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RRS DISCOVERY

CRUISE 144

22 JANUARY – 20 FEBRUARY 1984

GEOLOGY AND GEOPHYSICS OF AN AREA EAST OF THE GREAT METEOR SEAMOUNT

CRUISE REPORT NO. 161
1984

NATURAL ENVIRONMENT RESEARCH COUNCIL
INSTITUTE OF
OCEANOGRAPHIC
SCIENCES

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When citing this document in a bibliography the reference should be given as

SCHULTHEISS, P.J. *et al* 1984 RRS *Discovery* Cruise 144:
22 January - 20 February 1984. Geology and geophysics
of an area east of the Great Meteor Seamount.
Institute of Oceanographic Sciences, Cruise Report,
No. 161, 37pp.

INSTITUTE OF OCEANOGRAPHIC SCIENCES

WORMLEY

RRS DISCOVERY
Cruise 144

22 January - 20 February 1984

Geology and geophysics of an area east of the Great Meteor Seamount

Principal Scientist

P.J. Schultheiss

CRUISE REPORT NO. 161

1984

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ACKNOWLEDGEMENTS

The scientific objectives achieved during this cruise could not have been fulfilled without the wholehearted support and determination (sometimes with considerable perseverance in difficult circumstances) of the Master, Officers and Petty Officers. We thank them and the complete crew for their help in making this cruse a success. The PSO would also like to express his gratitude to the scientific personnel on board for their continual support and occasional perspiration which helped to ensure that this cruise was a success and continued for its full duration and to its planned destination.

Thanks are also expressed to R.B. Kidd who did much of the original planning but who unfortunately could not participate in the cruise. Gabrielle Mabley typed the manuscript.

ITINERARY

22 January (022) 1984	Departed Dakar, Senegal
20 February (051) 1984	Arrived Gibraltar

CRUISE OBJECTIVES AND BACKGROUND

The main objective of the cruise was to study the sediments and sedimentary processes in an area known as Great Meteor East (GME) - part of a feasibility study into the ocean disposal of high-level radioactive waste commissioned by the Department of the Environment. Previous cruises (Discovery 118, 126, 134 and Farnella 3/81) had done much of the ground work, consequently the area was already well known but not necessarily well understood for the purposes of our investigation.

It had already been ascertained that the surface sediments (at least the top twenty metres) consist of a series of distal turbidites (up to several metres thick) which uniformly cover most of the abyssal plain area and are interbedded by much thinner pelagic units of clays and marls. Within the area there are a number of abyssal hills whose character was not so well known. In particular, the sedimentary processes involved when massive amounts of material are deposited as turbidites are not clear. One objective, therefore, of this cruise was to look more closely at the pelagic/turbidite boundary to gain an insight into the mechanisms involved. It was intended to take long piston cores and conduct a camera survey over the pelagic/turbidite boundary to the south of the area to cover the objective.

Another major sedimentary objective revolved around the so-called 'faults' which had been observed on 3.5 kHz records on previous cruises. The nature of these features has been the subject of much discussion and, in an attempt to resolve some of the uncertainties and implications, a detailed seismic survey was planned for the area of their greatest known abundance. Using near-surface air guns and 3.5 kHz together with an experimental Near-Bottom High-Resolution Profiler developed by R. Babb it was intended to run a detailed survey over a small area with the aid of three 5 kHz bottom transponders to provide accurate navigation. The objective, apart from mapping and observing the 'faults' in relation to basement, was to record the features on magnetic tape for subsequent analysis and modelling.

Another main objective on the GME area was to investigate the possibility of pore water advection occurring naturally within the sediments. To meet this objective it was planned to measure both differential pore pressure using the new

Pop-Up Pore Pressure Instrument (PUPPI) and Heat Flow with the recently modified probe over a well navigated transect.

On a hill to the north, a previous cruise had photographed vast numbers of pebbles, the nature of which was not clear. During this cruise it was planned to run a camera survey over a hill in the west of the area to see if they exist there and, if so, to dredge for them if time permitted. In addition to this, it was planned to lay a transect of three current meter moorings on the abyssal plain, on the flank of the hill and on the top of the hill to look at bottom water current regimes around these abyssal hills.

On the passages to and from the GME area, GLORIA transects were planned to reveal the distribution and frequency of turbidite channels and pathways on the northwest African continental rise.

NARRATIVE (all times GMT)

RRS Discovery departed from Dakar at 1317 on day 022 (22 January 1984) as planned and headed NW into the Atlantic. An overall track chart for the cruise is shown in Figure 1. At 0900 the following morning (day 23) the PES and 3.5 kHz fishes were deployed and scientific watchkeeping began at 1100/023. The ship heaved to at 0400/024 to conduct a midships wire test (10959) of a command pinger before deploying GLORIA, the magnetometer and the SRP system (160 cu. in. air gun and single channel hydrophone). By 0930/024 the ship was underway with all systems working well. We were continually hampered for the next few days by northeasterly winds which delayed our arrival at the GME study area. Despite this, some excellent GLORIA sonographs were produced showing numerous channels running normal to the depth contours at the bottom of the West African continental rise. It was decided to extend the planned GLORIA transect up past the debris flow into the northwestern sector of the GME area where two abyssal hills occur. This transect was completed (after having observed the debris flow with remarkable clarity on the GLORIA records) at 0500/029 and the gear was brought inboard.

After a brief survey with the 3.5 kHz system a site with relatively thin sediment cover was located and the PUPPI was launched at 1152/029 (10960). After having monitored its descent and penetration the ship moved approximately six miles to the east where a midships wire test (10961) was conducted on a command pinger and an unmatched pair of glass hemispheres (one hemisphere of a bottom transponder had been damaged and a replacement was being tested). After a successful wire test the first curent meter mooring was laid on the abyssal plain (10962) at 2052/029.

The 5 kHz acoustic net, which was to be used extensively, consisted of three bottom transponders which were deployed on a 14 km equilateral triangle by 0110/030 (10963, 10964, 10965). At 0330/030 the SRP system was streamed and the detailed 'fault' survey began, running SRP, 3.5 kHz and the PES. The survey lines ran NW-SE and are shown in Figure 2. Two seismic refraction lines were incorporated into the survey (10966 and 10967), using disposable sonobuoys as receivers, at 2054/030 and 1742/031 respectively.

The SRP system was recovered after the ship had made a transect over the western hill at 2224/031. This showed that the hill was covered by what appears to be thick pelagic drape. A camera survey transect was made over the flank of the hill (10968) on day 032 but on recovery it was found that the camera monitor had flooded and no pictures had been taken.

Following a successful midships wire test (10969) at 1724/032, on two command pingers, the piston corer was deployed on the hill (10970) and recovered a good core. After having returned to the transponder net and run a few lines using the 3.5 kHz at acute angles to a 'fault line' the ship proceeded to Station 1060.

At 1015/033 the PUPPI was acoustically commanded to rise off the sea floor but failed to respond. Having ascertained that it was probably stuck in the mud and that the command pinger batteries would probably not last for more than a couple of days because of a 'timing out' fault, it was decided to try dragging for the device. This decision was based on the value of the data in PUPPI and the subsequent data that could be obtained on this cruise should we manage to recover it and not on the value of the instrument. A successful piston core (10971) was taken close to the PUPPI site at 1355/033 before the dragging attempt began. Despite believing that we had closed a loop on the seabed of nearly 4000m of rope and wire around the PUPPI (in a water depth of 5435 m) it proved unsuccessful in dislodging the instrument and the attempt was abandoned at 1400/034.

