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R.R.S. DISCOVERY CRUISE 73

3 JULY – 26 AUGUST 1975

GLORIA AND GEOPHYSICAL STUDIES ON THE MID–ATLANTIC RIDGE AND NORTH OF THE AZORES

CRUISE REPORT NO 34

1975

NATURAL ENVIRONMENT RESEARCH COUNCIL

INSTITUTE OF OCEANOGRAPHIC SCIENCES

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GLORIA and Geophysical Studies on the Mid-Atlantic Ridge and North of the Azores

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CONTENTS

DATES

Leg 1	Leave Barry	3rd July 1975	Day 184
	Arrive Ponta Delgada, Azores	31st July 1975	Day 212
Leg 2	Leave Ponta Delgada	3rd August 1975	Day 215
	Arrive Southampton	26th August 1975	Day 238

SCIENTIFIC PERSONNEL

A.S. Laughton	Principal Scientist	I.O.S. Wormley	Legs	1 and 2
R.C. Searle	Geophysics	" "	"	1 and 2
P.R. Miles	Geophysics	" "	"	1 and 2
P.M. Hunter	Geophysics	" "	"	1 and 2
R.G. Rothwell	Geophysics	" "	"	1 and 2
C.J. Spong	Geophysics	" "	"	1 and 2
D.G. Bishop	SRP	" "	"	1
W.E. Elford	SRP	" "	"	1
A.W. Gray	SRP	" "	"	1 and 2
M.L. Somers	GLORIA	" "	"	1
J. Revie	GLORIA	" "	"	1
B.J. Barrow	GLORIA	" "	"	1
T.H. Hogarth	GLORIA	" "	"	1
S.K. Willis	GLORIA	" "	"	1
R.D. Peters	GLORIA, Diver	" "	"	1
R.E. Kirk	PUBS, Diver	" "	"	1 and 2
D. Hill	Diver	I.O.S. Taunton	"	1
C. Hazelhurst	DPG	I.O.S. Barry	"	1 and 2
I. Innes	DPG	" "	"	1
B.D. Loncarevic	Visitor	Bedford Institute, Canada	"	1
R.B. Whitmarsh	Geophysics, PUBS	I.O.S. Wormley	"	2
J.J. Langford	PUBS	" "	"	2
R.J.P. Burnham	DPG	I.O.S. Barry	"	2
T.J.G. Francis	OBS	I.O.S. Blacknest	"	2
I.T. Porter	OBS	" "	"	2
P.L.C. MacKeith	OBS	" "	"	2
R.C. Lilwall	OBS	" "	"	2
D.H. Matthews	Seismics	Geodesy & Geophysics Cambridge		Leg 2

M. Nisbet	Seismics	Geodesy & Geophysics Cambridge	Leg 2
A. Claydon	Seismics	" "	Leg 2
S. Williams	Seismics	" "	Leg 2

SHIP'S OFFICERS

G.L. Howe	Master (Leg 1)
M.A. Harding	Master (Leg 2)
J.J. Moran	Chief Officer
A.R. Neil	Second Officer
W.R. Austin	Third Officer
R.H. King	Radio Officer
R.G. Hopkins	Catering Officer
C.S. Storrier	Chief Engineer
J.R. Richardson	Second Engineer (Leg 1)
C. Tottle	Second Engineer (Leg 2)
N.R. Walters	Third Engineer
G. Henderson	Fourth Engineer
C. Brown	Fifth Engineer
I.G. McGill	Fifth Engineer
B.J. Winchester	Chief Electrical Engineer
P.J. Parker	Electrical Engineer

SUMMARY OF CRUISE INTENTIONS

(1) GLORIA surveys of areas of the Mid-Atlantic Ridge

Following the success of the long range side-scan sonar (GLORIA) surveys in the FAMOUS area of the crest of the Mid-Atlantic Ridge in 1973 (Cruise 54), the same technique of producing sonograph mosaics of substantial areas was planned for three distinct regions, each related to specific scientific objectives. In each region, simultaneous bathymetric, magnetic and seismic reflection measurements were made.

(a) The axial zone, crestal mountains and high fractured plateau between 45° and 46°N:-

This area has been extensively studied by the Canadians during the last decade and good bathymetric, geophysical and geological data was available. The objectives were

(i) to locate and map linear fault scarps of the sort found in the FAMOUS area,

(ii) to locate and map transverse fracture zones (if any) which might offset linear features,

(iii) to make short range studies of the median valley to look for axial volcanic ridges,

(iv) to make a special study of the morphology and sediment distribution in the region of anomaly 5 west of the axis where a crustal drill hole is planned by the Deep Sea Drilling Project.

(b) The Kurchatov Fracture Zone

Mapping by Russian scientists has shown that the median valley is offset by 20 km. The GLORIA survey was planned to see whether linear fault scarps of the median valley trend curve inwards near the fracture zone, as was found in the FAMOUS area. It was also planned to determine the length of single fault scarps.

(c) 40°N, 23.5°W area examined on Cruise 68

The survey on Cruise 68 revealed an orthogonal pattern of faults displacing relatively young sediment overlying Eocene crust on the lower flanks of the Mid-Atlantic Ridge. The GLORIA survey was planned to examine this fault system in more detail and to map any extension of these trends.

(d) Passage data

GLORIA sonographs will be obtained on passage whenever possible to build up data on the morphological texture of the N.E. Atlantic.

(2) Joint Anglo-French seismic studies of the upper mantle north of the Azores

In 1974, long range refraction studies using explosives at sea and recording stations on land and on the seabed were made in collaboration with the Institut de Physique du Globe, Paris. Further seismic lines were planned to complete and complement the 1974 work, two pop-up bottom seismic recorders (PUBS) being laid by Discovery and shots being fired by IPG. Two seismic lines of 400 km were planned parallel to and west of the ridge axis and one crossing the crestal region at 43°N.

(3) Earthquake studies at 45-46°N

Studies of the occurrence and distribution of micro-earthquakes in the median valley were planned using five ocean bottom seismographs (OBS) to be deployed for eight days.

(4) Magma chamber studies

Seismic refraction lines along and across the median valley in the 45-46°N area were planned by the Cambridge group to look for evidence of and to determine the size of a magma chamber beneath the intrusive zone, by studying the attenuation of S waves. The three component seismographs of OBS and surface sonobuoys were to be used.

(5) Crustal studies of King's Trough

Additional seismic data is required on a geotraverse across King's Trough where H.M.S. Hecla has previously obtained gravity sections. Three refraction lines were planned using bottom recorders (PUBS) and about 70 km lines. The origin of King's Trough is still obscure.

(6) Stratigraphic section of the continental margin southwest of U.K.

A seismic reflection profile across the continental margin was planned as part of the site survey studies for a deep drill hole to be drilled during the passive margin programme of the Deep Sea Drilling Project.

(7) Velocimeter

Velocity sections of the upper 2000 m were planned as a necessary part of the interpretation of sonographs and of bottom recorded seismics.

(8) Passage data

Throughout the cruise echo-sounding and magnetic measurements were planned and as much seismic reflection profiling as time would allow.

NARRATIVE

Leg 1

Discovery sailed from Barry at 1100 on Day 184 in fine sunny weather westsouthwest towards Goban Spur on the continental shelf edge. At 10°W, echo-sounder and magnetometer watches were set and a seismic reflection profile started using the 160 cu. in. airgun and (after some problems) the wave shape kit. A good section of the slope and rise was obtained. It was the intention to launch GLORIA as soon as we were in deep water, but the weather had deteriorated and so the seismic profile was continued until it had improved enough for a launch. Considerable problems were experienced during this time, and throughout much of the first leg, with the compressors, but in spite of this very little profile was lost.

By midday 187 the weather chart still failed to give promise of calm weather so we headed SSW in search of the Azores high. We found calmer weather on day 188 at 45½°N, 19½°W and launched GLORIA without difficulty. A straight line track to our first survey area at 45°N would have put many of the expected targets on passage normal to the ship's track and hence not easily visible on the sonograph, so two legs of WNW and WSW were made and viewing was to 14.5 miles. At the most northerly point on these tracks we expected to see evidence of a fracture zone but found none and concluded that the bathymetric evidence for it was based on bad soundings.

The survey of the 45-46°N area of the Mid-Atlantic Ridge started at 1530/190. All lines were oriented 050°-230°, oblique to both the median valley trend and any possible fracture zone trend, were spaced 7 miles apart and viewing was towards the NW covering 14.5 mile range. The ten tracks of the main survey were completed by 1800/194 and were followed by five tracks spaced 5 miles and viewing NE at 7.2 miles oriented 140°-320° in the region of anomaly 5 where the DSDP drill hole is planned. The combination of GLORIA targets and seismic profile data enabled possible drill sites to be chosen.

After returning to the median valley, seismic profiling was stopped for a day (since there were no detectable sediments) and closer range (7.2 and 3.5 mile) sonographs obtained of the median valley looking into it from west and east, and of Magog Seamount just east of the valley at the northern end. The work in this area was completed by 0300/198 after some lines of the main survey had been repeated and some gaps filled. Apart from some force 6 winds at the start of the survey, the weather was particularly calm, the wave height not exceeding four feet.

The route to the Kurchatov survey area was chosen to be parallel to the median valley, on the high fractured plateau, but looking west toward the crestal mountains at 14.5 range with the purpose of looking for fracture zones. No evidence of clear cut E-W features was found although there were zones of faulting(?) oriented NE-SW. However we had clear evidence of the eastern side of the Kurchatov Fracture Zone when we crossed it on the evening of day 199.

The survey lines in the Kurchatov Fracture Zone area were planned to run parallel to the median valley and its associated faults and to look outwards from the median line so that inward looking scarp faces would be insonified. Nine tracks oriented 010°-190° were spaced by less than 7 miles and were completed by 1640/202. Four tracks at 080°-260° were steamed to give bathymetric profiles to relate targets to bathymetry and to give magnetic profiles for anomaly interpretation. Finally some 7.2' range sonographs were taken looking southwards into the fracture zone for more detail.

