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RESULTS OF RECONNAISSANCE GRAVITY SURVEYS OF HUDSON BAY

with maps: No. 112—Hudson Bay North
No. 113—Hudson Bay South

A. K. Goodacre, R. V. Cooper and J. R. Weber

DEPARTMENT OF ENERGY, MINES AND RESOURCES
Ottawa, Canada 1972

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RESULTS OF RECONNAISSANCE GRAVITY SURVEYS OF HUDSON BAY

A. K. Goodacre, R. V. Cooper and J. R. Weber

ABSTRACT - The results of 821 underwater gravity observations and about 4,000 km of sea-surface gravity profiles in Hudson Bay are presented in the form of two Bouguer anomaly maps. Analysis of the gravity data indicates that random errors of about ±3 mgal exist in the sea-surface and underwater gravity measurements. These errors are due mainly to random errors in navigation and bathymetric determinations, but part of the random error in the sea-surface gravity meter readings may be due to off-level platform errors and cross-coupling errors. Systematic errors in the gravity data should be generally small but they may be as great as 2 or 3 mgal in the eastern and northeastern parts of Hudson Bay where distortions in the electronic navigation system pattern were greatest. Unexplained constant shifts of 5 mgal or more occurred in six surface gravity profiles.

The Bouguer anomaly field of Hudson Bay shows no obvious correlation with the depth of the crust-mantle boundary, but it shows a partial correlation with the configuration of the Hudson Bay sedimentary basin as derived from magnetic and seismic data. The primary sources of variations in the Bouguer anomaly field are density variations within the Precambrian crystalline basement. The broad, regional gravity low over Hudson Bay may be a consequence of crustal loading during Pleistocene glaciation.

RÉSUMÉ - Les résultats de 821 observations gravimétriques sous-marines et environ 4,000 kilomètres de profils gravimétriques en surface, dans la baie d'Hudson, sont présentés sous forme de deux cartes des anomalies de Bouguer. L'analyse des données indique qu'il existe des erreurs aléatoires d'environ ±3 mgal dans les mesures gravimétriques en surface et sous-marines. Elles sont dues surtout à des erreurs aléatoires dans la navigation et les déterminations bathymétriques, mais une partie des erreurs dans les lectures gravimétriques en surface résulte peut-être d'une plate-forme hors niveau et d'interférences. Les erreurs systématiques dans les données gravimétriques devraient être généralement petites mais elles peuvent atteindre 2 ou 3 mgal dans les parties est et nord-est de la baie d'Hudson où les distortions dans le système électronique de navigation étaient les plus marquées. Des décalages constants non expliqués de 5 mgal ou plus se sont produits dans six profils gravimétriques en surface.

Le champ des anomalies de Bouguer de la baie d'Hudson n'indique aucune corrélation évidente avec la profondeur de la limite entre la croûte et le manteau mais il montre une corrélation partielle avec la configuration du bassin sédimentaire de la baie d'Hudson défini en fonction des données magnétiques et séismiques. Les principales sources de variations dans le champ des anomalies de Bouguer sont les variations de densité à l'intérieur du socle cristallin précambrien. L'importante anomalie régionale négative de la baie d'Hudson résulte peut-être de la charge corticale qui s'est produite lors de la glaciation du Pléistocène.

INTRODUCTION

In 1960, Canadian and American observers aboard the U.S.S. Archerfish, an American submarine, obtained several gravity profiles over Hudson Bay using a LaCoste and Romberg gimbal-mounted surface gravity meter. These measurements, which were the first shipborne gravity measurements made in Canada, unfortunately contain large, unexplained systematic errors and the results are now of only historical interest. In an effort to obtain reliable gravity data in Hudson Bay, the Gravity Division of the Dominion Observatory (now called the Earth Physics Branch) of the Department of Energy, Mines and Resources made, in 1961, about 30 sea-floor measurements from the M.V. Theta with a LaCoste and Romberg underwater gravity meter on a traverse from Churchill, Manitoba to the Belcher Islands. No further gravity work was done in Hudson Bay until 1965 when the Dominion Observatory made a total of 791 reconnaissance underwater gravity measurements from the M.V. Theron and the C.S.S. Hudson and the Bedford Institute of Oceanography collected about 4,000 kilometres of gravity profiles on the C.S.S. Hudson with a continuously recording Askania-Graf shipborne gravity meter. These sea-floor and sea-surface measurements, which consisted of traverses scattered throughout Hudson Bay (see Figure 1), were made as part of a combined geophysical and oceanographic survey in which the Marine Sciences Branch, the Dominion Observatory, the Geological Survey of Canada, and several Canadian Universities took part.

This report has been prepared to present all the currently available gravity data in Hudson Bay to the mining and petroleum exploration industries and to scientists interested in the geological structure of this region and in isostasy and vertical movements of the earth's crust. Geological interpretations of the underwater gravity measurements have already been published in the Canadian Journal of Earth Sciences (Innes *et al.*, 1967) and in the book, "Science, History and Hudson Bay" (Innes *et al.*, 1968), therefore, the emphasis in this report is on the heretofore unpublished surface gravity meter data. The sea-surface and underwater gravity data are presented in the form of two Bouguer anomaly maps. One map covers the northern portion of Hudson Bay; the other covers the southern part. Mercator's projection is used for these maps and their scale is 1:1,000,000 at latitude 61°20' N. Gravity data plots at other scales and on other projections and computer listings of principal facts may be obtained at cost from the Gravity Division, Earth Physics Branch, Department of Energy, Mines and Resources, Ottawa.

THE GRAVITY SURVEY

General information

The first phase of the Hudson Bay survey started early in the fourth week of July when waters, at least in the northern part of the Bay, were relatively free of ice. Underwater gravity readings were taken from the M.V. Theron and surface gravity readings observed on the C.S.S. Hudson while both ships sailed to Churchill, Manitoba to rendezvous on August 1, 1965. Oceanographic and other geophysical work were also carried out.

During the second phase from August 1 to August 21, the C.S.S. Hudson and M.V. Theron traversed from Churchill, Manitoba to the Ottawa Islands and then from the centre of Hudson Bay to Chesterfield Inlet, N.W.T. Both ships were involved during the daylight hours in short-range seismic refraction measurements. In the evening, the ships operated separately and the C.S.S. Hudson commenced sea-bottom gravity measurements and oceanographic stations. At midnight this work was discontinued and the ship made continuous sea-surface gravity and magnetic measurements until she rendezvoused at dawn with the M.V. Theron. At night, the M.V. Theron did routine underwater gravity and oceanographic stations and set off large chemical explosions for the crustal seismic investigation. The night-time gravity traverses were positioned so that the work of one ship would not overlap that of the other; in this way as much territory as possible was covered.

