

**END 723:**

**HMS Endurance**

**Scotia Sea**

**Geophysics**

**December 1972 - March 1973**

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## Falkland Islands Gravity Survey

Three thousand four hundred nautical miles of gravity and magnetic data were collected over the Falkland Island Shelf and Burdwood Bank occupying 12 1/4 days during the period 23rd February to 15th March, 1973. The data were collected on board H.M.S. Endurance using the LaCoste and Romberg gravimeter, number S40, on hire from the N.E.R.C. Research Vessels Base, Barry, and a Varian Magnetometer which was on loan from the Hydrographic Department. The sea was calm for most of the cruise; consequently most of the data is of good quality. A track chart accompanies this report.

### Background

Variations in the densities of bodies of rock in the earth's crust lead to changes in the value of gravity. These changes though small, 1 part in 10,000 of the value of gravity, are measurable. One formation that gives a large effect is a sedimentary basin. This is a region where relatively young rocks have been deposited in large quantities. If organic matter has accompanied this deposition it may have been converted to oil, and if the strata are suitably disposed it may also have been trapped. Because the rocks are all relatively young, they are less dense than the average for the crust as a whole. This leads to a lowering of the value of gravity above the basin. Such a basin has been found on the north side of Burdwood Bank which lies to the south of the Falkland Islands. The purpose of this survey was to delineate the area of the gravity low to permit a more quantitative and detailed seismic survey to be carried out at a later date.

### The Cruise in General

The gravimeter was flown out from Gatwick on 8th February. This was a flight earlier than planned but this was fortunate in that it allowed the process of customs clearance to begin sooner. I flew out to Buenos Aires on Sunday, 11th February and spent two days there waiting for the meter to be cleared by the Customs. In Buenos Aires I met Mr Bishop who had come from LaCoste & Romberg in Austen to install and check the meter. We both flew down to Mar del Plata on the Wednesday, On Thursday afternoon Mr Bishop and I assembled the meter assisted by two members of the crew. As it was getting late in the day when

assembly was finished the meter was left to reach thermal equilibrium overnight. On Friday the meter was switched on and Mr Bishop checked it out. Late in the afternoon he left to return to America.

During the night of 19th/20th February there was a malfunction of the meter. Not having sufficient knowledge to repair the meter I telephoned Mr England of LaCoste & Romberg for advice. Whilst carrying out his instructions I discovered the fault was caused by the meter overheating. I managed to get the meter functioning properly just in time for the ship's departure from Mar del plata on Wednesday, 21st February.

The survey proper started at 1500 G.M.T. on 23rd February, when we did a log running into the north of the Falkland Sound. One survey party was picked up at Speedwell Island and another dropped at Lively Island. From there to Port Stanley a short leg was run. Using the known gravity value at Barry a tie-in was obtained with the gravity base station at Stanley to within 1 milligal whilst at anchor in Port Stanley. The Marines and Flight were left at Moody Brook and the ship sailed Sunday mid-day to continue the survey. Passing Lively Island a second boat was left with the survey party. Shortly after this, whilst doing the line closest into the Falkland Islands it was learnt that the father of one of the crew had died. The Admiralty gave permission for him to be flown home. Unfortunately there were no seats on Monday's flight from Port Stanley so the ship headed for Rio Gallegos. On 28th February the ship anchored for several hours whilst the sailor was taken ashore to catch a flight to Buenos Aires.

The survey then continued until 8th March except for a small break when travelling down the Falkland Sound on 7th March. As a finishing touch to the hydrographic survey of the Sound. the First Lieutenant had wished to carry out a sidescan sonar sweep down the Sound. This was attempted on 7th March but it was found that the towing cable was damaged. The ship returned to Port Stanley on 8th March after calling at Lively Island to pick up a survey boat. The ship could not anchor in the same place as before but near enough to make only 0.1 milligal difference. The meter reading was about 0.2 milligal different from the previous tie-in, allowing for the movement of the ship at anchor.

We sailed on 11th March for Bleaker Jump, picking up the survey party on the way. 11th to 13th March was spent at Bleaker Jump carrying out a hydrographic survey. After dropping the survey party at Lively Island on 13th March the ship headed for Ushusia. Opportunity was taken to collect data on this last leg. On 14th March we hit the roughest weather of the cruise. I had anticipated dismantling the meter on this day but because of the rough weather it was left running until the Le Maire Channel.

