DR. M. T. JONES.

I.O.S.

R R S DISCOVERY

CRUISE 118

11 FEBRUARY - 30 MARCH 1981

GEOPHYSICS AND SEDIMENT SAMPLING IN THE NORTH EAST ATLANTIC

CRUISE REPORT NO 117

1981

NATURAL ENVIRONMENT RESEARCH COUNCIL

INSTITUTE OF OCEANOGRAPHIC SCIENCES

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Wormley, Godalming,
Surrey, GU8 5UB.
(0428 - 79 - 4141)

(Director: Dr. A.S. Laughton)

Bidston Observatory,
Birkenhead,
Merseyside, L43 7RA.
(051 - 653 - 8633)

(Assistant Director: Dr. D.E. Cartwright)

Crossway,
Taunton,
Somerset, TA1 2DW.
(0823 - 86211)

(Assistant Director: M.J. Tucker)

R.R.S. DISCOVERY
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Institute of Oceanographic Sciences,
Brook Road,
Wormley,
Godalming, Surrey, GU8 5UB
U.K.

CONTENTS

DATES

Leg 1	Departed Gibraltar 16th February 1981	Day 047
	Arrived Funchal, Madeira 10th March 1981	Day 069
Leg 2	Departed Funchal 13th March 1981	Day 072
	Arrived Gibraltar 30th March 1981	Day 089

SCIENTIFIC PERSONNEL

		Leg 1	Leg 2
T.J.G. Francis Principal Scientist	IOS Wormley	X	X
R.J. Babb	IOS Wormley	X	X
D.G. Bishop	IOS Wormley	X	X
E. Darlington	IOS Wormley	X	
D.E. Gunn	IOS Wormley	X	X
Q.J. Huggett	IOS Wormley	X	X
C.L. Jacobs	IOS Wormley	X	X
Ms. D. Jones	RVS Barry	X	X
R.B. Kidd	IOS Wormley	X	X
R.E. Kirk	IOS Wormley	X	X
B.G. Knowles	IOS Wormley	X	X
R.C. Lilwall	IOS Blacknest	X	
P. Mason	RVS Barry	X	X
S. McGiveron	IOS Wormley	X	X
M.J. Noel	IOS Wormley	X	X
R.D. Peters	IOS Wormley	X	X
R.C. Searle	IOS Wormley	X	X
P.J. Schultheiss	IOS Wormley	X	X
C.A. Tew	IOS Blacknest	X	X
P.P.E. Weaver	IOS Wormley	X	X
R.B. Whitmarsh	IOS Wormley	X	X
J. Garcia-Rodriguez	Spanish Observer		X
H. Jebli	Moroccan Observer		X

SHIP'S OFFICERS AND PETTY OFFICERS

	Leg 1	Leg 2
Master	P.H. Maw	P. McDermott
Chief Officer	P. McDermott	K.O. Avery
Second Officer	T. Morse	T. Morse
Third Officer	A. Barton	A. Barton
Chief Engineer	M. Barber	D.C. Rowlands
Second Engineer	G.M. Batten	G.M. Batten
Third Engineer	H.J.C. Peck	A. Grattidge
Fourth Engineer	B. Entwhistle	P. March
Fifth Engineer	G. Kimber	T. Comley
Fifth Engineer	T. Comley	K. Sullivan
Electrical Officer	P. Sharpe	P. Parker
Radio Officer	S. Thomson	S. Thomson
Purser/Catering Officer	R.M. Cridland	P. Higginbottom
Bosun	F. Williams	F. Williams
Carpenter	L. Cromwell	L. Cromwell

CRUISE OBJECTIVES

The primary objective of the cruise was to make geological and geophysical studies of the ocean floor over a wide range of sedimentary environments, plate ages and geographic latitudes - part of the feasibility studies into the ocean disposal of high-level radioactive waste commissioned by the Department of the Environment. To this end the bulk of the work carried out was aimed at understanding the processes affecting the sediments. The work was concentrated in four study areas: Great Meteor East and West, Cape Verde One and King's Trough Flank. Detailed objectives were as follows:

(1) Gravity (6.4 cm diameter) and Kastenlot (15 cm square box) coring for stratigraphic and geotechnical study.

(2) Temperature/Thermal Conductivity measurements in the top 5m of sediment by the "pogo-stick" method in order to observe lateral variability of heat flow and the extent of non-linear temperature gradients.

(3) Bottom photography with a new survey camera system to observe sedimentary features, glacial erratic distribution and extent of biological activity.

(4) Testing of a new High-Resolution Near-Bottom Profiler on the CTD wire, operating in the frequency band 5-10 kHz.

(5) Dredging for glacial erratic material with the IOS Epibenthic Sledge.

(6) Small Scale Seismic Experiment with PUBS and OBS designed to test a number of explosive and non-explosive bottom sources. If successful the experiment would throw light on the in-situ properties of the unlithified sedimentary layer.

(7) OBS observations along the line of the Oceanographer Fracture Zone to determine whether the low level of intraplate seismicity within the ocean basins is associated with such features.

(8) Underway geophysical observations including precision echo-sounding (10 kHz), magnetics, gravity, single-channel SRP with airgun and 2 kHz high-resolution profiling.

In addition to the above objectives a further purely scientific objective was included in the cruise - obtaining a series of acoustically-navigated cores in the vicinity of Theta Gap off N.W. Spain. However, bad weather and an engine-room problem on the second leg of the cruise prevented us from achieving this last objective.

NARRATIVE

LEG 1

Discovery sailed from Gibraltar at 1215/16 February (Day 047) and headed out into the Atlantic. At 1540/047 scientific watchkeeping began, initially operating only the PES (echo-sounder) and gravimeter. The track chart of Leg 1 is shown in Figure 1.

At 0900/048 we hove to and for the next couple of hours took advantage of the fair weather to conduct handling trials of the new Heat Flow Probe. At 1140 the ship got underway and the 2 kHz hydrophone array and magnetometer fish were streamed. Minor problems were encountered with both instruments, but by 1245 the 2 kHz system was functioning correctly and speed was increased to 10 kt. We proceeded at this speed to our first station at the northern end of the Madeira Abyssal Plain. The magnetometer problem was not finally solved until about 1730.

At 0700/050 we slowed to recover the 2 kHz streamer and the magnetometer and by 0740 we were hove to for a series of stations (Table 1). The first station (10295) was to take a gravity core using a 1000 lb MSES gravity corer. Everything proceeded smoothly until, some 200m before the corer was back at the ship, the wire went slack. On retrieving what was left it was apparent that the corer had been lost due to failure of a Talurit swaged eye in the strop between the trigger and the corer. The trigger itself was recovered but the trigger weight lost.

After this inauspicious start we continued with the Heat Flow Probe (station 10296) - our first attempt to deploy this particular instrument, built by Applied Microsystems Ltd. in Canada, in deep water. The probe was lowered to a maximum of 5787 m of wire out in 5542 m water depth but because of the wire angle did not penetrate the bottom. No pinger echo from the sea bed could be detected and it was decided to recover the instrument rather than proceed "blind". The station was concluded at 1635/050.

Before commencing the next station, no. 10297 with the Benthic Dredge, the ship moved some 7 miles WNW. The station began at 1807 with the ship heading 090^{o} at 1.5 kt. The aim was to land the dredge in a 3 n.m. wide patch of abyssal plain which we had identified during our move WNW. A total of 7709m of wire was paid out but we failed to get the dredge on the bottom and keep it there. Our mistake was probably to keep the wind (NE, force 4 throughout) too much on the beam, so that the ship never slowed down ($\leq$ 1 kt) enough to get the steep wire angle necessary to dredge in 5542 m depth.

Three stations had now been conducted without success. It fell to the next, station 10298 with the Kastenlot Corer, to break this spell of misfortune. 2.2 m of nannofossil ooze were recovered from the abyssal plain in a depth of 5547 m. Two pingers were used to control operations at this station. One, directly attached to the corer head pointed upwards; the other, 100 m up the wire pointed downwards. This system successfully indicated bottom penetration without the need of a bottom echo, though the latter was in fact observed. The corer, fitted with a 2 m barrel and 5 weights, was lowered into the bottom at 0.5 m/s. The same configuration was used for all Kastenlot Core Stations on the cruise.

As soon as the Kastenlot Corer was stowed, the next station no. 10299, followed with the Survey Camera. This station was successfully completed at 1330/051. At 1355 we got underway, streamed the SRP (seismic reflection profiling) array, magnetometer and a 160 in^3 airgun, and headed southwest towards the next station. By 1600 all instruments were operating and at 1610 speed was increased to 8 kt. An hour later the hydrophone array failed, the ship was slowed and the array and airgun recovered. The 2 kHz streamer was deployed in place of the SRP one and we continued at 10 kt toward the next station. It was apparent that the failure of the SRP array was because its tow cable had been twisted until conductors broke. The twisting was the result of the swivel in the tail rope section seizing up. No damage was incurred by the hydrophone sections themselves. Because no spare towing cable was available on board, this failure put an end to SRP on leg 1.

At 1403/052 we reached our next station position on the Madeira Abyssal Plain. After running over the position we turned onto a reciprocal course, slowed down and recovered the gear. By 1503 we were hove to on station. The next four hours were spent in sorting out the explosives in preparation for the Bottom Seismic Experiment planned for day 054. A Kastenlot Core Station (no. 10300) followed, but was unsuccessful because of premature closure of the core catcher doors. This in turn was probably caused by a too-abrupt stoppage of the winch whilst the corer was being lowered. Following the core station the ship moved some 10 n.m. NW before commencing station 10301, Heat Flow Probe. By this station the probe had been modified to hold a standard IOS pinger in its head. Eleven penetrations of the bottom were obtained, but penetration was only about 2 m of its 5 m length due to lack of weight. The Heat Flow station was concluded at 0746/053. The ship then moved back over the small hill to repeat the Kastenlot core. This was partially successful, only 0.5 m of sediment being recovered because the core catcher doors failed to close. The Kastenlot station was completed at 1218/053. For the next three hours the ship remained hove to while the shot-firing team practised the rigging of bottom charges in preparation for the morrow's experiment. No explosives were actually used in this dry run. At 1553 the ship got underway and we proceeded to the next station.

At 0343/054 the ship was hove to over the Madeira Abyssal Plain and the Bottom Source Experiment began. Two PUBS and an OBS were launched at 0353, 0753 and 0551 respectively in a tight group, little more than a kilometre across. Two types of explosive bottom source and two types of projectile were dropped in the vicinity of the bottom receivers during the course of the day. Accurate navigation of the ship was achieved by sound-ranging onto the acoustic transponders of the two PUBS. Details of the experiment and of the sources are given in the project reports entitled "Bottom Source Experiments" and "Shot Firing". Rigging of the explosive charges turned out to be very tedious. Because of this only four "Spade" charges and one Aquaflex charge could be rigged in the time available. Deployment of the projectiles was much easier, the ten one-ton weights being dropped between 1930 and 2149 and the six 120-kg projectiles between 2226 and 2334. On completion of the experiment at 0130/055, the PUBS and OBS were left on the bottom to detect possible seismic events until their recovery later in the cruise.

