I.O.S.

RRS DISCOVERY

CRUISE 142

20 NOVEMBER – 18 DECEMBER 1983

GEOPHYSICAL INVESTIGATIONS OF THE ROMANCHE AND ST. PAUL FRACTURE ZONES, EQUATORIAL ATLANTIC OCEAN

CRUISE REPORT NO. 157

1984

NATURAL ENVIRONMENT RESEARCH COUNCIL

INSTITUTE OF OCEANOGRAPHIC SCIENCES

INSTITUTE OF OCEANOGRAPHIC SCIENCES

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INSTITUTE OF OCEANOGRAPHIC SCIENCES

WORMLEY

RRS DISCOVERY

Cruise 142

20 November - 18 December 1983

Geophysical investigations of the Romanche and St. Paul Fracture Zones, equatorial Atlantic Ocean

Principal Scientist

R.C. Searle

CRUISE REPORT No. 157

1984

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ITINERARY

Departed	Dakar	16.45 GMT	20th November, 1983	(Day 324)
Arrived	Dakar	09.50 GMT	18th December, 1983	(Day 352)

SCIENTIFIC PERSONNEL

J.M. Campbell	IOS (W)	GLORIA
I. Hamilton	Univ. Birmingham	GLORIA Observer
M.J. Harris	IOS (W)	WASP acoustics
C.L. Jacobs	IOS (W)	Geophysics
D.A. Jones	RVS	Computer
S. Jones	RVS	Gravimeter, Magnetometer, SRP
G. Knight	RVS	Computer
B.G. Knowles	IOS (W)	Ocean Engineering
L.M. Parson	IOS (W)	Geophysics
C.D. Pelton	IOS (W)	Geophysics
I.P. Rouse	IOS (W)	Acoustic Navigation
M.R. Saunders	IOS (W)	Geophysics
R.C. Searle	IOS (W)	Geophysics (Principal Scientist)
M.L. Somers	IOS (W)	GLORIA
M.V. Thomas	IOS (W)/U.C. London	CASE student
R.F. Wallace	IOS (W)	Ocean Engineering

SHIP'S OFFICERS AND PETTY OFFICERS

S. Mayl	Master
N. Jonas	Chief Officer
M. Putman	2nd Officer
A. Louch	3rd Officer
C. Langley	Radio Officer
R. Cridland	Purser/Catering Officer
D. Rowlands	Chief Engineer
I. McGill	2nd Engineer
C. Phillips	3rd Engineer
A. Greenham	4th Engineer
N. Davenport	5th Engineer
K. Sullivan	Extra 5th Engineer
P. Edgell	Senior Electrician
F. Williams	CPO Deck (Bosun)
M. Harrison	PO Deck
S. Francis	PO Deck

OBJECTIVES

The cruise was funded entirely from the Science Vote and formed part of the Institute's project 3B1 'Mid-Ocean Ridges and Fracture Zones'. The specific objectives were as follows:-

To complete the GLORIA coverage of the Romanche Transform Fault (begun on Discovery Cruise 96);

to investigate the transverse ridges and troughs associated with the fracture zones and to determine their nature and origin;

to map the active plate boundary in St. Paul Fracture Zone;

to gain experience in using the survey camera (WASP) with acoustic navigation and in rugged terrain;

and to obtain GLORIA and other geophysical data on passage around Kane Gap and the Sierra Leone Rise for colleagues at University College, London, and the University of Kiel.

NARRATIVE (see Figure 1 for cruise track chart and table 1 for a summary of underway geophysical measurements)

Dakar to Romanche Fracture Zone

Discovery moved to the bunkering quay at Dakar on Sunday, 20th November (day 324) at 0826 GMT. Bunkering was complete by 1205, but sailing was delayed until 1645 for repair of a fractured main engine cooling pipe. While in Dakar, we received a message from Dr. Bonatti of Lamont-Doherty Geological Observatory regretting that he would be unable to join the cruise. No word was received concerning a possible Brazilian observer.

The ship hove to at 1600 on day 325 to deploy PES, hull-mounted Asdic and 3.5 kHz fish. Following that, 1500m of wire was run out from the midships winch to test the repair effected in Dakar. All seemed well. We then deployed GLORIA and the magnetometer, and resumed course at full speed. All instruments were switched on and logging began at 2238, day 325, when the 200 mile limit was reached. We then turned south along the continental rise towards Kane Gap.

Day 326 was spent in traversing Kane Gap, and the following day we crossed selected parts of the Sierra Leone Rise to obtain data for Professor Sarnthein of the University of Kiel and Dr. Jones of University College, London. We then proceeded directly towards the eastern end of the Romanche Transform Fault, aiming to come onto it at the point where GLORIA coverage on Discovery cruise 96 had left off (about $18^{o}35'W$).

A telex indicating that permission to work within 200 miles of St. Paul's Rocks had been refused was received in the morning of day 328.

At 328/1348 we reduced speed to deploy the 40 cubic inch airgun and short seismic array, and then resumed a speed of 8.5 knots. There was considerable trouble getting the airgun to work, and the record was very noisy. We therefore changed to the large (single-channel) array and 300 cubic inch gun at 328/2138, and resumed 8 knots at 2213. This change produced a good seismic record.

During the night it became clear that there was a phasing problem in the starboard GLORIA beam, and at 329/0945 GLORIA was switched off to investigate. As we were close to the Romanche Transform at this point, we doubled back while the GLORIA repair was taking place, and resumed the former southerly track at 1516 with GLORIA back on line.

Romanche Fracture Zone

Between 1800 and 2000 on day 329 we crossed the transform valley, and altered course at 2008 to begin a long traverse to the east, viewing the eastern end of the transform fault from the south with GLORIA. The fault was followed to its eastern junction with the Mid-Atlantic Ridge at about 330/1500 (near $16^{o}20'W$); we then crossed to its north side and ran back westwards, viewing it from the north.

There had been continual problems with the airguns, and it was finally decided that it would be impossible to continue with the large guns at towing speeds of around 8 knots, as there was slack in the tail section fittings which allowed them to vibrate excessively at that speed. We therefore finally changed to a 40 cubic inch gun at 330/2320, and thenceforth had little further trouble.

At 331/0733 we recrossed the transform, and then turned eastwards again to examine, with GLORIA, the fracture zone structure somewhat to its south. This line ended near the eastern Mid-Atlantic Ridge axis at 332/0522, when we turned to begin an orthogonal grid survey of the eastern end of the active part of the fracture zone.

