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DEACON LABORATORY

RRS DISCOVERY
CRUISE 177

26 AUG – 05 OCT 1988

GEOCHEMICAL AND GEOLOGICAL OBSERVATIONS OVER THE MADEIRA AND TAGUS ABYSSAL PLAINS

CRUISE REPORT NO. 205
1989

Natural Environment Research Council

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OCEANOGRAPHIC SCIENCES
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Geochemical and geological observations over the Madeira and Tagus Abyssal Plains

Principal Scientist

J. Thomson

1989

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ABSTRACT

This report describes the survey and sampling activities undertaken on a research cruise in the NE Atlantic. It comprises a narrative, equipment performance reports, station position information and a track chart. The principal scientific work conducted was:

(i) three short air gun surveys to define the abyssal plain limits in the north and south sub-basins of the Madeira Abyssal Plain,

(ii) collection of 15 m piston cores for palaeontological/sedimentological investigations of abyssal plain turbidite sequences and off-plain sequences,

(iii) collection of box cores and 2 m gravity cores for pore water and solid phase geochemical investigations of early diagenesis.

(iv) deployment of in-situ devices to collect profile data from the uppermost 1 m of the sediments for geochemical investigations of early diagenesis.

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ITINERARY

Departed:	Santa Cruz, Tenerife	26 August 1988
Mid-cruise port call:	Funchal, Madeira	15-17 September 1988
Arrived:	Viano do Castelo, Portugal	5 October 1988

OBJECTIVES

This cruise combined two ship-time proposals approved by NERC which had geochemical and geological objectives. The merged programme involved air gun surveys and piston coring for geological purposes, and shorter cores and in-situ sampling for geochemical purposes. The objectives were:

1. To investigate the stratigraphy of the south (Leg 1) and north (Leg 2) sub-basins of the deep Madeira Abyssal Plain, for comparison with previous findings in the central sub-basin (also termed the Great Meteor East area).

2. To investigate the diagenesis and metal relocations in the upper sediments of the above basins and in the continuously accumulated(?) sediments of the Madeira-Tore Rise.

3. To investigate the behaviour of the carbonate system in sediment pore waters above and below the carbonate lysocline.

NARRATIVE

Leg 1

Discovery was alongside at Santa Cruz, Tenerife, having completed Cruise 176. An advance party of two from Cruise 177 supervised the unloading of equipment from the holds from 23 August, so that the main party had a straightforward task installing and assembling equipment when they joined the ship on the morning of 25 August. A reporter and a photographer from the local newspaper "El Dia" visited the ship while this work was in progress to gather material for an article on Discovery and the cruise.

Discovery cast off at 1120Z Friday 26 August but did not get underway until 1300Z because of the need to complete paperwork arising from the late departure of a crew member. The vessel then set course for the southern MAP sub-basin, the major work area for Leg 1. Various pieces of heavy equipment were transferred from storage on the upper decks to their working positions on the poop during the afternoon of 26 August. The 10 kHz PES fish was deployed at 1540Z Saturday 27 August at the 200 mile limit of Spanish waters, and PES watches began at 1600 Z. The hydrophone and a single air gun were streamed at 1640Z but various problems with the record from the 160 cu. in. gun first used, with the performance of the 40 cu. in. guns subsequently tried, and finally with the hydrophone array, caused air gun work to be abandoned at 0015Z Sunday 28 August. The loss of the planned 80-hour survey into and around the southern sub-basin meant that the sampling and analytical systems had to be brought to a condition of readiness earlier than anticipated. This work was in progress through 28 August. Two deployments of the Kastenlot corer (11797 #1 and 11798 #1) were made on 28 and Monday 29 August, but both failed to recover a core despite the fact that the catcher doors were closed on retrieval. A box core and a piston core (11798 #2 and #3 respectively) were taken between 1140Z and 2200Z 29 August, followed by a wire test to 1 km water depth for the pH sensor of the in-situ pH profiler on the midships winch. Piston core 11799 #1 was taken between 1000Z and 1415Z Tuesday 30 August. The suite of instruments required for a chemistry station was run at Station 11800 between 1800Z 30 August and 0100Z Thursday 1 August: the pH profiler (#1), piston corer (for stratigraphic rather than chemical work, #2), the Kastenlot corer (#3), the Mark III in-situ pore water sampler (#4) and the box corer (#5). Piston core 11800 #2 was the first attempt to use an acoustically-activated electrolytic release link ("fizz link") in place of a pyro release on the corer safety pin. The "fizz link" operated satisfactorily but a misaligned electrical cable prevented the proper retraction of the safety pin. The corer was recovered to the ship's rail where a pyro was fitted and the core then taken successfully.

Repairs to the hydrophone had been in progress while sampling was underway, and an air gun survey was conducted between 0200Z Thursday 1 September and 2250Z Friday 2 September with a single 40 cu. in. gun. Station 11801 was on the same position as Station 11800, and runs of the pH profiler (11801 #1) and the Mark III sampler (11801 #2) were made between

2330Z 2 September and 0930Z Saturday 3 September. Piston cores 11802 #1 and 11803 #2 were taken on selected positions on the air gun survey track between 1200Z 3 September and 0030Z Sunday 4 September.

The work in the southern MAP sub-basin was then interrupted by a diversion to sample the pelagic sediments of a topographic high at approximately 4900 m water depth and a depression at 6000 m water depth, primarily for geochemical studies. Station 11804 was occupied from 1300Z 4 September until 0000Z Tuesday 6 September, when two Kastenlot corer (#1 and #5), two Mark III sampler (#2 and #6), two pH profiler (#3 and #7) and box corer (#4) runs were performed. Both Kastenlot cores recovered < 1 m of sediment because of the stiff nature of the sediment, despite a doubling of the number of corer head weights for the second run. During this station the winding burned out on the electric motor which powered the cooling plant for the container in which pore water squeezing was performed. An improvised procedure was devised for the remainder of Leg 1, whereby the cores were sectioned as rapidly as possible at ambient temperature in the container, the core sections cooled for a period (approximately one hour) in a refrigerated (4°C) chest, and then centrifuged or squeezed at 4°C.