At 2130/034 the first heatflow station began (10972) and made a successful transect using the acoustic net across the northern 'fault line'. The ship proceeded back to the western hill where another good piston core was recovered (10973) at 2100/035. A second camera survey was then attempted (10974) but with the same devastating result as had previously occurred. Another successful piston core (10975) was taken before the remaining two current meter moorings (10976 and 10977) were laid on the flank and top of the hill respectively, in worsening weather conditions.

During the early hours of day 037 some extra 3.5 kHz lines were put in over the 'fault line' before proceeding to station 10960 to observe whether the back-up release timer at 1016/037 had any effect on the stubborn PUPPI. It did not, and in very poor weather (Force 8) the station was abandoned at 1206/037. The ship proceeded to a northern hill to dredge for pebbles which had been photographed on a previous cruise because the weather prevented any other station work. By 2306/038, after two dredge attempts (10978 and 10979), we had recovered approximately 100 kg of mainly manganese-coated basalts ranging in size from small pebbles to large boulders.

In improving weather conditions the ship steamed back to the transponder net and at 0730/039 Babb's near-bottom high-resolution profiler was deployed at Station 10980 (Fig. 3). Despite the difficulties of towing this device some very good records were obtained. In particular it was proven that at least one of the 'faults' was indeed a sharp discontinuity. However, out of four confirmed crossings of the northern 'fault line' only one sharp discontinuity was found suggesting that the 'fault line' may not be a continuous linear feature. The profiling continued until 2205/040. At approximately 0130/041, as the gear was being recovered, the 100m CTD wire pennant fouled the propeller and became entangled. The engines were stopped and we were hove to until morning when an inspection took place from the rubber dinghy. After an attempt to free the wire by turning the propeller manually and heaving on the wire it was considered prudent to stop in case any damage should occur to the stern gland which might jeopardise the next cruise. At 1530/041 the 3.5 kHz, 5 kHz and PES fishes were recovered and we headed for Ponta Delgada on the bow thruster. The following day a further attempt was made to recover the gear and to free the wire. At one stage the ship was heading for Ponta Delgada astern at three knots on the bow thruster while teams of scientists took 15 minute watches operating the propeller shaft winding gear. The wire was very slowly being unwound by applying tension using the capstan. With great relief all round the wire came completely free at 1845/042 and we headed back to the GME area to resume the cruise programme. Both the 3.5 kHz and the PES fishes were deployed at 2130/042 and by 0600/043 a third attempt at a camera survey was being undertaken. Camera Station 10981 was as disastrous as the others and it was concluded that an intrinsic flaw in the metal end cap of the pressure case was to blame.

Core Station 10982 began at 1655/043 and was acoustically navigated using the remote interrogator onto a small target on the SE side of the fault which had been located on the near-bottom profiler records. A 17.72m core was recovered. At 0301 the heat-flow probe was launched (10983) and an acoustically navigated transect of 11 penetrations was performed over the 'fault', with thermal conductivity measurements being made on five of the dips. The final station of the cruise was a piston core (10984) which was once again acoustically navigated onto a target the other side of the 'fault' at 2115/044. However, an unexplained failure to trigger properly first time on the sea floor resulted in a very bent corer returning to the surface. To compound these difficulties one of the handling ropes fouled the propeller and again we had to wait until daylight for an inspection. After more strenuous shifts on the propeller shaft winding gear and pulling the rope on the capstan (not to mention the helping hand given under water by T.H. and P.J.S.) the rope came free at 1445/045. During this time one of the transponders (10965) was recovered and the other two (10963 and 10964) were safely on board by 1900/045.

At 1912/045 we began to launch GLORIA and by 2112/05 we increased speed to 8 knots with GLORIA, SRP, the magnetometer and the gravimeter all operating. We recorded another good GLORIA record of the debris flow as we passed out of the GME area and headed east towards Gibraltar.

The following two days did not reveal many features on the GLORIA sonographs despite having adjusted our intended track to maximize the few hours extra time that had become available. Between 0900 and 1120 on day 049 all the gear was safely recovered inboard; scientific watchkeeping ended at noon and the ship headed directly for Gibraltar in very calm waters. Discovery docked in Gibraltar on schedule at 09090/051 marking the end of Cruise 144.

GLORIA

The GLORIA-II system was used on passage from Dakar to the working area and then again on the passage from the working area to Gibraltar (Fig. 1). The vehicle was launched at 0840 on Day 24 after clearing the 200-mile line and recording started at 0930. The passage continued until 0500 on Day 29 when the vehicle was recovered on arrival in the working area. Conditions at the launch were reasonable with a slightly lumpy sea and about 20 knots of wind. During the passage conditions were considerably worse with winds in excess of 25 knots, but fortunately the wind was on the bow and the seas never got too big so although the passage was slowed a little the cable suffered no damage. Recovery was effected in the dark with a confused sea and a stiff breeze, by no means the worst conditions in which the vehicle has been recovered but not very good.

Fortunately, it was uneventful. The system produced some valuable and spectacular sonographs, principally of various sediment facies. Interruptions to recording were fairly few in number and only totalled about an hour.

Conditions were ideal for the second launch on Day 45 which went without a hitch. Sampling started at 2130 and continued until 0900 on Day 49. A little trouble was experienced from time to time with one of the tape cartridge drives resulting in data loss for a total time of 49 minutes in three and a half days. Unfortunately, the longest of these lasting 25 minutes was over the Agadir Canyon which was an area of particular interest. Recovery was effected at 1000 on Day 49 in a flat calm, without incident. Apart from a submarine volcano of impressive size encountered at the end, the sonographs on the second run were relatively featureless and much less spectacular than those on the first. The port-side records were marred to some extent by the re-appearance of an old fault in the beam steering components which manifests itself as a random and intermittent reduction of signal lasting from a few seconds to half a minute. Though it does not actually remove data, the resultant stripiness of the sonographs does make it harder to spot subtle features.

Sonographs obtained to the north of the Cape Verde Terrace show turbidity flow pathways originating from across the terrace and swinging to the northwest. Further pathways from sources on the African slope continue across the sonographs to the north up to 25°N, they are absent until 29°N. At 30°30' the large debris flow previously mapped during the Farnella 3/81 cruise is passed over with a particularly clear view of its 'toe'. On leaving the GME study area another view, this time of the northern edge of the debris flow, is seen; this shows far more internal structures than were seen from the other direction of insonification. Further to the east evidence of turbidity flow pathways is abundant. Opposite Madeira they are not so clear but there is still a slight hint of them. There is no clear indication of flows originating from the Agadir Canyon.

M.L.S. and P.M.H.

Seismic Reflection Profiler

A two-channel Geomechanique hydrophone array was deployed with a 160 cm^3 Bolt airgun. The system was run at eight knots during passage to and from GME and at 4.0 knots while on GME using acoustic navigation. The data was displayed on two EPC 4600 recorders using 15-100 Hz and 40-150 Hz filter pass bands and a variable six-second recording window. The depth sensor situated forward of the first active channel was calibrated on deck using a 'Tangye' hand pump and a calibrated pressure sensor. The gun depth was determined by attaching the pressure transducer to the gun during a calibration run at various speeds. It could be seen during the passage to Gibraltar that despite the comparatively high speed (8.0 knots) the array still towed at almost 20m depth. In future, Ashbrook depth controllers ought to be considered to restrict the depth to a 10m optimum.

C.P.