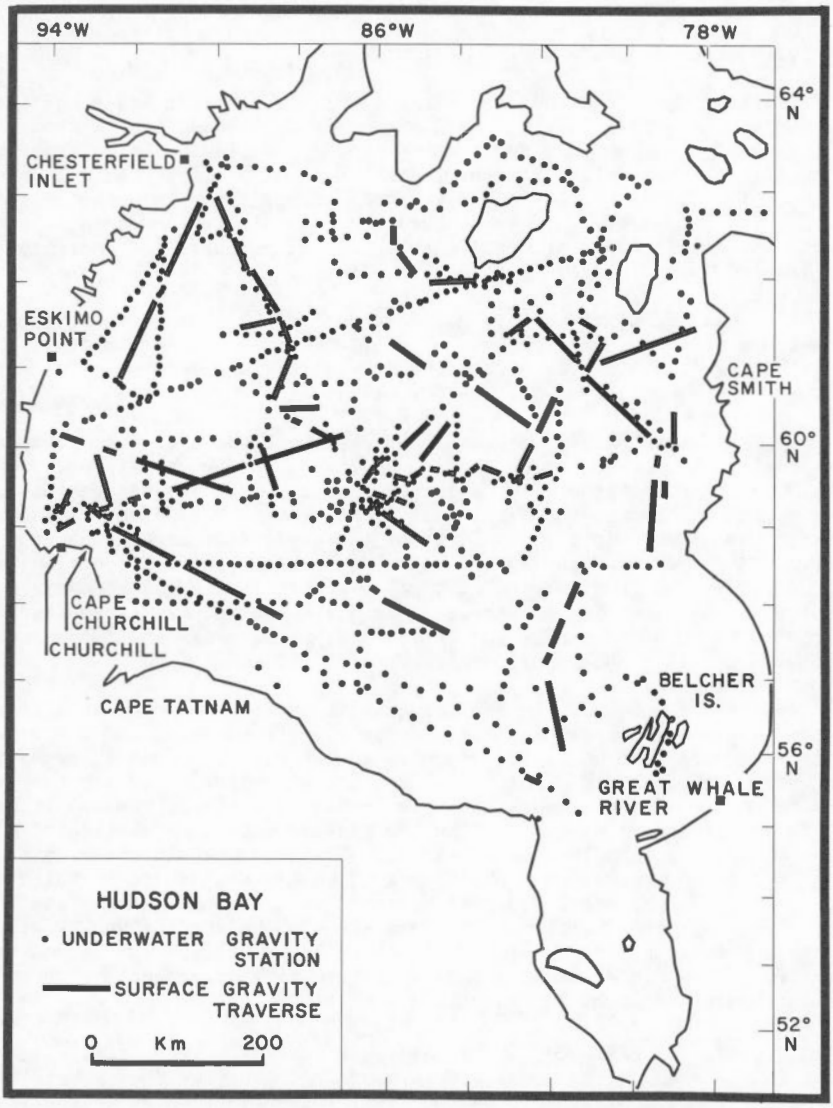

Figure 1. Map of Hudson Bay showing locations of underwater gravity stations and surface gravity meter profiles.

With the exception of the deep crustal seismic studies, the same type of work was done during the third phase from August 21 to September 10. The gravity and other geophysical and oceanographic measurements were located along a track which ran north from the centre of the Bay to Southampton Island, east behind Coats Island, back to the centre and then southeast towards the Belcher Islands. The weather, which had been extremely good all summer, then broke on September 4 and because of three days of high wind, some of the planned tracks were abandoned. The two ships then traversed separately back to Churchill, Manitoba.

The last phase consisted of traverses from Churchill, Manitoba to Great Whale River, Quebec by the C.S.S. Hudson and from Chesterfield Inlet, N.W.T. to Mansel Island by the M.V. Theron. The ships left Hudson Bay the third week of September.

The gravity meters and associated equipment

The LaCoste and Romberg underwater gravity meters are essentially land-gravity meter units suspended in gimbals and enclosed in a watertight case (Figure 2). After they are lowered to the sea floor, the instruments are levelled automatically and operated by means of a remote-control unit in the ship. A reliable connection between the underwater gravity meter and the control unit is essential. This is provided by a 13-wire armoured cable which connects the gravity meter to the control box and supports the instrument while it is lowered to and raised from the sea floor.

Hydraulic winches (Figure 3) are employed by the Earth Physics Branch for underwater gravity surveys. These winches provide smooth, positive control in both forward and reverse directions and therefore facilitate safe handling of the gravity meters at all times.

The only serious problem encountered with the underwater gravity meters during the course of the survey occurred when the gravity meter used on the M.V. Theron hit the side of the ship as it was being brought on board during stormy weather in the first week of September. The severe impulse separated the mercury in the capillary of the thermostat used to control the operating temperature of the instrument and, as a result, a discontinuity was produced in the gravity readings. This discontinuity was recognized and accounted for by repeating measurements at sea. The mercury thermostats in the gravity meters have since been replaced by thermistors and this change has eliminated all problems of temperature control.

The Askania-Graf sea-surface gravity meter is mounted on an Anschütz gyro-stabilized horizontal platform (Figure 4). These units and their associated control circuitry are operated in the C.S.S. Hudson in a small laboratory which is located amidships near the waterline. The laboratory is placed in this position because it is desirable to minimize the amplitude of the ship-accelerations experienced by the gravity meter. A multi-wire cable carries electrical signals from the Askania-Graf sea gravity meter to the centrally located Geophysical Data Logger (GEODAL) (see Figure 5) which stores the gravity readings, other geophysical data, navigational information and water depths. Sea-surface gravity results from the 1965 Hudson Bay survey were not computed until after the cruise was finished. However, the C.S.S. Hudson is now fitted with a computer and geophysical results are available a short time after the basic measurements are obtained.

Both the underwater and sea-surface gravity meters drift slightly. Control for the underwater measurements was therefore provided by base station readings at Ottawa, Ontario before and after the survey and at Churchill, Manitoba and Great Whale River, Quebec during the survey; control for the sea-surface gravity measurements was provided by readings at Dartmouth, Nova Scotia before and after the survey and at Churchill, Manitoba during the survey.