Passage from station 10303 was conducted at 10 kt with magnetometer and 2 kHz array streamed. At 1505/055 the ship hove to on station 10304 to deploy OBS 6A. The instrument was slipped at 1543, but not without receiving a couple of thumps against the ship's side during the launch. The ship remained hove to for a couple of hours to enable the next OBS to be rigged on the foredeck, then at 1740 proceeded west along the line of the Oceanographer Fracture Zone. During the night problems with the satellite navigator reduced the quality of the navigation. Nevertheless, at 0825/056 we had reached the next planned position for deploying an OBS. By this time, however, a southerly gale was blowing and the ship was moving too much to permit a safe launch. It was decided to abandon the original plan to deploy four OBS along the trend of the Oceanographer Fracture Zone and to head southwest to a point west of Cruiser Seamount. For most of the day the ship made only about 4 kt into headwinds of 30-40 kt. The weather made the 2 kHz streamer so noisy that it was recovered at about 0900.

By 1545/057 the ship was hove to west of Cruiser Seamount. The weather had moderated, but we waited half-an-hour before commencing the station to make sure the ship could hold position. Station 10305 made use of a Calvert core head modified to take an MSES core barrel, a neat piece of extempore engineering by Messrs. Peters and Knowles. This corer could not be triggered, but operated successfully as a simple gravity corer. As with the Kastenlot corer, a pinger attached directly to the core head was used to indicate penetration. A 1.57 m core was recovered.

After completion of the core station we remained hove to for a test dip of the prototype High Resolution Deep Profiler on the CTD wire. Unfortunately, problems were encountered with the hydraulic ring main which feeds the midships winch. At 2115/057, after an hour and three-quarters of frustation, the station, no. 10306, was abandoned without the instrument getting in the water.

The ship then proceeded south, passing over our next core site on the gentle slopes to the west of Great Meteor Seamount, at 0710/058. For the next two and a half hours tracks were run in the vicinity of this position until at 1020 we were hove to in position. Station 10307 followed, making use of the MSES/Calvert corer to recover 2.01 m of calcareous ooze.

Before the next station the remaining Aquaflex explosive was dumped. Station 10308 then began, using the Benthic Dredge in approximately 4100 m of water. After nearly seven hours in the water, in which a total of 7555 m of wire was paid out, the dredge was recovered with its top surfaces polished and the camera leads ripped out. Clearly, it had been upside down on the bottom for much of the time, although the pinger telemetry did not indicate this. Our reward for the seven-hour station was a tiny piece of pumice.

At 2120/058 station 10309 commenced with the Survey Camera and continued until 0137/059. The station was a failure because the flash units failed to operate, although they operated on deck both before and after the lowering.

The group of stations to the west of Great Meteor Seamount was concluded by station 10310 with the Kastenlot Corer. Only a very small amount of sediment was recovered, probably because the winch was stopped too soon. Nevertheless, when the corer was brought back to the surface a loop of the main warp was found to be snagged around the core head pinger. Station 10310 was completed at 0435/059 and by 0525 we were on our way south with the magnetometer fish and 2 kHz hydrophone streamed.

The passage south continued throughout day 059 in excellent weather. Partly because of this and partly because we were getting into an area of deeper water with clay sediments, the 2 kHz profiler produced some excellent records. At 0918/060 we arrived in the general area of the next station. The next six hours were spent running tracks to search for a suitable sediment pond in which to run the next batch of stations. The only previously available tracks in this area were the easternmost of Colette's NE-SW lines between Europe and South America. At 1506 we were hove to and commenced station 10311 with the MSES/Calvert corer. A fascinating Neapolitan slice of brown, yellow and green sediment was recovered.

The ship then moved north a little to an area of sedimented hills before beginning station 10312 with the Survey Camera. This proved to be a highly-successful station with good pinger telemetry, although the photographs obtained were uneventful. The Near-Bottom Echo Sounder, the telemeteredtrace of which is recorded with a magnification of 8x on the PES, gave an excellent record of the heave of the camera. The shipboard wave recorder was run during this station for comparison, this being the nearest we could get to obtaining a record of the heave at the top end of the wire.

On completion of the camera station the ship moved back over the plain and began a Heat Flow station at 0310/061. For this station, the probe had been modified by the addition of 500 lb of lead weights. Six penetrations were made but on recovery the thermistor string was found to have broken loose and no useful measurements were made. At the start of the station a 40 in^3 airgun and mini-streamer was deployed with the intention of obtaining a reflection profile along the line of the heat flow observations. However, with the wind on the port side, the HF probe lowered from the port 'A' frame and the airgun from the starboard 'A' frame, the airgun remained too close to the ship's side. Anxiety was expressed by the ship's engineers about its effect on the stern gland, although firing at only 800 psi, and so the attempt to profile was abandoned.

On completion of the HF station the ship moved south before commencing station 10314 with the Kastenlot Corer in much the same position as station 10311. A 2.40 m core was recovered of very similar lithology to that obtained at the earlier station. By 1500/061 the core station was completed. Getting underway, the ship then began a zig-zag route to the east, the purpose of which was to improve the definition of the distal Madeira Abyssal Plain. The details of this are described in the project report entitled Abyssal Plain (CV3) Survey.

At 0210/063 station 10315 began over an undulating sedimented plateau approximately 4900 m deep. The Benthic Dredge used at this station differed from that at the two earlier stations in having the rubber mat, attached to protect the nets, removed. It was felt that it added too much drag to the dredge in the water, aggravating the problem of getting the dredge to the bottom. A successful station ensued, the haul consisting of pumice, clinker, shark's teeth and some biological material. At 0859 the dredge station was completed after which the ship moved east to the site of the dredge haul to take a core; 1.75 m of sediment, ranging from marly calcareous ooze to pelagic clay, were recovered by the Kastenlot Corer at station 10316. At 1230 the ship was underway again, heading north.

The passage north continued until the evening of the following day. By 1840/064 the ship was hove to over a hill abutting the distal Madeira Abyssal Plain. OBS 7A, one of the two instruments whose earlier deployment along the Oceanographer Fracture Zone was prevented by bad weather, was launched at 1916 in 4961 metres of water. The ship remained hove to, to 'watch' the OBS land then moved north-east to the abyssal plain for a Heat Flow station. By the start of this station, 10318, a near gale was blowing from the south, forcing the ship to keep head to wind rather than follow the westerly course planned. On recovery of the probe, the thermistor string was again found to have broken off, but four successful penetrations had been made.

On the conclusion of station 10318 we waited for three hours for the weather to ameliorate before beginning the station 10319 with the Survey Camera at 0906/065. This camera station, over the distal Madeira Abyssal Plain at 5433 m depth, proved to be extremely successful. Numerous signs of biological activity were apparent in the photographs: trails, mounds and a holothurian.

The ship then moved back to the south to take two cores from the hill standing some 500 m above the abyssal plain. Station 10320 and 10321 used the MSES/Calvert and the Kastenlot corers respectively. By 2300/065 the ship was underway with the 2 kHz hydrophone and the magnetometer fish being streamed. Over the next twelve hours the ship proceeded to the next station, reoccupying as she went a series of Dutch 3.5 kHz lines acquired by HNLMS Tydeman in late 1980. Comparison of these two sets of records would allow the efficacy of our 2 kHz and the Dutch 3.5 kHz systems to be compared. Having these "calibration" runs will also ensure that our own and the Dutch interpretation of high resolution seismic profiling records will keep in step.

By 1100/066 we had reached the end of the Dutch tracks which we wished to reoccupy and began retrieving gear. At 1120 the ship hove to and at 1139 the last OBS, number 5A, was launched in 5405 m of water onto the Madeira Abyssal Plain (station 10322). Once the OBS had landed we moved position slightly before commencing station 10323 with the MSES/Calvert corer. This station was successfully completed at 1614 and was followed immediately with another attempt to test the High Resolution Deep Profiler, station 10324. Again problems with the hydraulic ring main frustrated our attempts to get the instrument into the water. The station was aborted at 1706 to be followed shortly after by station 10325 with the Kastenlot Corer. This succeeded in recovering a core from much the same position as the gravity core of station 10323.

On completion of station 10325 the ship got underway again to head north towards the site of the Bottom Source Experiment, station 10303, after which two PUBS and an OBS had been left on the bottom to record earthquakes. PUBS 2 and PUBS 6 were released without difficulty and recovered between 1351 and 1800/067. Both PUBS had by this time run out of magnetic tape, so we planned to refurbish one and relaunch it to continue recording during the ship's mid-cruise port call at Madeira.

Some six hours are required to turn around a PUBS, so after the recovery of PUBS 6 a final attempt to deploy the High Resolution Deep Profiler was made, station 10326. This time the problems of the hydraulic ring main were overcome and the instrument was lowered to 4000 m depth. Unfortunately a problem was now encountered with the instrument itself which prevented its successful operation. However, since this problem, described in more detail in the instrument report, only manifested itself when the instrument was submerged the station was not without value.

On completion of Station 10326 at 2125/067 the ship headed for Funchal. At midnight we hove to and at 0011/068 PUBS 2 was launched, just outside the Madeira 200 n.m. limit. After waiting over the sinking PUBS until a satellite fix had been received, the ship headed for Funchal. Scientific watchkeeping was concluded at 2300/068 and Discovery arrived alongside in Funchal early on 10th March (day 069).

IN PORT

The mid-cruise port call at Funchal allowed us to re-equip ourselves with two important items of equipment flown out from Research Vessel Services at Barry:

(1) A new Geomechanique tow cable for the SRP array replaced the cable twisted beyond repair on Leg 1.

(2) An MSES Gravity corer replaced the one lost at station 10295 and enabled us to take triggered cores on Leg 2.

LEG 2

Discovery sailed from Funchal at 1035 on 13 March (day 072) and once clear of the port headed west to the site where PUBS 2 had been deployed the day before we entered harbour. Although the main objectives of Leg 2 were in the King's Trough Flank area north of the Azores, the first few days had to be spent retrieving the OBS and PUBS left on the bottom on Leg 1.

Progress to PUBS 2 was good and the instrument was released on acoustic command as we crossed over its position. The ship then came round in a slow circle while hauling in the 2 kHz streamer and magnetometer. PUBS 2 surfaced at 1504/073 and was on board by 1525. The method of retrieval for the PUBS was by grappling the stray line, which releases when the instrument leaves the bottom, from the fore-deck. The stray line was then passed aft and the PUBS hauled out of the water by means of the after crane and a snatch block.

After recovery of PUBS 2 we proceeded west as fast as possible with the aim of getting OBS 4A on deck before nightfall. This did not transpire as the OBS refused to leave the bottom on acoustic command and we had to wait for release on its back-up clock at 2216/073. OBS 4A surfaced at 0014/074 and was inboard at 0029. The method of recovery for the OBS, which were not equipped with stray lines, was to hook onto them from the Shelter Deck then pass the line up for them to be hoisted by the forward crane.

After recovery of OBS 4A the ship got underway on an easterly heading, streamed the SRP array, airgun and magnetometer, then turned back to the west to profile over the OBS position before heading for OBS 6A.

At 1840/074 we were within acoustic range of OBS 6A and switched its transponder on. Streamed gear was recovered and the OBS released at 1950. At 2156 its flashing light was sighted on the surface and by 2234 it was on board. Course was then set to the next OBS, this time streaming only the 2 kHz array and magnetometer fish. This course put us beam on to a northwesterly swell so that the ship rolled heavily throughout the night.

OBS 7A was detected in beacon mode at 1142/075. Releasing at 1200 it surfaced at 1345 and was on board at 1402. At 1425 we were underway again and commencing to stream gear. This took longer than usual because the front section of the hydrophone streamer needed pumping up with oil. Once this problem was solved another developed in the compressed air distribution panel in the After Rough lab. which prevented the airgun from firing. By 1603 this fault was corrected, firing of the airgun recommenced and we turned to profile across the OBS 7A position on our way to OBS 5A.

