corréler avec des orientations semblables dans la province du Supérieur, soit à l'ouest de la Baie d'Ungava. Les anomalies de faible longueur d'onde de la zone 1 nous indiquent la présence de structure en dôme et bassin dans le terrane gneissique.

Introduction
The Superior and Nain provinces in northern Québec are separated by two NNW-trending Proterozoic belts, the New Québec Orogen and the Torngat Orogen. They began to develop around 2.3 Ga and were deformed around 1.8 Ga (Machado *et al.*, 1989; Taylor, 1979). On the western side, the New Québec Orogen separates two cratonic blocks (Superior and Rae provinces), while on the eastern side the Torngat Orogen separates the Rae and Nain provinces. The Rae Province may be reactivated Superior or Nain province.

In northern Québec and Labrador, the Rae Province is divided into the Kuujjuaq and George River segments (Goulet and Ciesielski, 1990b). The Kuujjuaq segment, which is located east of the Labrador Trough (Moorhead and Hynes, 1990; Perreault and Hynes, 1988), is a continental margin prism overlying crystalline basement forming an extension of the Superior Province. This basement crops out locally as thrust wedges and gneissic domes (Goulet *et al.*, 1987). In the eastern part, the George River segment contains Early Proterozoic metasedimentary rocks interspersed with Archean orthogneiss (Goulet and Ciesielski, 1990a). The eastern border of the George River segment is defined by the Abloviak shear zone.

East of this zone is a triangular crustal zone labelled Burwell terrane (Korstgård *et al.*, 1987). It is still unclear whether the Burwell terrane represents a detached section of the Nain craton or an independent Archean block (see Wardle *et al.*, 1990).

The gravimetric transect (A–B, Figure 1) extends from the western part of the George River segment, across the Early Proterozoic metasedimentary rocks of the Lake Harbour Group, the Abloviak shear zone, and the Tasiuyak gneiss, and ends in the Burwell terrane (Figure 1). Proterozoic and Archean rocks form dome-and-basin structures within the Rae Province. The Abloviak shear zone constitutes a highly deformed band (10–25 km wide) composed of mylonitized Tasiuyak gneiss and metasedimentary rocks of the Lake Harbour Group. The Burwell terrane is composed of granulite, migmatite and diatexite and grades into a quartz-feldspar-garnet gneiss to the west. In the Burwell terrane, the trend of the total magnetic field and of the magnetic vertical gradient is oriented E-W, in contrast to that of the Nain Province which is oriented N-S. This latter trend corresponds to that of Hudsonian shear zones in the Rae Province and Nain Foreland. The NNW aeromagnetic trend is characteristic of the northwestern front of the Torngat Orogen.

Gravimetric survey and methodology
Some 75 gravity points were measured along the 150 km transect (A–B, Figure 1). The gravity data were adjusted to the Bouguer anomaly map published by the Geological Survey of Canada (GSC) for the eastern Ungava Bay area. Gridding and smoothing of the data were performed through kriging to obtain contour lines (Figure 2). The shoreline gravity data, combined with GSC inland data, show an increase of Bouguer values to the NNE. Profile A–B was obtained from the kriged data presented on Figure 2. Based on the gravimetric characteristics of profile A–B and the geological subdivisions, the area is divided into 4 segments (Figure 3). The low gravity values of the first (southernmost) segment (60 km long) correspond to granitic gneisses and metasedimentary rocks of the Rae Province. Positive short wavelength gravity anomalies coincide with amphibolite bands. The intermediate values of the second segment (30 km in length) correspond to the Lake Harbour Group; the mean Bouguer value of this segment is 10 mGal larger than that of the first segment. This is mainly due to the higher density of the marbles which constitute an important fraction of the Lake Harbour Group. In the third segment (Abloviak shear zone), a pronounced positive gravity trend to the north (+ 20 mGal, 25–30 km width) coincides with the low aeromagnetic gradient zone and the mylonitized Tasiuyak gneiss. The typical gravimetric pattern of a fault model characterizes the Abloviak shear zone. The high density, low magnetic susceptibility segment of the paired-gravity-anomaly model (Gibb and Thomas, 1976) is also characteristic of a suture zone. The fourth segment (Burwell terrane), marked by high gravity values over a 35 km width, is characterized by a high density zone which is more or less homogeneous in terms of gravity and geology (tonalitic and granulitic

gneisses) and is underlain by a rock unit of average granodioritic composition. This segment is highly magnetic, implying a large change of metamorphic grade and/or composition in this fourth segment.

