G/39/70

Department of Geology,

University of Durham

REPORT ON R.R.S. JOHN MURRAY CRUISE TO THE REGION WEST OF THE HEBRIDES AND SHETLANDS, JUNE 1 to JULY 14, 1970

1. Scientific objectives

The objectives of the cruise were to continue investigations of the deep structure beneath the north Scottish shelf and margin and across the intervening deep channel on to the Faeroe Rise. During the first two weeks of the cruise, it was planned to make a preliminary survey of the shelf and margin to the west of the Outer Hebrides and to carry out preliminary traverses across the main seamounts and banks between Rockall and the Faeroe Islands, observing bathymetry, gravity, magnetics, doing seismic profiling (airgun and sparker) and using disposable sono-buoys. The original plan for the second period of two weeks was to carry out sono-buoy refraction surveys to determine sediment thickness beneath the Faeroe-Shetland channel and beneath conspicuous shelf gravity anomalies to the west of the Shetlands and Orkneys which had been discovered in 1967 and 1968. During the final period of two weeks, further lines across the shelf, margin and parts of the Faeroe rise were planned.

The cruise was originally divided into three legs as outlined above, calling at Stornoway and Lerwick between them. As a result of faults in the steering gear, the original plan had to be considerably modified and curtailed.

2. Personnel

Leg one (June 1 to June 20)

Durham: J.H. Peacock (senior scientist)
A. Ingles
G. Laving
A.G. McKay
R.Reeve (left on June 9)
A.B. Watts
M. Maconnochie) (joined on June 10)
J. Trythall)

R.V.U. D. Thomas

Leg two (June 20 to June 30)

Durham: M.H.P. Bott (senior scientist, left June 27)
C.W.A. Browitt
A Ingles
A.G. McKay
L. Arnold (left June 27)
C.H. Boynton
T.H. Thompson

R.V.U. D. Thomas

Leg three (July 1 to July 14)

Durham: J.H. Peacock (senior scientist)
B. Bidston
M. Bush
A.G. McKay
E. Himsworth
P. Kearey
M. Maconnochie
G. Westbrook

3. Equipment installed

The following equipment was installed at Barry during the week prior to the cruise: (1) airgun profiling system, comprising airguns, pulse recognition computer, E.M I. tape deck, and Mufax and Geospace display units; (2) disposably sono-buoy system comprising ten buoys and V.H.F. Eddystone receiver; (3) Bradley sono-buoy system borrowed from Birmingham Geology Department; (4) Askania-Graf ship-borne gravimeter with cross-coupling computer borrowed from Department of Geodesy and Geophysics, Cambridge.

R.V.U. provided E.G. & G. sparker profiling system with two hydrophone arrays, Varian magnetometer with spare fish, Kelvin Hughes MS 38 depth recorder and Flexotir array with two active sections. 6000 lb of geophex was loaded at Barry. It was originally intended to pick up a second load from Invergordon, but this had to be abandoned as a result of the curtailment of the cruise and 4050 lb was returned to Barry at the end of the cruise.

1. Narrative, leg one

This leg was originally intended to extend from June 1 to June 13 (Stornoway) with a call for gravity base reading at Oban. We sailed from Barry at 1800 (BST) on June 1. However, trouble developed with the ship's auto-pilot at 0000 on June 2 and it was necessary to put into Milford Haven for repair. Anchor was dropped at 0700 and after repair we sailed out of Milford Haven at 1800 on June 2. Between 2200 and 2400 on June 2 the Flexotir array was streamed for testing, and it was found that a D.C. amplifier was needed; this was built on June 3. Further testing of equipment was carried out on passage to Oban, and gravimeter and depth recorder were in operation. We went alongside at Oban at 0930 on June 4. A gravity base observation was made at Oban and we waited for the arrival of an aerial for use with the disposable sono-buoys which arrived later.

We sailed from Oban at 1630 on June 4 on passage to the first line of the Hebridean margin survey. After completion of manoevering to clear the Firth of Lorne, watch was kept on the gravimeter and depth recorder. The aerial for the sono-buoys was assembled and fitted to the top of the mast.