The final OBS was passed at 0547/076. Profiling continued until 0630 then we slowed to retrieve the gear before heading back to the OBS position. At 0816 its pinger was detected, but the instrument would not release an acoustic command. Release was achieved on the back-up clock at 1100, OBS 5A surfaced at 1257 and was inboard at 1327.

The ship then moved NNE to survey the line which the next station, 10328, with the Benthic Dredge would follow. At 1415 the station began. After an abortive first attempt to launch the dredge the right way up, it was successfully launched at 1449/076. The dredge was on the bottom from 1740-1940. While heaving in, a passing front caused the wind to veer from SSW to NW and bring the wind onto the starboard beam. The wind speed increased briefly to 30 kts and there was heavy rain. This caused the wire, led from the port 'A' frame, to press against the ship's side. As a result, heaving in had to be stopped from 2118 to 2148. But then the weather ameliorated rapidly and recovery continued. At 2245 the dredge was inboard and found to contain a substantial haul of pumice, clinker and a piece of gneiss.

Then followed the fourth attempt to run the High Resolution Deep Profiler, station 10329. At last the gods were smiling. Both CTD winch and instrument operated and some interesting records were obtained. A bottom-echo was detected soon after the instrument entered the water and sub-bottom reflections became apparent within a few hundred metres of the sea bed. At its closest the instrument was lowered to 15 m off the bottom. Recording on board the ship was by means of a Raytheon Line Scan Recorder. Penetration of the bottom to 45 ms was achieved, equivalent to about 33 m. The station finished at 0309/077. With magnetometer and 2 kHz array streamed the ship then headed NNE at 10 kt, firstly to acquire a couple of cores just south of the Gloria Fault Zone, then to move further north to the King's Trough Flank area.

At 0024/079 the ship hove to over the south flanks of the East Azores Fracture Zone and a triggered gravity core, using the MSES corer flown out to Madeira, was taken in 4460 m of water, station 10330. On completion of this station the ship moved north for a couple of hours to select a shallower site on top of a ridge, but still south of the Fracture Zone. Another triggered gravity core was then taken, in 2730 m of water, this being station 10331. At 0930/079 the station was completed and the ship got underway. The magnetometer fish and 2 kHz hydrophone were streamed and we proceeded northwest to the south flanks of King's Trough.

Very soon after moving north of the Azores the weather, as we had feared, deteriorated. In the early hours of day 080 a southwesterly gale blew up, forcing us to reduce speed to about 6 kt. However, by the afternoon the wind had slackened and we made more progress. At 1903 we hove to over a deep pond in the south of King's Trough Flank study area to take a Kastenlot core. Station 10332, our first attempt at this recovered nothing, probably because the core catcher pre-triggered due to the heave of the wire. Station 10333 was a repeat attempt and recovered 1.74 m of calcareous ooze and marly ooze containing some erratic pebbles. On completion of the Kastenlot station an attempt was made to take a triggered gravity core from the same site, station 10334. But soon after the corer had entered the water, before the pinger had been attached 100 m up the wire, it triggered - probably due to excessive heave of the ship. The wind was now gusting over 30 kt. On recovering the gear the trigger arm was found to be bent and the station was abandoned.

It was decided to finish with station work and to begin the SRP survey which had been planned. The ship got underway, streamed the gear and began airgunning at 0340/081. Near gale force winds blew throughout the day from the SW to SSW so that on our first westerly track a speed of only 5.5 kt was possible. Nevertheless good records were obtained. The noise level on the records increased at 1600 when the ship came round onto an ESE course, bringing the wind and sea onto the starboard quarter but the records were perfectly adequate to show sediment thickness.

By dawn on day 082 the wind had dropped sufficiently for station work. The gear was recovered and the ship hove to at 1030 for station 10335 with the Heat Flow Probe. A total of 8 penetrations of the bottom were made until around 1700 it was clear that the weather was deteriorating and it was decided to recover the probe. On recovery the top end of the thermistor string was found to have sheared away from its housing. The ship got underway, the gear was streamed and airgunning started at 1921/082 on a northeasterly course.

The following morning, day 083, the Chief Engineer requested that the ship heave to so that measurements could be made on cracks in the main engine bed plates. The gear was recovered and by 1000 we were hove to. We remained hove to for nearly 24 hours as a SW gale developed with the wind at times gusting to 50 kt. By breakfast the next day, 084, wind and sea had moderated sufficiently for profiling to continue. The gear was streamed and airgunning started at 0937/084.

Although the weather had improved, the 24-hour weather forecast indicated that another major depression was likely. The Chief Engineer was growing more anxious about the main engine bed plate cracks, although whether the cracks themselves were growing was not clear. The Master decided that it would be wise to leave the King's Trough Flank area and seek calmer waters to the southeast.

After breakfast on day 085 it was decided that progress would be speeded if the SRP array were recovered and replaced by the 2 kHz hydrophone, since the former was towed at speeds up to 8 kt whereas the latter could be towed at 10 kt. The switch was made, but in the end was to no avail as near gale force winds developed to hamper our progress. In the evening we switched from the 2 kHz system back to the SRP and began airgunning again at 1947/085.

Finally at 2230/085 the Master decided that the engine room bed plate problem was sufficiently serious to necessitate aborting the cruise. Course was set for Gibraltar. The airgun and SRP array were left streamed throughout the night and recovered between 0845 and 0924/086. Passage was then made to Gibraltar with just the magnetometer streamed.

The passage back to Gibraltar was uneventful until at 0934/088, while passing Cape St. Vincent, the PES fish briefly snagged a fishing net, damaging its faired towing cable. It was decided that this would be an appropriate point to recover all the towed gear and at 0954/088 scientific watchkeeping was concluded. At 0745/089 Discovery tied up alongside in Gibraltar.

T.J.G.F.

PROJECT AND EQUIPMENT REPORTS

ABYSSAL PLAIN (CV3) SURVEY

In the region of 24°-26°N, 27°-30°W the Madeira Abyssal Plain forms an embayment into the abyssal hills. The northern (distal) limit of the abyssal plain is poorly defined bathymetrically in this area, so it was decided to carry out a short bathymetric and 2 kHz profiler survey on passage between stations D10314 and D10315. The tracks to be taken were chosen on the basis of the existing bathymetric and seismic reflection profile data with the intention of providing several crossings of the abyssal plain edge.

The 2 kHz hydrophone was deployed at 1630/061 after the completion of station D10314. Proceeding south-east, the edge of the abyssal plain was encountered at 2342/061. Several small and sometimes uncharted abyssal hills were crossed before and after turning north-east at the first waypoint at 0300/062. Leaving the abyssal plain at 1045/062, the second waypoint was reached at 1130/062 and turning south-east again several fingers of the plain were crossed before reaching the final waypoint at 1530/062. From here we steamed north-east towards station D10315 finally leaving the abyssal plain at 1945/062. The 2 kHz hydrophone was recovered at 0158/063 on arrival at station D10315.

Throughout the thirty-three hours of the survey, noise on the 2 kHz record was a problem. This was especially so when the ship was running in the same direction as the sea when the plucking on the cable was greatest. Reducing speed from the normal 10 knots to 8 knots or less often showed a considerable improvement.

S.M.

GEOPHYSICAL SURVEY IN THE KING'S TROUGH FLANK STUDY AREA

Examination of existing records had suggested that an area approximately 41^{o}-$43\frac{1}{2}^{o}$N, 20^{o}-24^{o}W might prove suitable for further study as a HLRW disposal area. It appeared to have an almost continuous sediment cover with a fairly smooth sea-floor. Sedimentological studies of eight gravity cores taken in the area during Shackleton Cruise 8/79 suggested that the area has been characterised by suitably continuous sedimentation for at least the last 100,000 years. Since the existing geophysical coverage was quite limited (an average of about one track per square degree), there was an urgent need during this cruise to obtain more underway data, especially airgun and 2 kHz reflection records. We therefore planned to spend 2½ days obtaining such data along four, approximately 100 mile-long traverses oriented WNW-ESE (Figure 3). A secondary objective was to obtain profiles over the positions of two of the Shackleton cores, where no previous profiling had been done.

The weather was poor, and most of the survey was carried out in gale or near gale-force conditions. Although this resulted in noisy records, the data are generally of acceptable quality. A total of some 900 km (490 miles) of profile was acquired in a total of 70 hours steaming (excluding time hove to for stations or bad weather).

The data acquired represent a very useful addition to our knowledge of this area. The main result obtained from the airgun data is that the central part of the study area (22^{o})to 23^{o}W) is considerably more rugged and complex than previously supposed. Although the sediments are generally quite thick, basement outcrops along the crests of ridges are not uncommon here, and even where these are absent there are often steep sediment scarps (possibly with outcropping or near-outcropping consolidated sediments) overlying buried basement ridges. The sediment surface between $41\frac{1}{2}^{o}$N to $42\frac{1}{2}^{o}$N, 21^{o} to 22^{o}W is generally much smoother, but this area is bordered to the east by seamounts, one of which (just north of 42^{o}N, 21^{o}W) was previously unknown. However, the western part of the study area (23^{o}-24^{o}W) still looks quite promising. Our three WNW-ESE lines there all show continuous, generally smooth sediment cover, although one or two small sediment scarps occur there too.

The 2 kHz data suggest a wider variety of sedimentation processes than was previously suspected. Although the dominant echo type indicates a fairly smoothly draped, transparent layer, there are also areas of moderately acoustically stratified layers, and some undulating layers. These latter two types may indicate some degree of current control (turbidity and/or thermohaline current) of the deposition. In one area near 42½°N, 22½°W the 10 kHz echosounder record displayed closely-spaced hyperbolae associated with an apparently smooth seabed. This is indicative of small-scale surface roughness. Possible causes would be a boulder bed or a field of ripples. Unfortunately we were unable to investigate this further.

R.C.S.

STRATIGRAPHIC CORING

The main sampling tool for stratigraphic coring was to be the triggered gravity corer on loan from RVS Barry, which is capable of recovering a 12-foot length of core. This corer was lost at the first coring station over the northern Madeira Abyssal Plain when a swaged ferrule failed during recovery. The weight-stand of this corer could not be replaced until our mid-cruise port-call and thus we were obliged to turn to the shorter Kastenlot Box corer for our stratigraphic sampling, until a modification of the IOS (Calvert) gravity corer made it possible to employ the Barry corer's barrels again. Archiving and sampling of the Kastenlot cores proved more successful than was expected, however, and the modified "Barry-Calvert" corer became available before the first HLRW study area was reached. The latter coring method did not allow for triggering but we became adept at controlled free-fall coring employing two pingers - one on the weight-stand and one 100m up the main warp from the corer. After the Madeira port-call we reverted to using the triggered Barry corer again and two successful coring stations were made before bad weather interrupted our programme. All cores were opened aboard ship and described, photographed and sampled for shorebased analysis (Table 4). About 120 smear slides were also made and analysed with a petrographic microscope. A total of 570 samples was taken with which to begin shorebased studies of micropalaeontology, oxygen isotope stratigraphy, grain-size, X-ray mineralogy and carbonate content. During calmer intervals most of the micro-palaeontological samples were sieved and stored as residues.