The gravity trend of segments 1 and 2 is oriented NNE, with gravity values increasing in the direction of Ungava Bay. This suggests a thickening of the metasedimentary rock sequence of the George River segment and Lake Harbour Group in the SSE direction. In the southwestern part of profile A–B, the gravity trend is parallel to the profile. Consequently, a two-dimensional model is not exactly appropriate. However, as no gravimetric data are available under Ungava Bay, a three-dimensional gravity model cannot be obtained. The aeromagnetic trend for the same segments is generally NNW, which diverges from the gravity trend and suggests the occurrence of two different sources; the aeromagnetic signature being derived from the upper crust and the gravity signature mainly from the lower crust. For segments 3 and 4, the gravity trend is oriented approximately E-W. The change in trend from NNE (segments 1 and 2) to E-W takes place in the southern part of the Abloviak shear zone.

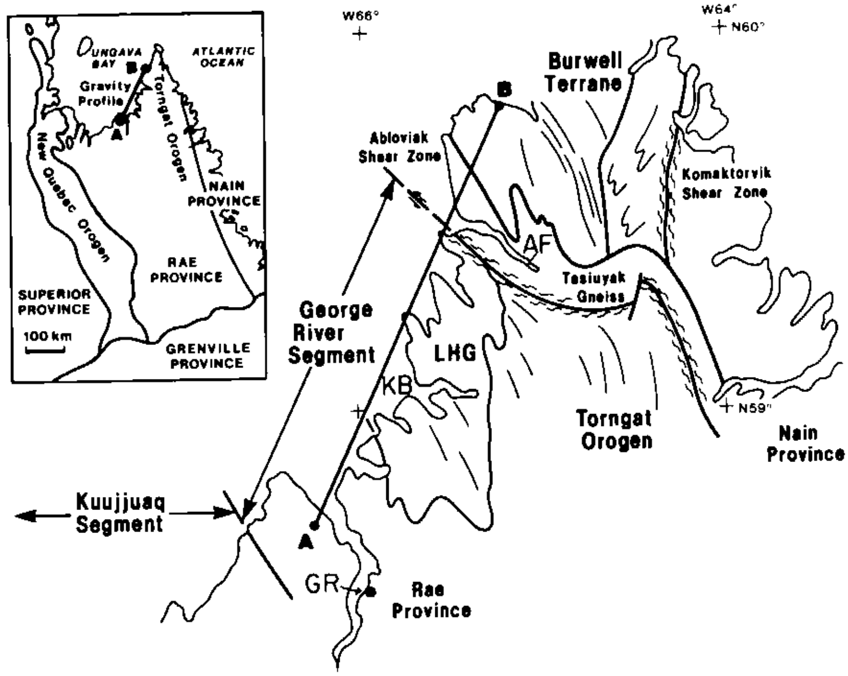


Figure 1 *Tectonic setting of the northeastern Canadian Shield and schematic geological map of the eastern shore of Ungava Bay showing the main geological subdivisions. The gravimetric transect A–B extends SW to NE from George River to Bell Inlet. **KB**, Keglo Bay; **GR**, George River; **AF**, Abloviak Fiord; **B**, Bell Inlet.*

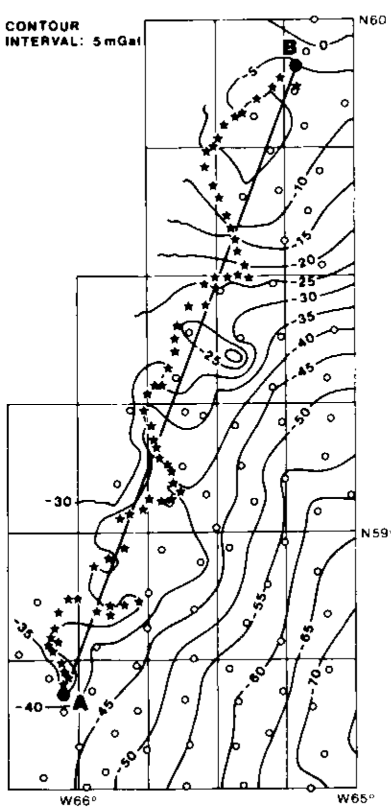


Figure 2 *Bouguer anomaly contour map of the area bounded by latitudes 58°30′–60°N and longitudes 65°–66°15′W. Contour lines are shown at 5 mGal intervals. Stars and circles represent the observation stations of this study and of the geophysics division of the Geological Survey of Canada, respectively. Line A–B shows the position of the gravimetric profile selected.*

