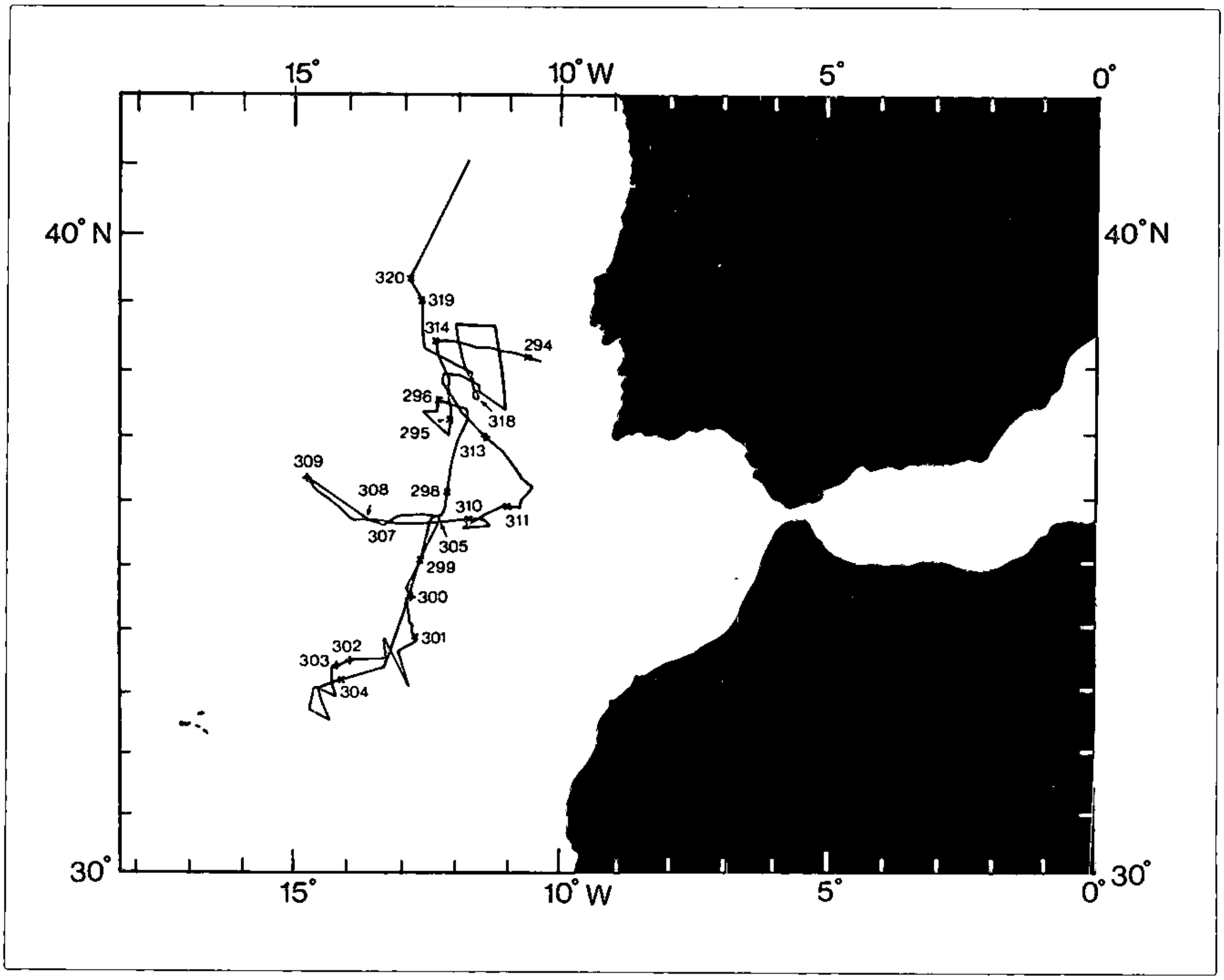
Institute of
Oceanographic Sciences
Deacon Laboratory

RRS Discovery Cruise 187

20 Oct - 20 Nov 1989

Geological and geochemical investigations in the Tagus, Horseshoe and Seine Abyssal Plains

Cruise Report No 223 1991



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CRUISE REPORT NO. 223

RRS DISCOVERY CRUISE 187
20 OCT-20 NOV 1989

Geological and geochemical investigations in the Tagus, Horseshoe and Seine Abyssal Plains

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ABSTRACT

The cruise was a success. On the coring side 25 piston, 7 kasten and 8 box cores were recovered. The PWS worked particularly well, with 14 successful deployments, indicating that this is now a fully developed and reliable vehicle. The pore water sampler is still considered to be in a developmental phase, nevertheless it gave useful results on 10 of its 13 deployments. As a result of these developments, potential improvements have been identified to increase its effectiveness in the future.

The results were achieved in the face of numerous problems. Firstly, the weather, which at first was entirely unsuitable for station work and later was sometimes reasonable but frequently worse than we would have liked. Secondly, the sediments themselves in the Tagus and Horseshoe Abyssal Plains were more sandy than we had expected. This led to numerous bent piston core barrels and shorter cores. The winch, which was used almost continuously, is showing signs of old age and was kept running only through the ingenuity and efforts of the engineers.

This was not a cruise where many conclusions could be drawn at sea, these will derive from the laboratory work which is to follow. We can, however, conclude that the northern part of the Tagus Abyssal Plain is covered by extensive thick sands. The southern part of the plain is composed of dark coloured turbidites with thick sandy bases, fine upper parts and thin pelagic layers. Similar turbidites and pelagics are found throughout the Horseshoe Abyssal Plain. Active and relic oxidation fronts are common and appear similar to those in the Madeira Abyssal Plain. In the Seine Abyssal Plain the turbidites have paler olive green colours - similar to those in the Madeira Abyssal Plain, and thick sands are not common.

KEYWORDS

ATLANTIC(NE)
DISCOVERY/RRS - cruise(1989)(187)
GEOCHEMISTRY
HORSESHOE ABYSSAL PLAIN
INTERSTITIAL WATER
MADEIRA ABYSSAL PLAIN
PORE WATER SAMPLER
SEDIMENT SAMPLING
SEDIMENTS
SEINE ABYSSAL PLAIN
SEISMIC PROFILES
TAGUS ABYSSAL PLAIN
TURBIDITES

ISSUING ORGANISATION

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CONTENTS **PAGE**

SCIENTIFIC PERSONNEL

WEAVER, Philip P.E. (Principal Scientist)	IOSDL
BRAITHWAITE, Anthony C.	IOSDL
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OLDFIELD, P.T.	Second Officer
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ROBERTSON, G.A.	Second Engineer
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CUETO, R.	Seaman 1A
DRAYTON, M.	Seaman 1A
VRETTOS,C.	Seaman 1A
JONES, G.	Seaman 1B
CRAB, G.	Seaman 1B
HESLOP, R.	Seaman 1B
SPROUL, B.	Seaman 1B
GROUT, D.	Seaman 1B
ALCOTT, L.	Cook
WILLIAMS, R.L.	Cook Steward
ACTON, P.	Second Steward
EVANS, P.	Steward
DUHAMEAU, P.	Steward
ROBINSON, P.	Steward

ITINERARY

Departed:	Lisbon	20th October 1989
Arrived:	Barry	20th November 1989

OBJECTIVES

To determine the sedimentary make-up of the Tagus, Horseshoe and Seine Abyssal Plains. To distinguish transported from pelagic sediments and to map as far as possible each lithological unit and determine flow characteristics for the transported units.

To identify the sources of the transported sediments in each abyssal plain and to distinguish between locally derived from the surrounding hills and distally derived from the Portugese and African margins.

To determine the timing of turbidite emplacement on each plain and compare this to that determined on other plains.

To calculate rates of accumulation and compare this to the thicknesses of the turbidite sequences as determined from seismic records to estimate the age of the abyssal plains.

