660

CRUISE REPORT

RRS DISCOVERY 215

A Geophysical Study of the Ocean-Continent Transition in the Iberia Abyssal Plain

19th July-22nd August 1995

Barry-Lisbon-Barry

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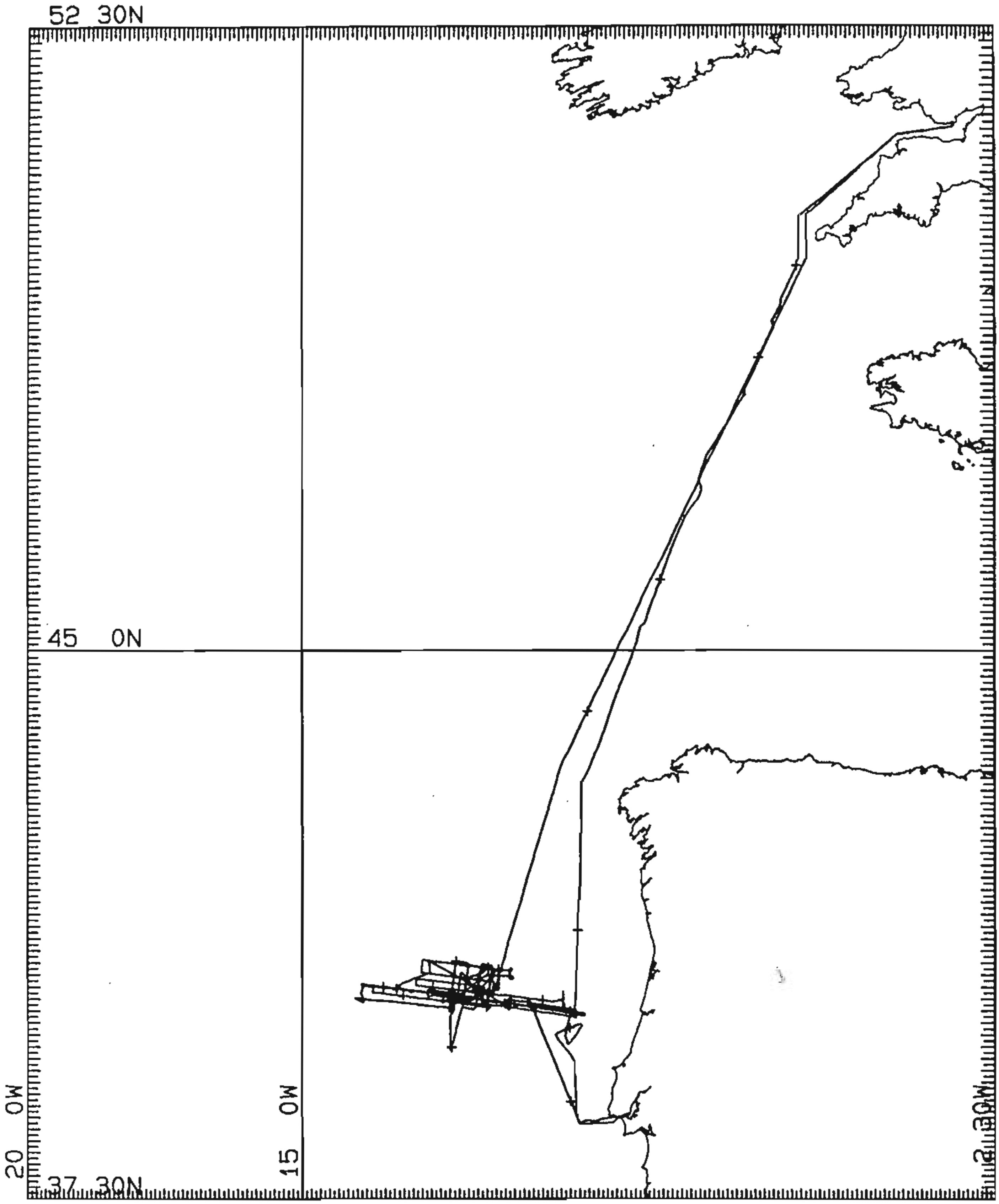
Contents | **Page Number**

SUMMARY

The Iberia Abyssal Plain segment of the west Iberian Atlantic Margin may be regarded as a typical example of a non-volcanic passive margin. A broad transition zone is present between thinned continental crust in the east, represented by tilted fault blocks, and a ridge of serpentinised peridotite in the west, beyond which oceanic magnetic anomalies may be identified. The objective of the cruise was to conduct a geophysical survey to characterize in detail the variations in crustal structure in this transition zone. The cruise was divided into two legs. On the first leg (Barry-Lisbon, 18th-28th July) we recorded a 200-km long deep towed three-component magnetometer profile extending from the transitional zone onto the continental slope to the east, and a shorter profile close to the continental slope, using the IFREMER SAR vehicle. The SAR also recorded side-scan sonar and high-resolution seismic profiles. There were some technical problems with the SAR, and during downtime we recorded seismic profiles using 500 m of the NERC multichannel hydrophone streamer. The second leg (Lisbon-Barry, 29th July-22nd August) was devoted to seismic work. We carried out two deployments of ocean bottom seismographs (OBSs), deploying 21 instruments along a 340 km line for the first experiment and 18 instruments in a 60 by 60 km grid for the second. Shots were fired into these instruments from a 12-gun, 6346 cu in airgun array towed at 20 m depth and fired every 40 or 50 s. The first experiment yielded good results from 14 OBSs, and the second yielded good results from 13 OBSs including the recording of many offline shots in a fully three-dimensional experiment. During the second experiment we also deployed the full 2.4 km, 48-channel hydrophone streamer at a depth of 20 m, and recorded ~ 1500 km of deep seismic reflection profiles. The second leg of the cruise was extremely successful: shipboard brute stacks of the multichannel data imaged coherent reflectors to a depth of 14 s two-way time, and shipboard OBS record sections showed high signal-to-noise ratios. In addition to the seismic data, we collected an extensive grid of bathymetric, gravity and surface magnetic data.

AUTHORSHIP

Sections where an author is named after the section heading were written by that author; the remainder of the report was written by T. A. Minshull. The entire report was edited by T. A. Minshull and R. B. Whitmarsh.



MERCATOR PROJECTION

GRID NO. 1

SCALE 1 TO 7000000 (NATURAL SCALE AT LAT. 50)

INTERNATIONAL SPHEROID PROJECTED AT LATITUDE 0

RRS Discovery Cruise 215 (July-August 1995)

Figure 1: Ship's track

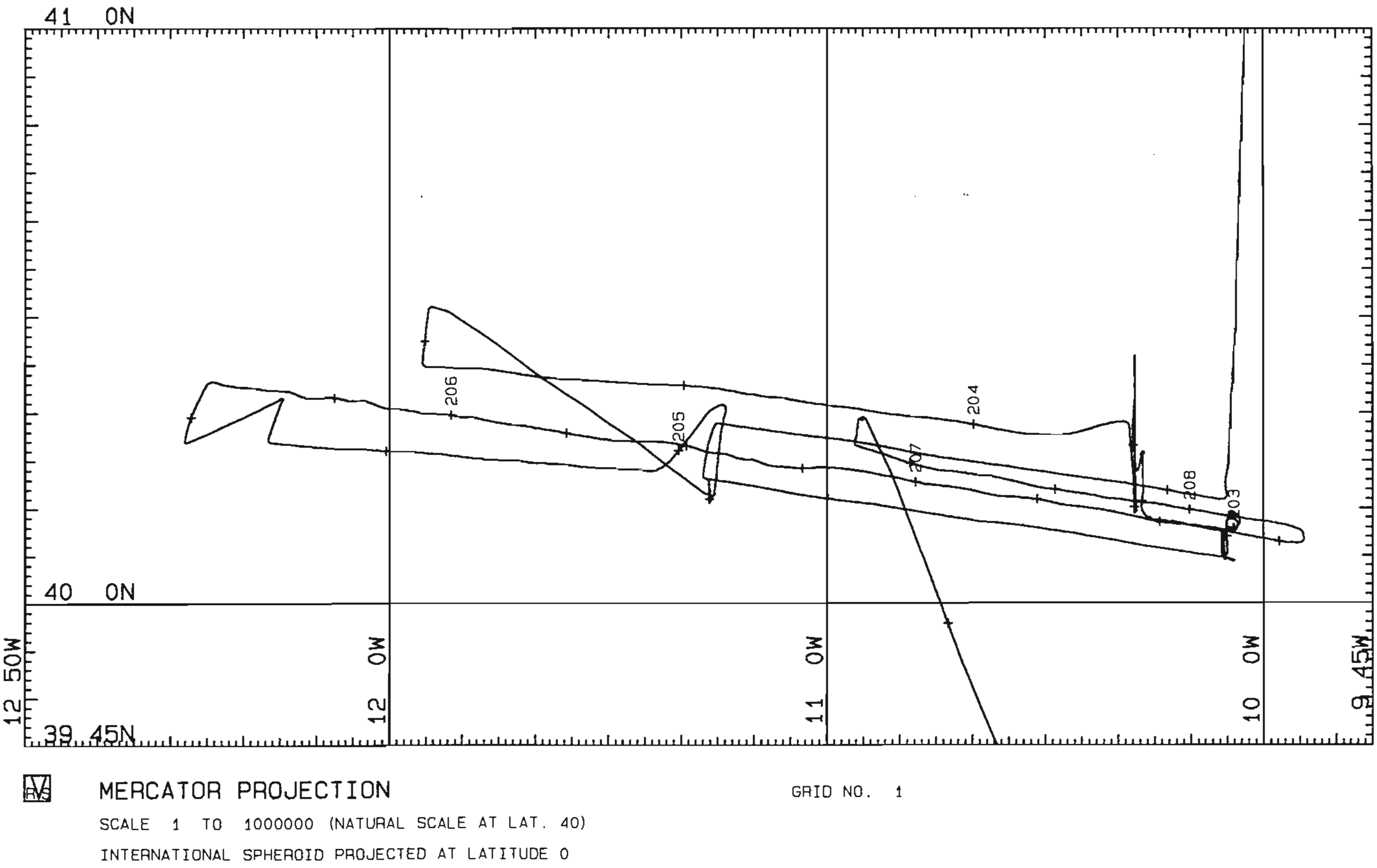


Figure 2: Ship's track, first leg

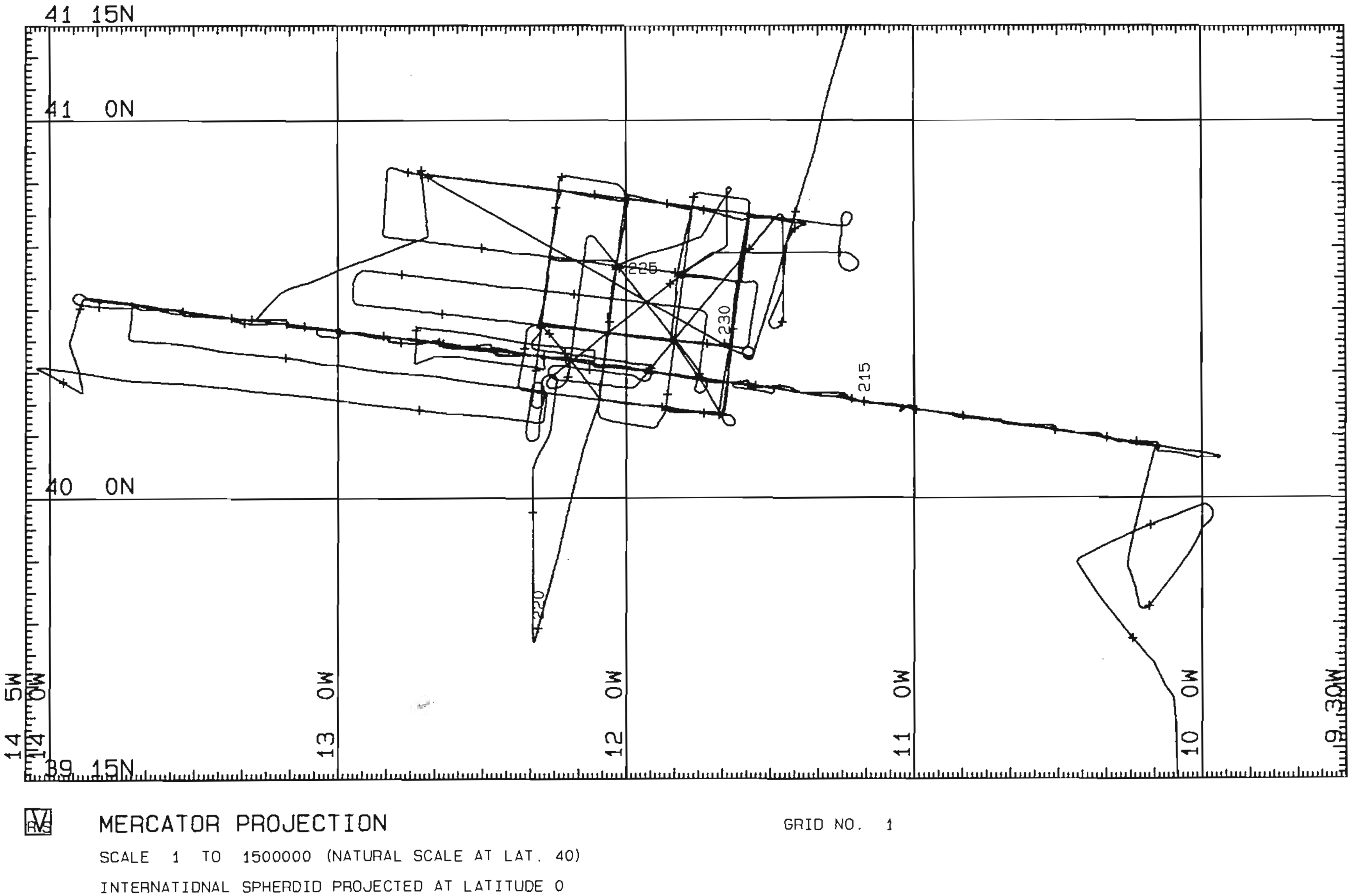


Figure 3: Ship's track, second leg

CREW LIST

Tim Minshull (PSO)	Cambridge
Tim Owen	Cambridge
Richard Smith	Cambridge
Simon Dean	Cambridge
Mark Muller (Leg 2 only)	Cambridge
Robert Whitmarsh	IOSDL
Peter Miles	IOSDL
Martin Saunders	IOSDL
David White	IOSDL
Jamie Pringle (Leg 2 only)	IOSDL
Simon Pickup	IOSDL/Royal Holloway
Simon Russell	IOSDL/Durham
Jean-Claude Sibuet (Leg 1 only)	IFREMER, Brest
Eliane le Drezen (Leg 1 only)	IFREMER, Brest
Pascal Oge (Leg 1 only)	Genavir, Brest
Jean-Claude Delmas (Leg 1 only)	Genavir, Brest
Bernard Pillaud (Leg 1 only)	Genavir, Toulon
Jean-Pierre Chopin (Leg 1 only)	Genavir, Toulon
Charles Blazy (Leg 1 only)	Genavir, Toulon
Pascal Pierre (Leg 1 only)	Genavir, Toulon
Franck Hennebelle (Leg 1 only)	Genavir, Toulon
Keith Louden (Leg 2 only)	Dalhousie
Robert Iuliucchi (Leg 2 only)	Dalhousie
Saverio Sioni (Leg 2 only)	UBO, Brest
Gabriela Fernandez (Leg 2 only)	CSIC, Barcelona
Hugh Evans	RVS
Tony Cumming	RVS
Gary White	RVS
Colin Woodley	RVS
Christopher Rymer	RVS
David Dunster	RVS
Stirling Jordan	RVS
Rod Pearce	RVS

Keith Avery	Master
Peter Newton	Mate
Richard Warner	Second Mate
Terry Morse	Extra Second Mate
Brian Donaldson	Radio Officer
Sam Moss	Chief Engineer
Jim Crosbie	Second Engineer
Clive Phillips	Third Engineer
Douglas Lutey	Electrical Engineer
Glen (Tiny) Pook	CPO (Deck)
Greg Lewis	PO (Deck)
Ian Thompson	Seaman 1A

Arthur Olds	Seaman 1B
Roy Avery	Seaman 1A
David Buffery	Seaman 1A
Stuart Cook	Seaman 1A
Alan Bridge	Motorman
Eddie Staite	Senior Catering Manager
Clive Perry (Leg 1 only)	Chef
Paul Dane (Leg 2 only)	Chef
Andy Duncan	Steward
Richard Edes	Steward
Peter Robinson	Steward

SHIP AND RVS EQUIPMENT PERFORMANCE (Tim Minshull and Bob Whitmarsh)

The ship in general performed well during the cruise, with only a couple of hours of scientific time lost when the SAR hydrophone became wrapped around the screw. The ships officers adhered closely to our navigational requirements, and the deck crew were very helpful. The catering received praise even from our French colleagues. The RVS scientific equipment in general also performed well during the cruise. The RVS technical staff worked with their usual skill and dedication through a very demanding cruise schedule, though their morale was clearly dented by recent changes to their working conditions. Some specific criticisms/suggestions:

1. The air conditioning in the Main Lab is not adequate for a geophysical cruise where a lot of equipment is installed. As well as being uncomfortable, the high temperatures in the lab were probably responsible for some of the problems with the Sercel. The Constant Temperature Lab is very poorly ventilated and overheats when computer equipment is in use if it is not being used as a cold space.