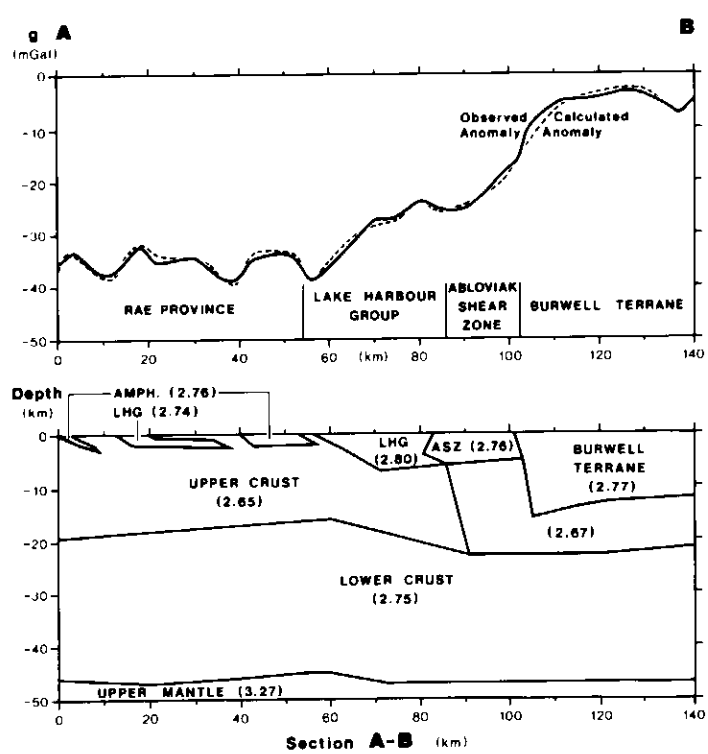


Figure 3 *Gravity profile projected along the line A–B and crustal model along transect A–B obtained by direct modelling of the gravity data.*

Over the Burwell terrane, the magnetic trend is also oriented E-W.

Figure 3 shows a cross-section of the Earth's crust along transect A–B (Figure 1). This section was obtained by direct modelling of the Bouguer anomaly data using the MAGRAV program (Broome, 1988), and represents the most probable geological model. Clearly, the gravity solution proposed is non-unique; other models could doubtless be presented. The only constraints available for the elaboration of this model are surface geological data, density contrasts and aeromagnetic data. In the crustal model presented, the Moho extends to depths ranging from 45 to 48 km with a slight rise at a distance of 60 km from A. Even though this crustal thickness may appear to be rather large for the Canadian Shield, it was the best solution (fit between observed and calculated gravity data) that could be obtained taking into account the surface density contrasts and the distribution of the gravity values along profile A–B. No seismic refraction data are available to constrain the depth to Moho. The crust is subdivided into upper and lower layers; the basis for this subdivision lies in the disparity of the aeromagnetic trends, the evidence of an underlying remobilized Archean crust (basins and domes) and a density increase with depth in the modelling of the gravity data. The lower crustal layer is modelled using a homogeneous composition with a mean density of 2700 kg•m^{-3}. Its upper interface ranges from a depth of 27 to 23 km (mean: 20 km) and its estimated mean thickness is 26 km. This discontinuity separates the relatively homogeneous lower crustal layer from the heterogeneous upper layer. The upper crustal layer is divided into two sectors (SW and NE). In the SW sector, extending from George River to the contact of the Lake Harbour Group and the Abloviak shear zone, the mean surface density determination of the upper crustal layer is 2650 kg•m^{-3} and the thickness is estimated to vary between 17 and 22 km (mean: 20 km). The density corresponds to that of granitic gneisses of the Rae Province. Lenses and bands of amphibolites extending to depths of 2 to 3 km (2765 kg•m^{-3}) are inferred as the cause of short wavelength, positive anomalies. Further NE, the Lake Harbour Group (2700–2800 kg•m^{-3}) is characterized by an intermediate wavelength positive anomaly; the maximum depth extent of this geological unit is thought to be 7 km and it is underlain by the granitic gneisses of the Rae Province.

The lower part of the upper crustal layer of the NE sector (from the Abloviak shear zone to the NE end of the profile) is denser (2670–2680 kg•m^{-3}) than similar parts of the SW sector and is inferred to lie beneath the Tasiuyak gneiss, which constitutes part of the Abloviak shear zone, and to lie 13 to 15 km under the Burwell terrane. The mean density of the Abloviak shear zone is 2760 kg•m^{-3} while that of the Burwell terrane is 2770 kg•m^{-3}. The density of the upper crust in the NE sector of the profile had to be increased to obtain a reasonable fit between the observed and calculated gravity values once the density contrast between the Abloviak shear zone and the Burwell terrane had been fixed. The depth extent of the Burwell terrane is mainly constrained by the wavelength of the gravity anomaly.