Airguns

The basic system used during the cruise was a single 1500c airgun with a 160 cubic inch air chamber, two guns were used in all. The system was used in conjunction with a Geomechanique two-channel array hydrophone, with a firing rate between 12 and 15 seconds. There were three breakdowns causing interruptions in programme. Two of these were due to failure of stainless steel bolts which hold the tail section to the gun. This was remedied by replacing the 7/16th bolts with half-inch bolts. The one other breakdown was due to a failure in a 16 ft trigger cable. One other failure was experienced which resulted in a flooded gun, caused by a pressure reducing valve failing in the compressor flat. Other than this, the airgun system worked as expected for the duration of the cruise.

K.S.

Magnetometer and Gravimeter

The Varion V75 magnetometer was towed on passage from Dakar and Great Meteor East and between GME and on passage to Gibraltar. The system worked well throughout with only ± InT scatter on all readings.

The data was reduced to IGRF 1980.

The Lacoste and Romberg Gravity meter, S40 was run on passage from GME to Gibraltar, all the data was tied to WHOI station 826 in Dakar using a Worden "Prospector" for the ship to base tie. Observations were reduced to IGSN '7'.

C.P.

3.5 kHz Profiler

The 3.5 kHz profiler transducer fish was deployed on 23 January 1984 and finally recovered on 18 February 1984. During this time the system was in continual use except for short periods when the 5 kHz transponder navigational system or the deep-towed profiler were being used. Throughout this period of operation it was only necessary to carry out routine maintenance in order to obtain good quality sonographs.

The records show penetrations of the sediment of up to seventy metres in some places. Good correlations with differences in reflectivity on the GLORIA sonographs and the changes in the 3.5 kHz echo-character are evident in many places. Using the half-second sweep enabled the full resolution of the system to be used with great effect.

M.J.H. and P.M.H.

Acoustic Navigation

During the passage from Dakar to the working area three bottom transponders were prepared for the 5 kHz acoustic navigation net. In the case of bottom transponder number BT1 this involved dismantling the instrument sphere to replace a damaged evacuation port. On disassembly, slight spoiling of the glass under the port O-ring sealing area was observed so an adapter plate was made with a larger O-ring on its undersurface. The instrument proved awkward to re-assemble and during the course of this operation one hemisphere, fortunately the lower unbreached one, suffered severe spoiling on the equatorial mating surface. It was decided to attempt to re-assemble the upper hemisphere with its electrical ports with an unmatched half from a plain buoyancy sphere. The best sealing position for the two halves is found by marking them up and rotating one half with respect to the other about their common axis until minimum leakage is found. The test for leakage is to evacuate the spheres as fully as possible and paint detergent solution round the equatorial join, when the bubbles of air can be seen running in. In this way it was possible with the first spare hemisphere to maintain, with a perfectly dry equatorial joint, at least 75% of the vacuum over a period of two hours. With the two halves properly sealed a wire test to 5300m was successfully carried out on arrival at the working area. After this the sphere was dismantled again and carefully re-assembled with the instrument installed.

The three transponders (BT1, BT2 and the tube transponder T16) were deployed on a 14 km equilateral triangle (Fig. 2). BT1 proved to be extremely sensitive and, in fact, on the first attempt discharged its ballast weight on ship noise while hanging in the water for testing prior to letting go. The subsequent estimated positions were:

'A'	(BT2)	on Chan 4	31°24.8'N 24°43.8'W
'B'	(T16)	on Chan 18	31°17.3'N 24°44.9'W
'C'	(BT1)	on Chan 14	31°24.2'N 24°52.4'W

These positions are known relative to each other to within ± 25m, but as yet no regression analysis has been carried out against the 16-day series of satellite fixes. This needs to be done before the area is next occupied, although again it is possible that a partial re-run of the 3.5 kHz profiler survey will serve to fix any new network to similar accuracy with respect to the geophysical features of the area.

The network was laid on Day 029 between 0200 and 0505 and all three transponders were recovered uneventfully on Day 045 finishing at 1815. The rise times through the water column being about one hour.

The transponder network was deliberately given the largest possible base, because the primary task was the detailed 3.5 kHz profiler and SRP survey of the area but for subsequent work it proved that the SE transponder, B, was rather remote and being relatively insensitive often ignored the interogation pulses. A further disadvantage of the wide network was the need, when using the remote interrogator, to fix the position of bottom instruments, to mount the RI at sufficient height from the bottom to allow for the upward curvature of sound rays at depth, and to ensure that the transponders of interest were not in a shadow zone. In fact, in the actual baseline a minimum theoretical height of 700 metres was required ever to hear two transponders, while 1-5 km was needed to ensure reliable communication. In the event, a compromise of 900 metres was chosen knowing that for the position envisaged 'A' would always be in 'sight' and 'C' might be. As it happened, precise navigation on both transponders was obtained. The instrument dips concerned were near-vertical dips so the extra error in the bottom 900 metres is not large.

It was intended to use the Ship DP system to run the fixes from keyed-in transponder times, and a Fortran program called 'PINGER' resides on the system. In the event this proved impossibly inconvenient and, more seriously, when only two transponder times were available there seemed to be no way of resolving the ambiguity. Fortunately, a fall-back position was available in the HP 9810 desktop calculator, and a program had been prepared to print out ranges from keyed-in times. For the remote interrogator a further program was written on the Geophysics HP 67 hand-held calculator. The ranges were put on the plot by hand using a beam compass. It should be pointed out that if the plotting is done manually there is no advantage whatever in computing Cartesian co-ordinates since it makes the plotting actually harder. Furthermore, automatic plotting by drum or x-y plotter would involve the director of operations in great working difficulties. In fact, from experience during cruises 142 and 144 it would seem that the best solution would be a micro-computer (e.g. the BBC) running in BASIC with a monitor and printer to record all transactions, with prompts to the operator to make operation easier.

The EPC 3200 facsimile recorder from which the times were read is not really suitable for this task, and twice the Raytheon LSR had to be substituted, with an enormous improvement in record quality and readability.

Finally, a few remarks about network scales and navigation of deep-towed instruments could be conveniently added here. It has already been noted that there is a conflict between the advantage of a wide set of baselines for the ship navigation, and the extensive bottom shadow zones encountered by remote instruments in consequence of this. Two possible solutions present themselves. First, one could lay a double network, with a smaller triangle for the remote navigation, or, second, one could use the wide net for the ship and a short baseline system for the deployed instrument. The ultimate accuracy of such a system depends upon the signal-to-noise ratio at the short base-line (i.e. the receiver), so clearly this has to be the remote instrument. The other side of the coin, of course, is the need to process the acoustic data locally and pass the information back to the ship through a very limited capacity communication channel. It is planned to prepare a report on this subject in the near future.

M.L.S.

Disposable Sonobuoys

Two successful sonobuoy deployments were made (Fig. 2), both used the non-explosive type of instrument. Station 10966 (2054-2306/030) was located on a line bearing 124°, to the southeast of the 'fault' study area. Over two hours of records were obtained out to a distance of 26 km.

Station 10967 (1742-1904/031) was located on a line bearing 270° to the west of the 'fault' study area. Over one hour of records was obtained out to a distance of 16 km. Initially, this station used an explosive type of sonobuoy but it was not possible to pick up any signals, an ordinary one was used instead. It should be noted that it is not possible to check the signals of an explosive sonobuoy before deployment, unlike the non-explosive types. The explosive sonobuoy had been stored in the explosives locker on the bridge deck for a long time and the humidity indicator had started to show an unsafe condition.

P.M.H. and C.P.

