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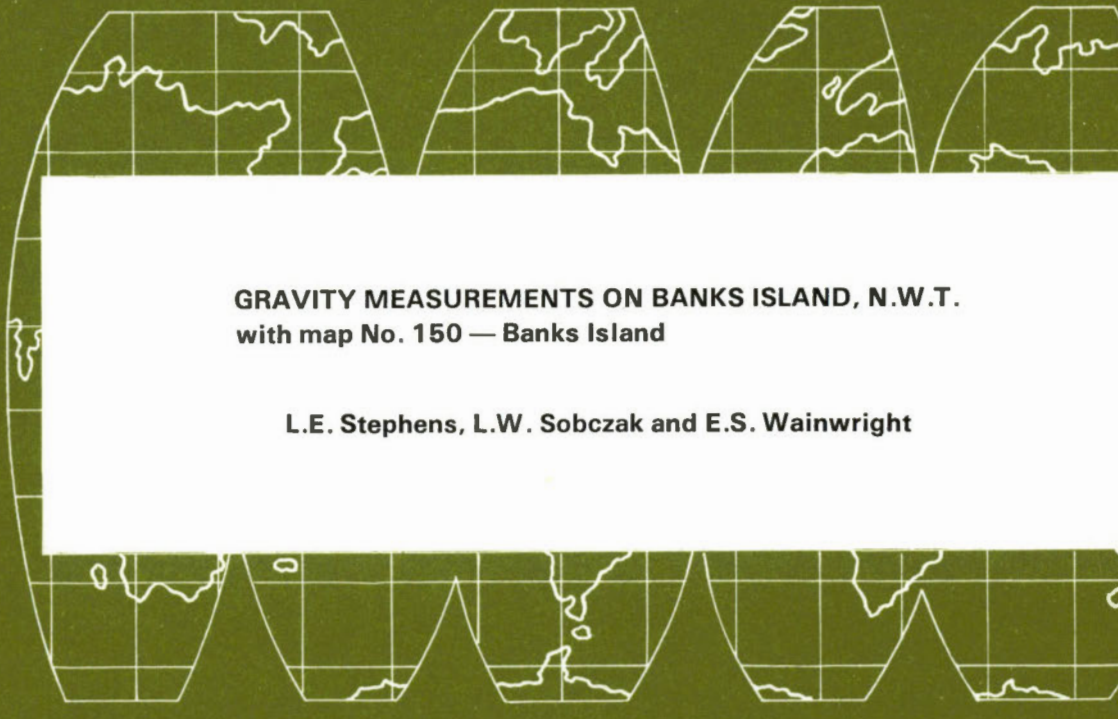

GRAVITY MEASUREMENTS ON BANKS ISLAND, N.W.T.
with map No. 150 — Banks Island

L.E. Stephens, L.W. Sobczak and E.S. Wainwright

DEPARTMENT OF ENERGY, MINES AND RESOURCES
Ottawa, Canada 1972

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INTRODUCTION

The regional gravity survey of Banks Island was completed in 1971 in response to requests from the oil industry. The survey of Banks Island is an important link between previous gravity surveys to the north and south, the results of which have already been published in the Gravity Map Series of the Earth Physics Branch by Sobczak and Weber (1970) and Hornal, Sobczak, Burke and Stephens (1970) respectively. On Banks Island, stations were located at intervals varying from 6 to 8 miles as in previous surveys designed to complete the national gravity mapping program. A gravity control network was established on the island to provide an accurate gravity datum for the survey and for more detailed surveys carried out by the oil industry.