Discussion and conclusions

The present study is the first attempt to obtain a detailed model of the Earth's crust in the NE sector of Ungava Bay. The main points to be retained from this investigation are the following: (1) depth to Moho is estimated at between 45 and 48 km; (2) two crustal layers (lower and upper) are present; (3) the lower crust is relatively homogeneous; (4) important lateral density variations exist in the upper crustal layer; (5) the upper crust density increases to the NE; this may correspond to an increase in regional metamorphic grade east of the Abloviak shear zone; (6) the Burwell terrane has a triangular shape as defined by gravity and aeromagnetic trends and differs in nature and origin from the Rae Province to the south; (7) physical properties (density, susceptibility) and associated gravity and magnetic fields suggest an origin and age for the Burwell terrane different from those of neighbouring structural provinces; (8) the Abloviak shear zone has the characteristic gravity signature of a fault; and (9) the SW limit of the Abloviak shear zone appears to be a suture zone dipping steeply to the NNE.

The last point implies that the metamorphism and complex deformation of the Abloviak shear zone was contemporaneous with the collision of the Burwell terrane and Rae Province. Structural studies by Goulet and Cisielski (1990b) suggest arcuate thrust faulting of the Burwell terrane onto the Rae Province, accompanied by synchronous to late sinistral movement along the Abloviak shear zone.

Acknowledgements

The authors thank the two referees, J.C. Mareschal and H.G. Miller, for their constructive comments and suggestions.

References

Broome, J., 1988, An IBM-compatible microcomputer workstation for modelling and imaging potential field data: Computers and Geoscience, v. 14, p. 659-666.

Gibb, R.A. and Thomas, M.D., 1976, Gravity signature of fossil plate boundaries in the Canadian Shield: Nature, v. 262, p. 199-200.

Goulet, N. and Ciesielski, A., 1990a, Structural section of the Abloviak Shear Zone, east Ungava Bay, Québec: Geological Association of Canada — Mineralogical Association of Canada, Program with Abstracts, v. 15, p. A49.

Goulet, N. and Ciesielski, A., 1990b, The Abloviak shear zone and the NW Torngat Orogen, eastern Ungava Bay, Québec: Geoscience Canada, v. 17, p. 269-272.

Goulet, N., Gariepy, C.P., Mareschal, J.-C. and Machado, N., 1987, Structure, geochronology, gravity and the tectonic evolution of the Northern Labrador Trough: Geological Association of Canada — Mineralogical Association of Canada, Program with Abstracts, v. 12, p. A48.

Korstgård, J., Ryan, B. and Wardle, R.J., 1987, The boundary between Proterozoic and Archean crustal blocks in West Greenland and Northern Labrador, *in* Park, R.G. and Tarney, J., eds., Evolution of the Lewisian and Comparable High Grade Terrains: Geological Society of London, Special Publication No. 27, p. 247-259.

Machado, N., Goulet, N. and Gariepy, C., 1989, U-Pb geochronology of reactivated Archean basement and of Hudsonian metamorphism in the northern Labrador Trough: Canadian Journal of Earth Sciences, v. 26, p. 1-15.

Moorhead, J. and Hynes, A., 1990, Pennine-style nappe structures in the internal zone of the northern Labrador Trough; Evidence for major early, WNW vergent basement transport, *in* Recent Advances in the Geology of the Eastern Churchill Province (New Québec and Torngat Orogens), Program and Abstracts, Wakefield Conference, Québec, March 9-10, 1990.

Perreault, S. and Hynes, A., 1988, Timing in the tectonic evolution of the NE segment of the Labrador Trough, Kuujjuaq, Northern Québec, *in* Geological Association of Canada — Mineralogical Association of Canada — Canadian Society of Petroleum Geologists, Program with Abstracts, v. 13, p. A97-A98.

Taylor, F.C., 1979, Reconnaissance geology of a part of the Precambrian Shield, northeastern Québec, northern Labrador and Northwest Territories: Geological Survey of Canada, Memoir 393, 99 p.

Wardle, R.J., Ryan, B. and Ermanovics, I.F., 1990, The eastern Churchill Province, Torngat and New Québec orogens: An overview: Geoscience Canada, v. 17, p. 217-222.