Station work

At 333/2315 we broke off the survey to commence five days of station work with the WASP survey camera and dredges, to be navigated by acoustic beacons. The area chosen was a part of the transform valley near its eastern end, where the transform fault was well-defined on the GLORIA images and where the depth appeared to be mostly less than the 6000m limit of our near-bottom instruments.

The streamed geophysical equipment was recovered by 334/0104, and the acoustic interrogator fish was then launched. Following a short PES survey, three acoustic beacons were laid (see Table 2 for beacon positions), and a survey of the baselines was begun.

At 334/1818 we hove to for the first WASP station (station number 10950; see Table 3 for station details). This was planned to cross the trace of the transform fault from north to south. Shortly after the camera was lowered into the water its acoustic monitor failed, and it was recovered.

We next moved to the north wall of the fracture zone for a dredge station (10951). The dredge entered the water at about 334/2210. There was some difficulty in rigging the dredge and keeping on station owing to the strong (2.5 knot) current in the area, but eventually the dredge was lowered and reached the bottom at 335/0057. Although it had been hoped to acoustically navigate this station, it transpired that we were just out of range of all but the nearest beacon. The dredge was hauled off the bottom at 0151 and was inboard with a good haul of rocks by 0434.

We moved back to the centre of the work area for a further test of the midships winch, which began at 335/0716. The wire was paid out to 4500m and then recovered, uneventfully.

Next another WASP station was attempted (10952). We began deploying the gear at 335/1103, but again the monitor failed shortly after entering the water, and it was recovered at 1142.

The next six hours were spent in towing trials for the Babb Profiler. A rig was made up in which the towing cable (CTD wire) had a weight attached some

50m ahead of the profiler vehicle, and the vehicle was partially supported by a glass float to make it almost neutrally buoyant, and had a small drogue attached to add drag. The tow cable was led aft from the midships winch using a snatch block at the base of the gallows, and was passed outboard over a block on the Schatt davit, which was swung out to starboard. With this arrangement the wire easily cleared the side of the ship. This appeared to provide a tow in which the vehicle streamed almost horizontally behind the tow weight, as required.

The towing trial was ended at 1806, and we proceeded to the supposed position of the transform fault for another dredge station (10953). This and all subsequent stations were acoustically navigated. The dredge was deployed at 335/2123, reached the bottom at 2357 and was hauled in starting at 336/0250. It was recovered at 0524, again with a good collection of rocks.

We manoeuvered to the start of the next WASP station (10954), at the same position as the previous ones, taking the opportunity to make an additional base-line crossing of the acoustic net. After a short delay while maintaining a constant heading to facilitate radio traffic, we began deploying the gear at 1053. This time we were able to pay out a considerable amount of wire, but eventually the monitor failed before reaching the bottom. The WASP was recovered by 1328, and another Babb Profiler trial was begun.

This employed an improved drogue and some other minor modifications, and this time 600m of wire was paid out. The ship's speed was brought up to 2 knots, and the ship was successfully turned with the vehicle under tow. The vehicle was recovered by 2013.

At 2040 we hove to for a wire test of the WASP acoustic monitor. This time the monitor failed at 4766m, and on recovery a faulty clock crystal was found. It was replaced, and at 337/0230 we began what was to be a successful WASP station, 10955. The station was planned to cross the transform fault in the region of station 10953.

The camera was rigged and began lowering at 0315. It was on the bottom by 0603, and we began recovery at 1025. The gear was back on deck at 1305. The only difficulty experienced during the station had been that the signal from the monitor became very weak when the ship was turned (as was necessary to guide the instrument along the desired track) more than about 30 degrees away from having the WASP dead astern. Steering the PES beam astern helped, but thwartships steering was really required, and was apparently not available.

A dredge station had been planned next, but signals from the 'red' acoustic beacon were getting very weak and, as it was feared that this indicated a deteriorating power supply, it was decided to attempt to recover this beacon forthwith. We were lying to near the beacon and transmitting the release signal by 337/1438, but despite repeated transmissions and careful listening we could not hear it. We lay to over its position as estimated from ranges to the other two beacons from 1740 until dusk, but neither heard nor saw it. The search was abandoned at 1918, and we proceeded to a final dredge station (10956) which was intended to sample a steep slope in the transform domain west of stations 10953 and 10955.

The dredge was lowered at 337/2037 and was on the bottom by 2321. It gave a 1 ton 'bite' at 2357, and was hauled in shortly afterwards, coming on board at 338/0216 with a good load of rock. We then manoeuvered to the final WASP station, 10957, for another run over the transform fault. We began lowering WASP at 0335, but the monitor failed at 0351, and the gear was recovered by 0638. Subsequent testing on board revealed that there had been a second fault, a corroded solder joint probably resulting from a small drop of seawater having fallen on the circuit board at some time.

At 0700 we steamed to the position of the 'green' beacon, released it at 0754 and had it on board by 0929. The 'blue' beacon was released at 1026 and recovered by 1207, and we then had a last look for 'red', but without success.

At 338/1320 the 3.5 kHz fish was redeployed, the interrogator fish recovered, and we came up to speed to launch GLORIA, magnetometer and the SRP gear. We resumed the grid survey at the eastern end of Romanche Fracture Zone at 1535.

Underway survey (resumed)

At 339/0751 we began a W-E line parallel to the shallow ridge north of the eastern end of the transform, viewing it with both GLORIA and the hull-mounted asdic. At 339/1456 we finally turned west, and began to work our way towards the western end of Romanche transform by way of a number of long traverses parallel to it, broken by short sections across it.

At 341/1650 we began a long traverse to the north to investigate the tectonic fabric between Romanche and St. Paul's Fracture Zones, and returned to Romanche by a long traverse southwards starting on 342/1621.

By 344/0236 we were running parallel to the Romanche transform again, viewing it from the north in a region where it had been ill-defined by the cruise 96 data. At 344/0833 we changed airguns, replacing the 40 cubic inch by a 300 cubic inch with refurbished tail section fittings. The refurbished gun towed happily at 8 knots.