With the help of two of the crew I dismantled and packed the meter on the morning of 15th March. We berthed at Ushuaia just before lunch. The aircraft that fly to Ushuaia (Fokker Friendships) were too small to carry the meter as cargo in one flight so the Naval Attache, with the help of the local Vice Consul, had arranged for a lorry to carry the meter to Rio Grande where direct flights to Buenos Aires are operated by Boeing 707s. The meter left by lorry on Thursday night for Rio Grande.

It arrived at Buenos Aires either late Saturday or Sunday. It was during this time that one of the boxes was damaged but luckily no harm came to any part of the gravimeter. I flew out from Ushuaia on Saturday morning for Buenos Aires. Captain Woodfield and I were offered seats in the Governor of Tierra del Fuego's aeroplane as the commercial flights were fully booked until Monday. On Monday night the meter was loaded onto the British Caledonian flight even though the Embassy had at that time not received the necessary Argentinian customs clearance. The flight was behind schedule and did not arrive until late Tuesday night at Gatwick. Customs clearance in this country was slow, the meter not being delivered to R.V.B. Barry until Friday afternoon.

### The Survey

The survey was designed to fill in the gaps in our knowledge of the variation in gravity and the fluctuations of the magnetic field around the Falkland Islands. We require this information to plan a seismic profiling and refraction study to be carried out in December 1973 during the R.R.S. Shackleton's next geophysical cruise in the Scotia Sea. The positions of the lines were planned as a grid pattern to cover the interesting area off the south-west of the Falkland Islands, reaching south to Burdwood Bank, plus a few lines around the island to fill in

generally and obtain crossovers with previous data. Nearly one third of this pattern had to be omitted because we were not permitted to cross the median line between the Falkland Island and Argentina. The ship time so gained was used by measuring extra line to the northwest to help fill in the large gap in our knowledge there. The small pattern of lines close to the southwest corner of the islands was chosen to sort out the contours where the gravity low of the Malvinas Basin meets the high which may be associated with an offshore extension of the Cape Meredith rocks. Additional unplanned lines were obtained because of the trip to Rio Gallegos. Also, on the last leg from the Falkland Islands to Ushuaia, the meter was left running longer than anticipated as it was too rough to start dismantling it.

The weather was very favourable for the greater part of the cruise, thus most of the data is of good quality. Only occasionally did the conditions deteriorate and reduce the quality of the data. On the last leg to Ushuaia the winds were gale force, but as the ship was heading into the sea there was little rolling - once or twice the cross-coupling exceeded 25 milligals. The autopilot failed on this leg.

I reduced about 75% of the data roughly, on board the ship I calculated values at 20 minute intervals, taking velocities, headings and latitudes by hand from the chart. Then with the help of the Satnav computer and a program the First Lieutenant wrote, I calculated the free air anomaly, added a simple 1-D Bouguer correction, then plotted the data. This enabled me to reallocate some lines. For 14 crossovers there is an average error of 2.7 milligals. One line appears to be rather poor and the two highest crossover errors occur along it (7 & 88 milligals). Missing these two values out reduces the average to 1.9 milligal. Looking at the crossovers, with the data collected on board R.R.S. Shackleton last year, using the same gravimeter, gives an average crossover of 2.6 milligals for 11 crossovers between the two sets of data. The two highest errors (both 5 milligals) occur with the same line as before, and missing these out reduces the average to 2.0 milligals. These crossovers with R.R.S. Shackleton data are very encouraging as I was doubtful of the accuracy of some of the earlier data. The two Shackleton lines running east-west to the south west of the islands were measured in very rough sea conditions. The gravimeter output had up to 30 milligal short

period noise, which I smoothed by eye, and the cross-coupling corrections often exceeded 40 milligals. The lines located to the east of the islands were collected in good conditions,

The data show the low over the north side of Burdwood Bank closes just to the west of the median line, and the gravity contours appear to be curling around southwards to the bathymetric low that separates Staten Island from Burdwood Bank.

I am at present engaged in working up the data more accurately. This entails recalculating the satellite fixes and positions of course alterations. Also, I am now reducing the data at five minute intervals which allows one to plot reasonably smooth profiles at a scale of 1:1,000,000. I shall also calculate 2-D Bouguer corrections which allow for variation of the bathymetry along a track.

The gravity, magnetics and bathymetry are all output on paper tapes. The Satnav is normal Teletype output. I brought all the gravimeter chart recorder rolls and all Satnav output back with me. The remainder of the data was left on H.M.S. Endurance as they required it to prepare bathymetric and magnetic charts for the Hydrographer. I informed Mr McPherson of the Hydrographic Department at Taunton of the data that I have in my possession. I hope to avail myself of the remainder when H.M.S. Endurance arrives back in this country.

