I.O.S.

DR MT JONES
IOS (BIDSTON)

RRS CHARLES DARWIN

CRUISE 9B/85

6 DECEMBER 1985 – 6 JANUARY 1986

GEOLOGY AND GEOPHYSICS OF THE GREAT METEOR EAST AREA MADEIRA ABYSSAL PLAIN

CRUISE REPORT NO. 182

1986

NATURAL ENVIRONMENT RESEARCH COUNCIL

INSTITUTE OF OCEANOGRAPHIC SCIENCES

INSTITUTE OF OCEANOGRAPHIC SCIENCES

Wormley, Godalming, Surrey, GU8 5UB.

(042 - 879 - 4141)

(Director: Dr A.S. Laughton FRS)

Bidston Observatory,

Birkenhead, Merseyside, L43 7RA.

(051 - 653 - 8633)

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

SEARLE, R.C. *et al* 1986 RRS *Charles Darwin* Cruise 9B/85: 6 December 1985 - 6 January 1986. Geology and geophysics of the Great Meteor East area, Madeira Abyssal Plain. *Institute of Oceanographic Sciences, Cruise Report*, No. 182, 45pp.

INSTITUTE OF OCEANOGRAPHIC SCIENCES

WORMLEY

RRS CHARLES DARWIN
Cruise 9B/85
6 December 1985 - 6 January 1986

Geology and geophysics of the Great Meteor East area Madeira Abyssal Plain

Principal Scientist

R.C. Searle

CRUISE REPORT NO. 182

1986

CONTENTS

SHIP'S PERSONNEL

Master	P. Warne
Chief Officer	S. Jackson
2nd Officer	S. Sykes
3rd Officer	R. Hagley
Chief Engineer	G. Batten
2nd Engineer	D. Anderson
3rd Engineer	C. Phillips
Electrician	P. Edgell
Radio Officer	J. Baker
Chief Petty Officer (Deck)	R. MacDonald
Seaman	P. Biggs
Seaman	G. Crabb
Seaman	S. Francis
Seaman	E. Owen
Seaman	D. Buffery
Motorman	M. Williams
Cook/Steward	W. Hawkins
Cook	C. Hubbard
2nd Steward	J. Osborn
Steward	C. Chattaway
Steward	C. Peters

SCIENTIFIC PERSONNEL

R.C. Searle	IOS, Geophysics	Principle Scientist
R.J. Babb	IOS, Applied Physics	TOBI
J. Bryan	IOS, Geophysics	Draftsman
D.E. Gunn	IOS, Geophysics	Coring
Q.J. Huggett	IOS, Geophysics	WASP
G.A. Lake	IOS, Ocean Engineering	Engineering
S.D. McPhail	IOS, Applied Physics	PUPPI
I.P. Rouse	IOS, Applied Physics	Acoustics
P.J. Schultheiss	IOS, Geophysics	PUPPI
S.J. Williams	IOS, Geophysics	SRP
C.H. Woodley	IOS, Applied Physics	TOBI
E. Woodward	IOS, Geophysics	Geophysics
D. Booth	RVS	Instruments
E. Lawson	RVS	Computer
R. Phipps	RVS	Engineering
J. Strangward	RVS	Engineering
M. Hounslow	Sheffield University	Heat flow

ACKNOWLEDGEMENTS

It is a pleasure to acknowledge the help at sea of the officers and crew of Charles Darwin; and in port the efforts of the RVS team who mounted the new conducting tow-cable in good time in Lisbon.

ITINERARY

6 December 1985	Departed Lisbon
6 January 1986	Arrived Glasgow

BACKGROUND AND OBJECTIVES

The cruise represented a continuation of our DoE research programme on oceanic radioactive waste disposal. A new instrument to be tried this time was the IOS deep-towed sonar TOBI. This instrument had been under development for some time, and cruise 9B was to be its first full operational test. Several other projects started on previous cruises were to be continued, and some gear was to be deployed or recovered for other groups at IOS. The detailed objectives of the cruise were therefore as follows:

1. To use TOBI to provide a detailed sidescan sonar and high resolution sediment profiler survey of a 10 km square area in the western part of GME and parts of the surrounding region including the edge of a neighbouring abyssal hill.
2. To use TOBI over the area of faults that had been intensively studied in previous cruises. The high resolution profiler was to be used to further define the way in which the faults offset the sub-surface sedimentary layers, and the sidescan was to be used to search for any seafloor expressions of faulting.
3. Pop-Up Pore Pressure Instruments (PUPPIs) were to be deployed in order to determine in-situ hydraulic gradients and hence infer pore-water movements (if any) in the sediments. The highest priority targets for PUPPI were on and near an abyssal hill, which was thought to be a possible candidate site for upward pore-water migration.
4. Heat flow measurements were to be made along two traverses close to previous ones in the "fault" area, in order to build up a two-dimensional grid of data to control 3-D modelling of heatflow through the sediments.
5. WASP camera runs were to be made over an abyssal hill, in order to delineate the field of manganese nodules discovered there on <u>Discovery</u> cruise 153, and over the line of a deep trawl (D10972/5) carried out earlier by IOS biologists, which had apparently recovered manganese nodules from the abyssal plain.

6. Kasten, piston, and box coring were all to be used to obtain samples for the further study of the manganese nodules and their possible relation to pore-water outflow.
7. Kasten and piston coring was to be used to obtain samples for geotechnical testing in relation to the PUPPI programme.
8. Seismic reflection profiling was to be conducted with high resolution sources (e.g. small air-gun array) in an attempt to image faults beyond the penetration limit of the 3.5 kHz system.
9. An attempt was to be made to delineate the 20-m-deep sand layer cored in the 10 km box by the ESOPE cruise, by use of 3.5 kHz profiling and perhaps also by overpenetrating with the piston corer.
10. A mooring containing sediment traps was to be laid in the GME area for the IOS Biology group.

Finally, time and weather permitting:

11. A mooring containing an Automatic Listening Station (ALS) was to be recovered for the IOS Marine Physics Group, and
12. A seabed camera (Bathysnap) was to be recovered for the IOS biologists.

RESULTS

Objectives 3, 5, 6, 8 and 10 were all achieved. Number 4 was partially achieved: only one extra heatflow line was obtained in the fault area, but a further complete line was established through the 10 km box, and two dips were made on or near a small abyssal knoll near the box. No time was available for piston coring, but objective 9 may be at least partly achievable using the 3.5 kHz records obtained. The early demise of TOBI prevented objectives 1 and 2 from being attained.

NARRATIVE

See Figures 1-2 for track and station position charts, Table 1 for station list, and Table 2 for underway geophysical observations. All times in GMT.

In Lisbon we were informed that it would not be possible to use the ship's electric drive on the main engine but only on an auxiliary, with consequently limited power. We also delayed sailing from Lisbon for 24 hrs to await the arrival of a box corer to replace the one inadvertantly offloaded in Funchal prior to the previous cruise.

Finally, RRS Charles Darwin sailed from Lisbon at 0800 on day 340 (December 6th), 1985. The PES fish and magnetometer were deployed at 1030, and we set course on direct (mechanical) drive for Ampere Seamount.

At 0906 on day 341 we recovered the magnetometer, switched to electric drive for quiet running, and hove to (station CD9B/1) for a trial of the WASP camera system over Ampere Seamount. (Subsequent tests showed a noise improvement of 12 dB as recorded at the PES fish, between electric and mechanical drive). The WASP station was completed by 1200, and after a short pause for engine room tests of the electric drive we launched the magnetometer and set course for GME at full speed (11-12 knots) on direct drive.

We stopped at 341/1404 to deploy the 3.5 kHz fish from the Schatt davit on the starboard quarter, where it remained for the rest of the cruise. In electric drive this position proved slightly noisier than we were used to with the more forward towing point on RRS Discovery, but the records were quite acceptable. However, we could not obtain usable records from here in direct drive, and an additional towing point farther forward on the starboard side is needed.

At 1400 on day 343 we slowed to deploy the seismic reflection profiling gear, and at 1612 we began SRP line 1, along a course of 250° into the centre of GME. This line ended at 344/0553. The towed gear was recovered by 0718, and we proceeded to take a sample of near-bottom seawater for use in PUPPI using the multisampler on the CTD wire (CD9B/2). This was combined with a wire test of some PUPPI and sediment trap components. The station was completed by 344/1230, and we proceeded to the position for the sediment trap mooring (station CD9B/3). Deployment of the mooring commenced at 1456, it was released at 1608, and was observed to reach the bottom at 1708.

At 344/1712 we set course for the positions of the two PUPPIs deployed during Darwin Cruise 6, and at 2112 began a survey to locate them acoustically. The pressure pipes on both instruments were cut, and one instrument (CD6/1) was released at 2329 (the other was to be left for 24 hrs before recovery). The first PUPPI was recovered by 345/0125.

We then proceeded to the starting point of a WASP line intended to cross the manganese nodule field on the nearby abyssal hill (CD9B/4). The WASP was deployed over the stern at 345/0334, and payed out to near the seabed by 0834. However, before it reached the bottom it became clear that the near-bottom echo sounder (NBES) on the instrument was not working, so it was recovered, coming inboard at 1226.