Near-bottom Profiler

A previous cruise had revealed the potential usefulness of the near-bottom profiler but had also emphasised the need for two major improvements, namely, much more precise navigation and a method of stabilising the transducer against vertical motion especially ship motion transmitted down the cable. The near-bottom profiler was designed by Richard Babb to be towed at 50-100 metres off the sea-floor. It uses a very short pulse of 7 kHz energy (two full cycles, after which the transducer is clamped by a thyristor to dissipate stored energy), which gives it a theoretical resolution of about 0.3 metres at sea-water velocity. This reolution is degraded with penetration due to the steady attrition of high-frequency energy. In the soft sediment of Great Meteor East strata with a nominal depth of at least 20 to 30 metres are revealed.

For a number of reasons the problem of navigation was not fully tackled. The transponder system was in use from the ship but the remote interrogator was not employed, so the uncertainty introduced by the catenary was not removed. However, precise acoustic navigation of the ship was available. Had there been the opportunity for a second dip the remote interrogator might have been used. The heave problem had been tackled by Babb by the use of an IOS deep-sea tide gauge. This has a frequency-modulated output accurate over the long term to a few centimetres at full ocean depth. With an ingenious electronic circuit, Babb has de-coded the tide gauge outfit and used it to modulate the timing of the transmit pulse to stabilise the apparent transducer depth. This gauge is known to have short-term fluctuation of several times its long-term stability, and the question was whether this could be filtered out and smoothed enough to use without introducing objectionable jitter in the records. Because this question was un-answered a second, mechanical line of defence had been worked out and tried briefly on Cruise 142. This was to make the transducer vehicle neutrally buoyant and to attach a weight to the towing cable some distance ahead of the vehicle, so arranging a crank in the tow with the last 100 metres being approximately horizontal. The profiler needs an armoured electrical towing cable and the only possible cable aboard Discovery was the CTD cable on the Starboard midships winch. Since the cranked cable towing arrangement was needed it was necessary to bring the cable aft by means of a large diameter snatch block at the foot of the starboard winch A-frame, and thence into the water over a similar block on the Schat Davit on the poop, with the davit slewed fully outboard to lead the towing point aft of the transom.

Due to a short circuit it had been necessary to remove 630 metres of CTD cable, and a good 100 metre length of the scrap was used as the CTD extension beyond the weight. This enabled the weight to be shackled to a proper termination on the CTD wire. Scrap anchor chain amounting to 180 kg was used for the towing weight and three Benthos glass spheres were used for buoyancy. It was calculated that this would make the instrument frame approximately 10 kg buoyant, but it was not possible actually to weigh the whole rig in air and water. Again the CTD wire is heavy whereas the horizontal leg should be neutrally buoyant, so it was not a perfect rig. However, it was very effective in removing the effects of the major short period ship motions as the records show. Because of the inability to do proper balancing trials it was not known with certainty that the rig was towing horizontally but calculations showed that the towing cable angle would dominate the attitude. This is borne out by the record which show evidence of heave-induced pitch, i.e. heave at the ballast weight causes the transducer frame to pitch, which superimposed on perhaps a standing pitch angle caused periodic variations in record intensity, due to the beam angle of the transducer array. The actual wave period heave on the record was insignificant.

The rig also served as a demonstration of the validity of the towing arrangement for the IOS TOBI, but it will be necessary to pay particular attention to pitch motion induced by towing cable motions.

The depth gauage proved to have an objectionable amount of short-term fluctuation in spite of a phase locked loop filter. In fact, using it online to compensate for heave would definitely have degraded the records. However, it will prove extremely useful in removing all periods longer than about 20 seconds if the series of delay values is smoothed. The depth gauge pulse was recorded as well as the acoustic signal so the experiment will be fairly straightforward to perform.

The difficulties in actually towing the rig arose mainly out of the fact that the CTD wire was close to the end of its scope and the winch was at its rated maximum load. This made it very difficult to fly the instrument near the bottom and restricted ship speeds to about 0.5 knots if the transducer was to remain close to the bottom. To compound the problem there was a significant surface current running, and ignorance of how far the rig was behind the ship forced some of the crossings of the feature of interest to be overdone for certainty and this slowed the whole operation. However, there were four proven crossings of the suspected linear feature of which only the last one contained a dramatic discontinuity in the record.

On the electronic-acoustic side, the rig appeared to be noisy except when wire was being veered. Also, it is suspected that the acoustic output was low but this was not certain and there was sufficient signal to serve the purposes of the experiment as long as the instrument was near the bottom.

The system was launched without incident at 1015 on Day 039 and was then towed until 2205 on Day 040 (Fig. 3). Five tapes of 3600 feet were filled in both directions amounting to over ten hours over several portions of interest. The tapes were not replayed on board but the recorder had read-after-write heads so the data is confirmed.

Recovery went well until the final stage of bringing the rig alongside when the piece of CTD wire used for the horizontal tow accidentally fouled the propeller. From the point of view of the Near-bottom Profiler it is only necessary to record that the instrument tube and tide gauge were recovered together with the buoyancy spheres, six of the seven transducer rings and five of the plastic wave guide rods. With great persistence and skill the ship's company managed to clear the propeller. The framework of the rig was damaged beyond repair.

M.L.S.

Piston Coring

For the first time after several cruises the piston coring system worked well. The main coring objectives were to core all the PUPPI stations, to core sediments at increasing heights above the plain on an abyssal hill, to core either side of a fault in the transponder area and to core through the debris flow to the south-east of the study area. Since PUPPI was lost on its first deployment only one PUPPI-related core was taken; lack of time at the end of the cruise also prohibited us from taking the debris flow cores. The newly-designed acoustic release worked well.

Three cores, D10970, D10973 and D10975, were taken on the low abyssal hill in the western part of the study area. From the S.R.P. crossings it was obvious that this hill was covered with draped sediments, and thus would provide an ideal area to core at various heights above the plain. The three cores were taken at

5332m, 5392m and 5418m respectively, and can be used to ascertain the thicknesses of turbidity currents which enter the area. Although no cores were split on board, 'P' wave logging of core D10975, and inspection of the cores through the smeared liners suggests that no thick turbidites were penetrated. Since core D10975 was taken only 15m above the plain level the turbid flow may turn out to be a very thin layer. Caution must be exercised, however, with the value of the water depth, since later transponder navigated cores showed that the corer could be up to 0.6 km away from the ship. Thus the corer could be considerably upslope or downslope from the ship's position. One interesting feature of these cores is a thick layer (over 3m in D10975) of red clay at their base. Such a thickness of red clay of Pliocene age has been recorded previously only in a single core from the Cape Verde basin. The origin of this clay, in only one core, has until now been enigmatic but, if the GME red clay should be of the same age, this would give us an insight into pre-Quaternary bottom water history in the North Atlantic.

Core D10971 was taken at the position of the PUPPI site and produced 12.98m of turbidites and thin pelagic units, typical of the abyssal plain. A liner section stuck in the lowest barrel of this core was removed by pulling with a block and tackle at one end and pushing with a hydraulic jack at the other.

After completion of the fault survey the transponders were used to navigate two cores, one on either side of a prominent fault. This fault showed progressively increasing offsets of reflectors with depth, and so we attempted a six-barrel core on the upthrown side of the fault and a seven-barrel core on the downthrown side. We also hoped to hit a prominent reflector which was apparent only on the upthrown side of the fault. The first core (D10982), on the upthrown side, produced 17.71m of core which should have penetrated the reflector. The second core (D10984) was a failure. Firstly, a pre-amp failed in the MUFAX during the firing of the release and, although it appeared as if the release had operated, the corer did not trigger when lowered to the seafloor. The firing procedure and re-lowering were, therefore, repeated and the corer triggered apparently normally on this second attempt. Either the pyro had not fired or the pin had not retracted on the first attempt. However, later, we found the core in a very bent condition. In retrospect, the lowering in an unprimed condition must have caused the bend which would then have been exagerated by the second lowering. Unfortunately, after returning the corer to its bucket on the ship's side, one of the handling ropes slipped off and became fouled in the propeller. This was because the bend in the core barrels went under the ship and forward, hence significantly shortening the distance from the end of the barrel to the handling point on deck. The corer was eventually brought inboard and the rope was later cleared from the propeller. Although there was about 16m of core in the barrel this may be mainly flow-in.