At 0530 on June 5 to the west of Barra, the magnetometer and sparker were streamed and the first line (70/1)* begun. This line ran over the Anton Dohrn seamount and ended in the vicinity of Rockall. Here, the ship hove-to while the engineers examined the steering gear which appeared to be faulty. The opportunity was taken to calibrate depth-sensors on the airgun harness and the Flexotir array. The Chief Engineer recommended that the ship should be taken into a dockyard for repair to the steering gear, and the

*lines are tabulated in Appendix 1 and are shown on the track chart.

Captain decided to head back towards the North Channel with a view to making for either Belfast or the Clyde. Consequently a previously unplanned survey line (70/2) was laid out to cross the terraced part of the margin to the northwest of Malin Head, and at 1840 on June 6 this was commenced. The airgun was operating during this line, apart from a short stop for repair. A disposable sono-buoy station (70/A)* was observed at 0435 on June 7. Towards the end of the line it became apparent that the gravimeter stabilized platform was going off level frequently, and the gravimeter was clamped at 1430, June 8, which was the end of the line on the Hebridean shelf. After this, we were on passage to Port Glasgow and were alongside at Lamont's Yard at 0600 on June 9

From June 9 to 11 the yard were repairing the steering gear. At this stage it was decided to alter the cruise programme by extending leg one by a further week to enable us to attempt to complete the survey to the west of the Hebrides. Consequently, leg two was reduced by a week and the proposed call at Invergordon for a second load of explosives was called off. To do this, certain personnel changes were necessary. R. Reeve left the ship and returned to Durham; M.Maconnochie and J. Trythall joined. During the time spent at Lamont's Yard certain repairs were made to the scientific equipment: the pressure-reducing valve on the compressor was serviced; the Loran C set was overhauled by Decca representatives; the gravimeter was examined and two relays were replaced in the Enograph unit.

We sailed from Port Glasgow at 1715 on June 11. It was necessary to put in at Stornoway after passage back to the Hebrides, where the Chief Officer was to be relieved (as arranged in original plan). We anchored in Stornoway at 0200 on June 13.

*Disposable sono-buoy stations are listed in Appendix 2 and are shown on the track chart.

Unfortunately the relieving officer had by mistake been booked to Benbecula. An attempt was made to meet up with him at Lochboisdale, but in the event we had to sail without him. While in Stornoway, a further fault appeared in the gravimeter platform. This was traced to the output stages of one of the servo-amplifiers and was repaired. We were in position off North Uist by 1030 on June 14, ready to continue the survey to the west of the Hebrides. Between this time and 0715 on June 19, three long lines (70/3, 4 and 5), two short lines (70/6 and 7) and 3 disposable sono-buoy stations (70/B, C and D) were completed as planned, and as shown in the track chart and table, with gravimeter, depth recorder, magnetometer and airgun working satisfactory, apart from minor repairs, during this time. As sea conditions were good, excellent results were obtained. At 1500 on June 19 we were alongside at Stornoway.

5. Narrative, leg two

While in Stornoway, repairs were made to the gravimeter filter circuit and the Bradley buoy system was tested ready for use. Sailing had to be delayed for a day as the Chief Engineer was taken ill, and we were one engineer short. A new engineer joined on 23 June and we immediately sailed (at 1600) on leg two of the cruise.

After sailing, we were on passage for a seismic refraction line planned to determine the sediment thickness beneath the Faeroe-Shetland Channel, but the course was altered slightly to cross a gravity low discovered in the earlier shelf surveys (line 70/8) and to obtain a further line (70/9) across the slope here. The gravimeter and magnetometer were in operation and the sparker was also used across the gravity low and the slope. We reached the start of the proposed seismic refraction line (J)* by 1620 on June 24.

*Seismic refraction lines J, K, L and M are tabulated in Appendix 3 and shown on the track chart.

A short test of the buoy system was done that evening, but it was considered too late to start the line in view of the difficulty of recovering the buoys in the dark.

