9/25/69

Department of Geology,
University of Durham

REPORT ON GEOPHYSICAL CRUISE TO ICELAND-FAROE RIDGE,

JUNE 7 TO JULY 18, 1969

WITH M.V. ARRAN FIRTH AND M.V. MORAY FIRTH

1. Scientific objectives

The objectives of the cruise were to investigate the crustal and upper mantle structure of the Iceland-Faroe ridge and to develop techniques of reflection shooting using an airgun source. During the first half of the cruise, it was planned to use the two-ship seismic refraction method to determine crustal thickness and layering. After this, the Moray Firth would return to the Tyne leaving Arran Firth to carry out seismic reflection measurements of layer 1 in conjunction with magnetometer measurements on the ridge. A subsidiary aim was to test and use disposable sono-bouys in conjunction with the airgun reflection source.

2. Personnel

Leg 1 (7 June to 25 June)

Moray Firth	M.H.P. Bott (from June 16)
	A. McKay
	D. Asberry
	A. Dobinson
	G.J. Laving
	G. Wilson
Arran Firth	J.H. Peacock
	C.H.A. Browitt
	A.P. Holder
	M.S. Maconochie
	A.B. Watts

Leg 2 (28 June to 18 July)

Arran Firth	J.H. Peacock
	A. McKay
	M.A. Hutton
	A. Ingles
	M.S. Maconochie

3. Fitting out

The two ships were fitted out prior to the cruise at the Wallsend Slipway and Engineering Company, in the Tyne. The Moray Firth was to be used only as a shooting ship during the first leg of the cruise, and was fitted out with wooden magazines in the fore-hold for 25,000 lb of geophex, which was loaded prior to sailing. Shot instant recording equipment, and echo sounder and Loran C were also installed, and a shooting platform was built on the stern deck.

The Arran Firth was to be used as the recording ship for seismic refraction lines and for the airgun and magnetometer profiling. The basic equipment including the EMI tapedeck were housed in a mobile laboratory that had previously been used as a communications caravan. This was fitted out at Durham prior to the survey and was installed in the fore-hold. Power for the scientific equipment was provided by three 5 KVA mobile generators, and these together with the W. & J. compressor for the airgun were placed in the hold. Loran A was installed in the Tyne, and the Loran C used by Moray Firth during the first leg was transferred to the Arran Firth on 25 June for the second leg of the cruise.

4. Narrative, leg one.*

The two ships sailed from the Tyne at 1800 hours on 7 June in calm sea and fine weather on passage for the Shetland-Orkney shelf, where a test seismic refraction line was planned to be shot. It was necessary to call at Kirkwall to collect some equipment which had been left behind on sailing. We arrived at Kirkwall at 2245 on 8 June, and sailed again

*Locations of seismic refraction lines and shot sizes used are shown in Appendix A.

with the equipment at 1800 on 9 June.

Both ships had reached the start of seismic refraction line A on the shelf by 0600 on 10 June and at 0800 Arran Firth lowered the hydrophone system. A few $2\frac{1}{2}$ lb shots were set off to test the system. After this, the hydrophone cable fouled on an obstruction but was freed after manoevering. The hydrophones were re-streamed using a Dahn buoy as guard against fouling, and this also improved the decoupling. Line A was shot between 1900 and 0100 on 11 June. Arran Firth then steamed to the position of Moray Firth for the reverse shoot. The reverse line B was shot between 1300 and 1900 on 11 June. The sea state throughout line A was 2, but it increased to 4 during line B. There were two misfires, and during the latter part of line A the transmitter on Moray Firth was inoperative because of run-down batteries, but the shot-times can be obtained throughout by using the correlation on BBC Radio 2, which was recorded on both ships. This line was primarily shot to establish the technique, but was also placed along the length of a large gravity 'low', in the hope of obtaining an estimate of the thickness of sediments overlying the basement.