To investigate the diagenesis and metal relocations in the upper sediments of the plains

NARRATIVE

Most of the gear for Cruise 187 was loaded at Barry in August. The remaining items were transported to Lisbon in two containers, one of which was to be used as the chemistry analytical container during the cruise. An advance party of three supervised the unpacking on 18th October so that the main party could install and assemble the equipment on the 19th. Two parties of Portugese visitors, from the Geological Survey and from the Fisheries Institute, were shown around the ship during the afternoon of the 19th. Contact was made with the British Embassy during the port call to confirm that an extension of the requested work area up to the Spanish/Portugese boundary would be allowed. Permission was confirmed after we had set sail.

Discovery departed from Lisbon promptly at 9 a.m. on 20th October, and set a course approximately SW to the Portugese 12 mile limit where the P.E.S. and 3.5kHz fish were deployed at 11.30Z. This course was continued until mid afternoon when the start of the first seismic line was reached. The weather was relatively calm during the day and the process of setting up equipment and moving heavy gear around the after deck was completed. After lunch the Master gave an introductory talk to the scientists and this was followed by an outline of the science programme.

The start point of the first seismic line was chosen so as to make a straight line for the first station in the NW of the Tagus Abyssal Plain without repeating a French multichannel line. A watergun survey was begun at 1630Z Friday 20 October but had to be abandoned at 0524Z Saturday 21 October because of a hole in the air hose near to the gun. A 40 cu. in airgun was deployed but later changed to a 160 cu. in. gun because of poor records. The degradation of the records was probably caused by the sea state which had a strong swell. This sea state and the deteriorating weather caused us to abandon the first station and continue seismic profiling with NS line through the Tagus A.P.

By late on Saturday 21st October the weather was improving and we decided to complete the seismic line and then proceed to a station in the west of the Tagus A.P. The airgun and hydrophone were recovered at 0317Z on Saturday 22nd October and we arrived at the first station (D11931) at 0930Z. The piston corer was deployed first. Nothing significant was noticed during the descent, but there was no change on the dynamometer reading of load on the warp, during what should have been the core penetration and pull-out. On recovery the corer bomb and barrel assembly were missing, but the trigger arm, trigger corer and acoustics were intact. The wire had parted at the trigger clamp. Inspection of the acoustic release showed a loose wire and a mis-connected wire, either of which could have caused an early firing of the pyro and withdrawal of the safety pin. Pre-triggering of the corer must have occurred during the descent.

We decided to continue with a full suite of chemistry sampling equipment at this site (D11931). First to go was the Kasten corer at 1430Z Saturday 21st October. This was recovered at 1815Z in a badly bent state, which necessitated scrapping the barrel and creating a replacement by cutting in half a 4 metre barrel. The reason for the bent barrel is unknown. The next deployment was of the Pore Water Sampler at 1836Z which took 80 ml of good quality pore water. The next 3 deployments all failed. They were, in order of deployment, box corer, Ph probe and Kasten corer. The box corer may have been pulled over on the seabed, but there was no damage. The Ph probe suffered from the flooding of its data logger and consequently recorded no data. The repeated Kasten corer showed streaks of sediment on the inside of the barrel but no sediment was retained, even though the doors of the catcher were closed. At 1520Z on 23rd October we repeated the box corer which returned full of mud. This mud was in such a soupy condition that it proved impossible to extrude it for chemical analyses, and so the only chemistry performed was for oxygen determinations.

The last deployment at this first site on Monday evening was a repeat of the piston corer, this time using a 12 m corer and an electrolytic release ("fizz link"). Unfortunately, soon after deployment the pinger trace showed that the fizz link had been fired, and so the corer was carefully brought back to the ship. This time the problem was a flooded acoustic release. The corer was redeployed using the one remaining release and a pyro firing mechanism. The corer was retrieved at 0249Z with 3 bent barrels and the trigger chain wrapped around the warp. There was however 7.5 m of sediment core showing sand and detrital wood at the base. The deployments on this first site had all been in a heavy swell which did not facilitate easy seabed sampling.

Discovery then proceeded to a site about 40 miles to the east, arriving at 1230Z on the 24th October. Our arrival was preceded by a rapid deterioration in the weather, with winds gusting up to 50 mph, and consequently we abandoned this site and headed south to the southern margin of the Tagus A.P. arriving just before mid-day. By this time calmer conditions prevailed and we decided to piston core with a 9 m barrel. During the descent of the corer the weather deteriorated again, but we did succeed in recovering a 4.3 m long core. We then continued to a site in the central narrow part of the Horseshoe Abyssal Plain to carry out a full station involving all the equipment. We arrived here at 1400 on 25th October. During the ascent of the first deployment (box corer) a violent squall hit the ship with winds reaching over 90 knots. The storms arrival was so rapid, and the winds so strong, that the ship was pushed off station. Scientific operations were halted for a short while until the squall passed, but when the box corer was recovered it had one broken spade closing wire, and thus an open door and no core.

The weather continued with squalls and moderate to heavy swells but we continued the programme with a PWS followed by the Kasten corer. The PWS collected small water samples but no core, whereas the Kasten corer worked well recovering 1.4 m of sediment. Continuing poor sea conditions forced us to abandon the rest of this station and move further south where the prospect looked more promising.

We arrived at a site (station D11934) in the northern part of the Seine Abyssal Plain at 0320Z on 26th October and began operations with a Kasten corer. This produced a good core, but the piston core which followed recovered only 3.5 m of sediment. These cores showed the sediments to consist largely of pelagic material with few turbidites, which was surprising for such a flat plain. We then deployed the box corer which returned empty and was immediately redeployed only to return with a very small disturbed core. Small gaps around the door closures were discovered and so the box corer was set aside for repair. The PWS recovered excellent water samples although it again failed to bring back a core. We tried the pH probe but a malfunction in the depth of penetration sensor meant that little useful data was recorded.

Station D11934 having been completed, we then set off to collect four piston cores from sites distributed about 30 miles apart throughout the Portugese sector of the Seine A.P. The first two attempts resulted in bent barrels, although there was a 6 metre long core in the first attempt. Due to a reducing stock of core barrels we then continued with a 9 meter long piston corer and took three good cores. Station D11939 was occupied on the 28th October for a full suite of chemistry sampling. All the equipment worked well with the exception of the pH probe which needed a second attempt due to battery problems and a lack of weight on the first run which prevented full penetration. The good weather conditions no doubt contributed to the greater success.

Discovery then began a short P.E.S. and 3.5 kHz survey between the south-western end of the Seine A.P. and the broad valley which sweeps down to the Madeira Abyssal Plain. We were looking for an overspill route from the Seine to the Madeira Abyssal Plain. No obvious channels were found and so we piston cored in the deepest part of one of the crossings in an area about 130 metres above the floor of the Seine A.P. (station D11940). This concluded the station work in the Seine A.P. and we headed north back to the Horseshoe A.P. towing the airgun and hydrophone array, arriving at 2300Z on the 31st October.

The weather was now much improved in the Horseshoe A.P. and so we reoccupied the position of station D11933 to complete the chemistry sampling. The pore water sampler, pH probe and box corer worked well, and the data was sufficiently interesting to merit chemical analysis of a piston core. Two piston cores were therefore taken at this site, stratigraphic comparisons between the two being facilitated by 'P' wave logging. Together with the previously taken kasten core this site provided a complete suite of chemical and geological data.

We then worked our way to the west, taking two piston cores on the way, before occupying a further full station (D11944) from 0800Z on the 3rd November, for geochemical sampling near the western margin of the Horseshoe A.P. This time all of the equipment worked well on its first deployment and so another complete data set was obtained. This was achieved despite a moderate to heavy swell which was reaching us from some severe storms well to the north. On completion of station D11944 we moved further west to look for a relatively flat site at around 2000-3000 metres water depth in the middle of a chain of seamounts which form the western boundary of the Horseshoe and Tagus Abyssal Plains. This station (D11945) was dedicated to analysing carbonate chemistry and the pore water sampler and pH probe were used. The site identified on the map proved to be large enough and flat enough and so little time needed to be devoted to surveying. The PWS did not operate on its first deployment because the sediment was too stiff to allow the legs to penetrate. These were removed for the second deployment and the instrument sampled the largest and most complete set of pore-water samples in its history. The sediment proved too difficult for the pH probe which was found to be bent on recovery.