Horizontal positions and depth measurements

A Decca electronic navigation system was used to determine the positions of geophysical and oceanographic measurements made in Hudson Bay. A Master and two Slave transmitting stations, located on the western side of Hudson Bay (Figure 1) at Cape Churchill, Cape Tatnam and Eskimo Point, respectively, broadcast continuous-wave signals that were on different frequencies but locked together in phase. Decca receivers, installed on ships and aircraft involved in the survey, measured the differences in phase between signals

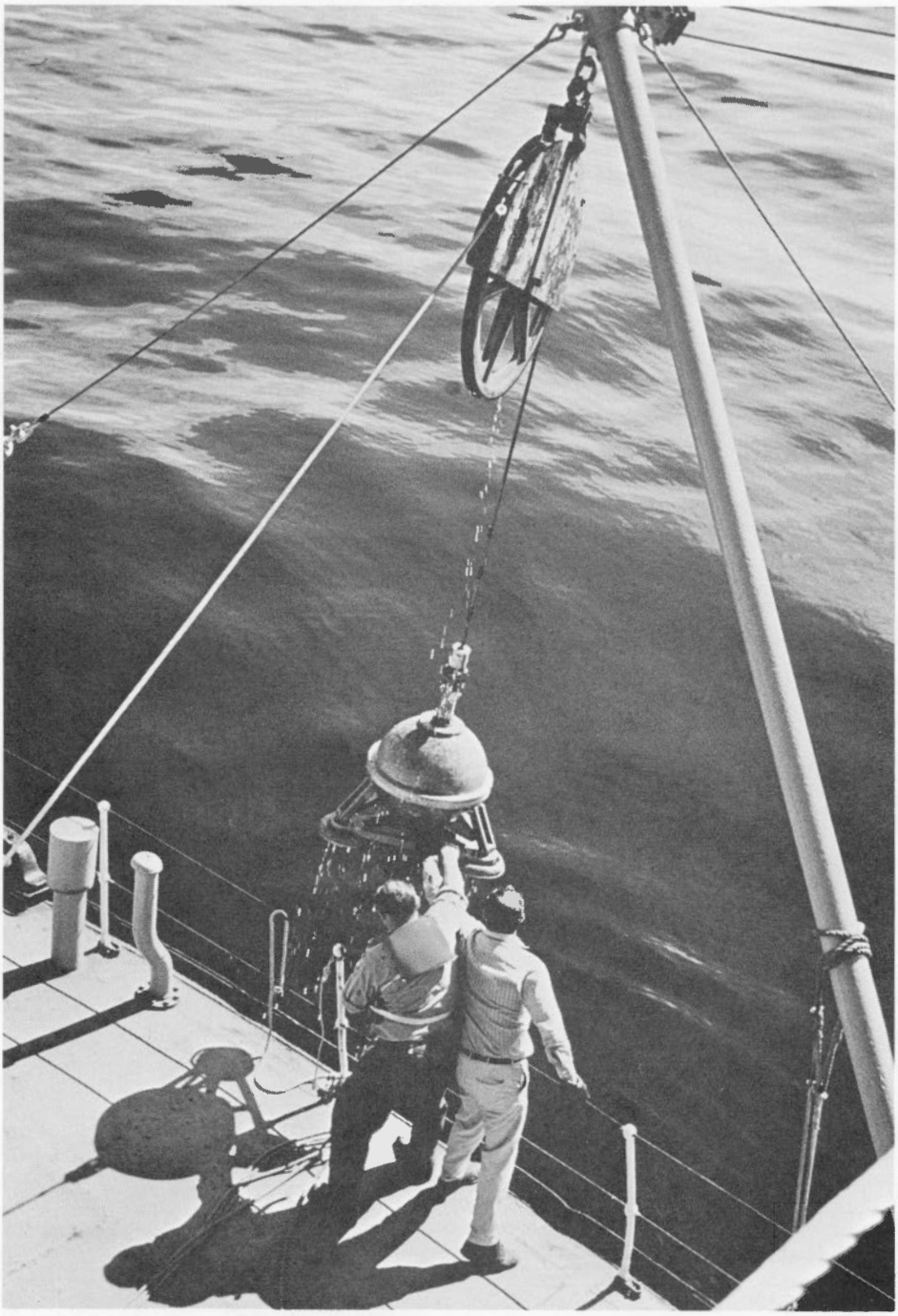

Figure 2. LaCoste and Romberg underwater gravity meter being brought on board after a sea-floor gravity observation.

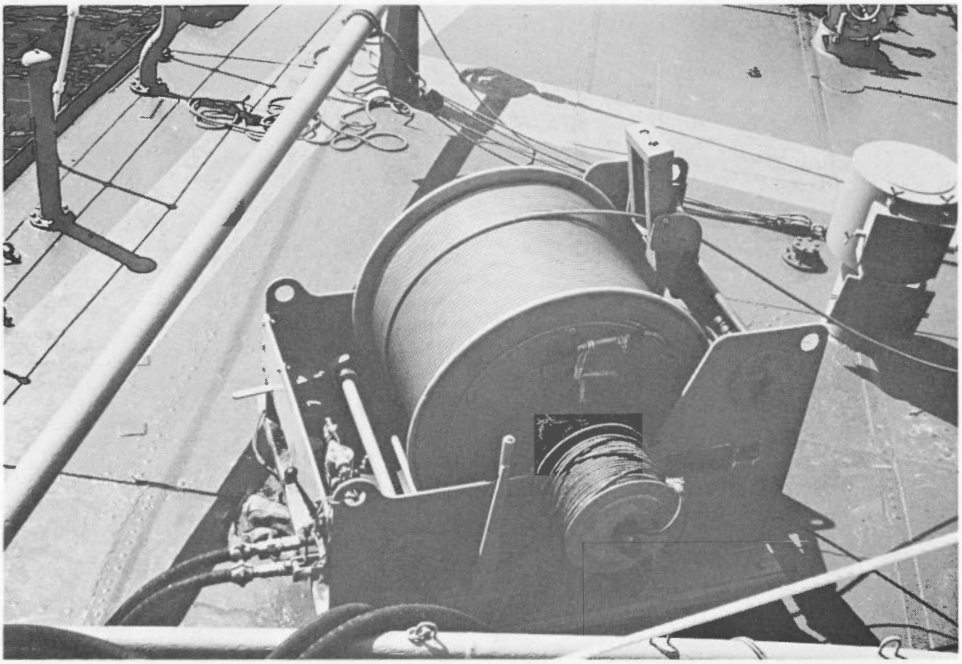

Figure 3. Swann hydraulic winch wound with Vector Cable Co. armoured cable.

from the Master-Red Slave and Master-Green Slave station pairs. The resulting readings, which were in units of lanes (one lane is equal to a phase difference of 360°) defined two position lines of constant phase difference; the intersection of the two position lines defined a geographical position.