At 344/1350 we turned south to cross an enigmatic feature ('Dark Plateau') that gave very low backscattering on GLORIA. This effect suggested that the sea bed should be very smooth, but our airgun and 3.5 kHz profiles indicated a rather hard bottom with a considerable amount of medium scale (100m) relief. In order to investigate further, it was decided to attempt a gravity core. Accordingly, the streamed gear was recovered at 1832, and the RVS gravity corer was lowered at 2045. It was recovered at 2330 with a small amount of stiff sandy foram ooze, but no lithified rock. GLORIA and the magnetometer were streamed by 345/0016, and we proceeded with the survey to the western end of Romanche Transform without SRP, in order to make up some time. In fact we were able to run at nearly 10 knots.

St. Paul's Fracture Zone

At 345/1508 we altered course at the western end of Romanche Transform to run along the median valley between Romanche and St. Paul's Fracture Zones. We turned west again at 346/0256 after crossing the southernmost of the St. Paul's Fracture Zone valleys, to see to our south the southernmost of several transforms within this fracture zone. We followed this transform past its intersection with a short spreading centre near 25°30'W, and continued to the 200 mile line from St. Peter and St. Paul's Rocks. There we turned north to cross several more of the St. Paul's Fracture Zone valleys and ridges, then turned south again and eventually east to pick up the second of the St. Paul's transforms (the one immediately to the north of the 25°30'W spreading centre). We followed this past its intersection with the spreading centre and continued on the same heading to 23°53'W, where we turned northeast on passage to the Sierra Leone Rise.

Return Passage

By 348/2051 we had made up some time, so decided to deploy the SRP gear for the last part of the passage across the Sierra Leone Rise. Initially a simple 300 cubic inch airgun was used, but this was changed for a 300 cubic inch gun with wave shape kit at 349/0352.

The 'leak' warning on the Asdic came on at 0715 on day 350, and the unit was immediately switched off. We recovered the magnetometer, SRP, GLORIA, 3.5 kHz fish and hull-mounted Asdic at 350/0842, and then proceeded with a final towing trial of the modified Babb profiler vehicle. The vehicle was lowered on 5500m of cable, and towed near the bottom for about one and a half hours, using the repaired WASP monitor and near bottom echosounder for control. The vehicle was recovered by 350/1751. The PES fish was then recovered, and the ship proceeded directly to Dakar, and berthed there at 0950 on day 352.

RCS

PROJECT AND EQUIPMENT REPORTS

Fracture Zones

The main programme of underway geophysics survey and station work provided a comprehensive GLORIA coverage, as well as magnetic, seismic and gravity profiles over the Romanche Fracture Zone and supplemented earlier GLORIA work at its western end (Discovery 96, 1979).

Ship's tracks were planned either to run parallel to main transform features so as to highlight these, or perpendicular to them whilst traversing from one side of a fracture zone to the other, so as to show up features parallel to the spreading fabric including the MAR sections.

The most extensive survey was made over the Eastern end of Romanche, between 16^{o}W and 19^{o}W. This area corresponds to that part of the F.Z. with the greatest relief where the valley floor reaches almost 8000m in depth at Vema Deep.

Two particularly long N-S traverses were performed at 17^{o}W and 22^{o}W each extending from 100 miles to the North to about 30 miles south of the transform.

These lines will be useful for gravity modelling of crustal and upper mantle structure beneath the fracture zone.

Active sections of the Romanche Fracture Zone and extinct parts of the St. Paul's Fracture Zone to the north were readily recognisable on GLORIA, although in detail the line of active displacement (the transform fault) often appears to be characterised by several composite linear features. The active transform fault zone can be readily followed throughout the Romanche fracture zone using overlapping GLORIA sonographs, from its westerly intersection with the mid-ocean spreading axis to within a few tens of kilometres of its eastern intersection where the fault trace becomes less distinct. Here the spreading ridge/transform fault junction appears to be characterised by a series of short offsets on several closely-spaced transform features with short spreading segments between, rather than a single displacement. At the western end of the Romanche Fracture Zone the junction is much simpler.

A series of prominent transverse ridges were observed up to 60 km away from the central fracture zone, outside of which an approximately N-S spreading fabric was predominent. Spectacular erosional gullies were seen on the shallow transverse ridge immediately to the north of the eastern end of Romanche Transform.

Although we were prevented from working within 200 miles of St. Paul's Rocks, we were able to investigate the eastern-most 100 km of the active part of St. Paul's Fracture Zone. Here we found evidence of two active transform faults separated by a 25 km-long spreading centre, thus partially confirming the pre-cruise hypothesis that this fracture zone contains several closely-spaced transform faults.

Five days station work was carried out in an area of approximately 100 sq. miles centred at 17°10'W, 0°05'N. This area had been chosen as an interesting one from prior examination of GLORIA sonographs, and included the floor of the main transform valley at a depth of about 6000m, with the trace of the transform running across a 5000m terrace on the south side of the valley.

Acoustic navigation using 3 acoustic transducers moored 100m off the sea floor and arranged in an approximately equilateral triangle was used to navigate the ship, dredge and WASP during 3 successful dredge hauls and 1 successful camera run. The results revealed a sea bed of sediment ponds separated by zones of scree-like material, with little unequivocal outcrop. One dredge haul returned a large proportion of tectonised rock, suggesting a proximity to an active fault zone, and another a high proportion of sedimentary rocks. The single successful WASP station crossed the trace of the transform fault as seen on GLORIA, but no convincing evidence of recently active faulting was seen.

A gravity core station operated on a plateau adjacent to the fault zone near 22°30'W returned mainly ooze.

LMP, MVT, RCS

Kane Gap and Sierra Leone Rise

Shortly after deployment of GLORIA we crossed a narrow sediment slide on the West African Rise that showed up well on the sonar. A spectacular double-lobed slide was also seen just to the northeast of Kane Gap, and on the return leg we crossed a large debris flow just south of Kane Gap that showed up on GLORIA. GLORIA also provided good views of outcropping rocks around Kane Gap, which should aid in determining the structural control of the area.

Running south from Kane Gap we insonified several previously unmapped volcanoes. However, although GLORIA was run on both the outward and return legs across the Sierra Leone Rise, and with a variety of track directions, we unfortunately could not resolve any sediment waves on the sonographs. In fact all of the well-sedimented areas on the Sierra Leone rise appeared monotonously featureless on GLORIA. However, spectacular records of sediment waves were produced by the 3.5 kHz profiler.

Time constraints prevented us from running the SRP system over much of the Sierra Leone Rise, but on the return leg we were able to run it between about 5°30'N and Kane Gap. A very useful record was obtained over that line.