2. There was a shortage of bench top palates during mobilisation, and a lot of man hours were spent making some new ones. There is also a shortage of floor and wall bolts in the scientific spaces for lashing down equipment.

3. The E/M log calibration was clearly poorly conducted. Throughout the cruise, the E/M log read about 1 knot higher than the GPS speed over the ground, independent of direction.

4. The magnetometer cable is too short for a ship of this size. The cable should be at least three times the length of the ship to be out of the influence of the ship's dipole field (Bullard and Mason, Deep Sea Research, 8, 20-27, 1961), so a 350-400 m cable is needed. A heading correction experiment showed that the short existing cable gives heading-dependent magnetic field variations of up to 40 nT, which is comparable to the size of the anomalies in much of our survey area. The lack of a proper tugger or winch for magnetometer deployment and recovery continues to waste ship time, and will waste even more time if and when a longer cable is purchased. The capstan presently used is very slow, and caused some amazement

among the French and American scientists on board. This suggestion was first made by Tony Laughton 25 years ago and has been repeatedly made by geophysicists ever since.

5. Procedures in regard to safe working loads (SWL) of deep tow cables need to be clarified. Five months before the cruise, RVS were informed of our expected maximum towing depth (5200 m), the maximum wire out (9000 m), the towing speed of the SAR (1.5-2 knts) and the weight of the SAR depressor weight (2.5 tons). A meeting was held to establish whether use of the SAR for this cruise was technically feasible, and we were told that it was. At sea we discovered that the technical staff had been given strict instructions not to exceed a SWL which would not allow any of our proposed work. Several hours were lost while permission to exceed this value, on a one-off basis was obtained from Barry. Not only should the appropriate calculations have been done by RVS at the cruise planning stage, but also users need to be clearly told, before any future deep-tow work is proposed, what limitations have been set by RVS on the use of the deep-tow cable.

6. The winch provided on the afterdeck for handling the SAR into its cradle was underpowered, and its failure at during a recovery could have caused damage to the SAR.

7. The port compressor line gave a lot of trouble due to soot blocking one of the filters, possibly due to oil being burnt on a previous cruise. The compressors would perform best if run up regularly by the ship's engineers; apparently they had not been used since Discovery 208.

8. The cause of the break in the airgun beam should be investigated carefully and if necessary preventive measures taken with the other beams before they are used again.

9. The Sercel tape drives were clearly in need of servicing. Fortunately our unplanned additional seismic work during SAR downtime on the first leg allowed them to be thoroughly tested and appropriate repairs made. The tape drives have always been the weakest link in the acquisition system, which otherwise performed faultlessly; they need thorough testing and servicing before each use.

10. A sonobuoy launcher is needed to send sonobuoys clear of the airguns and hydrophone streamer. Some progress has been made on an integrated acquisition system, but a maze of cables is still needed for recording on multiple receivers. Cross-talk between sonobuoy recording channels was a major problem on this cruise.

11. The Bridge anemometer appears to be poorly sited and gives unreliable wind speeds (and probably directions). This may have safety implications. The instrument should be resited, and in addition it would be useful to have a display of wind speed and direction in the Main Lab.

12. The XBT satellite communications aerial had been removed without informing the PSO. We were therefore unable to meet our commitment to the MOD to transmit

data to them in real time, which was a condition of receiving free XBTs from them, and could adversely affect the likelihood of similar arrangements in the future.

13. The E-mail service is too infrequent and compares unfavourably with services on the JOIDES Resolution and on French ships. The lack of a daily service encourages people to use the more expensive option of fax instead. On occasions, mail appears to get delayed in Barry.

CRUISE NARRATIVE

Thursday 13th July (194)

The Cambridge equipment arrived by lorry and was unloaded. The Dalhousie airfreight shipment also arrived. The SAR vehicle was already on the afterdeck, having arrived a couple of days early. We began setting up equipment in the Deck Lab. Keith Louden arrived and began setting up his OBSs in the Chemistry Lab.

Friday 14th July (195)

The SAR containers and personnel from Genavir, Toulon arrived. The IOSDL container arrived and was unloaded.

Saturday 15th-Sunday 16th July (196-197)

The Genavir party continued working in their containerised laboratories.

Monday 17th July (198)

The remaining participants for the first leg of the cruise arrived. A gravity base tie was made. Equipment was secured in preparation for sailing. A test lowering of the SAR over the stern was attempted. This was successful on the second attempt, after a block had been changed.

Tuesday 18th July (199)

The ship left Number 1 Dock at 0700 (all times GMT). There was a slight delay in the lock. There was a significant swell in the Bristol Channel, so equipment was securely lashed down. The ship slowed due to fog at about 1200. At 1815 the PES fish was deployed - the hull transducer was by then giving very poor data in the heavy weather.

Wednesday 19th July (200)

The EM log was calibrated in the morning, when we were in open water south of the Scilly Isles. This involved some 180 degree turns, and was completed in about two hours. The magnetometer fish was then deployed.

Thursday 20th July (201)

Work continued on wiring up the laboratories, setting up the OBSs, and preparing the SAR. During the evening it became clear that there were serious problems with the SAR. The capacitance of the deep-tow cable was somewhat larger than the SAR engineers had assumed, leading to a lot of power dissipation. The IFREMER container laboratory was unable to supply sufficient power due to saturation of the transformer. The microprocessor controlling the SAR drops out if the voltage drops much below 5V, and it was difficult to maintain it at this level for more than a short time. There was also a problem of distortion of signals coming back up the wire, again probably due to the high capacitance. Late night discussions between the SAR team and various other members of the scientific party failed to solve the problem. Since we were due to arrive at the work area at 0600 the next day, we planned some gravity and magnetics tracks 5 km either side of the planned main SAR profile (along IAM 9) as an alternative for the morning.

Friday 21st July (202)

Work on the SAR problems continued in the morning after the SAR engineers had had a few hours sleep. Meanwhile we followed the planned survey lines. The signal problem was solved by careful filtering. By early afternoon the power problem was mainly solved, with the SAR able to run continuously with the side-scan sonar, magnetometer and 3.5 kHz profiler all running, and for short periods (15s to 22 minutes) with the hydrophone active as well. The hydrophone apparently required a lot of extra power to run. Therefore we decided to operate the SAR without the hydrophone. SAR deployment began at about 1640 and the SAR and depressor weight were outboard by 1715. The SAR was lowered to 200 m depth prior to instrument checks. These checks revealed that no signal was being received from the SAR. At 1845, after a meal break, the SAR was recovered once more. The recovery was completed at 1930. There was a short delay when the Lebus winch, used for the final stage of recovery, malfunctioned, leaving the SAR still about 30 cm outboard. The recovery was completed using the main aft crane. It was quickly established that there was a leak in the connector between the depressor weight and the SAR, at the SAR end. The cable was cut and reconnected. A relaunch of the SAR commenced at 2200 and was completed in 17 minutes. With 200 m of cable out, control was transferred to the Main Lab. The SAR was lowered to about 750 m depth, then a brief haul test was done on the winch, which showed no problems.

Saturday 22nd July (203)

The SAR was towed in a complete circle at 750 m depth to calibrate the magnetometer. We were unable to turn to port because of shipping traffic, so we turned to starboard instead, requiring a further 270 degree turn to come onto line. At about 0155, after completing the calibration loop, and with about 3500 m of wire out, the SAR failed - it was drawing too much current. With no progress made on this problem, the decision was made at 0400 to begin hauling in the SAR. The hauling speed was initially very slow (8 m/min), with the winch apparently having problems with the weight of the SAR depressor weight, and alarms tripped each time the ship pitched in the swell. Recovery commenced at 0815. The depressor weight was successfully brought aboard, but the cable between the weight and the SAR was severed during attempts to grapple the SAR itself, due mainly to the 3-4 m of swell, and the SAR broke away. The vehicle is buoyant and was easily visible from the Bridge, but it does not have many grappling points, and there were several unsuccessful attempts at recovery. Once a rope had been attached, the recovery was fairly quick, and was completed by 0950. However, during the recovery the SAR drifted underneath the hull very close to the stern, and the neutrally buoyant hydrophone became snagged on the screw. The hydrophone was freed by manual turning of the screw, except for approximately 1 m which was apparently still snagged.

Clearly it was going to take some time to repair the SAR, so a decision was made to do some seismic profiling in the meantime. One airgun beam was already set up with three S80 waterguns. The SAR depressor weight and its cradle were unbolted from their position starboard of the SAR and secured on the deck forward of the SAR. The last 500 m of the multichannel hydrophone were then deployed and stoppered off to take the strain off the sections remaining on the drum. The deployment took about three hours. Once this was completed, there were problems with the Reftek gun controller, which were finally solved by changing a board. This meant than the first seismic line CAM125, an east-west line parallel to IAM9, was not started until about 2145. Ten channels of the streamer were outboard of the ship, and about 8 of these appeared to record usable data. However, the Sercel acquisition system cannot be configured to record less than the full 48 channels. The initial firing rate was 11s, with a 5s delay and a 4s record. Channels 41-48 were demultiplexed immediately after recording. The aft watergun failed at 2315, and later the centre watergun developed a leak, leading to a spurious second signal peak.

Sunday 23rd July (204)

Profiling continued on line CAM125. There were a number of problems with the Sercel, with many recording errors, and hence a large number of gaps in the line. The whole system had to be restarted several times. Tape drive A appeared to be causing particular problems, and was replaced for a short period with drive C. The problem was then traced to be unrelated to the drive, and recording recommenced on drive A. However, there were still many problems with drive A, and for the last few hours of recording only drive B wrote readable tapes. At 1058, profiling was stopped in order to get into position for a redeployment of the SAR later in the day. The problem on the previous deployment was related to water ingress into the swivel at the depressor weight, and repairs were expected to be complete by late afternoon.

Watergun recovery commenced at 1130 and hydrophone recovery at 1200. The recovery was completed very quickly, and the SAR depressor weight was also restored to its original position. At 1310 the magnetometer was deployed, and we then steamed at full speed to a point south of the SAR line to prepare for deployment. It then became clear that the SAR would not be ready for deployment until the following morning. The hydrophone was redeployed, stopping off after 500 m as before, and this time a beam of three airguns was deployed. Line CAM126 was started at 2250, with recording on the SAQ (RVS four-channel system) since the Sercel tape drives were still malfunctioning. This was an east-west profile to the south of IAM9. It took some time before the seismic data acquisition was optimised, since none of the signal conditioning features of the multichannel acquisition system were available, and it was necessary to use separate amplifiers and filters.

Monday 24th July (205)

The airguns stopped firing at 0807 and the guns and streamer were recovered. The SAR was now almost fully operational, with a spare hydrophone attached, the problem with the hydrophone signal solved, and only the 3.5 kHz profiler not functioning. The SAR was relaunched at about 1200 and slowly lowered through the water column. The airgun beam was redeployed once a turn had been completed, this time with two buoys on 5 m ropes, to keep the guns shallower for a higher frequency source, and shooting began when the SAR was in mid-water. At about 1600, with the SAR about 2 km above the seabed, alarms began to go indicating that the safe working load of the conducting cable was being exceeded. Lowering ceased until clearance was obtained from Barry to work to a safety factor of 2.0 rather than 2.5. The SAR at one point reached 30 m from the seabed as it was discovered that altitude adjustments were necessarily rather slower than on the French ships. Since the cable was then very close to its safe working load, a few hundred metres were hauled in. It was decided to fly the SAR at about 120 m altitude (higher than the normal 50-80 m), and hold it at that altitude by adjustments to the speed of the ship. This was later increased to 200 m to avoid interference between the seabed signal on the hydrophone and a secondary peak of the direct wave arrival. The seismic signal at the SAR was rather weak, and it was discovered that only 1500 psi of air pressure was reaching the deck. The shot interval was increased from 10 to 20 s, and this largely solved the problem.

Tuesday 25th July (206)

SAR profiling continued through the night without incident. It was realised that the low air pressure was due to a blocked filter between the compressors and the deck. Once this filter was removed, we were able to fire the airguns at a 10 s interval at 2000 psi. One airgun stopped firing at about 1630, and another at about 1800, so the airgun beam was brought in, after some debate about the wisdom of working on the afterdeck when the conducting cable was near its safe working load. The beam was found to be broken in half. The surface magnetometer was brought in during recovery, then redeployed. A 300 cu. in. airgun was deployed in its place, on a single gun umbilical on the starboard quarter.

Wednesday 26th July (207)

SAR profiling continued. Some rapid hauling in was needed as we approached a very steep slope at the bottom of the continental rise. The SAR was brought up to less than 1000 m depth for a 180 degree turn. We then profiled down the same steep slope, attempting to keep the SAR as close as possible to the seabed.

Thursday 27th July (208)

We began hauling in the SAR at 1000, and completed recovery at about 1500. The buoyed magnetometer was hauled in immediately prior to recovery, and the other magnetometer bottle deployed after the recovery. We then conducted a short experiment to determine the effect of the ship on the magnetometer. The ship completed full circles to starboard and to port. The magnetometer measurement varied by 40-50 nT. We then steamed at full speed towards Lisbon, bringing in the magnetometer and echosounder fish in shallow water at 2330.

Friday 28th July (209)

We came alongside in Lisbon early in the morning. Divers removed the remaining pieces of hydrophone from the screw. The SAR containers were finally unloaded in the afternoon after the crane that had been ordered failed to appear in the morning. The airgun umbilicals were moved into place, and a team of three Portuguese welders spent most of the afternoon and night repairing and strengthening the broken airgun beam.

Saturday 29th July (210)

We departed Lisbon at 0600 (0800 local time). At 1630, about 70 km south of the work area, we began deploying the multichannel streamer in order to balance it. The deployment took about 6 hours, since most of the bird collars were in the wrong place, but the streamer appeared to be well balanced already and could be driven at the desired depth of 20 m, except for the far end.

Sunday 30th July (211)

Streamer recovery began at about 0500, and the first OBS was deployed at the eastern end of the line at 1120. OBS deployments continued through the day at about 90 minute intervals. Unfortunately, a glass sphere housing one of the Cambridge instruments was dropped and broken during preparation, with damage to both halves.

Monday 31st July (212)

OBS deployments continued until about 0300, when the 12th instrument was deployed. Since we were running well ahead of schedule, and the final three Dalhousie instruments were still having their batteries charged, we then broke off to run two short gravity and magnetics lines. OBS deployments recommenced at 0830, and the remaining nine instruments were deployed by 2100, with the sixth Minidobs not deployed due to a fault in its A-to-D chip. There was a delay of approximately two hours for one of the Cambridge instruments when first there was a problem communicating with the release (due to a mis-transcribed code), and then to deployment with the wrong anchor weight, which had to be released when the instrument did not sink. Overnight, we ran two long gravity and magnetic profiles to allow time for completion of the fitting out of the four airgun beams.