We then began a wire test of the 5 kHz acoustic navigation beacons, using the CTD wire amidships (CD9B/5). However, the beacons failed to produce sufficient power and were recovered at 345/1500. This was followed by a box core (CD9B/6) in the centre of the nodule field. The corer was recovered at 345/2107 with a good sample including three nodules on the surface.

Following the box core we recovered the remaining PUPPI (CD6/3), which was on board by 346/0105. We then took a Kasten core in the manganese nodule field (CD9B/7), and proceeded to lay a PUPPI on the NE flank of the abyssal hill, just above the edge of the plain (CD9B/8). This was completed by 346/1226, and we then attempted another WASP run over the nodule field (CD9B/9). The camera was deployed at 1442, but the NBES failed to work. The gear was recovered, the NBES and monitor were replaced by spare sets, and it was redeployed at 1708. This time all appeared to go well until the camera reached the seabed, but then it took pictures only intermittently, so the station was aborted. Towards the end of this station a heavy swell began to build up, and persisted for the next two days, reaching 5 m or more at times.

The WASP was recovered by 346/2344, and we then proceeded to tension the new conducting tow cable by paying out to 4636 m with the TOBI weight on the end (CD9B/10). The opportunity was also taken for a further test of the 5 kHz transponders, which were fastened to the TOBI weight. This station ended at 347/0620, and we then proceeded to lay a PUPPI (CD9B/11) over a position where an earlier heatflow line (Discovery station 10972) had shown a high geothermal gradient. The PUPPI was laid by 1139, when we set off on a 3.5 kHz line intended to pass continuously over the positions of all the long cores obtained during the recent "ESOPE" cruise.

At 347/2151 this profiling survey was broken off to carry out the first heatflow line (CD9B/12). Since the acoustic navigation transponders were not nyet in place in the fault area, it was decided to try out the heatflow probe on an acoustically unnavigated line across the 10 km box. The probe went overboard at 2316, and the line progressed normally until 348/0525 when the alternator supplying the winch overloaded and caused a complete power blackout. The power supply was eventually resumed after going into direct drive, and the station was continued with mechanical propulsion from 0654. The probe was recovered by 348/1430, but the telemetering unit was lost, apparently by being shaken loose from its mountings, while hauling in. Subsequent thorough checking of the winch by ship's engineers and RVS technical staff revealed no fault in the winch, but to avoid a possible recurrence of the power blackout we were restricted to mechanical drive during use of the coring winch over the next five days.

When the heatflow probe had been recovered we began a series of airgun seismic profiling lines to cross the 10 km-square box, the heatflow line, and the CD6/1 and CD6/3 PUPPI positions. This was completed and the gear recovered by 349/0708.

We then deployed the 5 kHz fish from the midships gantry. Next we conducted another wire test of the 5 kHz beacons (CD9B/13), which showed a considerable improvement over their previous performance, and then proceeded to the abyssal hill for a Kasten core (CD9B/14) just above the position of the manganese module field. The station was successfully completed by 349/2038. We then attempted another box core over the nodule field itself (DC9B/15). Unfortunately the corer pretriggered, and was recovered empty at 350/0333.

The box core was followed by a final, shallow, test of the 5 kHz beacons, which was completely successful, and we started laying them, in the "fault area", at 350/0853 (stations CD9B/17 to CD9B/19). The last transponder had landed by 1815, and we then proceeded to survey their baselines. This was completed by 2057, when we departed toward the abyssal hill. We passed over PUPPI CD9B/8 and transmitted the signal to cut its pipe at 2145, and hove to at 350/2258 to deploy the WASP in a third attempt (CD9B/20) to obtain a SE-NW photo line over the manganese nodule field. The station went well until 351/0954, when the camera stopped firing after several hours on the seabed which produced useful data. The equipment was recovered by 351/1246.

We now made preparations for the first deployment of TOBI (CD9B/21), and by 351/1515 the vehicle was in the water. We began paying out cable at 1658. Initial signal returns were very weak, but it was hoped that they would improve when within range of strong reflectors on the seafloor. Veering of wire continued until 351/1946 when all signals ceased. At this point the vehicle was at about 4000 m depth, with about 5400 m of wire out, and a maximum wire tension of 3.3 tons at a towing speed of 1.5 knots. We began hauling in at 1957, and the depressor weight was recovered by 2245. At this point it was clear that there was excessive weight on the umbilical cable, which was leading straight down. After some difficulty the vehicle was recovered by using the capstan to haul in the umbilical, and was secured on deck by 352/0006.

Clearly the bouyancy spheres had imploded, causing irreparable damage: the space frame was badly buckled and broken; all pressure cases had leaked, and there was extensive damage to electronic components and sidescan transducers.

After a pause to catch our breath, we proceeded, at 352/0249, with another attempt to obtain a box core in the nodule field. This one (CD9B/22) succeeded, and a good sample of the sediment/water interface was obtained, although this time without nodules on it.

Following the box core we returned to the fault area to deploy a 10 kHz permanent transponder, to complement one deployed earlier from Marion Dufresne, and after some initial surveying the beacon was dropped at 352/1528. We then deployed the SRP gear and began a survey of closely spaced, acoustically navigated profiling lines over the faults, using 20 cubic inch airgun and 3.5 kHz.

The SRP survey ended at 353/1427, the streamed gear was recovered, and we set course for the area of the 10 km-square box. We laid three 10 kHz transponders there, of which the second failed to work immediately after being let go, and was replaced by another, giving us two working units (CD9B/24 and CD9B/25). We then proceeded to carry out a short, acoustically navigated, 3.5 kHz survey of a small knoll just outside the box, prior to laying a PUPPI there in the draped pelagic sediments over its top. The PUPPI was let go at 354/0501#(CD9B/26).

When the PUPPI had landed we returned to the fault area, on the way continuing the 3.5 kHz line linking the ESOPE core sites. We then (354/1400) recovered the PUPPI CD9B/11, and prepared for a heatflow line (CD9B/27) planned to extend a previous one (D10983) towards the northwest, where a significant pore pressure gradient had been measured over a sub-bottom basement high by PUPPI in 1984.

Following some modifications in the engine room, we were again allowed to use electric drive in combination with the main winch for this and all subsequent stations. The heatflow probe carried a jury-rigged tiltmeter and a near-bottom echosounder on the wire, to assist in running the station in the absence of the telemetering monitor lost during the previous run. However, there was no real-time monitor of the thermistor response. The probe was deployed at 354/1526, and recovered at 355/0749. Unfortunately the thermistor string was broken, and subsequent playback of the data revealed that this had occurred on the first dip of the line.

We now manoeuvered over the sub-bottom basement high to lay another PUPPI there (CD9B/28). The PUPPI was dropped at 355/1404, and after it landed we steamed southwest again for another WASP deployment. This run (CD9B/29) was to cover the line of station D11261/58, where earlier in the year IOS biologists had dredged manganese nodules, apparently from the abyssal plain. We began by running down the line to obtain a good 3.5 kHz record, then hove to at the southeast end of the line to deploy the gear. The camera was launched at 355/2000, but as soon as it entered the water it became clear that the monitor was not working properly, and it was recovered. A short 3.5 kHz survey of an adjacent abyssal hill was begun while repairs were carried out, and at 356/0000 the gear was relaunched. This time the monitor worked well, but the NBES remained solidly locked on minimum range, so again we recovered the gear, and replaced the NBES transducer with the spare. The system was finally launched again at 356/0130, and a very successful run ensued, the camera being recovered at 1301.

We now returned once more to the fault area, and hove to at 356/1622 for a third heatflow line (CD9B/30), this time to the southwest of the two previous Discovery ones. The probe was in the water by 1630, and the station ran successfully until the gear was recovered at 357/0810.

Following this we recovered two of the 5 kHz beacons for re-use in the box area, and then steamed southwest toward the small knoll near the box. While the transponders were being refurbished we deployed the WASP here at 357/1656 (CD9B/31), and proceeded to tow it from the abyssal plain, over the knoll, and back onto the abysall plain into the box. It was recovered at 358/0652.

At 358/1813 we laid the first of two 5 kHz transponders in the box (CD9B/32 and 33). Then, following a baseline survey, we set off for the northern end of the abyssal hill for the start of a seismic survey of it. This continued into a two-mile-spaced acoustically navigated survey of the box itself, the whole seismic survey lasting until 360/2100. During the survey we once again passed over the site of the PUPPI (station 26) and again tried to communicate with it, but to no avail.

After recovering the seismic gear and magnetometer, we prepared for a heatflow station over the knoll to the southwest of the box (CD9B/34). We approached the knoll using the 5 kHz transponders in the box, and deployed the probe over the edge of the knoll at 361/0130. At this time the wind rapidly rose from the 10 knots of the past few days to over 30 knots. It became impossible to follow the 5 kHz signals and keep the ship over the knoll, and at 0526, after only two dips, it was decided to recover the gear, which was inboard by 361/0849.

In view of the worsening weather, the captain now advised departure from GME as soon as possible if we were to have a chance of recovering the IOS Marine Physics Group's Autonomous Listening Station during the return passage. We proceeded to recover the 5 kHz transponders, but although all three signalled that they had fired their pyros, only one (CD9B/32) released. It was recovered by 361/1347; CD9B/33 had been tried first, and abandoned at 361/1112; we subsequently (361/1710) transmitted unsuccessfully to CD9B/19. The most likely reasons for failure would appear to be either faulty pyros or entanglement of the transponders in the mooring lines.