On June 26 a refraction line (J) was shot, but it took several hours to relocate the buoys in deteriorating sea conditions. The shots only appeared to be received satisfactorily up to about four miles because of the radio link. It was considered impracticable to reverse the line. Instead, gravimeter and magnetometer lines (70/10, 11, 12, 13 and 14) were observed, including a profile across the slope (70/13), as we sailed to east of the Shetland Isles to carry out further tests and improvements to the system. At 1130 on June 27 we called briefly at Lerwick to allow M.H.P. Bott (who had been taken ill) and L. Arnold (who had been badly seasick) to disembark.

During the remaining time left on leg two, it was planned to make seismic refraction lines on (1) the gravity low immediately to the west of south Shetlands (lines K and M), with the object of discovering whether it is caused by a granite or a basin, and (2) on the gravity high to the west of this low (line L), to determine the basement velocity. It was also planned to carry out further sparker, gravimeter and magnetometer lines (70/15 to 23) in these regions. We arrived in position for the start of the refraction line K (on the gravity low) at 1730 on June 27, but visibility was too poor for putting out the buoys, and therefore two sparker, gravimeter and magnetometer lines (70/15 and 16) were run across the gravity low in an east-west direction, at reduced speed in fog. The refraction line K was started at 1020 on June 28 and the buoys were picked up again at 1620. The ship's aerial was used and this considerably increased the range of the radio link. Survey lines 70/17 to 20 were done overnight, and an unreversed refraction line L was shot along the gravity high from 0210 to 0700 on June 29.

Line 70/21 was then run, and refraction line M, a reversal of line K, was shot between 1100 and 1510. Lines 70/22 and 23 were then observed and completed at 0350 on June 30. We sailed for Lerwick and arrived at 0700 on June 30 at the end of leg two.

6. Narrative, leg three

We sailed from Lerwick at 1420 on July 2, and headed for the start of a line across the Faeroe-Shetland Channel. However, a strong westerly wind produced a sea state in excess of that considered safe for the Flextir array. After heaving to during the night, on July 2 we headed for shelter in Clift Sound near Scalloway in Shetland. On July 5, a doctor, brought out to the ship's anchorage to examine the Chief Engineer, recommended his removal to hospital. For this we put into Scalloway but sailed again soon after at 1530 on July 5 as the weather was improving.

We sailed for the start of the planned line across the Faeroes-Shetland Channel, with gravimeter, depth recorder and magnetometer in operation. The Flexotir array was streamed at 2030 and the airguns put outboard. The line 70/25 was started at 0010 on July 6 and a disposable sono-buoy (70/E) was launched at 1300. This was followed by short lines 70/26, 27 and 28 on the Faeroe shelf. From 0900 to 1100 of July 7 we were hove to for repair of one of the ship's main engines, and completed line 70/29 at 1700. Line 70/30 was commenced and crossed the Wyville-Thompson ridge and Rosemary Bank. From 2100 on July 8 to 0100 on July 9 the airgun compressor was being repaired, during which time the line was retraced to ensure a good line across Rosemary Bank. Otherwise gravimeter, magnetometer, depth recorder and airgun profiling system were all performing satisfactorily, and a disposable sono-buoy (70/F) was

dropped at 1830 on July 8. Line 70/31 was commenced at 1700 on July 9, and disposable sono-buoys were dropped at 1920 (70/G) and 2300 (70/H). The compressor failed at 0200 on July 10, and as there was no spare pressure-release valve the repair could not be made. The line was continued without airgun profiling. At 0600 the weather was deteriorating rapidly and the Captain decided to head for shelter in Lochboisdale. At 1130 the gravimeter servo-amplifiers failed momentarily due to the bows banging into a large wave, so that the gravimeter and platform were clamped. We anchored in Lochboisdale at 2150.

We sailed for Barry on 11 July, sheltering for a time in the Sound of Mull on passage. We were alongside in Barry at 0330 on July 14.

