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I.O.S.

RRS DISCOVERY

CRUISE 149

15 JUNE – 10 JULY 1984

GEOCHEMICAL SAMPLING IN THE NORTH ATLANTIC

CRUISE REPORT NO. 169
1984

NATURAL ENVIRONMENT RESEARCH COUNCIL

INSTITUTE OF
OCEANOGRAPHIC
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INSTITUTE OF OCEANOGRAPHIC SCIENCES

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

(Director: Dr. A.S. Laughton FRS)

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

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

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

(Assistant Director: M.J. Tucker)

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INSTITUTE OF OCEANOGRAPHIC SCIENCES

WORMLEY

RRS DISCOVERY

Cruise 149

15 June - 10 July 1984

Geochemical sampling in the North Atlantic

Principal Scientist

T.R.S. Wilson

CRUISE REPORT NO. 169

1984

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Arrive North Shields 10 July 1984

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A.C. Braithwaite	
E. Chapman	
S. Colley	
F. Culkin	
E. Darlington	
P. Hooper	(East Anglia)
I. Jarvis	
K.S. Jørgensen	(Aarhus)
H. Kennedy	(Cambridge)
G.A. Lake	
R.D. Peters	
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P.J. Schultheiss	
J. Sørensen	(Aarhus)
H.E. Sutherland	
J. Thomson	
R.F. Wallace	
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Affiliations. All I.O.S. except:
Aarhus = Institute of Ecology and Genetics, University of Aarhus, Denmark.
Birmingham = Department of Geological Sciences, University of Birmingham, U.K.
Cambridge = Department of Earth Sciences, University of Cambridge, U.K.
East Anglia = School of Environmental Sciences, University of East Anglia, U.K.

SHIP'S OFFICERS

S.D. Mayl	Master
N.A.C. Jonas	Chief Officer
S. Sykes	2nd Officer
A.J. Brigden	3rd Officer
I.R. Bennett	Chief Engineer
F.C. Hammond	2nd Engineer
A. Greenhorn	3rd Engineer
G.L.R. Parker	4th Engineer
N. Davenport	5th Engineer
S.G.S. Bray	5th Engineer
D.J. Regan	Electrical Engineer
P. Higginbottom	Chief Purser/Catering Officer
M. Taperell	Radio Officer

OBJECTIVES

This cruise is part of a background environmental research programme related to the Heat Generating Radioactive Waste study. The main work area is designated 'GME', on the Madeira Abyssal Plain close to 31°30'N 35°W. Scientific objectives were:

1. To obtain sediment and pore water samples from five designated stations within the study area.
2. To supplement this by deeper sampling at the same station using the IOS piston corer.
3. To make shipboard analytical studies on this material in order to define the chemical (redox) state of the sedimentary environment, and its variation with depth and position within the study area. To return samples for laboratory study.
4. To test the modified PUPPI (in-situ pop-up porewater pressure instrument and to make a long term deployment of this device.

Lower priority process-related studies included:

5. An attempt to obtain sediment from a site just north of the study area where manganese incrustations have been reported.
6. Surficial sediment dissolved oxygen profiles in the abyssal Atlantic off the Porcupine Sea Bight. This relates to existing IOS biological studies in this area and to a need to obtain reference data to compare with the GME information.

In the event, all these objectives were accomplished.

NARRATIVE

Scientific fitting out of the laboratory and sampling equipment commenced on 11th June 1984, R.R.S. Discovery alongside at Funchal. IOS and ship's engineers working to repair aft Coles crane, successfully completed on 14th June. The scientific party embarked at 1030 hrs on 14th June and Discovery sailed as planned at 1036hrs (local) the next day. The 3.5kHz and P.E.S. transducer fish were deployed at 10.00 hrs GMT on 16th, and scientific watches were begun at this time, although for some time the 3.5kHz noise level was unacceptably high. Problems were also experienced with the nitrogen generator control system and with ventilation in the cool (Stbd) container, but all these defects had been rectified by the time Discovery arrived at Site A within the GME area at 0635hrs on 17 June.

