PRELIMINARY REPORT
GRAVITY SURVEY ALONG THE SEISMIC REFRACTION LINE FROM ICE ISLAND, N.W.T.

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April 19 - 30, 1985

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INTRODUCTION

Two gravity meters (G75 and G498) were used to make control ties from Resolute Bay to the Ice Island; one (G75) was set up on the Ice Island at the navigation hut in an insulated box and acted as base monitor and the other (G498) was used as a mobile unit for the period April 19 - 24. Then G75 was used as a mobile unit from April 29 and 30. Altogether seventy-seven gravity observations and 61 water depths were taken along the seismic refraction lines (Fig. 1).

Dave Forsyth of the Earth Physics Branch (EPB) was in charge of this line but the ultimate authority lay with Ruth Jackson of Atlantic Geoscience Centre (AGC) who was Chief Scientist at the Ice Island. George Hobson of PCSP coordinated all the camp activity and everything appeared to be going smoothly. Robert Duval and Michael Gilbert from Geodetic, Surveys and Mapping looked after the satellite navigation and orientation of the Ice Island. It did not move during April 17 to May 24, 1985. Mike Schmidt of EPB looked after the GPS system, seismograph, S56 gravimeter, and assisted with the Syledis navigation system and the gravity survey. No cross checks were made between Syledis coordinates and GPS coordinates along the refraction line due to constraints on use of aircraft.

During the survey a Bell 206 helicopter with Syledis navigation was used for 19.9 hours of flying time for the main refraction line B-E and for about 9 hours for the line from the Ice Island to Point E and the short line parallel to the coast (Ice Island to shot point G). There was a shortage of Bell 206 flying time which meant no regional work could be done.

Gravity Survey

G75 was used as a stationary base on the Ice Island for the first part of the survey and then was used as a portable unit from gravity station number 12049 to 12077. G498 was used as a mobile unit from gravity station 12001 to 12048. A total of 77 gravity observations were made.

G498 appears to drift quite a bit-nearly 1.5 dial division in 10 days. However the initial problem of sticking on the stops cleared up after a day of use.

Sobczak tested the gravity meter and Edo echo 9040 sounder on a short traverse April 19 from 82°N latitude to 81° latitude along 96°W longitude and found that the sounder did not work (discussed below).

Jack Davison, Systems Engineering Group, Bedford Institute of Oceanography, checked us out on the use of the Syledis navigation system.

A long and short seismic line was established more or less parallel to the coastline with shot points roughly 60 km apart (spreads) at A, B, C, D, E and F with recording sites (12) between B-C, C-D and D-E (Fig. 1). Also a line was completed between the Ice Island and shot point E_3. Gravity observations were taken at all shot points and recording sites.

Water depth Sounder

The 9040 echo sounder, which Sobczak picked up in Resolute Bay from Barry Hough of PCSP, was not boxed but open and it did not work. Morley Wright of AGC, a Sydelis technician, worked on these sounders before and determined that the output transformer was burnt out, probably a receiver card and maybe the transducer was nearly shorted, although it showed a resistance of 0.5 ohm. The hydrogaphers (Ken Hipton and party) at Tom Bay where Lisanne Loisier (EPB) was working the Gulf of Boothia area were unable to provide the resistance value for the transducer. As our sounder had a malfunction in it another complete 9040 sounder was requested.

Weber's seismic sounder was used instead. We spent 1 1/2 day experimenting with it. Even though many places were tried on the Ice Island the reflective energy from our small charges 1/4 to 1/2 kg which were placed in shallow wedges in the ice surface was absorbed. The sounder was then taken by skidoo to the pack ice off the Ice Island. One kg charge was found to be the optimum charge size there. The Ice Island would probably take about 10 kg charge to get a reflection through it. Weber's sounder requires maximum gain on channels 2 and 3, 1 kg dynamite charge, catch the photo sensitive paper immediately (<10 sec), roll it up and place it in your pocket for development back at camp. To develop the paper trace requires about 10 seconds exposure to light and be in a warm building.

On April 23, 13 gravity observations and 11 soundings were made. One trace was overexposed and the other did not give a clear enough reflection. On April 24, 27 shots were made with 1/2 kg charges in fresh new leads and thin ice and 1 kg for older ice. Again 2 traces were lost. On April 29 no traces were lost but on April 30 three traces were lost. At least three seismic spreads along the main refraction line were done with only four water depths missing. Weber's seismic sounder records the length of time in milliseconds from the time of shot to the time of a reflection is received. Because our distance between shot and geophone receiver was about 50 m a 17 ms time delay was added to the two-way travel times recorded. These were converted to water depths using Mathews' 1939 velocities.