Tuesday 1st August (213)

The second magnetics profile was completed at 1130 and the magnetometer recovered. Airgun beam deployment began at 1430 and was completed at 1830. By 2030 we were on a westward extension of the IAM 9 line with all twelve guns firing. Unfortunately we were not able to lock on to the Eastern Atlantic satellite for differential GPS corrections with the ship's heading near 090 degrees, so we quickly switched from shooting on distance to shooting on time at 40 s intervals. A number of problems were found with the System 2000 software logging the GPS, including a 16 s discrepancy between the logged time and GPS time. A leak in the shot hydrophone of the 400 cu. in. airgun meant that the Reftek gun controller had difficulty synchronising this gun, so it was synchronised by hand and then left with a static delay. Before synchronisation, it had drifted about 25 ms early.

Wednesday 2nd August (214)

Airgun shooting continued, with all twelve guns still firing. At about 0215, a pressure drop was noticed in the port side guns, down to about 1500 psi. This was diagnosed as due to a blocked filter. The filter was cleaned and the port side compressor restarted. The portion of the line affected by this problem was then reshot. Between 1110 and 1120, about 15 shots were missed when a number of other devices were added to the seismic trigger, in preparation for a sonobuoy launch. The problem was solved by taking the trigger from elsewhere. A trial sonobuoy was launched, mainly to test out the acquisition system, and gave good results. At 1800 the compressor pressure dropped again, and another portion of the line was reshot once the filters had been cleaned again.

Thursday 3rd August (215)

Shooting continued overnight with no problems, and the last OBS position was passed at about 0930. We then continued shooting up the steep scarp at the edge of the continental slope, finishing at 1102 in about 1500 m water depth. A test of the 400 cu. in. gun showed that this was not in fact firing, so it probably failed early on during the line. All four beams were inboard at 1420, by which time we were very close to the first OBS site. OBS recoveries then commenced, and continued throughout the rest of the day. The first Cambridge Minidobs had unexpectedly low signal-to-noise ratio. This was later diagnosed as due to a leaky hydrophone. The first IOS DOBS had a system crash about 90 minutes after deployment, and had recorded no useful data.

Friday 4th August (216)

OBS recoveries continued. The second IOS DOBS had also had a system crash, after a similar period of time. The glass housing of one of the Cambridge DOBS was found to be badly chipped and therefore not reusable. About an hour was spent at the site of the third IOS DOBS trying slightly different release frequencies before it finally released. This instrument had also suffered a system crash, but had at least recorded some useful data before crashing. The second Dalhousie DOBS (13th in the line) could not be released, and was abandoned after about 90 minutes of trying.

Saturday 5th August (217)

OBS recoveries continued. The 14th OBS, a Cambridge DOBS, had recorded no data because a connection to the clock battery had come apart when the instrument cooled to ambient temperature on the seabed. The 15th, a Dalhousie DOBS, was recovered successfully, and it was realised that the wrong release code had been used for the 13th, so we returned to this site and successfully recovered the OBS. One Minidobs came back half full of water and with a large chip at one of the connectors. Miraculously, the electronics were for the most part undamaged. The final IOS DOBS had also suffered a system crash.

Sunday 6th August (218)

The final instrument, a Dalhousie OBS, was recovered at 0420. This instrument had failed to record any data. The end 500 m of the multichannel streamer and one airgun beam were deployed to profile the basement at the western end of our shooting track, which was not covered by the IAM9 line. Shooting began at about 0730, and finished at about 1200. The profile had exceptionally low noise levels due to the flat calm sea. After this the streamer and guns were recovered and the magnetometer deployed during passage to the first OBS site for the second experiment. By this time enough tests had been carried out with the PDAS's (the recording systems in the IOS OBS's) to justify their redeployment, using only one channel to minimise the number of disk files written and hence hopefully to prolong their life. The first site was reached at about 1730, and OBS deployments continued through the evening.

Monday 7th August (219)

OBS deployments continued. A fifth Minidobs was constructed using parts of the flooded instrument and of the instrument with the faulty A-to-D chip. Deployments were completed at 2030. We then steamed for four hours to the south of the survey area, to allow for streamer and airgun deployment heading into the wind from the north.

Tuesday 8th August (220)

Hydrophone deployment began at 0030 and the streamer, four airgun beams and the magnetometer were all deployed by 0830. The first useful shot (triggered by the Sercel) was fired at 0902, shortly after the first instruments began recording at 0900. Some short extra profiles were acquired before the majority of instruments began recording at 1500. Differential GPS corrections were switched on and, since we were not on an easterly heading, good fixes were obtained. However, when we attempted to shoot on distance during the first seismic line, CAM128, the System 2000 software generated spurious triggers every 15-20 shots, and then no trigger at the next shot. This was too great a rate of data loss, so for the next line we returned to firing on time. For this survey we used a 50 s shot interval to reduce the effect of wrap-around multiples in the OBS data, since for off-line shots these would not be easily distinguished from ground waves. With the ship doing about 4 knts on the EM log, our speed over the ground varied from about 4.4 to 5.3 knts over the ground, to give shotpoint intervals of 110-140 m. At about 1515, as we approached the start of our main grid survey, there was a pressure drop on the port side airguns. We therefore turned away from the line in a 360 degree loop to starboard while these guns were turned off and the filter cleaned again. We then commenced the grid with all guns firing at about 1700, deploying a sonobuoy at the final OBS site, where in the end no OBS had been deployed. Profiling continued for the rest of the day, with data demultiplexed and stacked shortly after acquisition using the Promax software brought from Cambridge.

Wednesday 9th August (221)

Profiling continued, with relatively calm seas allowing the acquisition of very high quality multichannel data, though of reduced fold due to the long shot interval. The port side airguns were switched off for a further 15 minutes when once again the pressure dropped due to a blocked filter. This time the filter was removed altogether.

Thursday 10th August (222)

Profiling continued. Using Promax, we were able to produce full fold brute stacks 24-36 hours after data acquisition, which considerably aided the planning of the remainder of the survey.

Friday 11th August (223)

Profiling continued. The shot interval was reduced to 40 s for a few hours while we were on line with an IOS OBS (position 2) which had been programmed to record in windows based on a 40 s shot interval.

Saturday 12th August (224)

Profiling continued. About 1 m of swell developed during the night, ending a period of three days of exceptionally calm weather. Sercel tape drive B had a series of errors early in the morning, culminating in a broken tape, and was temporarily replaced by the spare, drive C. Wind speed increased during the day, reaching force 6-7 in the evening.

Sunday 13th August (225)

Profiling continued, now in 2-3 m of swell. At about 0400, the depth control birds were accidentally sent a command to surface, and this led to 30 minutes of noisy data before the streamer was once again stabilised near 20 m depth. The first depth sensor indicated a depth of only about 5 m, and the ship was slowed by 0.5 knt to allow the front of the streamer to sink a little. Through the day the wind speed built up, reaching force 9 in the evening. We continued at a slow speed (4.0 to 4.5 knts over the ground) in an attempt to keep the front of the streamer down as the swell built up.

Monday 14th August (226)

The swell continued to build up overnight, with the wind speed in the range 30-45 knts. The pitching of the ship brought the first few hundred metres of the streamer very close to the surface, despite further slowing of our speed through the water. Several times the compressors shut down because on big rolls oil flowed away from the suction pipes in the sumps. We therefore modified our planned shooting tracks to take a more favourable heading.

Tuesday 15th August (227)

Profiling was completed at 0627 and the ship turned head to wind to recover the magnetometer, airguns and streamer. Streamer recovery was completed at 1349. On recovery it was found that the first depth sensor (nearest the ship) had gone out of calibration and was reading 3-5 m too low, so the front of the streamer was not actually as shallow as we had thought. The first OBS was recovered at 1645, and recoveries continued through the evening. We were unable to release Cambridge OBS12. There were difficulties communicating with the release, but eventually consistent ranges were obtained, and several 'execute' signals were returned in response to 'release' commands. The most likely explanation was an implosion of the floatation spheres, which may have left the release lying on the seabed in an acoustic shadow of the instrument.

Wednesday 16th August (228)

Recoveries continued. Initially, IOS OBS55 could not be released, until after visiting another site, it was realised that the wrong release code had been used. After a series of failed XBT launches earlier in the cruise, a broken wire was found in the XBT launcher, and good results were eventually obtained from the probes.

Thursday 17th August (229)

Recoveries continued. The last OBS was inboard at 1700. We then returned to the site of Cambridge OBS12, collecting magnetics data on the way, for a further attempt to release it, but without success. A velocimeter dip was carried out in the same location, to a depth of 2200 m.

Friday 18th August (230)

Once the velocimeter was inboard, the magnetometer was redeployed and another heading correction experiment was done, this time steaming in a larger circle with a speed of 4 knts and a turn rate of 5 degrees per minute. This was completed at 0400, and we then set off at full speed for Barry.

Saturday 19th August (231)

We continued at full speed across the Bay of Biscay, with the magnetometer still deployed. At 2000 we were up on the continental shelf and scientific watchkeeping stopped.

Sunday 20th August (232)

The magnetometer was recovered at 0830.

Monday 21st August (233)

We arrived at RVS base at 0300. A gravity base tie was taken. Demobilisation began at 0900.

NAVIGATION

During seismic profiling, differential GPS corrections were received via satellite from a base station in Gibraltar and fed into the ship's Trimble GPS receiver. This gave positions accurate to ~3 m, for the receiving aerial. GPS positions were displayed in real time using a package called System 2000, hired from Fugro Starfix in Swindon. A problem with this system was that the Inmarsat receiver, used for the differential corrections, was shielded from the Eastern Atlantic satellite by the main mast when the ship was heading in an easterly direction. In these circumstances the radio officer would normally switch to the Western Atlantic satellite. However, the corrections from the Gibraltar base station were broadcast only on the Eastern Atlantic satellite. When not using differential corrections, we used uncorrected GPS from the Trimble and also from an Ashtech GPS receiver. Magnavox transit satellite navigation was also displayed in the main laboratory and logged. The Bridge had their own independent Decca GPS system with a live track plot. The output from the Trimble was also transmitted to the SAR container during the first leg of the cruise.

DATA LOGGING

Underway data were logged using the RVS Level A, B and C system, time tagged with times from the ship's master clock, which was synchronised with GPS time by a Radiocode receiver. Data were processed into MGD77 records at 10 s intervals. During times of differential GPS navigation, these data were logged via a Level A as well as by the System 2000 software. An additional Level A logged the seismic shot instants.

GRAVITY

The gravity field was sampled every 10 s using a LaCoste and Romberg shipboard gravimeter. Differential GPS navigation was used in data processing during times the differential corrections were enabled. Gravity base ties were taken at Barry at the beginning and end of the cruise.

Time	0830/198
Shipboard meter reading	12423.6
Calibration constant	0.9967 mGal/division
g alongside	981189.88 mGal
Height of meter below quay	3.75 m
g at meter on ship	981191.04 mGal

Time	0500/233
Shipboard meter reading	12426.2
g alongside	981189.88 mGal
Height of meter below quay	4.55 m
g at meter on ship	981191.29 mGal

Drift is +2.34 mGal in 35 days

MAGNETOMETER

The magnetometer was a Varian V75, with the fish towed about 160 m astern of the ship on the starboard quarter. For magnetic profiling during SAR work, buoyancy was added to the tow cable in the form of a polystyrene collar. The paper record was very noisy, particularly when walkie-talkies were in use nearby. This noise did not appear in the logged data. Magnetic anomalies were computed relative to IGRF 1990. A heading correction experiment carried out at the end of the cruise indicated that the measured anomaly varied by about 35 nT according to the ship's heading (Figure 4).

ECHOSOUNDER

Water depths were logged using a Simrad EA500 single beam echosounder operating at 10 kHz. This performed well throughout, and was also used for detection of pingers on the IOS (10 kHz) and Dalhousie (12 kHz) OBSs.

XBT LAUNCHES (Peter Miles)

Sippican XBT probes types T5 (maximum depth 1870m) and T7 (maximum 780m) were supplied by the Hydrographic Office at Taunton for deployment during the cruise, the data to be transmitted back via satellite after each launch. 15 XBTs were launched but only 7 operated - two of these to only 70m. An initial intermittent fault in the launcher, which eventually became inoperable, was responsible for most of these failures. In addition several launches also failed immediately on hitting the water apparently due to disconnection of the probe from the cable. Use of the test probe showed the launcher to be open circuit. Stripping the cable and renewing the connection corrected the fault and the launches operated correctly thereafter.

Several other problems arose with the system:

1. We were unable to transmit data back to the Hydrographic Office as the appropriate aerial was not on the ship. This caused some embarrassment as we had obtained the

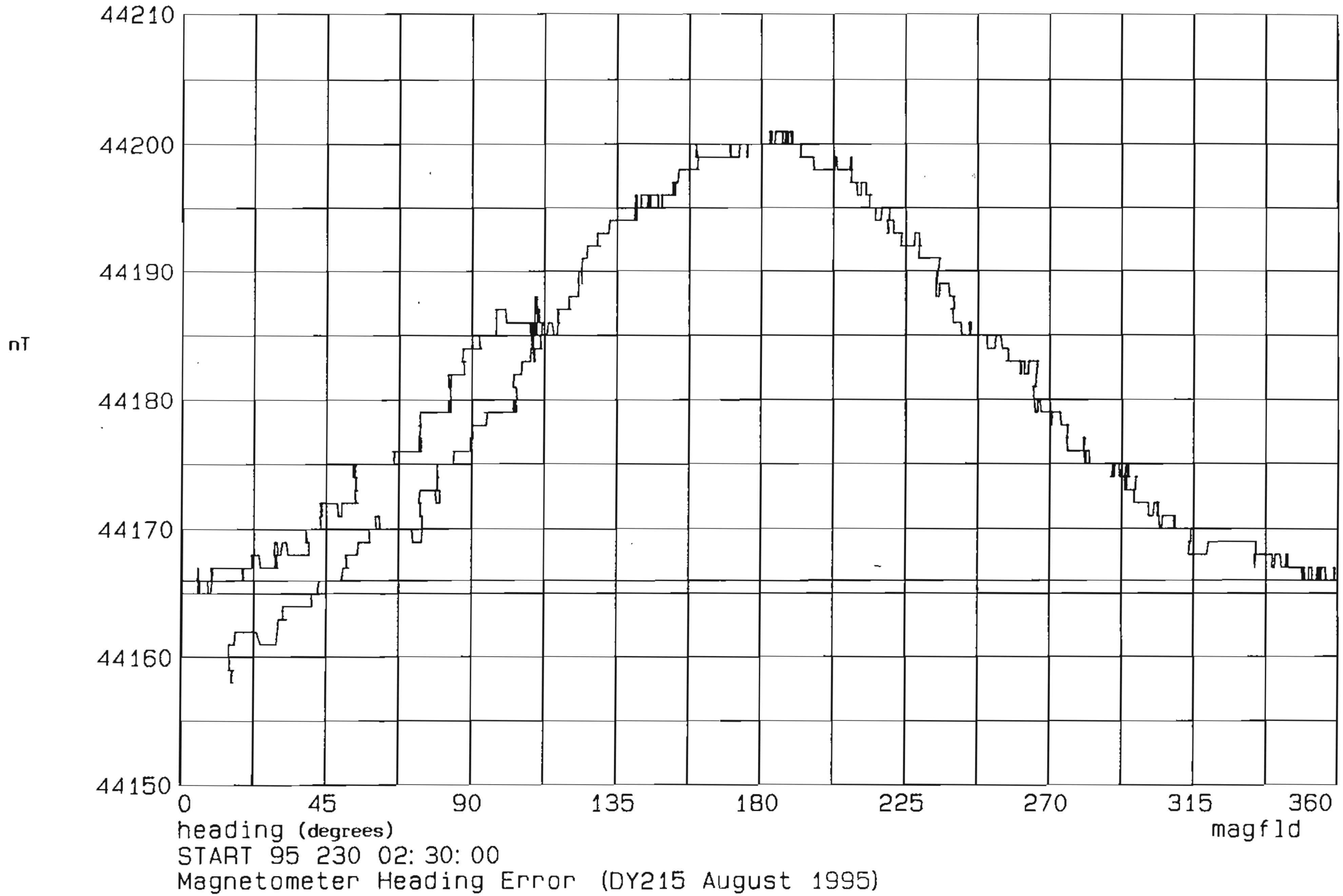


Figure 4: Result of heading correction experiment for surface magnetometer

XBTs free of charge on the understanding that we would transmit the data after each launch.