A short survey was undertaken prior to sampling in order to verify the relationship of the sample site to local topographic features and sampling began at 1050hrs. Kastenlot, box and piston cores, together with in situ porewater sampler deployments were made at this and subsequent stations (see Table 2). A wire test of the pop-up pore pressure instrument (PUPPI) electronics was also made during the sampling at this station. Sampling concluded at 0233hrs on 19th June and a successful test deployment and recovery of the PUPPI device followed before departing the first work site for a short survey in the region of the fault zone which had been investigated by geophysical techniques during a previous Discovery cruise (145). At the conclusion of the survey (1843hrs, 19th June), Discovery hove-to to deploy a 5kHz transponder interrogater fish. During this deployment control of the deployment rope at the aft capstan was lost. The rope slipped from the capstan and ran out of control along the deck and through the block. Since the fared cable had not at that time been secured, the fish was lost (Master's report dated 20th June refers). No one was hurt. Although the various fish used on board have been deployed many times without incident using the technique employed on this occasion, it is recommended that a review of the technique and equipment provided for fish deployment should be undertaken.

As no back-up transponder fish was available the planned deployment of acoustic navigational transponders was not made, and Discovery moved to the vicinity of a previously charted fault (Site B) for a sampling programme navigated by reference to the Transit navigational system. As there are currently occasional periods of up to several hours duration during which no satellite is available it was occasionally necessary to rely on the satnav DR system. Subsequent satellite passes usually revealed that this system was in error and thus seriously misleading for this purpose, except for short periods (less than 1 hour). Consequently it was necessary to repeat certain deployments later, as they had been made too far from the desired point. Positions listed in Table 2 are derived from satellite passes made during the relevant deployments unless otherwise noted.

Operations at the site B were protracted by the need to reposition the vessel between lowerings in order to keep the sample zone as small as possible. During the lowering of the piston corer (series 5, station 11136) a pretrip occasioned the loss of the corer, although the trigger and electronics were recovered. This station was ended at 2300hrs 20th June and a PUPPI deployment was made nearby at 0326 on 21st. After a survey lasting about six hours site C was occupied. This site was placed as far as possible from charted faults within about 5nm of site B, the purpose being to compare the chemistry of faulted and non-faulted sediments. Work on station 11137 concluded at 1252hrs on 22nd June station 11138 was occupied at site B, work concluding at 0836hrs on 23rd. Additional survey lines (PES and 35kHz) were run before arrival at site D at 2109hrs that evening. This site was chosen because a small topographic high offered the opportunity to sample a continuous pelagic section. Work on this station (11139) was concluded at 0830 on 25th June. By this time evaluation of the data recovery at the first three sites was sufficiently advanced that a selection could be made of operations which needed to be repeated in order to complete a high quality data set, and the period up to 22hrs on 27th June was occupied by three short stations designed for this purpose. The PUPPI deployed five days earlier was also recovered and an additional long term PUPPI was deployed. Discovery then moved to the north of the study area and occupied site E (station 11145) and site F (station 11146), the latter being complete by 0915hrs on 29th June.

As no information had been received on the refit port at which the cruise was to end it became necessary to terminate work on the GME study area at this time and to proceed north. The 3.5kHz fish was recovered and scientific watches suspended after leaving the study area. On passage, an injury to a crew member required diversion to Ponta Delgada (Azores), and he was landed there on medical advice. Subsequent to this, permission was sought and received to use three engines in order to make up lost time.

A station (11147) was worked on the abyssal Atlantic floor near the mouth of the Porcupine sea bight. This station was intended as a comparison for the GME data; the redox profile appears similar but it seems likely that the causal mechanism is not in this case coupled as directly to the lithological features of the site. Thus, the data from this station should assist in the evaluation of the relative importance of processes which are subsidiary at the GME site.

During the working of this station it was necessary to suspend operations because of the sea state. Swell caused the pretripping of one boxcore, and the MkII porewater sampler was severely damaged, apparently by becoming entangled in its own warp while on the seabed. However, useful box and Kastenlot cores and a Mk III porewater profile were obtained.