#### The LaCoste and Romberg Gravimeter

I have written a report of the performance of the LaCoste and Romberg Gravimeter S40. Copies of this have been sent to Mr O. Gonsalves at R.V.B. Barry and Mr McPherson at the Hydrographic Department, Taunton.

#### Acknowledgements

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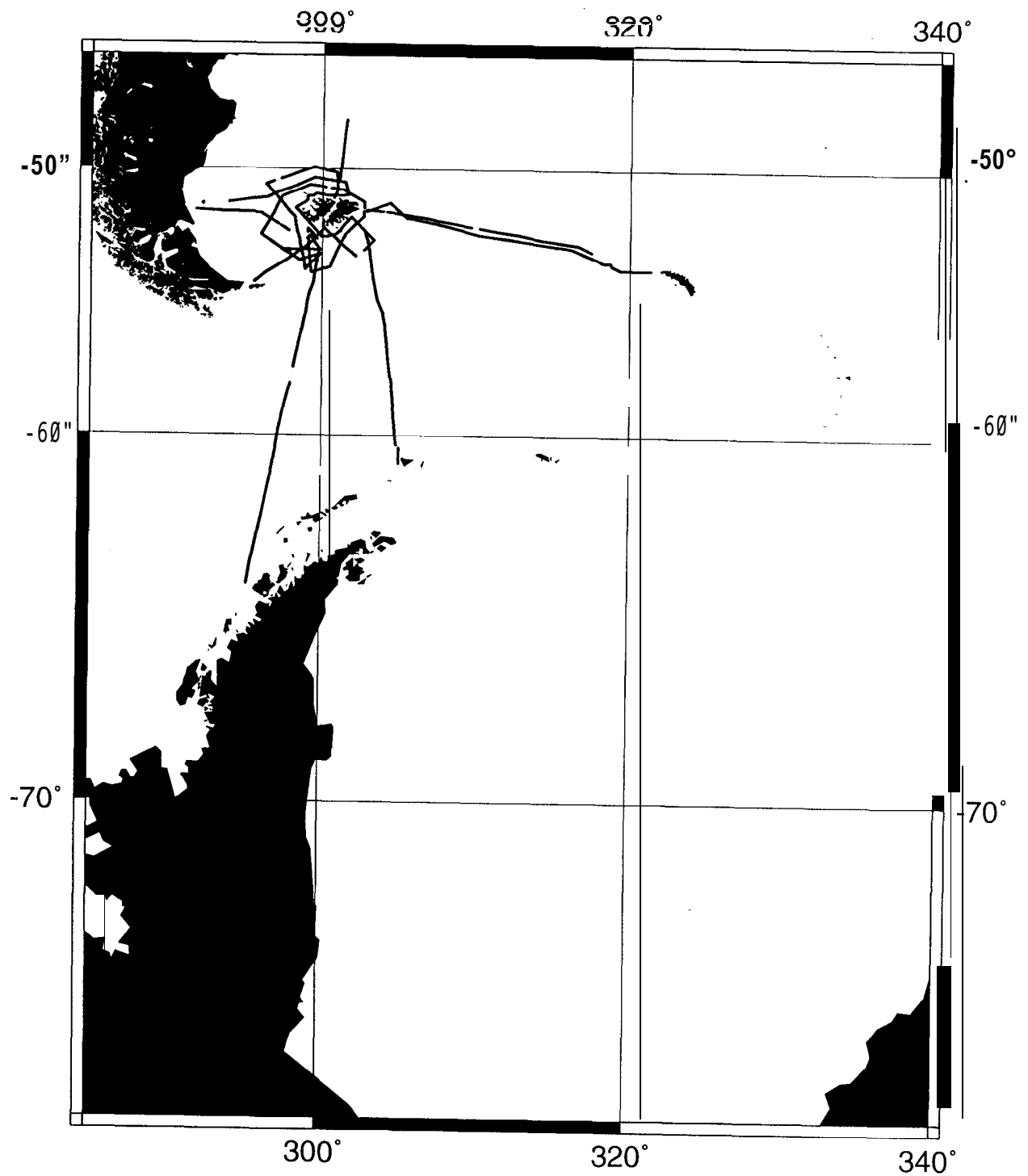
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