Discovery was on passage from 0000Z-1900Z 6 September to a deep (6 km) valley site where pelagic red clays and turbidites were known to exist. Following a short survey to ascertain the extent of flat bottom, this station (11805) was worked from 2120Z 6 September until 1400Z Thursday 8 September. Kastenlot (#1), box (#7) and 12 m piston (#5) cores were taken, along with deployments of the Mark III sampler (#2 and #6) and the pH profiler (#3). Box corer run 11805 #4 failed to recover a core because the corer was pulled over while hauling out of the sediment.

Following return to the southern MAP basin, a further air gun survey was undertaken between 1700Z Friday 9 September and 0600Z Saturday 10 September. A series of piston cores (11806 #1-11811 #1) were next taken at points selected from the air gun track and general bathymetry between 0630Z 10 September and 0230Z Monday 12 September. Cores 11806 #1 and 11807 #1 had 18 m barrels, but these presented handling problems and tended to bend the barrel sections. Station 11811 was occupied from 0800Z 12 September until 0430Z Tuesday 13 September, when deployments of the piston corer (#1), Mark III sampler (#2), pH profiler (#3) and Kastenlot corer (#4) were made. One door of the catcher of Kastenlot core 11811 #4 was open on retrieval, so that the core dropped out on recovery from the sea to the ship. The last core of Leg 1 (piston core 11812 #1) was taken between 0730Z and 1300Z Tuesday 13 September. Discovery set sail for Madeira at 1300Z 13 September and arrived at Funchal at 0900Z Thursday 15 September.

During the mid-cruise port call, Dr. J.H. Ebbing and Mr. S.D. McPhail left the ship, to be replaced by Mr. T.J. Pearce and Dr. T.R.S. Wilson for Leg 2. The agent arranged for the two electric motors for the refrigerated container to be rewound in Funchal during the port call.

Leg 2

Discovery cast off and sailed from Funchal at 1000Z Saturday 17 September, on a course for the northern MAP sub-basin. The Portuguese authorities did not nominate an observer to participate in this leg, but required a daily notification of the work intended in Portuguese waters over the next 24 hours. A rewound motor was installed satisfactorily in the refrigerated container used for pore water squeezing during the afternoon of 17 September.

The PES fish was deployed at 1615Z 17 September, but was run silent until 0400Z Sunday 18 September when scientific watches began. The air gun and hydrophone assemblies were deployed at 0430Z 18 September and a seismic survey was run until 1700Z Monday 19 September. On resumption of full cruising speed following the air gun survey, it was found that the PES record was very noisy, and that the fish towing assembly was shuddering. The PES fish was brought inboard at 1815Z and examined: no faults were found but the towing strut assembly was tightened and the unit redeployed at 2030Z when it gave satisfactory performance. Piston cores 11813 #1 and 11814 #1 were taken at selected points along the seismic track between 2100Z 19 September and 0900Z Tuesday 20 September. A full set of sampling devices was run at Station 11815 (#1 Kastenlot corer, #2 pH probe, #3 Mark III sampler, #4 and 5 box corer) for chemical work between 1630Z 20 September and 1115Z Wednesday 21 September. A further set of piston cores was taken (11816 #1, 11817 #1, 11818 #1, 11819 #1), again in areas chosen from the bathymetry and the air gun record, between 1630Z 21 September and 2240Z Thursday 22 September. The PES record had again deteriorated seriously in quality at passage speed, and the fish was recovered at 1100Z 22 September. An 0.008 inch shim was added to the spacer bar in the fish and the towing strut assembly re-tightened. This modification gave a satisfactory repair for the remainder of the cruise. Station 11820 was a re-occupation of the position of Station 11815, and the Mark III sampler (#1), two piston cores (#2 and #4) and the pH probe (#3) were run between 0500Z Friday 23 September and 0400Z Saturday 24 September. The piston core 11820 #2 was sectioned and squeezed on board for a chemical investigation suggested by the shorter cores. Two further piston cores (11821 #1 and 11822 #4) were taken to complete sampling in the northern MAP between 0830Z and 2230Z Saturday 24 September.

Discovery was on passage towards the area of the Josephine Seamount during Sunday 25 September. During the evening of 25 September a copper pipe in the refrigerated system of the pore water container cracked through vibration and was repaired by soldering. Stations 11823-11827 were primarily for pore water carbonate system investigations. The deepest station (11823) nominally 5500 m water depth, was worked from 0100Z Monday 26 September until 0300Z Tuesday 27 September, when the Kastenlot corer (#1), Mark III sampler (#2), pH profiler (#3), box corer (#4) and piston corer (#5) were run. The end cruise refit port was notified to the ship at 1600Z 26 September (Viano do Castelo, Portugal). The nominal 4500 m water depth station 11824 was occupied between 1230Z 27 September and 0500Z Wednesday 28 September, when all the devices for chemical sampling were deployed (Kastenlot #1, box corer #2, Mark III sampler #3, pH probe #4).

These same devices were also run at the nominal 3500 m station (11825) between 1000Z 28 September and 0340Z Thursday 29 September (Kastenlot #1, Mark III sampler #2 and #3, pH probe #4 and box corer #5). The Mark III pore water sampler did not penetrate the sediment fully on the first attempt (11825 #2) and the run was repeated immediately with the corer tube removed (11825 #3). The Kastenlot and box cores at this station (11825 #1 and #5) were also short, presumably because of the coarsening sediment with shallowing water depth. The weather had also worsened, with Force 6 or 7 winds and a swell running from the north: this made deck work difficult between Stations 11823 and 11827 inclusive. Station 11826 comprised a single corer run between 1500Z and 1715Z 29 September at a nominal 2500 m water depth: here the trigger corer from the piston corer assembly was run as a gravity corer, but no core was obtained. Station 11826 was abandoned. Discovery then returned to the position of Station 11824 for Station 11827, where the pH probe (11827 #1) was run from 0130Z-0500Z Friday 30 September and, after some amelioration in weather conditions, the Mark III sampler (11827 #2) was run from 1050Z-1445Z 30 September. Testing of the pH probe on deck revealed that mechanical damage had been suffered during the run on Station 11827, and would require repairs before further use.