At the conclusion of this station course was set for Mounts Bay in order to land equipment required by R.V. Frederick Russell. The Tyne pilot boarded R.R.S. Discovery at 1300 hrs on 10 July and the vessel was secured alongside by 1430 hrs.

T.R.S. Wilson

REPORTS OF PROJECTS

CORING OPERATIONS

Box, Kastenlot and piston cores were required to provide progressively deeper sediment samples for shipboard porewater extraction and subsequent solid phase analysis. The box and Kastenlot corers provided material which overlapped the penetration depths of the *in situ* porewater samplers (up to 1m) while the piston corer sampled down to 12 metres.

a) Box and Kastenlot corers

The I.O.S. box corer was used with a shear pin assembly and a damping device as modifications to the standard no-load release. The shear pin allowed payout of the corer at 1m/s until the pin shear depths was reached, and the damping device slowed the action of the corer no-load release mechanism. Both modifications performed well, but in moderate to bad swell conditions the tendency to pre-trip remained and two runs failed for this reason. The combined N.B.E.S./pinger device developed earlier operated satisfactorily to indicate whether the corer remained armed or had pretripped. In order to obtain cores as long as possible for sectioning, the box corer was run fully weighted.

The Kastenlot corer was used with 5 weights and a 2-3m stainless steel barrel: all cores obtained were close to the barrel length. Improvements made to this corer's catcher at I.O.S. following Cruise 135 were successful and no problems with door closure were encountered on this cruise,

In the main part of the work in the G.M.E. area, seventeen corer runs were made, of which fourteen were successful. Two of the failures (11136#3BX and 11139#4K) were associated with sea-swell conditions, while the third (11139#2BX) was caused by the failure of the shear pin to break. The following box and Kastenlot cores, all of which were of good quality, were obtained in the area:

Site A
11135#1K
11135#5BX
11135#7K
11140#1BX (University of Aarhus microbiological studies only)
11143#1BX (University of Cambridge REE Studies only).

Site B
11136#1K
11138#1BX

Site C
11137#1K
11137#3BX
11144#1K (Anaerobic sediments for DOE contract at Imperial College,
microbiology at Queen Mary College only)

Site D
11139#6BX (University of Cambridge REE studies only)
11139#8BX

Site E
11145#1BX

Samples of bulk sediment were reserved after detailed core sampling for various DOE contractors from whom requests had been received.

After departure from the G.M.E. area, box core 11146#1BX was collected from a small abyssal hill just north of the area. Manganese nodules have been photographed on and dredged from this hill, but none were found in the core.

Sea-swell conditions were poor on arrival at the final station at the mouth of the Porcupine Sea Bight. An early box core run (11147#3BX) failed because of pre-trip, but good cores were obtained (11147#1K and later in improved weather, 11147#5BX).

b) Piston coring

Six good piston cores were recovered in the G.M.E. area during the cruise and one corer was lost at station 011136#5. All coring was carried out in calm sea states (<4). The details of the rigging and the lengths of cores recovered are given in table 1. With Kasten and box cores taken at the same sites it was possible to compare the tops of all three corers. Only at one station (011138#x) was a significant amount of surface material missed in the piston core (≃ 1m). In all the others the amount missing was less than 50cm. A set of six lead weights (from the PUPPI) weighing approximately 120kg were used for triggering the corer as the trigger corer normally used was not available.

At station 011135#3 the acoustically activated safety pin was withdrawn from the trigger arm when the trigger weight was 20m from the bottom (same technique as used on previous cruises). A good core was recovered but the shock loading had dislodged the acoustic command pinger and it was lost. At the next station (011136#5) a modification to the support bracket enabled the command pinger to be held even more securely and in addition a small safety strop was wrapped around the transducer mushroom. The same procedure was then used at the next station (011136#5) with the safety pin being withdrawn when the trigger weight was 20m from the bottom. However, the corer pre-triggered immediately the pin had been withdrawn. The resulting shock load parted the wire just below the bronze wire clamp. The piston core head and 5 barrels were lost.

