SHACK 68

RRS Shackleton
Scotia Sea
Geophysics
November 1968 - April 1969

Scotia Sea Geophysical

Cruise Report

1968-69

Personnel

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Ships

Survey Vessel	R.R.S. Shackleton
Seismic Shotboat	R.R.S. John Biscoe

Major Equipment

Magnavox MX/702/h.p. satellite navigation system.
Cambridge Consultants proton magnetometer.
Bradley Seismic sonobuoy system.
S.I.E. Seismic recording system.
Thermionic Products T 4003 F.M. tape-recorder.
3000' 8 element hydrophone array.
Airgun seismic profiler system.

Survey Period

19th December - 30th December, 1968. Two ship seismic survey.
17th January - 14th February, 1969. Main geophysics programme.
24th March - 3rd April, 1969. Final magnetometer survey.

The track chart for the season is appended,

Introduction

The 1968-69 marine geophysics cruise in the Scotia sea followed, in general, the work of previous seasons and consisted of magnetic and seismic surveys. In previous seasons, because of navigational problems, all surveys were either of a broad reconnaissance nature or detailed surveys close to land where visual or radar fixing was possible. However, for the 1968-69 season a satellite navigation system was available which was capable of giving accurate fixes at one to two hour intervals. The accuracy of the fixes was suggested to be about 0.1 miles. This great improvement in navigational accuracy away from land made detailed surveys over interesting oceanic features possible.

Several areas of interest were proposed for the season and included detailed magnetic surveys over a suspected mid-oceanic ridge towards the centre of Drake Passage and over the southern slope of Burdwood Bank, and a magnetic and seismic survey of the double ridge feature between the South Shetland Islands and the South Orkney Islands. An experiment to detect reflected seismic arrivals from the Mohorovicic discontinuity at the base of the crust was also included. The capabilities and limitations of the seismic profiler under survey conditions were to be investigated.

The survey was conducted from ships of the British Antarctic Survey by kind permission of the director, Sir V. Fuchs. R.R.S. Shackleton, Captain D. Turnbull, was used for most of the survey but R.R.S. John Biscoe, Captain T. Woodfield, acted as 'shotboat' for the two ship seismic work. The research was supported by a grant from the Natural Environment Research Council.

The Satellite Navigator

The satellite navigation system proved very successful in spite of software problems and minor breakdowns. It was found that the frequency and accuracy of fixing was quite adequate for the detailed magnetic surveys with a mean line spacing of five miles. The basic system consisted of the Magnavox satellite navigation receiver interfaced to a Hewlett Packard 2115A computer and Teletype teleprinter for processing and output of the satellite data. Magnavox were also to supply the software.

Problems occurred with the software throughout the season. The navigator was installed on R.R.S. Shackleton for geophysical sea trials by a Magnavox engineer and it was found that the navigation programme NNSS4 contained an error as, although good fixes were obtained whilst stationary errors of up to three miles or more occurred when underway. The replacement programme NNSS5 arrived shortly before the ship sailed for Antarctic but it soon became apparent that there was a problem with this programme as occasionally the computer became stuck in a computational loop, gave no output and overwrote part of the programme thus necessitating reprogramming of the computer. This reprogramming interval varied from a few hours to several days and the fault was suggested to be caused by a bad satellite transmitting unintelligible data to the receiver which the programme was incapable of treating. This programme was used for most of the survey. An 'improved' programme MAPS 35568 reached the ship in mid January and found to contain a number of faults, one of which was corrected onboard and gave no fixes. It was subaequently corrected by Magnavox and reached the ship in March. It gave a series of good fixes in Stanley but only a few fixes at sea. NNSS5 was thus used again. If information on the programmes had been forthcoming it may have been possible to deal with some of the problems encountered.

Few hardware breakdowns occurred during the survey, the major one being the wearing out of the bearing of a drive cog in the teleprinter which had to be rebrushed as no spare was carried. At the end of the survey during the ship's last call at Stanley faults developed in the computer and, in view of the inexperience with the equipment of the personnel remaining onboard and it being the end of the survey, the equipment was closed down.

The navigator was in use for a total of 3106 hours during which 2751 satellite passes were observed of which 1787 yielded acceptable fixes, giving a mean fix interval of 1.8 hours. Much of this time the ship was not involved in survey work and the navigator was running automatically with little close attention. Results obtained during the magnetic survey, for example the following data, show the marked improvement when the navigator is kept under close surveillance.

Line 7-8 Time 84.5 hours Passes 126
Accepted Fixes 91 Latitude 60°s

During this period the computer was reprogrammed five times but as a close watch was kept the computational loop was quickly spotted. Five intervals between fixes of greater than two hours occurred, the largest being 4 hours 14 minutes. The four largest intervals coincided with the reprogramming of the computer. The mean time between fixes was thus 0.93 hourly Series of fixes taken while the ship was at anchor or alongside indicated that the r.m.s. deviation of the fixes from their mean value was about 0.2 miles although the MAPS 35568 programme gave a significantly better result. A comparison of the mean position with the position of the ship taken from a chart is subject to uncertainty in the charted position and is not given. Errors arising from errors in the velocity of the ship are quoted as being typically less than 0.25 miles for an error of one knot and thus the fixes at sea may be expected to be accurate to better than one mile.