In the first four cores there was a large gap between the top of the sediment and the piston at the top of the barrel. Similar 2-3m gaps had been present in previous cores. We attempted to solve this problem, firstly by tying the warp very securely to the bail at the top of the corer to ensure no slip of the piston during lowering and to ensure that on triggering the weaker ties on the coil of warp on the trigger arm would break first. This did not solve the problem but is probably a useful precaution. Secondly, we attempted to improve the seal between the piston and the liner by tightening the piston using a lever on the allen key and a stilson spanner on the liner. Core D10982, which was subjected to this treatment, did produce a nearly full barrel and so we propose to continue with this method. A summary of the wire and chain lengths used for the corer on this cruise is given in Table 2.

P.P.E.W. and D.G.

Pop-up-Pore-Pressure-Instrument: PUPPI

Following the highly successful deep water trials of PUPPI on Discovery Cruise 141 it was planned to deploy the instrument up to six times on Cruise 144. It was intended to have a line of stations across a basement valley to look for any naturally occurring pore-water advection If successful, the final deployment would be left for five months to look at the long-term effects of pore pressure on the instrument. As it happened, this plan never got far off the ground.

PUPPI was deployed at 1152/029 (Station 10960) with six ballast weights from the midships winch using a modified release mechanism which proved to be a far safer launch technique than had been used previously from the aft hold hatch. It decended at 2.5m s^{-1} as expected through the 5435m water column and penetrated fully with no measurable tilt (<10°). The EPROM logger had been programmed to allow recovery to occur at two-day intervals up to eight days when the back-up clock was set to fire the pyros. After four days (1015/033) the acoustic firing system was operated indicating that the pyro-firing relays had closed. However, PUPPI did not rise from the sea bed. In addition, the acoustic beacon did not 'time out' after the expected 40 minutes and after a few hours the pulses became irregular and stopped. The release mode beacon was switched on successfully again but it was feared that the batteries would fail before the back-up clock fired in a further four days time. It was thought that the most likely explanation as to why the instrument would not rise off the bottom was because it had over-penetrated in the mud and that the excess buoyancy was insufficient to overcome the resultant suction.

Consequently, an attempt was made to drag a long wire around the instrument; the idea being that the disturbance would be sufficient to free PUPPI from the mud allowing it to rise under its own buoyancy. The drag line was made up of 1900m of rope with 4 x 50 kg chain sections acting as sinkers attached to 1500m of auxiliary wire. The main coring warp was attached to the auxiliary wire and a 0.5 tonne suppressor weight was bulldog-clamped at 1000m up the coring warp. We laid this complete length on the sea floor, a total of 4400m, and encircled PUPPI using a combination of satellite fixes and transponder ranges. This 26-hour operation, however, failed to have any impression on the instrument at all, although on recovery most of the rope was found to be missing caused by what looked like a cut by a blunt object.

We returned to the station at 1000/037 and found, much to our surprise, that the release beacon mode was still transmitting weakly. However, the instrument failed to rise after the back-up clock timer had fired and the instrument was abandoned.

There are three possible causes of this failure: (a) both pyros had leaked and failed; (b) both or either of the glass spheres had leaked; (c) PUPPI had over-penetrated the mud suction was holding it down. Out of these three, the third seem the most likely. No more drops were performed as this was the only instrument available for this cruise.

P.J.S., S.McP. and B.H.

Heat-flow - Instrumentation

Consequent upon the realisation that the logger would have to be re-built due to the partial flooding of its pressure case on the last Heat Probe dip of Cruise 134; it was felt that this setback could be turned to good account by seizing this opportunity to replace the tape unit in the probe with a non-volatile solid-state memory. This would enable the replay of collected data directly from the pressure case to the computer without the intermediate step of using a tape reader.

The Acoustic Telemetry System was to remain as before. A Solid State Memory Heat Probe was subsequently designed and constructed. The new logger was completed and de-bugged during the first part of the cruise in time for Station 10972 when good data was written to the memory and later read to the ship's computer.

It was also hoped that the relay which had been used in the previous Heat Probe could be replaced with solid state devices since these held out the promise of injecting precisely repeatable pulses of thermal energy into the sediments. Whereas arcing of the contacts on the relays indicated that the precise amount of thermal energy delivered to the sea-floor by the previous unit was questionable.

A problem with the timing circuit precluded the operation of the Heat Pulse on the first station; however, this fault had been overcome in time for the second station when the total system performed satisfactorily in all respects.

Deployment

Since the 3.5 kHz survey conducted during the earlier part of the cruise had demonstrated the presence of extensive sediment faulting in the GME study area it was decided that heat-flow measurements would concentrate around these features to see if they were associated with rapid pore-water advection. The heat-flow measurements made use of the acoustic net which located the fault survey.

Two approximately linear transects were run over a NE-SW trending fault feature (Fig. 3) which had a clear signature on the 3.5 kHz and near-bottom profiler surveys. During the first station (10972) eleven sediment penetrations were made along a 9 nm transect trending SE across the fault. During this station the ship's position was located with respect to the bottom transponders and it is estimated that one measurement came within several hundred metres of the fault plane. No in-situ conductivity measurements were made.

During Station 10983, a parallel transect of eleven dips was run across the same fault at a point where the 3.5 kHz survey indicated the development of a graben-type feature. A remote interrogator 900m above the probe permitted more accurate navigation and consequently two of the dips were placed within 100m of each fault plane in the graben. The probe was unable to penetrate the sediments within the graben centre possibly suggesting a harder consistency here. Temperature decays from five heat pulses will enable in-situ thermal conductivity estimates for this station.

The Heat-flow Probe was deployed from the launching trolley supplied by RVS Barry and the data transferred to the ship's computer from the instrument via our interface unit completed during the first part of the cruise.

E.D. and M.J.N.

Survey Camera

In retrospect, it now seems all but certain that a slowly-worsening crack in the centre of a pressure case end-cap has caused a complete lack of photographic data to be collected on this cruise.

On the first dip, Station 10968, the system was put over the side in good shape - but within a few minutes of reaching the seabed partial flooding of the electronic control circuits had disabled the system. On recovery, the damage was not found to be too extensive and was made good. At this stage it was believed that the leak had been caused by a scratch on the internal 'O' ring seating surface of the switch lever. A new lever was produced and all 'O' rings were replaced ready for the second dip at Station 10973. This proved to be slightly more disastrous than the first. However, once more repairs were effected to the damaged electronics and the suspected area of leakage reduced to a possibly poorly-seated Dowty seal on the pressure transducer transducer. This transducer was removed and replaced with two blanking plugs, one on each face of the end-cap.

The system entered the water at Station 10981 functioning faultlessly, only to be flooded once again. On this occasion the leak was much more serious and an inspection of the end-cap revealed a flaw at a point where the end-face is drilled to accept a thermistor. Consequently this hole penetrates near to the external face of the end-cap and may be a weak point.

Trials will be conducted in the pressure facility at Wormley, the end-cap will be re-stressed and if necessary the design will be modified. It must, however, be said that this design of end-cap has been successfully used for many years on the biological net monitors, so it may well be that we have been unlucky enough to receive an end-cap which has been manufactured from a piece of material with an intrinsic flaw.