For the remaining stations only 4 barrels were used (limited by the number of joiners available) and the withdrawal of the safety pin was delayed until the trigger weight was judged to be within two metres of the bottom. In this way it was thought that in the event of any further pretriggering a good core could still be obtained and the shock loading lessened by the resistance provided by the sediments. This proved to be the case but the loading still resulted in bending (and in one case nearly completely shearing) the piston pin. Good cores were obtained at the last five stations and it was concluded that the soft sediments did not provide enough resistance to stop the corer with only 4 barrels on it, hence the piston came hard up against its stop on penetration rather than on pull out. The only other problems encountered were two fractured liners and one badly bent barrel.

J. Thomson
F. Culkin
P.J. Schultheiss
H.E. Sutherland
C. Pudsey
P. Hooper

POREWATER EXTRACTION

A total of 160 porewater samples were produced from 13 cores (Kasten, box and PWS Mk III) using hydraulic squeezing, after sample preparation under nitrogen in a cooled container laboratory. A further 182 porewater samples were obtained from piston cores by centrifugation after subsampling of the split cores under nitrogen in the cool container, using syringes. The plastic bag designed for this purpose worked well after initial difficulties with condensation on the inside, and with the practical problems of dealing remotely with lengths of core. Some improvements to the design are however necessary following the failure of the access zip after a short time due to sediment contamination. It is also imperative that samples taken from the piston cores are centrifuged and filtered as soon as possible after removal to reduce the risk of chemical reactions and consequent loss of soluble metals such as iron.

S. Colley
P. Hooper
C. Pudsey
H. Kennedy
R. Alexander
I. Jarvis
E. Chapman

IN-SITU POREWATER SAMPLING

a) Mk III Porewater Sampler

During the cruise the PWS III was deployed a total of ten times including two wire tests to 1000m. Porewater samples were successfully obtained on all but the first deployment to the sea bed. Three cores were collected, one of which was squeezed. A further core was lost during landing the sampler on deck. Considerable experience was gained in the operation of this relatively new and complex device; remaining problems are here discussed briefly.

During Cruises 147 and 135 problems had been encountered with the operation of the hydraulic ram which controls the lowering of sampling probes into the sea bed. The vave (V1) which should be opened when the machine reaches the sea bed was found to be closed, preventing the sampling probes moving down. On Cruise 147 it was found that by repeating the landing it was apparently possible to "shake" V1 open. On the first lowering 11135#4, the sampler was landed on the bottom four times, the valve V1 appearing to remain closed. All subsequent lowerings were carried out with the pin removed from V1 so that the probes could fall freely into the sediment. Thus the ram system served the purpose of controlling the rate of descent of the probes, but did not act so as to index the final position of the plate relative to the sediment surface. It is desirable to obtain this latter function, and it is clear that design modifications will be necessary to attain this.

To improve the reliability of the system a multiple firing circuit was fitted to V3, the main high pressure control valve. This circuit attempted to open the valve 3 times at approximately 30-second intervals. This circuit was used on three deployments (11135#8, 11136#2, 11137#2). On each of these lowering V3 failed to open the first time the sampler was landed, but did open on a second landing probably on the first firing pulse to the valve.

For subsequent lowerings (11139#S, 11143#3, 11146#2 and 11147#2) the capacitance of the circuit firing V3 was increased to 4 times the original specification, giving a stronger pulse to the valve pin. This was found to solve the problem.

Earlier attempts to improve the firing of V3 by filling the valve with Diala oil B (drop 11136#2) and fitting the pressure drop restrictor on the hunting valve (drop 11137#4) did not appear to effect a measurable improvement.

The samples collected on each of the above first three lowerings gave a number of samples containing water from the water column rather than porewater. (Water column water is identifiable by its low silicate content compared to porewater.)

After tests it was concluded that this contamination of the samples was being caused by a deficiency of the oil-side pressure balancing system.