The last PUPPI (CD9B/28) was cut at 361/1916. It had been intended to carry out a last heatflow line (a repeat of the failed CD9B/27) next to allow the PUPPI 12 hours of post-cut recording, but in the face of rising winds (now up to 45 knots) we decided to heave to overnight and ride out the gale. The PUPPI was recovered next morning (362/0925) in force 7 wind and heavy seas. We then recovered the 3.5 kHz and 5 kHz fish and secured all gear on deck before going into mechanical drive, streaming the magnetometer, and setting course for the ALS at 362/1106.

We arrived at the ALS position at 0800 on January 1st and recovered the magnetometer. The wind was blowing 30 to 35 knots with worse forecast. It was therefore considered imprudent to attempt recovery of the ALS at once, and we hove to hoping the weather might improve. In contrast, it worsened, blowing force 9 by 1100 and force 10 gusting to 11 or 12 (65 knots) by 2200. Heavy winds and seas continued throughout the night and next day. When eventually the weather moderated it was too late to recover the ALS, and we got under way again at 0654 on day 003. At 0840 we streamed the magnetometer.

We crossed onto the continental shelf at about 004/0900, and recovered the magnetometer and PES fish at 1042. We then resumed passage to Glasgow, arriving there about midday on January 6th, after a brief call at Milford Haven en route to take on charts.

PROJECT AND EQUIPMENT REPORTS

Pop-Up-Pore-Pressure-Instrument (PUPPI)

The primary objective of the PUPPI programme in the GME area is to investigate and quantify any pore water advection which may be significant to the radioactive waste disposal feasibility study. Pore water velocities greater than 1 mm/year are considered to be significant. Past data (primarily that collected on Discovery Cruise 153) has indicated that pore water movement is not a general feature within the area. However, at one site over a sub-bottom basement high a significant reading was obtained showing a small amount of downward advection (about 3 mm/year)

Since Discovery Cruise 153 some modifications to the PUPPI have been made. These include: higher resolution differential pressure transducers, a second pore pressure port located at the mid point of the lance, a modified logger to record the data from two transducers, and a pre-release pipe cutter to improve the accuracy of the in-situ zero calibration.

The specific objectives for this cruise were to:

1) Test the new features on the PUPPI and investigate general features of pore pressure dissipation and recorded tidal cycles.

2) Occupy new sites within GME especially on abyssal hills, over the sub-bottom basement high and on a site where a non-linear temperature gradient measurement had indicated significant advection.

Two PUPPIs had been laid within the 100 sq.km. box on Darwin Cruise 6 in August 1985 for long term deployments (approx. 3 months). These two PUPPIs were recovered without incident.

Preliminary results from these two deployments show that:

1) there was no residual differential pore pressure after over 100 days on the sea floor (hence no significant pore water advection);

2) a measurable zero pressure transducer drift occurs over a period of up to 30 days for both the high-and low-range transducers;

3) the measured attenuated tidal cycles have the same amplitude for both transducer types: it is tempting to conclude that the transducer compliance is, therefore, not a major cause of the effect;

4) the 14 day period of spring and neap tides is easily visible;

5) the inclusion of the pre-release pipe cutter provides a greater level of accuracy and confidence of the in-situ zero calibration.

Using the two instruments recovered at the beginning of the cruise, four further deployments were made (stations CD9B/8, 11, 26 & 28 - positions are given in the station list). All deployments were made using the higher resolution transducers and the pre-release pipe cutter. The water used to fill the transducers and piping was GME bottom-water collected using the General Oceanics multisampler at a depth of 5434 m during station CD9B/2. The instrument used at stations 8 and 26 (PUPPI No. 2) was deployed on low abyssal hills and had only a single port at the tip. Stations 11 and 28 were on the aybssal plain and a mid-lance port and transducer were used on the instrument (PUPPI No. 4) in addition to the port at the tip.

CD9B/8 (1130/346-1300/352) The PUPPI was deployed on the flank of the large abyssal hill, 38 m above the level of the plain, close to core D10975. At this height the turbidites are much thinner and the majority of the sediment cover is pelagic.

Only about 2.5 m of the lance penetrated the sediments (calculated from the accelerometer record) but it remained vertical. The pressure record shows a normal insertion transient followed by the decay. Tidal cycles were recorded until the cut, which showed no residual pore pressure.

A camera, flash unit and an extra 13 inch sphere were inserted into the stray line 4 m above the instrument. Unfortunately the camera flooded as a result of a crack in the pressure case and the flash unit was broken during the recovery. Therefore, no photographs were obtained.

CD9B/11 (0930/347-1423/354) This station was located near a heat flow site (D10972 Dip 5) that had been interpreted as having a high upward pore water advection velocity (108 mm/yr) from an analysis of a non-linear temperature gradient. The PUPPI used (No. 4) had a mid-lance port in addition to the tip port. The data showed that at the mid-lance port a lower insertion pressure, a slower decay rate and smaller tidal cycles were recorded than at the tip port. No residual pore pressure was recorded.

CD9B/26 (0320/354-1700-358) was a site on the top of a small knoll (36 metres above the abyssal plain) to the SW of the 100 sq km box. PUPPI No. 2 was deployed with 5 weights and only a small 10 inch sphere on the stray line to increase the terminal velocity to 2.15 m/s. However, it still did not fully penetrate the sediments but had no measurable tilt. On day 358 no trace of the instrument could be found using acoustic commands. There had either been a complete or partial failure of the command beacon or the PUPPI had for some unknown reason released itself. The release procedure was followed and after no success a search was conducted in the direction of the surface current for about 12 miles (the radio beacon should have been detectable up to a further 10 miles). One other attempt was made to talk to it two days later before the PUPPI was finally given up as lost. The reason remains a complete mystery.

CD9B/28 (1233/355-0900/362). This site was over the sub-bottom basement high close to stations D11182 and D11184. A significant negative pressure gradient had been interpreted from the data obtained from D11184. The heat flow line CD9B/27 also ran very close to this site. PUPPI No. 4 was used with the same configuration as for CD9B/11. The position was accurately navigated using the bottom transponders and the 3.5kHz profiler. Data from this deployment is similar to that obtained from the other abyssal plain site (CD9B/11) with the mid-lance port showing a lower insertion pressure, a slower decay rate and smaller tidal cycles than the tip port. No residual pore pressure was recorded.

In conclusion the objectives for this cruise were accomplished. In particular the new features on the PUPPI's have worked reliably. The observation of attenuated tidal cycles is not now believed to be an artifact of the measurement system. However, it is still not fully understood and further experiments are necessary to quantify the effects of the system on the real pressure fluctuations before it can be used to determine the in-situ permeability. In particular this includes the effect of swopping the ports of the differential pressure transducer and quantifying the compliance effects of the nylon pipe by increasing its length significantly.

We consider there is now no conclusive evidence of pore water advection occuring in the GME area. The data from station D11184 that indicated a small downward flow must now be regarded as suspect as the two other stations in that vicinity (D11182 and CD9B/28) did not record any pressure gradients. Although GME has not been extensively covered, at least one PUPPI deployment has been made close to, or over, most of the major geological features within the area. The main area still to be investigated that is most likely to have any pore pressure gradients is over the abyssal hills.

PJS, SDMcP, DEG.

WASP

The Wide Area Survey Photography (WASP) camera system was deployed on six occasions giving four successful camera runs. The system is identical to that used on Discovery Cruise 153 (IOS Cruise Report No. 172) except for the first run which shall be described below. An IOS MK4 underwater camera was added to the system for colour photography. Unfortunately the low film capacity of this camera was exhausted before it reached the seafloor. Therefore, no colour photography of the seafloor was carried out. Details of the WASP stations are given in Table 3.

Station CD9B/1

This station was conducted to test some circular polarizing filters. Shallow water over Ampere Seamount (but greater than 200m to get below the photic zone) was selected in order to cut down the amount of time needed to carry out the experiment. Both the Benthos and the IOS MK4 cameras were loaded with Ilford XP-1 black and white film. Four flash units were used, each with a circular polarizing filter attached. The IOS MK4 camera also had a filter, whereas the Benthos camera, unfiltered, was used as a control.

When the WASP system was switched on for a pre-deployment test, one of the flash units malfunctioned (a loud bang was heard and vacuum created in the pressure case) and had to be replaced.

The WASP system was launched from beneath the stern A-frame gantry at 1024 (Day 341) and lowered to the seafloor at 30 m/minute. After approximately 150 frames (i.e. 40 minutes) had been shot, the WASP was hauled in and recovered. The films were removed for processing back at the IOS.

Station CD9B/4

The system was rigged for normal (unfiltered) operation so the filters were removed and two extra flash units were mounted on the frame. The Benthos camera was loaded with 61 m of 400ASA thin-based black and white film. The camera aperture was set to f3.5-4 and data chamber to f5.6. The whole system was programmed to cycle at 16 second intervals.

