

9/40/70

UNIVERSITY OF GLASGOW

Department of Geology

Cruise of M.V. Surveyor, 23 June - 13 July 1970

PRELIMINARY REPORT

Seismic refraction and other geophysical measurements
in the Sea of the Hebrides (south and west of Mull)

The principal scientific aims of the programme were

- 1) to investigate the continuation of the Great Glen Fault and associated faulting in the area from Lismore Island to south west of Colonsay -- locating its position, finding whether it bifurcates, and elucidating its history of Post-Palaeozoic movements by determining the development of Mesozoic and younger strata on both sides of it;
- 2) making detailed investigations of the submerged Tertiary igneous centre near Stanton Banks which had been recognised from the I.G.S. aeromagnetic maps by the Geophysics Section of I.G.S. some years earlier.

The methods to be used were

- 1) a seismic refraction programme consisting of 11 lines grouped in 4 areas. A probable position of the Great Glen Fault had been derived from the I.G.S. aeromagnetic maps. 9 lines were laid out in its supposed vicinity, with 3 of the lines to the N.W. of it, 3 to the S.E., and 3 crossing it. The first group of 3 lines (Lines 70/1, 70/2, 70/3) lies immediately south of Carsaig, Isle of Mull; the second (Lines 70/5, 70/4, 70/6) to the west of Colonsay; and the third group (Lines 70/7, 70/8, 70/9) 30 miles to the S.W. of Colonsay. Lines 70/10 and 70/11 form one single east - west traverse across the igneous centre, symmetric about the probable position of the major gravity maximum. The total line - mileage was 75 miles, making 150 miles of traverse when shot both ways.

The original plans included a programme of sea-bottom gravity stations along and near the seismic lines to better define (than the ship-borne meter) any anomalies associated with the fault, or critical values on the major gravity anomaly associated with the Tertiary centre.

Detailed sparker and magnetic profiles on a grid of lines trending N.W./S.E. about $1\frac{1}{2}$ to 3 nautical miles apart was to be run during the hours of darkness. The Lacoste-Romberg ship-borne gravity meter would be operated at the same time time.

In the event, an exceptional spell of near continuous high winds affected the quantity of work done and the quality of results obtained. During the three weeks of the cruise the winds averaged about Force 5 with a liberal sprinkling of gale warnings -- and usually coming from the most unsuitable quarter, the S.W.

Further difficulties arose through the failure of some apparatus. The sea-bottom gravity meter had been sent, some months before the survey, to be repaired by a sub-contractor of the manufacturer, in U.S.A. Despite frantic efforts by R.V.U. it was not returned in time for the survey and is still in the States. The Lacoste-Romberg meter was not functioning properly at the start of the survey and eventually the fault was found when one of the gyros failed completely. A replacement gyro was delivered to Oban by R.V.U. on 29 June and no further trouble was experienced. One sono-buoy was made non-functional when the hydrophone cable was (mysteriously) broken when out on line 70/5 and the hydrophone lost. Two of the remaining sono-buoys gave intermittent trouble or failed during the final days of the survey and on the last line shot, only one buoy was operating perfectly. Additional T-X points were obtained on the later lines, to maintain the planned coverage, by firing additional charges.

Despite these difficulties about 2/3 of the proposed refraction programme (8 of the 11 lines) were completed, a total of 55 line-miles i.e. 110 miles of traverse. 153 usable records were obtained from the shots fired.

After the first two traverses on Line 70/4, good radio reception was maintained and first arrivals were clear even on unprocessed records. The significant improvement in quality of results over those obtained the previous year (John Murray Cruise 69/3) was obtained (i) by shooting charges at greater depth (about 40 ft), and (ii) improving radio-reception, mainly by the addition of 3 screen-wires (quarter wavelength) run from earth lead on receiver aerial connection.

440 sea-miles of gravity/magnetic/sparker profiles plus another 120 of gravity alone were completed.

The sparker was run at 1 or 3 KJ; initially 1 KJ was used almost exclusively, but later two power units were used to give a firing rate of $1\frac{1}{2}$ sec. at 3 KJ. The 9-element spark array was tried, but the 3-element array was used for most of the time. The multi-element hydrophone array gave a considerable amount of trouble, and for much of the time it had to be used without pre-amplifiers. When the multi-element array was being repaired a single-element pinger hydrophone was used with reasonable success. An external filter allowing a greater choice of cut-off frequencies than the internal filter was a considerable advantage in reducing noise.

The main limit on the quality of the records is the high noise level. Some of the records taken in fairly rough weather are of very poor quality, partly because the ship was unable to reduce speed sufficiently in rough seas. Others are quite good, with penetration of 200 feet or more in superfcials and some evidence of dips in bed rock.

The location of the lines is shown on the accompanying map.

Gravity traversing was run at a ship's speed of 6-7 knots, and occasionally at 10 knots. The cross coupling error was normally between 0-5 mgal, but in rough seas it rose to values of 10-20 mgal with maxima as high as 30 mgals recorded.

Scientific equipment used:

(i) (from I.G.S./R.V.U. Equipment Pool)

1. Lacoste-Ronberg ship-borne gravity meter,
2. Barringer proton magnetometer,
3. 3- and 9-element sparker systems, multi-element hydrophone, and 254 seismic recorder,
4. Water velocity meter,
5. 1000 ft detonating cable.

(ii) (from Glasgow University)

1. Seismic refraction equipment, with 4 sono-buoys, plus T.I. 8000 seismic reflection channels for processing records on board.