In general the satellite navigator has proved simple to operate and during the season the ship's watch keeping officers often updated the initialization data after course and speed changes. The accuracy of the system did not attain the accuracy of 0.1 miles quoted by Magnavox but the results obtained do show a vast improvement on that previously attainable.

The Magnetic Survey

The survey covered a total of about 7800 miles (14500 km.) of magnetometer traverses, shown on the accompanying track chart.

The magnetometer used for the survey was, as in previous years, the much modified Cambridge Consultants magnetometer. A new set of magnetometer bottles had been constructed for the season based on polyurethene formers. These proved quite satisfactory during their short test runs during sea trials but when used for the survey the ends of the formers broke off under the sustained vibration of survey conditions. This failure was due to a lack of strength in the special polyurethene glue used to stick the ends of the former to the core of the bottle. Two bottles used during the 1967-68 season were subsequently used and proved quite adequate. A bottle encapsulated in fibreglass was flown down as a spare late in the season and proved very good. Apart from a few minor instrumental breakdowns the magnetometer worked successfully all season.

A large part of the total mileage of magnetometer traverse was obtained by taking advantage of any spare time available whilst the ship was on passage from one commitment to another. The period set aside at the end of the season for magnetic survey work was again troubled by inclement weather with the ship hove to for several days in gales. However, some 1280 miles of survey were covered in 11 days of which 5 days

were lost due to bad weather; this indicates the small amount of time lost due to instrumental breakdowns. The ship broke off from the magnetic survey and proceeded to Stanley via South Georgia covering 900 miles of magnetic traverse enroute.

A large portion of the proposed detailed survey-areas has been covered at the designated line density. It is interesting to note the effect of the strong currents to the south of Cape Horn and it was here that a large time interval between fixes could cause the ship's track to drift quite a way from the intended course. Few of the north-west - south east oriented tracks were covered due to a lack of time.

Two Ship Seismic Survey

The proposed two-ship seismic work fell into two parts. First the seismic reflection experiment designed to look for reflections from crustal layers down to and including the Moho and secondly the shooting of three long seismic refract lines over the ridge between the South Orkney Islands and the South Shetland Islands. A period of sixteen days, to include Christmas, was originally set aside for the work. R.R.S. Shackleton acted as the recording ship and the R.R.S. John Biscoe as the shooting ship.

It was the first time the R.R.S. John Biscoe had been used as a seismic shooting ship and this side of the operation had to be built up. Explosives were stored in the old mail room in the forecastle and in "ready use" magazines near the after hold. The former was too small to contain our normal magazines and was converted into a magazine by lining it with dunnage. Detonators and primers were stored in an empty victualling store.. A section of railings on the stern were removed to make way for a firing platform where charges were made up and ditched. Fuse firing was used for the first time

and proved very simple and reliable. Charges could be made up easil in three minutes compared with the eight minutes required for electrical firing. The burning rate for the safety fuse increased with dept that for floating charges being half that for sinking charges . Once these rates were determined the variation of the burning time from the calculated value was less than 10%. Some charges were floated at depths of about ten feet and twenty feet from large polythene bags in order to reduce the number of bubble pulses from the explosion small holes were made in the bags to ensure that they sank in case of misfire. The shot instant was detected in the usual way by hydrophone and geophone, and transmitted by radio to the recording ship.

The inboard side of equipment on the recording ship was as in previous years with the exception that the seismic data were also recorded on a sixteen channel FM magnetic tape recorder, a Thermionic Products T 40030 The long hydrophone array used to detect the seismic arrivals has been described adequately in earlier notes. It was first put out in Bransfield Strait to test the ease of handling and to check out the system. It was used in the vertical mode and difficulty was experienced in trying to suspend it vertically due largely to drag set up by the ship. A more important problem however was the seepage of seawater into the connections on the main cable and at the individual hydrophone breakouts in spite of checking and double checking the connectors and 0 rings. This is a likely cause of the interference seen between some of the hydrophone channels.