For drop 11143#3 a free moving neoprene rubber bellows was fitted to the pressure balance the oil side and this was filled with Diala B oil. Analysis of the samples suggested that about 40ml of water column water had been collected.

For drop 11146#2 the bleed bolt on the water side of sampling manifold was replaced by a bellows of about 30ml volume. The silicate measurements for this drop show a great improvement.

For drop 11147#2 the mounting for the bellows was machined out to increase the volume to about 50ml. The silicate data for this site are very promising; the data fit a smooth curve, except for two low points; an excellent result obtained under difficult sea conditions. Since the accelerometer trace indicated some disturbance of the sampler by wire-transmitted ship movement, the two aberrant samples may well be due to down-probe seepage during sampling.

Cores were successfully brought to the surface on 4 of the drops although one core was lost before an end-cap could be fitted. On drop 11139#5 the photographs show that a core was pulled from the mud, but this core was lost during recovery through the water column. On drop 1147#2 the core barrel was snapped off when the sampler overturned on pull out. In future, a core catcher must be provided for this device and the core barrel must be given some support for about 30cm below the plate.

b) Mk II Porewater Sampler

A total of eight deployments were made of which five resulted in useful samples. Two failures were attributed to mechanical problems and one to sampler tow-over during sampling. This is a creditable performance for a system of this type, in which a relatively complex series of electrical and mechanical operations are required during a relatively prolonged deployment to the ocean floor.

This was the first attempt to utilise a sample collection system based on the use of chromatographic sampling valves. These were attached to the Mk II device and then sample loops were filled directly on the ocean floor. On return to the laboratory these valves were mounted in turn on a sensitive chromatographic system for the separation and analysis of the dissolved oxygen, nitrogen and argon. The valves functioned perfectly: teething troubles were experienced with the new analytical system so that the hoped-for increase in sensitivity was only achieved late in the cruise. The experience gained should however be most useful in the extension of this work to future cruises.

A.C. Braithwaite
E.Chapman
E. Darlington
D.J. Hydes
T.R.S. Wilson

POP UP PORE PRESSURE INSTRUMENT: PUPPI

On Discovery cruise 144 a PUPPI was abandoned in the GME area after it had failed to release from the bottom. It was concluded that the instrument had over-penetrated in the soft mud and that the excess buoyancy was insufficient to overcome the resultant suction forces. The prime objective for cruise 149 was to test the mechanical systems of the modified PUPPI.

The following modifications had been made in order to decrease the terminal velocity and increase the resistance to penetration:-

a) the lance was increased in length from 3m to 4m

b) a disposable cone was fitted above the lead weights which increased the available bearing area by a factor of four and enabled some additional penetration to occur

c) the number of lead weights was reduced from six to three

d) a 13 inch diameter glass sphere was towed behind the instrument which decreases the terminal velocity on descent and increases the force available to lift the package of the bottom after release.

In addition the modified PUPPI was also fitted with an optical detector just above the cone, which produces an extra acoustic pulse, to indicate any unacceptable overpenetration.

The PUPPI was successfully deployed as planned at three stations. At the first two (011135#9 and 011136#6) the instrument behaved without fault. The sensors indicated that it had travelled vertically through the water and into the mud with a terminal water velocity of $1.65ms^{-1}$. It penetrated up to a point somewhere on the cone. At station 011135#9 the instrument was released after only 17 minutes in the sediment, whereas at station 011136#6 it stayed down for almost 5 days. Both recoveries were made at night, aided by the flashing light. The ascent velocity was $0.9ms^{-1}$.

Pore pressure records from these first two deployments showed peak insertion pressures around 90kPa which decayed with time. However, a number of apparently sharp pressure changes occurred on the record which are thought to be caused by an instrumental problem.

The final deployment was made close to a 'fault' in the GME area at station 011141. Again all went well apart from a tilt indication which was occurring on deck and hence it is believed to be inaccurate. It is planned to recover this PUPPI on Discovery cruise 153 in Oct/Nov 1984 and if successful will enable the long term behaviour of the instrument to be accurately assessed.