Discovery was in transit to the Tagus Abyssal Plain from 1500Z 30 September until 2200Z Saturday 1 October, when a station in the south of the plain was worked. Station 11828 was occupied from 2200Z 1 October until 2315Z Sunday 2 October. All five sampling devices were run, but again the Kastenlot corer failed to retrieve a core. There was time to run only four devices at the final station (11829) in the northern Tagus Abyssal Plain because of the required arrival time at the refit port, and because of the need to have shipboard analyses completed and all equipment packed for off-loading on arrival. Station 11829 comprised a box corer run (#1) a Mark III sampler run (#2) a pH profiler run (#3) and a piston corer run (#4). The piston corer with its attendant triggering and acoustic safety pin assembly was lost on deployment at this station. It appeared that the warp locking plates had slipped down the warp after the corer was launched, and that the warp had then parted. The station was abandoned at 2140Z Monday 3 October because there was insufficient time to assemble another piston corer or to run further chemistry work. PES watches ended with Station 11829, although the PES fish was not recovered until 1100Z Tuesday 4 October. Discovery proceeded towards Viano do Castelo through Tuesday 4 October, when chemical analysis was completed and most packing of equipment to transit boxes was completed. The vessel was secured alongside at Viano do Castelo at 1130Z on Wednesday 5 October.

SAMPLING AND EQUIPMENT REPORTS

1. SAMPLING: CORING OPERATIONS

Box, Kastenlot and piston cores were required to provide progressively deeper sediment samples for shipboard pore water extraction and subsequent solid phase analysis for sediment characterisation, bioturbation and dating studies and stratigraphy. The box and Kastenlot corers provided material which overlapped the penetration depths of the in-situ pH probe and pore water sampler devices, while the piston corer sampled down to 15 metres.

Box Coring

This was the first cruise where the IOS box corer was used with the release mechanism modified to incorporate an auto-retractor. The release is actuated by firing the auto-retractor using an IOS 10 kHz acoustic control system. This system had proved successful on Discovery Cruise 160 with a standard retractor. Twelve deployments were made with this device in water depths of 2700-6050 m with eight successful core recoveries. Three of the unsuccessful deployments resulted from the failure of the acoustic control system to fire the auto-retractor. The remaining unsuccessful box corer deployment was due to the corer being dragged over on the sea bed during recovery.

The auto-retractor system proved to be very successful. Only once during the cruise did the auto-retractor fail to re-cock on deck which necessitated stripping-down to release and replacement of the pin. The ability to re-cock the release greatly reduced the turn-around time between corer deployments and eliminated the cost of consumable re-use kits for the standard retractor.

The generally quiet weather conditions made the task of manoeuvring the box corer on its frame about the after deck into position for deployment and subsampling less difficult than on previous cruises. The wheels on the box corer frame are vulnerable to corrosion while the corer stands on deck exposed to the elements and this, coupled with the general unevenness of the deck, makes the job of bodily moving in excess of a ton of equipment a task requiring great care to ensure the safety of those undertaking the manoeuvre.

Kastenlot Coring

Twelve deployments of the Kastenlot corer fitted with a 2.3 m stainless steel barrel were attempted, resulting in seven successful recoveries. Problems were experienced with the core catcher doors failing to close as the corer was pulled out of the sediment which resulted in either partial or total loss of the material sampled. Replacement of the catcher springs and increasing the sensitivity of the catcher mechanism failed to overcome the problems encountered in coring stiff carbonate and pelagic sediments.

Deployment of the Kastenlot corer over the stern rail with less than the full complement of weights highlighted a problem with the lifting strop: its inability to maintain the corer in the horizontal position during deployment and recovery with its accompanying handling difficulties. Modification of the core catcher and lifting strop design and refurbishment of the Kastenlot weightstand cradle need to be undertaken before the next cruise.

Piston Coring

Piston coring was very successful and produced a total of 25 cores, of which only three were shorter than 10 metres. The only core which was opened on board was 11820#2 which was analysed for geochemistry. All the cores were P-wave logged, however, and the logs revealed that the cores are of good quality with little evidence of flow-in or other sediment disturbance. The sediment colour, as seen through the liner and at the cut end of the cores, together with the P-wave logs, allowed the determination of the extent of turbidite sediments in the cores and these interpretations were used to identify further coring sites.

For most cores a 15-metre barrel was used and, as can be seen from Table 1, this was frequently filled with 13-14 metres of sediment. This represents excellent core recovery which may have been aided by the use of long lengths of liner. For most cores, 2 x 6 metre and 1 x 3 metre lengths were used which gave only two liner joints for the piston to pass. This reduces the ability of the piston to draw in water as it passes joints, thereby leading to better quality cores.

One other modification was employed on this cruise, the split piston. This device operates normally during corer penetration but, if the corer does not fully penetrate, the pull-out force breaks a shear-pin in the piston and only the upper part moves up the liner to the piston stop. This prevents sediment being sucked into the liner and should eliminate flow-in. The P-wave logs show little evidence of flow-in but this awaits confirmation when the cores are opened. Problems with the split piston were encountered as it frequently shattered or remoulded the liner at the very top of the core. It appeared that the separation of the piston was creating a vacuum. To overcome this, a groove was cut down the side of the upper section, thus allowing water to pass more freely.

Several barrels were bent during the coring operation, some during the retrieval of cores with 18-metre long barrel sections. It is possible to take 18-metre long cores from Discovery but a third handling rope should be used on the core barrel to bring it to the horizontal position during retrieval. Care should also be taken to ensure that the lowest handling line has slipped down to its correct position, since the slipping of this line during retrieval can also cause barrels to bend.

The last piston core station resulted in the total loss of the piston corer, trigger arm and corer and acoustics package. From an analysis of the situation, it appears that the warp was not held correctly in the brass wire clamp and thus, after launch, the warp pulled through the clamp and the corer reached such a velocity that it broke free when the piston hit the stop. There is no doubt that the clamp was fully tightened on deck but part of the warp must have lodged between the plates of the clamp and not lain in the moulded groove. Thus, when the weight of the corer was taken, the warp would have pulled into the groove thereby slackening the grip of the clamp.