After completing lines A and B, we sailed towards the Iceland-Faroe ridge. At 0830, 12 June, we set course along east of Faroes, the forecast being 6-8 northwest. At 0000, 13 June, we were north of the Faroes, but at 0300 we turned back for shelter in a gale. At 0900 we anchored at Vedvig in the island of Videro, and remained on anchor until 0000 on 15 June.

Both ships sailed for Vestmannahavn at 0000 on 15 June, but at 0230 on finding the sea state better than the forecast the course was altered and we headed for start of refraction line C. At 1300 the start of the line was reached, and by 2000 the first 16 shots had been completed. At this stage

Arran Firth lost the Dahn buoy and during search for it the propeller cut the hydrophone cable. An attempt at repair was unsuccessful, and as sea conditions were deteriorating it was decided to make for Vestmannahavn to make the repair and to pick up M.H.P. Bott. Arran Firth reached Vestmannahavn at 1000 and Moray Firth at 1230 on 16 June.

The repair was done and M.H.P. Bott joined the Moray Firth. At 1415 on 17 June both ships sailed for the start of line C, the forecast being 5-7. At 2100 Arran Firth had moored the Dahn buoy and Moray Firth proceeded to occupy position for shot C17. The remaining part of line C was shot between 0130 and 0630 on 18 June. By 1200 Arran Firth had joined Moray Firth ready for the reversal (line D), but weather deteriorating with wind 6-7. Both ships hove-to until 1930 on 19 June, when the Arran Firth anchored the Dahn-buoy ready for line D. A small fault in the hydrophone cable was repaired, and Moray Firth started shooting at 2330. Shots 1 to 7 were fired, but further shooting was postponed from 0100 until 1600 on 20 June for a further modification to the hydrophone system. Line D was completed at 2300 on 20 June 95 km from the recording ship. By this time the sea was calming with a forecast of 4-5, and both ships headed for line E.

For line E and subsequent lines an adapted form of the hydrophone system was used, and proved successful. Line E was shot by Moray Firth between 1130 and 2100 on 21 June. Both ships were on position for the reversed line F at 1020 on 22 June, and this line was shot between 1100 and 2015.

The two ships sailed independently towards the start of line G, which was in deeper water to the south-west of the ridge. It was intended to shoot two reversed lines perpendicular to each other, one of them

perpendicular to the magnetic lineations and one of them parallel. Both ships had reached the start of line G by 1830 on 23 June. Line G was shot between 1830 and 2300 on 23 June and the reverse line H was completed in deteriorating sea condition between 0500 and 0930 on 24 June. With a forecast of 6-8 and sea conditions becoming unsuitable for further work, the cross refraction lines were abandoned and both ships headed for Vestmannahavn. Arran Firth reached Vestmannahavn at 1500 and Moray Firth at 1730 on 25 June.

Loran C was transferred from Moray Firth to Arran Firth for use on the second leg. A. McKay transferred from Moray Firth to Arran Firth, and C.H.A. Browitt, A.P. Holder and A.B. Watts transferred from Arran Firth to Moray Firth. M.A. Hutton and A. Ingles joined Arran Firth. After bunkering Moray Firth sailed for the Tyne at 1000 on 26 June, and after a delay of about 24 hours caused by a gale we reached Wallsend at 1330 on 29 June. The remaining explosives (about 4000 lb) was offloaded on 30 June, and the ship was handed back to NERC.

5. Narrative, leg 2*

The second leg of the cruise was devoted to experimental air-gun profiling, the testing of disposable sono-buoys and to a magnetic survey of part of the Iceland-Faroe Ridge.

At 0630 on 28 June the Arran Firth sailed from Vestmannahavn and at 1030 hove to in sheltered waters 10 miles NE of Thorshavn in order to test the airguns at various depths. After some success, the guns began to give trouble because the compressor was delivering air charged with water droplets, which interfered with their firing mechanism in several ways. Some time was

* Locations of lines are shown in Appendix B.

spent on the compressor trying to isolate the fault, but at 1900 on 29 June it was decided to head back to Vestmannahavn and seek the advice of the manufacturers. The remainder of that day and the next were spent in Vestmannahavn. Further work on the compressor failed to improve its performance. Humidity measurements were taken at the request of Williams & James (the manufacturers). At 1600 on 1 July the ship sailed for Kirkwall to meet an engineer who would be flown out there. On passage to Kirkwall a magnetometer line (a) was done. At 0015 on 3 July, the ship was alongside in Kirkwall. The Williams & James engineer had decided to fit a sea-water-cooled condenser to the output of the final stage and most of this work was completed the next day.