E.D. and Q.J.H.

Rock Dredging

During the suspension of other activities owing to poor weather, two short dredge runs were carried out over a low abyssal hill previously photographed on cruise D134 (Fig. 1). An IOS rock dredge (mouth size 0.75 x 0.4m mesh size 1.5 cm) was rigged at the end of 5m of studded link chain above which was attached a 10° tilt switch pinger. The target was a bench on the side of the hill, approximately 200m off the abyssal plain (the centre of the hill reached 500m height). Many loose pebbles and some outcrop had been photographed on this bench, some of which were believed to be glacial erratics.

The first station D10978 was forced to run downhill owing to a delay during deployment which took the ship over the crest of the hill. Five "bites" of the target were taken, however, the dredge returned empty.

The second station, D10979, was run over the target as planned and, though we lost sight of the pinger (due to its extreme range) the dredge was deemed "down" and, upon hauling in, a peak load of 9.4 tons was recorded on the dynamometer. The dredge returned packed full of rocks, the largest (a manganese-coated pillow basalt) was wedged in the dredge mouth. A total of approximately 100 kg of rock was recovered including a few pebbles which may be glacial erratics.

Q.J.H.

Current meter moorings

Three current meter moorings each with 3 ACMS at 10m, 100m and 1000m off bottom were deployed.

Nominal positions were on the peak and flank of the hill and on the plain. Mooring positioning on the peak and flank was successfully achieved in wind force by over-running required depth observed on PES by 1.5 miles and falling back during deployment. Moorings were then released when correct depth indicated on PES.

All operations went very smoothly. The new forward 'A' frame significantly improved deployment operation due to increased height and reach.

I.W.

Computing and Data Logging

The data logging and computing systems were used during Cruise 144 for collecting and processing navigation, depth, magnetic, gravity and meteorological parameters. Charts of ship's track, annotations and profiles of geophysical parameters were produced as required.

A facility for receiving data from the heat probe was added and used during the cruise.

An opportunity arose during the cruise to compare computed and corrected navigation against navigation produced by an acoustic ranging system. The results obtained from the computing system agreed favourably with those obtained from the acoustic system, allowing for errors when the ship was turning.

It is worth noting that the weather conditions were particularly clement during the period when the comparison was made.

D.L. and K.P.

Winches and Hydraulic Systems

The traction winch and aft hydraulics system was run for a total of 140 hours during the cruise. During this period of time the traction winch and main hydraulic power pack worked very well, apart from two main problems. The first being a fair number of leaking connections and a leaking hydraulic brake unit for the core warp storage drum.

The other main problem was that the brakes on the traction winch were slipping on outboard loads of over 3 tons.

These were adjusted and it was found that when adjusted correctly there was no more adjustment left. New brake units have been ordered and should be fitted in Gibraltar or, if not, in Oporto.

In all other respects the system worked very well.

The FWD ring-main hydraulics, the midships winch and the double barrel capstan winch were run for extensive station work. The DBC bayed three transponder navigating moorings plus three current meter moorings. The midships winch was also used mainly for Babbs near-bottom profiler and for several wire test of acoustic equipment. The hydraulic power pack gave no trouble at all.

The speed and directional control value for the DBC was changed and the midships winch was made ready for complete removal from the ship so maintenance could be carried shore side of Gibraltar.

The No. 1 VMP 37 compressor was used for all the airgun work running a 160 cu/in airgun at approximately a 13 sec firing rate for a number of days at each end of the cruise. No problems were encountered with the compressor although the pressure regulating valve on the main valve board was changed because it would only pass 800 psi.

B.G.K. and T.J.H.

TABLE 1 - Station List

STATION No.	TYPE	POSITION		WATER DEPTH u.c.m.	TIME (GMT)		COMMENTS
		LATITUDE N	LONGITUDE W		START	FINISH	
10959	Wire test, command pinger	18°59.8'	19°59.7'	3263	0518/024	0701/024	Station successful
10960	PUPPI	31°31.4'	24°53.1'	5372	1147/029	1200/037	Instrument lost. Conclusion: over-penetration in soft mud, mud suction prevented its return.
10961	Wire test, command pinger & glass sphere	31°31.0'	24°45.9'	5371	1343/029	1635/029	Unmatched halves of glass sphere did not leak. Station successful.
10962	Current meter mooring	31°31.1'	24°45.5'	5375	1700/029	1924/029	Mooring laid on abyssal plain.
10963	Acoustic Transponder A	31°24.85'	24°43.75'	5373	2018/029	1625/045	Laid, operated and recovered successfully.
10964	Acoustic Transponder B	31°17.35'	24°44.90'	5376	2252/029	1900/045	Laid, operated and recovered successfully.
10965	Acoustic Transponder C	31°22.20'	24°52.40'	5375	0110/030	1220/045	Laid, operated and recovered successfully.
10966	Sonobuoy	31°19.6' to 31°10.1'	24°40.25' to 24°26.8	5370	2054/030	2307/030	Station successful, good record obtained.
10967	Sonobuoy	31°29.9' to 31°29.9'	24°49.4' to 24°58.0'	5370	1742/031	1905/031	First sonobuoy did not function. Second sonobuoy functioned, station successful.
10968	Survey Camera	31°25.4' to 31°29.1'	25°00.1' to 25°12.8'	5370 to 5203	0334/032	1553/032	No results, camera monitor pressure case leaked.

TABLE 1 - Station List continued 2

STATION No.	TYPE	POSITION		WATER DEPTH u.c.m.	TIME (GMT)		COMMENTS
		LATITUDE N	LONGITUDE W		START	FINISH	
10969	Wire test, two command pingers	31°29.6'	25°05.5'	5220	1724/032	2100/032	Station successful.
10970	Piston core	31°28.6'	25°05.5'	5272	2140/032	0310/033	4 barrels, good core 11.41 m, trigger core 2.39 m.
10971	Piston core	31°31.5'	24°54.8'	5370	1355/033	1821/033	5 barrels, good core 12.98 m, trigger core 3.0 m (close to PUPPI site, 10960).
10972	Heat flow	31°29.0' to 31°24.5'	24°54.5' to 24°47.5'	5371	2130/034	1317/035	11 penetrations, no conductivity measurements, successful station
10973	Piston core	31°28.8'	25°06.3'	5330	1534/035	2115/035	5 barrels, good core 11.29 m, trigger core 2.84 m.
10974	Survey camera	31°25.5' to 31°31.6'	25°00.0' to 25°07.6'	5370 to 5203	2208/035	0642/036	No results, camera monitor pressure case leaked again.
10975	Piston core	31°31.0'	25°02.3'	5356	1015/036	1534/036	5 barrels, good core 12.57 m, trigger core 2.84 m.
10976	Current meter mooring	31°31.1'	25°02.6'	5336	1833/036	2100/036	Mooring laid on flank of hill.
10977	Current meter mooring	31°29.8'	25°09.5'	4950	2257/036	0054/037	Mooring laid near top of hill.
10978	Rock dredge	32°38.7' to 32°35.8'	24°19.3' to 24°15.8'	4867 to 5361	0246/038	1007/038	Nothing recovered.