E. Darlington
P.J. Schultheiss

CHEMICAL ANALYSIS

a) Nutrient Analyses

Shipboard determinations of the micro-nutrients silicate phosphate and nitrate were carried out using a "Chemlab" continuous-flow automatic analysis system. The output from the analyser was fed into a microcomputer which carried out the data reduction. The software for this which was tested during Cruise 147 now appears to have been fully debugged and the system ran smoothly. The analyser was mounted in the Chemistry "Clean" container fitted on the port side of Discovery for this cruise. When the ship was running on three engines the contents of this container suffered a high level of vibration. Fortunately, the equipment does not appear to have been damaged by this. The precision of some analytical runs was reduced by electrical noise in the ship mains supply, a problem which did not occur during Cruise 147.

A total of 1406 determinations were made including standards and test runs, and 863 samples were analysed.

An attempt was made to determine ammonia using the 'Chemlab' analyser. The method has worked well during tests at Wormley, but on the ship severe contamination of the samples occurs as the sample cups are exposed to the atmosphere while waiting to be analysed. An ammonia-free micro environment needs to be built around the sample changer.

b) Trace Metal Determinations

Iron and manganese were determined colorimetrically in approximately 800 samples. The reagents used were formaldoxine for manganese, and ferrozine for iron, measurements were made on ½ml samples acidified immediately after filtering. Measurements were made using a Pye Unicam SP6-500 spectrophotometer fitted with a 4cm flow-cell. The methods worked well giving consistent results.

Aluminium was determined in 88 samples using a scaled down version of fluorimetric method previously used successfully for water column samples. One ml of sample was diluted with one ml of surface seawater to give sufficient volume to flush the flow cell of the fluorimeter effectively (Perkin Elmer LS-2).

c) Dissolved oxygen

Dissolved oxygen profiles were measured on subcores taken at stations 11135-11138, 11142, 11143 and 11145. The method used was modified only slightly from that developed on cruise 149, and the analysis provides an important index of the redox state of the sediment complementary to that obtained from the manganese and iron analyses.

J. Sørensen
K.S. Jørgensen
E. Chapman
D.J. Hydes

MICROBIOLOGY

Denitrification (in-situ activity) was measured in the redox boundary zone at stations 11135, 11137, 11140, 11142 and 11145. The procedure was identical to that used previously (cruise 124) except for the addition of controls to discriminate between bacterial denitrification and chemical nitrate reduction (chemo-denitrification).

Incubations of differing duration were carried out during the cruise, and the ampoules returned to the Aarhus laboratory for NO_2 assay.

Heterotrophic potential measurements were made on sediment from stations 11140 and 11147, selected from both oxic and anoxic layers. Samples were incubated with enrichments of labelled acetate, and in some anoxic layers nitrate was also enriched. The purpose of this study is to attempt to separate hetrotrophic processes from non-heterotrophic processes such as nitrification and manganese oxidation.

J. Sørensen
K.S. Jørgensen

SUMMARY

Cruise 149 was a very successful sampling exercise. A total of 26 cores were taken, along with 18 deployments of the porewater samplers, 2 PUPPI recoveries and 3 deployments. The on-board processing worked well, a total of 342 porewater samples being separated and analysed on board for nutrients, iron and manganese, with a small number of oxygen and other gas samples. These analyses, which were available within a few hours of sampling, were an invaluable guide in evaluating the significance of the material collected and in planning further sampling. The achievement of such rapid investigation of fresh material gathered at sea is of course necessitated by the labile redox-sensitive nature of the system under study. A considerable investment of manpower and skill is necessary to collect and process such quantities of material rapidly, and the quality of the results obtained is a tribute to the dedication of those who carried out the work.

T.R.S. Wilson

ACKNOWLEDGEMENT

It is, as ever, a great pleasure to be able to acknowledge the professional support of the Master, Officers and Crew of R.R.S. Discovery, without which none of the work described here could have been performed.