JHB, DEG, PJM, TJP, RAP, RGR, HEW, RFW, PPEW, ATW, DW

2. SAMPLING: PORE WATER EXTRACTION

Approximately 520 pore water samples were produced from 18 cores (Kastenlot, box, piston and those from the in-situ pore water device). The extraction methods utilised were hydraulic squeezing in a low temperature (< 4°C) container and centrifugation at a low temperature. Core cutting, sample preparation and post-extraction filtration were carried out in a nitrogen atmosphere in inflatable glove bags. Samples were produced for shipboard analyses of nutrients and metals. Other samples were stored for trace metal analysis. Suites of pore water samples were also collected and sealed in glass ampoules for carbon isotopic analysis (H. Kennedy), and other sealed samples were analysed for total CO_2 content on board.

A trial was made of a whole box core subcore squeezing system adapted from a recent publication (Jahnke, Limnology & Oceanography **32**, (1988) 1214-1225). Although it was unsuccessful on this occasion, it shows potential for the future.

SC, HAK, TJP

3. SAMPLING: IN-SITU MARK III PORE WATER SAMPLER

This was the fourth and most successful cruise on which the porewater sampler Mark III has been operated to date. The instrument was deployed seventeen times, which is more than the total of deployments for the previous three cruises. Samples were successfully obtained for nutrients, carbonate system and trace metal determinations. Experiences on the cruise allow a number of recommendations to be made for work to be carried out before the next use of the instrument.

Pore water was extracted from the sediments on eleven of the deployments, including one at a water depth of 6055 m (11805 #6). One drop was terminated at 1100 m wire-out because the valve on the oil side-pressure balancing bellows had been sent down closed. This was detected by a rise in the piston in the sample manifold which triggered the first sample volume reed switch.

ACB, DJH, ATW

4. SAMPLING: PORE WATER ANALYSIS

Pore water oxygen was measured directly on core subsamples by gas chromatography of headspace gases after equilibration in a closed container. Over 130 subsamples from eleven cores were processed for this measurement during the cruise.

Two separate auto-analyser systems were run for other pore water analyses. Silicate, phosphate, iron and manganese were determined on 2-ml samples acidified with 50 µl of 2.4 M hydrochloric acid. Nitrate, nitrite and ammonia were determined on 1 ml of pore water diluted with 1 ml of surface sea water (*cf*. note (vi) below). The concentration ranges determined were:

Si	0-300 µM	PO_4	0-7.5 µM	Fe	0-45 µM	Mn	0-45 µM
NO_3	0-30 µM	NO_2	0-5 µM	NH_4	0-100 µM		

Overall, the system ran successfully and no data were lost due to failures of the system.

A larger number of problems than usual were encountered during the cruise:

(i) The BBC-Master computer main processing chip was faulty when the machine was first switched on. It was replaced by the Master normally used for data logging, and another Master was brought out to Madeira for Leg 2.

(ii) The BBC system Centronics GLP printer paper-advance control failed the second day of operation. This was replaced by a spare printer which operated satisfactorily.

(iii) One channel on the chart recorders was faulty when connected up. As one channel was spare this did not present a problem, but the system had no back-up capacity.

(iv) The IOS-built A-D converter for the BBC system, which was being used for the first time, appeared to work well. It was free from the capacitance effects which make setting up the Commodore PET A-D system less than straightforward. However, in operation the system was less reliable than the PET system. Particularly on the PO_4 channel, it tended to lose synchronisation with the output peaks, even when the peaks were well defined. This also occurred on the Si channel when the system was operated without a "dwell bubble". This suggests that the BBC system is more sensitive to variations in peak shape than the PET system although, as both operate from the same algorithm, it is not obvious why this might be so.

(v) The sample changer on the $NO_3/NO_2/NH_4$ system broke down two days before the end of the cruise. This sample changer was working on its sixteenth cruise since 1983 and was the first failure of any part of the auto-analyser apparatus. Considering the stresses that sixteen cruises have placed on the system, further such failures must be anticipated in the future.

(vi) NO_3 and NO_2 were determined using the normally recommended sulphanilamide method on this cruise rather than the previously used IOS method. The sulphanilamide method gave improved sensitivity and superior peak shapes when compared to our previous method. The problem with the nitrate determination was that the batch of ammonium chloride (BDH AnalaR grade), from which the buffer solution for this method was prepared, was contaminated with nitrate. Contamination was sufficient to make the method non-linear when a top standard of 30 μM NO_3 was used, even when the sample-buffer ratio was 1 to 12. Unfortunately, to maintain the efficiency of the Cd-reductor column, the buffer concentration could not be reduced so, to get a linear response up to 30 μM, NO_3 samples and standards were run diluted one-to-one with surface seawater (as noted above).

NCH, DJH

5. SAMPLING: IN-SITU pH/POROSITY PROFILER

This cruise provided the first opportunity to test this prototype instrument in the deep ocean. A total of five deployments were made on the first leg and eight on the second. Of these, five failed to return useful data, the most common problem being due to excessive drag causing movement of the frame relative to the sensor carriage during lowering. The effect of this is to fill the instrument memory with spurious data before the sea bed is reached. A modification to the system which inhibited the position sensor signal until the sea bed was reached eventually removed this problem.

Of the eight lowerings which returned data, four exhibited excessive noise. This was eventually traced to random corrosion potentials, mainly due to the use of a zinc-coated security wire to seize the bolts on the pH probe case. Steps were taken to remove or isolate all possible sources of such noise and much quieter records resulted. Towards the end of the cruise, sporadic noise was again encountered; the cause was not traced but the problem was sufficiently infrequent that data could be recovered from affected deployments.

Overall, performance was satisfactory for a novel prototype instrument. The capability to recover pH data has been demonstrated and sufficient operating experience gained to assist in the further development of the instrument.

ACB, AED, BLGCMK, SDMcP, TRSW

6. EQUIPMENT: IOS

Engineering

The aft traction winch was the main deck system used on this cruise. One of the luff ram pins on the Schatt davit was found to be badly worn and could not be replaced at sea. Spares were ordered for the refit. The low tension dynamometer sheave bearing was also found to be worn out but, when filled with grease, it was still useable. Again, spares were ordered for the refit and both these repairs will be done at that time.