On 5 July, the airguns were tested once more and the air supply appeared satisfactory. On 6 July at 0630, when the gales had abated, the ship sailed towards the Faroes, by way of Westray Firth. The magnetometer was streamed and line (b) completed on passage to a position east of Sandoy, where the airgun-testing was resumed. Two of the guns performed reliably, and magnetic tape records of the pulse forms were obtained.

At 0500 on 8 July, the Arran Firth made for the start of a magnetic survey of a rectangular area on the ridge. This survey, occupying the next 5 days, was made up of east-west lines 4 km apart. During this period, airgun profiling records were obtained over part of the survey area, and one of the disposable sono-buoys was tested with good results.

At 0900 on 13 July, this survey area had been covered and the ship headed off towards the deeper water to the SW of the ridge. Magnetometer and airgun profiling were in use. On 14 July at 1530 this run had to be discontinued because of ship-time considerations. One sono-buoy did not

work, but 2 others were successfully tested on the return to Vestmannahavn, where the ship tied up at 2300 on 15 July.

The ship sailed for the Tyne at 1100 on 16 July. The aquaflex explosives were used in conjunction with a sono-buoy over the Shetland-Faroe Channel, as the compressor appeared to be in a dangerous condition. The shot firing cable used proved unreliable, and the pulse-length from the aquaflex is rather long, but, given a better cable, this system might be useful as a standby.

The cruise finished at 2200 on 18th in Wallsend.

6. Notes on equipment

Varian magnetometer: This was reliable as usual, but the signal lockout circuit was faulty; this was disengaged at the beginning of the cruise.

Air guns. Two of these were inoperative due to ingress of water into the solenoid firing valves. The remaining two worked with 100% reliability towing at 7 knots, firing in tandem. Firing accuracy better than $\pm$ 4 msec.

Correlation detector; Not used because of depletion of number of guns and the sporadic appearance of 10 v spikes on the main power supply.

Sono-buoys: We had two failures out of the six used, one due to our inexperience in launching and the other due to a faulty buoy. This system used in conjunction with the airguns was very successful and certainly requires no more development, other than having buoys available in a wide range of transmitting bands. The aquaflex

system of shooting was not so successful, but this was partly due to the fact that the firing cable had not been professionally made and did not stand up to the shocks generated.

Loran C: The unit worked well but in difficult areas for good reception it requires expert supervision.

Explosives: No difficulty was encountered in firing shots up to 300 lb. A lower launching platform (say 1-2 ft above deck) would be much more convenient.

Refraction hydrophone system: Difficulty in using earlier system owing to cable cut, but later system completely satisfactory in up to force 5-6.

Compressor: This was the least satisfactory piece of equipment, and gave considerable trouble. A separate report is being forwarded to the NERC Research Vessel Unit.

7. Scientific Results

(1) Four reversed refraction lines were shot, one on the shelf and three between Faroes and Iceland. Excellent recordings were obtained on the north-western reversed line on the ridge (E and F) on the line in the deeper water to the south-west (G and H). The results have not yet been evaluated, but there is distinct indication that the ridge is not underlain by normal oceanic crust.

(2) A detailed magnetic survey has been carried out near the crest of the ridge, with sufficiently close line spacing to show the true character of the magnetic anomalies in this complicated region. Some airgun profiles

were obtained at the same time, giving the depth to the top of the supposed magnetic layer 2.

(3) It was found that layer 1 is very thin over the crest of the Iceland-Faroes ridge in the parts where airgun profiles have been done. This will considerably aid the interpretation of both gravity and magnetic anomalies of the region, obtained on this and earlier cruises.