Two Kastenlot cores were recovered from the northeast Madeira Abyssal Plain separated by two degrees of latitude. D10298 contained 30 cm of brownish marly nannofossil core overlaying 1.7 m of grey nannofossil ooze. This site is in 5547 m water depth and the upper 30 cm of sediment is interpreted as indigenous sediment deposited at or below the C.C.D. (carbonate compensation depth). On the other hand, the nannofossil ooze below is interpreted as a pelagic turbidite deposited relatively rapidly below the local C.C.D. This ooze has been sorted during transport and is devoid of sand size foraminifera. The other core, D10302, contained grey marly ooze to a depth of 51 cm terminating here in a volcanic tephra horizon. Both cores appear to be Quaternary in age.

The two coring sites in the Great Meteor West study area were located at either end of a north-south 2 kHz seismic profile. The profile and the sites were located for comparison with earlier studies by Dutch scientists on HNLMS Tydeman. D10305 on the abyssal plain west of Cruiser Seamount recovered 1.57 m of alternating oozes and marly oozes with a volcanic tephra horizon at 57-62 cm. D10307 from the lower rise of Great Meteor Seamount is a similar alternation of oozes and marly oozes but with evidence of slumping in the lower parts of the sequence. Both cores show evidence of re-working in their nannofossil content but preliminary studies of nannofossils and foraminifera suggest that they are Quaternary throughout.

Further south in a deep basin within the Mid-Atlantic Ridge flank province an attempt was made to take a Barry/Calvert core and a Kastenlot core at the same site in 6130 metres water depth. The sequence recovered shows 60 cms of brown pelagic clay overlaying 157 cm of calcareous ooze in D10311, the 6.4 cm diameter gravity core. An almost identical sequence was recovered in D10314, the Kastenlot box corer, but with the depths as 84 cm overlaying 156 cm respectively. The different thicknesses reflect different degrees of core shortening. The calcareous ooze unit is interpreted as a pelagic turbidite which has been injected into a pelagic clay environment below the C.C.D. The ooze appears to be Quaternary in age and this suggests a sedimentation rate for the pelagic clay unit of at least 0.03 cm/10^3 years. D10316, a Kastenlot core, was located on a ridge near the distal Cape Verde abyssal plain in 4966 m water depth. This 1.75 m sequence of marly calcareous oozes, marls and calcareous pelagic clays reflects a history of varying dissolution of the calcareous microfossils during their deposition close to the local C.C.D.

Five degrees of latitude further north in the Great Meteor East study area we cored a similar ridge in 5005 m water depth. Here we hoped to recover a sufficiently calcareous sequence to construct a local reference stratigraphy for comparison with Dutch cores in deeper parts of the study area. D10320 and the Kastenlot core at the same site recovered a sequence that was remarkably similar to that 300 miles further south. The lower continental rise station D10323, located in 5406 metres water depth in western part of the study area, recovered a pelagic clay sequence which is interrupted at a number of levels by more calcareous distal turbidite and slump units.

Recognising our need for a latitudinal spread of cores for stratigraphic studies and for more information on changing levels of dissolution, two stations were located at different depths on the southern ridge flanking the East Azores Fracture Zone. D10330 from 4460 m water depth is a sequence of calcareous oozes and chalks with tephra horizons and intermittent slump units which appears to be Quaternary in age throughout. D10331 in 2730 m water depth is almost entirely made up of Pliocene chalk topped by a winnowed foraminiferal sand. Clearly at the top of this ridge we were able to sample outcrop only.

In the King's Trough study area only one core was taken, a Kastenlot core from a deep basin (4133 m W.D.) in the southwest of the area. It contains a similar sequence to eight cores previously acquired from this area (Shackleton Cruise 8/79) being made up of alternations of calcareous ooze and marly calcareous ooze with glacial erratic clasts and a tephra horizon. It is almost certainly Quaternary in age throughout.

R.B.K., P.P.E.W.

MAGNETIC SUSCEPTIBILITY MEASUREMENTS ON CORES

The low field magnetic susceptibility of seven MSES corers and one Kastenlot core were measured as an aid to cataloguing their sedimentary stratigraphy. The instrument comprises an antivibration mounting which supports the balanced a.c. coil detector through which the core is slowly passed with the aid of rollers. Movement of the core and the magnitude of the magnetic susceptibility are drawn continuously on an X-Y recorder.

The cores examined were D10298, 10305, 10307, 10311, 10320, 10323, 10330 and 10331. As expected, very low magnetic susceptibility was found to be associated with the carbonate sediments with higher susceptibilities within clay and marl bands containing a higher proportion of terrigenous material. High susceptibility was also a feature of volcanic ash layers, one of which was successfully predicted in core D10305. From a study of smear slides, two peaks in the profile from core D10331 were also found to coincide with ash layers which were invisible on the surface of the core.

In the transition zones between carbonate ooze and marls intermediate values of susceptibility reflected the degree of intermixing due to burrowing. Large individual burrows could also be detected as minor features in the magnetic profiles.

M.J.N.

PHYSICAL PROPERTIES

The main objective of the physical properties programme was to collect a suite of sediment samples with a minimum of disturbance from appropriate study areas. These samples were then to be transported to the laboratory at Wormley for testing their consolidation and permeability characteristics. For this purpose the 15 cm square cross-section Kastenlot corer with a 2 m barrel was used. Ten Kastenlot core stations were attempted (eight on the first leg) and six successful cores were recovered (Table 1). Premature closure of the catcher doors led to the four unsuccessful attempts. This was overcome later in the programme by modifications to the doors to make them less sensitive to the ship's heaving motion. Two pingers, one attached to the corer head, and the other 100 m up the wire, enabled full control of the corer to be maintained during the whole operation. On board the cores were photographed and described before being sub-sampled. Specially designed tools allowed 75 and 50 mm diameter rings, 20 mm high to be inserted into the centre of 80 mm lengths of the core. These were cut out and trimmed together with an archive sample taken from one corner of the core section. Over 100 ring samples were taken from the six cores and, apart from a few which were taken back by air, were stored under water in racks in the cold room until the ship's return to the UK in July. In addition to the ring samples, 75 cm^3 samples were taken at 8 cm intervals down all Kastenlot cores for bulk density/porosity measurements on shore.

An osmotic-electrolytic knife was used to accurately trim the ring samples, prepare the archive from the Kastenlot core and split the Barry cores. This technique proved far superior to the more normal techniques of plain knives and cheese wires. To observe fine detail in sedimentary structures there is some evidence from uncontrolled sediment fractures that fractured surfaces provide more detailed information than any cutting technique. An experimental fracture box designed to fracture a block of sediment from the Kastenlot core along a predetermined plane proved the technique to be viable for all but very soft sediments. Comparisons of fractured, cut, and smeared surfaces verified the quality of fracture surfaces when normally illuminated.

An electronic top pan balance (on loan from Oertling Ltd. for evaluation at sea), incorporating experimental digital filtering algorithms designed to compensate for the ship's motion, was tested. It was concluded that in moderate sea states (up to sea-state 5) it could weigh up to 600 g with an accuracy of $\pm$ 1 g if left for at least 10 minutes. Although this accuracy may suffice for large weights it produces a $\pm$ 5% error on a 20 g sample. Test data from this cruise is being sent to Oertling so that they can improve their filtering techniques.

P.J.S.

HIGH RESOLUTION NEAR-BOTTOM PROFILER

The equipment was completed at sea but various problems with the midships winch delayed the first trial until the end of the first leg. On that occasion the system failed to operate because the receiver preamplifier oscillated violently. A post-mortem suggested that this problem was caused by capacitive coupling between the sea-water earth return of the CTD wire and the unscreened leads of the transducer array, and the preamplifier was modified to reduce its susceptibility to the form of coupling.

On its second trial during the second leg the system operated satisfactorily. Bottom echoes were detected with the instrument just below the sea surface in 5 km water depth. With the instrument suspended 40 m above the bottom, sub-bottom layers down to more than 30 m below the bottom were detected.

Although the sea was very calm at the time of the trial, the bottom return showed 3 m peak-to-peak heave with 5 km wire out, and it is clear that heave is not significantly attenuated as it propagates down the wire.

This trial indicated that, with the addition of a heave compensating system, the instrument would be a useful geophysical tool. Unfortunately bad weather prevented any further trials during the second leg.

R.J.B.

HEAT FLOW

Our objectives during this cruise were two-fold: (1) to gain experience in operating the heat probe in water depths up to 6000 m and in a variety of sediment types; (2) to search for regular lateral variations in heat flow over small areas of sea-floor which together with non-linear temperature gradients would be evidence for a pore water movement.

The probe was deployed at 5 stations, yielding a total of 18 penetrations at which good data was recorded. The total would have been higher were it not for repeated mechanical failures. At station 10296 the probe was lowered to 5787 m wire out but bottom penetration was not attempted because no bottom echo was received from the wire pinger. The pressure cases leaked slightly, damaging the electronics. At station 10301 probe head and wire pingers were used to improve the positioning with respect to the sea-floor resulting in 11 dips although the data showed that the maximum penetration had been only 2 m. For station 10313 and subsequently, 500 lb of lead weight were added to the instrument and this ensured a full 5 m penetration, as shown by mud smears, but unfortunately the thermistor tube became detached at the lower end causing part of the logger housing to become flooded and pressurised. This happened again at station 10318 but there was good data from 4 full penetrations. The damage to the thermistor tubes was eventually attributed to overtightening of this component combined with the bending of the strength member which occurs with a non-vertical pull-out. Hence at the last station, 10335, the string was left slack but after the third dip this broke again, this time at the top, moreover the strength member was bent. The bottom may have been unusually hard at this station.

Our experiences have revealed severe weaknesses in the mechanical design of this instrument. Small leaks were difficult to prevent with the piston O-ring type of seal and major corrosion was present on the pressure cases after the first station. The logger and heat pulse electronics performed well but the probe is clearly too lightly constructed for deep sea use. Despite the size and weight of the probe no major handling problems were experienced.

M.J.N.

SURVEY CAMERA

During the previous year, a new survey camera system had been assembled, comprising a Benthos model 372 camera, eight separate flash units each comprising one Vivitar model 283 flash gun and power-pack for up to 1600 shots, a high-frequency near-bottom echo-sounder (NBES) and an acoustic command and telemetry monitor. A purpose-built frame was also available for carrying these units. The NBES was capable of measuring its height above the sea bed to a precision of a fraction of a metre, in the range 8 m to 150 m. The monitor was programmed to switch the camera on and to cycle it every 15 seconds when the NBES indicated a height of $\leq$ 18 m, and to switch it off for greater heights. Alternatively, the NBES could be switched off (by remote command at a modulation frequency of 480 Hz) in which case the camera could be switched on or off by remote command at 500 Hz. Preliminary calculations suggested that photographs should be obtainable at heights of up to 18 m above the bottom.

The system had been deployed for two test dips on cruise 116, but only on the second one had a small number of frames been recorded. These showed some bottom features, but at very low contrast, probably because of severe back-scatter caused by too small a camera to flash spacing. It was, therefore, expected that a considerable amount of experimentation with the arrangement of camera and flashes would be required during cruise 118 to obtain optimum performance.

Station 10299

The first station (10299) was carried out in 5547 m of water over the northern Madeira Abyssal Plain. The camera was mounted on the front of the frame, with four flash units as far away as possible (the nearest was about 80 cm from the camera). One pair of flashes was angled five degrees forward, and one pair five degrees aft, of the vertical. The camera was angled about five degrees aft.

Maximum camera aperture (f3.5) was used, with FP4 black-and-white film (125ASA).