At 1435/204, the Kurchatov Fracture Zone survey was completed and a south going track was run looking east to see how far the very narrow linear echoes could be followed. A crossing was made of an E-W sediment basin (fracture zone?) WNW of Graciosa, followed by an east going track planned to examine the western extension of the West Graciosa Basin, and a north-going track across it. These tracks were in the vicinity of a possible position for the Azores triple junction, but extra data will be necessary to study the area properly.

At 1308/205 the three phase supply to the GLORIA vehicle finally shorted, having given some signs of trouble several days before. That meant that active rudders, beam steering, monitoring meters etc. were out of action. However some pictures were still coming in

although the quality had deteriorated considerably. It was decided to keep going in the hope of getting adequate pictures for the trend studies north of the Azores and in the Cruise 68 area. Luckily the sea was extremely calm and the weather fine so that yaw should have been minimal. However at the Cruise 68 area adequate pictures were not being obtained and on day 207 at 40°N 23°W, the GLORIA vehicle was recovered. The weather was ideal without sea or swell, which was just as well since there were difficulties with the davit hydraulics during recovery.

The remainder of leg 1 was devoted to a study of the eastern extension of the Kurchatov Fracture Zone and its relation to the large seamount, named Howe Seamount in honour of the retiring Master of RRS Discovery, G.L. Howe, at 40°15'N 26°40'W. North-south tracks were run across the area and it was established that the fracture zone extended as far east as about 27°W. This work was completed at 1600/211, the seismic reflection profiling gear recovered and the ship made directly for Ponta Delgada on Saõ Miguel where she berthed at 0830/212.

In Ponta Delgada, there was a considerable change of scientific personnel. The GLORIA team and some others left, and the PUBS team, the OBS team from Blacknest and a seismic team from the Department of Geodesy and Geophysics, Cambridge University all arrived, and set about getting their respective equipment ready for Leg 2. Léon Steinmetz and his colleagues from the Institut de Physique du Globe arrived in their chartered ship, the Ptolemée on Saturday (214) and planning meetings were held regarding the coming week of joint seismic work.

Leg 2

We sailed from Ponta Delgada at 1000/215, steamed around the west end of Saõ Miguel and headed NNW towards the laying position for PUBS for the Anglo-French seismic work. On passage into a choppy sea and headwind, we passed along the length of Howe Seamount. It turned out to have several peaks of about 400 fathoms, which appear to have been subaerially eroded and subsided.

Two PUBS were laid on day 217 10 and 70 miles west of the median valley at 43°20'N, while Ptolemée laid the OBS from the Centre

Océanologique de Bretagne, at a position closer to Flores. Routine radio contact was maintained with Ptolemée while she shot three seismic lines to PUBS, the French OBS and the land stations. PUBS was programmed to record for 5 minutes every half hour and could record for three days.

During this time Discovery steamed south (stopping en route for sonobuoy tests and a velocimeter station) to make some crossings of the western extension of the Kurchatov Fracture Zone. Seismic reflection profiling started at 0800/218 and four crossings demonstrated that the fracture zone extended at least as far west as 31°20'W. No evidence was found of the large seamount at 41°00'N, 31°15'W which had been contoured from some spurious sounding data. The seismic profile was continued northward up the line of the westernmost seismic line as far as PUBS 2 which was recovered at 0530/220. However PUBS 1 failed to come up in spite of the requisite relays operating and it had to be abandoned. Either both pyro-releases failed or else the instrument became jammed on the bottom.

On completion of this Anglo-French project, we steamed north to the 45°N area where, on day 221, a dan buoy with a radar transponder was laid on the top of a ridge just west of the median valley. Two Ocean Bottom Seismographs (OBS) were laid in the median valley on day 221, a small survey of part of the median valley was made during the night to aid the interpretation of GLORIA sonographs obtained on Leg 1, and two more OBS laid west of the valley on day 222. The fifth OBS was laid on day 223 having been delayed by pinger trouble. Radar ranges from the transponder were very poor (under 8 miles), possibly the result of a different configuration of transponder and passive reflector. After an improvement in the weather during the days 218-220, the sea had risen again and there were several rain squalls. These may have contributed to poor radar propagation conditions.

Once the OBS were laid, we steamed north up the median valley, laid four sonoradio buoys and shot a seismic refraction line southwards towards and past the OBS using 100 lb charges with intervening shots from the 1000 cu. in. airgun (Line D). After an offset to the east, a second line (E) was shot without airgun towards the NNW obliquely across the median valley. The sonobuoys were recovered by

2200/223 and we steamed south to recover D/B 1 leaving the OBS to record earthquakes. The entire period that the OBS remained down has been called station 8889.

The passage east to King's Trough went along its axis and the first PUBS was laid for seismic refraction station 8890 on the flat bottom of the trough. A velocimeter station (8891) to 2000 m gave the necessary velocity data for interpretation of the PUBS results. The line to the ESE was shot first with the airgun, and then some charges. PUBS 2 was laid at the far end of the line and charges fired back to PUBS 1 which was recovered. The return to PUBS 2 was partly shot with an airgun and PUBS 2 then recovered by 2400/225. Unfortunately the tape recorder in PUBS 1 had run prematurely so no shots were recorded and the line had to be reversed later.

Since we had time to spare (bad weather time) before OBS were due to lift off, we profiled back along the seismic line, then made several crossings of the western end of King's Trough to delineate its termination better. These showed another en echelon basin to the north and hinted at E-W features comprising the trough and its ridges.

Seventy miles east of the valley we fired a 300 lb shot to the OBS, then at sixty miles laid three sonoradio buoys for seismic line F across the valley (station 8892). The end parts of the line used the 1000 cu. in. airgun and mixed charge sizes were used in between. The buoys were recovered by 1800/228 having drifted some 8 miles east. This pressed us for time to get back to the valley and lay D/B 2 before OBS 1 surfaced. However we made good speed with three engines, laid D/B 2 with radar transponder by 0200/229, and were able to make some OBS fixing runs with the 1000 cu. in. airgun before OBS 1 lifted off on its own internal clock at 0400. It was recovered using two swimmers operating from the rubber dinghy and picked up aft. However OBS 2 failed to lift off at 1000 (owing to a failure of the explosive bolt?) and had to be abandoned. After a short survey and a velocimeter station (8893) to 2000 m, OBS 3 was seen to lift off and was recovered.

During the evening some measurements of the 160 cu. in. airgun pulse were made using a hydrophone on the hydrographic electrical winch. OBS 4 and 5 were recovered on day 230 without incident and D/B 2 picked up. The four OBS recovered had been recording for 8 days

and after recovery were left sealed until returned to the laboratory.

The passage back to King's Trough was designed to examine further the western extension of the feature. The reversal of seismic line 8890 was made on day 231 with two PUBS laid at the western end, and two sonobuoys (for shallow structure) at the eastern end using airgun and explosives (station 8894). A second line (8895) was shot along the ridge flanking King's Trough to the south with a PUBS at both ends. Between these two lines, a seismic reflection profile was made across the axis of the trough and along the line of station 8895. Before leaving King's Trough, bathymetric survey lines were made across the south margin at 5 mile spacing to give more detail of structural trends.

The passage home from King's Trough started at 0900/234 and was made in continuously calm weather, making measurements of bathymetry and magnetics only. The ship berthed in Southampton at 0730/238.

PROJECT REPORTS

(1) GLORIA operation

The equipment was essentially the same as in 1973, except that a flux gate stabiliser had been fitted to the gyro-compass and the option of a narrow vertical beam was not available as the outer rows of transducers had been removed. The launching, recovery and towing arrangements were identical and merit no further description here. The presentation, recording and photographic arrangements were also pretty well unchanged, but were streamlined a little.

The provision of the flux gate for cruises 71 and 73 allowed for the first time the vehicle's correct magnetic heading to be known, and recorded, so it is in principle possible to determine the direction in which each pulse was transmitted. This fact together with the track overlaps will enable the yaw-induced aberrations in the records to be recognised and explained. Unfortunately the amount of data is enormous and any analysis will take a considerable time. The yaw record was presented on an 8 channel recording galvanometer together with vehicle roll, pitch and vertical acceleration. The other channels displayed the ship's course, acceleration on the poop, towing tension, and the transmission pulse envelopes.

The receiver gain settings and recording levels were carefully

preset to avoid any overload on the tape while making maximum use of the dynamic range available. Both AGC and fixed gain channels were replayed and scaled negatives produced within 24 hours of recording throughout the cruise, the anamorphic scale being determined from corrected navigation data. Prints to the appropriate scale for making the mosaic, shortly followed, so it was possible to keep the GLORIA data nearly up to date with the survey.

As mentioned elsewhere in this report a gyro failure towards the end of the leg caused a loss of vehicle and beam steering and vehicle data. This undoubtedly caused a degradation of the records, but it is not possible to say how serious since the area was new to GLORIA coverage and it is not certain that the terrain will produce strong side-scan echoes. The gyros had given good service, having been purchased cheaply on the surplus market after manufacture in 1950 and 15 years service in military aircraft. The premature recovery of the vehicle was so late in the cruise that there was not enough time to replace the faulty gyro and prepare another launch.

M.L.S.

(2) GLORIA survey at 45°N (Fig. 2)

The area between 45° and 46°N, and between 27° and 30°W includes the median valley, the crestal mountains both sides of the valley and the high fractured plateau west of the valley. It has been surveyed in considerable detail by the Bedford Institute, Canada between 1965 and 1969 and good bathymetric and magnetic charts were available. Many of the peaks have been dredged and photographed and a series of papers published on the geology and geophysics of the area.

In the analysis of the geology, it was apparent that although the general bathymetric trend of the median valley is 019°, there were indications that this is comprised of shorter segments of a more northerly trend which are progressively offset. However, no major fracture zones had been observed. The aim of the GLORIA survey was to determine the gross morphological and the textural trends and to look for evidence of offsets or fracture zones, and to determine whether there are other mechanisms which determine the length of the crestal and older ridges.