The WASP system was launched at 0334 (Day 345) and lowered to the seafloor at 30 m/minute. The target was the flank of an abyssal hill (named NOD hill) where a manganese nodule field had been photographed on Discovery Cruise 153. The water depth was from 5200 to 5440 m.

Unfortunately the Near Bottom Echo Sounder (NBES) failed to operate (it remained locked onto its 80m maximum altitude) so the WASP was recovered at 1226 (Day 345) and station abandoned.

On examination, a loose wire was found on the NBES circuit, this was re-soldered and the system prepared for its next dip.

Station CD9B/9

The WASP system was set up as for station CD9B/4 to run over the same target. It was launched at 1425 (Day 346), however, within half an hour it was obvious that the NBES was still faulty and the WASP was recovered in order to change the NBES and control electronics. The relaunch was at 1708 and when the WASP reached the seafloor the NBES functioned correctly, however the camera was only firing intermittently and so the WASP was recovered at 2342 and station abandoned. The whole system was stripped down and examined; however, no faults could be seen. It was carefully reassembled and prepared for the next dip.

Station CD9B/20

The WASP system was set up as for station CD9B/4 to run over the same target. The launch was slightly delayed to repair some minor damage sustained by the WASP whilst it was being launched. At 0000 (Day 351) it entered the water and was lowered to the seafloor at 30 m/minute. Just as the WASP reached the seafloor a malfunction of the acoustics on the WASP occurred, however it was not too severe and the station was successfully run until 1012 (when the film was judged to have run out). The malfunction appeared to be the result of a battery which had short circuited; unfortunately, as a result, one of the pressure cases had corroded beyond repair and had to be renewed.

The processed film revealed that the WASP had photographed the target revealing a variety of manganese nodules lying on the sea floor.

Station CD9B/29

The WASP system was set up as for station CD9B/4. On this occasion the target was a low abyssal hill to the south east of the study area. This target was chosen in order to discover the source of some manganese nodules and encrustations dredged by the biology group during Discovery Cruise 156.

The WASP was launched at 2000 (Day 355) but had to be recovered as the system malfunctioned. With considerable effort, Steve McPhail and Richard Babb traced the fault to an integrated circuit and they repaired it. The system was relaunched (after a brief delay to change the NBES) at 0130 (Day 356) and a successful station was run. The WASP was recovered at 1030 and the film showed a seafloor ranging from rock outcrop to a manganese nodule covered seafloor. Manganese nodules of both the spherical and flat forms were observed in the proximity of outcropping basement on the western flanks of the hill. The camera did not reach the abyssal plain itself, but we think it most likely that the nodules dredged by the biologists came from the hill.

Station CD9B/31

The WASP system was set up as for station CD9B/4. On this occasion the target was an extremely low (only 50 m altitude) abyssal hill near the edge of the 10 km square box. This target was chosen with two aims in mind. The first was to obtain some photographs from within the study area itself. The second was to observe the transition zone between the pelagic sediments of the hill and the surrounding turbidites. The ship was navigated using 10 kHz beacons for this station as the small size of the hill made accurate positioning essential.

The WASP was launched at 1656 (Day 357) and ran successfully. It was recovered at 0645 (Day 358) and the film showed that the target had been successfully crossed.

Despite persistent problems with the system the data collected were of high quality and the main photographic objectives of the cruise were achieved. I would like to thank Steve McPhail and Richard Babb for their help and co-operation without which this work could not have been carried out.

QJH.

Heat Flow

The objectives of the heat flow studies were:

1) to examine the non-linearity of temperature profiles with the added precision of a new thermistor string with a thermistor spacing of 0.5 m, instead of the 1.0 m spacing previously used in GME on Discovery 144.
2) To look for evidence of large scale porewater movement by comparing measured heat flux to a numerical model of the heat conduction in the sediment and basement. Heat flow measurements across areas with a large variation in basement depth would be most sensitive to this comparison.

The heat flow measurements were performed with the IOS/Cambridge heat flow probe, identical to that used on Discovery Cruise 144, except for the new thermistor string, and stations after CD9B/12 were performed with a modified tilt pinger owing to loss of the heat flow telemetry unit.

Station CD9B/12 The first heat flow traverse, across the 10 km box area, intersected a shallow basement ridge to the west of the box. There was no acoustic navigation, and the height of the probe off the bottom was assessed by a wire pinger. After a ship's power failure during the station the ship turned to direct drive which gave a noisy PES record with the resultant loss of any bottom echo. The rest of the station was guided by the amount of wire out and the accelerometer record. Twelve 12 Successful dips occurred with conductivity measurements on most of these .

On hauling the heat probe back to the ship the telemetry unit broke away and was lost. This loss did not damage the logger case.

Station CD9B/27 Following the loss of the telemetry unit a tilt pinger was modified and fitted with an accelerometer, so that it could be mounted on the head of the heat probe, and so assess time of penetration and angle from vertical. Additional clamps for the logger case and tilt pinger were made, as too was a protective cover and strap for the logger case. The probe was deployed with a near bottom echo sounder on the warp and was acoustically navigated with a 5 kHz remote interrogator. The thermistor string broke on the first dip, although this was not known until the probe was recovered after 21 dips.

Station CD9B/30 This station was undertaken to traverse a deep sediment basin in the main study area and a basement ridge to the northwest. A spare thermistor string with a 1.0 m spacing of thermistors was used, otherwise the same configuration as Station 27 was used. 21 successful dips were performed.

Station CD9B/34 Multiple dips were attempted in pelagic sediments on a 'knoll' south of the 10 km box area. The instrument configuration was the same as for station 30. Acoustic navigation of the ship and probe failed because of worsening weather conditions and bowthruster noise on the EPC record. The station was aborted after the 2nd dip because of the lack of accurate navigation and the fact that the ship had drifted off course. Dip 1 was in pelagic sediments on the side of the knoll.

I would like to thank Steve McPhail for his considerable help during this cruise.

MH

Seismic Reflection Profiling and 3.5 kHz

SRP

Five distinct SRP surveys were carried out making a total of some 85 hours of data which covered a distance of some 780 km. Survey 1, on days 342/343 covered the final run into GME from the continental rise across the abyssal plain. Survey 2 on days 348/349 consisted of 3 lines in the SW survey area. Survey 3 on days 352/353 was an acoustically-navigated box survey of the Central Study (fault) Area. Survey 4 on days 359/360 was a grid survey of the local abyssal hill (Nod Hill) and Survey 5 which continued straight on after 4 on day 360 was an acoustically-navigated grid survey of the 100 square km box.

The SRP system consisted of a variable array of airgun sources charged by the ship's compressor; a deck control board; a gun firing control and synchronisation unit; a Geomechanique hydrophone streamer; a 19 inch electronics rack comprising amplifiers, filters, trigger and delay units and depth indicator; an EPC 4600 analogue graphic recorder and a Store 4DS 4-channel FM tape recorder. The streamer comprised: a 200 m lead in; a 50 m stretch section; a 25 m weight section; a second 50 m stretch section; a two channel depth indicator; two 50 m, 48 element, active hydrophone sections; a 50 m passive section and finally a tail rope.

Owing to RVS speed restrictions all surveys were steamed at a speed of approximately 5 kts. The streamer was deployed through the fairlead on the starboard side of the aftdeck and the airguns were deployed using the small cable winches on the aft A-frame. For Surveys 1 and 2 the depth indicator was calibrated on deck using an oil-filled hand-pump. Unfortunately at the restricted towing speed the streamer ran at depths of at least 25 m, well in excess of the theoretical optimum quarter wavelength depth for maximum signal reinforcement by the sea surface reflection (=5m for a nominal 75 Hz central frequency). However it is possible that reinforcement occurred at the five quarters wavelength depth of 25 m and this may be a preferable depth in all but the calmest of seas. Nonetheless it would be wise to ensure in future that supplies of the correct streamer oil are available for buoyancy adjustment. Indeed it is essential that spare oil is carried in case major leakage occurs from the streamer sections.

Due to a faulty amplifier PCB no data were recorded from channel 2 in the course of Survey 1, but otherwise good data were recorded at all times.

A selection of airguns was available for use with chamber sizes of 160, 40 and 20 cu.in. The firing unit provided for the synchronisation of up to six guns simultaneously. On Survey 1 a 160 cu.in. and a 40 cu.in. gun with waveshape kit were deployed but it was found that the 40 cu.in. gun gave adequate penetration alone. On Survey 2 a 40 cu.in. gun with waveshape kit and a plain 40 cu.in. gun were deployed but again it was found that a single gun was adequate. In all subsequent surveys the 40 cu.in. gun with waveshape kit and a 20 cu.in. gun were deployed and it was found that the 20 cu.in. gun on its own gave reasonable penetration and better resolution, although there appears to be some undesirable reverberation on some of the records, presumably due to the lack of a waveshape kit. This could be removed by digital processing if required. It is considered that the use of a 20 cu.in. airgun was sufficent for most purposes partly because of the low absorbtive character of the distal abyssal plain sediments and partly because of the low level of ship noise (all the surveys were conducted in electric drive). In future it is considered that use of an even smaller gun (with waveshape kit) may be warranted in order to improve resolution of reflectors in the upper 100 to 500 m of sediments. Alternative sources such as a Uniboom or sub-tow boomer might also be considered for high resolution work in quiet conditions.