The compressors were used for three short air-gun surveys. New unloader valve rubbers were fitted to No. 2 compressor at the beginning of the cruise. Neither machine gave any trouble.

The refrigeration container gave endless trouble due to high ambient temperature and vibration. The main electric motor burnt out due to the machine cutting in and out on low pressure; another motor was found but that also burnt out. Both motors were rewound in Madeira and one fitted as soon as we sailed. The container worked well for a week, then it lost all its gas due to a fractured pipe. This was repaired but fractured again after a week. A new fitting was installed and this lasted until the end of the cruise. The refrigeration unit should be replaced before another cruise as it is totally unsuitable for this application, being too big and far too powerful. A smaller unit fitted outside the container feeding cold air into the container would be a better idea.

RFW, ATW

Acoustics and Telemetry

The three modified releases were used for arming the box and piston cores. Eleven box core deployments using the auto-retractor and CR 2414 or CR 2415 were carried out. Twenty-four piston core deployments using CR 2414 or CR 2556 were carried out.

Box Corer

Leg 1: CR 2415 was used throughout with no acoustic failures. One box core failed due to the corer being pulled over, the other three were successful.

Leg 2: CR 2415 was modified to give an indication of relay operation. It failed to fire on the first deployment and was replaced with CR 2414. A fault was found in the firing circuitry of CR 2415 and corrected, but it also failed on its second deployment, although it worked on deck. CR 2414 was used thereafter. This worked successfully until the final deployment when it failed to fire the auto-retractor although it worked on deck.

It has been recommended that auto-retractors should not be used below 2500 m although the one on the box corer was used down to 6000 m.

Both releases failed after about four deployments, although both subsequently worked satisfactorily on deck. This implies that the auto-retractor requires fairly new batteries to guarantee operation.

Piston Corer

Four piston cores using a pyro and CR 2414 were successfully taken. CR 2556 was modified to lock the relay on, to provide a release relay operation indicator and an external arming pin operation indicator. Twenty-one deployments using CR 2556 and a "fizz link" were made, with two failures and one near failure. The first failure was due to the "fizz link" sticking and preventing the pin from retracting: the release was re-orientated to prevent this. The second deployment also stuck but shook loose when hauling and a core was taken. After further modifications, no more failures occurred until the last station (loss of corer).

Other Acoustics

Bottom finding on the corers was done using the Chemistry Group 30 V beacon. The PWS monitor gave no problems but has a highly suspect battery pack with some leakages. The pH probe used the old PWS Mark-II beacon which at 15 V gave a barely adequate bottom echo return.

DW

7. EQUIPMENT: RVS

Seismics

The purpose of the seismic lines was to examine the sediment layers near the surface with the aim of determining which areas contained pelagics or turbidites. The air gun system being used was not the best tool for achieving these results but, by using a small (40 cu. inch) gun and using frequencies higher than normal, a satisfactory set of records was obtained.

The first deployment of the seismic system produced good results for about two hours, then several failures occurred almost simultaneously. First, the air gun trigger lead developed an earth (sea) leak at the outboard connector. This produced a common mode voltage that caused the trigger box permanently to energise its output resulting in over-heating and burning-out a large wattage resistor. This common mode voltage passed from the air gun through the trigger box and up to the timer/delay box where it blew the output driver circuit. The trigger lead was replaced and the air gun redeployed. The gun now fired correctly but the seismic array had become very noisy. The seismic array was recovered and two of the spring sections had had their skins pulled out from their end-connector. At that point, the seismic line was abandoned.

The second seismic line was started by using the 30 metre hydrophone. This hydrophone proved to be very sensitive to ship and sea noise and the returning echoes from the air gun were lost in this ambient noise. The seismic array was quickly re-assembled without the damaged spring sections and deployed. The seismic line was restarted and the system produced good and reliable data.

The damaged spring sections were repaired and inserted back into the seismic array. The hydrophone skins became detached from their connectors because they were incorrectly (poorly) assembled by the company that re-skinned them. On one section, the skin was so irregularly cut that it was only clamped by about 10 mm of its circumference. The other section parted because its collar was put on backwards and the clamp only half-tightened. Also, on all the spring and passive sections the banding was missing from both ends.

The last two seismic lines with the repaired array produced good data without any equipment failures. After each seismic line, the tapes were re-played to give an additional hard copy record of the data. Hard copy records from a previous cruise were reproduced for various frequencies to extract additional information from the data tape.

PJM, RAP

Computing

The shipboard computing system ran continuously and reliably for the duration of the cruise. The system was used for logging navigation and bathymetry information. Track charts and annotated depth charts were produced for the seismic lines and a live navigation display was produced for the various coring and chemistry stations.

A live navigation display using a graphics terminal was set up as an experiment in the chart room of the bridge. The system was set up so that, by pressing the F1 key, live GPS could be run. The F2 key would do the same but for the Magnavox MX 1107, and the F3 key would list the GPS data as it is received by the system. The experiment proved to be successful and a spare graphics terminal will be permanently installed on the bridge.

PES Fish

The PES fish became noisy as the ship's speed increased above nine knots. The noise was caused because the towing arm chattered on its bushes. If the towing arm end-stop was tightened up fully, the cheeks would clamp the towing arm solidly. To overcome this problem, a thin shim of beryllium copper was put on the end of the end-stop so that, when it was tightly secured, the towing arm was only just able to move freely. This was a temporary repair and it must be rectified in the near future.

TV Surveillance System

The TV camera would not focus correctly. On inspection, it was found that the whole lens assembly had vibrated loose. The lens was re-assembled using Locktite on the bolts and set up the correct distance between the lens and the tube. The camera worked and focused well. The automatic iris did not work and the spare did not totally solve the problem. The whole camera system should be serviced in the near future.