Survey tracks were chosen to run at 050-230° in order to detect both median valley and fracture zone trends, and were spaced at

7 miles so that an acceptable overlap occurred between adjacent tracks, each sonograph extending to a maximum range of 14.6 miles. Viewing was always to the NW so that for the greater part of the survey, scarps facing in towards the median valley would be insonified. A total of thirteen parallel tracks gave a ground coverage of 5000 sq. miles in about five days. Two tracks were run parallel to and looking into the median valley at a range of 7.2 miles and one at a range of 3.6 miles in order to resolve more detail of the constructional median volcanic ridges, and to look at close range at Magog Seamount from three sides.

First studies of the resultant mosaic made it clear that the dominant trend in the area is 010° and that the median valley consists of en echelon segments of constructional volcanic ridges. There were no clear indications of E-W fracture zones or of continuous offsets, although there were several parts of the area with NE-SW trends extending over limited distances.

Seismic reflection profiles were made over the whole area and an isopach map constructed of the sediment basins. The sediment thickness integrated over distance intervals of 20 km (approx. 1.5 My) showed a linear increase with age. In the western part of the area considerable thicknesses of sediments were affected by faulting, indicating that tectonic activity still occurs several million years after crustal formation.

The bathymetry obtained on the survey (navigated by satellite navigation) was compared with that obtained in the earlier Canadian surveys navigated on anchored buoys which were fixed by celestial observations and later by satellite navigation. In nearly all areas errors of contour positions did not exceed 1 mile, and in most cases were considerably less. During leg 2 (Fig. 3), bathymetric data were obtained by short survey tracks and by random passage tracks in the median valley area which will enable the shorter range GLORIA sonographs to be interpreted in terms of echo-sounding profiles.

Magnetic data were collected throughout the survey and these will be compared with Canadian data obtained 10 years earlier to assess the secular variation coefficients of the I.G.R.F.

A.S.L.

(3) IPOD site survey at 45°N

The purpose of this survey was to assist in determining a suitable site for an IPOD drill hole in the region of anomaly 5 at 45°N. Previous studies by Bedford Institute and Dalhousie University have defined bathymetry and magnetic field in some detail, so we concentrated on GLORIA and seismic reflection profiling, though bathymetry and magnetics were also logged routinely. The area between 45°15' and 45°45'N, 29°00' and 29°30'W was surveyed in detail. The 14' range GLORIA coverage from the main 45°N survey (see previous section) was supplemented by five 5' spaced traverses looking northeast at 7' range (Fig. 4).

Total sediment thickness in milliseconds of two-way travel time was read every 6 min (0.7'), and contoured using the existing bathymetry and the GLORIA records as control.

In choosing possible drill sites, the following criteria were considered:-

(a) sediment thickness should exceed 100 msec (two-way);

(b) the site should lie over a magnetised block of uniform polarity, preferably anomaly 5;

(c) the site should be clear of fracture zones;

(d) the site should avoid areas of recent tectonic activity if possible and be well away from obvious basement faults.

The SRP records showed that sedimented areas could be divided fairly easily into undeformed and deformed areas. The latter were characterised by uplifted and faulted sediments. GLORIA targets, indicating steep scarps, were confined to areas of deformed sediment or outcropping volcanic basement.

Three possible sites were chosen:-

Site	Latitude N	Longitude W	Sediment thickness (ms)	Day/time on SRP record
A	45°23.5'	29°27.0'	300	194/2315
B	45°26.5'	29°22.0'	400	195/0143
C	45°31.4'	29°27.8'	350	(194/2146 (195/0232

Site A is the first preference, and easily meets all the criteria. B is in a very similar tectonic and sedimentary setting, but is rather close to the edge of anomaly 5. C is also in a good tectonic

and sedimentary position, but it is near a possible 12 km dextral offset of the anomaly just north of 45°30'N, possibly the site of a minor fracture zone.

R.C.S.

(4) Kurchatov Fracture Zone

(a) Detailed survey of axial area (Fig. 5)

The main aim of the Kurchatov Fracture Zone survey was a GLORIA study of the fault trends and general tectonics of the Fracture Zone which, unlike the FAMOUS area fracture zones, appeared to be relatively distant from other fracture zones. Most of our tracks were oriented N-S, to show clearly the expected trends parallel to the Mid-Atlantic Ridge axis, and to see any curvature on these as the Fracture Zone was approached.

Just under five days were spent in the axial survey, during which about 1000 miles of track were covered at 7 knots. Sonographs were produced at a scale of 1:200,000, which is about the largest size which can conveniently be obtained with the processing equipment, and this proved to be an excellent working scale. Two main sonograph mosaics were produced, viewing to the west in the western two-thirds of the area and east in the eastern two-thirds, with some overlap in the centre mainly over the median valley. The fracture zone itself was also viewed with north- and south-looking sonographs.

Away from the fracture zone long, straight targets parallel to the Mid-Atlantic Ridge axis were observed which, however, exhibited fine detail which could be matched on overlapping sonographs viewing from different ranges. This proved that the system can resolve fine structure on targets parallel to ship's track without undue contamination by yaw-induced artifacts, and also facilitated adjustment of tracks within the limits of navigation errors to obtain the best fit. While most of these N-S targets remained parallel, a few (about 20%) curved up to 30° from the axial direction over parts of their lengths, crossing other targets before dying out. These trends are randomly oriented E and W of north, and do not appear to be related directly to the major Ridge or Fracture Zone structures. A second-order trend, much less clearly defined than the N-S pattern, is superimposed and consists of faint targets and alignments of target terminations, trending NE-SW.

As the N-S oriented targets approach the Fracture Zone they curve toward the direction of offset. Few targets curve in the opposite sense. The Fracture Zone itself was shown to have a rather complex structure, with a saw-tooth shape in plan. The position of the transform fault appears to have fluctuated somewhat to the north and south in time. Constructional ridges could be identified within the Mid-Atlantic Ridge median valleys, and these apparently extend en echelon across the Fracture Zone.

Seismic profiling was carried out on all tracks, but very little sediment was observed except within the fracture zone and at the extreme east and west edges of the survey area.

To compliment and aid in the interpretation of the main sonograph mosaics, four roughly east-west tracks were run crossing the MAR and the Fracture Zone. Precision echo-sounding on these profiles enabled almost all GLORIA targets crossed by them to be identified with steep scarps.

Contouring of magnetic anomalies revealed a strongly linear pattern parallel to the ridge axis, with clear offsets and possibly some 'end effect' anomalies over the fracture zone. Preliminary anomaly identifications on the E-W profiles indicate small variations in spreading rate in the four quadrants of the Fracture Zone. However, anomaly identifications west of the median valley were not easy to make, and a large mountain in the northwest quadrant has virtually no magnetic anomaly over it. The central anomaly was well-defined, but is considerably wider and more complex than predicted by standard models.

(b) Eastern and western extensions of the Fracture Zone

Following the main survey, we traced the eastward extension of the Fracture Zone on the remainder of leg 1 (Fig. 6), and its westward extension in leg 2. The Fracture Zone is ill-defined bathymetrically away from the MAR crestal mountains because its form is largely obscured by thick sediments. We therefore looked for its extension as a basement feature, and profiled parallel to the MAR axis to avoid confusion from crossing basement ridges of that trend. This scheme proved very successful.

As suggested by the detailed survey, the form of the whole Fracture Zone is rather complex and it extends in a series of zigzags (especially in the east) rather than as a simple linear feature.

However, the general trend of the whole fracture zone is roughly linear and it strikes slightly south of east.

The most characteristic cross-section of the fracture zone is an asymmetric V-shaped basement valley, with the sense of asymmetry reversed between the eastern and western sections.

R.C.S.

(5) Cruise 68 area survey

During Cruise 68, a 10,000 km^2 area near 40°N, 24°W was surveyed with echo-sounder, magnetometer and reflection profiling. Prominent WNW-ESE scarps of faulted sediments had been detected cutting across the general trend of MAR-oriented ridges, and it was intended to study these scarps in more detail using GLORIA.

The area was approached just after midnight 206/207, 1½ days after the failure of the GLORIA three-phase power supply and consequent loss of steering control. Since the breakdown we had obtained what appeared to be reasonable GLORIA records, though there was no way of knowing how much information was actually being lost. As we entered the Cruise 68 area, it was possible to correlate GLORIA targets with previously surveyed basement outcrops. It was planned to make an initial reconnaissance at 14' range, followed by detailed studies at shorter range. However, there was no sign of the expected sediment scarp from a distance of 9' and looking directly towards it. We therefore approached to within 2' and switched to 7' range, and although targets then appeared these were only where basement outcrops were expected, and were rather weak. It was therefore decided that further work with GLORIA would not be very productive, and at 0800 on day 207 we decided to recover the vehicle.

In spite of the loss of GLORIA, two new reflection profiles were obtained over the area to augment the data obtained in Cruise 68. Also, the profiles obtained on passage to and from the area will be of considerable significance for regional studies of sedimentation and tectonics.

R.C.S.

(6) Seismic refraction experiments using PUBS

During the cruise four separate experiments involving eight PUBS lays were carried out. One PUBS was not recovered from the sea

bed.

(a) Anglo-French experiment

This experiment consisted of a three-day two-ship seismic refraction operation to complete work begun in August 1974. Two PUBS were laid to record 250 kg shots fired by the Institut de Physique du Globe group on board M.V. Ptolemée. Three lines were fired across and west of the Mid-Atlantic Ridge just north of the Azores out to ranges of 400 km. PUBS recorded 63 shots spread over about $2\frac{1}{2}$ days and good data were obtained from the PUBS which was recovered. The other PUBS failed to leave the bottom although current had almost certainly been passed through the pyrorelease devices. It is thought that this PUBS may have become trapped either under overhanging rocks or by coming to rest on top of a rock in such a way that the PUBS was tilted, a condition which we later discovered would prevent the ballast release mechanism from operating.

(b) King's Trough experiments (Fig. 7)

The remaining three experiments were all normal single-ship refraction profiles and involved firing 80 shots of $12\frac{1}{2}$ to 300 lbs and about 8 hours of airgunning with the 1000 cu. in. chamber firing mostly every 2 minutes. Two east-west lines, forming a reversed profile, were fired along the bottom of King's Trough out to 80 kms. The third line, also east-west, was just south of the ridge extending west of Anti-Altair and was relatively short (55 km). Some excellent data were obtained from these lines. Other data were spoilt or lost due to faulty tape recorder batteries or to a crackly noise heard on the tapes of one of the PUBS which cannot at present be attributed to any instrumental fault.