8. Acknowledgements

We should like to express our warm thanks to Captain Eastland of the Moray Firth and Captain Guy of the Arran Firth for their help, co-operation and hospitability during the cruise, and to the officers and crew of the two ships. These ships were fitted out for our use under the direction of Mr. J.C. Cleverley of the R.V.U. and we are most grateful for his help.

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

July 1969.

Appendices

A. Position of Refraction Lines.

Line letters.	Positions	Bearing	Length (km)
A, B	59°54'N, 03°34'W; 60°14'N, 03°13'W	025°	45
C,D	62°38'N, 08°47'W; 63°14'N, 09°46'W	140°	83
E,F	63°22'N, 10°22'W; 64°05'N, 12°14'W	130°	136
G, H	62°00'N, 16°10'W; 61°37'N, 15°20'W	135°	70

Shot Firing Schedule

Table gives, for each line, the weight (lb) of the shot and the approx. distance (km) from the receiving ship.

Line

Shot No.	A lb	A km	B lb	B km	C lb	C km	D lb	D km	E lb	E km	F lb	F km	G lb	G km	H lb	H km
1	2½	2	2½	2	2½	1	5	3	10	7	10	2	10	2	10	2
2	2½	4	2½	4	2½	3	5	4	15	9	25	5	20	4	20	4
3	2½	6	2½	6	2½	5	10	6	25	12	25	6	20	6	20	7
4	2½	8	10	9	10	7	15	8	25	15	25	9	25	8	25	9
5	10	10	10	11	10	9	15	10	25	17	25	11	25	10	25	12
6	10	12	10	13	10	11	25	12	25	20	25	12	50	11	50	14
7	10	14	25	15	25	13	25	14	50	23	25	14	50	13	50	16
8	25	17	25	17	25	15	25	13	50	25	50	16	50	14	100	18
9	25	20	25	20	25	17	25	14	50	28	50	19	100	16	100	20
10	25	23	25	23	25	19	50	18	50	33	50	22	100	19	100	21
11	25	26	50	26	50	27	50	22	50	38	50	26	100	22	100	27
12	50	29	50	29	50	30	50	27	100	44	50	31	100	26	200	31
13	50	33	100	32	100	37	100	30	100	50	100	36	200	30	200	35
14	100	37	100	36	100	41	100	36	100	55	100	45	200	34	300	48
15	100	41	100	40	100	46	100	41	200	63	100	51	300	41	300	54
16	100	45	200	44	100	51	200	46	200	69	200	57	300	46	300	61
17			200	48	200	57	200	52	200	74	200	63	300	50	300	67
18					200	62	200	59	200	82	200	69	300	55	250	75
19					200	65	200	67	300	90	300	75	300	62		
20					200	68	200	72	300	99	300	85	300	70		
21					200	83	200	77	300	109	300	94				
22							200	83	300	117	300	103				
23							200	89	300	127	300	118				
24							200	94	300	136	300	127				
25											300	136				

Appendices

B. Magnetometer Surveys — Position of lines

(i) Long, isolated lines

(a)	61°26'N	05°34'W	to	59°59'N	02°18'W
(b)	60°19'	04°38'	to	61°47'	06°28'
(c)	63°37'	10°00'	to	62°26'	14°45'
(d)	62°26'	14°45'	to	62°08'	14°40'
(e)	62°08'	14°40'	to	62°08'	07°30'