2. The 'SEAS' XBT software refused to accept the tens of minutes longitude digit, replacing it with a zero.

3. The program generated a file write error for the diskette drive on two occasions, losing the data. Printing the drop profile and inflection data while still in memory allowed us to save paper listings of the data. These files could not be accessed after exiting the acquisition program.

4. When attempting to format a new data diskette, to circumvent problem 3, the system DOS 5.02 did not have a FORMAT command operating and the instructions in the manual could not be followed. A new disk was formatted on another PC running the same version of DOS. This was then initialised on the XBT system and run as data disk 2.

The XBT recording system was clearly in need of a service.

XBT Launch summary

No[1]	Fileno	Time	Type	Latitude	Longitude	Depth(m)	Bathymetry(m)
1	001	1007/ 201	T7	43°49.6'N	9°37.1'W	70	2381
3	003	0924/205	T7	40°20.0'N	12°15.4'W	650	5207
4	004	1950/205	T5	40°21.1'N	12°02.7'W	500	5180
10	009	1550/210	T7	40°27.5'N	13°10.6'W	170	5277
13	012	2025/228	T5	40°47.6'N	12°00.2'W	700	5096 [2]
14	013	1140/229	T5	40°45.8'N	12°14.3'W	1870	5230
15	014	1920/229	T5	40°51.5'N	12°42.7'W	1870	5262 [2]
16	015	2300/229	T5	40°24.0'N	11°38.7'W	1870	5128 [3]

[1] only XBTs which recorded useful data are listed
[2] write file error, printer listing only
[3] Data disk 2

SAR

The SAR ("Système Acoustique Remorqué") was hired for the first leg of the cruise from IFREMER, Brest, via a collaborative arrangement with Jean-Claude Sibuet. Originally we had planned to use the RVS TOBI for this cruise, but it was not available in time. The SAR is a similar deep-towed vehicle to TOBI, with a side-scan sonar, a 3.5 kHz profiler, and a three-component magnetometer. A recent addition to the SAR is a 30 m, single channel hydrophone. The SAR weighs about 3 tons and has a 2.5 ton depressor weight. It goes to sea with two containerised laboratories. The maintenance laboratory was installed on the afterdeck, and the power and signal processing laboratory was placed on the container slot on the port side of the Forecastle Deck. This was linked to the conducting cable via a shielded co-axial cable to the junction box in the winch room. The SAR was driven by Bernard Pillaud and Jean-Claude Delmas from the Main Laboratory, where a full display of the SAR data was repeated on a screen from the container laboratory, via radio communications to the Bridge and winch cabin.

<u>**SAR Scientific Report**</u> (Jean-Claude Sibuet)

Description of the SAR equipment

Four tools are operated on the Ifremer SAR system:

Sidescan sonar:
The SAR is a deep-tow sidescan sonar operated at about 100 m above the sea bottom at a towing speed of about 2 knots. The frequency of the sidescan sonar is 170-190 kHz and the lateral range is 750 m on each side.

3.5 kHz sub bottom profiler:
This was not used during the cruise.

3-component magnetometer:
A 3-component fluxgate magnetometer has been recently installed on SAR. The sensor is located at the end of a 1.3-metre long glass-epoxy container fixed behind the SAR in order to reduce its magnetic effect (Figure 5). It is composed of three double axis fluxgates provided by the Sinomag company (Grenoble, France) and mounted orthogonally in a permaglass block. The precision of the mechanical positioning is +/- 0.3 degree. With an electronic angular compensation device, this value decreases to 0.001 degree. An analog computer gives the amplitude of the total magnetic field from the three recorded orthogonal components of the magnetic field with an accuracy of $5x10^{-5}$ oersted in the 0 - 1 kHz band. The three analog components and the total field are digitised and integrated in the SAR real time system of data transmission to the ship (Figure 5). Magnetic values are recorded together with the SAR navigation parameters every 1.5 seconds.

Pasisar:
A 30-m-long single channel streamer is towed by the SAR in order to complement surface ship seismic data (Figure 6). Two configurations are available for the streamer depending of the frequency bandwidth. In this experiment, we used 7 groups of 3 hydrophones mounted serially every 2 m. Two different arrangements of surface ship seismic source were used during the experiment:
3 Bolt airguns (700, 466 and 200 cu.in.) shot every 21s at the beginning of the experiment and then every 12 s.
One 300 cu.in. Bolt airgun shot every 9 s

The geometry of the SAR acquisition system is such that the size of the Fresnel zone is considerably reduced compared with a surface-towed system. Analog seismic data are frequency modulated and transmitted trough the towing cable and digitised onboard the ship by using an adapted DELPH2 system (Elics).

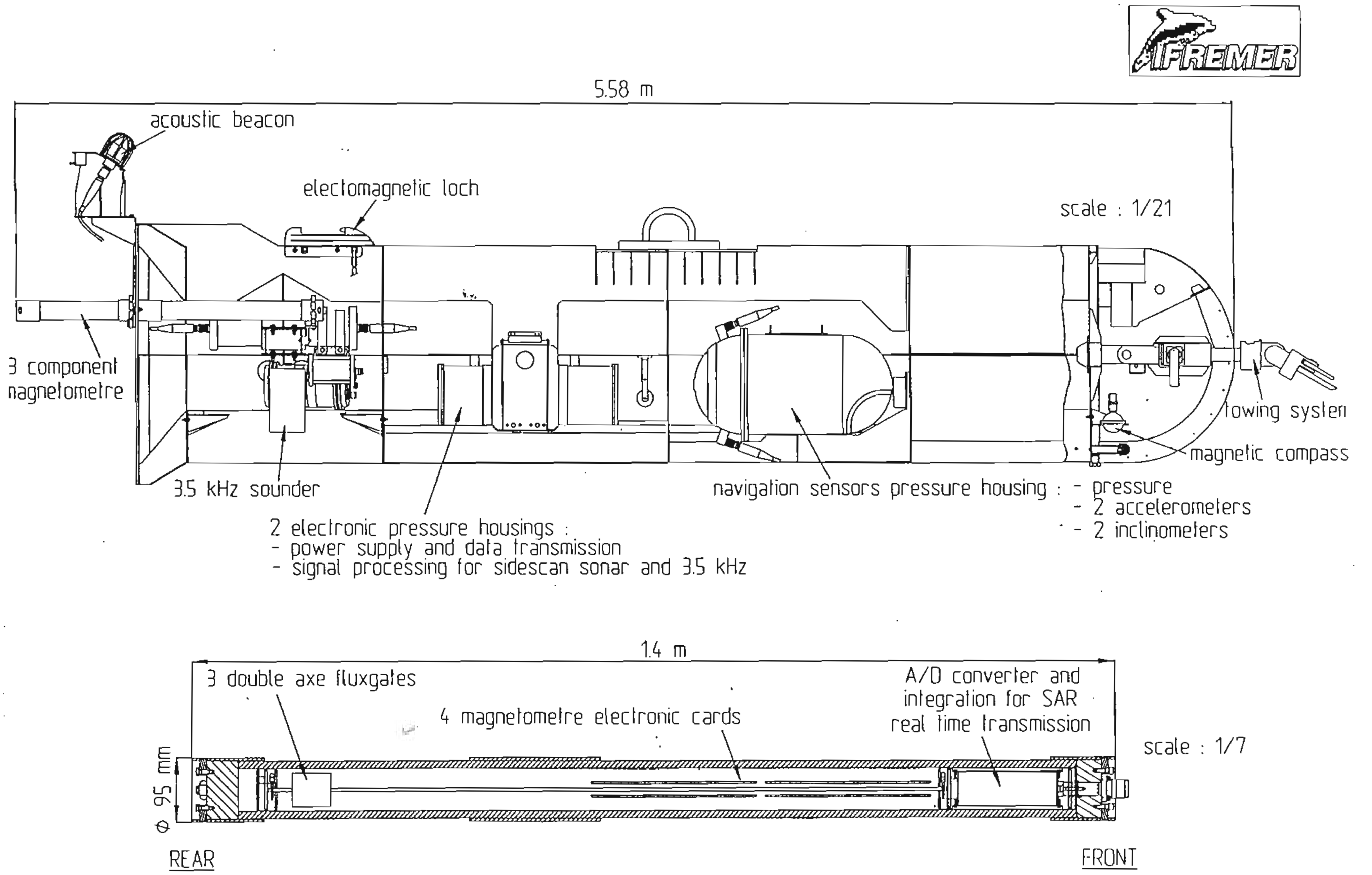


Figure 5: SAR vehicle (top) and pressure housing containing 3-component magnetometer (bottom)

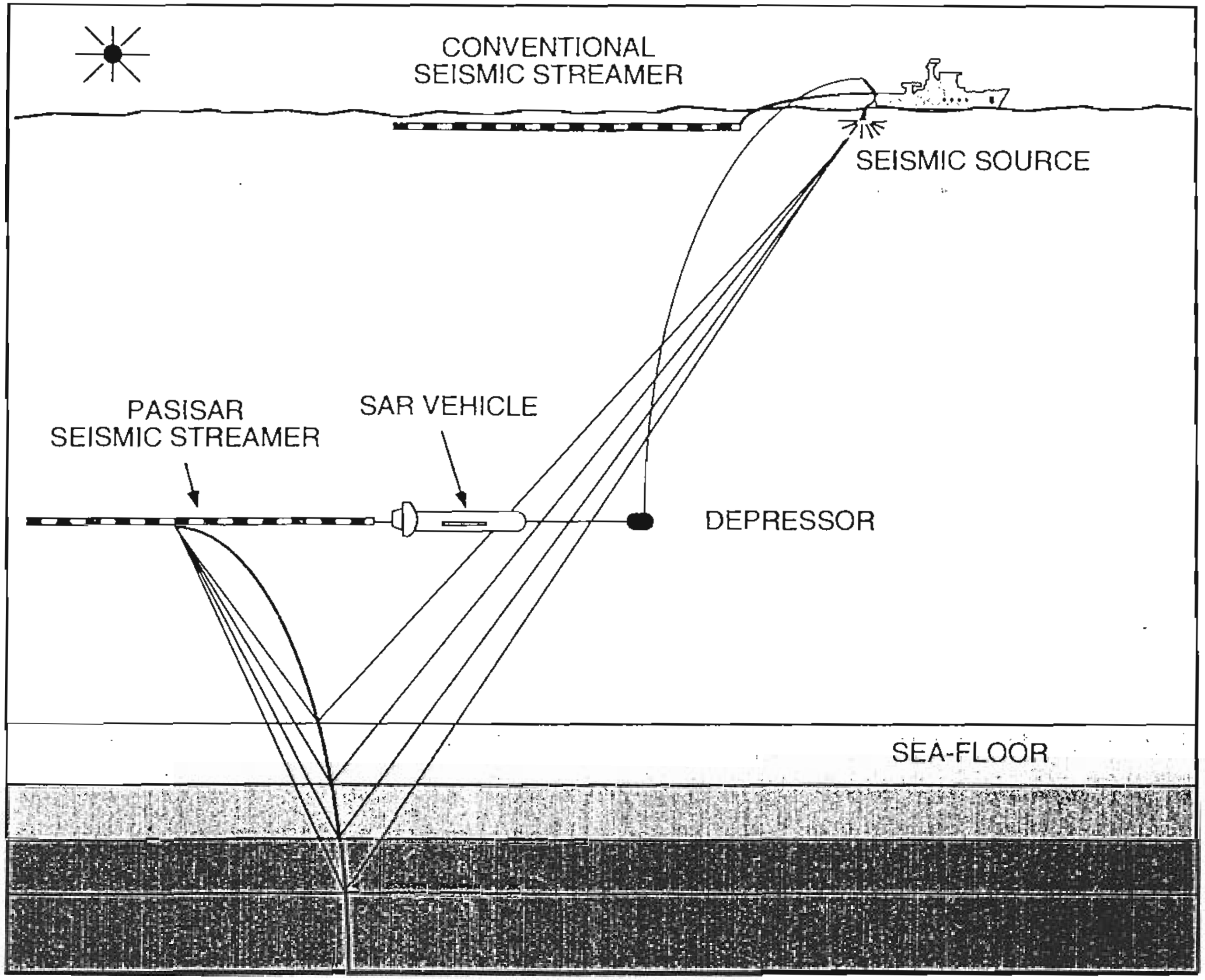


Figure 6: Geometry of Pasisar experiment. Surface streamer was omitted on Discovery 215.

Operations

During the cruise, a 200-km long roughly east-west profile was acquired in the Iberia Abyssal Plain continental margin across the transitional and thinned continental crust from 5200 m to 1400 m water depth. The mean towing depth was approximately 200 m above the seafloor. As the lower continental slope was very steep, the SAR was pulled up a few miles before the base of the continental slope was reached in order to avoid damaging both the equipment and the towing cable. The ship then turned onto a reciprocal course and a 65-km long complementary profile was acquired parallel to the previous one 1.5 mile to the north. This profile was realised downslope, with the SAR close to the seabed.

Data acquired during the survey

The sidescan data display features only on the continental slope. The 3.5 kHz was not acquired during the survey because of equipment failure. However, this improved the quality of seismic data because normally the 3.5 kHz is recorded every 1.5 s as noise on the streamer. To correct the measured magnetic field and its 3 components for the magnetic heading effect of the SAR, compensation curves for the total magnetic field and the 3 components were established before running the first profile by describing a navigation loop with the SAR towed at 1264 m from the ship. We discovered that the pitch of the SAR vehicle has an influence on both the total magnetic field and the vertical and horizontal Y along-axis components and that the SAR vehicle has no rolling motion as the horizontal X component, perpendicular to the SAR, was regular as a function of the SAR heading. Examples of the compensation curves are given in Figures 7 to 10. The sub-bottom penetration on the Pasisar system was generally less than 1 s. Because the direct signal arrives just before the bottom reflection, and because the bubble arrives about 105 ms after the main peak, the SAR was towed at about 200 m above the seafloor in order to avoid mixing the direct and reflected signals. An example of the data acquired is shown in Figure 11.