TABLE 1 - Station List continued 3

STATION No.	TYPE	POSITION		WATER DEPTH u.c.m.	TIME (GMT)		COMMENTS
		LATITUDE N	LONGITUDE W		START	FINISH	
10979	Rock dredge	32°37.3' to 32°34.8'	24°29.9' to 24°21.4'	5347 to 4867	1206/038	2306/038	* 100 kg of boulders and pebbles recovered, mainly basalts with thick manganese coatings.
10980	High-resolution near-bottom profiler	31°22.0' to 31°28.0'	24°47.0' to 24°55.0'	5371	0659/039	0120/041	Good records obtained. Four proven crossings of linear 'fault' feature. Equipment damaged on recovery. Propellor fouled.
10981	Survey camera	31°21.7' to 31°22.1'	25°25.1' to 25°16.7'	5371	0535/043	1222/043	No results, camera monitor pressure case leaked yet again, concluded: possible hair-line fracture in end cap.
10982	Piston core	31°27.04'	24°48.27'	5371	1655/043	0236/044	Six barrels, acoustically navigated using remote interrogator 900 m up wire, good core 17.74 m trigger core 3.2 m.
10983	Heatflow	31°27.9' to 31'24.9'	24°50.8' to 24°47.7'	5371	0301/044	1925/044	11 penetrations acoustically navigated using the remote interrogator. 5 conductivity measurements, successful station
10984	Piston core	31°26.89'	24°48.78'	5371	2115/044	0430/045	Seven barrels, acoustically navigated using remote interrogator. Failed to trigger first time, second attempt worked, 5 barrels bent, probably a disturbed core. Propeller fouled during recovery.

TABLE 2 - Piston coring parameters

Core	No. of Barrels	Trip chain Length (m)	Wire Length (m)	Trig. Core Length (m)	Core Length (m)
D10970	4	18.3	22.6	2.39	11.41
D10971	5	22.6	26.2	3.00	12.98
D10973	5	22.6	26.2	-	11.29
D10975	5	22.6	27.1	2.84	12.57
D10982	6	26.2	29.3	3.20	17.74
D10984	7	29.4	33.2	-	-

TABLE 3 - Underway Geophysical Observations

GLORIA	
Start	Stop
0930/024	0500/029
2130/045	0900/049

SRP	
Start	Stop
0900/024	0520/029
2200/029	2200/031
2130/045	0900/049

NEAR-BOTTOM PROFILER	
Start	Stop
1000/039	2240/040

3.5 kHz	
Start	Stop
1000/023	1500/029
1936/029	0412/032
0348/033	0939/033
2100/034	1736/038
0024/041	0224/041
2145/042	1421/043
2248/043	1018/049

SONOBUOYS	
Start	Stop
1) 2054/030	2306/030
2) 1610/31	Aborted
3) 1742/031	1904/031

MAGNETOMETER	
Start	Stop
0930/024	0500/029
2000/045	0900/049

GRAVIMETER	
Start	Stop
0300/045	1200/049

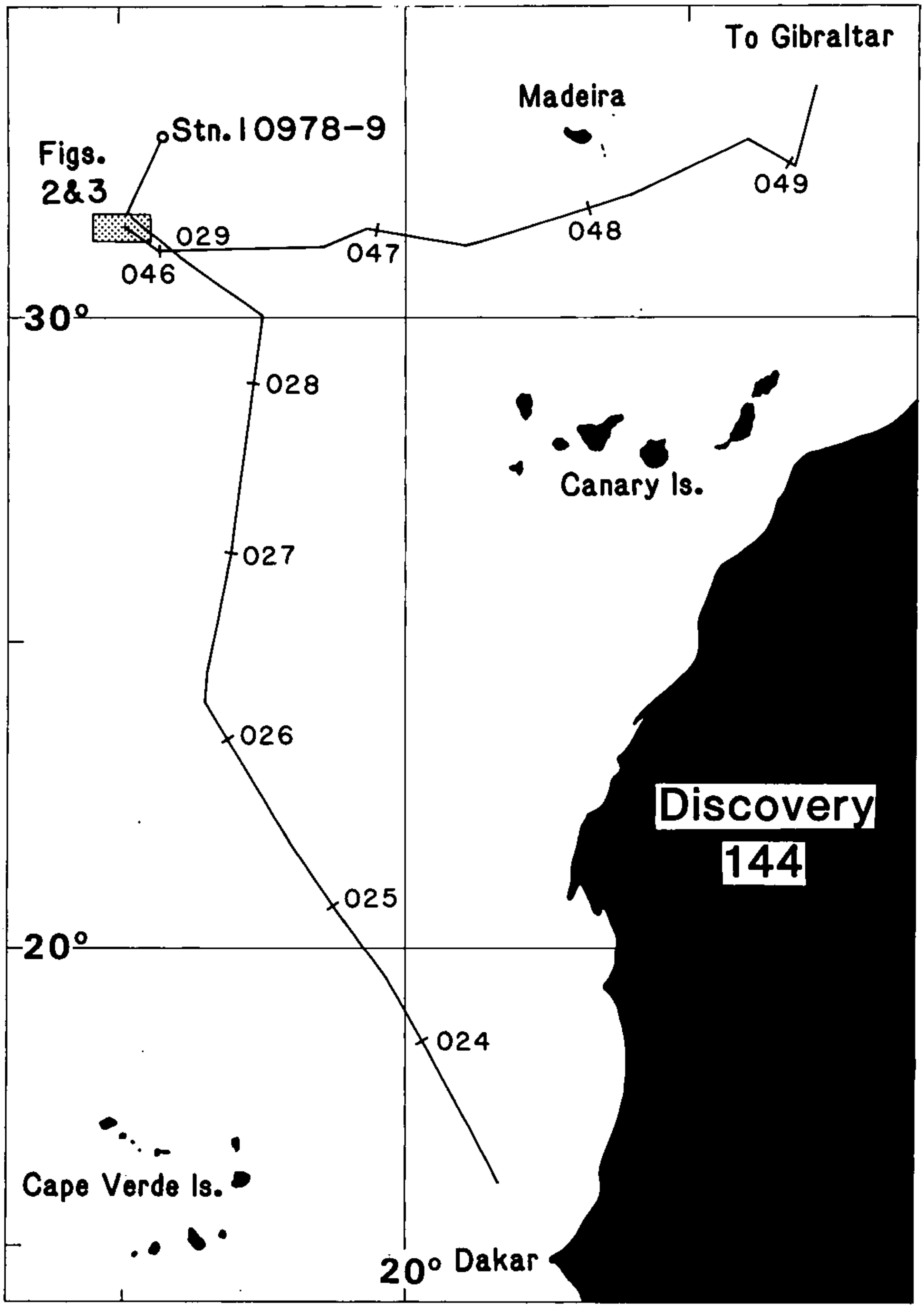
To Gibraltar
Madeira
Stn. 10978-9
Figs. 2&3
029
046
047
048
049
30°
028
Canary Is.
027
026
Discovery 144
025
20°
024
Cape Verde Is.
20° Dakar