The camera was lowered at 0.8 m/s on the main warp (at greater speeds the wire overran the camera frame) with the ship hove to. When the camera was near the bottom, the ship went ahead at 0.75 kt. Ten minutes later the camera began to rise (at about 4 m per minute) as indicated by the NBES and for the next one-and-a-quarter hours the height was controlled by paying out wire, to keep the camera between an estimated 5 m and 15 m above the bottom. The NBES worked extremely well, and enabled us to operate the instrument very close to the bottom with a great deal of confidence. The only caveat is that it could not resolve heights of less than 8 m, apparently because of excess ringing in the transducer. If this problem could be overcome to give a minimum range of 4 m or less, the instrument would be excellent.

The best way to adjust the height of the camera would be by continuous, slow paying out of wire to match the tendency of the instrument to rise. However, with the present winch it is impossible to pay out slowly enough, so the instrument follows a sawtooth profile, rising slowly then falling rapidly as wire is paid out. It would also be very advantageous if the person watching the Mufax recorder could himself control the wire pay-out directly.

The film was developed on board after the station using the newly-acquired automatic processor. After some teething problems setting it up, this processor worked well. The results obtained were better than for cruise 116, but still suffered from low contrast. Even so, sea bed details could be readily discovered on frames taken at heights of 10-12 m, especially where the contrast of the subject was high. The light was rather unevenly distributed, with a strong concentration toward the centre of the frame.

Station 10309

For this station, the camera was mounted down toward the rear of the frame, with four flashes ahead of it. The camera-flash spacing was about the same as for the previous station, but the two pairs of flashes were angled ten degrees and thirty degrees aft, and the camera was angled seventeen degrees aft. This was intended to (a) spread the illumination more; (b) give more oblique illumination; and (c) reduce backscatter by having the light source slightly behind the camera. Other factors were the same for station 10299.

The station was carried out over the lower rise of Great Meteor Seamount, in 4139 m. This time the wire was paid out with the ship moving ahead at 0.5 kt. The camera height was much more stable, though a considerable amount of hauling and paying out were still required to maintain the precise height required.

The NBES was modified to try to reduce the minimum height resolvable, but no improvement was achieved.

During this station, the monitor trace failed to show that the camera was operating, and on recovery we found that the film had run, but the flash units had not worked. The fault was traced to a broken connection between one flash unit and its pressure-case end-cap, which must have been shorting out the trigger signal.

Station 10312

This station was run over a low abyssal hill (depth about 6000 m) near 25°N, 31°W. The same set-up and procedure were used as for the preceding station. The instrument remained near the bottom for three hours, covered 2½ miles and took 676 pictures of the bottom. The station was successful, and the film showed a remarkable paucity of biological activity - presumably a consequence of the greater depth - compared with station 10299. The oblique lighting arrangement did provide stronger shadows, but overall contrast was not significantly better and there was a strong gradient in the intensity of illumination.

Station 10319

For this station it was decided to return to vertical incidence photography, but to extend the frame so as to increase the camera-flash spacing. The frame was extended by 36 inches (0.9 m) and the camera mounted at the rear pointing four degrees forward. Two pairs of flashes were again used, angled fifteen degrees forward and ten degrees aft. The minimum camera-flash separation was 2.0 m. This time HP5 film (400 ASA) was used.

The station was run over the Madeira Abyssal Plain in the Great Meteor East study area, water depth approximately 5400 m . The station worked well except that after two hours on the bottom we had completely lost the monitor trace, and found it impossible to recover it by steering the PES beam. We were, therefore, forced to terminate the station before all the film had run.

The photographs were extremely successful, in spite of the fact that one flash failed to work because of a faulty connection. Bottom details were visible at heights of 18 m, and good contrast was obtained at 10 m. A total of 477 bottom photographs was obtained over a distance of 2.0 miles. The success of this station persuades us to retain this same general arrangement with the extended frame.

The photographs revealed the greatest biological activity of all three successful stations, with numerous mounds and trails and a number of individual benthic organisms visible.

Stations were planned at King's Trough and Theta Gap for leg 2, but could not be carried out because of bad weather and the shortened cruise.

Although the system basically worked well in its final configuration, three factors need to be improved:

(1) It is vital to improve reception of signals from the monitor, if the full capacity of the system for making long traverses is to be utilised. Conceivably, this might require a special receiving array to be built on the ship.

(2) Again, to facilitate longer (and faster) traverses, the drag/weight ratio of the frame and mounted components must be decreased. At present, tow speeds above 0.75 kt are impracticable.

(3) We had persistent problems with the General Oceanics connectors between the flash units, at least three of which were found to be faulty. Probably a more reliable type (e.g. Marsh and Marine) should be installed.

R.C.S.

BENTHIC DREDGE

A Benthic Dredge was provided by the IOS Benthic Biology team and modified to add extra strength to the net and frame in order to collect coarse-grained rock material from abyssal plain environments. The sledge was monitored using an IOS pinger to show temperature, camera triggering, attitude (right way up/upside down), tilt ($< 30^{o}$) and metres travelled on the sea bed (using an odometer wheel). A total of four stations were attempted, two of which successfully produced the material being sought.

(1) Station D10297 5542 corr. m.

Launched on the main warp from the port "A" frame the sledge was lowered at 0.5 m/s. The wind was kept on the port bow with the ship's speed at 1.5 kt to keep the wire off the side. The main PES fish was used to monitor the sledge and it was found that the range of the sledge astern was too great for accurate monitoring. At 7709 m wire out payout was stopped as the remaining warp was seen to be bruised and possibly unsafe. In order to land the sledge the ship's speed was reduced to ½ kt and the sledge sank slowly to the sea bed. The sledge would not land as intended so the station was abandoned. Mud was found on the frame, but the net was empty and the film unexposed.

(2) Station 10308 4130 corr. m.

At this station the ship was kept head to wind at 1.5 kt reducing to 0.8 kt as the sledge neared the bottom (identified by bottom echoes). After 7555 m wire had been paid out the winch was stopped and the sledge continued to move astern (indicated by pinger traces). The slack wire laid on the sea bed became tangled around the sledge and a load of 4.3 tons was recorded as the sledge lifted off. The net yielded one piece of pumice and the upper surfaces of the frame had been polished. The camera leads were ripped off and the film did not run.

(3) Station D10315 4940 corr. m.

For this station the rubber mat fixed under the net for protection was removed as it was felt that it added too much drag. Payout was at 0.5-0.7 m/s with a ship's speed of 1.5 kt head to wind. The sea bed was reached with 5998 m of wire out and a further 280 m of wire was paid out to stabilise the sledge on the sea bed. The monitor indicated that the sledge was horizontal and the camera activated. However, the odometer wheel did not function. The sledge was kept on the bottom for 2 hours and the haul consisted of 23 pieces of pumice and clinker (ranging from 1.5-3 cm maximum diameter) and assorted biological specimens. The film jammed in the camera and no useful pictures were obtained. The total amount of wire out was 6381 m .

(4) Station D10328 5412 corr. m.

After one abortive attempt to launch the sledge it was lowered to the bottom at 0.5-0.7 m/s at a ship's speed of 1.5 kt head to wind. The monitor indicated that the sledge was on the bottom at 7700 m of wire out and a further 200 m of wire was payed out. As the sledge lifted off a further 150 m of wire was paid out. Eventually it was found to stay on the sea bed at a ship's speed of 1 kt. It was towed 2 n.m. along the sea bed and the net yielded a large haul of pumice, clinker, erratics and assorted biological specimens. The odometer wheel failed to work and it was thought that the failure was due to a pressure effect on the wheel as the film (150 frames) indicated that the sledge was running along the sea bed correctly and the wheel functioned perfectly when tested on board ship. Maximum wire out was 7351 m .

Q.J.H.

INTRAPLATE SEISMICITY

Four intraplate sites had been chosen before the cruise, along the eastern arm of the Oceanographer Fracture Zone, at which to deploy OBS and PUBS to detect any local seismicity associated with the fracture zone, or from elsewhere. Two PUBS and one OBS deployed at the easternmost site (station 10303) and one OBS at the second site (station 10304). Poor weather, including winds of over 30 knots, prevented deployments at the other two planned sites. However, it was possible to lay the remaining two OBS later during Leg 1 (stations 10317 and 10322) and to re-lay PUBS 2 about 50 km east of the first site (station 10327) on the run into Madeira.

The PUBS recorded on the sea bed for a total of 21 days 10 hours representing 8 days for each of two PUBS at one location (station 10303) and 5 days 10 hours at station 10327. All recordings are of fair to good quality except for the presence of a spike with a 3.2 second period caused by a faulty gear train in both PUBS tape-recorders. Preliminary aural analysis of one station 10303 tape has not detected any earthquakes; two quakes may have been recorded at station 10327.

Recording with the OBS was only fifty per cent successful, the two failures both being due to tape-recorder problems. The tape recorder of OBS 4A failed to unclamp, so did not run. The tape recorder of OBS 6A ran for about a day before the feed spool shed a loop and the recorder ground to a halt. However, no signals were detectable on the length of tape which ran. OBS 7A (station 10317) OBS 5A (station 10322) both recorded successfully. Analysis of their tapes is in progress.

Parameters of the OBS and PUBS deployments are given in Table 2.

R.B.W., R.C.L., T.J.G.F.

BOTTOM SOURCE EXPERIMENT

It is of interest to develop effective seismic sources which operate on the sea bed in order to study the dynamic and static elastic moduli of the sediments. Sources which generate shear waves or surface waves are potentially the most valuable because shear-wave velocity is a sensitive indicator of the state of a sediment.

Four different sources were tried (station 10303). Two sources consisted of free-fall weights (Table) and the others incorporated explosives.

SOURCE	LENGTH (m)	DIAMETER (cm)	WEIGHT (kg)	TERMINAL VELOCITY ($m.s^{-1}$)	MOMENTUM (mkgs)	KINETIC ENERGY (Joules)
Projectile	6.9	7.6	120	17	2040	17340
Concrete weight	2.1	60	1000	4.1	4100	8405

The concrete weights and six projectiles were dropped in the vicinity of PUBS 6 and OBS 4 situated about 1 km apart (PUBS 2 had been inadvertently dropped about 1.7 km to the west due to a navigational problem). PUBS 6 recorded clear signals from all the sixteen weights; at PUBS 2 the signals from only some of these were discernible. OBS 4 failed to record. The concrete weights generated sufficiently energetic signals (predominantly about 3 Hz) to be recognised on a horizontal geophone at over 2.2 km range. Although at least five times more energy is contained in the shear-wave arrivals seen on the two horizontal-geophone traces the vertical geophone trace, up to ranges of about 1.2 kms, exhibits a clear, normally-dispersed wave-train arriving after the S phase which is probably a form of Rayleigh wave. Weak compressional wave arrivals can also be seen out to about 1 km.

Only four of the projectiles yielded clear signals at the PUBS, the most distant one being about 1 km away. The waveforms produced are similar to, but weaker than, those from a concrete weight (Fig. 4).

The above results are very encouraging and clearly the weight drop method deserves further development (N.B. there is currently no way of determining the "shot instant" of the concrete weights). The table suggests that the seismic energy produced by a weight depends more on its momentum than on its kinetic energy. Probably the rate of conversion of momentum (impulse) to seismic energy is also important and, therefore, further sources of this sort should possess fairly blunt noses as well as sufficient momentum.

R.B.W.

