UNIVERSITY OF GLASGOW

Department of Geology

R.R.S. John Murray Cruise 8/71 23 June - 14 July

PRELIMINARY REPORT

Geophysical investigation — Little Minch and Sea of the Hebrides

CONTENTS:

1. OBJECTIVES

The original aims of the survey were:

(i) to investigate, in detail, sedimentary basins and associated major fractures at the southern margin of the Minch, i.e. between northern Skye and the Outer Hebrides: seismic refraction and reflection lines to be shot over the basins to determine the nature and extent of their sedimentary infills with sparker and magnetometer profiles supplying information on near-surface geology and on the margins of the basins; sea-bed gravimeter observations to be made, primarily in the area of Loch Snizort, to clarify the known, but ill-defined, gravity anomaly occurring over one of the basins;

(ii) to further our investigation of the Malin Centre, begun on a cruise of M.V. Surveyor in 1970, by sea-bed gravimetry;

(iii) to take some sea-bed gravity readings in Lough Foyle for Professor Murphy of the Institute of Advanced Studies, Dublin.

A fault in the sea-bed gravimeter of R.V.U. was recognised immediately prior to the cruise. As a result of the meter

being thus inoperable, the programme was amended: gravity work being omitted from objective (i) and being replaced by sparker/magnetometer traverses in objective (ii), whilst objective (iii) was abandoned.

2. SCIENTIFIC PERSONNEL

Dr. A. C. McLean (Senior Scientist)	Glasgow University	25 June - 12 July
Mr. W.T.C. Sowerbutts	" "	" "
Mr. A. Faruquee	" "	" "
Mr. D.K. Smythe	" "	" "
Mr. R. Cumberland	" "	" "
Mr. D. Finlayson	" "	25 June - 8 July
Mr. T. Fitton	R.V.U.	23 June - 14 July
Mr. P. Mowat	Decca	26 June - 30 June

3. SCIENTIFIC EQUIPMENT

R.V.U.

- Varian magnetometer
- E.G. & G. sparker
- Muirhead P.D.R.
- Decca track plotter and main chain receivers
- Decca Hifix receiver
- Firing cable
- Sound velocity meter

Glasgow University

- Bradley sono-buoy equipment
- T.I. 8000 seismic instrument

I.C.I.

- Flash blaster

4. SUMMARY OF OPERATIONS

About 120 shots of I.C.I. Aquaseis were fired in the seismic survey on lines 1 and 4 in the Little Minch (see map). Up to four buoys were used to detect arrivals at ranges of up to 11km., though hydrophone failures reduced the number of usable buoys to one for the latter stages of the survey period. After experiencing difficulty in detecting refracted arrivals at shot-buoy distances of more than 7km, efforts were concentrated on shooting in closer proximity to the buoys in an attempt to observe reflected arrivals. Later arrivals than the first breaks have been observed, but their identity will not be clearly established until after further processing of the results. The sound velocity meter was used to record water velocity on most days of seismic survey.

In the same area (see map), 850km of sparker/magnetometer/P.D.R. traversing was completed.

Over the Malin Centre and during transit from the Firth of Clyde (see map), 170 km and 180km, respectively, of sparker/magnetometer/P.D.R. traversing was completed.

Position fixing in the Little Minch was by Decca Hifix Little Minches Chain, with Decca Main Chain 6C (North Scottish) used as a check. Elsewhere Decca Main Chain 3B (North British) was used.

5. PERFORMANCE OF EQUIPMENT AND QUALITY OF RESULTS

(i) Seismic refraction and reflection

a) Shooting system.

Multiples of 100m lengths of I.C.I. Aquaseis were detonated from a towed firing cable by a Bay Flash Blaster. A high 'first-time' misfire rate of about 35% was encountered: the rate was reduced by tying metal rings to the sea-return

detonator wire in order, firstly, to reduce the sea/wire contact resistance and, secondly, to ensure that the buoyancy of the Aquaflex did not prevent the detonating connector from reaching the firing ball (with the ship steaming at 1½-2 knots for firing depth of 15-20m). The remaining misfires, and occasional premature discharge of the blaster, may be attributable to ageing of the blaster flash tube.

