THE GRAVITY SIGNATURE INDUCED BY THE LOADING OF AN OLD ATLANTIC TYPE MARGIN BY A QUATERNARY SUBMARINE FAN : EVIDENCE FOR A THICK MECHANICAL LITHOSPHERE

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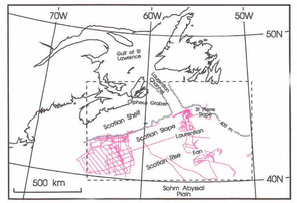
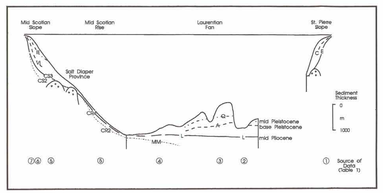
ABSTRACT

The Laurentian Fan is a major Plio-Pleistocene deposit located on the slope and rise of the 180 Ma Atlantic-type passive margin of Nova Scotia where the crustal type ranges from thin continental to oceanic. This feature comprises predominantly fine grained sediment 1500 m thick in places, covering an area of more than 100 by 300 km. The bulk of the deposition accumulated within the last 3 Ma, buf with minimal deposition in the last 50 ka. This depositional feature is clearly echoed by a free air gravity anomaly of over 50 mgals indicating a marked lack of local compensation in the lithosphere. Sediment isopachs of the fan deposit were assembled from seismic data, with biostratigraphic control of ages derived from well data and submersible samples. The isopach data were gridded and the 3-dimensional gravity field over the depositional complex was calculated using standard methods. The deflection of the compensating density contrast at the Moho by the load of the fan was calculated using an thin elastic plate model. Plate thicknesses approaching 200 km were needed to reduce deformation of the Moho, thereby increasing the net gravity anomaly over the fan to match that observed. This study suggests that the long term strength of this Atlantic type passive margin is much higher than that predicted using loading estimates of oceanic islands, and is more congruent with lithospheric thicknesses derived from postglacial rebound studies. It also shows that Quaternary sedimentation produces a significant gravity signature on the Canadian continental margin. Gravity maps may prove a valuable reconnaissance tool for identifying major Quaternary depocentres on the continental margin.

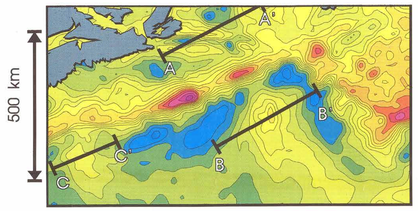
Map showing regional setting of the Scotian Margin and Laurentian Fan and the seismic data base (magenta lines) used to determine isopachs





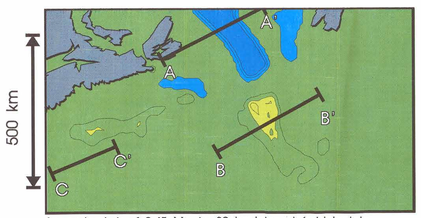
Schematic seismic cross-section of the continental margin showing correlation of key seismic reflectors and interpreted ages.

Data sources: (1) Piper and Normark, 1989; (2) Uchupi and Austin, 1979; (3) Piper and Normark, 1982; (4) Ebinger and Tucholke, 1988; (5) Swift, 1987; (6) Mosher et al, 1989; (7) Piper and Sparkes, 1989.



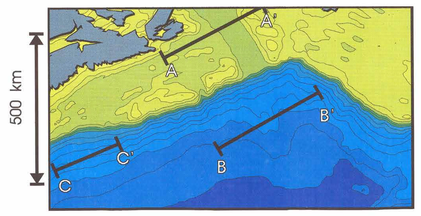
Observed free air gravity anomaly (mgals), gridded at 10 km intervals.

-80 -60 -40 -20 0 20 40 60 80 100



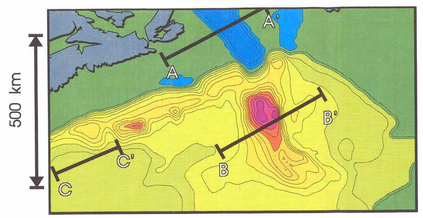
Isopachs (m) of 0.45 Ma to 30 ka interval (mid to late Pleistocene, since the onset of shelf-crossing glaciations), gridded at 10 km intervals. Negative values indicate erosion.

-400 -200 0 200 400 600 800 1000 1200 1400 1600



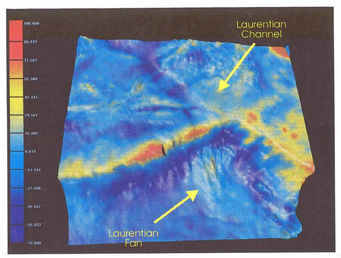
ETOPO5 bathymetry (m), gridded at 10 km intervals.

-6000 -5000 -4000 -3000 -2000 -1000 -500 -250 -100 -50 0



Isopachs (m) of 3.0 Ma to 30 ka interval (mid Pliocene to late Pleistocene) gridded at 10 km intervals.