SHOT FIRING

Two types of bottom charge had been planned: one consisted of 3.1 kg of "Geophex" in a pressure case attached to a 'spade' which it was hoped would penetrate the sediments; the other a double line of "Premium 100 Aquaflex" buoyed up to stand vertically above the sea-floor. Each charge was fired electrically, using a clockwork timer to complete the firing circuit after the charges were laid. The Geophex was initiated with an ordinary no-8 star electric detonator, the Aquaflex with high pressure detonators and primers taped to the charge. It had been intended to fire five of each type of charge, but in the end there was only time for four Geophex and one Aquaflex charges.

The Geophex charges were rigged as follows (this is a summary only: several technical details and details of safe practice have been omitted for the sake of brevity - do not use this description as a shotfiring guide). The Geophex stick was placed in its pressure housing, the plug in the end-cap, the end cap attached and the pressure case bolted to the 110 kg 'spade'. The spade was attached to the free end of a 100 m-long plaited synthetic rope wound around the afterdeck capstan and through the starboard A-frame. One end of a 100 m-long firing cable (two core, rubber insulated) was plugged into the pressure case. The charge was hoisted outboard, and then lowered, the firing cable being taped to the rope at intervals of about 2 m. The cable was kept taut, since we believed the rope would slacken when it was released to fall through the water. However, it was subsequently suggested by the Master that synthetic plaited rope continues to extend for some time under load, so that it could have stretched (and broken?) the firing cable before the charge was released.

When all the rope and firing cable had been paid out, one of the timers was set to a 2-hour interval, taped to the rope and connected to the firing cable (the timer case also contained a 9V cell to provide the firing current). The rope was then cut to release the charge.

Each of these Geophex charges took about 1½ hours to rig. All of them failed to fire.

Toward the end of the afternoon it was decided to try an Aquaflex charge. Again in summary, it was rigged as follows:

A weight was tied to the end of an 80 m length of laid polypropylene rope wound onto the capstan. The two free ends of a doubled, 62 m length of Premium 100 Aquaflex were taped to the rope just above the weight (doubled lengths of explosive had been made up and spooled the previous day; all cut ends of Aquaflex had been sealed). The weight was hoisted outboard and it and the Aquaflex paid out, the two being taped together at 2 m intervals, again with both the rope and the explosive cord taut. When the top (doubled over) the end of the Aquaflex was reached, a water-proof primer and high-pressure detonator was attached to each of its two limbs, and the detonators were connected to a firing cable. This was then paid out, with the rest of the rope, taping as before. At the top of the rope a syntactic foam float was attached (via to a corrodable link) to support the charge, a timer was connected to the firing cable, and the rope was cut to release the charge.

This charge took about 2 hours to rig. There was only time for one such charge, but it fired successfully.

Clearly these methods of rigging the charges were too time consuming, and (in the case of Geophex) very unreliable. We consider that the two most likely causes of failure were:

(1) The firing cables were damaged, either during the rigging or while the charge fell through the water. (It may be significant that a firing cable used in a dummy practice run and subsequently recovered was found to be damaged).

(2) The timers were very unreliable. We tested 13 timers in the laboratory

before using them, and of these, three were found to have, or develop, broken escapements. They were prone to stick and so failed to go off.

We would therefore make the following recommendations:

(1) A stronger firing cable should be used, at least for the Geophex charges. If it were strong enough to support the weight of the charge (e.g. old CTD cable), the rope and time-consuming taping procedure could be dispensed with.

(2) More robust timers should be used, preferably electronic.

(3) A proper safety ohm-meter should be available to allow testing of firing circuits.

R.C.S.

PUBS

Two PUBS were used i) to assist in trials of a variety of bottom sources and ii) to assess intraplate seismicity west of Madeira. Three deployments were made in two different locations giving a total of 21 days 10 hours recording on the sea bed. The preliminary results of these experiments are given elsewhere in this report. The deployments also enabled a further assessment to be made of the recently modified gear train in the Nagra tape-decks which allows the PUBS to record continuously for over 8 days.

The PUBS performed almost perfectly for each deployment. The only serious problem was with the tape-recorders which had been assembled at IOS. The new motors showed no obvious signs of wear or deterioration but the gear trains, on examination after all the deployments, were faulty. The faults were all associated with screws which needed tightening. Fortunately, the above faults seem to have become serious only gradually while on the sea bed. The first few days recording of the first lay of each tape-recorder therefore have good signal:noise but the faults in the first gear train of both tape-recorders later caused very severe wow with a 3.2 second period.

A new hydrophone, made by Ocean & Atmospheric Sciences, Dobbs Ferry, New York (model E4SD), was also tested on PUBS 6 (station 10303). It was not possible to compare the new and the IOS-made hydrophone (fitted to different PUBS) since no common signal was clearly detected by both at station 10303. However the O.A.S. hydrophone did work but the gain required with it was probably underestimated by a factor of two.

R.B.W., R.E.K.

GRAVITY OBSERVATIONS

LaCoste Romberg marine gravimeter S.84, which had been on heat since Discovery left Barry in January, was used to measure gravity throughout the cruise. It performed without any serious problem. The drift rate was measured by checking against base stations ashore at Funchal, Madeira and at Gibraltar before and after the cruise. The mean rate was +0.2 m.gals/day.

Gravity readings were logged by the IBM 1800 computer and converted to free-air anomalies using the 1967 International Gravity Formula.

R.B.W.

HYDRAULIC RING MAIN

Extensive adjustment of the Hydraulic Ring Main was necessary in order to get the Midships Hydraulic Winch to operate. Problems with the Ring Main led to two of the four stations attempted with the High Resolution Near-Bottom Profiler being abandoned.

T.J.G.F.

TABLE 1: STATION LIST

STATION	TYPE	START TIME	END TIME	POSITION LATITUDE	POSITION LONGITUDE	WATER DEPTH CORR. METRES	COMMENTS
10295	Gravity Core	0740/050	1135/050	$36^{\circ}31'N$	$18^{\circ}26'W$*	5215	Corer lost within 200 m of return to surface due to failure of 'Talurit' splice in strop between trigger and corer.
10296	Heat Flow Probe	1230/050	1635/050	$36^{\circ}30'N$	$18^{\circ}22'W$*	5542	Probe not lowered into bottom because no pinger echo. Maximum wire out 5787 m. Slight leakage of water into pressure case.
10297	Benthic Dredge	1745/050	0443/051	$36^{\circ}29'N$	$18^{\circ}23'W$*	5542	Failed to dredge bottom with 7709 m wire out. But mud on instrument indicated that it touched briefly.
10298	Kastenlot Corer	0553/051	0834/051	$36^{\circ}24'.7N$	$18^{\circ}20'.0W$+	5547	2.2 m core recovered. 30 cm clay nannofossil ooze overlying re-worked nannofossil ooze. Pinger directly attached to core head.
10299	Survey Camera	0905/051	1330/051	$36^{\circ}26'.2N$	$18^{\circ}20'.8W$+	5547	Successful
10300	Kastenlot Corer	1928/052	2155/052	$34^{\circ}20'.2N$	$21^{\circ}33'.8W$+	5045	2m core box with pinger attached to core head. Unsuccessful because core catcher closed on way down.
10301	Heat Flow Probe	2320/052	0746/053	$34^{\circ}27'N$	$21^{\circ}41'W$*	5210	Pinger directly attached to probe head. 11 penetrations of bottom but little penetration due to lack of weight.

continued.........

STATION	TYPE	START TIME	END TIME	POSITION LATITUDE	POSITION LONGITUDE	WATER DEPTH CORR. METRES	COMMENTS
10302	Kastenlot Corer	0920/053	1218/053	34°19'.9N	21°34'.2W+	5035	2 m core box. Corer went right in but only 0.5 m core was recovered because core catcher failed to close and much slipped out.
10303	PUBS/OBS Bottom Source Experiment	0343/054	0130/055	32°35'N	22°30'W*	5262	Two PUBS and OBS deployed in small area. Ship acoustically navigated by transponders on PUBS. One Aquaflex charge fired on bottom, 10x 1 ton weights dropped, 6 high speed projectiles. 4 bottom charges failed to explode.
10304	OBS 6A deployment	1505/055	1740/055	32°59'.6N	24°54'.1W+	5388	Instrument banged ship twice during launch. Good transponder.
10305	Gravity core	1634/057	1900/057	31°45'.0N	29°49'.1W+	4139	MSES barrel fitted to Calvert core head. Pinger on core head. 1.57 m calcareous ooze with tephra layer 57-62 cm.
10306	High Res. Deep Profiler	1930/057	2115/057				Prototype instrument on CTD wire. Station abandoned before instrument got wet because of troubles with hydraulic ring main.
10307	Gravity Core	1023/058	1300/058	30°12'.8N	29°11'.5W+	4001	MSES barrel fitted to Calvert core head. Pinger on core head. Gentle slopes west of Great Meteor. 2.01 m of calcareous ooze recovered.
10308	Benthic Dredge	1350/058	2055/058	30°15'N	29°13'W*	4130	Dredge turned upside down and dug in. Spikes in tension up to 4.3 tons on heaving in. Only tiny piece of pumice recovered!

continued........

STATION	TYPE	START TIME	END TIME	POSITION LATITUDE	LONGITUDE	WATER DEPTH CORR. METRES	COMMENTS
10309	Survey Camera	2120/058	0137/059	30°17'N	29°14'W*	4139	Unsuccessful. Ran film, but flash failed to operate.
10310	Kastenlot Core	0232/059	0435/059	30°12'.3N	29°11'.2W+	3972	Very small amount of sediment recovered, probably because winch stopped too soon.
10311	Gravity core	1508/060	1810/060	25°39'.2N	30°57'.6W+	6129	MSES barrel fitted to Calvert core head. Pinger on core head. 2.17 m recovered. Brown pelagic clay over-lying yellowish gray then green calcareous clay.
10312	Survey Camera	1912/060	0212/061	25°42'N	30°59'W*	6050	Successful.
10313	Heat Flow Probe	0310/061	1100/061	25°45'N	30°56'W*	6140	500 lb weights added to top of drill pipe. Thermistor string broken loose at bottom end on recovery. No useful measurements.
10314	Kastenlot Core	1200/061	1500/061	25°38'.3N	30°57'.3W+	6130	2.40 m core recovered. Very similar to Station 10311.
10315	Benthic Dredge	0210/063	0859/063	26°12'N	26°59'W*	4940	Successful. Dredged for approx. 2 hours. Handful of pumice, clinker, shark's teeth, brittle stars, echinoids. Film jammed.
10316	Kastenlot Core	1010/063	1223/063	26°13'.2N	26°59'.1W+	4966	1.75 m of mottled brown to pale yellow sediment ranging from marly calcareous ooze to pelagic clay. Near Benthic Dredge site.

continued............

STATION	TYPE	STARTS TIME	END TIME	POSITION LATITUDE	LONGITUDE	WATER DEPTH CORR. METRES	COMMENTS
10317	OBS 7A deployment	1840/064	2016/064	31°04'.1N	25°49'.2W	4961	On hill 500 m above distal Madeira abyssal plain.
10318	Heat Flow Probe	2142/064	0554/065	31°15'N	25°43'W*	5433	10 penetrations. Bottom end of thermistor string found broken off on recovery. 4 penetrations successful.
10319	Survey Camera	0906/065	1545/065	31°15'N	25°43'W*	5433	Successful. Evidence of considerable biological activity - mounds, trails, organisms.
10320	Gravity Core	1708/065	1950/065	31°05'.2N	25°50'.0W+	5005	2.0 m of alternating marls and oozes. Hill 500 m above distal Madeira abyssal plain.
10321	Kastenlot Core	2015/065	2245/065	31°04'.8N	25°49'.3W+	4978	1.65 m recovered. Same site as 10320.
10322	OBS 5A deployment	1120/066	1246/066	30°20'.3N	24°06'.8W	5405	Madeira abyssal plain
10323	Gravity Core	1258/066	1614/066	30°21'.7N	24°06'.8W+	5406	1.67 m recovered. Alternation of oozes, marly oozes and pelagic clay. Turbidite from 51-81 cm.
10324	High Res. Deep Profiler	1615/066	1706/066				Prototype instrument on CTD wire. Station aborted due to troubles with hydraulic ring main. Not lowered into water.
10325	Kastenlot Core	1715/066	2005/066	30°22'.9N	24°05'.8W+	5407	1.06 m recovered. Ooze, marly ooze, pelagic clay strongly bioturbated throughout.
10326	High Res Deep Profiler	1824/067	2125/067	32°36'N	22°29'W	5260	Lowered to 4000 m. Instrumental problems.

continued...........