More than 50 PUBS launches and recoveries have now been made in the past 8 years.

R.B.W.

(7) Ocean Bottom Seismographs

Five OBS were taken to sea on this cruise with the dual objective of recording earthquakes along the Mid-Atlantic Ridge axis and acting as seismic refraction receivers of explosive and airgun shots for the Cambridge group. On the first leg of the cruise the instrumentation spheres and test equipment were stored in the After Bio

Lab, the top spheres and sinkers at the after end of the Boat Deck. This made the task of setting the equipment up in Ponta Delgada between the two legs much easier than would have been the case if the gear had been crated. By the evening before the ship sailed the five OBS were running on their external batteries and ready for sea. Four were on the poop deck between the coring winch and the crane, the fifth on the open deck immediately above the coring winch.

No difficulties were encountered between sailing from Ponta Delgada and reaching the operational area six days later. Daily checks were made of the current drawn from the external supplies and the OBS clocks were calibrated twice daily against radio time signals (principally MSF on 60 kHz). Deployment began at 1023/221 and continued to 0203/223. Navigation during the OBS deployment was by Satellite Navigator and radar ranges and bearings on a radar transponder buoy moored over the top of the crestal mountain, Confederation Peak. To some extent the live trackplot makes radar plotting superfluous, but occasionally gaps of several hours occur between sat. fixes, rendering the live trackplot inaccurate. The radar plot also facilitates the identification of bad sat. fixes, some of which do not appear to be correlated either with high/low elevation or manoeuvring during the course of the fix.

The OBS were deployed in an array stretching some 25 km east-west and half that distance north-south. At the eastern end of the array OBS II lay close to the axis of the median valley. At the opposite end OBS V was on the far slope of Confederation Peak. Most of the difficulties during deployment were the result of pinger problems. The first attempt to launch OBS III was abandonned when its pinger failed to switch on. When the instrument sphere was reopened the pinger restarted and the intermittent fault could not be found. Eventually it was decided to risk launching the instrument without a working pinger. The pingers of OBS IV and V operated but were too feeble to be much use for tracking. Only OBS I and II had strong pingers. The radar transponder could be detected out to a range of about 7.5 n.m., so that all the OBS with the exception of OBS II were laid within radar range.

All the OBS were equipped with "magnetic jelly bottles" which allow the orientation of the horizontal components of the seismometers

to be determined. These were built by the Cambridge group and attached to the OBS just before launching. Each consisted of a cylindrical aluminium alloy pressure case housing a jelly bottle insulated with expanded polystyrene. A magnet was suspended by a thread inside the jelly. The thermal time constant of the arrangement is such that the jelly does not set until after the instrument has landed on the bottom.

The explosive and airgun shots were confined to the day after deployment and the day before recovery, leaving four uninterrupted days in between, with the ship operating away from the ridge in the King's Trough area, during which the OBS might record earthquakes. The 1000 cubic inch chamber was used for all the airgun shots. The direct water waves from the airgun shots will enable the relative positioning of the OBS to be improved.

The OBS were recovered between 0710/229 and 1118/230. Four were recovered successfully, but OBS II remained on the bottom. Its pinger switched on at the appropriate time and since the relay operating this is in parallel with the explosive bolt, the possible causes of failure are (in order of decreasing probability) as follows:

1. Break in continuity of circuit to detonator or dual detonator,
2. instrument jammed on bottom,
3. floatation sphere flooded.

This was the first loss in 18 launches in the deep ocean. The OBS II pinger was still going strongly when we passed over it the following day.

The remaining OBS were recovered without difficulty. The explosive bolts of OBS III, IV and V were heard on the Precision Echo Sounder; that of OBS I could not be heard because the last airgun shot was fired simultaneously. No bolt was heard to fire with OBS II, but this is not conclusive as the ship was still at that time approaching the position from some distance away.

Since they do not carry stray lines (a source of seismic noise) the OBS were hooked onto the after crane and a pair of steadying lines attached by two wet-suited swimmers. This enabled them to be brought inboard without thumping the ship's side. The rubber dinghy was launched to support the swimmers and tow the OBS to the vicinity

of the crane. The time required for this operation progressively decreased and for the final recovery the dinghy was in the water for only 13 minutes.

The OBS were opened up on return to the shore laboratory. It was found that the tape of OBS V had not run, but that all shots, even some from King's Trough, had been recorded on the other three instruments.

T.J.G.F.

(8) Explosion Seismology at the Ridge Crest using OBS and Sonobuoys (Fig. 3)

The objective of this Cambridge experiment was to obtain seismograms from OBS laid west of the median valley at 45°N from shots fired east of the valley at moderate ranges in order to study the attenuation of P and S waves propagated in the crust and upper mantle as they cross the region of the postulated magma chamber. Four sonobuoys were to be deployed on two occasions at the ends of the shot lines to supply necessary crustal structure information.

In the event, the sonobuoys were laid four times: two for trial on August 5th (217), four in the median valley at the northern end of line D on August 11th (223) for lines D and E, three at the eastern end of line F on August 15th (227) and two in King's Trough on August 19th (231). Two good records were obtained from the test line but only two on lines D and E and only one good and one less good from both lines F and the line in King's Trough. Failures are attributed to water seeping into the hydrophones through potting araldite that had not hardened completely.

Two tons of explosive were fired in 35 charges during lines D, E and F. Line D, inadvertently far from straight, extended along the axis of the median valley to a position 40 nautical miles SSW of the sonobuoys and line E ran 40 miles from SSE to NNW, diagonally across the valley, ending near the sonobuoys. Line F extended 70 miles from ESE to WNW from a shot ten miles east of the sonobuoys to one fired over the crestal mountains west of the median valley among the OBS. The pattern of shots was designed primarily for the OBS from which no records are yet available but the failure of OBS II to pop-up means that we shall not be able to determine the structure under the median valley. (It was found subsequently that OBS V had failed to record so that the resultant data is from three OBS only). D.H.M.

(9) Seismic reflection profiling

(a) Scientific results

During leg 1, 24½ days of profiling was carried out, all at approximately 7 kts, and covering a distance of 3900'. Of this, 1100' were recorded in the 45°N survey area and 770' in the Kurchatov Fracture Zone area. In leg 2, 640' of profiling were achieved in just under 4 days.

The profiling began with a run across the continental margin at Goban Spur, using the 160 cubic inch gun with a wave-shaper kit. This was the first time a WSK had been used successfully. However, only one of the two kits available would work; the other had a slightly different design and the gun would not seal when it was fitted. When flat sediments were reached beyond the continental rise, the system performance with and without WSK was compared. EPC records and a jet-pen display of the first (sea-bed) reflection were examined. It was found that the relative amplitude of the bubble-pulse oscillations fell off faster with the WSK, as expected. However, the absolute amplitude of the first pulse was also reduced by about 60%. The WSK therefore appears to be effective, but its use may be undesirable in areas where the energy available for penetration or discrimination of signal from noise is already limiting the system performance.

At 0925 on day 189 we changed to the 40 cubic inch chamber, which was used for the remainder of the cruise. Based on experiments as we approached the MAR we chose to display data on the EPC band-pass filtered between 60 and 100 Hz and printing only the negative side of the signal. This gave an excellent display for the two detailed survey areas on the MAR, and proved quite capable of penetrating sediment thicknesses of more than 600 msec. (Data continued to be recorded unfiltered on tape).

The surveys at 45°N and at the Kurchatov Fracture Zone are described separately in this cruise report. In addition to those areas and the passage tracks, most of the profiling (about 430') was over King's Trough, for tectonic studies and to assist the interpretation of the refraction lines shot there. The weather was excellent, and we obtained some of our best records ever of King's Trough.

One profile was run parallel to and west of the MAR to assist in

interpreting one of the joint IOS/IPG refraction lines.

The passage tracks also provided excellent profile data, though we had no time to profile on the return passage to U.K. The outward track gives an almost continuous profile from Goban Spur to the Mid-Atlantic Ridge, and the passages to and from the Cruise 68 area provided two good, E-W profiles of the region between the Azores and King's Trough.

(b) Equipment

The no. 1 Williams and James compressor again gave a great deal of trouble, but it is a tribute to the compressor mechanics that the amount of profiling time lost as a result was negligible.

A single Bolt PAR airgun with 40 or 160 cu. in. chamber was used as a sound source. Airguns were recovered for preventive maintenance at least every 4 days, a spare being kept ready for immediate use. This meant that very little time was lost due to gun failures.

A Géomechanique hydrophone array was used, the signal being the summed output of two 50 m active sections. The spring section, damaged on a previous cruise, had not yet been replaced and its absence was thought to be contributing to a noisy record. Towing the array from loops of elastic did not noticeably reduce the noise.

The recording system gave considerable trouble, especially on the second leg. At one stage the EPC broke down due to a failed resistor in the 28V power supply. This was located and repaired after $2\frac{1}{2}$ hours. The Bell & Howell CPR 4010 tape recorder gave continual problems. Tape was not spooling properly, and was becoming badly wrinkled along one edge, making replay difficult. During leg 2, the tapes recorded on this machine became excessively noisy and were impossible to replay. Most of the tape recording for leg 2 was eventually done on a Racal recorder borrowed from the GLORIA team. This worked quite satisfactorily.

R.C.S.

(10) Velocimeter Stations

Three velocimeter stations (table II) were conducted during leg 2 to obtain data to aid in GLORIA and seismic refraction interpretation. Station 8888 was 50' west of the MAR median valley near 43°N; 8891 was in King's Trough; and 8893 was in the median valley southeast of Confederation Peak.

All three stations reached a maximum depth of 2000 m (the maximum operating depth of the Plessey velocimeter). They all revealed a steep fall to a local velocity minimum near 150 m, with the absolute minimum being reached between 1200 and 1400 m. However, the King's Trough profile was considerably more complicated than the other two, having four velocity minima at 300, 800, 1200 and 1400 m. The velocities at station 8893 were about 6 m s^{-1} lower than for the other stations between 500 and 1000 m. All three profiles converged below 1500 m.