The source gave clear water-breaks up to the maximum shot-buoy distance (11km), but gave no clear refracted arrivals beyond 8km. The cause was thought to be the roughness and high acoustic impedance of a sill outcropping on the sea-bed, since there appeared to be a weak correlation between the presence of the sill and the amplitude of refracted arrivals, but the suspicion was not confirmed by repeatedly weak arrivals on line 4 (clear of major intrusions subcropping on the sea-floor) despite using shots of up to 300m of Aquaflex. It seems likely that the seismic source is not sufficiently powerful when used with our detection system, at ranges beyond 5km where larger point charges would give more satisfactory results.

b) Recording system.

On-board apparatus functioned well. The radio-link with the buoys was very good - a ¼-wave whip aerial was mounted atop the foremast with four ¼-wave wires leading down at 45° from the aerial base to provide an 'earth-surface'. Other users of Bradley equipment may note that earthing (through a 1uF capacitor) of the unused 'wow and flutter cancellation input' terminal of the galvo amplifier in the demodulators increased the overall signal-to-noise ratio by a factor of 5.

Leaky hydrophone seals reduced the number of usable buoys to one for the latter part of the survey. Good

mechanical decoupling of buoy and hydrophone was achieved by the use of two carefully adjusted floats on the 30m linking cable. One buoy was successfully anchored in 150m of water, by use of a 200m line and a light boat anchor, without undue hydrophone disturbance in winds of up to Force 5.

c) Quality of results.

Good refracted arrivals (especially at the N.W. ends of lines 1 and 4) were obtained at ranges up to about 5km, beyond which the only clear arrivals were water breaks. Processing of filtered playbacks may reveal further information. The reflection work carried out at the S.E. end of line 4 appears more promising, with several late events arriving at up to 4 seconds, though correlation is hindered by the sparsity of reflector coverage, caused by the hydrophone failures.

(ii) E.G. & G. Sparker

A 9 element spark array was used discharging 1000 J with a 1 second firing period. The output of the multi-element hydrophone array was fed to the model 254 recorder operated with a sweep time of 0.5 seconds and a bandpass of 80-800Hz. Record quality was fair, being limited mainly by sea noise, and an average sea-bed penetration of 50m was obtained. The equipment functioned well, apart from two failures — the repeated blowing of a transistor necessitated replacement of the recorder unit (see log) and the power supply generator overheated due to a fuel leak into the lubricant. The failures resulted in about 50 hours of lost time. An external filter would be a useful accessory to the recorder.

(iii) Varian magnetometer

This functioned satisfactorily throughout, apart from a two-hour period when a phase-lock fault was being rectified.

(iv) P.D.R.

This functioned satisfactorily throughout, apart from one minor failure quickly rectified. The recorded output of this unit is in the opposite sense to that of other recorders (notably the sparker) -- a minor inconvenience which might be avoidable.

(v) Sound velocity meter

This functioned satisfactorily throughout.

(vi) Decca position fixing

The Little Minches Hifix chain proved of great value in the survey of that area. One measure of the value of a fixing system is that the probable error of the fix be of smaller magnitude than uncertainties in the position of towed (or suspended) instruments relative to the ship (or buoy); on this basis, the Decca main chains in the area fail the test (unless a great deal of time is spent on calibration against independent fixes) whilst the Hifix chain passes. The Hifix system was referenced each morning of the active survey in the Little Minch. The main chain (6C - North Scottish) was recorded in the Little Minch area as a check on the Hifix and also was used, together with the track plotter, to facilitate the seismic work, i.e. buoy and shot positions were pre-plotted on the track plotter to act as a quick guide to navigation in the occupation of the required stations. Elsewhere, the North British chain (3B) proved adequate.