Fig. 1

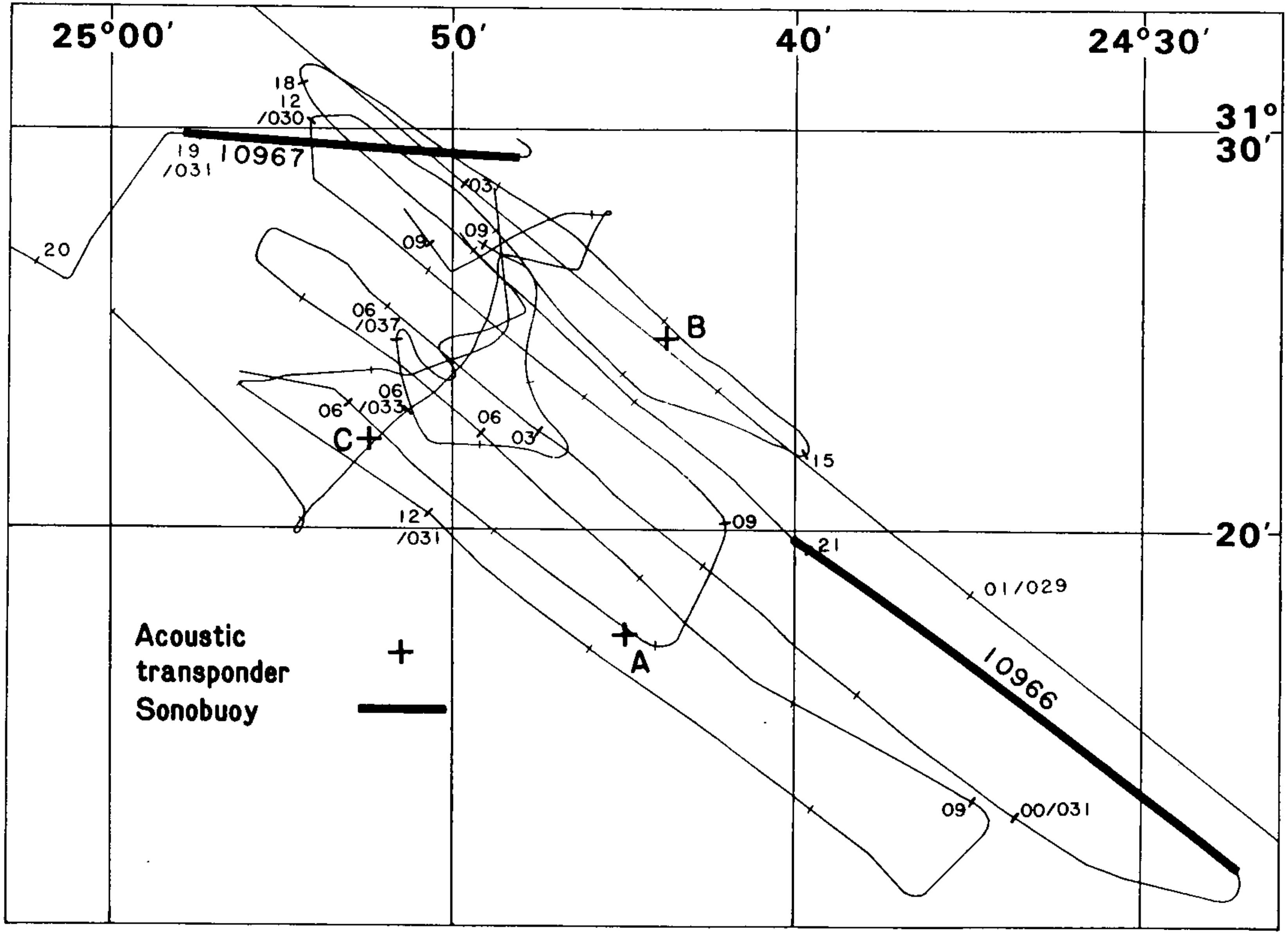
25°00′
50′
40′
24°30′
31°
30′
20′
10967
10966
18
12
/030
19
/031
20
/03
09
09
06
/037
06
/033
06
06
03
C
B
A
15
09
21
12
/031
01/029
09
00/031
Acoustic transponder
+
Sonobuoy

Fig.2

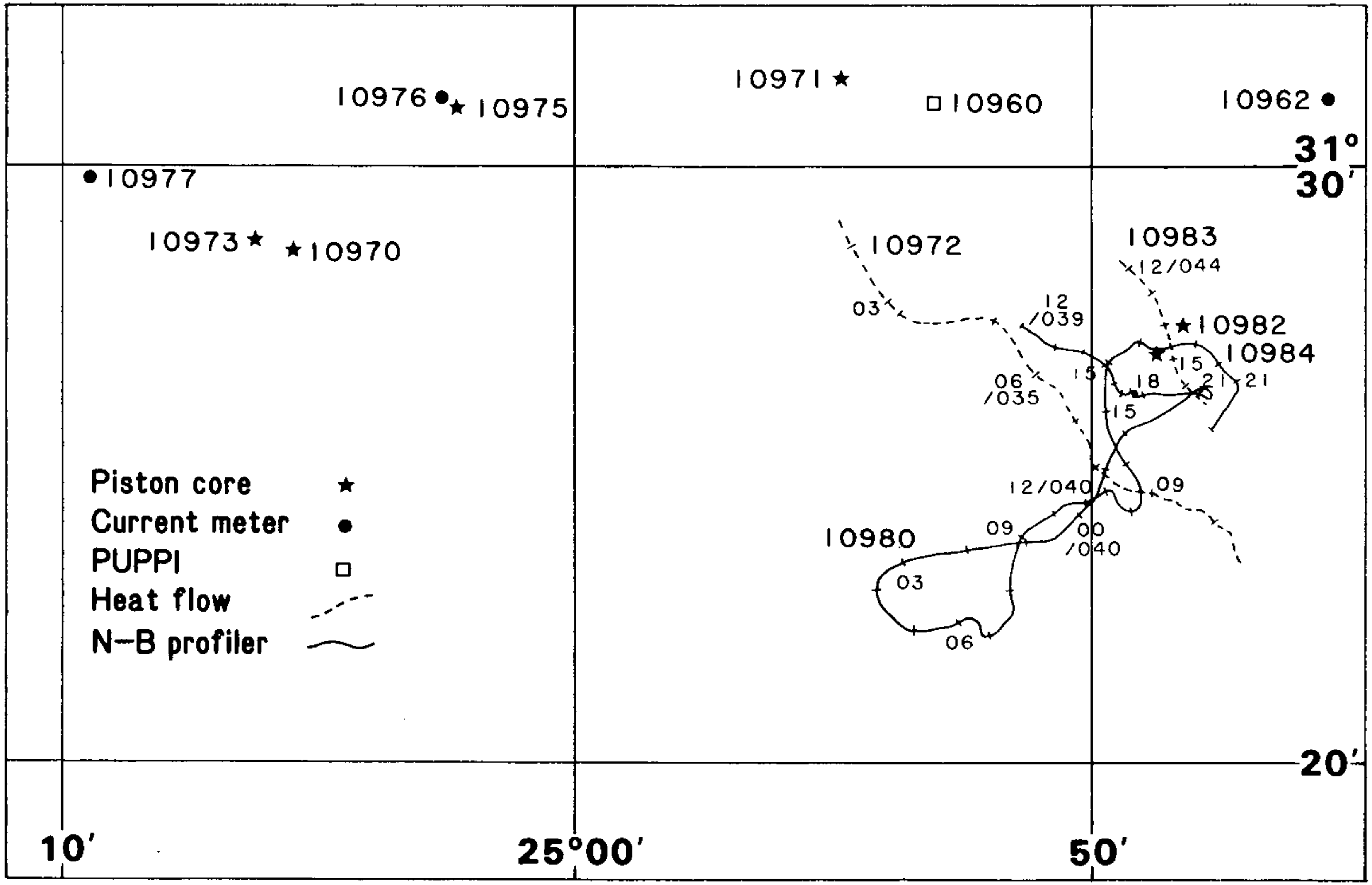
10976 ●
★ 10975
10971 ★
□ 10960
10962 ●
31°
30′
● 10977
10973 ★
★ 10970
10972
10983
12/044
03
12
/039
★ 10982
10984
06
/035
15
18
15
21
21
15
12/040
09
09
10980
00
/040
03
06
20′
10′
25°00′
50′
Piston core ★
Current meter ●
PUPPI □
Heat flow
N–B profiler

Fig.3