Table 1 Piston coring parameters

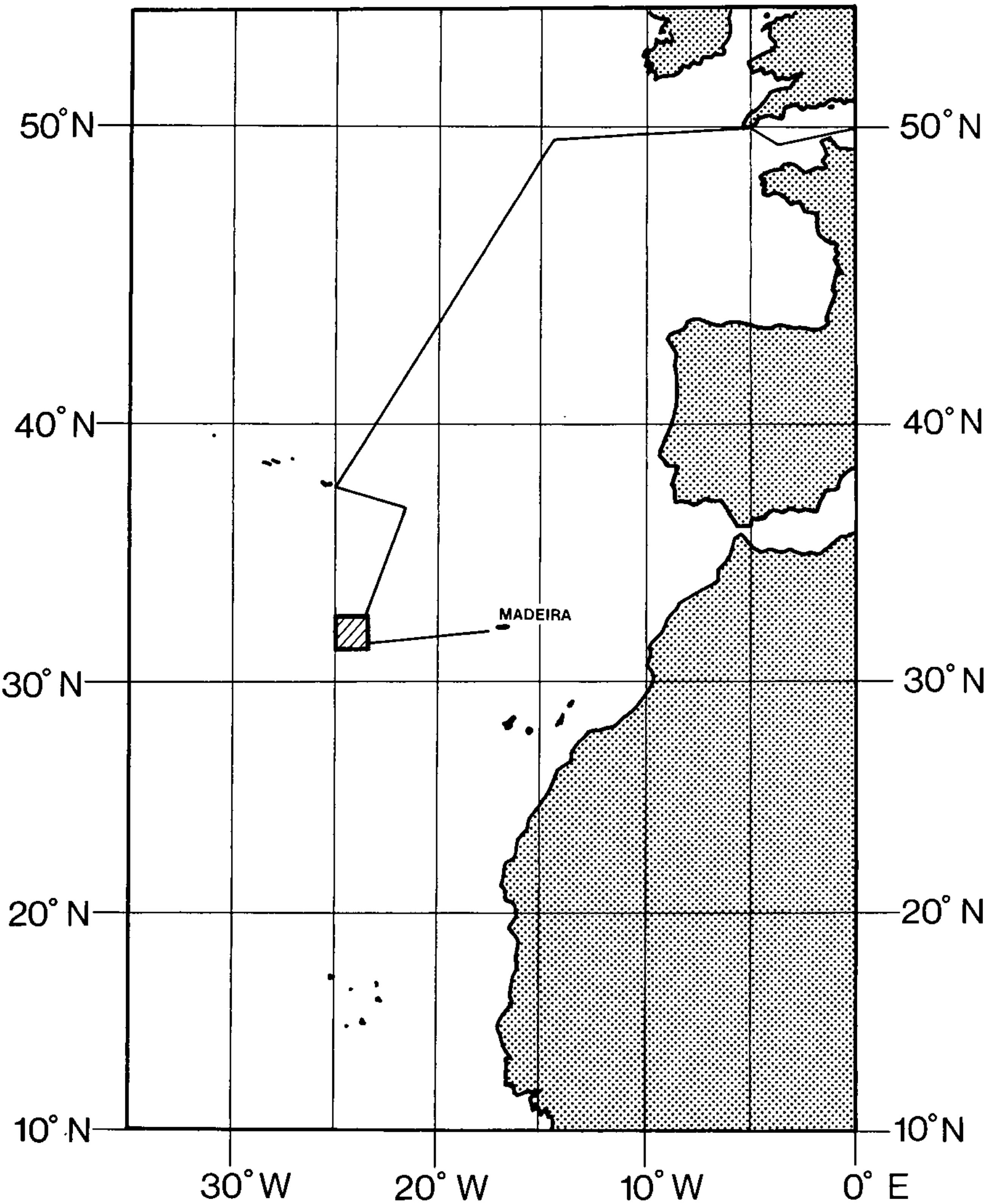
Core	Barrel length (m)	Trip chain length (m)	Wire length (m)	Core length (m)	Remarks
011135#3	14	23	25.6	12	Lost acoustic command unit
011136#5	14	23	25.6	11	Pre-trigger lost corer
011137#5	12	21	24.5	11	Fractured liner
011138#3	12	21	24.5	9.5	Bent piston pin
011139#7	12	21	24.5	11	Bent piston pin
011145#3	12	21	25.0	11.7	Bent piston pin and fractured liner