9000 lbs of Marine Seismex explosives were loaded at Fairlie and were used completely during the course of the survey. The charges were in canisters of 16 $\frac{2}{3}$ lb, 33 $\frac{1}{3}$ lb, and 50 lb. A few charges of 100 lb were fired experimentally in an attempt to improve arrivals over longer distances.

Charges were detonated electrically using a shooting cable let out 700 feet, from the stern. The only difficulty experienced in shooting, were misfires where only detonator and booster exploded. This was probably due to the poor condition of some of the Marine Seismex. Several canisters had rusted through, allowing explosive to leak out and sea water to leak in. Although some charges were fired at depths up to 40 ft -- deeper than recommended by the manufacturer -- this appeared to have little effect on misfires. On the other hand the correlation between rusted canisters and misfires was high.

Scientific Personnel

A. C. McLean	Glasgow University, Senior Scientist	23 June - 11 July
M. J. Hall	"	"
Mr. R. Cumberland	"	"
Mr. L. Cunningham	"	"
Mr. A. Faruquee	"	"
Mr. D. K. Snythe	"	"
Mr. J. Cheshire	C.S.U. II I.G.S.	23 June - 10 July
Mr. S. Jones	R.V.U.	23 June - 13 July
Mr. G. Day	Marine Geophysics, I.G.S.	23 June - 1 July

Summary of Log

22 June: Ship berthed at NATO Pier, Fairlie. 9000 lb Marine Seismex, 210 boosters, 210 detonators loaded. Seismic equipment installed. Gravity base established beside ship.

23 June: Postponed sailing to effect repairs to ship-borne gravity meter, so that a tie could be made at the Fairlie base. Gales forecast. Late arrival of fuel and laundry.

24 June: Sailed from Fairlie at 2 p.m. Severe gale encountered in North Channel. Retrieved all gear and sheltered in Red Bay, Northern Ireland overnight.

25 June: Gale continuing, sailed at 2 p.m. taking route in lee of Islay and Jura. Sheltered overnight off West Loch Tarbert.

26 June: Proceeded to seismic Line 70/4 and continued work until 9.30 p.m. Fault in gravity meter traced to gyro; meter and platform clamped. Sparker/mag. profile lines G12, G14 run overnight.

27 June: Winds 4 to 5. Continued seismic refraction survey (Lines 70/4 and 70/5). Weather improved to Force 3.

Sparker/mag. lines G16, G18, G20, G22, and H0 run overnight.

28 June: Winds 4 to 5 deteriorating. High seas. Continued sparker/mag. profiling in Firth of Lorne area (H3, H6, H4-5, A77, B50, B53, B56).

29 June: Gale imminent. Lines B51, A79, A74, A72 run. At 11 a.m. berthed in Oban and made arrangements for delivery of spare gyro. Gyro arrived by train in afternoon and gravity meter repaired. Continued high winds.

30 June: 8 a.m. sailed for Tertiary centre (UK/US Gravity Range 1) (with gear out) to test gravity meter over bottom stations. Winds 5 to 7. 2 p.m. forecast: gale warning. Retrieved sparker and magnetic gear but proceeded with gravity profiling. 9 p.m. Force 9 gale. Made for shelter in Sound of Islay.

1 July: Anchored off Port Askaig 4 p.m. Attempted to put Mr. Day ashore, but failed to start engine of Zodiac. Winds 6 to 8 continuing.

2 July: 5 a.m. sailed for Oban. Gale 7 - 9 continuing. Berthed 9 a.m., Mr. Day left ship. Strong gusts of wind side-on to ship in Oban harbour prevented ship from putting to sea despite several attempts to get clear.

3 July: Winds 5 to 6. Ship under way 6 a.m. to Seismic Line 2. Continued shooting during daylight hours. Gravity sparker/mag. (Line G8) run overnight in same area.

4 July: Wind Force 5. Refraction Line 70/3. Continued shooting during daylight. Sparker/mag. run overnight (Lines G6, G4, G2, G0).

5 July: Wind Force 4-5 increasing to 6. Shot Seismic Lines 70/5 and 70/6 till late afternoon. Line abandoned to recover sono-buoys as weather rapidly deteriorated. Gravity

mag./sparker Lines H8, H10, H12 run overnight, but recording abandoned at midnight as sea noise caused an intolerable deterioration of record quality. Sheltered in lee of Mull (Craignure Bay).

6 July: Winds 5 to 6. Sea very rough. Proceeded to seismic Line 70/6, weather improving. Shot during daylight hours. Gravity sparker/mag. run overnight.

7 July: Winds 4 to 5. Proceeded and shot seismic Line 70/11. Gravity mag./sparker run in Stanton Banks area.

8 July: Winds 5 to 6. Shot Line 70/11 in opposite direction, and Line 70/10. Sono-buoy 1 only, fully functional. In evening proceeded to Line 4 to complete shooting. All explosives used by nightfall.

9 and 10 July: Winds 5 to 6 deteriorating to 7. Gale forecast. Sparker/mag. run in Stanton Banks area, Lines G10, F31, B, C, B59, B62, B64, B66, B68, B70, B72, B74, B76, B78, C50, C52, C54, C56. Berthed at Oban at 18.00 hours Friday, 10 July. Messrs. Cheshire and Smythe left ship. Scientific gear sorted for unloading or stowing in hold.

11 July: All gear belonging to Glasgow University unloaded on quayside by 8 a.m. Ship sailed for Barry 10 a.m. with Mr. S. Jones on board. All other scientific personnel disembarked.

A. G. McLean,
Senior Scientist.