The 2 signals from the streamer were fed into separate amplifiers then recorded on tracks 1 and 2 respectively of an analogue magnetic tape using the Store 4DS in FM mode. Recording speeds of 15/16 or 15/8 inches per sec. were used. A 6 or 10 minute timing pulse was recorded on channel 4 and a trigger pulse was recorded on channel 3. The read-after-write signals were bandpas filtered at 50-150 Hz or at 100-200 Hz then directed to the EPC during acquisition in order to produce an online tape monitor record with a 2 or 4 s sweep rate. The gun firing interval was eventually set at 11 s in order to avoid data being overprinted by multiple reflections at shorter intervals. A delay before print of generally 6.5 s was selected for the EPC. Thirteen 7" and seven 8" Ampex magnetic tapes were used to record the data. The tapes were subsequently replayed through a 100-200 Hz bandpass filter to the EPC at 2 s and 4 s effective sweep rates to produce good quality graphic records. All the data collected was of good quality although repeated use of the ship's radio transmitter on day 359 caused short bursts of noise to overwrite the data. All the data were photographed and printed onboard to enable a preliminary interpretation of the data to be made.

3.5 kHz

The fish was towed throughout from a pendant on the Schatt davit on the starboard quarter. It was deployed and recovered using a line led forward to a block near the midships gantry then aft again to the capstan, and with the help of the after crane to provide a 'skyhook' to hold the large block through which the rope was rove. This towing position proved slightly more noisy (in electric drive) than the more forward one that we have employed on Farnella and Discovery, but the records were still acceptable. However, with the ship in direct drive only a poor seafloor reflector could be seen, and there was no penetration.

RCS

The 3.5 kHz fish was deployed and recording began at 1418 on day 341 en route to GME from Lisbon. The system was subsequently in use for most of the time spent in GME, being switched off from time to time in order to prevent interference with underwater acoustic transmissions (5 and 10 kHz acoustic navigation and 10 kHz acoustic telemetry).

A sweep rate of 1 s was used for short periods and a 0.5 s sweep rate was selected the remainder of the time. Good quality records with penetration of up to 100 m were obtained at speeds up to 8 kts when the ship was in electric drive. The fish was eventually recovered after recording ceased at 1705 on day 361, shortly before departing from GME.

Minor inconvenience was caused by the lack of detailed depth markings and automatic day/time annotations. Triggering problems which were encountered when operating in programmed mode were eventually cleared by thorough cleansing of the stylus belt, the styli and stylus holders. Previously extensive use had been made of normal, unprogrammed mode.

17 rolls of 3.5 kHz data were produced (inc. rolls 2B,2C,3B; last roll: No. 14) during the cruise and these were photographed onboard with 35 mm monochrome film. Developing and printing were carried out in the ship's darkroom. Turnaround (6 hours minimum between commencing photographing and mounting the dried prints) was significantly slower than that achieved with the polaroid Land camera on previous cruises but this may be considered a small price to pay for the advantages of optional print reversal, repeat prints, enlargements from one negative, and significantly lower material costs. However, printing on this cruise was made difficult because no focussing aid or timer were available.

SRJW

TOBI

The conducting tow cable for Darwin as delivered in August 1985 proved to be incompatible with the Lebus scrolls fitted to the winch. New scrolls were fitted in Lisbon before Cruise 9B, by Ivor Chivers and a large team from RVS. With this change they were able to wind the cable on to the winch drive without major difficulty and well ahead of schedule. A splendid effort.

Graham Lake made up the epoxy-bonded termination of the cable, and we tested it on deck to a load of 1.25 tons with no sign of failure.

Next, the cable was deployed with only the TOBI depressor weight on the end, to tension the wire and check that reeving under load was satisfactory. 5400 m of wire was deployed at 2 kts. Maximum tension on ship-motion-induced surges was 3.1 tons, about 25% greater than the "average" tension. Hauling in at 20 m/min. increased the tension by about 0.1 ton.

Meanwhile, work on the electronics continued. The triggering system tried on Darwin Cruise 6 proved unworkable, and new boards to implement a more elaborate system were installed. These boards worked well on deck.

After these changes, the whole system was deployed as a first test of the side-scan system. The deployment procedure was the same as that used on Cruise 6, except that the vehicle was lifted from a sheave at the top of the A-frame using a line run forward to the capstan. These changes were not an improvement: the capstan cannot be controlled delicately enough.

The winch was stopped with 200 m wire out in an attempt to detect a side-scan echo. A very faint echo was detected on the paper recorder: it appeared that the gain of the receiver TVG curve at short range was far too low. More wire was paid out in an attempt to obtain a bottom echo, and, hopefully, a side-scan image. At 2500 m depth, as indicated by the vehicle depth guage, a clear surface echo was seen, but no bottom echo. However, the sidescan transmitter occasionally failed to fire, there were violent fluctuations in signal level, and outbreaks of intermittent spiky noise on the paper record. All these features suggested slipring trouble.

At 4000 m depth, with 5400 m wire out, all signals were lost, and the vehicle power supply ran into current limit. Electrical failure of one of the cable terminators was suspected, so retrieval began.

When the weight was lifted on deck, it became apparent that the umbilical cable was hanging vertically in the water and was under heavy load, suggesting that some or all of the vehicle buoyancy had been lost. It proved impossible to haul in a bight of umbilical by hand, so a wire was attached to the weight, sitting in its cradle on deck, and the capstan used to haul the weight bodily forward by some 5 m. The weight was then secured to a strong point on deck, and the line from the capstan used to haul in a bight of umbilical by means of a rope stopper on the umbilical. It was then possible to take a riding turn of the umbilical around the capstan, and haul in the rest of the umbilical in a continuous operation until the breakout recovery strop was reached.

The vehicle was lifted from the water by attaching the breakout strop to the end of the coring warp. It emerged from the water vertically rather than horizontally. Later we saw that one of the lifting strongpoints had broken away from the vehicle frame. Fortunately the great height of Darwins' A frame enabled us to lift the vehicle straight on to the deck even in the vertical position.

All the foam blocks and all the glass spheres had disappeared, leaving only a few tattered remnants of hard hats. Virtually every member of the space frame was split, bent or buckled, and virtually every weld had cracked or broken. The end caps and contents of the profiler tube had disappeared completely, and the inside of the tube was heavily scored presumably by one end cap being forced through it. The end caps of the main tubes were loose, but there was some hope that the contents might have survived. Likewise, the sidescan transducers appeared undamaged.

Later examination showed that the main tubes had leaked slightly, but the contents had been destroyed by the shock wave of the sphere implosion. Electrical checks of the sidescan transducers showed them to be non-operational. Removal of the back plates showed why: the ceramic rings in the motor stacks had been shattered by the blast. The titanium front plates are, however, probably reuseable.

The depth guage reading, the PES record and the wire scope all indicate that disaster occured at 4000 m depth, and it seems almost certain that it was triggered by failure of a single sphere, which then caused a domino implosion of the remainder.

The spheres were all tested by the manufacturers to 10000 psi and issued with test certificates, so the most likely cause would seem to be either that one of the spheres had inadvertently been certified but not actually tested, or that one had been damaged in some way.

RJB

We were initially surprised by the extent of the damage, but at 4000 m the potential energy of one 17-inch sphere is 0.8 MJ. Reference to Applied Geophysics (Telford, Geldart, Sheriff & Keys, Cambridge University Press, Figure 4.71, p.334) revealed that this is equivalent to the released energy of 0.4 lb of 60% dynamite.

RCS

Acoustic Navigation

5kHz Acoustic Navigation

The 5 kHz acoustic navigation system consists of a number of seabed mounted transponders which can be interrogated by either the shipboard deck system, for ship navigation, or a remote interrogator pinger, for navigation of underwater vehicles or equipment. By measuring the time between transmitting to a transponder and the receiving reply a range can be obtained. This is done for each transponder. Each range is drawn as a circle on the chart, the intersection being the current position of either ship or remote pinger depending on what is being navigated. Simultaneous positions of ship and pinger can be plotted. The computations for converting the reply time to horizontal range were performed on a programmable calculator.

Since last used, on Cruise D153, both the deck unit and transponder had been extensively modified. Because of this four wire tests had to be done so as to set up the transponder and deck unit sensitivities correctly. During the course of these wire tests one transponder transducer was damaged and another found to be leaking. On each wire test all three transponder releases were tested. On each test all three releases fired correctly.

On Day 350 the three transponders were deployed in the fault area in an approximate equilateral triangle formation of baseline 6 km. (see fig. 2 and table 4).

Baseline crossings were made so as to establish the relative positions of the transponders (table 5).

During the next 7 days a 24 hour airgun and 3.5 kHz sub bottom profiler survey, positioning for the deployment of two PUPPIs and, using the remote pinger, two Heat Flow runs, one of 12 hours and the other of 16 hours duration, were all successfully navigated.

On day 357 the red and blue transponders were recovered. Due to a mix up with release frequencies both transponders were released from their moorings simultaneously. No problems were experienced in tracking both transponders to the surface and when on the surface both were still transponding well. A visual sighting of the blue transponder (which carried a flag) was made, whilst picking up red, at a range of approximately 3 miles.