Gravity and magnetics were run over the whole of the Sierra Leone Rise tracks for the benefit of Dr. John Jones at University College, London.
RCS

GLORIA

The system was launched at 1730 on day 325 in good, calm conditions without trouble. The first recovery for station work was on day 334 and all gear was safely inboard by 0130. In the interval the system had been used at the 40 sec (16 mile) range throughout, but had not been entirely trouble-free. In particular there was a gap in transmission coinciding most unfortunately with the ship passage through the Kane Gap - an area of great interest. During the first half of the cruise the sonar power amplifiers were continuously troublesome starting at switch-on with the Port Common T/R relay having failed in a way which has not occurred before. Gradually the transmission system bedded down and the faults were ironed out. It is of course difficult to work on repairs with the system in operation so the break for station work provided a welcome opportunity to repair spare amplifiers. Thereafter the transmission system gave only minor and intermittent trouble, though there was considerable difficulty controlling the temperature in the Portakabin which often reached 33^{o}C.

The system was re-launched for the second phase of survey on day 338 at 1500 and after two hours of tests on the TVG amplifiers and pulse power amplifiers logging was started. This continued until day 344 when the vehicle was recovered to do a core station at 1840. It was relaunched at midnight and logging restarted at 0030 on day 345, continuing thereafter until the final recovery at 0840 on day 350.

Throughout the deployments the vehicle and cable had no faults at all. There was considerable vehicle yaw from time to time, and though tightening the control on the ship's auto-pilot improved matters a bit, there were frequent periods of severe yaw induced apparently by current shear.

Cruise 142 was the first deployment of the RCA COSMAC microprocessor digital logging system, recording on the Tandberg TDC 3000 digital cartridge recorders using DC300 XL cartridges. The major fault to occur on this system was a failure of one of the TDC 3000 formatter cards, causing a series of tapes with virtually no data to be passed through the system in rapid succession. Fortunately, this proved to be an isolated fault and the spare functioned well to the end. The system was prone to occasional mains interference though less frequently after extra filtering had been supplied to the logger. One of the COSMAC control cards developed a problem causing it occasionally to put the COSMAC into its RESET state. It was then necessary to re-start the system. A change of card cured this problem. The COSMAC logger was apart from these two problems a great success being compact, easy to use and simple. One or two software changes are needed and one or two more desirable but nothing essential was missing.

The replay system, also a COSMAC micro, performed well except for the minor irritation of occasionally, when replaying with slant range correction, reverting to uncorrected replay. It is then necessary to restart and type in the whole correction table again. Similarly, if the Muirhead K300 synchronisation jumped as it occasionally did, the correction table was lost. It was necessary to do some modifications to the replay characteristics of the digital to analogue converters feeding both the online recorder and the Muirhead replay system.

During the passage from the survey area to the Kane Gap and through the latter, 30 second (10 mile) range was used with a 2 sec. pulse, as this was better matched to the propagation limited maximum range.

MLS

Seismic reflection profiling

The SRP system was run from 328/1424 to 333/2322, from 338/1535 to 344/1832, and from 348/2123 to 350/0842, a total of 13 days. This gave continuous coverage over the Romanche FZ with the exception of the last day of work there. For that day and for most of the passage it was not used, to enable the ship to cruise at over 8 knots. However, there was time to run the system during the last 11 hours run over the Sierra Leone Rise, and a good record was achieved there.

Initial deployment was with the 30m short hydrophone streamer, but that proved to be completely inadequate at the 8 knot towing speed employed, and it was soon replaced by the larger 2-section array, which was much better. The 1500c airguns proved initially unsuitable for towing at 8 knots because the tail fittings were badly worn, allowing excessive vibration and eventual fracture. The fittings were refurbished during the cruise and towards the end we were able to deploy these guns successfully, but for most of the cruise we had to work with the smaller 600B guns and 40 cubic inch chambers.

Data were tape-recorded and selected sections replayed during the cruise. All the records from the fracture zone survey were interpreted on board, and the major reflectors from 178 hours of survey were digitised and stored on the ship-board computer using the new Complot series 7000 digitising table.

The data is input into the computer using program DIGSEIS, which records 8 channels of data, channel 0 being the basement, 1 the surface and allowing 6 channels for other seismic layers. Digitizing can be in any order of channels, the number being controlled by the keys on the cursor. The data is stored on a file, which is periodically terminated to write it to the master file. There is, as yet, no facility for editing the data apart from re-digitizing. The files are thus kept small to cope with any errors and also to prevent data loss through possible computer malfunctions.

Program DIGIN records the data, sorts and writes it to the RVS master file. This program aborted several times for unknown reasons, resulting in having to re-run or re-digitise. Once the data is stored in the master file it can be listed or plotted as other data fields.

RCS, MRS

Shipboard computer

At the beginning of the cruise, the raw navigation calibration program was modified to allow the application of a constant offset during E.M. log calibration. This modification was in use throughout the cruise.

On the whole, the logging was trouble-free. The only data loss was when (a) a wire in the gyro encoder connector snapped and the gyro gave a false reading, and when (b) the computer stopped for some unknown reason. It was restarted within 4 minutes and continued normally.

The failure of a 100 kHz reference frequency from the ship's clock, which is used by a Borer clock to keep computer time, was noted when the computer clock started gaining 11 secs/hr. A standby 100 kHz source was introduced and the computer clock reset.

A new VDU-based data entry system was used for manually logging soundings, and proved very successful.

The automatic navigation updates that used to be available on the old IBM 1800 system were missed; instead updates have to be manually initiated on the new system. This was done twice a day in order to provide corrected depths and tracks in a timely fashion for GLORIA data processing.

The absence of a manual data-file editing program was a moderate problem, and some time was devoted to developing one during the cruise.

In addition to the routine logging and reduction of data, there was moderate use of the "user" computer by shipboard scientists, mainly for acoustic navigation calculations, program development and word processing.

DAJ, RCS

Acoustic Navigation

The station work between days 334 and 338 was controlled by acoustic navigation. Three transponder floats were moored 100m above the sea bed in an equilateral triangle of side approximately 8 km (Table 2). Two sources of the transponders' 'receive' signal (5.1 kHz) were used, one being on the ship, the other on the vehicle being tracked. These two sources were syncronised and interleaved so as to give unambiguous readings. The time delays between the outgoing pulses and the replies were used to compute the ship's and the vehicle's positions.