Gravity data have been used extensively by the oil industry to assist in the analysis of sedimentary basins in the Canadian Arctic. A measure of this activity is provided by the fact that industry has acquired some 20,000 gravity observations on ice and on land during the 1970-71 field seasons. These stations have been integrated with the results of government sponsored surveys to provide improved compilations for use in basin analysis. The results of one such study of the Sverdrup Basin have recently been published by Grant and Prendergast (1971). Geological reconnaissance mapping by geologists of the Geological Survey of Canada has shown that the rocks of Banks Island are almost wholly Phanerozoic sediments ranging in age from Devonian to Tertiary (Thorsteinsson and Tozer, 1962; Douglas, Norris, Thorsteinsson and Tozer, 1963). Large areas are covered by unconsolidated Tertiary and Quaternary sediments which obscure the geological structure of Banks Island. Geophysical methods are thus of prime importance in mapping the island. Apart from gravity data, aeromagnetic data and seismic reflection surveys done by industry the only other geophysical data available in the area are a few aeromagnetic survey profiles described by Gregory, Bower and Morley (1961) and some high altitude aeromagnetic profiling described by Haines (1967). Elf Oil Exploration and Production Canada Ltd. have drilled two dry holes to depths of 4,518 feet and 6,719 feet and are currently drilling a third hole. Data from these holes will provide invaluable information for the interpretation of geophysical results on the island.

SURVEY LOGISTICS

The gravity survey of Banks Island was carried out in two phases (see Table I). The first phase of gravity surveying was based at Sachs Harbour during April 1971 and consisted of work within the Bernard River Bird Sanctuary. This area lies in the southwest quarter of the island and was surveyed before April 15 since low-flying aircraft were prohibited entry after that date. In the second phase the remainder of the island was surveyed from a base at Shoran Lake during June and July.

The surveys were conducted with a crew of four men. Transportation in the form of a Bell 47G4 helicopter, and DeHavilland Twin and single-engine Otters, and camp facilities were supplied by the Polar Continental Shelf Project base at Tuktoyaktuk. Several loads of fuel were shipped from Tuktoyaktuk by Bristol. Some fuel caching for the island was done in April but most of it was completed in June. In April, bad weather resulted in 10 lost days out of $18\frac{1}{2}$, whereas the survey in June was delayed by two weeks due to the poor condition of the air-strip at Sachs Harbour during the spring thaw.

Table I. Summary of Survey Logistics

	Phase One	Phase Two
Dates	April 11 to 19	June 21 to July 19
Observers	L.E. Stephens	E.S. Wainwright
Transportation	Bell 47G4 (CF-SEF) Twin Otter Single Otter	Bell 47G4 (CF-SEF) Single Otter Helio Courier
Instruments	LaCoste-Romberg G173	LaCoste-Romberg G75
Station Sequence	6001-71 to 6190-71	6191-71 to 6725-71
Total Stations	190	535
Base Camp Location	Sachs Harbour	Shoran Lake

During the surveys, a total of 725 stations was established and an additional 12 control stations were distributed over Banks Island to maintain an accurate datum for the field stations.

GRAVITY MEASUREMENTS

Control network

A control network of 12 stations was established over Banks Island with LaCoste-Romberg gravimeters. This network was adjusted using a Gauss-Seidel iterative method. After adjustment the standard deviations of the observed gravity values were less than 0.025 mgal. The primary gravity values are related to the National Gravity Net (McConnell, 1970). LaCoste-Romberg gravimeters were used for all the gravity measurements because of their very low drift characteristics and their ease of operation at below-zero temperatures. Errors in the observed gravity values of the field stations are in the range 0.15 to 0.25 mgal. The control stations now located on Banks Island are listed in Table II; descriptions and values of these stations are available on request.

Vertical and horizontal control

Elevations for most of the field stations were determined using Wallace and Tiernan altimeters which were read concurrently with the gravimeters. Control elevations for the altimeters were provided by APR measurements, DND bench marks and sea level. Altimeter ties were made between traverses and to known elevations and the readings were corrected for temperature and humidity. The elevations were adjusted by means of a Gauss-Seidel iterative method in which all elevation data are adjusted simultaneously by a method of least squares. Of the 917 elevations for the Banks Island survey, 713 were adjusted by 0 to 9 feet, 157 by 10 to 19 feet, 38 by 20 to 29 feet and 9 by 30 to 39 feet with respect to the original data.