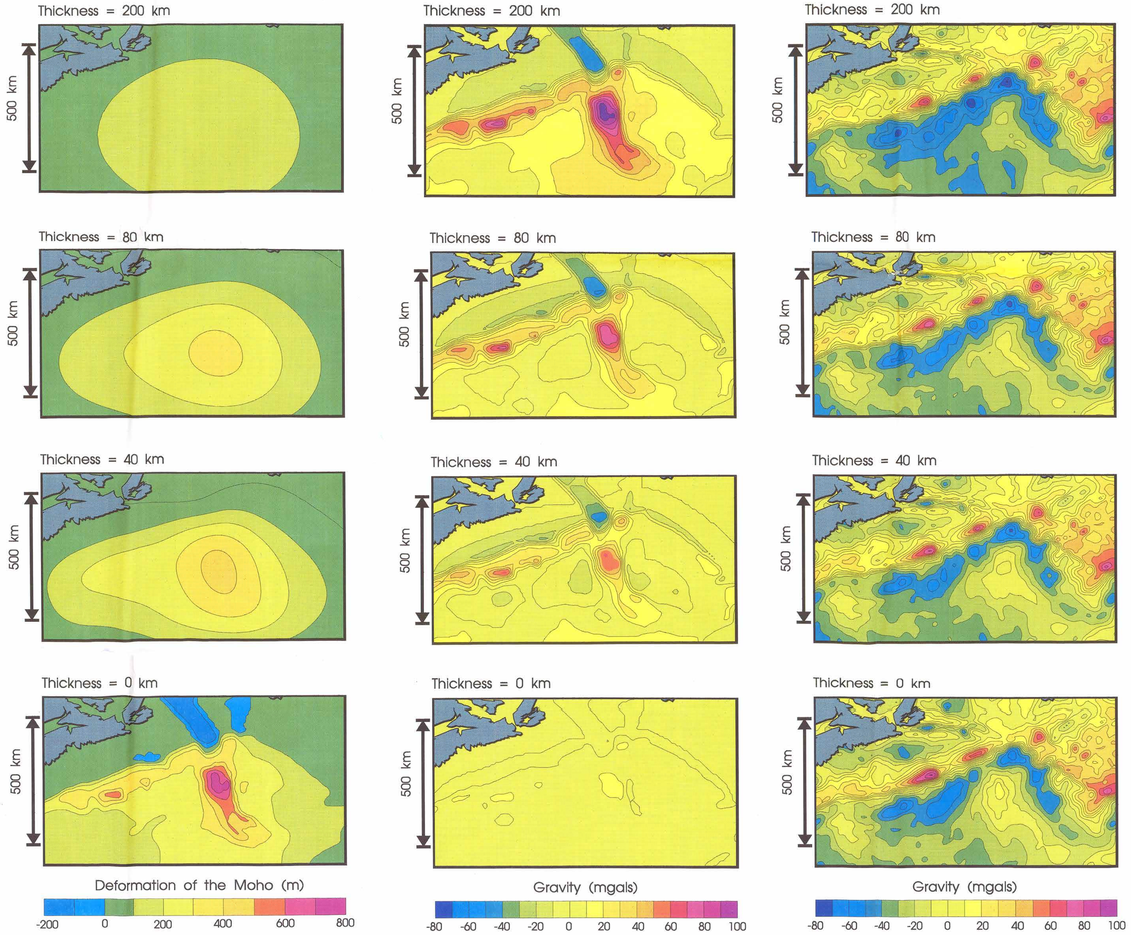
-400 -200 0 200 400 600 800 1000 1200 1400 1600



Gravity (colour) mapped onto bathymetry (relief) shows a high degree of correlation over the Laurentian Fan and Channel.

Deflection of the Moho by the Sediment Load

The deflection of the moho by the 3.0 Ma to 30 ka sediment load distribution is calculated using an elastic thin plate model of the lithosphere, employing varying thicknesses. The zero thickness model corresponds to Airy isostacy. As the elastic plate thickness increases, the moho deflection is progressively reduced.



Calculated Gravity

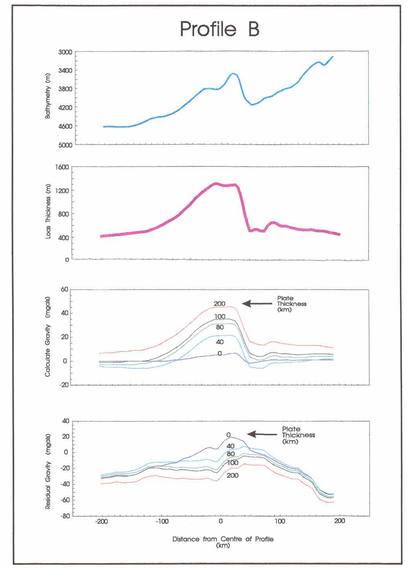
The contribution to the gravity field caused by sediment loading comprises a positive contribution of the sediment and a negative contribution attributable primarily to the moho deflection underneath. In the Airy limit, the calculated gravity is negligible. As the lithospheric strength increases, progressively longer wavelength components of the calculated gravity appear.

Residual Gravity Field

The residual gravity field (mgals) is calculated by subtracting the calculated gravity component from each flexural model from the observed free air gravity field. The anomaly over the Laurentain Fan is gradually removed as the elastic thickness of the underlying lithosphere is increased to >100 km.

Profiles of Data along Line B

A series of profiles of bathymetry, load thickness, calculated gravity and residual gravity are plotted for measurements along line B. The gravity profiles show the progressive removal of the fan anomaly as the lithospheric strength is increased.



Conclusions

(1) Gravity anomalies provide a rapid means of identifying possible deep-water Quaternary depocentres. Commonly, the stratigraphic control on such depocentres is poor.

(2) The existence of such large gravity anomalies over Quaternary sediments indicates that the weight of the sediments is supported by elastic stresses in the lithosphere. The use of an Airy compensation model in modelling on this margin is inappropriate.

(3) Elastic thickness must exceed 100 km to model the observed gravity anomaly. This estimate is more than double the estimates previously used in basin modelling studies on this margin and agrees better with estimates deduced from post-glacial rebound studies.

(4) An anomaly over the western Scotian Margin (Line C) does not correspond to a major thickness of Quaternary sediment, but may indicate a Miocene depocentre.