PJM

SUMMARY

This cruise was the first of a planned series of IOSDL cruises where both geochemical and geological objectives were combined. The rationale was that piston cores could be collected by a relatively small number of personnel for shore-based stratigraphic and palaeontological investigations, while allowing a larger number to conduct labour-intensive geochemical investigations on board. In general, this strategy worked satisfactorily and a good collection of material and data to meet the cruise objectives was achieved.

At the time of writing, a full examination and interpretation of the material and data collected has not been performed but noteworthy among the initial interpretations are:

(i) At the deepest site worked (Station 11805) an organic-rich turbidite $>$ 10 m long was found under a red clay section. An active progressive oxidation front was demonstrated in this turbidite by pore water studies and is inferred from previous work to have been active for 0.3 m years. The Kastenlot core was sampled in great detail to examine the zonation of redox sensitive elements in the turbidite, near the active oxidation front.

(ii) At Station 11815 (re-occupied as Station 11820) there was a predominantly oxic pore water condition to at least 9 m (piston core 11820#2), despite the near-surface anoxia in shorter cores (11815#1 and #5) caused by the presence of a recent turbidite. The conclusion is that the turbidites at this site (which are thin but common), are insufficiently organic-rich to sustain anoxia for long. Despite this, reduction haloes are observed under many of the turbidites as evidence of temporary anoxia. It may be possible to elucidate the mechanism of formation of such haloes from the pore water profiles in the shorter cores.

(iii) The bathymetric and seismic data reveal that the north and south extensions of the abyssal plain are small and limited to narrow bands running approximately N-S. The adjacent areas are slightly shallower and have undulating topography. Cores from these areas reveal mixed

thin turbidites and pelagic layers. Cores from the abyssal plain areas appear to contain the same sequences of turbidites seen in the central GME area.

ACKNOWLEDGEMENTS

I should like to record the thanks of the scientific party to Discovery's officers and crew for their contributions to this cruise. The deck crew gave invaluable assistance with equipment handling and with driving the aft traction winch.

I should also like to acknowledge the consistent efforts of the scientific personnel to ensure success throughout this long cruise. Several items of essential equipment gave trouble at one time or another but these problems were overcome with ingenuity and good humour as well as determination. It is a pleasure to acknowledge this professionalism and to note that much less would be achieved in work at sea without such high grade effort.

JT

TABLE 1 - Details of work performed on Cruise 177 (Leg 1)

Station Number	Date	Latitude (°N)	Longitude (°W)	Equipment	Water depth (uncorr. m)	Time (Z) Out	Time (Z) In	Notes
-	27/viii 28/viii	26°59.5' 26°57.0'	21°46.7' 22°30.3'	Airgun	-	16.38 end	begin 00.15	Multiple system failures: aborted
11797#1	28/viii	27°29.1'	25°55.6'	Kastenlot	5210	16.56	20.26	No core but catcher doors closed
11798#1	29/viii	27°34.0'	27°40.3'	Kastenlot	5210	07.12	10.50	No core but catcher doors closed
11798#2	29/viii	27°33.5'	27°39.7'	Box	5210	11.42	15.43	Surface slightly disturbed
11798#3	29/viii	27°33.8'	27°39.1'	Piston	5210	17.52	22.02	15 m barrel, 11.66 m core
11798#4	29/viii	27°33.5'	27°38.7'	pH probe	-	22.37	23.48	Wire test, mid-ships winch
11799#1	30/viii	28°46.3'	26°27.4'	Piston	5270	09.52	14.18	15 m barrel, 13.71 m core
11800#1	30/viii	28°25.0'	25°48.5'	pH probe	5275	18.42	23.07	
11800#2	31/viii	28°24.5	25°48.7'	Piston	5270	00.28	10.37	Release failed to operate: brought to ship and repeated. 15 m barrel, 14.80 m core
11800#3	31/viii	28°25.8'	25°47.4'	Kastenlot	5275	11.18	14.49	165 cm core
11800#4	31/viii	28°25.1'	25°47.9'	PWS	5270	16.50	20.51	No samples, ram valve shut
11800#5	31/viii 1/ix	28°25.5'	21°47.7'	Box	5273	21.23	 01.00	Good core
	1/ix 2/ix	28°27.1' 28°25.5'	25°45.8' 25°50.0'	Airgun	-	01.56 end	begin 22.18	SPP survey at 6 kt
11801#1	2/ix 3/ix	28°26.4'	25°46.4'	pH probe	5275	23.35	 04.38	
11801#2	3/ix	28°25.5'	25°47.0'	PWS	5274	05.19	09.22	No samples, bottom detector wiring fault
11802#1	3/ix	28°34.8'	25°18.9'	Piston	5275	12.05	17.00	15 m barrel, 12.91 m core
11803#1	3/ix 4/ix	28°09.6'	25°28.1'	Piston	5250	20.21	 00.31	15 m barrel, 13.67 m core

TABLE 1 - continued (2) Leg 1

Station Number	Date	Latitude (°N)	Longitude (°W)	Equipment	Water depth (uncorr. m)	Time (Z) Out	Time (Z) In	Notes
11804#1	4/ix	26°50.7'	27°07.7'	Kastenlot	5005	13.07	16.08	55 cm core
11804#2	4/ix	26°51.3'	27°08.1'	PWS	4920	17.04	21.13	Bottom not detected
11804#3	4/ix 5/ix	26°52.4'	27°06.7'	pH probe	4712	22.21	 02.30	
11804#4	5/ix	26°52.3'	27°07.2'	Box	4790	03.13	06.31	Good core
11804#5	5/ix	26°52.1'	27°08.6'	Kastenlot	4910	11.37	14.39	98 cm core
11804#6	5/ix	26°53.3'	27°08.9'	PWS	4830	15.43	19.38	Good core, 120 ml of samples
11804#7	5/ix 6/ix	26°53.7'	27°06.7'	pH probe	4722	20.03	 00.12	
11805#1	6/ix 7/ix	25°39.8'	30°57.0'	Kastenlot	6050	21.20	 00.10	230 cm core
(11805#2)	7/ix			PWS		01.50	02.45	Run aborted: sampled in water column
11805#2	7/ix	25°39.7'	30°57.6'	PWS	6055	04.03	08.35	Bottom not detected
11805#3	7/ix	25°39.9'	30°56.2'	pH probe	6051	09.09	14.15	
11805#4	7/ix	25°39.0'	30°57.5'	Box	6050	14.53	18.57	No core
11805#5	7/ix 8/ix	25°39.8'	30°57.4'	Piston	6050	20.33	 01.48	12 m barrel, 11.74 m core
11805#6	8/ix	25°39.6'	30°57.5'	PWS	6050	02.40	07.48	Sampled
11805#7	8/ix	25°40.8'	30°57.9'	Box	6047	09.22	14.01	Good core
	9/ix 10/ix	28°36.1' 29°03.0'	26°42.1' 25°31.0'	Airgun	-	17.49 end	begin 05.34	SPP survey at 6 kt
11806#1	10/ix	29°03.3'	25°30.1'	Piston	5292	07.36	11.36	18 m barrel, 15.09 m core