6. SYNOPSIS OF DAILY LOG

25 June — Glasgow party signed on, equipment installed and explosives loaded at NATO pier, Fairlie, Ayrshire. Sailed from Fairlie at 1400 hrs; sparker/magnetometer/P.D.R. traverse (hereafter referred to as 'traverse') begun

at 1540 hrs. Proceeded towards Malin Centre, Sparker transistor blown and replaced.

26 June — Wind 3-4. Traversing Malin Centre until transistor blew again at 1400 hrs. Proceeded to Oban; picked up Mr. Mowat; proceeded towards Little Minch.

27 June — Wind 4-5, freshening to 6. Seismic: 4 buoys launched at A (W. end of line 1), 3 shots (x 100m) fired (3-10km) eastwards from buoys. Anchored West Loch Tarbert (Scalpay) overnight. Hydrophone buoyancy adjusted.

28 June — Calm seas, wind force 3-4 freshening. Repeated previous day's seismic, fired 9 shots (8 x 100m, 1 x 200m) most at close range, weak arrivals beyond 4-5km. Anchored at A overnight.

29 June — Wind force 3. Repeating seismic runs of previous days. 13 shots fired (including 4 x 200m, 1 x 400m) over range of 0-9km. Some misfires; good arrivals up to 7km. Some hydrophones leaking. Proceeded to Oban.

30 June — Arrived Oban 0630 hrs. Mr. Mowat disembarked. Replacement sparker recorder loaded. Sailed at 1100 hrs. Proceeded to Little Minch. Traversing overnight.

1 July — Wind force 5-6, high seas. Traversing in Little Minch.

2 July — Wind 4-5, sea moderating. Seismic: at middle of line 1, using 3 buoys, initially, finally only 1, fired 25 shots (4 x 200m, rest 100m) mostly at close range for reflection, but some shots up to 10km both sides of buoys. Several misfires; weak arrivals beyond 5km. Traversing from 2100 hrs.

3 July — Traversing until 0330 hrs. Sparker generator breakdown. Proceeded to Stornoway. Arrived 1000 hrs. Received spares, repaired hydrophones and generator. Ship's cook disembarked with 'slipped disc'.

4 July — Stornoway. Continued hydrophone checks. Interpretation of sparker records to date with view to moving seismic lines.

5 July — Replacement cook arrived. Sailed at 1545 hrs. Traversing in Little Minch overnight.

6 July — High seas, wind 5-6. Seismic: 1 buoy launched with anchor at W. end of line 4 (P), fired 8 shots (4 x 100m, 4 x 200m) at ranges up to 5km; fired 2 shots into buoy at E. end of line 4 (Q). Sea noise too great. Traversing in Loch Snizort from 1700 hrs. -- abandoned at midnight after complaint about 'trawling'.

7 July — Sea choppy, no swell, wind 2-3. Seismic: buoy anchored at E. end of line 4 (Q), 39 shots fired (1 x 300m, 13 x 200m, rest 100m) at up to

8km to west of buoys, some shots for reflection to east of buoy. Erratic firing improved by using metal rings on det. wire 'sea-return'. Traversing from 2100 hrs.

8 July — Wind 4-5. Mr. Finlayson disembarked at Uig (1000 hrs). Fired 14 shots (all 100m) for reflections into buoy at Q. Good arrivals. Proceeded to B' to reverse shoot western end of line 41. Fired 4 shots but trouble with misfires. Traversing from 2100 hrs overnight.

9 July — Wind 3-4. Seismic: repeated reflection work at Q, fired 11 shots. Completed traversing in Little Minch.

10 July — Wind force 4-5, heavy swell. Proceeded to Stanton Banks area (Malin Centre). Commenced traversing at 0900 hrs.

11 July — Seas worsened overnight, wind 5-6. Completed traversing at 1700 hrs. Proceeded towards Oban.

12 July — Berthed Oban 0730 hrs. Glasgow party signed off and unloaded equipment.

pp. Dr. Adam C. McLean,
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