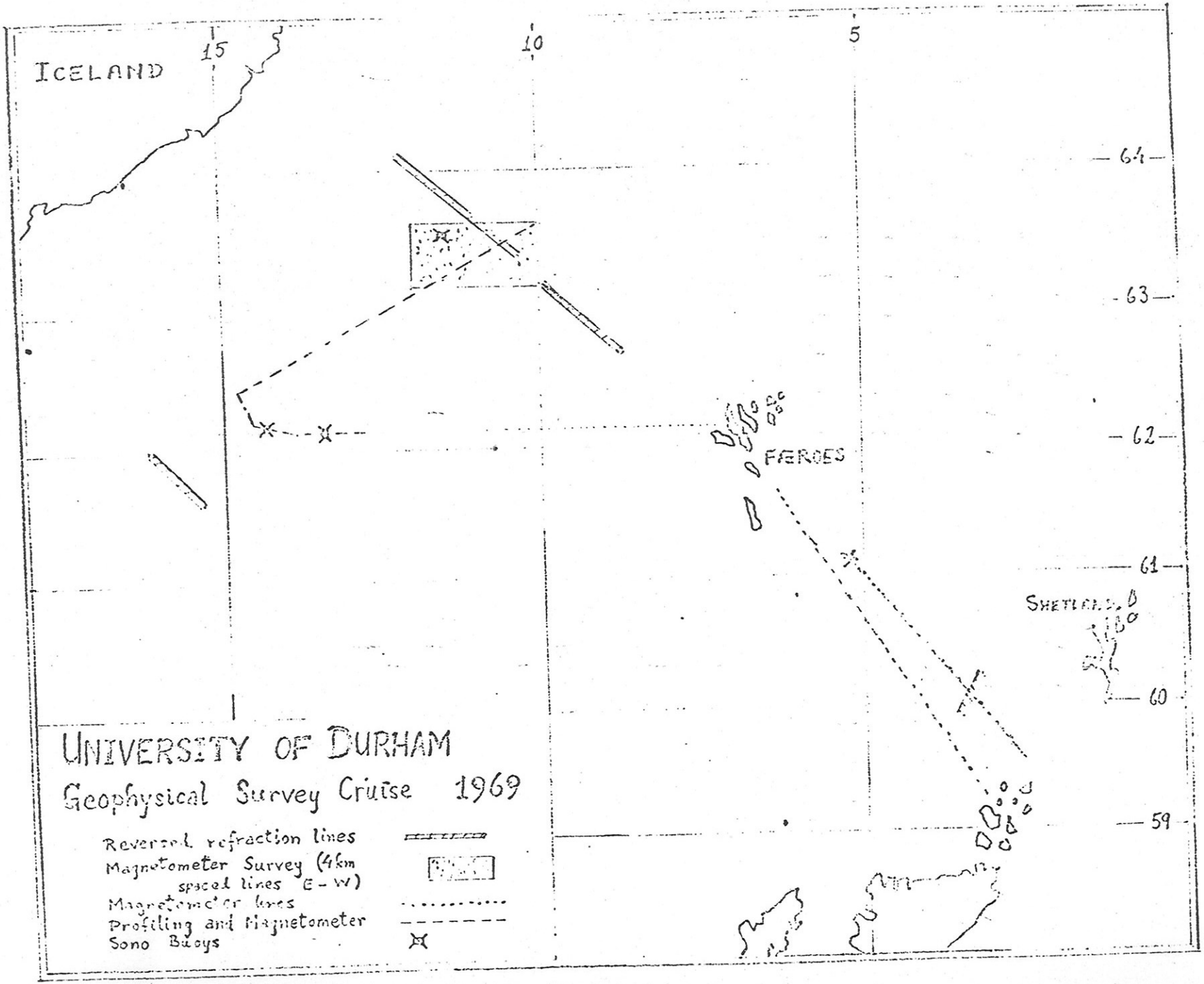
(ii) Close Net

60°09'N to 60°37'N; 10°W to 12°W

Ten lines running E - W at 4 km spacing. Part of line A above forms a NE - SW diagonal, cutting all of these lines.

Positions of Sono-buoy drops

1. 63°35'N 11°30'W
2. 62°26'N 14°45'W (did not function well)
3. 62°03'N 14°16'W
4. 61°55'N 13°20'W
5. 61°06'N 05°15'W (used with aquaflex explosives)


ICELAND
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FAEROES
SHETLAND
UNIVERSITY OF DURHAM
Geophysical Survey Cruise 1969
Reversed refraction lines
Magnetometer Survey (4km spaced lines E-W)
Magnetometer lines
Profiling and Magnetometer
Sono Buoys