Identification of land marks was provided by 1:102,860 air photographs while the station positions were plotted on 1:250,000 topographic maps for determining their co-ordinates. The measured co-ordinates from the topographic maps are considered to be accurate to within 1,000 feet. The major difficulty in navigating over Banks Island in April was that 85 per cent of the low topographic relief was snow-covered thereby obliterating most traces of river channels and shorelines. An average of one hour a day was lost for this reason. In most cases, however, the identification of station positions was accurate to 100 feet.

Terrain corrections were not applied to any of the stations as most of the topography on Banks Island is low. One exception to this occurs at stations located on or near cliffs on the north and south coasts where terrain corrections of not more than 4 or 5 mgal may be required. A change in elevation of 2,460 feet near Cape Lambton is by far the greatest relief on the island.

Bouguer anomaly values

The observed gravity data were reduced to simple Bouguer anomaly values using the computer-oriented method described by Tanner and Buck (1964). A density of 2.67 g/cm^3 was used in the Bouguer reduction. Inaccurate elevations contribute the largest error in the reduced gravity data. Errors of 25 feet would cause Bouguer anomaly errors of 1.5 mgal and with other factors considered, the overall accuracy of most Bouguer anomaly values is better than 2 mgal.

Bouguer anomaly values at all stations were used to compile the enclosed gravity map of Banks Island (GMS 150, scale 1:500,000). The principal facts for all gravity stations and descriptions of control station locations are available at cost from the Gravity Division, Earth Physics Branch, Department of Energy, Mines and Resources, Ottawa, K1A 0E4.

BOUGUER ANOMALY MAP

The geology of Banks Island is briefly described by Thorsteinsson and Tozer (1962). Most of the island is overlain by Tertiary and Quaternary unconsolidated sediments, the greatest thickness being on the western half of

Table II. Control Stations Located on Banks Island

Station Number	Location	Latitude	Longitude
9003-68	Cape Prince Alfred	74° 29.6'	124° 20.7'
9043-69	Sachs Harbour	71° 59.6'	125° 17.2'
9101-71	Sachs Harbour	71° 59.3'	125° 14.8'
9102-71	Meek Point	72° 53 0'	125° 05 1'
9103-71	Bernard Island	73° 34.7'	124° 06.4'
9104-71	Shoran Lake	73° 30.5'	120° 18.4'
9105-71	Johnson Point	72° 46.4'	118° 27.9'
9106-71	Bernard River	72° 43.1	121° 49.1'
9108-71	Colquhoun Point	74° 32.1'	121° 51.6'
9109-71	Knight Harbour	73° 33.7'	115° 32.6'
9110-71	Jesse Harbour	72° 15.5'	120° 08.8'
9111-71	Mercy Bay	73° 48.6'	119° 10.9'
9112-71	Cape Lambton	71° 05.2'	123° 04.3'
9113-71	Able Creek	73° 34.7'	120° 15.3'

the island. Cretaceous shale and sandstone of the Christopher and Isachsen Formations outcrop along the Thomsen and Atitok Rivers. Upper Devonian sandstone and limestone of the Melville Island Formation occur east of the Thomsen River in the northeast corner of Banks Island. Precambrian sediments lie unconformably beneath Cretaceous sediments near Cape Lambton at the south end of the island.

The gravity field east of the Thomsen River is relatively featureless and is underlain by a sequence of Devonian sediments. West of the Thomsen River the gravity anomalies have dominantly northerly trends; however a belt of northeasterly trending gravity lows cuts across these northern trends in the southern half of the island. The sedimentary cover obscures the relationship between the gravity anomalies and basement structure, but by analogy with other sediment-covered shield areas it is highly likely that many of the local gravity anomalies are related to structures within the Precambrian.

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