R.C.S.

(11) Passage data

Throughout the cruise, bathymetric and magnetic data were continuously collected.

On Leg 1, seismic reflection profiles were obtained of the crossing of the continental margin on Goban Spur, and continuously to the 45°N area of the Mid-Atlantic Ridge. Apart from a short respite during the median valley run at 45°N, profiling was continued throughout leg 1 until completion of the survey of the eastern extension of the Kurchatov Fracture Zone. On leg 2 seismic profiling was limited to the survey of the western extension of the Kurchatov Fracture Zone, King's Trough and its extension westward and to profiles along seismic refraction stations.

GLORIA sonographs were obtained on passage to the Mid-Atlantic Ridge after launch, from the 45°N survey area to the Kurchatov Fracture Zone parallel to and looking towards the ridge axis, in the vicinity of the Azores triple junction and on tracks north of the Azores prior to recovery.

A.S.L.

(12) Data Collection and Editing

Navigation, bathymetric and magnetic data were collected and edited on board using the shipboard IBM 1800 computer and the MPX operating system. The editing procedure involved generation of navigation plots, bathymetric lists and magnetic profiles every 24 hours and their systematic analysis for errors.

Navigation was assessed by inspecting plots of corrected data for spurious values of speeds and courses usually in the form of spikes, and by comparing a running plot kept by the bridge with daily

computed plots of the ship's track and satellite fixes at a scale of 1 in 1 x 10^6. The computer automatically rejected fixes which gave rise to apparent currents between fixes of greater than 2 kts. Other satellite fixes were manually rejected because of bad elevation or coincidence with a ship's course change. Whenever a fix was manually rejected or accepted, an off-line program was run to update the course corrections and recompute regional magnetic field and Matthews area corrections.

The stored total magnetic field values were plotted on the Visual Display Unit and compared with the magnetometer record for differences. In this way errors, usually in the form of data spikes, were detected and corrected.

The P.E.S. record was removed from the Mufax recorder daily and checked for mistakes. The record was then compared with a list of depths logged in the CDAT file. Any corrections were re-entered via the P.E.S. input console and written into the CDAT file during the next course correction update.

Large scale charts of ship's track, depth and magnetic anomaly were plotted for the detailed survey areas as well as 1 x 10^6 tracks, magnetic anomaly and bathymetry of the complete cruise.

Data report plotting routines could not be tested owing to hardware problems that can be solved during a future cruise. The data lost due to an operator accident during Leg 1 was digitized and entered on to disk in an abbreviated format.

P.R.M.

(13) Shipboard computer

The main function of the computer system throughout Cruise 73 was to provide an accurate record of the ship's track. This was achieved by a combination of satellite fixes and D.R. from the E.M. log and gyro.

The GLORIA surveys on Leg 1 needed good navigation (1) to enable the computation of anamorphosing ratios for the sonographs and (2) to enable the construction of sonograph mosaics.

Satellite fixes were examined daily and the low quality fixes were rejected. It was noticed that the current vectors generated by the course update program were consistently to starboard and abaft the beam. This implied a bad calibration of the E.M. log and after

an analysis of the vectors the calibration constants were changed.

The computer was also used to pulse and log the magnetometer, to log bathymetry and meteorological data, and to generate processed data. Peripherals used included the Visual Display Unit for live track plots and profile plots and the drum plotter for the daily production of track plots on a range of scales. Track charts and charts with magnetic anomalies and bathymetry were made daily at 1:1,000,000. In the survey areas the scale was changed to 1:200,000 and at times 2"/n.m.

The equipment performed adequately for most of the cruise. The following is a summary of detected faults:

(a) When the external clock was not available for reference the internal clock lost six minutes in ten hours.

(b) At the start of Leg 2 the satellite navigation system only used the low frequency channel for producing fixes. This was traced to a faulty connection on one of the circuit boards. During the seismic refraction surveys the ship's A.C. power supply failed although the routine sampling was stopped for a few minutes each time an explosive charge greater than 100 lbs was fired and the discs were turned off for protection. For several hours afterwards bad fixes were obtained and the internal batteries of the satellite receiver were suspected of not maintaining the correct ambient temperature in the receiver.

(c) The air-conditioning failed on two occasions due to pump motor failures, allowing the temperature to rise appreciably in the computer room. One of the computer room units was replaced.

(d) The plotting office VDU developed a fault and was replaced by the spare.

A number of improvements to the software were suggested. The main areas were (1) plotting routines, both profile and track, and (2) satellite navigation.

C.H.

(14) Meteorological observations

Meteorological observations were logged automatically by the computer and manual checks were made each day at dusk from the following instruments:

(1) Bridge screen thermometers (port and stb'd)

(2) Bridge barometer

(3) M.O. sea temperature (R.A.S.T.U.S.)

(4) M.O. anemometer (relative wind)

(5) Ship's speed and course.

These readings and the corresponding data produced by the computer were recorded in a meteorological log to provide a running comparison.

Throughout both legs of the cruise, all the scientific instruments functioned well, requiring only general servicing. Data were obtained throughout the cruise.

On analysis, the comparison series showed a good correlation, showing that the readings obtained from all the instruments were of good quality. The analysis revealed that only 5% of the readings differed by more than half a unit of measurement, and these errors were mostly attributed to interfering radio transmission affecting the bridge barometer, the wheelhouse-top thermometer and possibly the solarimeter. Some differences of 1-2° between the R.A.S.T.U.S. sea temperature and the computer logged temperature occurred which could not be explained.

R.G.R.

(15) Navigation

The prime navigation aid throughout the cruise was the transit satellite. Nearly all predicted transits within the elevation range of 10 to 70° were used although there were some that failed to give a satisfactory fix on account of inadequate dopplers or because of course and speed changes during transit. Fixes giving currents exceeding 2 kts were automatically rejected, and those which, for a variety of other reasons were considered inaccurate, were rejected manually. The two component E.M. log and the gyro compass provided dead reckoning data between fixes from which currents and course corrected positions between fixes were obtained.

On day 192, the calibration factors used in the computer for the two components of the E.M. log were altered following an analysis of the apparent currents on repeated reciprocal tracks in the 45°N area.

To aid the operations of laying and recovering the OBS, dan buoys carrying radar transponders were laid in a depth of 600 fathoms using 4 mm wire. The poor ranges (less than 10 miles) were partly

attributed to an alteration of the geometry of the transponder and passive reflector, and partly to the humid weather conditions.

A.S.L.

TABLE I

DAN BUOY POSITIONS

D/B	Laid	Recovered	Lat.N	Long.W	Remarks
1	0613/221	0100/224	45°23.2'	28°09.9'	Radar transponder
2	0119/229	1213/230	45°23.5'	28°08.5'	Radar transponder

TABLE II STATION LIST

Stn. No.	Type	Equipment used	Date	Time(Z)/Day No. From	To	Lat. N Long.W	to	Lat. N Long.W	Comments
8887	S.Refr.	PUBS (2)	5- 8 Aug	0515/217	1654/220	43°18' 29°19'		43°16' 30°34'	Joint Anglo-French project. Shots fired on three lines by 'Ptolemée'. PUBS A lost.
8888	V	V	5 Aug	1942/217	2106/217	42°47' 30°29'		- -	To 2000 m.
8889	S.Refr. and E.	OBS (5) SB (4) AG1000	9-18 Aug	0824/221	1213/230	45°20' 28°00' (approx)		- -	(a) 9 days micro-earthquake observations. (b) 2 seismic refraction lines (D,E) along and across median valley using airgun and explosives. Various shots within 30' radius. OBS 2 lost.
8890	S.Refr.	PUBS (2)	12-14 Aug	2250/224	0122/226	44°09' 23°01'		43°50' 22°08'	Axis of King's Trough. Explosives and airgun. Shots recorded from one direction only.
8891	V	V	12-13 Aug	2328/224	0038/225	44°08' 23°01'		- -	To 2000 m in King's Trough.
8892	S.Refr.	OBS (5) SB (3) AG1000	15-16 Aug	2216/227	1820/228	45°04' 26°32'		45°24' 28°11'	Line perpendicular to median valley using explosives and airgun.
8893	V	V	17 Aug	1448/229	1606/229	45°15' 27°58'		- -	To 2000 m in median valley.

Stn. No.	Type	Equipment used	Date	Time(Z)/Day No. From	To	Lat. N Long.W	to	Lat. N Long.W	Comments
8894	S.Refr.	PUBS (2) AG1000	19-20 Aug	1150/231	1057/232	44°09' 22°54'		43°48' 22°02'	Reversal of station 8890.
8895	S.Refr.	PUBS (2) AG1000	21 Aug	0048/233	1710/233	43°49' 23°21'		43°41' 22°46'	South margin of King's Trough.