Although useful signals were obtained throughout Hudson Bay and the repeatability of the Decca measurements was excellent, sky-wave interference at night could cause a Decca receiver to become unlocked from the ground-wave transmissions, particularly if the receiver was more than 200 km from the shore stations. When the interference ceased and the receiver was again locked onto the ground-wave signals, the Decca readings were often shifted by an integral number of lanes and the geographical positions were in error by an amount dependent upon the location of the receiver in the Decca pattern. This problem was minimized by traversing during daylight hours between temporary marker buoys. This technique provided consistent results throughout the season and enabled most of the positions to be referred to Decca coordinates for landmarks at Churchill, Manitoba.

Results from radar, astronavigation and aerial photography indicate that systematic or fixed errors are less than 1 km (Goodacre, 1968). Random errors were generally less than 1 km everywhere. The systematic errors may seem rather large but it should be pointed out that this is a result of using Decca at extreme ranges.

Water-depth information was obtained on board the C.S.S. Hudson by means of an Edo transducer and an Alpine Precision Echo Sounding Recorder; the

M.V. Theron was equipped with a Kelvin-Hughes echo sounder. No checks on the accuracy of the Hudson Bay water depths are available but experience in the Gulf of St. Lawrence (Goodacre *et al.*, 1969) indicates that it is difficult to reduce random errors in depth values below ±3 metres and systematic errors below 1 per cent. It is expected therefore that errors of at least this magnitude are present in the Hudson Bay water depths.

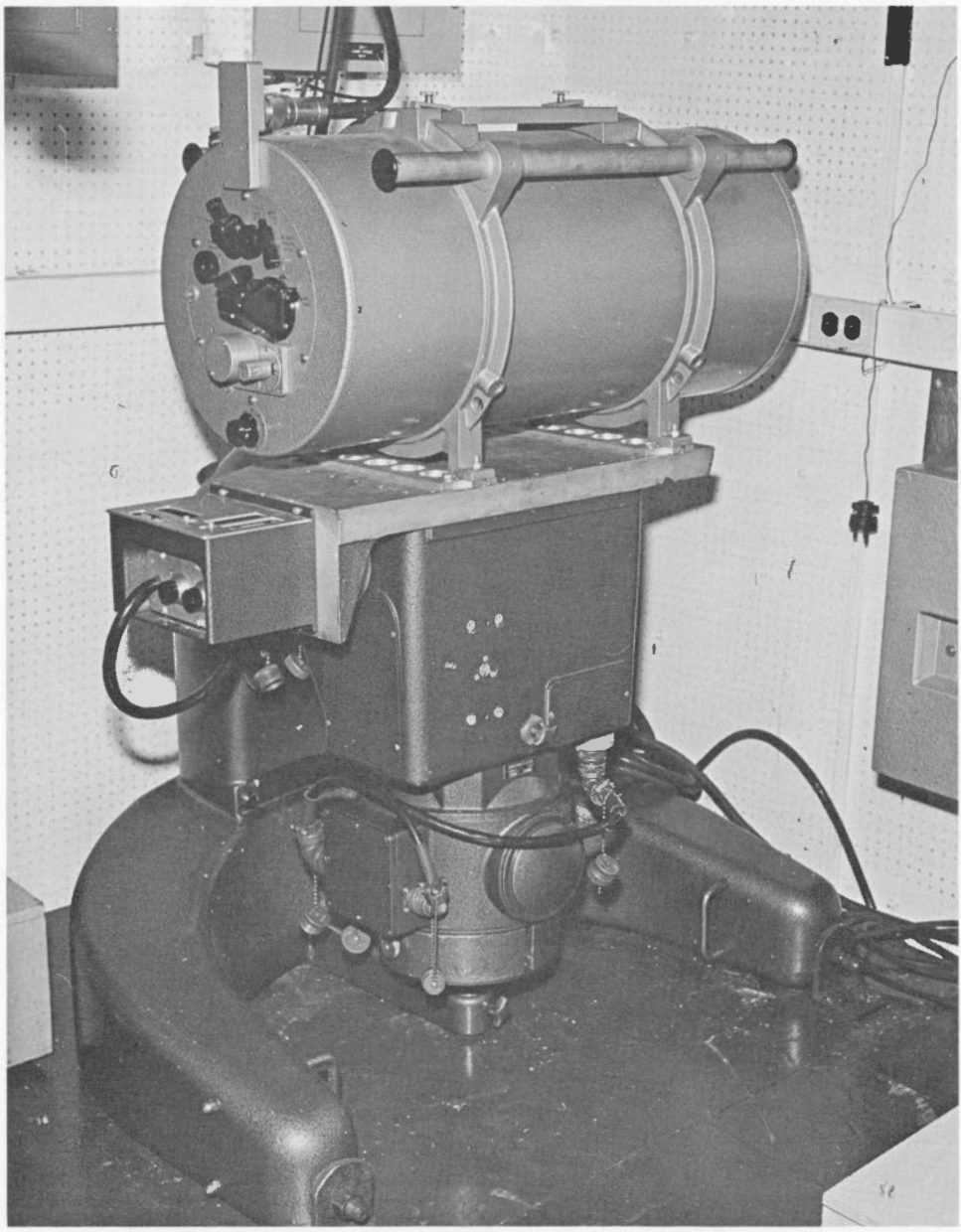

Figure 4. Askania-Graf surface gravity meter and Anschütz gyro-stabilized platform in operation aboard C.S.S. Hudson.