Discovery then proceeded back to the western edge of the Horseshoe A.P. to begin an E-W seismic line along the length of the plain. We began the line at 0910Z on the 5th November using the watergun, but the record was degraded by some drop-outs in the signal. At 1030Z the gun began to leak air and was retrieved. No immediate source of the leak was found and so the 160 in^3 airgun was launched and used to complete the line. The seismic line ended in the eastern part of the plain at 0130Z on the 6th November, and we proceeded to piston core at two sites in the eastern half of the plain. An Hydraulic oil leak on the davit had been gradually worsening during the last few stations and it was decided to identify the source and rectify the problem before beginning the second of these piston cores. An oil seal on the davit was replaced, curing most of the leakage. The second piston core was then taken and followed by a full geochemistry station (D11948) in the North-eastern part of the plain. Problems were encountered here with both the PWS and the pH probe, and the kasten corer failed to recover sediment on two deployments. A problem with the catcher doors was suspected and the equipment was passed to the engineers for minor modification. Two box cores were taken so that the very interesting oxygen profiles obtained from the first one could be verified by closer sampling intervals in the second one. This completed the geochemical sampling in the Horseshoe A.P. but we took two more piston cores near the eastern margin of the plain before leaving.

After completion of the work on the Horseshoe A.P. at 1725Z on the 8th November we moved northwards into the Tagus A.P. and began operations with a piston core station. More problems were encountered, however, with the back tension valve on the winch, and there was a three hour delay while the problem was solved - eventually by bypassing the valve altogether. The piston core was completed by 1100Z on the 9th November and we then proceeded to a geochemistry site (D11952) in the western part of the plain. The PWS did not work on its first deployment because the firm substrate prevented penetration of the stabiliser legs. The legs were removed for the second deployment which worked well. The pH probe worked exceptionally well, producing the best results of the cruise. The box and piston corers also provided good cores, but the kasten corer again failed on two separate deployments. Following the geochemistry site we moved westwards to take a piston core (station D11953) in the centre of the plain. Although we were far from the presumed sediment source, coarse sand was encountered, and two core barrels were bent on the first deployment and one on the second deployment when a short corer was used to try to obtain a limited sedimentary sequence. No core was recovered.

With the evidence pointing to sands throughout the northern part of the plain, we decided to run a second geochemistry station towards the south-east where finer grained and softer sediments were suggested by the 3.5 kHz record. This station (D11954) was occupied from 2000Z on the 11th November and all the equipment worked successfully, except for the pH probe which worked on its second deployment. We left station D11954 at 0100Z on the 13th November and headed north to find a suitable site for a piston core. This proved difficult since the 3.5 kHz records indicated thick sands throughout the east and north-east of the plain. Eventually, after surveying to the north, west and then south, we decided on a site in the north-central part of the plain. The deployment was delayed by a problem with one of the 3 winch motors, but after 2 hours the cause was identified and put right. We proceeded with the piston corer in worsening weather conditions, which probably were the cause of a failure of the "fizz-link" release and subsequent pretriggering of the corer at about 4000 metres water depth. The corer was brought back to the ship and redeployed with a pyro release. Although the release worked this time the seabed proved too sandy and a further core barrel was bent with the gain of no core. The widespread occurrence of sand in the north of the plain prevented any further work here, but we did decide to revisit a site in the northwest corner, which although above the general plain level, had been shown on previous cruises to contain turbidites. This site (D11956) was occupied at 0600Z on the 14th November and produced a good piston core.

Discovery then proceeded to the area of the Tore Seamounts to occupy two geochemistry and coring stations, one on the top of the circular ring of seamounts and one in the deep depression in the middle of these seamounts. The shallower station was occupied at 1800Z on 14th November after a short survey to find a suitable flat site. The box corer, kasten corer, PWS and pH probe all worked well on their first attempt, but some problems were experienced with the piston corer launch. The wire clamp which holds the main warp onto the trigger arm of the piston corer failed while the corer was still in the bucket, necessitating the renewal of the clamp. This was the same problem which led to the loss of a corer on *Discovery* cruise 177. It appears that the clamps have a limited life of about 20 piston cores. Following this repair a good core was retrieved.

November, and arrived at 1700, finding a suitable site on a flat plain with little difficulty. The kasten corer was deployed first and returned full of soft mud. The piston corer was deployed next, but during its descent the ship drifted off the edge of the plain, and we spent some time regaining our position. Eventually a good core was recovered although the 'P' wave log indicated differences between this core and the kasten core. It was possible that the piston corer, through being towed some way behind the ship, had missed the plain. We then deployed the PWS and pH probe, both of which worked well. The next deployment was of the box corer, and again we drifted off the plain during its descent, and spent some time regaining station. The sediment was too soupy to be retained in the box corer and the last of the core was seen escaping during corer recovery. The box corer was recovered at 2050Z on the 16 November leaving just enough time to repeat the piston core in a second attempt at hitting plain sediments. Through careful manoeuvring of the ship, we were able to retain our position this time although this did lead to a steep wire angle. A good core was recovered.

The last station was completed at 0248Z on 17th November and a course was set for Barry. The 3.5 kHz and P.E.S. fish were left operational until 1400Z on the 17th November so that we could survey across the Iberian Abyssal Plain. Strong winds were experienced through the 18th November associated with an intense depression to the south of us. Although this gave us a rough passage we persevered so that we could arrive in Barry on time on the 20th November. The winds abated on the 19th November and we arrived in Barry at 1100Z on the 20th November.

PPEW

SAMPLING AND EQUIPMENT REPORTS

Coring Operations

Box, Kastenlot and piston cores were required on this cruise to provide progressively deeper sediment samples for geochemical pore water and solid phase sampling, as well as stratigraphic and sedimentological studies. The box cores provide relatively undisturbed surface sediments, the kasten cores provide large volumes from the upper few metres and piston cores sample the deeper sequence.

The success rate with the box and kasten corers was poorer than normally experienced, because of the poor weather conditions encountered during this cruise. The piston corer worked well but the lengths of cores were restricted because of the coarse sandy sediments encountered.

Box Coring

The IOS box corer was used throughout the cruise. This is a 30 x 30 cm square section corer which takes cores between 40 and 70 cm long, dependant on sediment consistency. In its present configuration the corer cannot operate until an acoustic signal is sent to fire either an IOS auto-retractor or an ICI retractor. The corer is run into the sea-floor with its shovels open, the acoustic actuation signal is sent and the corer is triggered, so that the corer shovels move to capture the core and seal the top of the box on retrieval.

The corer used on *Discovery* Cruise 184 was employed on this cruise without maintenance in the intervening interval. Either late in Cruise 184 or early in Cruise 187 a small gap (3-4 mm) developed between the base of the box and one shovel. This caused washout of the first 5 cores before the fault was recognised and remedied. These cores were also taken under poor box coring conditions (Force 6-7 winds with swell) and the surfaces were poor on recovery to deck. Subsequent box core runs were made in better conditions, and good quality cores were recovered. The first 10 runs were made with an IOS auto-retractor, which then suffered a broken jaw, and the last 4 runs were made with an ICI auto-retractor.

Of the 14 deployments of the box corer, 8 provided good quality cores which were sub-cored to provide samples for detailed pore water oxygen, nutrient and trace metal profiles. An archive sub-core of each was also retrieved for further reference. Six cores were either completely washed out or were so badly disturbed that only bulk samples were taken.

JT

Kastenlot Coring

A Hydrowerkstatten Kastenlot corer was used throughout this cruise. This is a 15 x 15 cm square section gravity corer which can be used with barrels between 2 m and 6 m long. At the first deployment a 2.5 m barrel was irreparably damaged when the corer failed to penetrate fully with a fully weighted head. A 2 m barrel was used on all subsequent deployments with half of the head weights removed.