TABLE 1 - continued (3) Leg 1

Station Number	Date	Latitude (°N)	Longitude (°W)	Equipment	Water depth (uncorr. m)	Time (Z) Out	Time (Z) In	Notes
11807#1	10/ix	29°31.6'	25°13.8'	Piston	5345	18.15	23.06	18 m barrel, 17.39 m core
11808#1	11/ix	29°11.3'	24°58.9'	Piston	5301	04.42	08.48	15 m barrel, 13.49 m core
11809#1	11/ix	29°27.3'	24°45.5'	Piston	5282	13.00	18.22	15 m barrel, 14.42 m core
11810#1	11/ix 12/ix	29°56.1'	24°59.0'	Piston	5360	21.56	02.40	15 m barrel, 13.04 m core
11811#1	12/ix	30°12.2'	24°45.3'	Piston	5370	08.38	12.42	15 m barrel, 14.64 m core
11811#2	12/ix	30°12.7'	24°46.4'	PWS	5370	13.57	18.57	107 ml of samples
11811#3	12/ix	30°12.7'	24°45.1'	pH probe	5370	19.35	23.59	
11811#4	13/ix	30°12.6'	24°44.7'	Kastenlot	5370	00.40	04.25	Core lost on retrieval: one door failed to close
11812#1	13/ix	30°23.7'	24°18.9'	Piston	5375	08.00	13.00	15 m barrel, 14.16 m core

TABLE 1 - continued (4) Leg 2

Station Number	Date	Latitude (°N)	Longitude (°W)	Equipment	Water depth (uncorr. m)	Time (Z) Out	Time (Z) In	Notes
-	18/ix 19/ix	32°58.7' 32°45.4'	20°55.1' 23°18.0'	Airgun	-	04.36 end	begin 16.56	SPP survey at 6 kt
11813#1	19/ix 20/ix	33°12.0'	23°30.3'	Piston	5357	21.00	01.14	15 m barrel, 14.58 m core
11814#1	20/ix	33°20.3'	23°07.7'	Piston	5346	04.50	09.06	15 m barrel, 12.00 m core
11815#1	20/ix	33°30.4'	22°37.0'	Kastenlot	5330	11.41	15.14	2 m core
11815#2	20/ix	33°31.0'	22°36.3'	pH probe	5326	15.50	20.52	
11815#3	20/ix 21/ix	33°30.0'	22°38.2'	PWS	5330	22.52	02.19	156 ml of samples
11815#4	21/ix	33°31.0'	22°37.3'	Box	5330	02.48	06.41	Acoustic command fault: no core
11815#5	21/ix	33°30.1'	22°37.4'	Box	5330	07.21	10.48	Good core
11816#1	21/ix	32°49.2'	22°19.6'	Piston	5345	16.50	20.54	15 m barrel, 14.41 m core
11817#1	21/ix 22/ix	32°25.1'	23°31.6'	Piston	5355	23.50	04.54	15 m barrel: penetrated to 3.0 m only because of indurated layer
11818#1	22/ix	32°47.1'	23°54.1'	Piston	5365	09.14	13.35	15 m barrel, 14.62 m core
11819#1	22/ix	33°06.6'	23°57.7'	Piston	5360	17.17	22.42	15 m barrel, 13.47 m core
11820#1	23/ix	33°29.8'	22°37.8'	PWS	5330	05.26	11.18	276 ml of samples
11820#2	23/ix	33°29.3'	22°37.5'	Piston	5330	12.05	16.36	15 m barrel, 13.13 m core: for chemistry
11820#3	23/ix	33°29.9'	22°38.0'	pH probe	5330	18.10	22.28	
11820#4	23/ix 24/ix	33°30.2'	22°37.8'	Piston	5330	23.07	04.00	15 m barrel, 4.67 m core: badly bent

TABLE 1 - continued (5) Leg 2

Station Number	Date	Latitude (°N)	Longitude (°W)	Equipment	Water depth (uncorr. m)	Time (Z) Out	Time (Z) In	Notes
11821#1	24/ix	33°39.5'	23°12.3'	Piston	5340	10.26	15.00	15 m barrel, 12.46 m core
11822#1	24/ix	33°50.8'	22°35.8'	Piston	5336	17.59	23.32	15 m barrel, 5.89 m core: badly bent
11823#1	26/ix	36°27.8'	18°35.3'	Kastenlot	5487	00.53	04.54	2.3 m core, repenetrated once
11823#2	26/ix	36°28.1'	18°36.3'	PWS	5490	05.31	10.11	209 ml of samples
11823#3	26/ix	36°27.9'	18°33.5'	pH probe	5490	10.37	15.14	
11823#4	26/ix	36°26.8'	18°35.9'	Box	5485	16.15	20.13	No core: acoustic failure
11823#5	26/ix 27/ix	36°28.0'	18°34.9'	Piston	5490	22.17	03.00	15 m barrel, 10.3 m core
11824#1	27/ix	35°46.4'	17°35.9'	Kastenlot	4740	12.30	16.27	No core
11824#2	27/ix	35°47.3'	17°35.7'	Box	4715	17.21	20.30	Good core
11824#3	27/ix 28/ix	35°46.7'	17°35.7'	PWS	4730	21.41	01.11	128 ml of samples
11824#4	28/ix	35°47.3'	17°35.3'	pH probe	4730	01.29	05.03	
11825#1	28/ix	35°39.5'	16°40.9'	Kastenlot	3785	10.08	13.04	
11825#2	28/ix	35°41.6'	16°39.8'	PWS	3784	13.58	17.05	Did not trolley fully
11825#3	28/ix	35°40.3'	16°39.8'	PWS	3780	18.19	21.10	145 ml of samples
11825#4	28/ix 29/ix	35°40.2'	16°40.0'	pH probe	3780	21.47	00.36	
11825#5	29/ix	35°40.6'	16°39.4'	Box	3780	00.55	03.40	10 cm core only
11826#1	29/ix	35°24.9'	16°12.5'	Gravity	2780	15.18	17.12	No core
11827#1	30/ix	35°46.3'	17°34.5'	pH probe	4730	01.30	05.12	