On day 359 the red and blue transponders were redeployed in the 10 km. box area at a separation of about 10 km. These were then used on an airgun/3.5 kHz survey. The transponders were clearly visible on the recorder at horizontal ranges up to 20 km, the blue transponder being seen at 26 km on one leg of the survey. An acoustically navigated Heat Flow run was also attempted at a range of 20 km; however this proved impossible to navigate owing to the long range and the high ambient noise due to rougher weather.

On Day 361 the blue transponder was recovered. Both the red and green transponders went through their release sequences but failed to release from their moorings. The causes for this are under investigation.

10 kHz Acoustic Navigation

The 10 kHz acoustic navigation works on the same principles as the 5 kHz; that is the transponders are interrogated by a pulse from the ship and the time difference between the transmitted pulse from the ship and the transponders' reply is converted to a range.

One 10 kHz transponder had already been deployed in the fault area on a previous cruise. Another 10 kHz transponder was laid in this area and both were used along with the three 5 kHz transponders in the navigation of that area.

The 10 kHz transponders are a disposable item and have no release mechanism. They do however have a very long life and should last at least 1½ years of moderate use.

The transponder replies are displayed on the PES Mufax recorder and using the beamsteering unit ranges of up to 13 km were obtained. At present, however, the beamsteering on the PES fish is only in the fore/aft direction. This means that transponders abeam of the ship had a much shorter range of 4 to 5 km.

Whilst using the 10 kHz transponders and the 3.5 kHz sub bottom profiler at the same time, the third harmonic of the 3.5 kHz triggered the transponders. This produced multiple traces on the recorder and made correct interpretation difficult.

By using both 5 and 10 kHz systems good navigation was obtained in both work areas.

IPR

Coring

Box Coring

The IOS Box Corer (see IOS Report no. 106, 1980) was used in order to take undisturbed samples of sediments and sediment surfaces on an abyssal hill adjacent to the 100 square kilometre box study area. This was being done in order to examine a manganese nodule field (discovered on Discovery Cruise 153) and analyse the sediment to see if current activity has occured.

Station CD9B/6The hydrostatic release was primed with a shear pin designed to fail at approximately 3600 m and launched from the midships A frame in 5286 m of water. Penetration occured at 1829 (Day 345) and a good core with four manganese nodules on its surface was recovered.

Station CD9B/15The corer was rigged as for Station CD9B/6; however, even though the midships A-frame was being used the excessive sea state caused the corer to pre-trigger and so no sediment was obtained.

Station CD9B/22On this occasion the hydrostatic release was primed with a 5000 m shear pin. Penetration occured at 0436 and a good core (but no nodules) was obtained.

During this station the ship drifted upslope to a water depth of 5228 m (at 0436) which was thought to be just off the edge of the nodule field.

Both of the succesful cores were subsampled and stored for analyses back at the IOS.

Kastenlot Corer

The Kastenlot corer was used with a 2 m barrel in order to sample the same sites as the box corer but with greater penetration. Two cores were taken, (Stations CD9B/7 on the nodule field and CD9B/14 just above it) both of which were stored for analysis at the IOS.

Single Sample Sediment Traps

Mooring configuration

Four sediment traps on a single mooring were deployed on the abyssal plain in GME. Each trap consists of a conical collecting funnel with sample cups arranged to collect falling sediments. A small quantity of chloroform is placed in the sample cups to preserve the sample. Fins keep the traps facing into the current so that the mooring rope does not obstruct the path of the sediment.

The mooring consists of a ballast chain, an acoustic release, traps at heights of 4, 10, 100 and 1000 m off the sea-floor, bouyancy of 6 x 17 inch "Benthos" spheres, a stray line and a 10 inch sphere for recovery.

To prevent the sediment being washed out when the mooring is recovered, valves just above the sample cups are closed prior to recovery. The distance apart of the traps makes it impractical to close the valves under control of a single release, and the cost of four separate releases would be prohibitive, and so it was decided that the valves should be closed under control of four separate timers, set to operate some short time before the mooring is to be released.

Testing of auto-retractors and timers

The valves themselves are held open by a recently developed (D. Gaunt IOS) recockable retractor. This is designed to be mechanically and electrically interchangable with the standard IOS retractor, with the benefit that it can be re-cocked without needing to break "O ring" seals or replace any parts.

When the retractor fires, a length of stretched "bungy cord" pulls the valve closed.

This was to be the first time that the auto-retractors were used in deep water for a scientific deployment, so it was thought to be prudent to wire test the auto-retractors and timers. The timers were set and the wire test carried out. All four retractors fired satisfactorily at a depth of 5300 m.

Deployment of sediment traps

Originally it was planned to deploy the sediment trap through the aft "A" frame using the main capstan. The Master considered this dangerous since the capstan operator's view of the deployment was obscured by the multichannel seismic hydrophone drum. The alternative was to use the mid-ships "A" frame. The 1000 m of nylon mooring rope was wrapped around the main coring drum and then as it was payed out the Rexroth auxiliary winch was used to stop off for the attaching of the traps and bouyancy. This resulted in the mooring rope being contaminated by grease, though as much as possible was removed as the rope was payed out. One small problem was encountered with the last sediment trap section. This section of sediment trap and bouyancy was too long to lift, and it was also thought that the bouys were too close to the sediment trap and might affect the sediment collection. A 10 m section of nylon rope was introduced, allowing the lifting of the last sediment trap and bouys in two lifts. The whole operation went very smoothly and is probably an easier more controllable method of deployment compared to using the aft "A" frame.

Timers were set for 1200 hrs Day 132 (12th May) 1986.

Traps deployed: 1608/344/85
On sea-bed: 1708/344/85

Latitude: 31°32.9 N
Longtitude: 24°40.2 W

SD McP
DEG

Computers

The new A-B-C system was installed, but there was little software available for the level C processor, so the computer was used almost entirely for data logging. This proceeded with few problems, and almost no data was lost owing to malfunctions. Towards the end of the cruise we made extensive use of the computer for plotting tracks and other data, and a continuous listing of most underway data was prepared.

However, it must be said that the processing and display software available was very limited. The most important lack was the ability to compute and display real-time dead-reckoning (so-called "live track plot"). We relied entirely on ten minute printouts from the Magnavox 1170 satellite navigator for this purpose, but they were not really adequate, and certainly no substitute for a proper real-time plot of DR. There were also long delays (several days) before satellite-corrected navigation data could be processed. This caused some inconvenience; on other cruises (e.g. for GLORIA work) it would be critical. Finally, the software for listing (printing) data and writing formatted data tapes was inadequate. Having said that, it must be said that the shipboard support of the computing facilities was excellent, within the very severe limitations of the software.

RCS

Miscellaneous Equipment

The PES and magnetometer worked well, with only routine maintanance being required.

The E/m logs worked well, but were in need of calibration. The thwartships log was clearly giving an inaccurate output, but we had no opportunity to calibrate it.

The main winch was used extensively, both over the midships gantry for coring and over the stern for towing the WASP camera and the heatflow probe.It was also used for deploying the sediment traps. The main problem encountered was two power overloads on the winch circuit during heatflow station CD9B/12. The second of these caused a complete power blackout. The winch was carefully checked by the ships' engineers following this incident, but no obvious cause could be found, although it was pointed out that there is no proper way of calibrating the safety cut-out. Some modifications were made in the engine room to provide a higher level of protection in future, and we had no recurrence of the trouble.

The remote winch control boxes were very valuable and extensively used, although poor electrical connections caused a few problems. The connection to the after deck outlet was reterminated early in the cruise. A proper stand is required for that unit.

The TV surveillance system worked well and was very useful.

Better lighting is needed in the region of the stern A-frame.

Table 1: Station List

Station Number	Equipment	Latitude deg min N	Longitude deg min W	Water Depth corr m	Day/time Left Ship	Day/time On bottom	Day/time On board	Comments
CD9B/1	WASP	35° 04'.0 to 35° 02'.9	12° 57'.1 to 12° 57'.0	400 to 550	341/1024	341/1048 to 341/1128	341/1200	Test polarizing filters.
CD9B/2	Wire test, water sample	31° 30'.0	24° 36'.6	5444	344/0900	344/1100	344/1230	Successful.
CD9B/3	Sediment trap	31° 32'.9	24° 40'.3	5445	344/1608	344/1708		Laid.
CD6/1	PUPPI	31° 17'.6	25° 19'.6	5444	229/1340	229/1435 to 344/2329	345/0125	Laid in 10 km box on previous cruise. Successful recovery.
CD9B/4	WASP	31° 30'.7 to 31° 27'.0	25° 21'.6 to 25° 13'.4	5130 to 5236	345/0334		345/1226	NBES failed.
CD9B/5	Wire test transponders	31° 27'	25°13'	5241	345/1300		345/1500	Low sensitivity
CD9B/6	Box Core	31° 24'.9	25° 16'.4	5283	345/1606	345/1829	345/2107	On Mn nodule field. 60 cm core with Mn nodules.