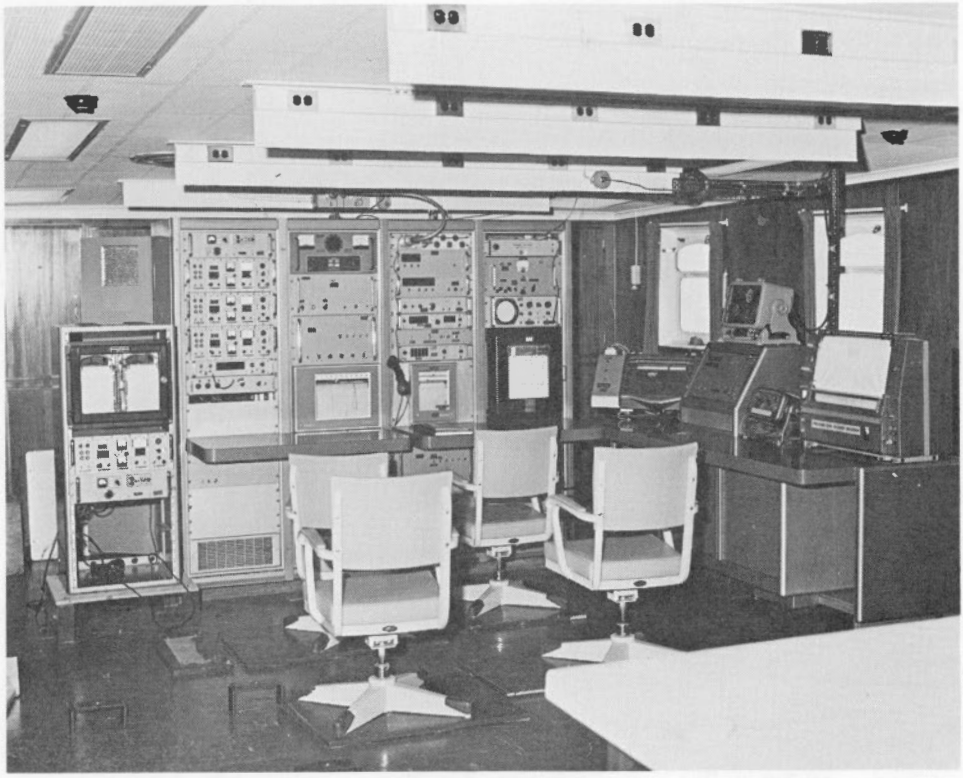

Figure 5. Geophysical data logging equipment (GEODAL) aboard C.S.S. Hudson.

REDUCTION OF THE GRAVITY OBSERVATIONS AND ESTIMATION OF ERRORS IN THE BOUGUER ANOMALIES

Reduction of the gravity data

The gravity results, presented as simple Bouguer anomalies, are directly comparable to the gravity data available for the land areas surrounding Hudson Bay (Innes, 1960; Tanner, 1961; Tanner and McConnell, 1964; Gibb and McConnell, 1969; Gibb and McConnell, 1970). To reduce the underwater gravity observations to a common elevation datum, the observed gravity readings were extrapolated to the sea surface taking into account the normal free air vertical gradient of gravity and the attraction of the layer of water above the instrument, according to the following relation:

$$g_s = g_{obs}\ (1 - 2d/R) + 4\pi\gamma\rho d$$
$$= g_{obs} - 0.223\ d \quad \text{(mgal)}$$

where g_s is the gravity at the surface

g_{obs} is the observed gravity

R is the radius of the earth

γ is the gravitational constant

ρ is the density of sea water ($1.03\ g/cm^3$)

d is the observed depth in metres.

Surface gravity values were obtained from the sea-surface gravity meter by averaging the readings over a five-minute interval and applying the Eötvös correction, E, (Heiskanen and Vening-Meinesz, 1958)

$$E = 14.5\ V\ \sin\phi\ \cos\lambda$$

where V is the ship's true speed (km/hr)

ϕ is the ship's course (degrees)

λ is the ship's latitude (degrees)

Bouguer anomalies were calculated in the usual way by adding to the surface gravity value a correction of 0.068d mgal for the mass deficiency of water with respect to rock of standard density 2.67 g/cm^3 and subtracting a theoretical gravity value (g_{th}) at the station computed from the International Gravity Formula of 1930. The Bouguer anomaly is given by:

$$\Delta g\ \text{(Bouguer)} = g_s + 0.068d - g_{th}\ \text{(mgal)}$$

where d is water depth in metres.

Sources of error

In areas of rugged underwater topography the approximation of the topographical variations by a plane surface is not adequate and a terrain correction must be applied to the 'simple' Bouguer anomaly to form a 'complete' Bouguer anomaly. No detailed analysis of the magnitude of the terrain correction was made for the Hudson Bay gravity data but this correction rarely exceeds 1 mgal in areas where the bathymetry is relatively smooth (Goodacre *et al.*, 1969) and therefore the effect of terrain should be negligible in most parts of Hudson Bay.

Corrections for marine tide (Bott, 1961) were not made; the maximum error in neglecting this correction is about 0.5 mgal.

An analysis of the Shipborne Gravimeter Testing Range near Halifax, Nova Scotia (Goodacre, 1964) indicates that the error in the adopted vertical gradient due to anomalous mass distributions is probably less than 1 per cent in many areas. As Hudson Bay is generally shallow, the effect of anomalous vertical gradients in the reduction of the underwater gravity data should be small. This effect is not a factor in the reduction of the surface gravity meter data.

An important source of error in the reduction of surface gravity meter data exists in the determination of the Eötvös correction, E. Under conditions of excellent Decca navigation and averaging position fixes over five-minute intervals, the error in the Eötvös correction is estimated to be about 0.6 mgal (Bower and Loncarevic, 1967). However, in Hudson Bay the system for digitizing the Decca coordinates did not work properly and the best that could be done with the surface gravity data was to apply a constant Eötvös correction to each surface gravity profile. The magnitude of the error in this correction is therefore unknown at any given data point but it probably exceeds 1 mgal in many instances.

Two important sources of instrumental error in stabilized-platform sea-surface gravity meter readings are cross-coupling and off-level platform errors (LaCoste and Harrison, 1961). Off-level errors will be discussed briefly in the next section, but no information is available from the Hudson Bay survey about the magnitude of cross-coupling errors. These errors vary according to the type of gravity meter, the size of the ship, the ship's course and the sea-state and they may exceed 10 mgal in rough weather. However, cross-coupling errors are not likely to contribute more than 2 or 3 mgal to errors in the Hudson Bay sea-surface gravity data as the sea was generally calm throughout the survey except, of course, during the storm in the first week of September, 1965.