V = Velocimeter

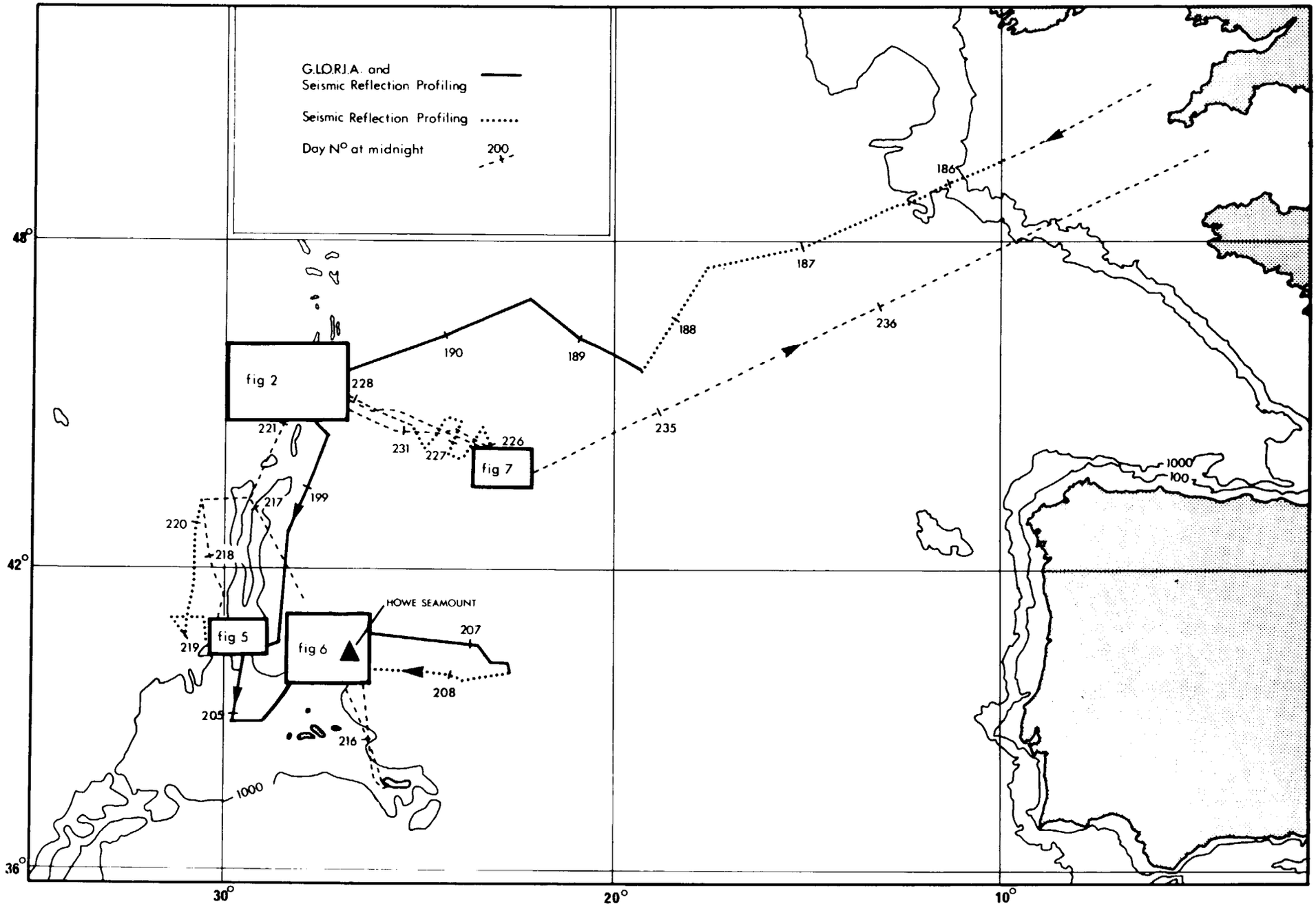
S.Refr. = Seismic Refraction line

E = Earthquake observations

PUBS = Pop-Up Bottom Seismic Recorder

OBS = Ocean Bottom Seismograph

AG1000 = 1000 cu. in. airgun


G.LO.R.I.A. and
Seismic Reflection Profiling
Seismic Reflection Profiling
Day N° at midnight
200
48°
42°
36°
30°
20°
10°
fig 2
fig 5
fig 6
fig 7
HOWE SEAMOUNT
186
187
188
189
190
199
205
207
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216
217
218
219
220
221
226
227
228
231
235
236
1000
100

FIG 1

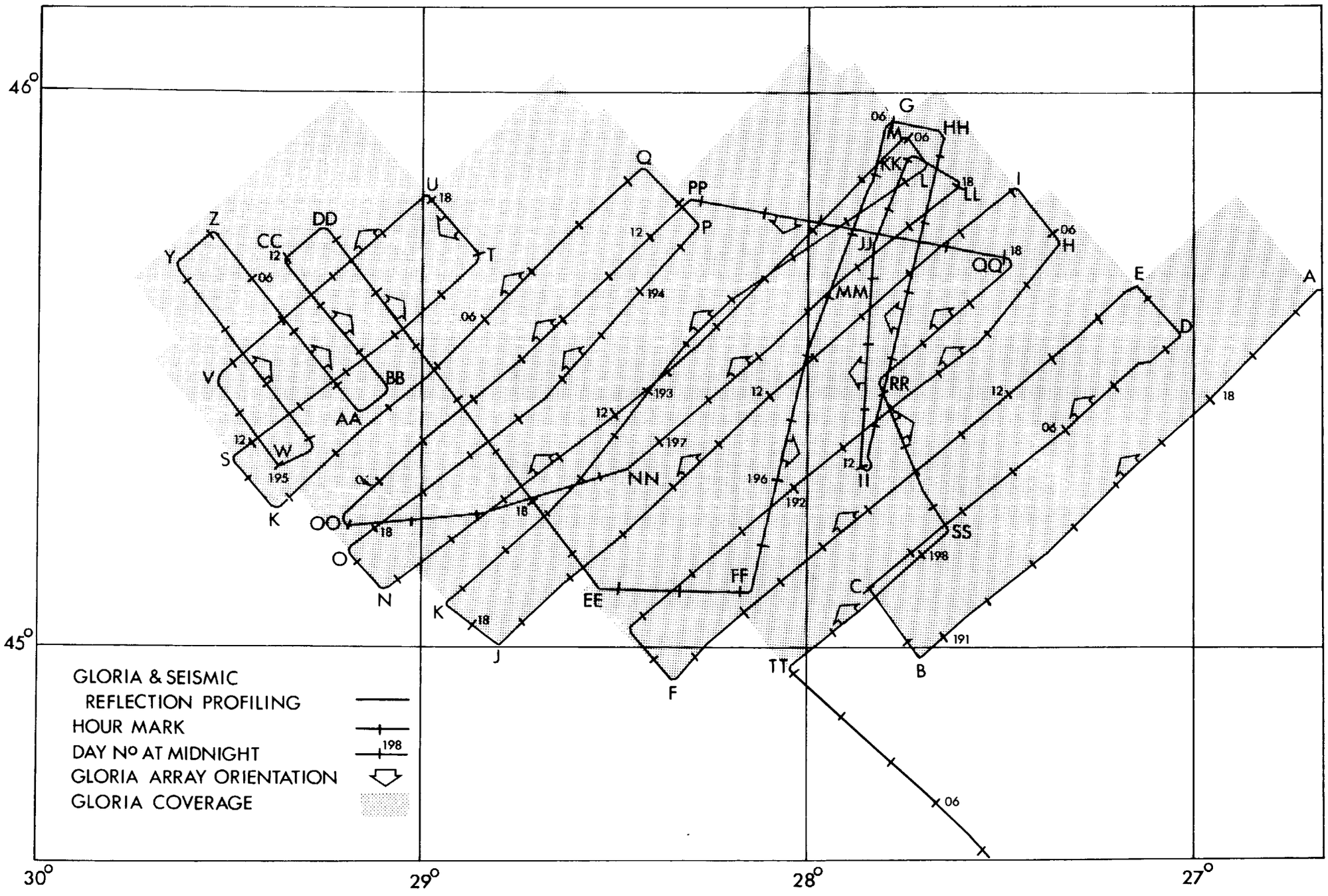
46°
45°
30°
29°
28°
27°
GLORIA & SEISMIC
REFLECTION PROFILING
HOUR MARK
DAY Nº AT MIDNIGHT
198
GLORIA ARRAY ORIENTATION
GLORIA COVERAGE

FIG 2

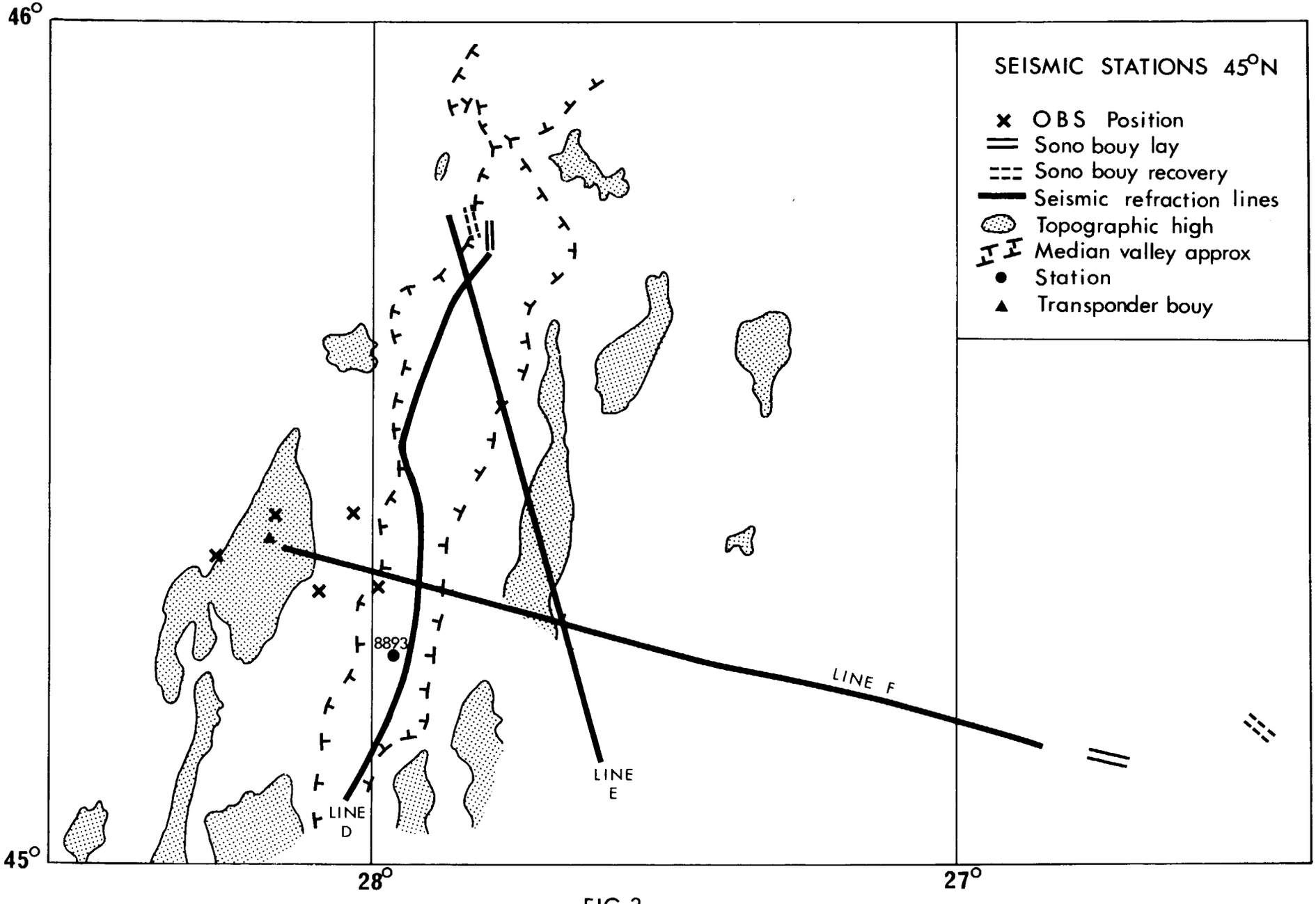
46°
45°
28°
27°
SEISMIC STATIONS 45°N
OBS Position
Sono bouy lay
Sono bouy recovery
Seismic refraction lines
Topographic high
Median valley approx
Station
Transponder bouy
8893
LINE F
LINE E
LINE D