Using this system two dredge stations and the WASP runs were acoustically navigated, fixes being obtained at 10 minute intervals. Ranges up to 15 km for all three transponders were achieved and used for ship navigation; however, due to the rugged terrain of the area the vehicle navigation largely depended on ranges to just two transponders, the maximum range being of the same order.

During the cruise a suite of computer programs was written for navigation of both ship and vehicle using a transponder triad. As these became available they greatly simplified the task of navigation and data handling. An existing program 'COKAT' was rewritten for the ship's computer. This was used to fix the position of the transponders on the seabed by using the measured transponder ranges and simultaneous satellite fixes for the ship. A total of 23 fixes were used and the final positions of the transponders was accurate to 10 m (see Table 2).

On recovery one transponder was lost due to probable premature battery failure. The other two transponders were securely recovered.

This is the first time that geological equipment has been acoustically navigated near the sea floor by IOS, and much valuable experience of such procedures was gained. Not only were the positions of the remote instruments determined, but this information was used to manoeuver the ship so as to guide the instruments over predetermined positions. To a large extent this was successful, in spite of difficulties caused by surface currents of up to three knots.

IPR, RCS

WASP Survey Camera

The WASP camera system was assembled using a recently modified frame with double flash unit clamps and extra strengthening members. Further modifications include the addition of four scaffold poles to provide extra shielding against the rugged sea floor expected in the fracture zone, and the uprating of the towing bridle from 8 mm to 13 mm wire.

Prior to the cruise the frame and camera equipment had been towed in the wave tank to test stability and trim. However, during these tests a maximum 6 flash units were attached as opposed to the 4 units we decided to use on the cruise. Four units can provide enough lighting and also allows for a full set of spare units. The frame therefore required re-trimming at sea, and it was apparent from the photographs obtained later that this had not been too successful, with the camera adopting a nose-down attitude under tow.

Dry testing of the system produced only two problems. One flash gun was inoperative due to a faulty thyristor, and the whole unit had to be replaced as no spare was available. Secondly, the LED depth indicator on the camera was also out of action due to a faulty integrated circuit and this was replaced.

During the 5-day period between days 334 and 338, five camera stations were attempted. Unfortunately due to problems with the monitoring gear (see below) only one station was successful (Station 10955). This run produced approximately 150 ft (1200 frames) of thin based black and white film which was successfully processed, although the film appeared somewhat over-developed, possibly because of the high operating temperatures required to stabilise the processor with the ambient temperatures (around 30^{o}C). Successful prints were made from these negatives however, and from examining the camera height display it was apparent that the best results were obtained below 10 metres.

The back-scattering from the Benthos compass rendered it unreadable on most frames, and a non-reflective covering will have to be sought.

The film processor is unnecessarily large and difficult to operate, even under ideal sea state conditions. It occupied a great deal of space in a lab. already being used for GLORIA photography, and hence it was impractical to operate both systems simultaneously. No mechanical problems arose during processing, but whilst emptying the tanks a pipe came loose and flooded the electric pump which then burnt out. Filling and emptying the tanks remains a difficult and messy operation and re-designing of the processor should be a priority.

The acoustic absorption provided by the new nylatron mounting for the near bottom echo sounder transducer greatly reduced the noise problems that had been encountered with the original system. This meant that there were very few spurious readings of the height off the sea bed during the photographic survey. However, problems were encountered with the WASP monitor electronics. These were caused by a combination of previous sea water damage and the distortion of a printed circuit board due to the compression of the monitor housing under hydrostatic pressure. These faults caused the crystal oscillator, from which all the pulse trains are derived, to stop when the WASP was at depths in excess of 2000 metres. The main cause of this fault was initially masked by a defective quartz crystal in the oscillator circuit. The failure of the flash detector to operate at depths greater than 30 metres was probably due to the lack of back scattered light in the clearer deep water. In future the detector will need to be repositioned to provide the optical sensor with a direct view of the flash gun windows.

CDP, MJH

PES, Magnetometer, 3.5 kHz and Gravimeter

These instruments were all run continuously throughout the cruise, with the exception of the periods of station work when the magnetometer and 3.5 kHz were recovered. No major problems arose with any of the units.

Background electrical noise visible on the PES at high gain settings had been a persistent problem on previous cruises, and was finally traced to a poor earth contact in the signal input cable at the rear of the bench unit. Once this was rectified the unit gave superb performance.

The new VDU-based depth entering system was very successful and popular with watchkeepers. The PEST automatic depth digitiser was run during passage over the Sierra Leone Rise and worked well, but it could not cope with the more rugged fracture zone terrain, or with interference from the 3.5 kHz.

The 3.5 kHz was towed from the starboard boom, and gave excellent records throughout the cruise. Both ½s and 1s pulse repetition rates were employed at different times.

The magnetometer and gravimeter both worked uneventfully, although the gravimeter was off-line for a short period on day 329 when the VARIAC transformer for its power supply caught fire. The fire was extinguished, the transformer replaced, and normal operation continued.

Gravity base ties were made to IGSN stations in Dakar before and after the cruise, and established a total drift of +0.68 mgal over 28 days.

RCS

Hull-mounted Asdic

The asdic was run continuously throughout the cruise, except during the period of station work when the water was consistently too deep for any usable returns. Unfortunately the correlator unit was not available, and this rather restricted the performance. Only the starboard transducer plate was fitted.

Working in narrow-beam echosounder mode we were generally able to sound to around 4000m. The unit was used in sidescan mode for several hours on day 339 to study a shallow (1000m) transverse ridge north of Romanche Transform; reasonable sidescan records were obtained down to about 2000m water depth.

On day 349 the leak detector light came on, so the unit was shut down. It was retracted into the hull, with some difficulty, on day 350.

RCS

Deep Profiler Towing Trials

Three towing trials were made with the Babb deep towed profiler during the cruise with the following objectives:-

(1) To transfer the towing point from amidships right aft on the starboard side. This would give the ship far greater manoeuvrability than a direct tow off the midships winch.

(2) To put a crank in the tow near the tow vehicle by hanging a weight on the cable and attaching buoyancy to the framework and adding drag, and thus to provide a pitch stable platform by correct disposition of tow point, weight, buoyancy and drag.

(3) To gain experience and increase efficiency in handling and operating such a tow.