Estimation of the magnitude of systematic and random errors

Systematic errors in the Bouguer anomalies in Hudson Bay due to systematic errors in observed gravity, observed depth and navigation and to lack of corrections for terrain and marine tide may be as great as 2 or 3 mgal, particularly at the extreme ranges of the Decca system on the eastern side of Hudson Bay or in the northeastern portion where the water is deepest. Elsewhere, the anomalies should exhibit little systematic error.

The magnitude of random errors in the gravity data may be estimated by considering the scatter of anomaly values obtained at repeated stations. The root mean square (r.m.s.) deviation of the Bouguer anomalies at 10 repeated underwater stations is 2 mgal and the r.m.s. deviation at 12 surface meter line crossings is 3 mgal. These error estimates compare favourably with estimates of ±1 mgal for underwater gravity results (Goodacre *et al.*, 1969) and ±3 mgal for surface gravity meter data (Bower and Loncarevic, 1967).

If random errors in the surface and underwater gravity meter data are normally distributed and uncorrelated, the r.m.s. difference between surface and underwater Bouguer anomaly values should be about 3 to 4 mgal. This seems to be the case as the standard deviation of 52 differences between surface and underwater Bouguer anomaly values is 4.3 mgal. Nevertheless, the histogram of these differences (Figure 6) exhibits a somewhat irregular, skewed shape and the skewness suggests that some of the errors in the gravity data are not normally distributed. The slight skewness towards negative values appears to be characteristic of data obtained with the stabilized-platform-mounted Askania-Graf gravity meter as histograms of (i) differences between sea-level gravity values obtained with an Askania-Graf instrument on the Halifax test range (Bower and Loncarevic, 1967) and sea-level values computed from underwater gravity data (Goodacre, 1964) and (ii) differences between free air anomalies obtained with an Askania-Graf gravity meter in the Gulf of St. Lawrence (Haworth *et al.*, 1971) and anomalies computed from underwater data (Goodacre *et al.*, 1969) also exhibit a negative skew. Bower and Loncarevic (1967) suggest a possible reason for this skewness is that the stabilized platform is not always perfectly level. Whenever the platform is off-level the surface gravity meter reading will always be less than the true value. The distribution of differences in each of Figures 7 and 8 may therefore result from three sources of error: (i) normally distributed errors in the underwater gravity data, (ii) normally distributed errors in the surface gravity readings due to normally distributed errors in the Eötvös correction, cross-coupling errors, etc., and (iii) Rayleigh-distributed errors in the surface data caused by slowly varying, off-level platform conditions.

We may estimate the magnitude of the Rayleigh-distributed errors in the following way. Assuming that the mean value of the normally distributed differences is zero and that there are no numerically positive Rayleigh-distributed errors we can "fold the histogram over" and subtract the number of cases for a given positive class interval from the number of cases for the corresponding negative class interval to form a histogram of the excess number of cases of negative differences. This type of histogram is presented in Figures 9 and 10 for data from the Halifax test range and from the Gulf of St. Lawrence. Although the shapes of these histograms are irregular, they resemble the shape of the Rayleigh-distribution which has a distribution function, f(r), of the form:

$$f(r) = r/\sigma^2 \; e^{-r^2/\sigma^2}$$

The peak of a Rayleigh-distributed variable, r, occurs at the value $r = \sigma$ where σ is the standard deviation of the variable. It is seen by inspection of Figures 9 and 10 that the standard deviation of the Rayleigh-distributed errors, postulated to occur in the surface meter data, is about 5 mgal on the Halifax test range and about 3 mgal in the Gulf of St. Lawrence.

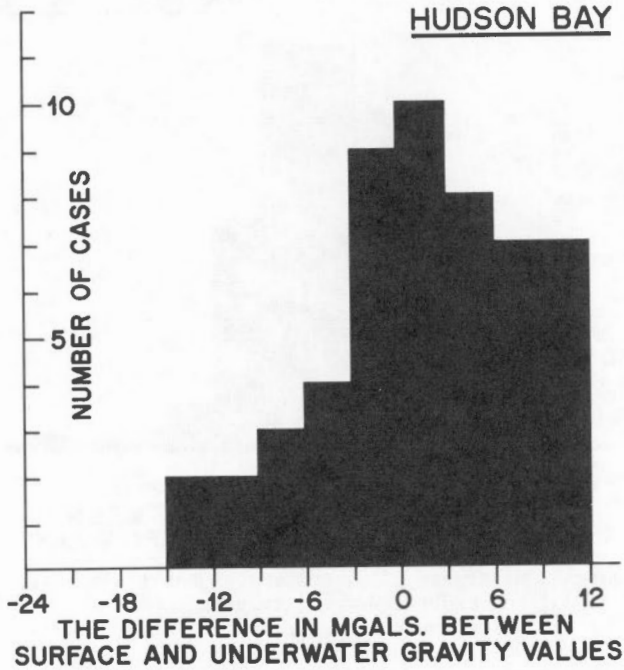

Figure 6. Histogram of discrepancies between surface and underwater Bouguer gravity anomalies in Hudson Bay.

These standard deviations correspond, according to Bower and Loncarevic (1967), to standard deviations of platform tilt of 10 and 7 minutes of arc respectively. It seems reasonable, therefore, that similar platform operating conditions occurred in the Hudson Bay survey and that some of the negative differences between the surface and underwater anomaly values are due to off-level errors in the stabilized platform.

It was clear when the surface and underwater gravity data from Hudson Bay were first compiled that the Bouguer anomaly values in some of the surface gravity profiles were shifted a constant amount above or below the underwater anomaly values which fell along the profile. Such systematic off-sets in surface gravity meter data occur elsewhere (Bower and Loncarevic, 1967) and they are probably caused, at least in part, by non-linear mechanical and/or electrical response in the surface gravity meter system (Bower and Watt, 1963). In the case of the Hudson Bay data, these off-sets may also be caused by errors in the Eötvös correction or by cross-coupling errors. The surface gravity results were adjusted to coincide with the underwater data if the difference between the surface and underwater data was greater than ±5 mgal. Four profiles were adjusted in this manner. Two profiles in which discrepancies ranged from 25 to 50 mgal were discarded.

DESCRIPTION AND DISCUSSION OF THE BOUGUER ANOMALY FIELD

Description of gravity field

To facilitate discussion of the gravity field, a simplified Bouguer anomaly map of Hudson Bay and vicinity is presented in Figure 11; the gravity maps accompanying this report can be referred to for greater detail.