There were 6 failures in a total of 13 Kastenlot deployments. It appeared that these were caused by the mechanically-actuated triggers of the core catcher pre-triggering in the water column. On deployment D11952 #7, however, the triggers were firmly taped to prevent this happening, but the tape was too strong to yield in the sediments so that the catcher did not operate at all. Two different designs of catcher were used. An IOS - modified design appeared to be particularly susceptible to pre-triggering, and perhaps should be faired to give a less bluff shape in the water column. This design, however, has been very satisfactory on previous cruises where calmer sea surface conditions were encountered.

The 7 successful cores were taken with an unmodified Hydrowerkstatten catcher. These cores were heavily sampled for pore water oxygen, nutrients and trace metals, and for detailed solid phase sampling guided by the stratigraphy and sediment colours. An archive sub-core of each was also taken for further reference.

JT

Piston Coring

The piston coring on this cruise was approached with a certain amount of confidence, after a very successful coring cruise in the Madeira Abyssal Plain in 1988, (Cruise D177). Unfortunately, we were reminded that under certain conditions the piston corer does have limitations in terms of sea state and sediment type.

Silty and sandy sediments were encountered in the more proximal areas of the Tagus and Horseshoe abyssal plains. These proved difficult to core and many core barrels were bent in the process. Reliability was improved by reducing the length of barrel to 9, 6 or even 3 metres in some cases. The sea state frequently rose to force 6 and 7 during some core stations, which did not prevent coring, but excessive movement of the ship can and probably has reduced the length of some of the cores by as much as 3 metres.

There were a few technical problems all of which were solved on the cruise. On station D11931 a lose wire in the acoustic release fired the pyro on the trigger arm safety pin. This triggered the corer in the water column causing the loss of the main core weight and four barrels.

The new Fizz links with their release indicator were used when ever possible. These Fizz links are cheaper than pyros and have the advantage of giving a positive indication that they have released. Unfortunately the Fizz links proved to be unreliable in sea states of force 6 or above. Excessive movement of the corer vertically in the water column can wear through the wire on the Fizz link. This occurred on two occasions during the cruise, leading to pre-triggering in both cases, but fortunately without loss of the coring system.

In spite of the technical problems, frequent rough weather and coarse sediments, the piston coring was a success and 25 cores were taken giving a total of 155.5 m of core. Table 1 gives a list of corer, freefall and trigger chain lengths.

Core Length (m)	Free Fall (m)	Trip Chain Length (m)
16.5	6	20
13.5	6	17
10.5	6	15
7.5	5	10.5
4.5	4	7.5

DEG

Pore Water Extraction

Pore water extraction was carried out on 270 samples from box and kasten cores and from one piston core using hydraulic pressure squeezing. The refrigerated container worked reliably, but some of the equipment is showing signs of its age.

SC

In-situ Mark III Pore Water Sampler

The in-situ sampling on this cruise was devoted mainly to study of the carbonate system. The 14-port IOSDL Mk III in-situ sampler was deployed a total of 14 times. It sampled successfully at all stations attempted, though in two cases a second deployment was required after the first had failed. In both cases the reason for failure appeared to be the use of stabilising legs which were too long for the local sediment conditions; long legs are required for soft sediments, but if the sediment is unexpectedly hard these legs can prevent the sampler seating correctly on the sediment surface. At stations 11945 and 11952 this apparently occurred; a repeat with the long legs removed succeeded in each case.

As this excellent operational record indicates, this instrument is now a fully developed and reliable vehicle. Because of the pressure-sensitivity of the carbonate system, such devices are necessary in order to recover samples of pore-water for carbonate study. In conjunction with the prototype pH profiler, a uniquely comprehensive study of the carbonate system was undertaken. The in-situ samples were removed from their storage chambers and analysed for pH and total carbon dioxide immediately on recovery. In addition, analyses for Nitrate, Nitrite, Ammonium, Phosphate, Silicate, Manganese and Iron were made on ship, and where sample size permitted alkalinity samples were stored for analysis at Wormley after the cruise. The camera record, in conjunction with the analysis profiles thus obtained, permits the in-situ data to be related to solid-phase core data at the same site, and provides the necessary control on sample quality.

A complex device of this type requires the contributions of many people for success. Since it requires 20 minutes sampling time on the sea-bed, the instrument places considerable demands on the ship's officer of the watch. If the ship moves too far from the landing point during sampling, the instrument will tow over and be damaged, and the samples will be lost. It is instrumented to detect the onset of this condition. In spite of conditions which were often rather marginal, no such problem was encountered during this cruise. This is a tribute to the skills of the officers concerned.

ACB, DJH, SPW, TRSW

Pore Water Analysis

Dissolved Oxygen Analysis

Dissolved oxygen was measured on samples from ten IOS box cores and seven Kastenlot cores. A new microelectrode technique was used for analysis of the first seven cores, giving high sampling resolution especially for the box cores studied. Breakage of all five electrodes then necessitated the use of the Chromatographic method employed on earlier cruises. Analytical precision and sampling resolution suffered as a consequence, but much useful data was still obtained.

Trials of a commercially produced oxygen electrode were carried out but its poor performance made it unsatisfactory for this application.

Nutrient Analysis

Pore water samples from 8 Box, 7 Kasten and 1 Piston Cores and 1 In-situ Pore Water Sampler deployments were processed for the determination of dissolved ammonia, nitrate, nitrite, phosphate, silicate, iron and manganese - a total of 516 samples. The segmented continuous flow auto-analyser system employed on IOS sediment geochemistry cruises since 1983 was used.

All the pore waters analysed were filtered through a Whatman 542 paper filter followed by Nuclepore 0.4 micron filter. Rigorous washing in surface sea water was required to remove the nitrate contamination inherent in the paper filters. Subsamples for use on the auto-analyser were separated while the samples were still under nitrogen. The samples for the determination of Si, PO4, Fe and Mn were collected directly into 2ml auto-analyser vials containing 50mL of 2.5M Hydrochloric Acid.

For the concentration ranges found on this cruise the set up of the auto-analyser was adjusted to give linear working ranges of (colorimeter gain in brackets) NH4-75uM(5.2), NO3-30mM(3.6), NO2-2mM(6.4), Si-300mM(3.6),PO4-10mM(2.4), Fe-50mM(2.6), Mn-50mM(2.5). Modifications to the methods relative to IOS Report No. 177 were:-

1. Ammonia used an orange/green sample tube.
2. Nitrate and nitrite the standard sulphanilimide and NED reagents were used.
3. Nitrate used an orange/green sample tube.
4. Nitrite used a white sample tube and a red tube for the buffer solution.
5. Phosphate used an orange/white sample tube.
6. Silicate was determined at 660nm ub a 10mm path length cell using a red pull-through tube.

The following problems were encountered during the cruise:-

1. The chemistry groups sole working PET4000 micro-computer died and had to be replaced with a PET3000. This older machine was not compatible with the disc drive and we had to revert to loading the programme from tape.

2. The heating bath controller on the ammonia failed. This reduced the quality of the analyses for two days until Steve McPhail was able to build a new one. Steve's controller appears to work better than the old commercial one holding the temperature to better than 0.1°C.

3. On this cruise the nitrogen species peaks were read using the BBC-B computer system. Using the same 8 second time windows for peak recognition as worked well in the PET based program the BBC program does not locate the falling edge of the peaks as reliably as the PET. This was solved by making the window asymmetric about the expected peak position opening the window 10 seconds before and closing it 4 seconds after.

DJH

In-situ pH/Porosity Profiler

Because of the pressure-sensitivity of the carbonate system in sea-water, errors arise when deep-ocean samples are recovered to the surface. One possible way to study this important system, which is linked to long-term climate fluctuations, is to make measurements directly in-situ. The pH profiler deployed on cruise 187 has been produced for this purpose. It is the result of a collaboration between IOSDL and the University of Liege, Belgium, funded in part by an EC twinning agreement. The prototype device is lowered to the sea bed on the main warp. On landing, three probes slowly penetrate the sediment, recording profiles of pH, conductivity and magnetic susceptibility. A data set is recorded every 2 mm of travel down to a maximum depth of 850 mm. The data is stored in a solid-state data logger, and is downloaded to a host computer when the instrument is recovered to the ship. Table 1 lists the pH profiler deployments.