CD6/3	PUPPI	31° 19'.1	25° 18'.3	5444	235/0214	235/0302 to 345/2244	346/0105	Laid near 10 km box on previous cruise. Successful recovery.
CD9B/7	Kasten Core	31° 25'.6	25° 17'.3	5269	346/0308	346/0534	346/0757	On Mn nodule field. Successful: 1 m core.
CD9B/8	PUPPI	31° 30'.2	25° 03'.6	5407	346/1130	346/1222 to 352/1047	352/1256	On edge of abyssal hill. Successful.
CD9B/9	WASP	31° 30'.4 to 31° 27'.0	25° 23'.7 to 25° 18'.3	5444 to 5319	346/1708	346/2029 to 346/2130	346/2344	Flash not operating.
CD9B/10	Tension TOBI cable and test transponders	31° 23'	25° 14'	5380	347/0134		347/0620	Cable tensioned to 4636 m. Adjusted transponder sensitivities
CD9B/11	PUPPI	31° 26'.8	24° 53'.4	5444	347/1052	347/1139 to 354/1200	354/1402	Near high heatflow result from D10972/5 Successful.
CD9B/12	Heatflow	31° 20' to 31° 15'.5	25° 18' to 25° 32'.2	5444 to 5442	347/2316	348/0140 to 348/1046	348/1430	Over 10 km box. Successful - 12 dips.
CD9B/13	Wire test transponders	31° 10'	25° 30'	5443	349/0932		349/1311	Almost correct.

CD9B/14	Kasten core	31° 26'.7	25° 21'.1	5150	349/1722	349/1858	349/2038	Core recovered from above Mn nodule field.
CD9B/15	Box core	31° 25'.0	25° 16'.7	5283	349/2206	350/0058	350/0333	No core - pretriggered
CD9B/16	Test transponders	31° 26'.0	25° 15'.0	5221	350/0418		350/0628	Successful.
CD9B/17	5 kHz transponder	31° 25'.8	24° 52'.6	5444	350/0906	350/1025 to 357/0926	357/1105	"Red" beacon, fault area. Transponder at 5344 m.
CD9B/18	5 kHz transponder	31° 28'.0	24° 52'.3	5444	357/1242	350/1403 to 357/0926	350/1154	"Blue" beacon, fault area. Transponder 5344 m.
CD9B/19	5 kHz transponder	31° 25'.8	24° 49'.4	5444	350/1655	350/1815		"Green" beacon, fault area. Transponder at 5344 m. Failed to release.
CD9B/20	WASP	31° 23'.8 to 31° 28'.7	25° 12'.5 to 25° 17'.1	5218 to 5268	351/0000	351/0412 to 351/0954	351/1234	Overe Mn nodule field Successful.
CD9B/21	TOBI	31° 16'.9 to 31° 25'.3	25° 13'.4 to 25° 14'.0	5444	351/1515		352/0006	Bouyancy spheres imploded, wrecking vehicle. Vehicle recovered.

CD9B/22 Box core	31° 25'.9	25° 17'.1	5257	352/0249	352/0436	352/0733	Successful. Probably sampled just above nodule field.
CD9B/23 10 kHz transponder	31° 31'.5	24° 47'.9	5444	352/1528	352/1720		"Orange" beacon, fault area (non-recoverable). Transponder at 5244m.
CD9B/24 10 kHz transponder	31° 13'.5	25° 24'.3	5444	353/1950	353/2106		"Black 2" beacon, box area(non-recoverable). Transponder at 5244 m.
CD9B/25A 10 kHz transponder	31° 15'	25° 28'	5444	353/2158			Non-recoverable. Failed in water.
CD9B/25B 10 kHz transponder	31° 14'.8	25° 27'.7	5444	353/2233	353/2347		"Orange 2" beacon, box area (non-recoverable). Transponder at 5244 m.
CD9B/26 PUPPI	31° 12'.3	25° 28'.2	5408	354/0501	354/0543		Laid on small knoll to SW of box area. Failed to return.
CD9B/27 Heatflow	31° 27'.4 to 31° 34'.6	24° 48'.3 to 24° 54'.5	5445	354/1526	354/1745 to 355/0515	355/0749	Extending heatflow line D10983. Thermistor string broke - one dip only.
CD9B/28 PUPPI	31° 32'.3	24° 52'.9	5444	355/1404	355/1457 to 362/0653	362/0925	Over subbottom basement high, fault area. Successful.

CD9B/29	WASP	31° 00'.5 to 31° 04'.0	24° 57'.1 to 25° 05'.1	5285 to 5443	356/0130	356/0443 to 356/1030	356/1301	Over line of D11261/58. Successful.
CD9B/30	Heatflow	31° 21'.3 to 31° 30'.2	24° 49'.5 to 25° 01'.7	5445	356/1630	356/1830 to 357/0512	357/0810	Over fault area. Successful - 21 dips.
CD9B/31	WASP	31° 08'.3 to 31° 19'.6	25° 28'.4 to 25° 21'.4	5444 to 5423	357/1656	357/2036 to 358/0349	358/0652	Over knoll SW of box. Successful.
CD9B/32	5 kHz transponder	31° 16'.5	25° 18'.5	5444	358/1813	358/1924 to 361/1156	361/1347	"Blue" beacon, box area. Transponder at 5344 m.
CD9B/33	5 kHz transponder	31° 20'.9	25° 23'.4	5442	358/2034	358/2203		"Red" beacon, box area. Transponder at 5344 m. Failed to release.
CD9B/34	Heatflow	31° 11'.9 to 31° 17'.9	25° 29'.1 to 25° 30'.2	5423 to 5445	361/0130	361/0325 to 361/0526	361/0849	Over knoll - 2 dips only.

Notes:

1. Positions refer to the ship at times when gear left (and returned to) it. They are based on the satellite-corrected navigation data.
2. Depths are water depth under ship.

Table 2: Underway geophysical observations

Measurement	Start	Stop	Comment
Computer logging	85/340/1048	c.86/004/1018	
PES	340/1500	c.004/1030	Continuous except for some stations.
Magnetometer	340/1158	341/0916	Reduced to 1GRF 1980.0
	341/1234	344/0644	Reduced to 1GRF 1980.0
	359/0158	360/2052	Reduced to 1GRF 1980.0
	362/2026	c.001/0800	Reduced to 1GRF 1980.0
	c.003/0848	c.004/1018	Reduced to 1GRF 1980.0
3.5 kHz	c.341/1410	342/2248	Direct drive - very noisy
	342/2248	342/2356	Electric drive - quiet
	342/2356	c.343/1400	Direct drive
	c.343/1400	348/0525	Electric drive
	348/0654	c.348/1430	Direct drive
	c.348/1430	c.349/0920	Electric drive
	c.349/0920	350/0345	Direct drive
	350/0345	350/2258	Electric drive
	350/2258	352/1000	Direct drive
	352/1000	362/1042	Electric drive
SRP	343/1612	344/0553	160cu.in. gun without WSK and 40cu.in. gun with WSK
	348/1752	348/0636	40cu.in. gun with WSK and 40cu.in. gun without WSK
	352/2005	353/1427	40cu.in. gun with WSK and 20cu.in. gun without WSK
	359/0155	360/2054	20cu.in. gun without WSK and 40cu.in. gun with WSK

Table 3: WASP stations

Station No.	Day	+ Time		+ Position		Depth (M)*
		Start	Finish	Start	Finish	
CD9B/1	341	1048	1128	35° 03'.75N 12° 57'.0W	35° 03'.0N 12° 67'.0W	425
				approximation		
CD9B/4	345	unknown		31° 27'.62N 25° 20'.95N	31° 27'.13 25° 18'.66	5300
CD9B/9	346	2029	2130	31° 29'.3N 25° 21'.5W	31° 28'.75N 25° 20'.65W	5300
CD9B/20	351	0412	0954	31° 24'.3N 25° 12'.8W	31° 25'.75N 25° 16'.8W	5200
CD9B/29	356	0443	1030	31° 02'.15N 24° 57'.05W	31° 03'.5N 25° 01'.7W	5300
CD9B/31	357/358	2036	0349	31° 10'.1N 25° 28',15W	31° 15'.8N 25° 23'.6W	5400

\+ Time and positions (Sat nav) for camera on the seafloor.
* Corrected, average depth during run.