Table 2 Summary of Operations

STATION	SERIES	EQUIPMENT	TIME/DAY (GMT)	POSITION LAT. °N	POSITION LONG. °W	COMMENTS
		PES & 3.5KHz	0900/168			Transducer deployment
11135	1	K	1112/169	31°11.7'	25°06.0'	Site A
	2	PUPPI	1529	31°12.7'	25°10.6'	Wire test
	3	P	1838	31°15.9'	25°11.1'	
	4	PWS 3	0247/170	31°11.2'	25°05.7'	
	5	BX	0754	31°11.3'	25°10.0'	
	6	PWS 2	1345	31°13.0'	25°12.6'	
	7	K	1821	31°16.1'	25°13.3'	
	8	PWS 3	2241	31°17.8'	25°13.4'*	
	9	PUPPI	0250/171	31°18.4'	25°14.3'*	Test deployment and recovery.
11136	1	K	2137/171	31°26.2'	24°49.5'	Site B
	2	PWS 3	0213/172	31°26.2'	24°47.6'	
	3	BX	0727	31°26.3'	24°48.8'	
	4	PWS 2	1313	31°26.6'	24°49.6'	Corer lost
	5	PUPPI	0326/173	31°22.1'	24°54.3'	Deployment
11137	1	K	0926/173	31°25.1'	24°46.7'	Site C
	2	PWS 2	1357	31°25.3'	24°46.2'	
	3	BX	1831	31°25.6'	26°46.1'	
	4	PWS 3	0047/174	31°22.9'	24°46.1'	
	5	PISTON	0746	31°23.6'	24°47.2'	
11138	1	BX	1348/174	31°26.2'	24°49.4'	Site B
	2	PWS 2	2010	31°27.1'	24°49.6'	
	3	PISTON	0312/175	31°25.6'	24°49.3'	
11139	1	PWS 3	2109/175	31°24.7	25°10.9'	Site D
	2	BX	2234	31°25.3'	25°10.6'	
	3	PWS 2	0254/176	31°24.5'	25°11.2'*	
	4	K	0749	31°24.6'	25°11.0'	
	5	PWS 3	1140	31°25.9'	25°12.5'	
	6	BX	1608	31°25.9'	25°11.3'	
	7	P	2231	31°24.3'	25°11.0'*	
	8	BX	0350/177	31°25.4'	25°12.2'	
11140	1	BX	0915/177	31°12.7'	25°10.0'	Site A
	2	PWS 2	1527	31°12.6'	25°09.4'	
1141	1	PUPPI				Recovery
	2	PUPPI	1041/178	31°27.2'	24°48.5'	Deployment.

11142	1	K	1200/178	31°22.2'	24°46.2'	Site B
11143	1	BX	2034/178	31°12.3'	25°10.1'	Site A
	2	P	1211/179	31°12.0'	25°11.4'	
	3	PWS 2	1005	31°13.4'	25°09.6'	
11144	1	K	1813/179	31°23.0'	24°47.9'	
11145	1	BX	0336/180	32°07.6'	24°43.5'	Site E
	2	PWS 2		32°07.5'	24°44.0'	
	3	P		32°06.6'	24°45.5'	
11146	1	BX	2321/180	32°36.4'	24°22.3'	
	2	PWS 3	0434/181	32°35.2'	24°21.1'	
11147	1	K	1845/185	49°42.8'	14°40.4'	
	2	PWS 3	2222	49°37.1'	14°34.1	
	3	B	1019/186	49°43.0	14°39.6'*	Pre-trip
	4	PWS 2	1429	49°42.4'	14°39.5'	
	5	PWS 3	2029	49°40.8'	14°38.6'	
	6	B	2209	48°42.6'	14°40.6'*	

* Indicates dead-reckoning position



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