TABLE 1 - continued (6) Leg 2

Station Number	Date	Latitude (°N)	Longitude (°W)	Equipment	Water depth (uncorr. m)	Time (Z) Out	Time (Z) In	Notes
11827#2	30/ix	35°46.4'	17°35.5'	PWS	4755	10.49	14.45	225 ml of samples
11828#1	1/x 2/x	37°02.7'	12°42.1'	Piston	5060	23.30	 04.38	15 m barrel, 7.6 m core
11828#2	2/x	37°03.8'	12°40.7'	pH probe	5060	05.37	09.19	
11828#3	2/x	37°02.4'	12°44.6'	Box	5060	09.52	13.47	Good core
11828#4	2/x	37°03.9'	12°43.3'	PWS	5060	14.36	18.53	102 ml of samples
11828#5	2/x	37°03.7'	12°41.1'	Kastenlot	5062	19.23	23.18	No core
11829#1	3/x	38°34.5'	12°33.8'	Box	4828	08.25	11.45	No core
11829#2	3/x	38°35.1'	12°30.4'	PWS	4835	12.30	16.34	153 ml of samples
11829#3	3/x	38°34.1'	12°33.0'	pH probe	4830	17.00	20.29	
11829#4	3/x	(38°35.0')	(12°32.2')	Piston	-	21.24	-	12 m corer assembly lost

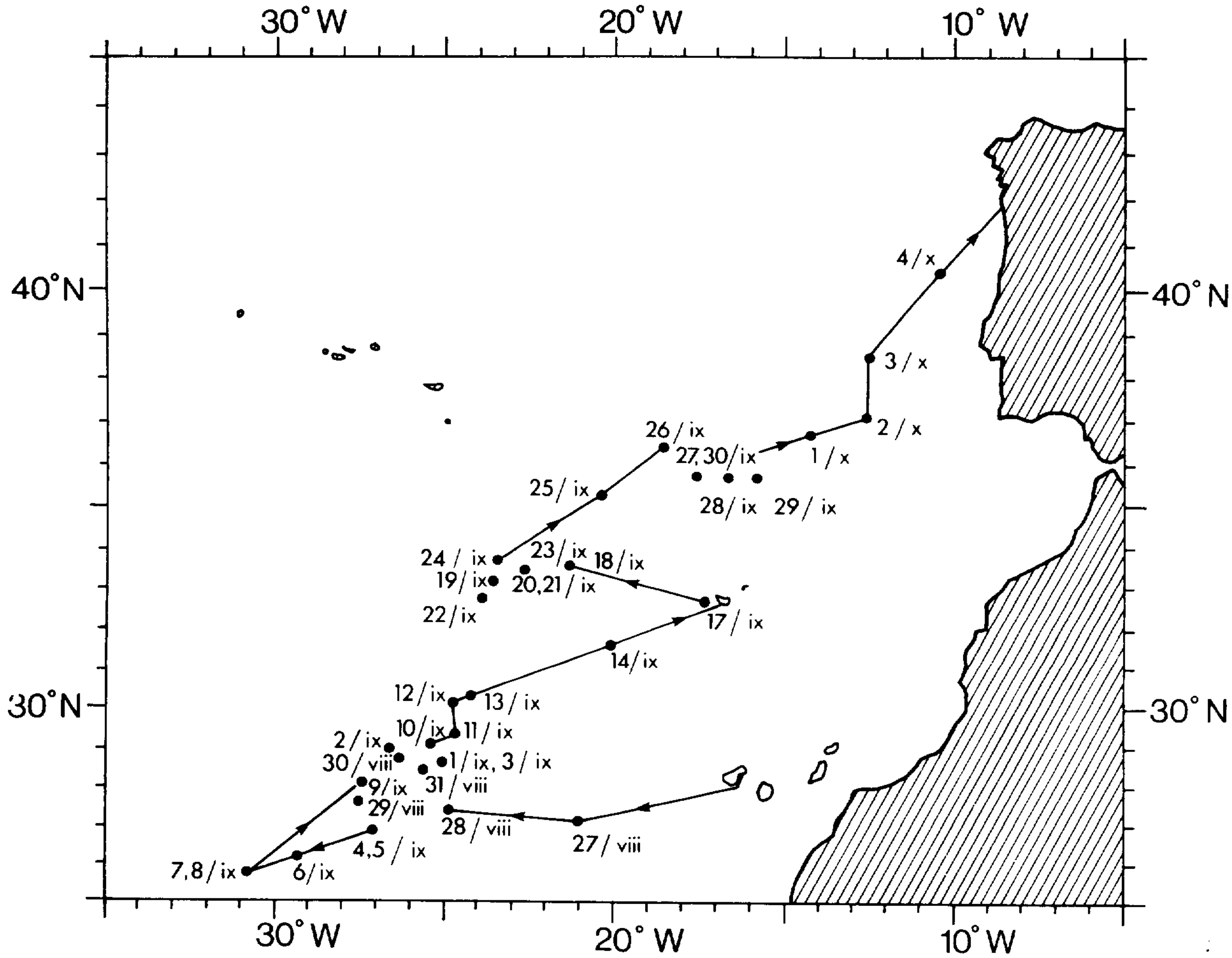

Figure. 1 "RRS Discovery" Cruise 177: map of midday positions, 26/viii/88 – 5/x/88