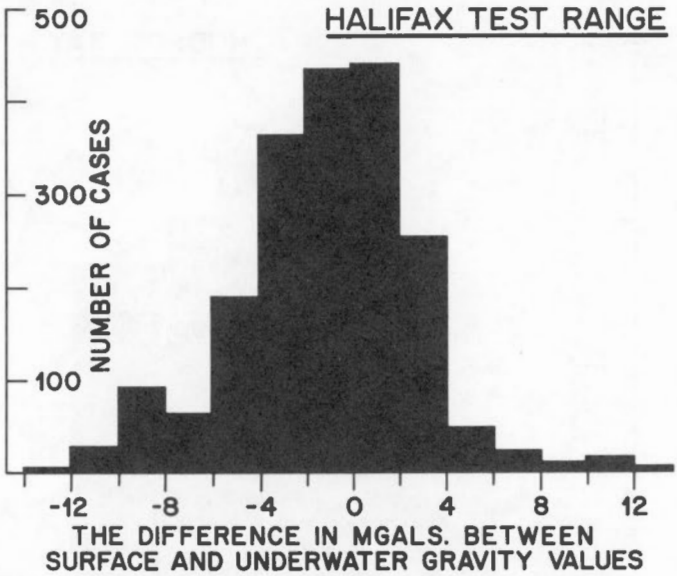

Figure 7. Histogram of discrepancies between surface and underwater gravity data from the shipborne gravimeter testing range near Halifax, Nova Scotia.

Within the map-area, the Bouguer anomalies range more than 95 mgal, varying from less than -75 mgal north of Churchill, Manitoba to more than +20 mgal at a point approximately halfway between Mansel Island and the Ottawa Islands. The mean value of the Bouguer anomaly field over Hudson Bay is about -25 mgal; therefore, in Figure 11 the lined and dark areas designate regions of relatively positive anomaly whereas stippled areas indicate negative regions.

The gravity field over Hudson Bay is dominated by a broad positive anomaly zone which extends some 500 km southwest from the northern tip of Quebec to the centre of Hudson Bay. This zone is enhanced on its southeastern side by a narrow trough of intensely negative anomaly. A roughly circular gravity high occupies the west-central portion of Hudson Bay and a broad negative anomaly area lies over the western shoreline. The anomaly field in the southwestern part of Hudson Bay is relatively flat and featureless, whereas in the southeastern part, near the Belcher Islands, the north-south gravity trends are in marked contrast to the east-west trends on the nearby mainland.

Geological significance of the gravity field

The main variations in the Bouguer anomaly field cannot be easily reconciled with changes in the depth of the crust-mantle boundary (Innes *et al.*, 1967; Weber and Goodacre, 1968) but can be satisfactorily explained in terms of structures within the crust (Innes *et al.*, 1968). For example, Paleozoic and Proterozoic sedimentary formations are expected to depress the gravity field. Magnetic data (Hood, 1966) and shallow seismic results (Hobson, 1968) indicate that sedimentary formations attain their maximum thickness near the centre of Hudson Bay and that isolated basins occur north of the Coats-Mansel Islands area and to the south of the Belcher Islands. No gravity data are available immediately to the south of the Belcher Islands. However, the gravity low which separates the roughly circular positive anomaly in the west-central part of Hudson Bay from the broad positive zone in the northeastern part and the gravity low between Coats Island and Southampton Island correlate in a broad fashion with the basement depressions defined by Hood (1964).

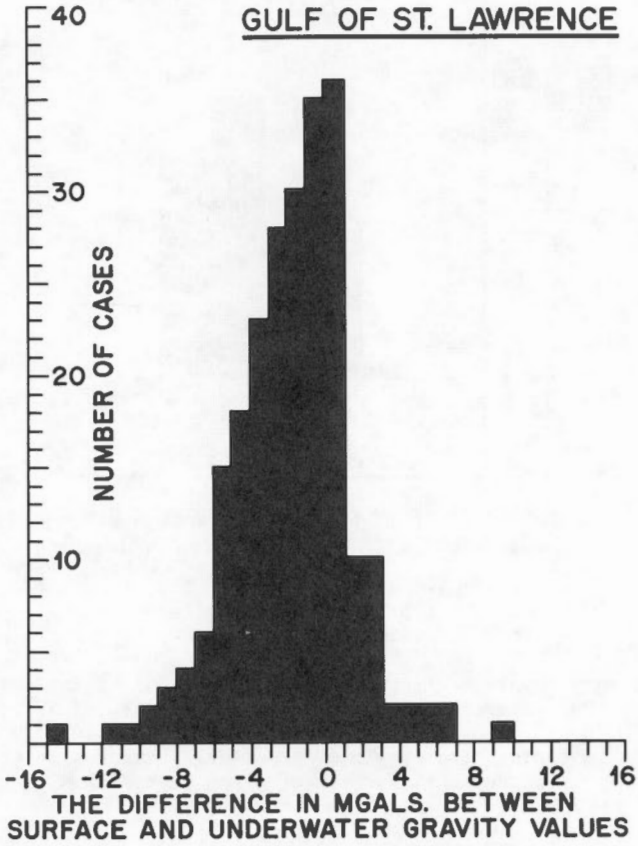

Figure 8. Histogram of discrepancies between surface and underwater free air gravity anomalies in the Gulf of St. Lawrence.

Empirical relations between compressional wave velocity and rock density (Nafe and Drake, 1963) indicate that the seismically determined sedimentary strata can depress the gravity field a maximum amount of about 15 mgal; this effect is only one-sixth of the total anomaly range. Therefore, it seems that the main sources of the Bouguer anomaly variations lie generally within the Precambrian crystalline basement.

The extensive positive anomaly areas in the northern half of Hudson Bay probably reflect the presence of heavy metamorphic and/or basic volcanic rocks similar to those found in the Ungava peninsula of northern Quebec (Kretz, 1960). Conversely, massive batholiths of low-density granite probably produce the gravity minima in the broad negative region on the western side of Hudson Bay. Low-density granite may also create the long, narrow trough of intensely negative anomalies in the Ottawa Islands - Cape Smith area, although Tanner and McConnell (1964) suggest that these latter negative anomalies may instead be due to a deep-seated mass deficiency which provides isostatic support for the load of basic rocks in the Cape-Smith - Wakeham Bay volcanic-sedimentary belt (Kretz, 1960). The north-south trending zones of positive and negative anomaly in the vicinity of the Belcher Islands are associated with highly folded Proterozoic sedimentary and volcanic rocks (Jackson, 1960).