FIG 3

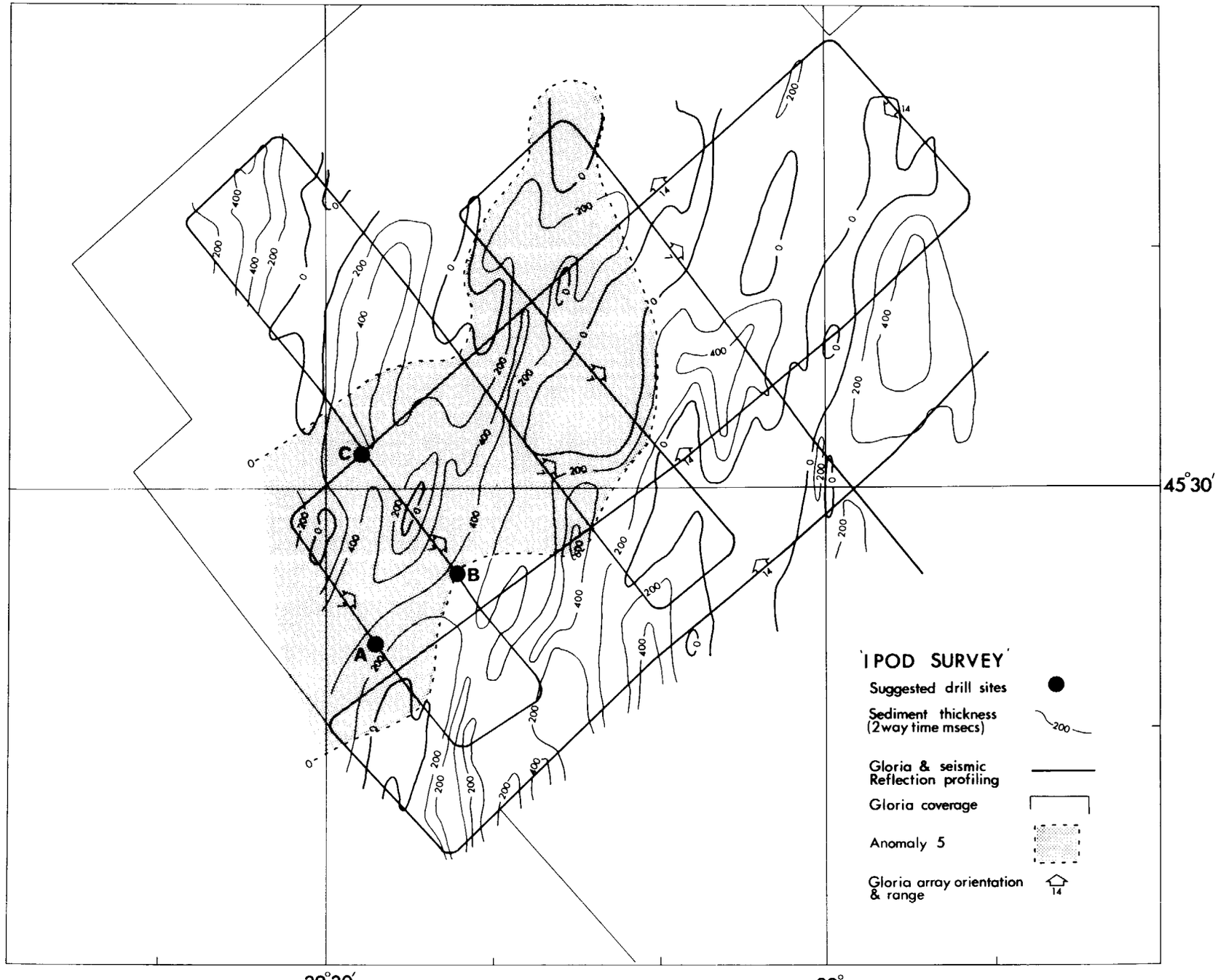
45°30′
29°30′
29°
A
B
C
'IPOD SURVEY'
Suggested drill sites
Sediment thickness (2way time msecs)
Gloria & seismic Reflection profiling
Gloria coverage
Anomaly 5
Gloria array orientation & range
14

FIG 4

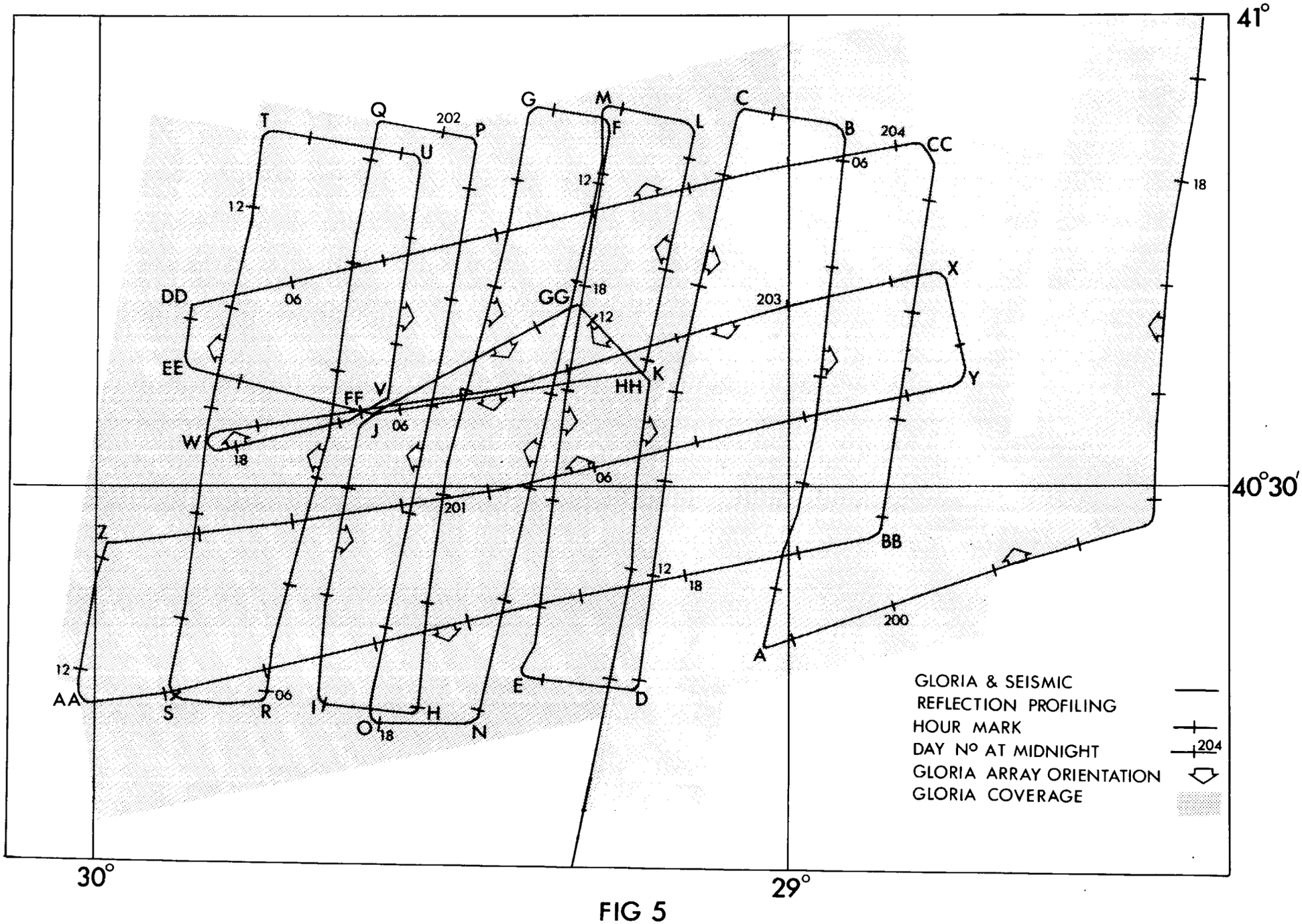
41°
40°30′
30°
29°
T
Q
202
P
U
G
M
F
L
C
B
204
CC
06
12
18
DD
06
GG
18
12
X
203
EE
FF
V
HH
K
Y
W
18
J
06
06
201
Z
BB
12
18
200
12
AA
S
12
R
06
I
H
O
18
N
E
D
A
GLORIA & SEISMIC
REFLECTION PROFILING
HOUR MARK
DAY Nº AT MIDNIGHT
204
GLORIA ARRAY ORIENTATION
GLORIA COVERAGE