7. Comments on equipment

Airgun profiling equipment: The Durham University airgun profiling system was in use with the Flexotir array on legs one and three. The system was operating on reduced pressure and only one airgun could be used due to the size of the compressor. The speed was maintained between 5 and 6 knots during profiling, but a finer control of speed would facilitate balancing of the outboard systems. Excellent results were obtained on all the profiles and the basement was never lost. The maximum observed two-way penetration below the seabed was 5 seconds, and the resolution was excellent on the sedimentary layerings, particularly over the Hebridean margin and over George Bligh, Bill Bailey and Rosemary banks. At present the results have only been displayed unprocessed. Full processing of the profiles (on magnetic tape) is expected to be completed during the coming months, using the pulse-polarity computer, filtering,

and possibly the Modular I computer. In all, some 1500 n.m. of profile was obtained.

Disposable sono-buoys: On ten selected sites U.E.L. disposable sono-buoys were used but only with mixed success. In the majority of cases the units output high acoustic noise. This is being claimed by U.E.L. as a fault in the buoy itself and it is hoped that by working in consultation with Durham this fault may be traced. In the good results obtained, we were able to get wide angle reflections from major sedimentary layerings, particularly on the line between the Hebrides and George Bligh bank were we were able to refract the basement which was lying at some 2 km depth. Six usable and two good profiles were obtained.

Graf gravimeter: This operated satisfactorily for most of the cruise despite some small failures, including bad connections, fault in the servo-amplifiers for the platform and partial failure of the 300 second filter circuit in the output to the display. There was also a heavy drift rate observed which we understand is a recently acquired characteristic of the instrument. Good gravity results were obtained during most of leg one when sea conditions were ideal, and in the heavier swells prevailing during legs two and three moderate results were obtained.

Varian magnetometer and E.G. & G. sparker: operated satisfactorily and without serious incident.

Bradley sono-buoy system: The dipole aerial provided with the system was limited to about four miles range, but the full range was obtained on using the ship's main aerial. On the shelf it was only possible to use charges up to 25 lbs with 75 second fuses because

of the effect on the ship's electrical systems; this was accentuated by the shallow water combined with a high velocity seabed, but it restricted the full use of the system.

8. General comments

The original plans for the cruise had to be considerably modified as a result of the need to put into Glasgow for repair of the steering gear. Unfortunately this occurred in the middle of the first half of the cruise when weather conditions were ideal. This meant that we only had about 7 days useful work during the first three weeks of the cruise. At this stage the weather deteriorated and prevented full use of the available time during the second half of the cruise. This meant that we only managed to complete about half of the planned gravity, magnetic and profiling lines and that the sono-buoy refraction work was drastically reduced. However, good scientific use was made of the available time and equipment operated without serious snags. In particular, the excellent results obtained using the airgun profiling system fully justified the development of this equipment.

9. Acknowledgements

We should like to express our warm thanks to Captain Justin and Captain Perry, and to the officers and crew of the R.R.S. John Murray for their help, cooperation and hospitality during the cruise. We are grateful to the staff of the R.V.U. for their contribution to the success of the cruise and for their quick action when difficulties occurred. Mr. D. Thomas of the R.V.U. accompanied two legs of the cruise and gave us invaluable assistance. The

gravimeter was kindly loaned to us for the cruise by the Department of Geodesy and Geophysics, Cambridge, and the Bradley sono-buoys by the Department of Geology, University of Birmingham.

M.H.P. Bott
A. McKay
J.H. Peacock

July 1970

Department of Geology,
South Road,
Durham.