<u>SAR Technical Report</u> (Bernard Pillaud)

Preparation for the cruise

The actions carried out during the preparation phase are summarised below:

18/11/94	Proposition of a charter mission by J.-C. Sibuet.
12/01/95	Estimate of the marginal cost of such an operation provided by Genavir. This estimate was requested by M. Demon on 18/11/95.
03/02/95	Commercial proposal furnished by the Bureau des Opérations Commerciales (BOC).
16/02/95	Information by J.-C. Sibuet concerning priorities relative to the availability of the different SAR sensors.
21/02/95	Meeting in Barry with NERC staff so as to define the necessary modifications for use of the SAR on board RRS Discovery (cf. report dated 24/02/95, J.P. Chopin). The magnetometer being considered as a major priority, technicians began to struggle hard to make it

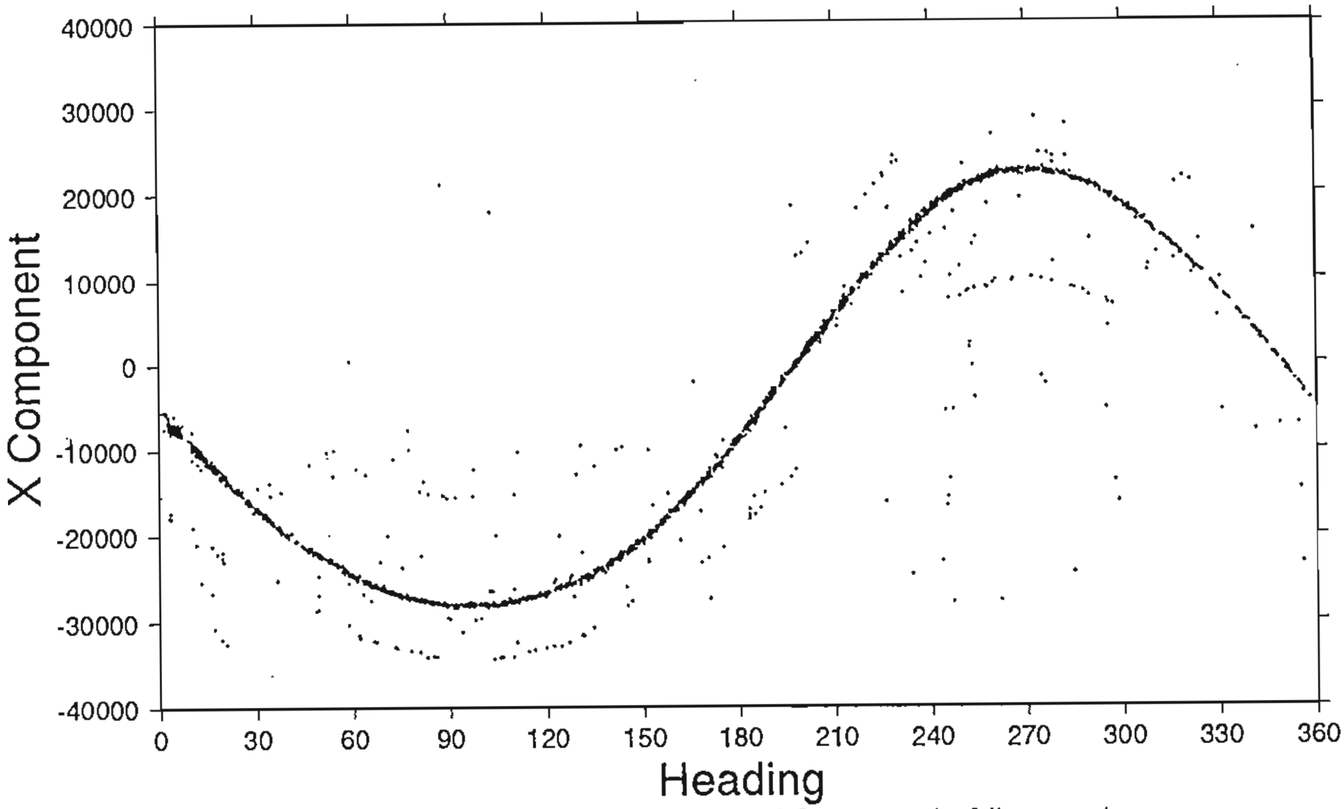


Figure 7: Variation with heading of SAR measurement of X-component of magnetic field after pitch correction

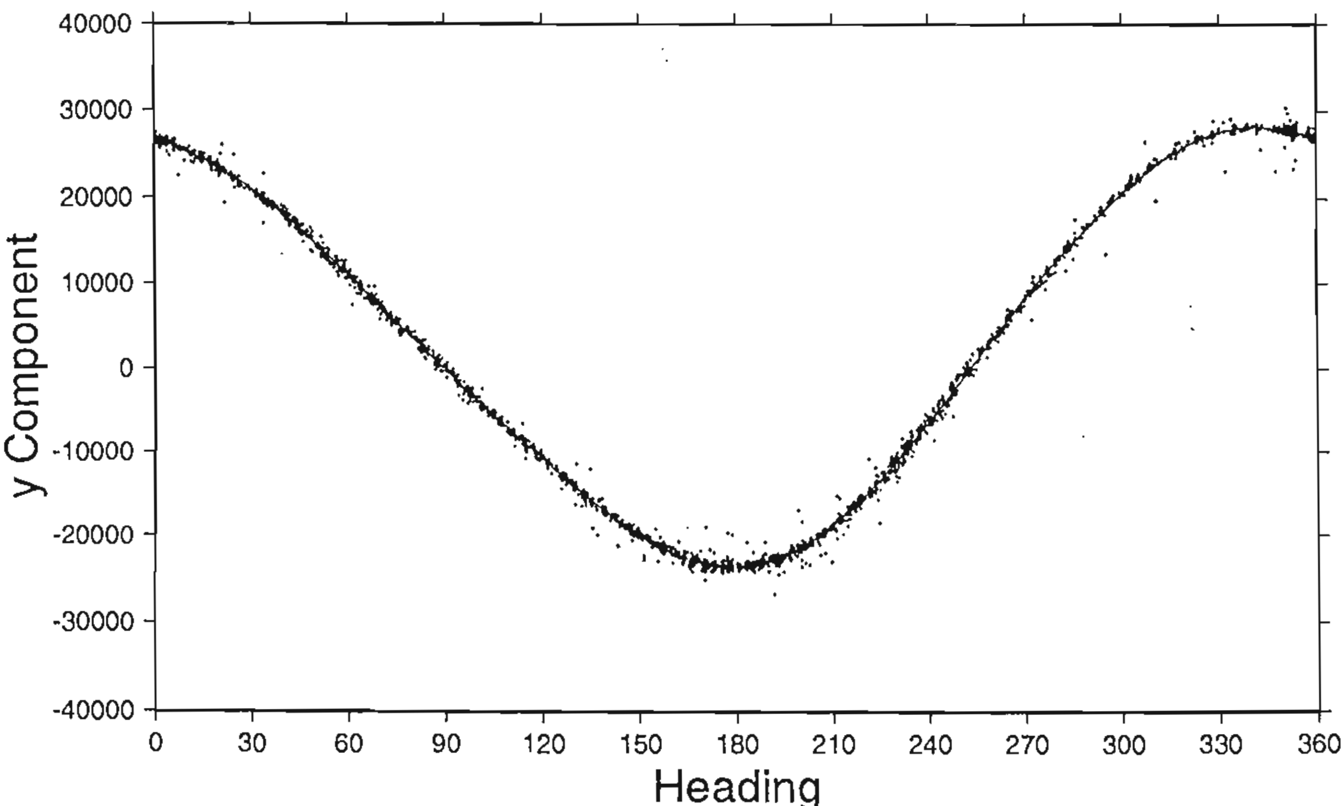


Figure 8: Variation with heading of SAR measurement of Y-component of magnetic field after pitch correction

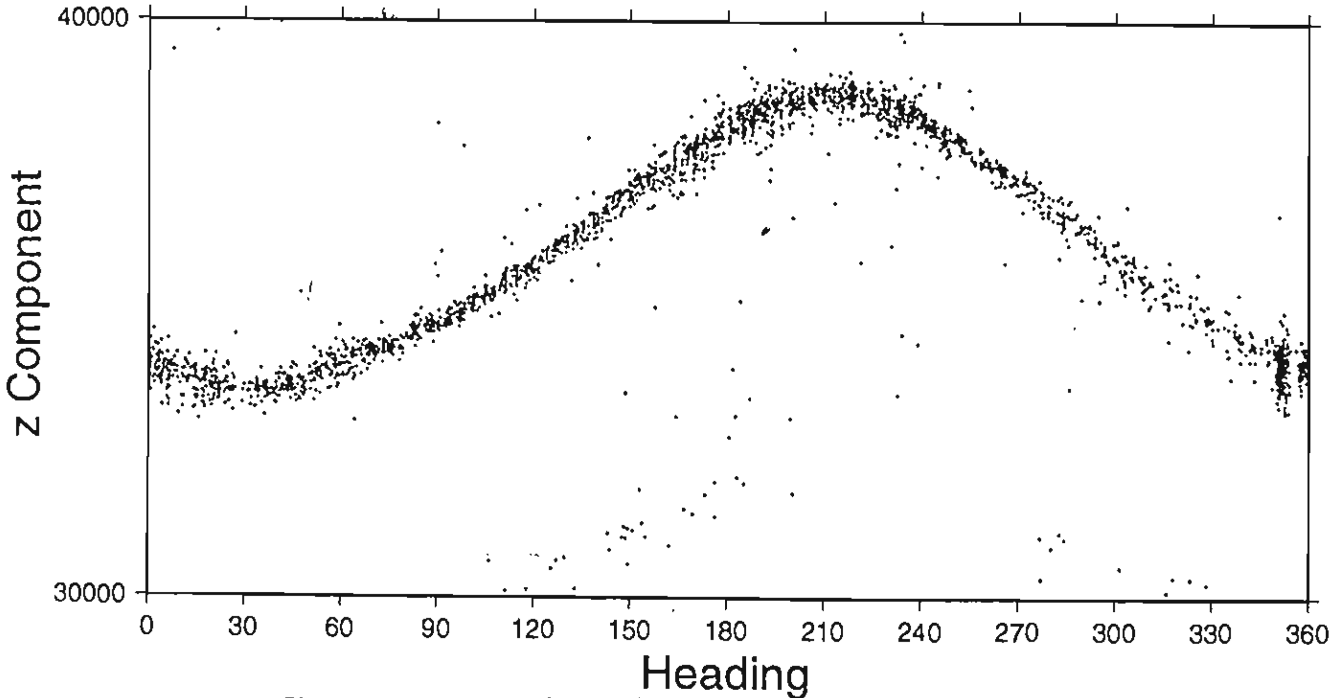


Figure 9: Variation with heading of SAR measurement of vertical component of magnetic field after pitch correction

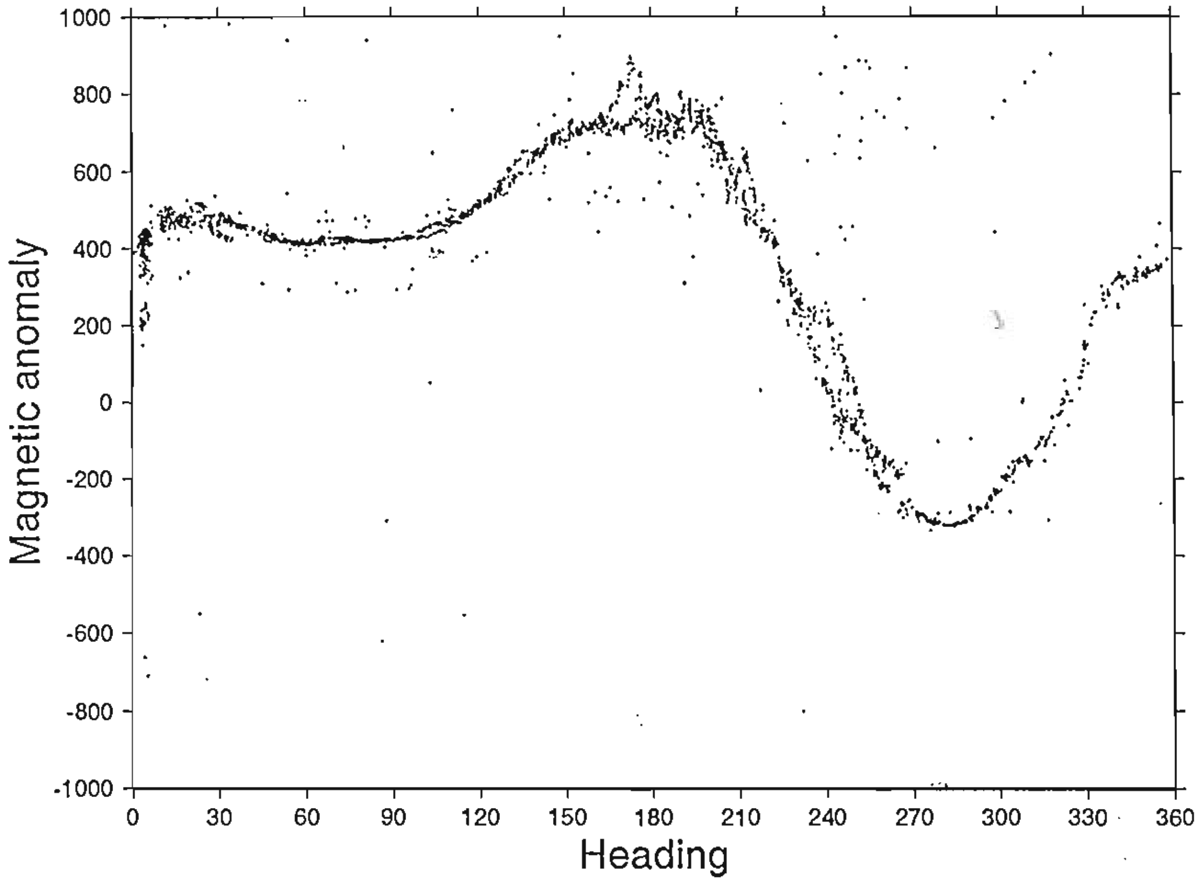


Figure 10: Variation with heading of SAR measurement of total magnetic field after pitch correction

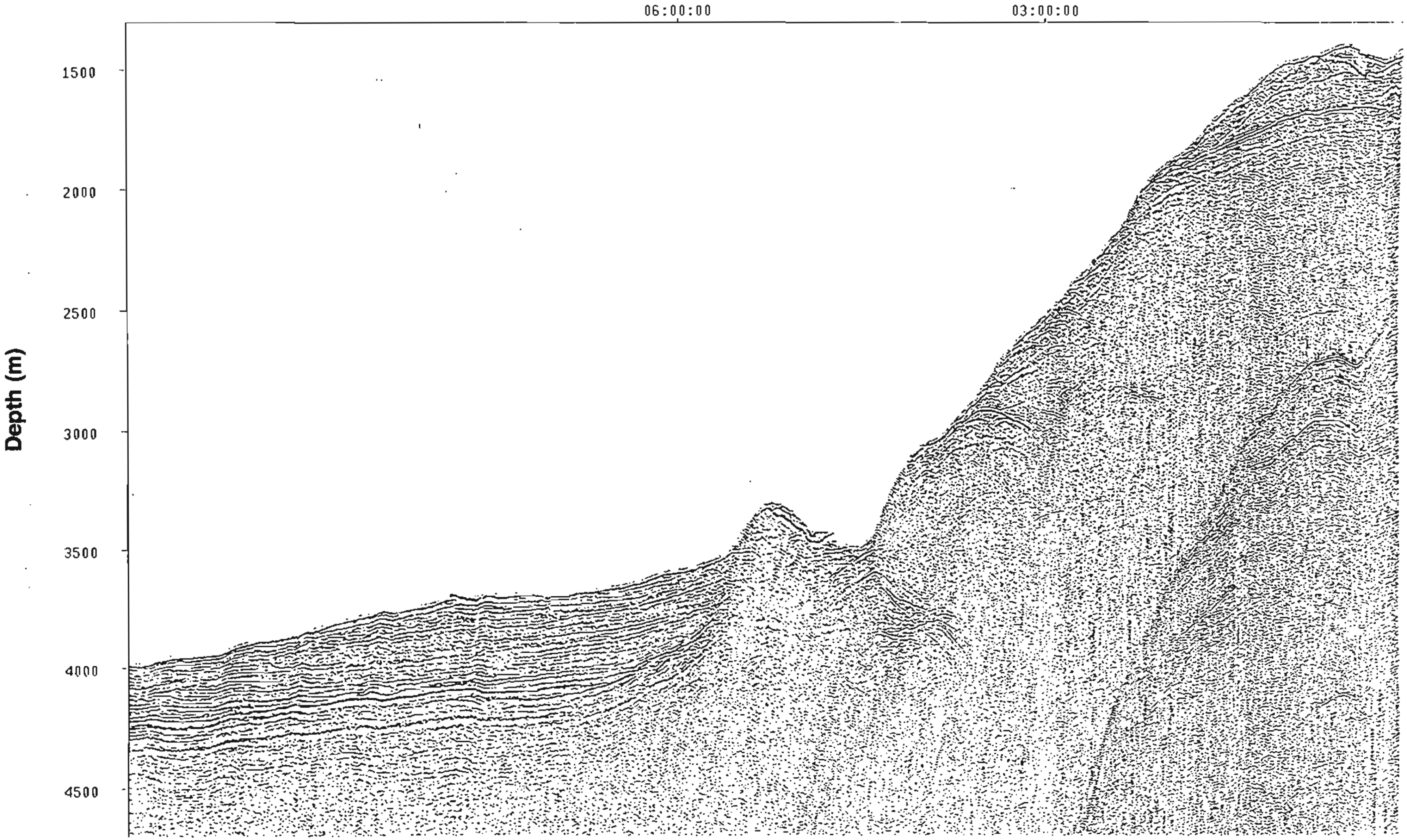


Figure 11: Part of Pasisar data after filtering, trace equalisation, deconvolution and geometric corrections

	operational on SAR.
Late April 95	Sea trials of SAR during POSID cruise. SAR systems worked properly with the exception of the streamer (too noisy).
June 1995	The problem of the noisy streamer is tackled. The solution (end of June) comes from separating the earth of the streamer from that of the Thomson pressure case.
07/07/95	Signature of the transport insurance.
10/07/95	Loading of SAR and transport to Barry.