Table 4: Acoustic Transponder Positions

Transponder	Channel	Reply Frequency (kHz)	Latitude	Longitude	Depth (m)
Red 1	4	5.663	31°25'.84N	24°53'.05W	5344
Blue 1	8	5.883	31°28'.08N	24°51'.72W	5344
Green	11	6.061	31°25'.76N	24°49'.38W	5344
* Black 1	-	10.0	31°28'.29N	24°52'.92W	5244
* Orange 1	-	10.0	31°31'.25N	24°50'.25W	5244
Red 2	4	5.663	31°20'.45N	25°53'.00W	5344
Blue 2	8	5.883	31°16'.37N	25°18'.60W	5344
* Black 2	-	10.0	31°13'.86N	25°24'.25W	5244
* Orange 2	-	10.0	31°14'.78N	25°27'.56W	5244

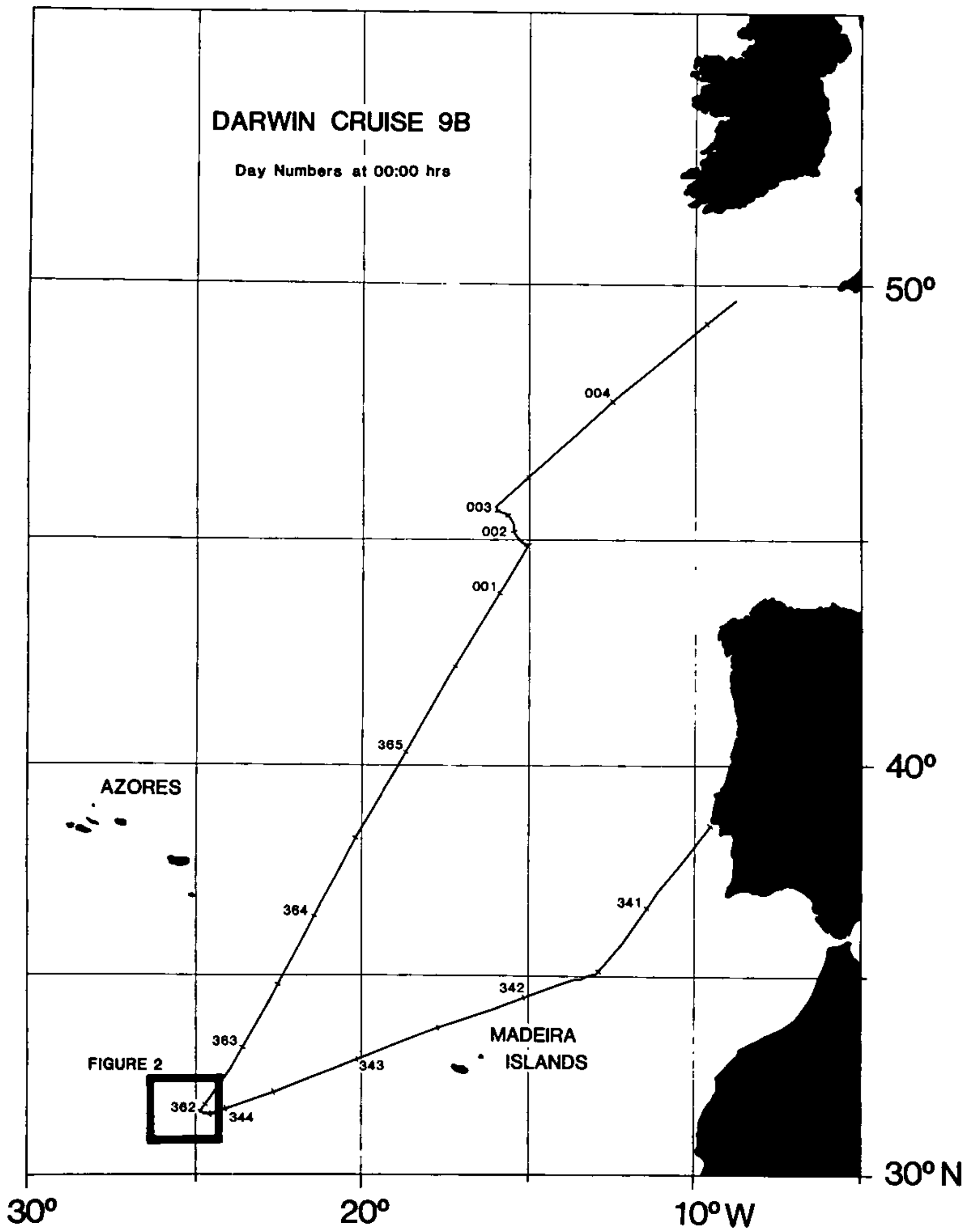
* These transponders are still in place. They are non-recoverable, and can be used by anyone for navigation.

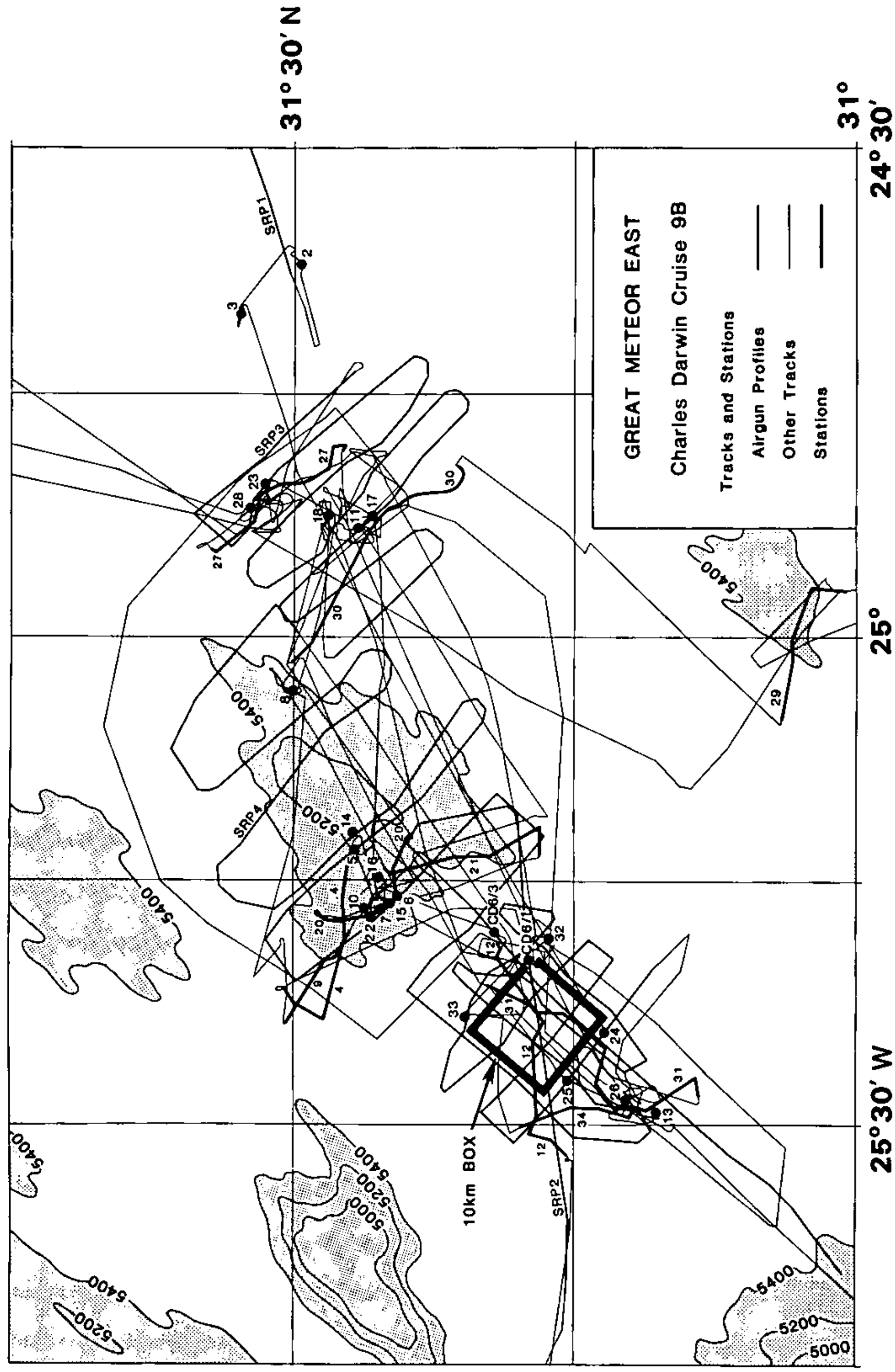
The absolute positions of these transponders are estimated to be accurate to ±150 m, except for Orange 1 which is ±250 m.

Table 5: Acoustic Transponder Baselines

Transponder pair	Baseline (km)	Accuracy (km)
Red 1 - Green 1	5.87	±0.02
Red 1 - Blue 1	4.66	±0.02
Red 1 - Black 1	4.56	±0.02
Red 1 - Orange 1	11.02	±0.25
Blue 1 - Green 1	5.71	±0.02
Blue 1 - Black 1	1.95	±0.02
Blue 1 - Orange 1	6.39	±0.25
Green 1 - Black 1	7.40	±0.02
Green 1 - Orange 1	10.32	±0.25
Black 1 - Orange 1	7.00	±0.25
Red 2 - Blue 2	10.35	±0.02
Red 2 - Black 2	12.45	±0.15
Red 2 - Orange 2	12.85	±0.15
Blue 2 - Black 2	10.10	±0.15
Blue 2 - Orange 2	14.56	±0.15
Black 2 - Orange 2	5.52	±0.02

Note: The baselines with accuracies of 0.02 km were determined by baseline crossings. The others are measured differences between the best estimate absolute positions (see Table 4).


DARWIN CRUISE 9B
Day Numbers at 00:00 hrs
004
003
002
001
365
364
363
362
FIGURE 2
344
343
342
341
AZORES
MADEIRA
ISLANDS
50°
40°
30° N
30°
20°
10° W


GREAT METEOR EAST
Charles Darwin Cruise 9B
Tracks and Stations
Airgun Profiles
Other Tracks
Stations
31°30'N
31°
24°30'
25°
25°30'W
10km BOX
SRP1
SRP2
SRP3
SRP4
5400
5200
5000