Navigation

A Syledis (SR3 and beacon) navigation system (medium-range radio positioning system) was used (brochures on the system are available with Sobczak). The seismic line was in an area where the distance was about twice range of sight even though the four transmitters placed on shore were at high elevations. Generally one had to hover about 200 feet above the station, get a fix, land, get the observations, take off and hover about 200 feet above the point, lock in the transmitters and go to the next site. However, until lock was made (which could take up to 15 minutes as it did once with blowing snow) you could not go anywhere.

Even though Syledis is time consuming in warming up and locking it is very accurate, repeatable, and easy for navigational use. All sites established earlier by seismic people between C-D and D-E were relocated. The ice had not moved.

Jack Davison of AGC who installed the Syledis system claims the accuracy to be 1 - 5 m. The Syledis system records to one hundredth of a second (one second in latitude is 31 m and in longitude 4.5 m at the Ice Island). However, the transmitter location on shore were positioned initially by GPS. Because it was not possible to record the GPS data, post processing results are not available and thus the accuracies of the GPS locations cannot be precisely determined. At worst one could expect errors of up to 40 m which would naturally be propagated by the Syledis system. Internal checks made indicate the error to be significantly less.

Results

Locations of gravity and water depth observations, seismic refraction recorder sites and shot points established during the spring of 1985 from the Ice Island base are shown at a scale of 1: 500,000 on a polar stereographic projection in Figure 1 together with gravity measurements made in 1963 on the westerly side of the map and in 1983 on the easterly side of the map. A large area still remains to be mapped.

Water depths in meters are shown in Figure 2. These have been corrected for velocity changes according to Mathews Tables 1939. A few additional hydrographic stations taken from the Arctic Geophysical Review study done in 1978 are shown for the unmapped area northwest of Nansen Sound. Figure 2 reveals 2 channels (northwest of Nansen Sound and north of Sverdrup Channel) and 3 plateaus (northwest of Cape Bourne, Meighen Island, and Axel Heiberg Island). These features strike normal to the coastline, and may represent either horst and grabens structures or a couple of glaciated channels. These channels widen seaward and vary in depth along strike with the deepest depths being near shore. This largely unmapped area appears to be quite complex in bottom morphology.

Free-air anomalies along the seismic refraction lines indicate gravity lows in the region of the channels and highs over the plateau areas (Figure 3). The Ice Island is situated on the southerly flank of a large gravity high with peak values in excess of 30 mGal. On the northwestern flank of this high crossed by a seismic refraction line is a steep gravity gradient of about 16 mGal in 5 km where water depths are more or less constant. The normal large Free-air anomaly highs along the shelf break appears to be offset.

Bouguer anomalies (Fig. 4) show no correlation with water depths and an elliptical high trending northeast-southwest with the Ice Island on the southern edge of it. This high is flanked by gravity lows on the shoreward and seaward sides. This high, with peak values in excess of 40 mGals and steep gravity gradients (16 mGal in 5 km), probably indicate a near surface dense mafic rock complex. Local gravity highs over the islands to the south and north of Cape Bourne may indicate the type of mafic rocks for the Ice Island high. We predict that this mafic structure will probably obscure the near surface stratigraphy.

Recommendations

1. Gravity Division should have their own water depth sounders. Maybe some could be obtained from Crown Assets. Thirty of these were returned by AGC about 1 - 2 years ago. AGC now use an Elac 72. Dave Halliday is checking this out.

2. Syledis navigation is excellent for survey work up to 100 km but beyond that it becomes marginal and must use the hover mode.

3. A short description on the use of Weber's sounder should be included with the unit and a manual.

4. The geology of the Cape Bourne area should be obtained.

Statistics

Ice Island Project No. 85-804
Instrument Nos. Lacoste Romberg G498, G75
Detail stations assigned 12001 - 12500
Detail stations used 12001 - 12077
Control stations assigned 9021 - 9100
Control stations used 9021
Water depth sounder Edo 9040 - did not work
Water depth sounder used - seismic reflection (Weber's sounder)
Field book number use 7 and 14.
Observers: L.W. Sobczak, Mike Schmidt
Transportation: Bell 206 helicopter (JKN)
Pilot - Dave White
Engineer - Al. Singh
Navigation - Syledis with filter 41.

Captions

Figure 1 Location of gravity and water depth observations (last two digits give year of observation). Solid lines indicate seismic refraction lines and shot points are lettered A, B, C, D, E, F, and G. Sydelis transmitter locations are indicated as Trans 1-4.

Figure 2 Water depths in meters (contours at 100 m intervals).

Figure 3 Free-air anomalies (contours at 10 mGal intervals).

Figure 4 Bouguer anomalies (contours at 10 mGal intervals).