The original period was reduced to twelve days due to rearrangment of the ship's programme. The first four days were spent travelling to the first seismic refraction line and waiting for the weather to improve. Winds of force 7 or greater were present throughout this period. A break was

taken for Christmas and the ships proceeded to the reflection experiment area on Boxing Day arriving early on the 28th December. Reflection shooting proceeded for the rest of the day finishing up with an unreversed seismic refraction line back along the draft path of tthe recording ship. Reflection shooting continued the next day but was terminated before mid-day as both radio transmitters on the R.R.S. John Biscoe broke down. The transmitters were repaired in time to commence shooting the next morning but the weather worsened and the hydrophone array was recovered at mid-day. It was damaged during recovery and a double hydrophone array as used in previous seasons was suggested for use on the refraction lines if the weather improved. However, R.R.S. Shackleton required an extra day for engine repairs. A profile of shots was achieved by allowing the recording ship to drift and firing shots close to the ship at intervals of about half a mile along the drift path. Charge sizes of 50 lbs. and 100 lbs. were used and a total of thirty shots fired. Although fewer shots were fired than originally planned, mainly due to the bad weather conditions, much useful experience was gained in the use of the new equipment. A wide variety of shots were fired and it should be possible to find out the most favourable shot conditions. The hydrophone array appeared to give a good signal-noise ratio even under relatively bad sea conditions and it should be mentioned that the damage to the array was not directly caused by the sea conditions on the last day.

Sonobuoy Seismic Survey

Previous seismic investigation has investigated the South Orkney Islands block and Bransfield Strait and the proposed sonobuoy seismic lines were placed to investigate the submarine double ridge between these two. The position of the lines were altered from those given in the proposed 1968-69 programme in view of more recent bathymetric data. A new sonobuoy seismic system was used which, unfortunately, had not been adequately tested before the season due to its late delivery. It was hoped that the new system would enable greater ranges to be obtained than with the old sonobuoy system,

The period for the magnetic and sonobuoy seismic survey of the area commenced on January 20th and was extended to sixteen days as no refraction lines had been shot during the two ship seismic period. Out of this sixteen days, six days were spent shooting, three days on a magnetic survey, three days lost due to bad weather and four days spent on testing the sonobuoy equipment. Midway through the period the ship went to Stanley to collect spares for the satellite navigator. A larger portion of the time than expected was spent on the equipment as the radio range for the system fell far short of the specification, a range of eight miles being achieved compared with the specified twenty miles. The whole system was checked out and all transmitters and receivers returned as they had gone off tune during the trip south. The transmitters gave out strong signals which could be heard clearly at all ranges with the ship's main receiver but at ranges above eight miles the signal being fed to the demodulator units in the seismic system receiver was too small to obtain a coherent demodulated signal thus indicating that the gain of the receiver preamplifier may be too low. The

gain for this unit was quoted by the manufactures. The charges were again fired using safety fuse which was found to be a very quick and simple method. Charges could be made up in less than three minutes making it possible to shoot a complete line at full speed and still obtain the desired shot spacing.

Nine lines were shot with maximum ranges from three to eight miles, the loss of the r.f. carrier signal being the limiting factor, The lines were shot as split spread configurations using the sonobuoy which gave the maximum range. A preliminary consideration of the results indicates the existance of a basement layer, seismic velocity about 5 km/s, at depths of less than 0.3 km. below the seafloor along the ridge to the east of Elephant Island. The basement layer was found at a depth of about 0.5 km. an the seismic line immediately to the east of Clarence Island but further east along this second ridge three layers were found with the third, basement, layer at a depth of a few kilometers,

Explosives

Explosive charges , primers and detonators were stored from previous seasons at Deception Island, At the beginning of the season 100 x 1 lb. charges were brought to Deception Island from Stanley by R.R.S. John Biscoe. H.M.S. Endurance delivered 140 x 50 lb charges and supplies of primers, detonators and safety fuse. After the eruption on Deception Island in February 1969 some explosives and all detonators and primers were moved to Stanley. The present disposition of explosives is as follows:

Explosives		Stanley	Deception Island
50 lb.		51	113
25 lb.		42	234
10 lb.		119	8
1 lb.		434	
Primers		740	
Detonators	electrical	992	
	fuse	205	
	percussion	288	

The FIDASE hut on Deception Island is now not suitable for the storing of explosives but the tank containing the charges remains sound,

Seismic Profiler

Two days were set aside for the testing and preliminary running of the seismic profiler equipment in the Bransfield Strait. Advantage was taken of bad weather during sonobuoy seismic work to test the equipment in fairly shallow water in the lee of Clarence Island. The equipment was tried at various speeds up to ten Knots. At ten knots the airgun was found to tow very near the surface and broke surface occasionally when large waves were present. The signal noise ratio was found to be reasonable at speeds of up to eight knots and in water depths down to 1000 fathoms,

Two crossings of the Bransfield Strait were made, sub-bottom reflections were obtained for a large proportion of the records with reflections seen to a maximum of 0.5 secs. (about 1500 ft.) beneath the sea floor. Records were markedly poorer when deep water, in excess of 2000 fathoms, was reached off the north-west of the South Shetlar Islands and few if any sub-bottom reflections could be seen. The signal to noise ratio could have been improved by the

ship going slower, it was making about nine knots, but time did not allow this, Records were made with no filtering of the received signals and thus they should be enhanced when suitable filtering is employed.

Bathymetry

Bathymetric data were recorded along all the survey tracks. They have been corrected for variations in sea water velocity after Matthews' tables and will be used to update our bathymetric charts in the area.

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