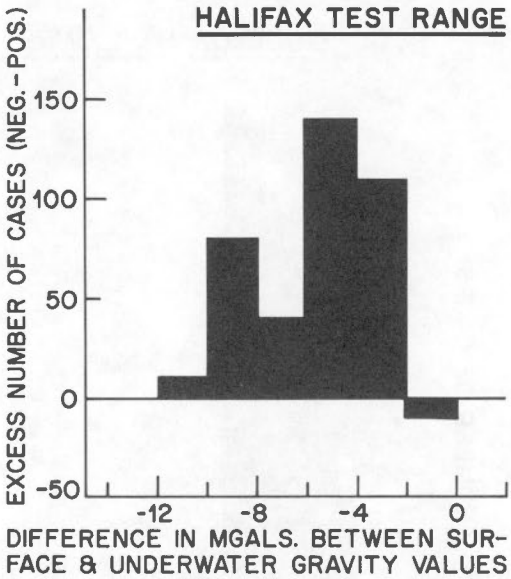

Figure 9. The asymmetry of the histogram in Figure 7. See text for details.

For more complete structural interpretations of the gravity anomalies in Hudson Bay, the reader is referred to papers by Innes *et al.*, (1967), Innes *et al.*, (1968), Gibb and Walcott (1971), and Gibb (1971). The latter two papers attempt to explain the origin of structural features in and around Hudson Bay in terms of current theories of plate tectonics.

Significance of the regional anomaly field

As was mentioned previously, the regional level of the Bouguer anomaly field over Hudson Bay is about -25 mgal. This negative field probably represents a broad, deep-seated mass deficiency associated with the loading effects of the recent Laurentide ice sheet (Innes, 1960; Innes *et al.*, 1968). Innes *et al.*, (1968) point out that if this mass deficiency is due entirely to laterally displaced mantle material of density 3.3 g/cm^3, the crust beneath Hudson Bay should rise about 180 m. If this happens, Canada's large, shallow inland sea will almost completely disappear.

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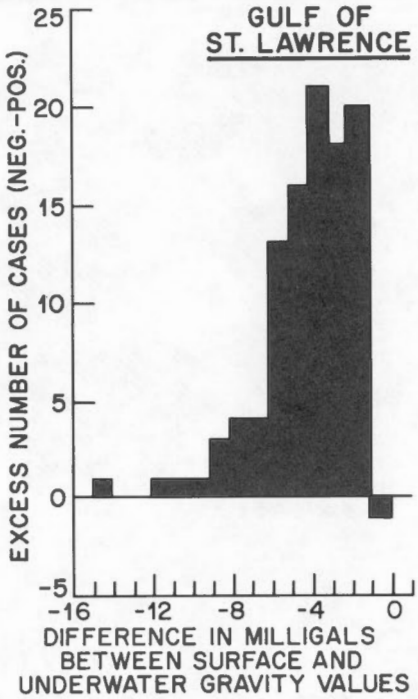

Figure 10. The asymmetry of the histogram in Figure 8. See text for details.

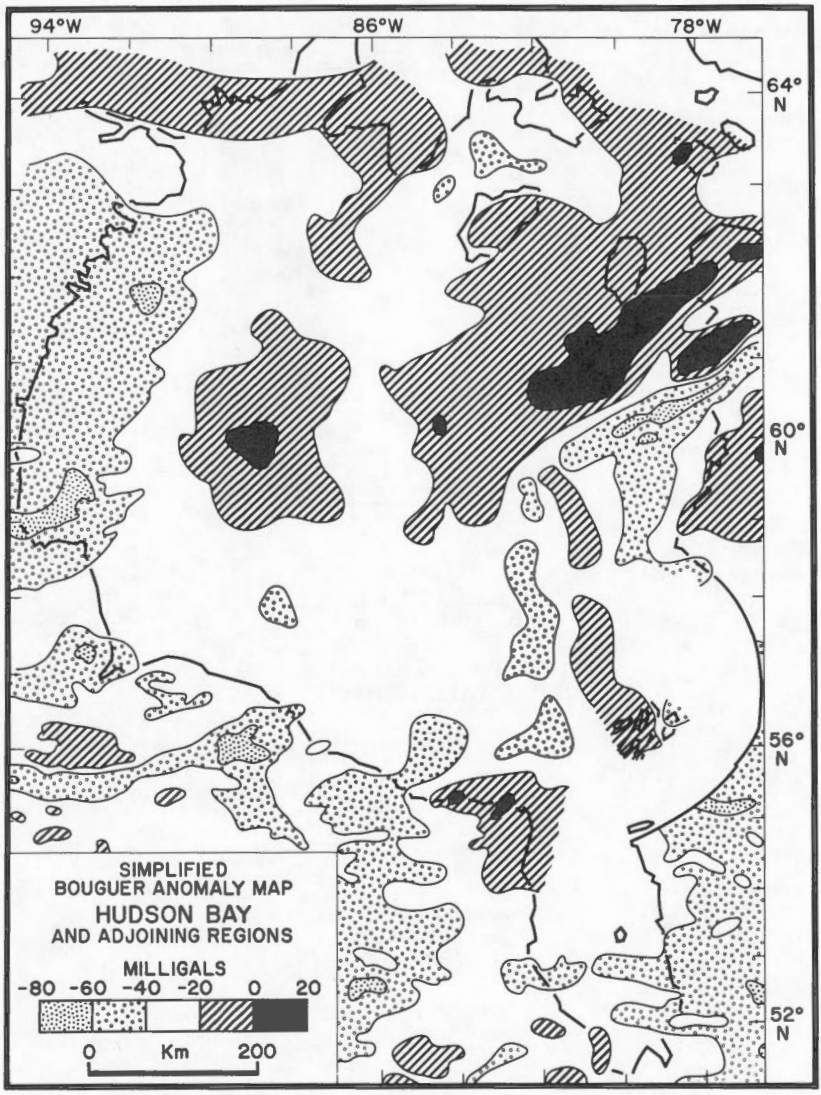

Figure 11. Simplified Bouguer anomaly map of Hudson Bay.

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