The pH profiler was deployed a total of 13 times. Useful data was obtained for 10 deployments. On the first deployment the data logger pressure case flooded; immediate conservation measures were taken, and it fortunately proved possible to repair the logger. On two other occasions the shaft encoder (which records the distance the probes penetrate the sediment) was damaged. This seriously affected the quality and quantity of data obtained on these occasions. In future the shaft encoder will have to be more robust and better protected.

The initial pH profiles were marred by random noise spikes which seemed to result from currents induced by corrosion of the instrument frame. Attempts to reduce this by the liberal application of Vaseline, insulating tape and the electrical insulation of the main warp from the instrument ultimately proved successful. pH profiles substantially free of this noise were then obtained.

The magnetic susceptability probe is in an early stage of development, but performed well throughout the cruise. Improvements will need to be made in the temperature and mechanical stability of the sensor. Sub-cores, taken from box cores at the same stations, will be used to verify the in-situ magnetic susceptability data.

The conductivity probe worked reliably apart from a slight instability in readings of bottom water conductivity, thought to be caused by corrosion of the two monel electrodes. This could be improved by use of precious metal electrodes, or to use a four-electrode design which is inherently considerably less sensitive to contact resistance.

The pH profiler deployments on D187 were very successful both in terms of scientific data and instrument development. Useful scientific information was recovered, and clear indications of the requirements for further development of this prototype were obtained.

ACB, AED, SDMcP, TRSW

Acoustics and Telemetry

Piston Coring

An acoustic release was used to arm the piston corer prior to taking a core, firing either a pyro-release or an IOSDL "fizzlink" to release a piston approximately 20m above the seabed. Fizzlinks have, in their current design, half the breaking strain of a pyro, and there were problems using them in rougher weather.

The first core was to be taken using a pyro. Due to an internal fault in the acoustic unit the pyro was fired, probably in the first hundred metres or so, the corer pretriggered and the bomb was lost. The release was modified to fire fizzlinks, but was flooded on the next deployment. A further 7 cores were taken using the second unit and a pyro until the first unit had been rebuilt and tested. One core was taken in 4300m of water, but on the following deployment the release channel went into oscillation, firing the fizzlink and pretriggering the corer at approximately 4000mwd. The box core release was used in its place, with a pyro, and later modified to fire fizzlinks. CR2432, which had been left on board from a previous IOSDL cruise was used to fire the box core. This configuration was used for the remainder of the trip with no further failures on the part of the acoustic releases.

Eleven cores were taken using fizzlinks until one broke at 5000mwd, with the wind at force 6-7 and a heavy swell running, causing the corer to pretrigger. The next core was successful in calm weather, but the following core also pretriggered in heavy swell conditions. After this fizzlinks were only used in relatively calm conditions (force 4 or less). This made a total of 11 pyros, 10 of which were successful, and 21 fizzlinks, 18 of which were successful.

Box coring

The acoustic releases used to fire the box core on the seabed were successful on all 13 deployments.

DW

Equipment: RVS

Seismics

Three seismic lines were undertaken during the cruise. The seismic data was simultaneously recorded on an analogue system and a digital system. The sound source was a water gun but it became intermittent and was replaced with the bolt airgun. The analogue data tapes were replayed at thirty two times real time for frequencies of 50-75 Hz, 100-150 Hz and 200-300 Hz to highlight different details in the data.

Computing

The shipboard computing system was used to log navigational information and station data. Charts were produced showing the ships track, annotated station positions and annotated corrected depths for the seismic lines.

3.5kHz Seismic System

This system was used successfully during the seismic lines and on passage between sampling stations.

PJM

Engineering

The only winch system used on this cruise was the aft-hydraulic traction winch. We experienced problems with both the pump back pressure control system and the back tension on the main storage drum. Steve McPhail and Dave White re-converted the automatic pump back pressure control to a manual control system and we had no further problems.

To overcome the problem of the lack of back tension on the main storage drum, we bypassed the solenoid that electrically controls the back tension. This gave a constant, but non-variable, pressure to the winch driver as the electrical control was no longer available on the console. This proved to be an effective remedy and enabled the use of the aft-traction winch to continue for the remainder of the cruise.

We were impressed with the way the ship's crew handled the winch driving which enabled its use 24 hours a day. They were extremely conscientious and a pleasure to work with.

In summary, the technicians experienced no major mechanical failures considering the advancing age of the machinery.

RFW, SW, RAP

SUMMARY

The cruise was a success. On the coring side 25 piston, 7 kasten and 8 box cores were recovered. The PWS worked particularly well, with 14 successful deployments, indicating that this is now a fully developed and reliable vehicle. The pore water sampler is still considered to be in a developmental phase, nevertheless it gave useful results on 10 of its 13 deployments. As a result of these developments, potential improvements have been identified to increase its effectiveness in the future.

The results were achieved in the face of numerous problems. Firstly, the weather, which at first was entirely unsuitable for station work and later was sometimes reasonable but frequently worse than we would have liked. Secondly, the sediments themselves in the Tagus and Horseshoe Abyssal Plains were more sandy than we had expected. This led to numerous bent piston core barrels and shorter cores. The winch, which was used almost continuously, is showing signs of old age and was kept running only through the ingenuity and efforts of the engineers.

This was not a cruise where many conclusions could be drawn at sea, these will derive from the laboratory work which is to follow. We can, however, conclude that the northern part of the Tagus Abyssal Plain is covered by extensive thick sands. The southern part of the plain is composed of dark coloured turbidites with thick sandy bases, fine upper parts and thin pelagic layers. Similar turbidites and pelagics are found throughout the Horseshoe Abyssal Plain. Active and relic oxidation fronts are common and appear similar to those in the Madeira Abyssal Plain. In the Seine Abyssal Plain the turbidites have paler olive green colours - similar to those in the Madeira Abyssal Plain, and thick sands are not common.

ACKNOWLEDGEMENTS

On behalf of the scientific party I would like to express my sincere thanks to the officers and crew for their contributions to this cruise. We did not get the weather we hoped for, but we did manage to achieve all the objectives. The deck crews in particular did a splendid job, being professional, helpful and cheerful throughout.

I also wish to acknowledge the consistent efforts of the scientific staff for remaining optimistic during the early part of the cruise when the weather and equipment were conspiring against us, and enthusiastic during the later stages when the data and samples began to flow. The ship's age has begun to show by giving problems with some of the basic facilities, and yet these discomforts were generally borne with a smile by officers, crew and scientists alike. It was a pleasure to be involved with such a professional team.

PPEW

TABLE 1 - Station List

Station Number	Date	Latitude	Longitude	Equipment	Mean Water Depth (m uncorr.)	Time (z) Out	In	Notes
D11931#1	22/10	37°25'7N	12°18'W	Piston corer	5065	9.30	1.46	12 m barrel; bomb and barrels lost due to core pretriggering on descent.
D11931#2	22/10	37°27'N	12°18.3'W	Kasten corer	5063	14.30	18.15	2 m barrel; severely bent; no core.
D11931#3	22/10	37°29'N	12°17.9'W	PWS	5065	18.36	23.06	80 ml of porewater
D11931#4	23/10	37°31.3'N	12°15.9'W	Box corer	5065	23.49	04.42	No core.
D11931#5	23/10	37°31.4'N	12°14'W	pH probe	5065	05.15	09.32	No data.
D11931#6	23/10	37°28.7'N	12°19.07'W	Kasten corer	5065	10.29	14.29	2 m barrel; no core.
D11931#7	23/10	37°31.3'N	12°19.6'W	Box corer	5065	15.20	19.20	Core recovered, but very soupy.
D11931#8	23/10	37°34.2'N	12°15.3'W	Piston corer	5065	21.30	02.49	7.5 m core; 3 bent barrels
D11932	24/10	36°53'N	11°57.8'W	Piston corer	5075	12.47	18.00	Good core length, 4.3 m.
D11933#1	25/10	35°45.9N	12°19.4'W	Box corer	4830	04.24	08.41	No core, one door strap broken.
D11933#2	25/10	35°45.8'N	12°20.1'W	PWS	4833	09.07	13.25	No core, 38 ml of porewater
D11933#3	25/10	35°45.9'N	12°18.7'W	Kasten corer	4833	13.52	18.02	Good core length, 1.31 m.
D11934#1	26/10	34°38.5'N	12°51.6'W	Kasten corer	4428	03.21	06.07	Good core length, 1.46 m.
D11934#2	26/10	34°36.3'N	12°53.6'W	Piston corer	4428	09.17	13.36	Core length 3.46 m.
D11934#3	26/10	34°35.7'N	12°51.4'W	Box corer	4422	13.59	17.18	Empty
D11934#4	26/10	34°35.2'N	12°49.4'W	Box corer	4422	17.30	20.31	Small core, disturbed by being partly washed out.