Survey narrative

Thursday 13th July	Arrival at Cardiff and Barry in the evening.
Friday 14th July	Equipment is loaded on board. Identification of water and power supply capabilities. Power cables installed.
Saturday 15th July	Power supply connected. Cable termination for the SAR is prepared. Identification of junction boxes for routing data cables. Installation of the V and its arms.
Sunday 16th July	Cable termination connected to the SAR. Video and remote piloting systems installed. SAR switched on for a test and subsequent investigations.
Monday 17th July	Handling equipment is prepared. Final locating of the SAR's position on deck. Problems with the software (LTSA, EPROM VME) are checked. Remote piloting system connected. Trial of partial SAR deployment and final configuration for the handling equipment adopted.
Tuesday 18th July	Getting under way at 08:00. Definitive handling equipment installed. End of piloting PC installation. Table fixed.
Wednesday 19th July	Navigation screen installed on the bridge. At 16:00 the tow cable was connected to the SAR. SAR is tested with deep towing winch: connector to be re-made.
Thursday 20th July	SAR is tested with the Discovery cable. Work on modifying SAR to the Discovery cable.
Friday 21st July	SAR is adapted to the Discovery cable. 16:00 SAR is in the water without the streamer. 19:30 SAR is picked up (fault in SAR connector). 22:10 SAR in the water for magnetometer calibration. 02:00 SAR system hung up, re-booted.
Saturday 22nd July	03:00 SAR stopped: No more power consumption but voltage and isolation are correct. Defect is identified: ammeter died because of current >11 A. 08:00 SAR picked up (with sea state 4 and wind force 5 from the north). The attachment device of the SAR broken on a series of three strong swells. SAR drifts away. Captain refused to launch a Zodiac. The end of the streamer tangled in the screw during the SAR recovery. 11:00 SAR on deck. All the rest of the day was spent repairing the fault and the damage caused during the recovery.

Sunday 23rd July	11:00 Repairs finished. SAR launch aborted because of transmitter breakdown (fuse blew in the power) Afternoon: Check and repairs. SAR is in working order at 22:00.
Monday 24th July	11:30 SAR launched. 19:30 SAR is near the sea-floor, heading to the east at 5147 m depth. There are some difficulties with the winch.
Tuesday 25th July	SAR is towed above a nearly flat sea-floor, depth decreasing very slowly. Depth at 00.00: 5170 m; depth at 24.00: 4600 m. 16:00 the beam for towing the air-guns broke in two.
Wednesday 26th July	Same sea-floor morphology as the previous day until 16.00. From 16:00 to 24:00: slope of the margin, SAR depth ranges from 1400 m to 3000 m. 19:00 turned onto reciprocal course, depth 1600 m, immersion 900 m, westerly heading. 24:00 depth 3500 m.
Thursday 27th July	00:00 depth 3500 m. 10:00 began hauling in. 14:30 SAR at the surface. 15:10 SAR on deck, heading for Lisbon. 15:15 post-recovery check-list, SAR being dismantled.

Damage and problems encountered

Despite all precautions taken during the preparation of the survey, the SAR began its operations with a succession of break-downs:
- Normal failures which were related to running the SAR or to operation at sea.
-Abnormal failures which were systematically encountered at the beginning of each deployment, maybe caused by bad transport conditions (trucking). We could prevent these troubles by using inflated cushions while transporting by lorry.

Software:

Trouble with displaying the correct date: the new date is displayed but it is cleared after a few cycles and the older one is displayed.

Electrics/Electronics:

Faults with connectors on the electrical cable (connector re-made twice)
Failure of SAR transmitters (power transistors).
Failure of SAR power box (fuse).

Problems with the sounder. Firstly attributed to a modification of the sounder then to interference affecting the "multiplex" (the upgoing channel has been filtered but not the downgoing one). We have not investigated the details of this failure for lack of time, the sounder being considered as a secondary device. It is possible that these troubles are related to the same ones mentioned above and are attributable to one or more power transistors of the transmitter box.

Weakness of the 5 A circuit-breaker of the PC power supply (exchanged for one rated at 10A).

Hanging up of the SAR system caused by power supply of Pasisar. It is possible this fault was brought about by limited power when using the British cable. This fault did not happen when using the test cable or Ifremer's deep-tow SAR cable.

Random amplitude loss on sonar reception (on average for 5 mins per hour) coincident with an unrequested "return to zero" of all TVG channels.

During the last hour of towing, we noticed strong interference on the streamer signal directly related to SAR cycles without anything else abnormal occurring. The origin of this interference has not been identified.

Mechanics:

Defect in the mobile joint of the depressor weight (ingress of water, seized up).

Termination of the electrical cable of the SAR broke (note that the disposable weight was not released).

Magnetometer fore-pedestal broken (SAR hit the hull on Th. 22 July).

During the final recovery the neck of the "V" was damaged (by the friction of a steel sling while hoisting) and should be changed.

Adapting the SAR to the Discovery

Troubles due to the cable of the Discovery (principal difficulty):

The electrical capacity of the Discovery cable is greater than ours, inducing a very high electrical consumption: normal consumption of the SAR is 1.3 A with the test cable and 2.5 A with the deep-tow cable. On board the Discovery consumption was:

- 1.3 A on test cable (evidence that SAR was normal).
- 5.7 A on deep-tow cable.
- 4.8 A on deep-tow cable alone (open circuit).

This overconsumption cannot be avoided and it was necessary to increase the rating of the circuit-breaker of the power supply box (rated in principle at 10 A it jumped systematically to 5 A). Moreover, since the ammeter of the same box was limited at 5 A, we had to double the rating of the ammeter to 10 A.

Strong interference on the depth-to-surface link: The VME rack was unable to decode SAR signals. This problem has been very hard to solve. It was corrected by a series of filters and intercalated amplifiers between the SAR and the VME. The solution was found empirically; it consisted of:

- First filter: High pass 1 kHz, amplification 20 dB.
- Second filter: High pass 50 kHz, amplification 20 dB.
- Attenuator - 17 dB.
- Third filter: High pass 200 kHz, no amplification.
- Fourth filter: Low pass 1 MHz, no amplification.

Problems with the vessel itself (size of the ship):

- The lengths of the cables caused all devices to work at the limit of their range.

- Video extension for piloting, two additional amplifiers were plugged in so as to have a useful image without excessive fatigue.

- Portable PC for piloting supplied by two transformers RS232/RS422.

- Need to re-enforce the coaxial cable linking the electronics container to the rotary contact.

- Need to establish a VHF communication between the winch operator (in the main lab) and the SAR container ("French" network). When the winch remote control failed (27/07 at 14:00), an additional UHF "English" network was installed between the main laboratory, the bridge, and the winch control cabin.

- The height of the transom: in order to hook the recovery Nylon rope the SAR had to be very close (too close in fact), to the transom. When swell is heavy, the SAR is hanging below the stern and the tether (4 screws, number 6 size) takes the weight.

- A modification of the rig was tried: A Nylon rope (size 14) is tied along the electrical cable between the depressor weight and the second bump of the SAR in addition to the harness. Doing so, a winch can be used for picking up the SAR without considerably reducing the ship's speed. A second Nylon rope (size 12), attached (in addition to the harness) between the second bump and the nose of the SAR, permits the guide-rope coiled on the SAR to be recovered without having to hook it with a gaff. This procedure, which gave good results, will be adopted in the future.

Problems raised by staff and by general rules:

The winch for the deep-tow cable is power limited to conform with the regulations and the alarm is automatically switched on when tension is over 7.1 tonnes (breaking strength is 16.8 tonnes, factor of safety of 2.5). An exception was made which permitted us to work with a 2.0 factor of safety (maximum load 8.4 tonnes). This enabled us to work between 0.7 and 1.8 knots and to use the vessel speed to adjust the altitude of the SAR. This solution, acceptable on a very flat sea-floor would not permit work over rugged bathymetry. Moreover, the interpretation of data will be complicated by the frequent speed variations. The disinclination to use the Zodiac cost us the loss of the streamer.

Results and conclusions

The balance is positive, in so far as the major part of the work was accomplished: 565 line km were acquired in 92 hours (75 hours without any interruption between 1500 and 5200 m depth), with continuous acquisition of side-scan, seismic and magnetic data.

The SAR proved its adaptability which permits us to work with other vessels than those of Genavir, and even with foreign vessels using their own cables (though this adaptation may be a source of problems). If such a survey has to be attempted in the future, it would be desirable to plan a time for on board testing (preferably not during a week-end, unless it is not located near the vessel home-port). This would make us sure to get under way only after having conducted thorough tests in a satisfactory manner (the deep-tow cable was available for connection to the SAR only the day after departure, in the late afternoon).

The Pasisar seismic system works correctly and the problems of noise induced by power supplies are now completely solved as well as the interference introduced by the streamer on the general functions of the SAR. However, one unsolved problem remains; random amplitude fluctuations affect the signal on the streamer. It seems however that these fluctuations could be related to the SAR cycles. In addition, the amplitude of the signal seems to be poorly related (on similar sea-floor features) to the power of the surface source. A cruise to evaluate the Pasisar with different sources would certainly be useful. The SAR itself works correctly and the present sidescan arrays are still usable to a distance of 500-600m.

The magnetometer works correctly. We still noticed some interference almost certainly due to the beacon's steel pressure case. We also demonstrated that the pitch of the SAR strongly influences the magnetic field (even the total magnetic field). Finally, the X and Y components are swapped somewhere in the system.

As regards the mechanics, the technique and the procedure for the attachment devices are now perfectly mastered.

We also have to notice :

- The problems with the date on SARIM.
- Sounder modifications still have to be implemented.
- The transport conditions which dictate that each lorry journey leads systematically to a succession of troubles at the beginning of surveys.
- Navigation remains problematic at such depths. The new software should help a lot but it is unrealistic to think about obtaining perfect results unless we proceed to a total remodelling of the navigation system.

AIRGUN AND WATERGUN TRIGGERING

The time standard for the cruise was GPS time. A variety of triggering systems were used. In each case, the trigger was sent to the Reftek gun controller, which then fired the airguns/waterguns 50 ms after the trigger time. The same trigger also triggered the Sercel 48-channel acquisition system, the SAQ four-channel system, and various EPCs and Waverley recorders used for display purposes.

1. During SAR work, the trigger was provided from the SAR container laboratory.

2. During attempts to trigger on distance, two triggers were generated by the System 2000 software. The first was an initialisation trigger, which started the Sercel up and the tapes spinning. A second trigger, 1s later, was then sent to the Reftek. The position of the ship and the shot time according to the System 2000 Unix clock was logged by the System 2000. This Unix clock drifted up to tens of second away from

GPS time, and was monitored at regular intervals against GPS time. The exact time of the second trigger (to the ms) was also recorded by a Level A attached to the Sercel, though with no unique shot number attached. Triggering from the System 2000 was not found to be reliable: spurious extra triggers were generated typically every 10-20 shots, and as a result the next trigger was missed. A fax to the suppliers elicited a bug fix several days later, but this was too late to be useful, so we declined to implement it.

3. During shooting on time, the initialisation trigger was generated by a PC controlling the Sercel, and the trigger to the Reftek followed 1 s later. The exact trigger time in GPS time was again recorded on the Level A, but this time with a unique shot position number attached. Some profiles were shot at 40 s interval , with the trigger time 1s after the even minutes, while most were shot at 50 s interval to reduce the effect of wrap-around multiples on the OBS data.

Shot trigger times were independently logged by Keith Louden against GPS time.

DIMENSIONS

Distance from GPS and sonobuoy aerials to stern	71.5 m
Height of GPS aerial above sea surface	30 m
Height of sonobuoy aerials above sea surface	33 m
Distance from stern to centre of airgun array (12 guns)	77 m
Distance from stern to front of first hydrophone channel	285 m

SEISMIC SOURCES

The ship was equipped with four Hamworthy compressors with a nominal capacity of 400 cfm each. During line CAM125, we used three S80 (80 cu. in.) waterguns towed from a single 7 m beam at a nominal depth of 5 m, and fired at 11s intervals. During line CAM126 we used 700, 466 and 200 cu. in. guns towed from a single beam at a nominal depth of 10 m, and fired at 23 s intervals. This same source was used during the SAR work, until gun failures and the demise of the beam necessitated its replacement with a single 300 cu. in. gun towed on a single gun umbilical. During line CAM127, again we used a 3-gun source towed from a single beam, with a 600, 400 and 300 cu. in. chambers, a nominal towing depth of 20 m (true depth around 17 m), and a 23 s shot interval.