1. The towing system led the wire off the davit head block through a snatch block at the foot of the davit then aft just outboard at forecastle deck level through another snatch-block at the Schat davit head. With the Schat full outboard and a little aft the wire was led clear aft and the ship was as controllable as she could be with a deep wire deployed. The two extra blocks while undesirable from the point of view of handling the wire are greatly preferable to the risks of a direct mid-ship tow. This system also transfers the rigging work aft to the poop which though cluttered is still the only practicable location.

2. Objective number 2 was not fully achieved due to shortage of buoyancy. The clump weight (about 75 kg of anchor chain) was easily attached to the wire by a selvagee strop. A bend restrictor (banana) was seized onto the wire and the clump support line seized into this. Thereby the wire (at 100m from its end) was handled gently and not severely bent (Figure 3).

The desired pitch stability was not fully demonstrated, as the lack of buoyancy meant that the natural cable bend was less than that of the banana. Also, stopping off the wire to fit the above was for the same reason slightly unsatisfactory. The crank in the cable turned out to be only about 20^{o} instead of the full 40-45^{o} needed to make the final tow horizontal.

Some adjustment will be needed in the disposition of tow-points on the profiler frame to achieve a good trim, but it was not possible to finalise these because of (a) the lack of means to weigh components and find centres of gravity at sea and (b) the aforementioned lack of sufficient buoyancy. However, enough was learned to make the problem easier on Cruise 142.

3. The first two trials were shallow deployments, while the third was a deep one with the WASP depth monitor attached. The latter reached within 20 metres of the sea bed in 4500 metres of water. The WASP monitor with its expanded depth scale was a great convenience and gave some indication of the heave. For the reasons stated the crank in the cable was not fully effective and the heave amounted to about 2-3 metres effective peak-to-peak amplitude. It is necessary to proceed at 0.7 to 0.9 knots to get a reasonable cable angle (60 degrees below vertical) and still reach the bottom without exceeding the tension limit of 1000 kg on the CTD wire. However, to ensure correct streaming it will be necessary to start at 1.5 knots and slow very gradually as deployment nears completion. At the same time the payout rate needs careful attention, being a balance between the desire to reach the bottom quickly and the need to maintain the tow system properly streamed. It will require several hours to stabilise the tow, and several tows to become reasonably efficient.

MLS

TABLE 1: UNDERWAY GEOPHYSICAL MEASUREMENTS

	On	Off	Comments
GLORIA	325/2238	329/0945	40s pulse repetition rate
	329/1516	333/2322	40s pulse repetition rate
	338/1535	344/1832	40s pulse repetition rate
	345/0131	347/0955	40s pulse repetition rate
	347/1000	350/0842	30s pulse repetition rate
PES	325/2238	350/1824	
Magnetometer	325/2238	333/2322	Reduced to IGRF 1980.0
	338/1535	344/1832	
	345/0131	350/0842	
3.5 kHz	325/2238	350/0842	½s and 1s pulse repetition rates
Asdic	325/2238	339/0751	Mostly in narrow-beam echosounder mode
	339/0751	339/1345	Mostly sidescan mode
	339/1345	349/1500	Mostly echosounder mode
SRP	328/1424	328/2213	40 cu. in. gun and short array
	328/2213	330/1300	300 cu. in. gun and full array
	330/1457	333/2322	40 cu. in. gun
	338/1535	344/0833	40 cu. in. gun
	344/0915	344/1309	300 cu. in. gun
	344/1326	344/1832	300 cu. in. gun and wave-shape kit
	348/2123	349/0318	300 cu. in. gun
	349/0352	350/0842	300 cu. in gun + WSK
Gravimeter	325/2238	350/1824	Tied to IGSN 77. Drift +0.02 mgal/day

TABLE 2: ACOUSTIC BEACON POSITIONS

Beacon	Latitude	Longitude	Depth* (m)	Laid	Recovered
1 "Red"	$0^{o}04'.35N$	$17^{o}10'.18W$	5435	334/0546	--------
2 "Green"	$0^{o}08'.13N$	$17^{o}07'.83W$	5789	334/0911	338/0929
3 "Blue"	$0^{o}04'.05N$	$17^{o}05'.42W$	5953	334/1150	338/1207

*Depth of beacon in corrected metres. All beacons were 100m above sea floor.

TABLE 3: STATIONS

Station	START				END				Instrument	Comments
	Time[1]	Lat.	Long.	Depth[2]	Time[1]	Lat.	Long.	Depth[2]		
10950	334/1818	$0^o08'.7N$	$17^o08'.5W$[3]		334/2011	$0^o08'.3N$	$17^o09'.4W$[3]		WASP	Abandoned near surface: camera monitor failed.
10951	335/0057	$0^o13'.1N$	$17^o07'.9W$[4]	5200	335/0151	$0^o13'.7N$	$17^o06'.9$[4]	5200	Dredge	[5]Samples of ooze, pebbles and small boulders of possibly siltstone, basalt, metagabbro and ultramafics from foot of N. wall.
10952	335/1103	$0^o07'.6N$	$17^o08'.8W$[3]		335/1142	$0^o07'.9N$	$17^o09'.3W$[3]		WASP	Flash indicator failed. Station abandoned.
10953	335/2357	$0^o04'.8N$	$17^o07'.3W$[4]	5800	336/0250	$0^o03'.5N$	$17^o07'.5W$[4]	5300	Dredge	Rocks recovered from near to transform trace. Basalt, gabbro, ultramafic and small quantity of (?) siltstone. Samples are substantially tectonised.
10954	336/1053	$0^o07'.8N$	$17^o08'.4W$[3]		336/1328	$0^o09'.2N$	$17^o09'.1W$[3]		WASP	Monitor failed. Abandoned station.

TABLE 3 continued............

	START				END					
Station	Time[1]	Lat.	Long.	Depth[2]	Time[1]	Lat.	Long.	Depth[2]	Instrument	Comments
10955	337/0603	$0^o06'.6N$	$17^o08'.8W^4$	5700	337/1025	$0^o02'.9N$	$17^o09'.2W^4$	4800	WASP	Successful station. Approximately 1000 frames shot over trace of transform fault.
10956	337/2321	$0^o05.8N$	$17^o11'.6W^4$	5800	337/2358	$0^o04'.8N$	$17^o11'.8W^4$	5600	Dredge	Rocks recovered from on or near trace of transform: Basalts with isotropic and layered gabbros. Possibly some lithified sediment.
10957	338/0306	$0^o05'.2N$	$17^o12'.0W^3$		338/0638	$0^o06'.1N$	$17^o12'.5W^3$		WASP	Monitor failed at 725m. Station aborted.
10958	344/2045	$0^o55'.7S$	$22^o30'.8W^3$	3500	344/2330	$0^o55'.2S$	$22^o30'.6W^3$	3500	Gravity Corer	Small sample of stiff, sandy foram ooze.