STATION	TYPE	START TIME	END TIME	POSITION LATITUDE	LONGITUDE	WATER DEPTH CORR. METRES	COMMENTS
10327	PUBS 2 deployment	0000/068	0043/068	32°36'.3N	21°56'.7W	5238	Launched at 0011/068. Waited for Sat Fix then headed for Funchal.
10328	Benthic Dredge	1415/076	2245/076	30°25'N	24°05'W*	5412	Successful. Dredged for 2 hours. Maximum wire out 7351 m. Camera photographed dredge bar. Pumice, clinker, piece of gneiss.
10329	High Res. Deep Profiler	2248/076	0309/077	30°21'N	24°06'W*	5402	Successful. Lowered to 15 m off bottom. Operating near bottom 0020-0145. Bottom penetration up to 45 ms. Instrument heave 3 m.
10330	Gravity Core	0024/079	0425/079	36°49'.0N	20°18'.8W+	4460	Triggered. 1.52 m recovered, largely foram nanno chalk.
10331	Gravity Core	0655/079	0930/079	37°07'.9N	20°04'.8W+	2730	Triggered. 1.67 m recovered. 5 cm of foram sand overlying 1.62 m of Pliocene from nanno chalk.
10332	Kastenlot Core	1903/080	2142/080	41°07'.5N	22°59'.8W	4111	Nothing recovered. Core catcher probably pre-triggered due to large heave.
10333	Kastenlot Core	2200/080	0050/081	41°07'.3N	22°57'.1W+	4133	1.74 m of ooze and marly ooze with some erratic pebbles.
10334	Gravity Core	0100/081	0143/081	41°07'N	22°58'W		Corer pre-triggered within 100 m of surface due to large heave. Station abandoned.
10335	Heat Flow Probe	1030/082	1830/082	42°07'N	21°48'W*	4060	8 penetrations. Top end of thermistor string found broken off on recovery.

*Mean position for station and corresponding depth

+Position of ship and depth at time instrument reached bottom

TABLE 2: OBS and PUBS PARAMETERS

INSTRUMENT	LAUNCHED	RECOVERED	LATITUDE N	LONGITUDE W	DEPTH corr. metres	REMARKS
PUBS 6	0353/054	1800/067	$32^{\circ}34'.9$	$22^{\circ}29'.4$	5262	Recorded
OBS 4A	0551/054	0029/074	$32^{\circ}35'.5$	$22^{\circ}29'.2$	5262	Tape recorder failed to unclamp
PUBS 2	0753/054	1545/067	$32^{\circ}35'.4$	$22^{\circ}30'.4$	5262	Recorded
OBS 6A	1543/055	2234/074	$32^{\circ}59'.6$	$25^{\circ}54'.1$	5388	Ran for about one day before tape-recorder jammed
OBS 7A	1916/064	1402/075	$31^{\circ}04'.1$	$25^{\circ}49'.2$	4961	Recorded
OBS 5A	1139/066	1327/076	$30^{\circ}20'.3$	$24^{\circ}06'.8$	5405	Recorded
PUBS 2	0011/068	1525/073	$32^{\circ}36'.3$	$21^{\circ}56'.7$	5238	Recorded

Table 3: Underway Geophysical Observations

Leg 1

MAGNETOMETER		SRP		2 kHz	
Start	Stop	Start	Stop	Start	Stop
1754/048	2236/048			1240/048	0730/050
2330/048	0706/050			1540/051	1400/052
1430/051	1430/052			1550/053	0300/054
1606/053	0306/054			0145/055	0900/056
0200/055	1442/055			2117/057	1000/058
1754/055	1530/057			0520/059	1430/060
2118/057	0918/058			1635/061	0158/063
0530/059	1424/060			1340/063	1300/064
1536/061	0136/063			2316/065	1100/066
1300/063	1812/064			2035/066	1230/067
2330/065	1112/066			0100/068	2310/068
2100/066	1236/067				
0118/068	2300/068				

Table 3: Underway Geophysical Observations

Leg 2

MAGNETOMETER		SRP		2 kHz	
Start	Stop	Start	Stop	Start	Stop
1430/072	1336/073			1358/072	1318/073
0136/074	1842/074	0150/074	1840/074	0153/074	1830/074
2306/074	1200/075			2306/074	1145/075
1448/075	0642/076	1500/075	0638/076	1513/075	0620/076
0342/077	0006/079			0336/077	0000/079
0954/079	1842/080			0943/079	1710/080
0300/081	0848/082	0340/081	0840/082	0350/081	0830/082
1906/082	0930/083	1921/082	0935/083	1918/082	1930/083
0924/084	2242/084	0930/084	0905/085	0904/084	1712/085
2300/084	0936/088				

Table 4: Summary of Core Sampling

CORE	TYPE	LENGTH (m)	ARCHIVE	NO. OF SUBSAMPLES TAKEN FOR ANALYSIS ON SHORE +
D10298	Kastenlot	2.20	√	25
D10302	Kastenlot	0.51	-	3
D10305	MSES/CALVERT	1.57	√	64
D10307	MSES/CALVERT	2.01	√	82
D10311))*	MSES/CALVERT	2.17	√	35
D10314)	KASTENLOT	2.40	-	-
D10316	KASTENLOT	1.75	√	71
D10320))*	MSES/CALVERT	2.00	√	78
D10321)	KASTENLOT	1.65	√	-
D10323))*	MSES/CALVERT	1.67	√	45
D10325)	KASTENLOT	1.06	√	-
D10330	MSES	1.52	√	60
D10331	MSES	1.67	√	59
D10333	KASTENLOT	1.74	√	48

* coring at approximately the same site

+ n.b. does not include 'physical properties' subsamples

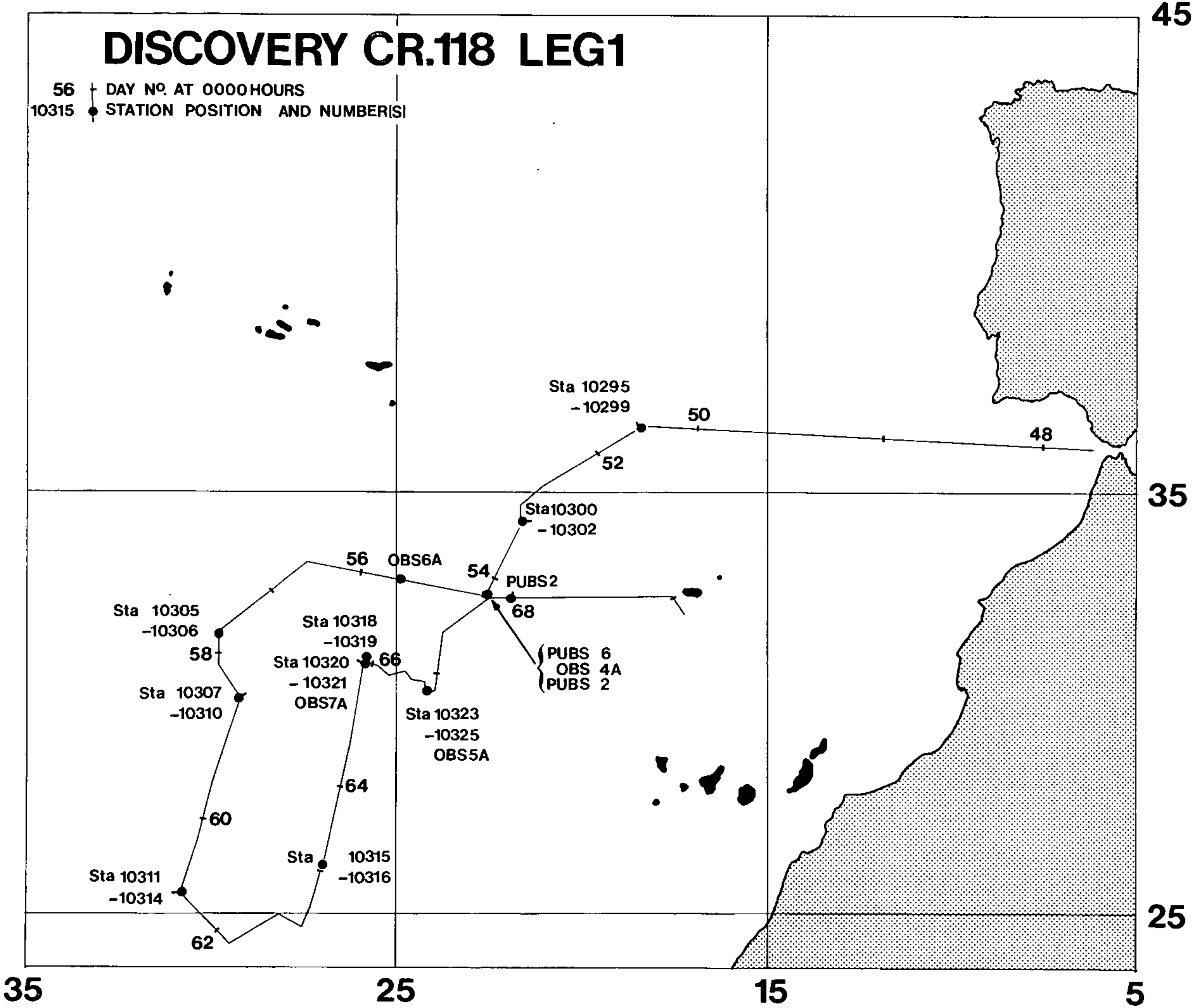
DISCOVERY CR.118 LEG1
56 DAY Nº. AT 0000 HOURS
10315 STATION POSITION AND NUMBER(S)
Sta 10295
-10299
50
48
52
Sta10300
-10302
56
OBS6A
54
PUBS2
68
Sta 10305
-10306
Sta 10318
-10319
58
Sta 10320
-10321
OBS7A
66
PUBS 6
OBS 4A
PUBS 2
Sta 10307
-10310
Sta 10323
-10325
OBS5A
64
60
Sta 10315
-10316
Sta 10311
-10314
62
45
35
25
35
25
15
5