For the remainder of the second leg, we used a 12-gun array on four beams (Figure 12) with a total capacity of 6346 cu. in, fired at 100 m intervals on line CAM128, 40 s intervals for the first half of line CAM144, and 50 s intervals at all other times. At a nominal towing depth of 20 m, source modelling suggested that this would give a powerful, low frequency source suitable for the OBS work and deep reflection profiling, at the expense of losing resolution in the sediment cover. During the first OBS deployment, the true depth was 16-17 m, so the ropes to the buoys were extended for the second OBS deployment (and multichannel acquisition) to give a true depth of 20 m. Airgun pressure was maintained at around 1900 psi, and was

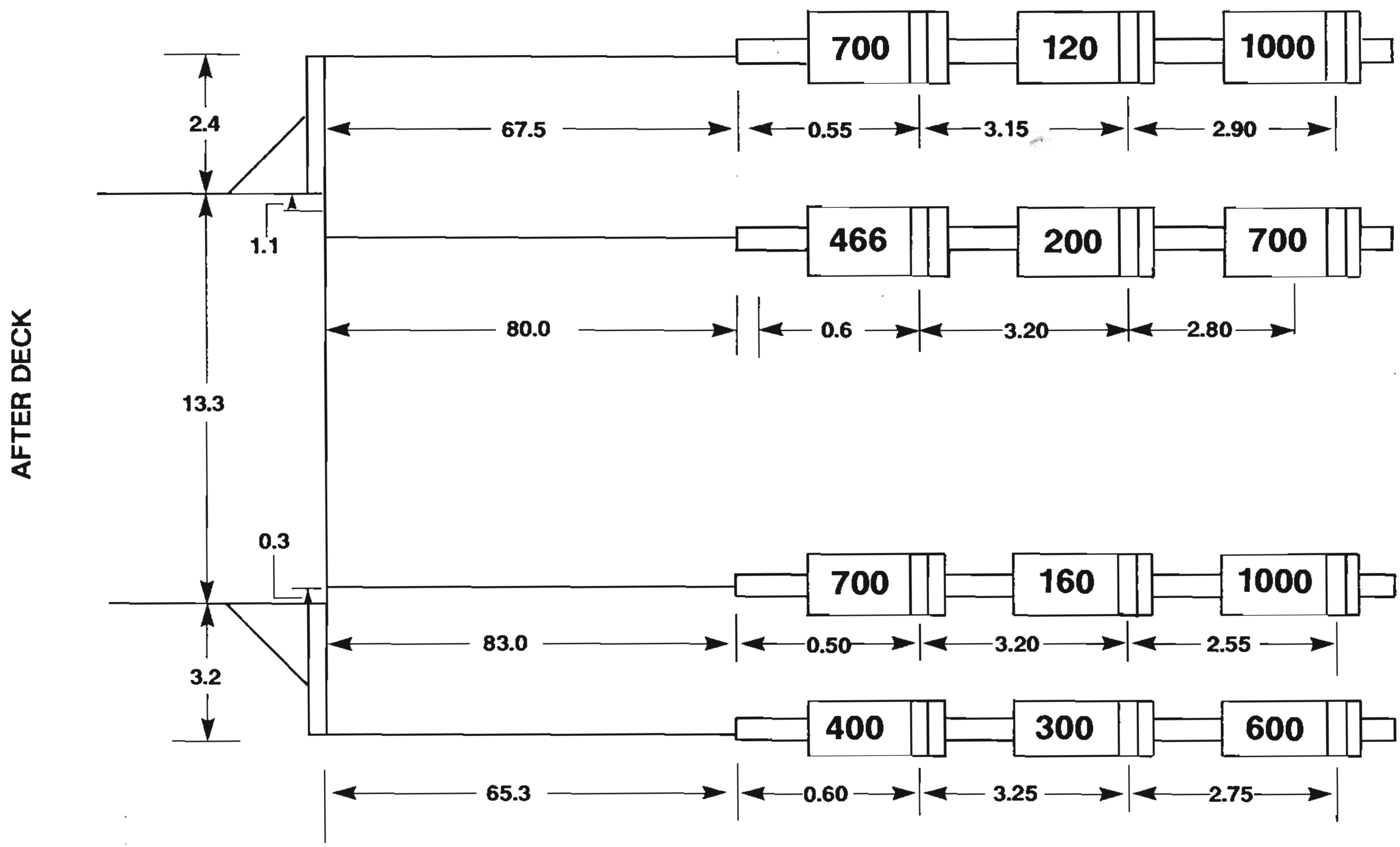


Figure 12: Airgun layout
(Distances in metres, gun volumes in cu. in.)

monitored regularly by the watchkeepers. Several times the pressure dropped below this on the port side due to a filter which became blocked with soot. Initially this filter was cleaned every 12-24 hours, an operation which required shutting down the port side guns. Eventually the filter was just removed. Smaller, single beam arrays were used during the first leg of the cruise, and for profiling basement beyond the western end of the IAM9 line. Overall the airguns performed extremely well: during the first period of shooting, only one airgun failed (at an unknown time because its shot hydrophone had already failed), while during the second period all twelve guns fired continuously without problems for a period of nearly seven days. The only major problem was the broken beam during the first leg of the cruise.

MULTICHANNEL STREAMER

The multichannel streamer consisted of 48 x 50 m active sections, 5 spring sections, a tow cable and a tail rope, with 14 individually addressable birds to control the depth, 8 calibrated depth sensors to monitor the depth, and 5 "retrievers" to provide buoyancy if the streamer sunk below a predefined depth. The configuration of the streamer is shown in Figure 13. The streamer was towed at a nominal depth of 20 m. Most of the streamer was successfully held at this depth, but the first depth sensor indicated depths 5-10 m shallower, and this part of the streamer could not be pushed deeper due to the failure of the first depth control bird. The streamer had very good signal-to-noise ratios throughout the survey, even during times of rougher weather, perhaps because we towed it deeper than usual.

MULTICHANNEL SEISMIC LINES

Line CAM126 was recorded in SEGY format on the SAQ four-channel digital acquisition system. Otherwise, multichannel data were recorded in SEGB multiplexed format on an SN358 with two tape drives (A and B) and a spare (drive C). The Sercel, along with most of the other equipment performing underway data acquisition, was installed in the Main Lab, and the lack of adequate air conditioning in this lab led to overheating during the first leg of the cruise. This probably contributed to the poor initial performance of the system. Prior to use on the second leg, both tape decks were carefully serviced. In addition, a number of fans were purchased in Lisbon to keep air moving around the Main Lab and reduce the overheating. There were fewer problems thereafter, and many of these may be attributed to external problems such as short tapes, and tapes which snapped. Lines are listed in Table 1 and locations given in Figures 14-15. Record length was 4 s, with 5 s and later 6 s delay, on CAM125, 8 s with 6 s delay on CAM126 and CAM127, and 10 s with 6s delay thereafter. Sample interval was 4 ms.

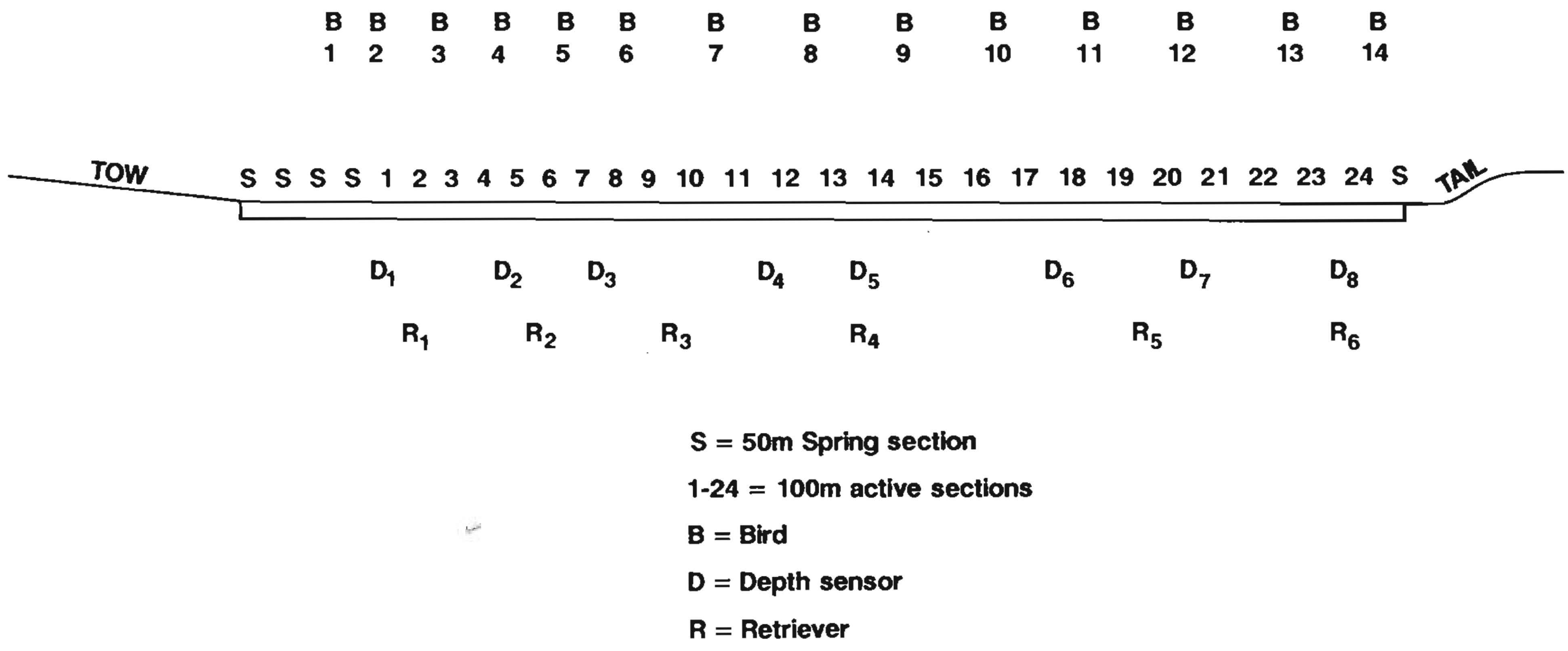
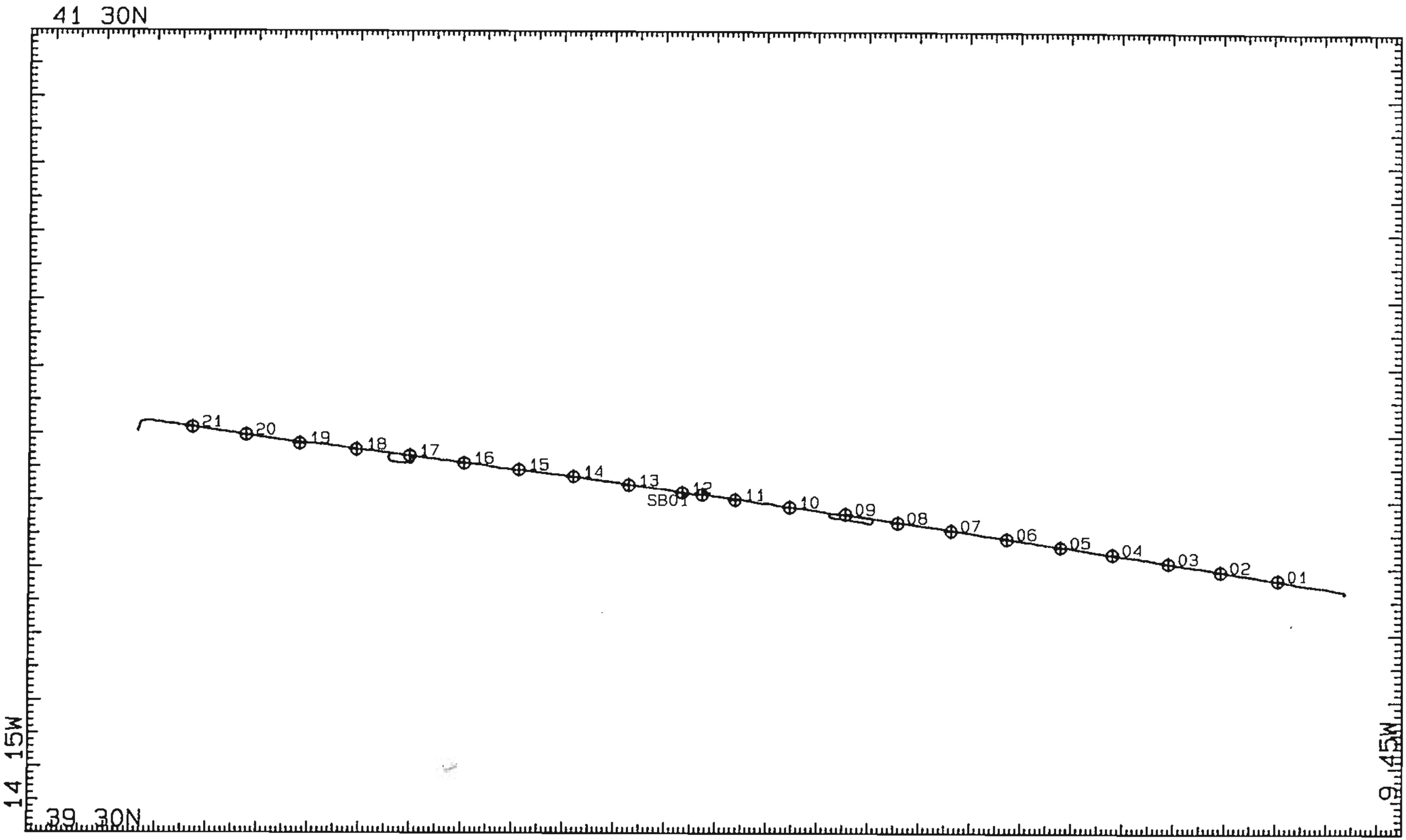


Figure 13: Multichannel streamer configuration

Table 1: Multichannel Seismic Lines

Line number	First shot	Last shot	First tape	Last tape
CAM125	2147:00/203	1058:36/204	1A	38B
CAM126	2250:19/204	0807:43/205	SAQ1	SAQ3
CAM127	0753:57/218	1235:19/218	1A	12B
CAM128	0902:41/220	1055:38/220	13A	14B
CAM129	1123:00/220	1334:40/221	15A	17A
CAM130	1335:30/220	2353:00/220	18B	31A
CAM131	2353:50/220	0205:30/221	32B	34B
CAM132	0206:20/221	0843:00/221	35A	43A
CAM133	0843:50/221	1135:30/221	44B	47A
CAM134	1140:30/221	1817:10/221	48B	56B
CAM135	1818:00/221	1945:30/221	57A	58B
CAM136	1946:20/221	0307:10/222	59A	68B
CAM137	0308:00/222	0435:30/222	69A	70B
CAM138	0436:20/222	1028:50/222	71A	78B
CAM139	1029:40/222	1241:30/222	79A	81A
CAM140	1242:10/222	1918:50/222	82B	90B
CAM141	1919:40/222	2131:20/222	91A	93A
CAM142	2132:10/222	0918:00/223	94B	109A
CAM143	0918:50/223	1128:00/223	110B	112B
CAM144	1128:40/223	0200:00/224	113A	134B
CAM145	0200:50/224	0408:50/224	135A	137A
CAM146	0409:30/224	1051:10/224	138B	146B
CAM147	1052:00/224	1728:40/224	147A	155A
CAM148	1729:30/224	2237:50/224	156B	162B
CAM149	2238:40/224	0514:30/225	163A	171A
CAM150	0515:20/225	0811:10/225	172B	175A
CAM151	0812:00/225	1916:10/225	176B	190B
CAM152	1917:00/225	2044:30/225	191A	192B
CAM153	2045:20/225	0406:10/226	193A	202B
CAM155	0407:00/226	0915:20/226	203A	209A
CAM156	0916:10/226	0957:50/226	210B	210B
CAM157	0958:40/226	1322:50/226	211A	215A
CAM158	1323:40/226	1647:00/226	216B	220B
CAM159	1647:50/226	0220:20/227	221A	234B
CAM160	0221:10/227	0627:00/227	235A	240B



MERCATOR PROJECTION

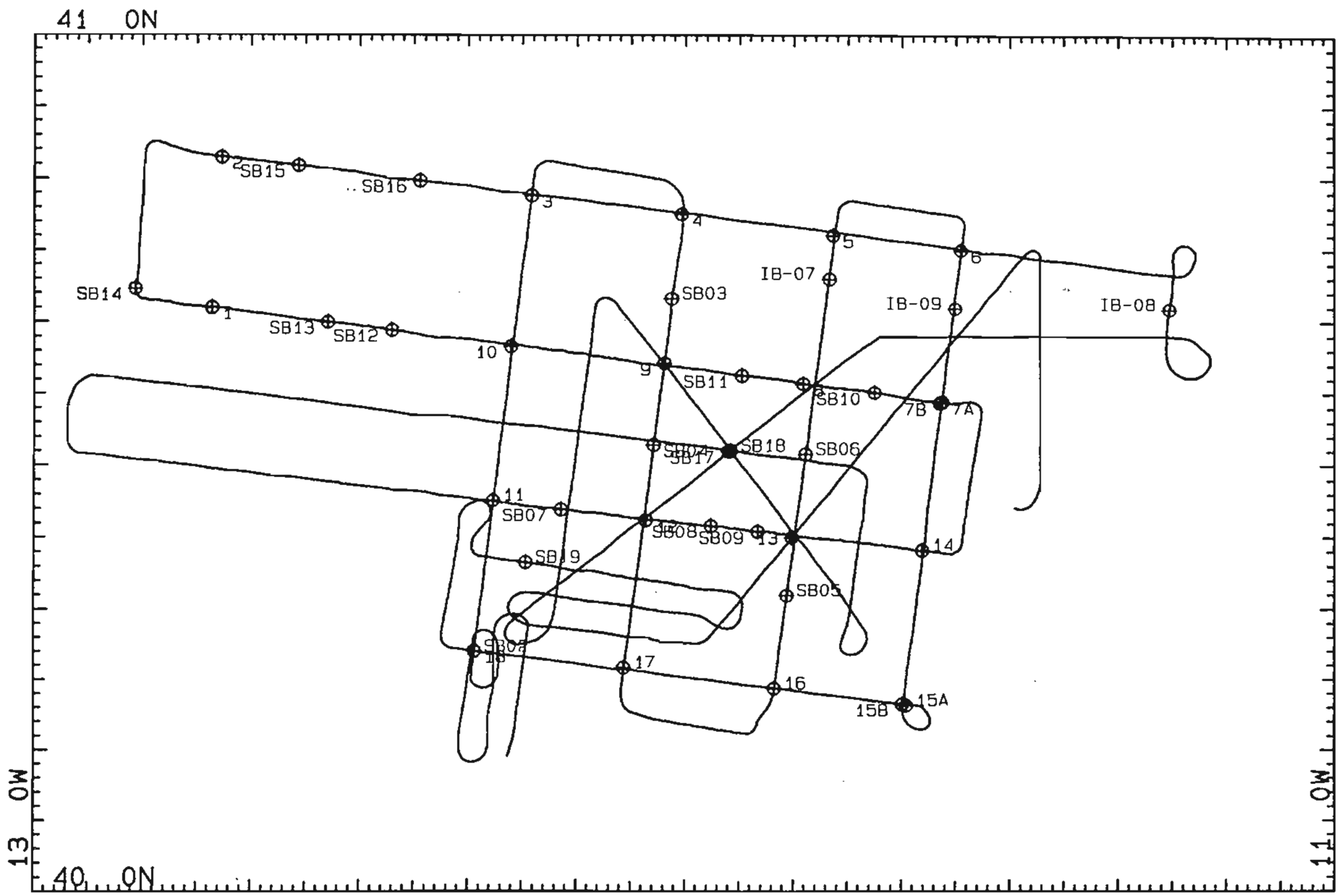
SCALE 1 TO 1500000 (NATURAL SCALE AT LAT. 40)

INTERNATIONAL SPHEROID PROJECTED AT LATITUDE 0

GRID NO. 1

— Track plotted from bestnav

Figure 14: Shooting track for first OBS deployment
DOBS locations are numbered 1-21. SB = Sonobuoy.