Station Number	Date	Latitude	Longitude	Equipment	Mean Water Depth (m uncorr.)	Time (z) Out	In	Notes
D11934#5	26/10	34°34.1'N	12°47.4'W	PWS	4422	20.49	00.47	Successful 212 ml porewater; no core.
D11934#6	27/10	34°32.9'N	12°50.3'W	pH probe	4422	01.06	05.10	No data - only 6 cm penetration.
D11935	27/10	34°25.6'N	12°53.4'W	Piston corer	4415	07.43	12.10	5.7 m core; 3 bent barrels.
D11936#1	27/10	33°58.4'N	12°43.5'W	Piston corer	4417	16.38	20.44	No core - 1 bent barrel.
D11936#2	27/10	33°58.4'N	12°47.4'W	Piston corer	4417	21.44	01.39	Good core length, 7.5 m.
D11937	28/10	34°07.8'N	13°23.6'W	Piston corer	4416	05.13	09.00	Good core length, 7.5 m
D11938	28/10	33°29.9'N	13°13.2'W	Piston corer	4412	13.17	17.08	Good core length, 7.5 m
D11939#1	28/10	33°30'N	13°52'W	Kasten corer	4420	20.50	23.54	Good core length, 1.16 m
D11939#2	29/10	33°31'N	13°47.7'W	PWS	4420	00.22	03.54	No core - 187 ml porewater
D11939#3	29/10	33°29.5'N	13°44.1'W	Box corer	4420	04.10	08.10	Good core length, 44 cm
D11939#4	29/10	33°30.0'N	13°51.3'W	pH probe	4420	10.19	13.53	No data - battery problems
D11939#5	29/10	33°29.8'N	13°52.4'W	Piston corer	4420	14.54	18.28	Good core length, 6.5 m
D11939#6	29/10	33°29.1'N	13°52.8'W	pH probe	4420	18.50	22.16	Data logged
D11940	30/10	33°02.9'N	14°35.4'W	Piston corer	4292	16.43	20.25	Good core length, 6.2 m
D11941#1	31/10	35°43.9'N	12°21.4'W	Box corer	4830	23.05	02.33	Good core length, 0.7 m
D11941#2	1/11	35°44.4'N	12°21.2'W	pH probe	4830	03.44	08.23	Data logged

Station Number	Date	Latitude	Longitude	Equipment	Mean Water Depth (m uncorr.)	Time (z) Out	In	Notes
D11941#3	1/11	35°44.7'N	12°20.6'W	Piston corer	4830	10.12	13.55	Pretriggered due to oscillation in release.
D11941#4	1/11	35°43.7'N	12°21'W	Piston corer	4830	15.00	19.19	Good core length, 9.16 m
D11941#5	1/11	35°43.6'N	12°21.1'W	PWS	4825	20.08	00.10	No core, 107 ml of porewater
D11941#6	2/11	35°44.7'N	12°21.3'W	Piston corer	4830	01.30	06.02	Good core length, 11.38 m
D11941#7	2/11	35°46.4'N	12°23.7'W	PH probe	4830	06.50	11.33	Datalogged
D11942	2/11	35°47.2'N	12°52.5'W	Piston corer	4830	14.23	18.28	Good core length, 8.78 m
D11943	2/11 3/11	35°40.9'N	13°18.3'W	Piston corer	4830	21.06	04.30	Good core length, 8.77 m
D11944#1	3/11	35°43.2'N	13°36.1'W	PWS	4820	07.59	12.30	No core, 130 ml porewater
D11944#2	3/11	35°49.4'N	13°41.2'W	Kasten corer	4815	13.30	17.28	Good core length, 1.83 m
D11944#3	3/11	35°42.8'N	13°35.7W	pH probe	4820	18.49	23.37	Data logged
D11944#4	4/11	35°44.4'N	13°37.7'W	Piston corer	4820	00.41	04.45	Good core length, 8.2 m
D11944#5	4/11	35°43.4'N	13°38.7'W	Box corer	4820	07.49	09.36	Good core 0.45 m
D11945#1	4/11	36°21.4'N	14°45.2'W	PWS	2656	18.17	20.41	No data - probes did not penetrate fully
D11945#2	4/11	36°21.4'N	14°44.7'W	PWS	2650	21.24	23.39	Excellent data - all parts full
D11945#3	5/11	36°20.6'N	14°46.5'W	pH probe	2645	00.15	02.56	Probe bent - no pH data
D11946	6/11	35°36.3'N	11°14.9'W	Piston corer	4827	03.10	08.24	Good core length, 7 m long. 9 m barrel

Station Number	Date	Latitude	Longitude	Equipment	Mean Water Depth (m uncorr.)	Time (z) Out	In	Notes
D11947	6/11	35°36.3'N	11°47.3'W	Piston corer	4825	13.00	17.00	Good core length, 4.5 m 9 m barrel
D11948#1	6/11	35°53'N	11°11.6'W	Box corer	4825	20.56	00.35	Good core length, 0.62 m
D11948#2	7/11	35°53'N	11°12.2'W	PWS	4825	01.33	05.33	45 cm core, 115 ml porewater
D11948#3	7/11	35°53.3'N	11°11.7'W	Piston corer	4825	06.25	10.14	Good core length, 8 m 9m barrel
D11948#4	7/11	35°53.4'N	11°10.4'W	pH probe	4824	10.53	15.15	Data logged
D11948#5	7/11	35°52.2'N	11°12.8'W	Kasten corer	4822	15.54	19.12	No core
D11948#6	7/11	35°53.6'N	11°11.6'W	Kasten corer	4822	19.45	23.16	No core
D11948#7	8/11	35°56.3'N	11°11.2'W	Box corer	4820	23.25	03.20	0.6m good sediment surface
D11949	8/11	35°00N	10°43.9'W	Piston corer	4820	07.05	11.12	Good core length, 5.5 m 9 m barrel
D11950	8/11	36°13.6'N	10°29.5'W	Piston corer	4805	13.36	17.25	Good core length, 7 m 9 m barrel
D11951	9/11	37°20.8'N	11°51.6'W	Piston corer	5080	06.50	11.00	Good core length, 9.6 m
D11952#1	9/11	37°57.7'N	12°14.7'W	Kasten corer	5045	15.45	19.17	No core
D11952#2	9/11	37°55.3'N	12°12.1'W	PWS	5044	20.21	00.30	35 cm core; no porewater
D11952#3	10/11	37°54.5'N	12°12.7'W	pH probe	5044	01.35	06.03	
D11952#4	10/11	37°55.9'N	12°13.1'W	Box corer	5045	07.10	11.44	Good core length, 0.42 m
D11952#5	10/11	37°55.9'N	12°11.4'W	PWS	5045	12.53	17.05	No core; no porewater