FIG 5

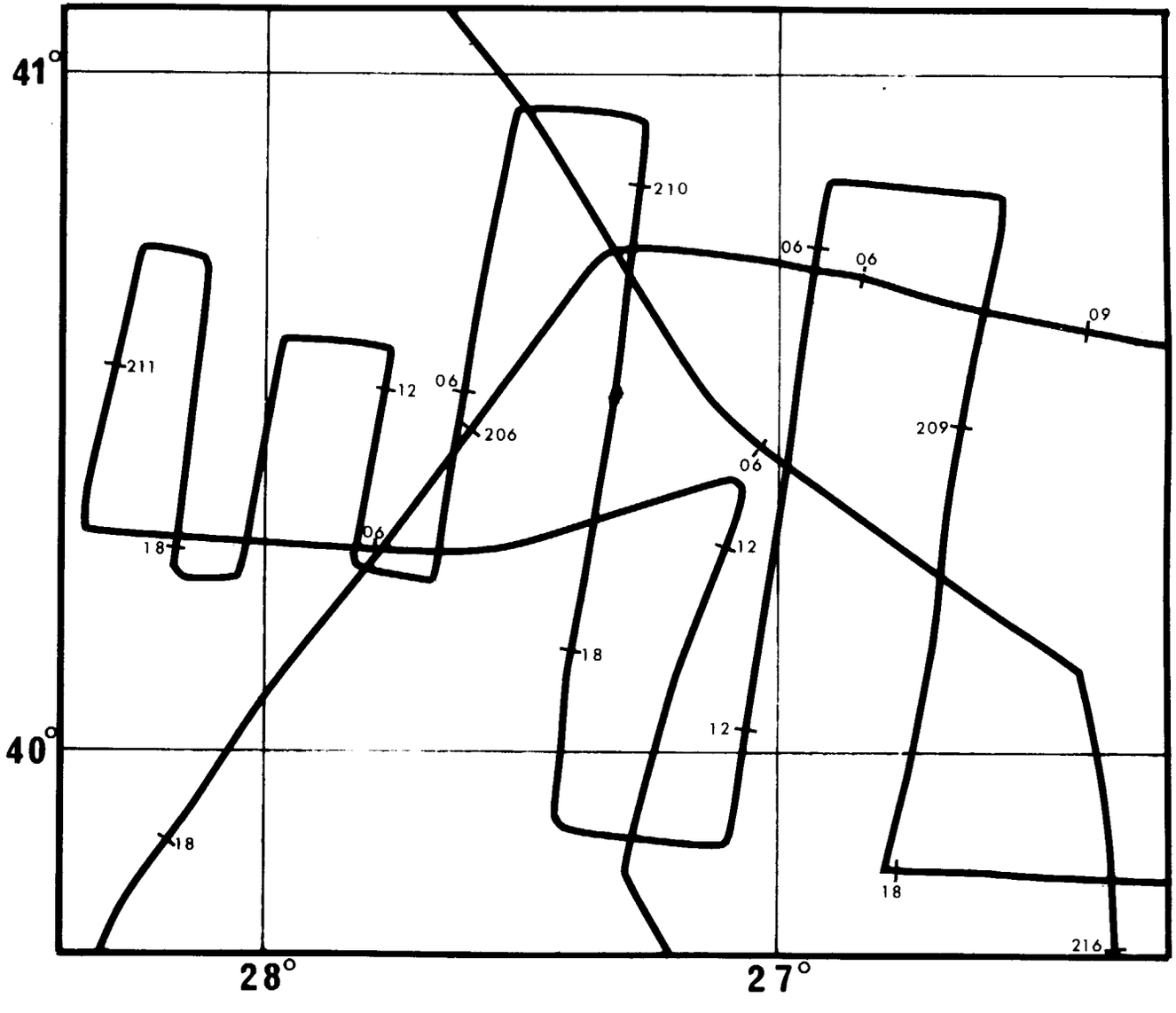

FIG 6

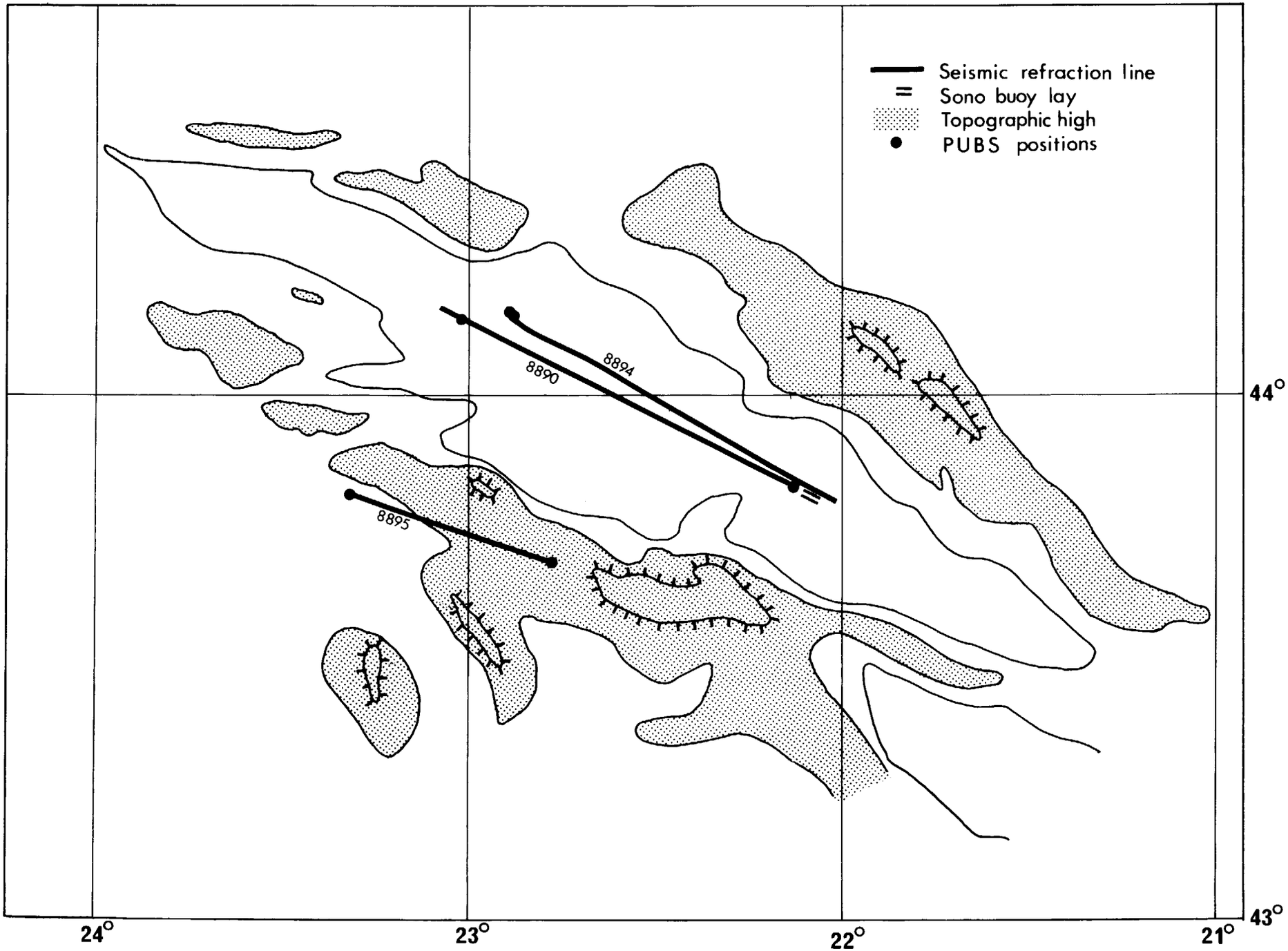
Seismic refraction line
Sono buoy lay
Topographic high
PUBS positions
8894
8890
8895
44°
43°
24°
23°
22°
21°

FIG 7

CRUISE REPORTS

CRUISE No. and/or DATE,	REPORT No.
R.R.S.	"DISCOVERY"
1 (International)	Published and
2 (Indian Ocean)	distributed by the
3 (Expedition)	Royal Society
	NIO CR[1]
4 February – March 1965	4
37 November – December 1970	37
38 January – April 1971	41
39 April – June 1971	40
40 June – July 1971	48
41 August – September 1971	45
42 September 1971	49
43 October – November 1971	47
44 December 1971	46
45 February – April 1972	50
46 April – May 1972	55
47 June – July 1972	52
48 July – August 1972	53
49 August – October 1972	57
50 October 1972	56
51 November – December 1972	54
52 February – March 1973	59
53 April – June 1973	58
	IOS CR[2]
54 June – August 1973	2
55 September – October 1973	5
56 October – November 1973	4
57 November – December 1973	6
58 December 1973	4
59 February 1974	14
60 February – March 1974	8
61 March – May 1974	10
62 May – June 1974	11
63 June – July 1974	12
64 July – August 1974	13
65 August 1974	17
66 August – September 1974	20
68 November – December 1974	16
74 September 1975	33

[1]NIO CR — National Institute of Oceanography, Cruise Report.

[2]IOS CR — Institute of Oceanographic Sciences, Cruise Report.

CRUISE REPORTS

CRUISE No. and/or DATE	REPORT No
R.R.S. "CHALLENGER"	
August – September 1974	IOS CR 22
R.V. "EDWARD FORBES"	
October 1974	IOS CR 15*
January – February 1975	IOS CR 19
May – June 1975	IOS CR 28
July 1975	IOS CR 31
R.R.S. "JOHN MURRAY"	
April – May 1972	NIO CR 51
September 1973	IOS CR 7
March – April 1974	IOS CR 9
October – November & December 1974	IOS CR 21
N.C. "MARCEL BAYARD"	
February – April 1971	NIO CR 44
M.V. "RESEARCHER"	
August – September 1972	NIO CR 60
R.V. "SARSIA"	
May – June 1975	IOS CR 30
R.R.S. "SHACKLETON"	
August – September 1973	IOS CR 3
January – February 1975	IOS CR 18
March – May 1975	IOS CR 24
February – March 1975	IOS CR 29
M.V. "SURVEYOR"	
February – April 1971	NIO CR 38
June 1971	NIO CR 39*
August 1971	NIO CR 42*
D.E. "VICKERS VOYAGER" and "PISCES III"	
June – July 1973	IOS CR 1

*Not distributed