Notes:
1 Times indicate duration of instrument on bottom for successful stations, time in water for unsuccessful ones.
2 Depth at position of near-bottom instrument, to nearest 100m.
3 Positions of ship at beginning and end of station. Positions based on acoustic navigation except for station 10958.
4 Position of instrument on bottom, based on acoustic navigation except for station 10951.
5 Rock descriptions are based on preliminary shipboard analysis of hand specimens only.

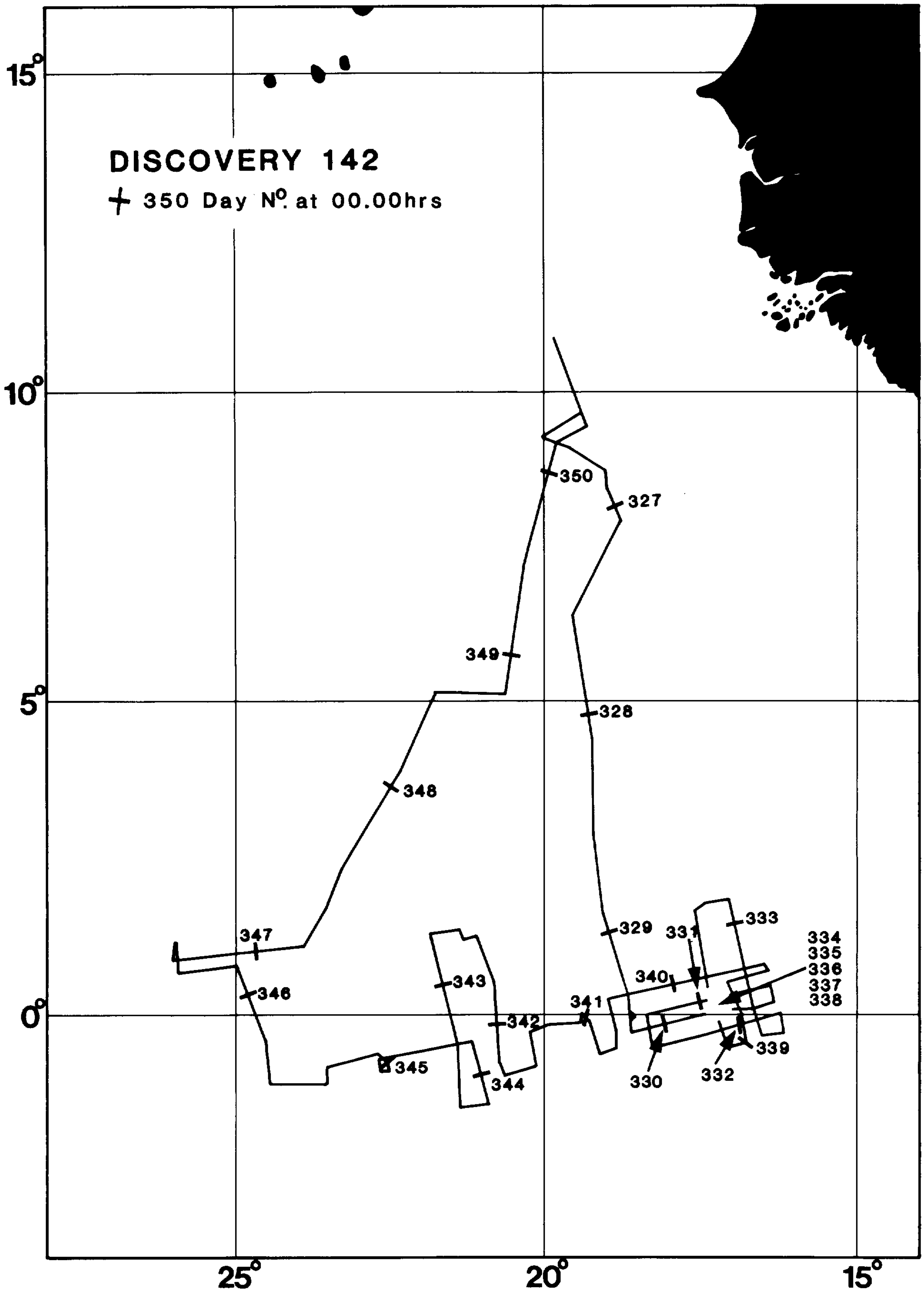
DISCOVERY 142
350 Day N°. at 00.00hrs
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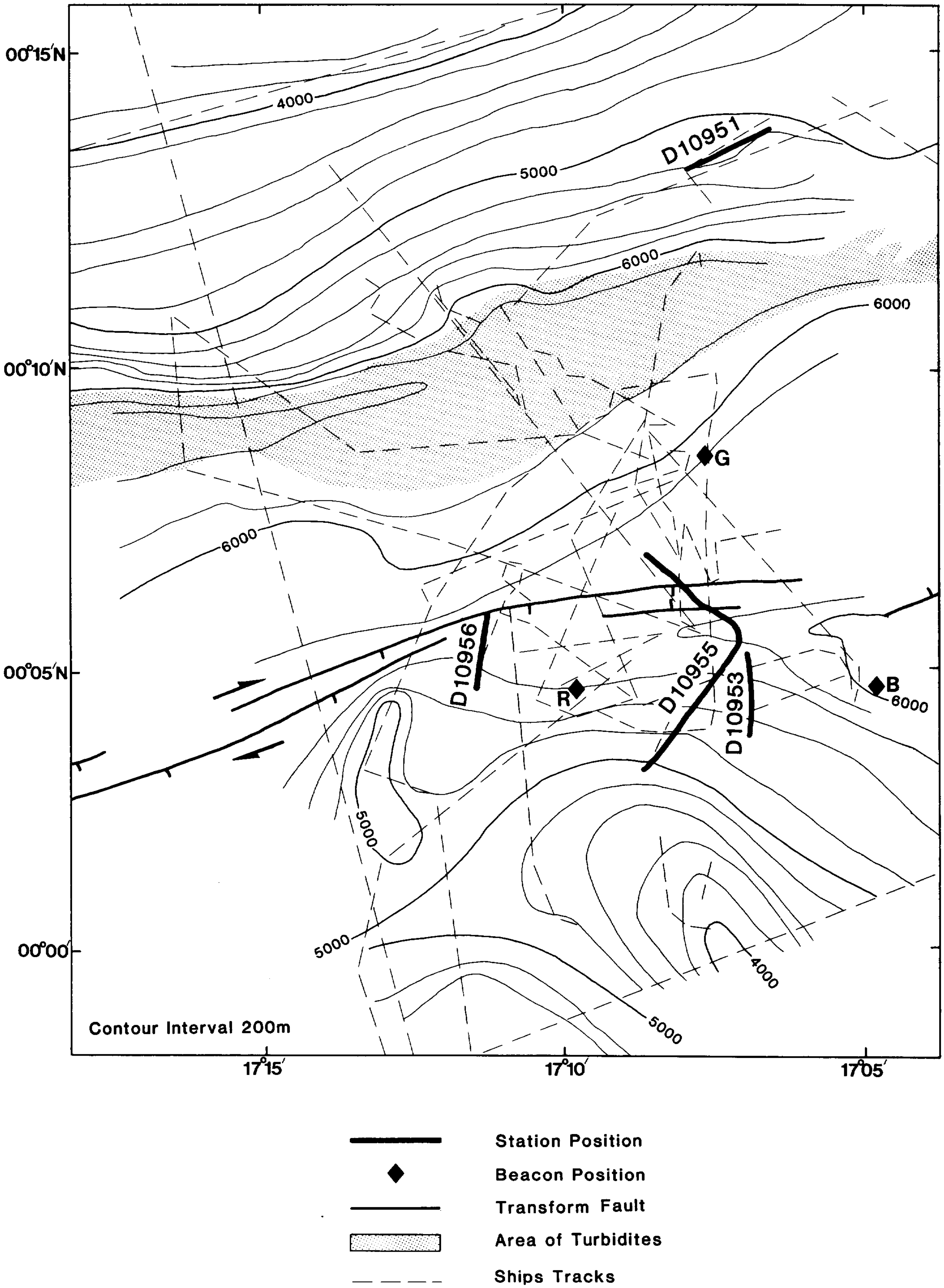
Figure 1