Station Number	Date	Latitude	Longitude	Equipment	Mean Water Depth (m uncorr.)	Time (z) Out	In	Notes
D11952#6	10/11	37°55'N	12°12.3'W	Piston corer	5040	17.57	22.25	Good core length, 6.31 m
D11952#7	10/11	37°56.5'N	12°11.8'W	Kasten corer	5042	23.21	03.03	No core
D11953#1	11/11	37°46.8'N	11°32.6'W	Piston corer	5050	06.36	10.59	No core - 2 barrels bent
D11953#2	11/11	37°46'N	11°33.7'W	Piston corer	5050	12.04	16.15	No core - 1 barrel bent
D11954#1	11/11	37°23.9'N	11°04.1'W	Kasten corer	5070	20.00	23.50	Good core length, 1.44 m
D11954#2	11/11 12/11	37°24.3'N	11°04.4'W	PWS	5070	00.35	04.40	52 cm core; 118 ml porewater
D11957#3	15/11	39°05'N	12°36.9'W	pH probe	3525	02.53	06.14	
D11957#4	15/11	39°03.6'N	12°36.4'W	Kasten corer	3547	07.07	09.40	Good core length, 1.12 m
D11957#5	15/11	39°02.4'N	12°35.3'W	Piston corer	3585	11.27	14.17	Good core length, 6.4 m
D11958#1	15/11	39°23.3'N	12°51.7'W	Kasten corer	5461	17.03	21.04	Good core length, 1 m
D11958#2	15/11 16/11	39°28.8'N	12°52.0'W	Piston corer	5460	22.00	04.30	Good core length, 8.4 m
D11954#3	12/11	37°23.8'N	11°05.9'W	pH probe	5070	04.54	09.25	
D11954#4	12/11	37°25.2'N	11°05.4'W	Box corer	5070	10.15	14.12	Good core length, 0.61 m
D11954#5	12/11	37°24.5'N	11°06.1'W	Piston corer	5070	15.22	19.29	Good core length, 5.3 m
D11954#6	12/11	37°25'N	11°04.6'W	pH probe	5064	19.55	00.50	

Station Number	Date	Latitude	Longitude	Equipment	Mean Water Depth (m uncorr.)	Time (z) Out	In	Notes
D11955#1	13/11	37°56.5'N	11°40.7'W	Piston corer	5045	13.42	16.58	Pretriggered due to breakage of fizz link
D11955#2	13/11	37°54.9'N	11°37.7'W	Piston corer	5045	18.04	22.46	No core - 1 barrel bent
D11956#1	14/11	38°22.6'N	12°38.6'W	Piston corer	5045	06.18	10.24	Core recovered to adjust chain length
D11956#2	14/11	38°21.9'N	12°35.6'W	Piston corer	4825	10.35	14.26	Good core length, 8.5 m
D11957#1	14/11	39°03.7'N	12°36'W	Box corer	3540	18.41	21.21	Good core length, 0.37 m
D11957#2	14/11	39°03.4'N	12°41.1'W	PWS	3585	22.37	02.08	No core; 243 ml porewater
D11958#3	16/11	39°23.6'N	12°52.0'W	PWS	5450	05.08	09.30	0.65 m core; 128 ml porewater
D11958#4	16/11	39°23.4'N	12°51.5'W	pH probe	5462	10.21	14.46	
D11958#5	16/11	39°23.5'N	12°50.9'W	Box corer	5460	15.34	20.52	No core recovered - sediment presumed too soupy
D11958#6	16/11 17/11	39°23.6'N	12°47.4'W	Piston corer	5470	22.16	02.48	Good core length, 7.1 m

TABLE 2 - Airgun/Watergun Lines

Station Number	Date	Latitude	Longitude	Equipment	Mean Water Depth (m uncorr.)	Time (z) Out	Time (z) In	Notes
	20/10	36°17.5'N	9°53.5'W	Watergun		17.20		Failed at 0524Z 21/10 due to hole in air hose
	21/10	38°28'N	11°59'W	Airgun			3.17	40cu in changed at 2154Z 21/10 for 160cu in to improve records.
	30/10	33°04.6'N	14°30.3'W	Watergun		21.34		Seismic survey of Seine Abyssal Plain
	31/10	34°50'N	12°40'W				17.17	
	5/11	35°45'N	13°54.8'W	Water/airgun		09.48		Watergun changed for airgun @ 11.45
	6/11	35°45.1'N	11°24.8'W				01.30	

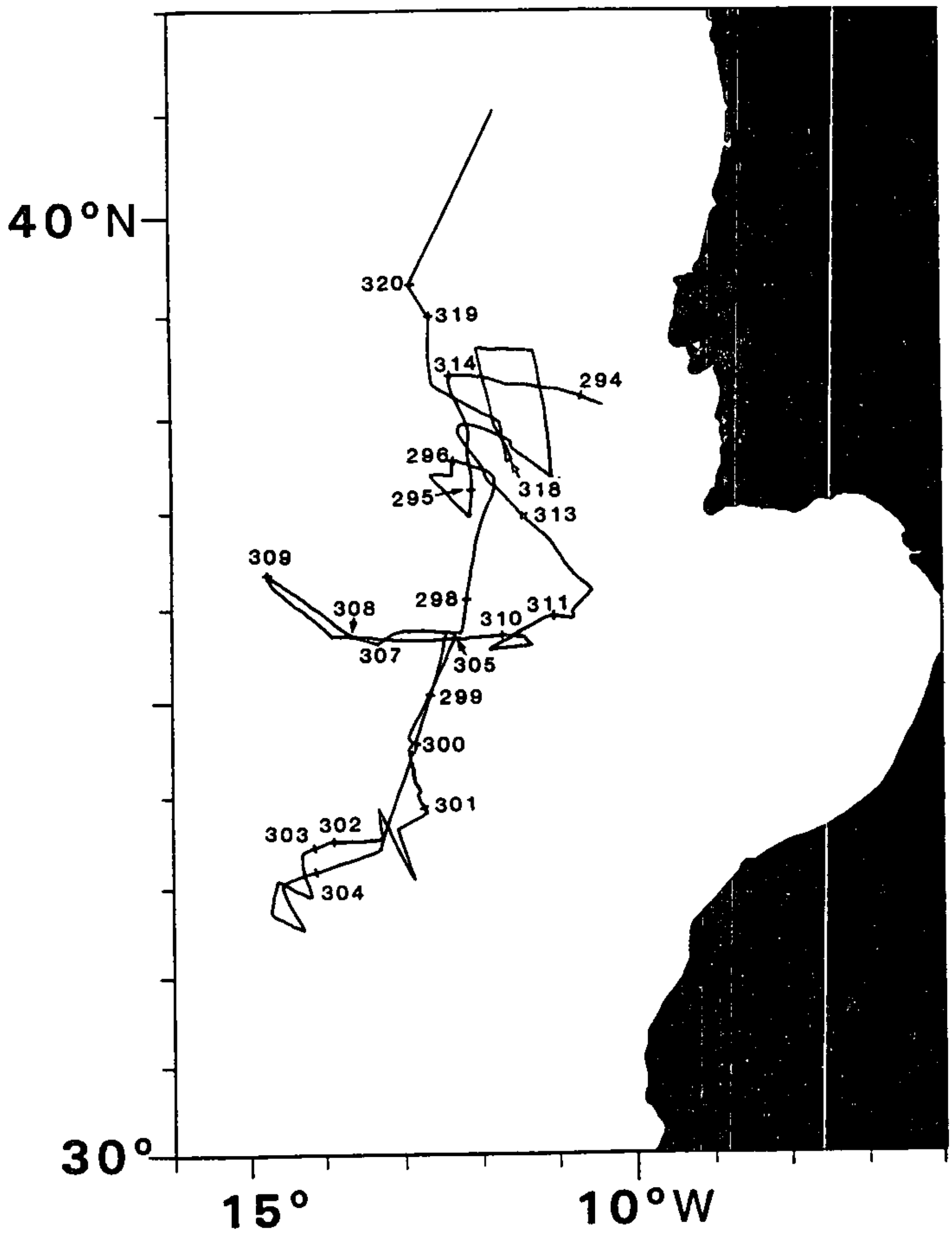

Figure 1 Track chart for *RRS Discovery* Cruise 187, 20 Oct-20 Nov 1989 showing 0000Z positions.