FIG. 1

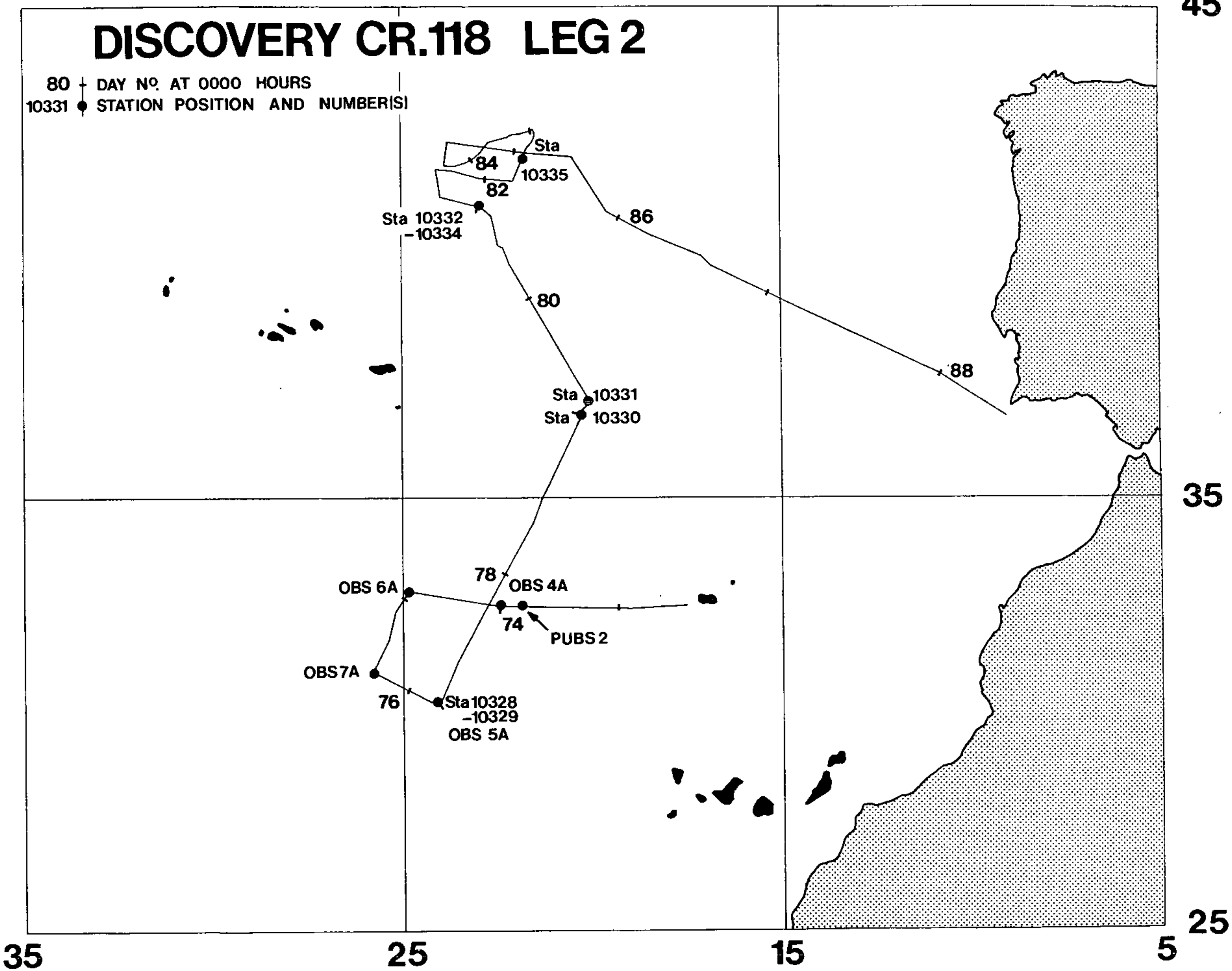
DISCOVERY CR.118 LEG 2
80 DAY NO. AT 0000 HOURS
10331 STATION POSITION AND NUMBER(S)
Sta
84
10335
82
86
Sta 10332
-10334
80
88
Sta 10331
Sta 10330
78
OBS 6A
OBS 4A
74
PUBS 2
OBS7A
76
Sta10328
-10329
OBS 5A
45
35
25
35
25
15
5

FIG. 2

KING'S TROUGH FLANK AREA

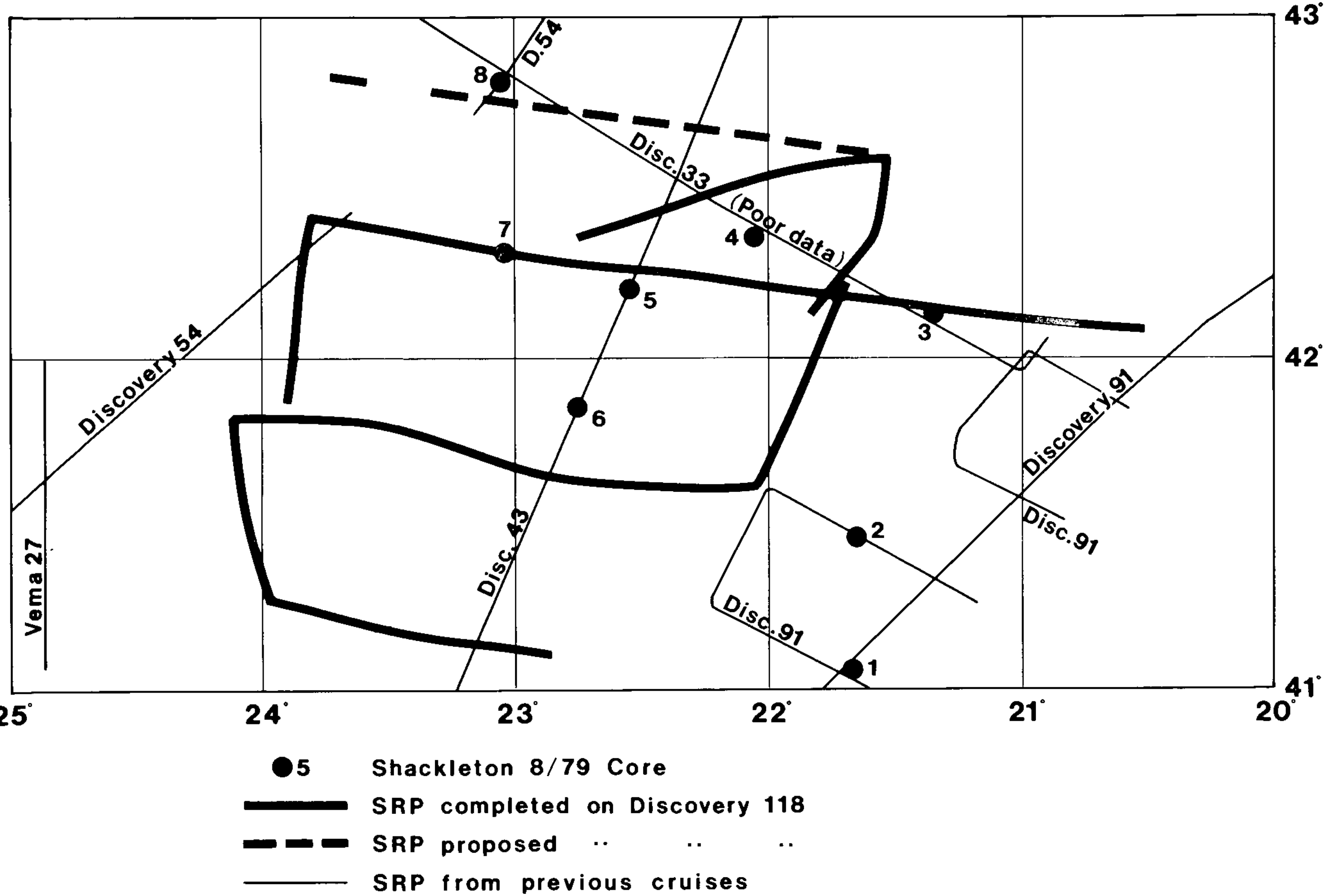

FIG. 3

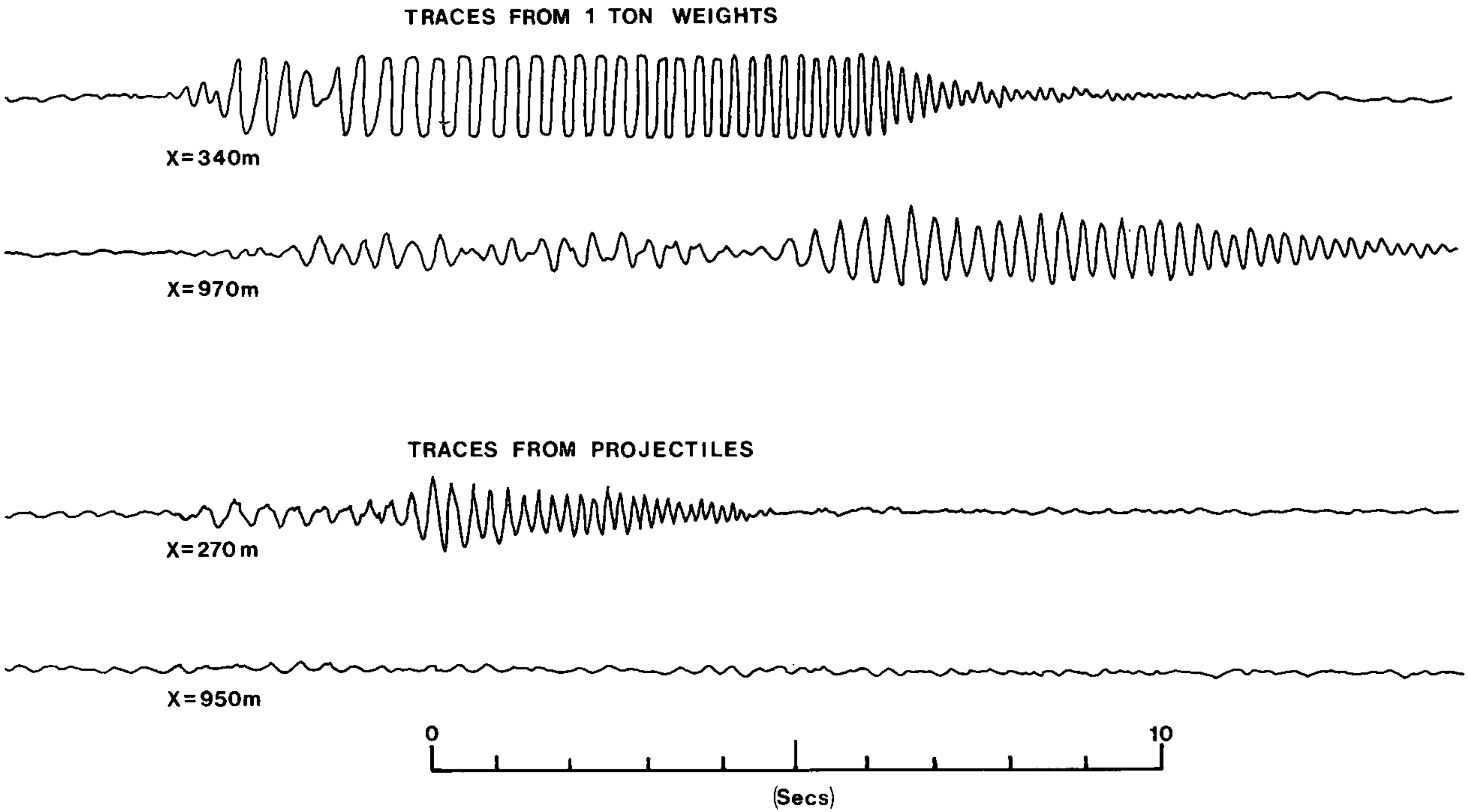
TRACES FROM 1 TON WEIGHTS
X=340m
X=970m
TRACES FROM PROJECTILES
X=270 m
X=950m
0
10
(Secs)

FIG. 4