APPENDIX 1

Survey Lines

Date	Line	Start		End		Course	Instruments*	
June 5 - 6	1	57°01'N	07°38'W	57°4[illegible]'	13°40'	282°	DGMp	6 ft from SE decreasing
6 - 8	2	57°37'	13°40'	55°38'	07°19'	120°	DgMas	" " " "
14 - 15	3	57°41'	07°37'	58°55'	13°50'	290°	DGMas	3 ft from NW
15 - 17	4	59°07'	13°51'	60°36'	10°10'	050°	DGMAs	5 ft from ESE
17 - 18	5	60°36'	10°10'	58°28'	06°28'	140°	DGMas	" " "
18	6	58°21'	06°48'	59°03'	08°17'	310°	DGMpa	4 ft from SE
18 - 19	7	58°51'	08°36'	58°29'	07°20'	130°	DGMA	" " "
23 - 24	8	58°37'	06°06'	59°52'	04°28'	026°	DGMp	2 ft from SSW
24	9	59°52'	04°28'	60°30'	04°50'	340°	DGMP	4 ft from SE
25	10	60°47'	04°28'	62°00'	02°38'	035°	DGM	6 ft from SW
25	11	62°00'	02°38'	62°00'	03°40'	270°	DGM	8 ft from SW
25	12	62°00'	03°40'	61°36'	03°50'	191°	DGM	9 ft from SW
25	13	61°36'	03°50'	60°55'	00°42'	116°	DGM	10 ft from SW
27	14	60°55'	00°42'	60°27'	00°42'	180°	DGM	6 ft from SW
27	15	60°03'	01°37'	60°03'	02°25'	270°	DGMP	2 ft from SW
28	16	60°00'	02°25'	60°00'	01°33'	090°	DGMP	" " "
28	17	60°05'	01°40'	59°58'	02°45'	260°	DGM	" " "
28	18	59°58'	02°45'	60°07'	03°09'	305°	DGM	" " "
28	19	60°05'	03°12'	59°57'	02°47'	125°	DGM	" " "
29	20	59°57'	02°47'	60°15'	03°15'	306°	DGM	" " "
29	21	59°59'	02°55'	60°05'	01°38'	097°	DGM	" " "
29	22	59°53'	01°40'	59°53'	02°18'	270°	DGMP	" " "
29	23	59°48'	02°18'	59°48'	01°04'	090°	DGMP	" " "
July 5	24	60°08'	01°29'	60°03'	02°59'	260°	DGMa	7 ft from SW
6	25	60°03'	02°59'	60°55'	04°00'	330°	DGMAs	" " "
6	26	60°55'	04°00'	61°04'	04°23'	296°	DGMA	" " "
6	27	61°04'	04°23'	61°31'	05°03'	320°	DGMA	5 ft from SSW

July		7	28	61°31'	05°03'	61°40'	06°07'	293°	DGMA	5 ft from SSW
		7	29	61°40'	06°07'	61°15'	05°48'	151°	DGMA	" " "
	7 -	9	30	61°15'	05°48'	58°51'	10°44'	213°	DGMAs	8 ft from S
	9 -	10	31	58°51'	10°44'	58°20'	09°07'	120°	DGMas	9 ft from S

*Abbreviations for instruments:

D	depth recorder
G	gravimeter
M	magnetometer
P	sparker profiling
A	airgun profiling
s	wide angle reflection station

a small letter indicates that observations were made on part of the line only.

APPENDIX 2

Wide Angle Reflection Lines (Disposable sono-buoys)