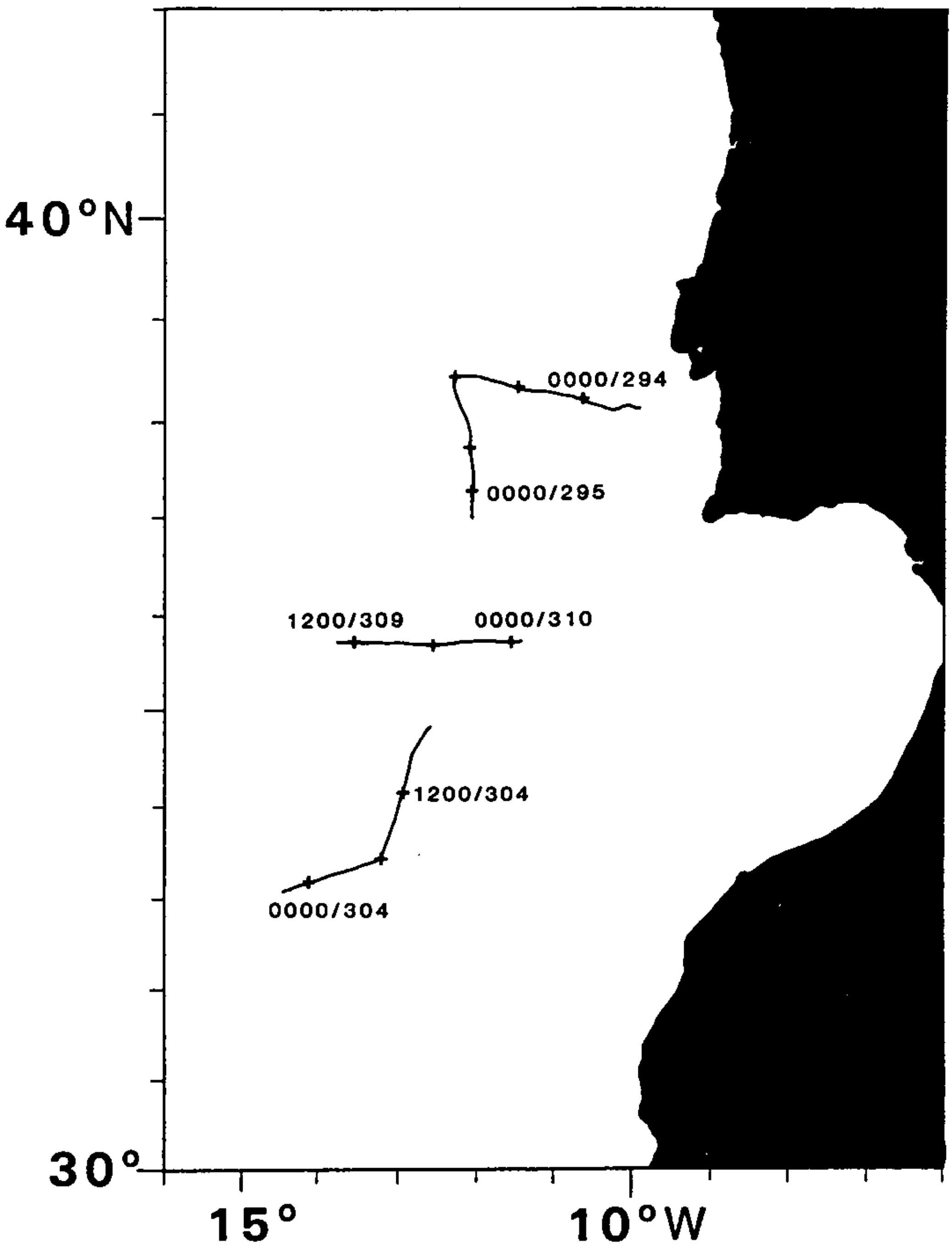

Figure 2 Airgun and watergun lines shot on RRS *Discovery* Cruise 187

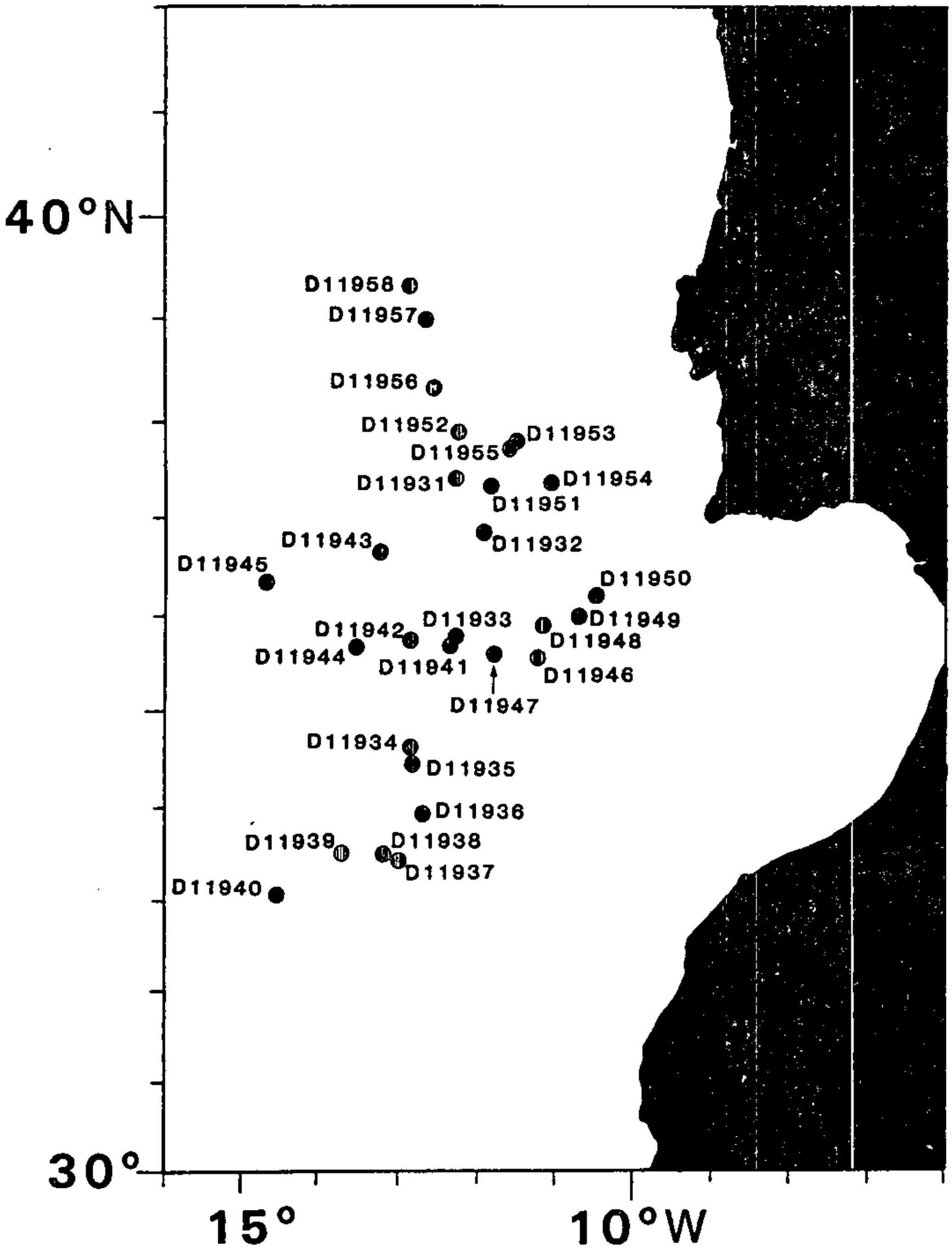

Figure 3 Station positions occupied on *RRS Discovery* Cruise 187