00°15'N
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00°05'N
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D10955
D10953
G
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B
Contour Interval 200m
Station Position
Beacon Position
Transform Fault
Area of Turbidites
Ships Tracks

Figure 2

Detail of Crank in Deep Profiler Towing Cable

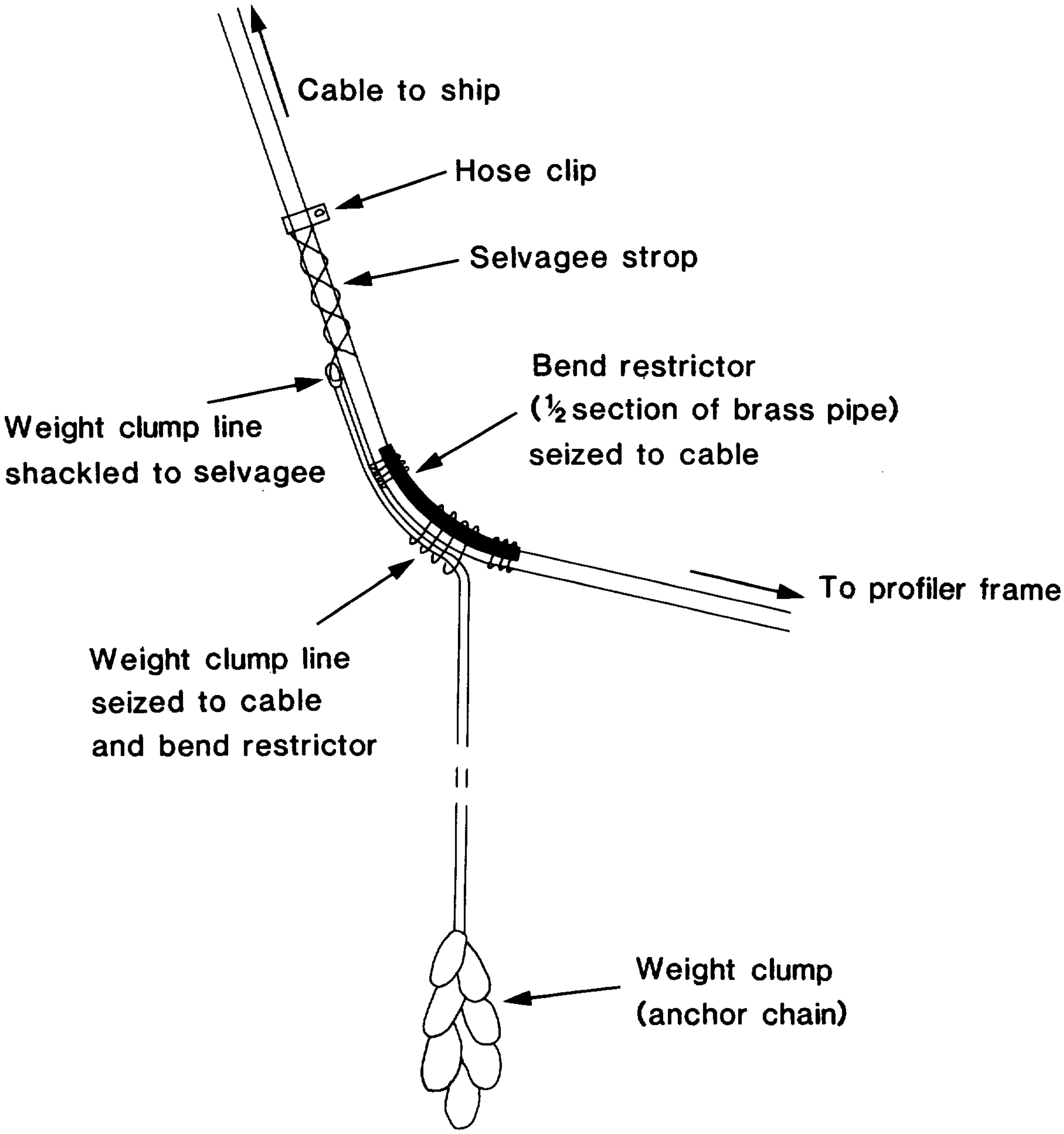

Figure 3