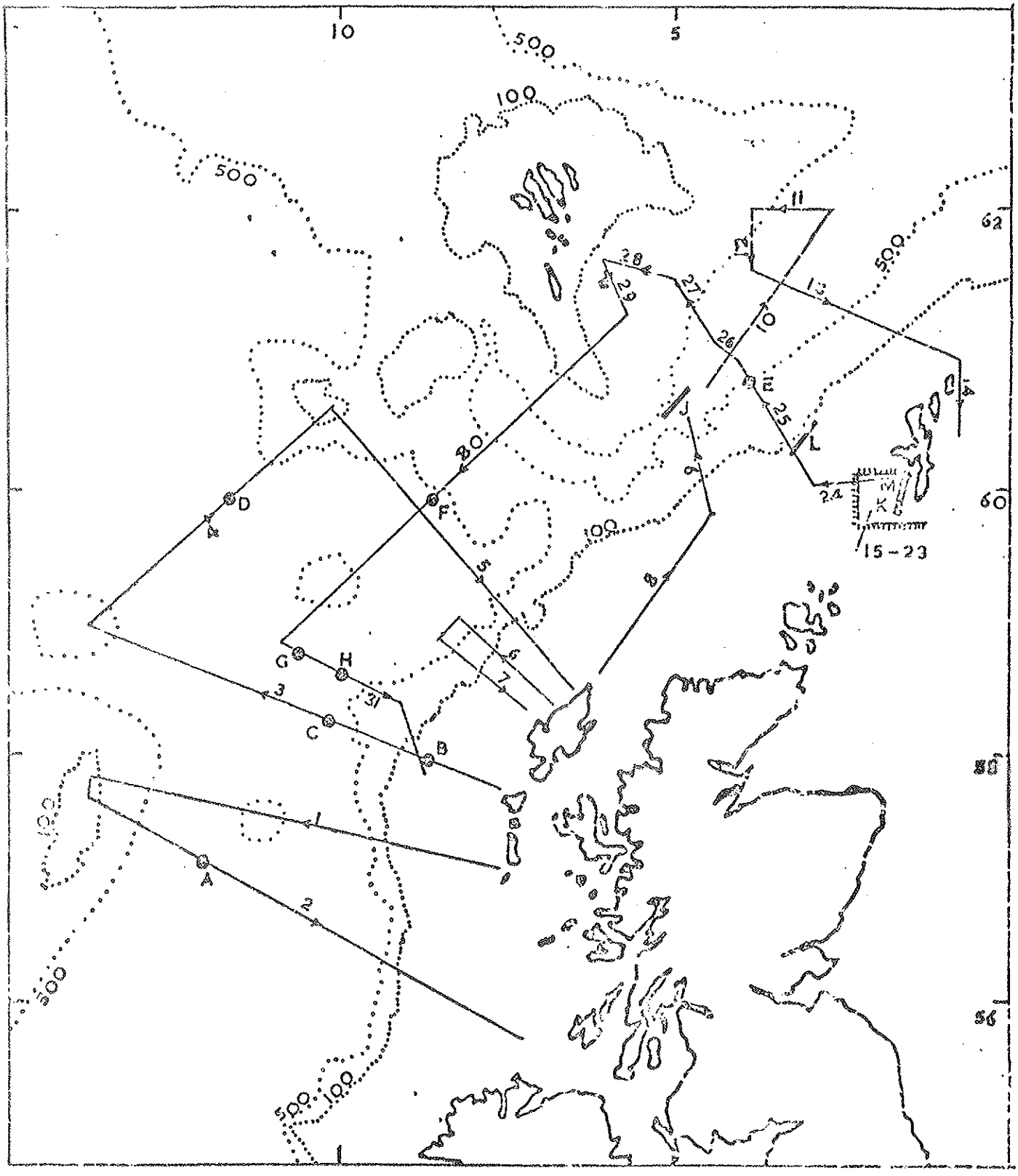
No.	Position Launched		Survey Line Number	Direction of Line
A	57°06'N	12°08'W	2	120°
B	57°56'N	08°39'W	3	290°
C	58°11'N	10°08'W	3	290°
D	59°57'N	11°35'W	1	050°
E	60°50'N	03°45'W	25	330°
F	59°56'N	08°58'W	30	215°
G	58°46'N	10°30'W	31	120°
H	58°37'N	09°54'W	31	120°

APPENDIX 3

Refraction Lines (Bradley Buoy system)

	Position of buoy-drop		Direction of shooting	Length (kilometers)
J	60°43'N	04°39'W	213°	12
K	60°04'	01°33'	195°	20
L	60°19'	03°20'	033°	20
M	59°55'	01°38'	015°	20

K and M form a reversed pair of lines; J and L are single lines.



University of Durham
Geology Department,
R.R.S. John Murray
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Boundary of S.W. Shetland Survey

Wide angle reflection station

Refraction Line

Bathymetric contours at 100 and 500 fathoms