MERCATOR PROJECTION

SCALE 1 TO 750000 (NATURAL SCALE AT LAT. 40)

INTERNATIONAL SPHEROID PROJECTED AT LATITUDE 0

GRID NO. 1

Figure 15: Shooting track for second OBS deployment
DOBS locations are numbered 1-18, SB = Sonobuoy,
and IB-07, IB-08 and IB-09 are proposed drillsites.

MULTICHANNEL PROCESSING (Simon Pickup)

Introduction

Onboard multichannel processing during the cruise was done using Promax, the seismic data processing package from Advanced Geophysical. The software was installed on a Sparc 1 Sun workstation which was directly attached to a 2Gbyte disk drive and a 1/2" tape drive. There were three aims to the onboard processing. Firstly to demultiplex the SEGB field data recorded on 1/2" tape by the data acquisition system and output it to 8 mm exabyte tape in SEGY format ready for final processing after the cruise. Although there was no exabyte drive attached directly to the Sun workstation it was possible to transfer the data over the Discovery computer network to an exabyte drive attached to an RVS workstation. The other aims of the onboard processing were to undertake quality control checks on the data so that any acquisition problems could be dealt with and to produce quick brute stacks so that, if necessary, survey lines in the latter part of the cruise could be relocated over any new scientifically interesting targets.

Data Processing

First Leg

The two seismic lines acquired during the first part of the cruise provided an excellent opportunity to test the effectiveness of the onboard processing system and allowed us to perform early quality control checks on the data before going into the second leg, the main period of multichannel acquisition. The first profile, CAM125, was shot with a watergun source and only 8 channels of the streamer were recorded on the Sercel. Checks on the shot gathers and frequency spectra from this line illustrated that the signal to noise ratio was low due to a relatively small source although the data quality was good enough to image top basement. It was also noted that there were a large number of missing shots due to problems with the Sercel recording equipment. As there was a particularly large gap in the middle of this profile, 182 shots, it was decided to split the line into 2 profiles, CAM 125a and CAM125b. The processing sequence used on these lines were essentially the same as that applied to all the data during the second leg of the cruise (see Table 2) although an f-k migration was applied to a section of CAM125b using a constant velocity of 1500 m/s. This migration was carried out in order to improve the image of a possible rotated fault block within continental crust.

Line CAM126 was shot using airguns and 4 channels of the hydrophone array and was recorded on the SAQ data acquisition system. Quality control checks showed that the data contained a 50 Hz mains frequency and spurious energy spikes at certain places and on certain channels along the line. This noise suggested that there were some problems with the SAQ recording system. The 50 Hz noise was removed by application of a notch filter and the spikes removed using an amplitude clip to remove any signal with an amplitude greater than a predefined value.

Second Leg

To produce brute stacks of all the major seismic lines during the second leg it was essential to set up a simple but effective processing sequence which would take up as little cpu time as possible and could easily be adjusted for each profile. The processing sequence used is summarised in Table 2.

Table 2: Onboard Multichannel Processing Sequence

1. Input SEGB data from tape, demultiplex and write to disk.
2. Velocity Analysis
   Single trace display to obtain approx. time of seafloor and top basement events.
   These event times are used to construct a crude table of stacking velocities.

time (s)	velocity (m/s)
sea floor	1500
top basement	1600 to 1800
10.5	2500
13.5	4000

3. Stacking velocities checked by applying NMO correction to every 100th CDP.
4. Edit bad shots
5. Common midpoint sort
6. Spherical divergence correction
   Using stacking velocities
7. Trace amplitude equalisation
   Applied over an 8-10 s window
8. Normal moveout correction
9. Common midpoint stack
10. Time variant bandpass filter
    Ormsby filter

application time(s)	low cut (Hz)	high cut(Hz)
6.0-8.0	4-7	50-70
9.0-16.0	4-7	30-50

    interpolating between application gates
11. Automatic gain control (time variant)
    500 ms window from 7.0-7.5 s
    3000 ms window from 10.0-13.0 s
    interpolating between times
12. Plotting
13. Output shot gathers and stacks to 8 mm exabyte tape in SEGY format

Prestack Processing

First of all the data were demultiplexed on input and written to disk in Promax's own internal data format. A single trace display was then produced so that the seafloor and basement event travel times could be picked. The travel times of these horizons were then used to construct a crude stacking velocity table for each profile. Rms stacking velocities of 1500 m/s, 2500 m/s and 4000 m/s were assigned to the seafloor, 10.5 s and 13.5 s time lines respectively. The rms velocity assigned to the top basement varied from 1600 m/s to 1800 m/s according to its depth below the seafloor. The resultant stacking velocities were then tested by applying the corresponding normal moveout correction to every 100th CDP to check that the correction was reasonable. In general this very crude velocity analysis proved to be very effective and much quicker than using semblance plots, particularly after applying it to the first line or so when a feel for a good velocity function had developed.

After creating a velocity function the data were run through steps 3 to 13. Before stack this consisted of editing out any bad shots which were noticed during the recording and applying a spherical divergence correction, trace amplitude equalisation and normal moveout correction. Trace amplitude equalisation was used to reduce the effect of any high amplitude noisy traces on the stack.

Other prestack processes which were tested include bandpass filtering and predictive deconvolution. Bandpass filtering applied before trace amplitude equalisation produced good results and helped suppress any high amplitude, low frequency noise. However it also increased the processing time and would have made it difficult to obtain brute stacks of all the major lines during the cruise. Predictive deconvolution was tested on line CAM127 where only one gun beam, consisting of 3 airguns, was used as a source. From looking at the autocorrelation function of the source wavelet it was evident that for final processing deconvolution would be necessary since a large bubble pulse was present between 70 and 100 ms after the first break. As a result CAM 127 was processed with predictive deconvolution using an operator length of 300 ms and a predictive gap of 48 ms. However, predictive deconvolution was not applied to any of the subsequent lines since it would have considerably increased the processing time. In the final processing it may also be useful to try source signature deconvolution since the source wavelet can be obtained from any of the ocean bottom recording instruments.

Post Stack Processing

After stack a time and variant bandpass filter and automatic gain control (AGC) were applied. The bandpass filter was aimed at removing low and high amplitude noise from the lower part of the section. It was noted during the design of this filter, which was primarily based of the result of f-k plots, that the presence of low frequency wave noise was very limited. This was mainly due to the fact the hydrophone array was operating at around 20 m below the water surface, too deep to be affected by the action of waves. The application of a time and spatially variant AGC was to ensure that all major sedimentary reflectors were represented whilst attempting to maintain the true amplitude of deep basement reflectors.

Summary

On the whole the onboard processing was very successful with all our main aims being achieved. All the field data were demultiplexed and output as SEGY files on 8 mm exabyte ready for final processing, quality control checks performed and brute stacks produced which helped us to locate extra lines acquired after the initial survey had been completed. The only problem encountered during the processing was one of computer and network communications speed which meant that the processing was always a day or two behind the acquisition. Although the computer system used was adequate a more powerful workstation as well as an exabyte drive attached directly to the processing workstation would have undoubtedly enabled us to process the data at a faster rate. It would also have been useful to have a Versatec electrostatic plotter (or similar) on which to print the profiles as opposed to the colour A4 inkjet printer which was used.

OCEAN BOTTOM SEISMOGRAPHS

A total of 22 OBSs of five different types were brought on the cruise:

1) Two Cambridge OBSs (12 and 13) in deep-water tubes, recording a single hydrophone channel on four Sony Walkman cassette decks. During the first deployment, these recorded at 128 Hz sample rate, with an anti-alias filter ramping down between 32 and 64 Hz. During the second deployment, to extend the recording period, OBS12 was deployed with a new EPROM with 64 Hz sample rate. It was not possible to change the anti-alias filter, but resampling of data from the first deployment to 64 Hz without filtering indicated that there would not be a significant aliasing problem. These were deployed with Oceano RT161 releases and Novatek flashing lights borrowed from RVS. OBS12 was not successfully released and remains on the seabed. OBS13 had only recorded on the first three tapes; the reason for malfunction of the fourth was not obvious.

2) Four Cambridge OBSs (16-19) in glass spheres (SOBS). These had the same electronics as the tubes, and OBS16 was also deployed on the second deployment with a 64 Hz EPROM. One glass sphere was broken during handling in preparation for the first deployment, but since one of the Minidobs was not operational (see below), its glass sphere was borrowed and all four instruments were deployed. There was a shortage of releases available from RVS due to competing demands from a cruise on RRS Charles Darwin, so in addition to one Oceano RT361 and one RT661 from RVS, we borrowed two RT661's in IOS pressure tubes from IOSDL. These IOS releases used pyros. On the first deployment, one instrument, OBS18, did not record because a connection in the battery pack pulled out when the instrument cooled down at the seabed. One sphere was also damaged, and since one of the Minidobs spheres was also damaged, only OBSs 16 and 17 could be used for the second deployment. Both recorded in full. Clock drifts were monitored for both these instruments and OBSs 12 and 13 relative to the Cambridge "Lucky 7" scientific clock, which was in turn monitored against GPS time using the IRIGB code from the RVS clock and a four-channel jet-pen recorder.

3) Six Cambridge Minidobs (20-25). These were relatively new instruments in glass spheres, recording hydrophone data at 256Hz sample rate on SCSI hard disks, and with internal Oceano release cards operating a burnt wire release mechanism. (see below)

4) Four IOS OBSs (055, 065, 165 and 215, see below)

5) Six Dalhousie OBSs (A-F, see below)

The OBS locations and recording times for each OBS are summarised in Tables 3 and 4.

Minidobs (Tim Owen and Richard Smith)

Four minidobs had been completed and very thoroughly tested in the Lab, but two new ones had not been exhaustively tested before embarkation. Problems with CPU boards meant that we were very short of fully functioning spares. The 4 Oceano release cards we needed had arrived shortly before leaving, and had been carefully assembled but not thoroughly tested. We were therefore kept busy during the leg to Lisbon setting up the instruments and checking the releases. We experienced problems with one instrument (#22) early on and put it on one side to be sorted out when the others were completed, as we thought it had a CPU problem, and we were not certain of having a fully operational spare. The sphere for this instrument was given up to the SOBS team to replace their shattered sphere. We had completely checked the known good 5 instruments and measured clock drift rates in the lab by the time of first deployment. As we were preparing for deployment, we experienced a problem with the release system in #21, and exchanged that unit for the one from #22.

We were using plastic frames and attached a small length of chain (about 2 kg) to the rig for stability. A 17" float was attached to the 12 m strayline, and recovery aids were a small flag and a Novatech Xenox strobe light. We had a set of new releases made of slightly different material and to less precise tolerances, so we were concerned that they would not be forced open by any shock loads during launching. The trays on the bottom of the frame made it very easy to rig releases in the lab, although it was very difficult to plug in the release and hydrophone in the limited space under the sphere. Our release test box and the ability to turn on the release and measure the voltages on the release link and then turn them off gave a good feeling of confidence. Each minidobs was tracked down for 10 minutes to ascertain the sink rate, which was about 60 m/min.

First Deployment

The instruments were released after 36-72 hours by using the dunking transducer from about 3 miles off the site. The TT301 deck unit ranged without difficulty, and release was effected about 10 to 11 minutes after transmitting a pair of release codes. As soon as the minidobs was observed to release, the ship was moved to about 700 m off the instrument deployment position, by which time it had usually reached about 2500 m, at an ascent rate of 76-80 m/min. Instruments were spotted very quickly on the surface at ranges up to 700 m since the weather was fair (Force 3). The Novatech light unbalanced the minidobs considerably, and was almost underwater much of the time. The small, bright flag was quite visible, but a reflective strip might be a good idea, particularly if the light failed. They were easily grappled

TABLE 3: FIRST OBS EXPERIMENT

Posn	Dobs	Lay	Position	Shotpoint	Depth	lay date, time	recording starts	recording ends	comment
		Latitude	Longitude	IAM-9	(u/c m)				
1	M20	40 08.30	10 09.32	13720	3886	30/07/1995 1121	01/08/95 13:00	03/08/95 16:00	leaky hydrophone
2	B16	40 09.54	10 20.58	13510	4196	30/07/1995 1325	02/08/95 02:00	03/08/95 18:22	
3	W165	40 10.79	10 30.82	13310	4451	30/07/1995 1433	01/08/95 13:00	01/08/95 19:00	disk corrupted
4	M21	40 12.16	10 41.90	13100	4687	30/07/1995 1608	01/08/95 13:00	03/08/95 23:10	
5	B12 (tube)	40 13.20	10 52.16	12900	4828	30/07/1995 1712	02/08/95 02:00	03/08/95 20:48	
6	W56	40 14.43	11 02.69	12700	4908	30/07/1995 1902	01/08/95 13:00	01/08/95 19:00	disk corrupted
7	B13 (tube)	40 15.70	11 13.70	12490	4988	30/07/1995 2010	01/08/95 23:00	03/08/95 17:38	
8	D C	40 16.82	11 24.26	12290	5077	30/07/1995 2122	01/08/95 13:00	03/08/95 23:00	
9	B17	40 18.00	11 34.46	12090	5119	30/07/1995 2245	01/08/95 19:00	03/08/95 13:51	
10	D F	40 19.12	11 45.46	11885	5147	31/07/1995 0012	01/08/95 13:00	03/08/95 23:00	
11	M23	40 20.17	11 56.15	11680	5167	31/07/1995 0127	01/08/95 13:00	04/08/95 17:40	
12	W55	40 21.26	12 06.60	11480	5022	31/07/1995 0242	01/08/95 13:00	02/08/95 07:00	disk corrupted
13	D B	40 22.39	12 17.07	11280	5210	31/07/1995 0856	01/08/95 13:00	04/08/95 23:00	
14	B18	40 23.63	12 27.95	1075	5214	31/07/1995 1000	01/08/95 13:00	01/08/95 13:00	battery failed
15	D D	40 24.69	12 38.66	870	5230	31/07/1995 1114	01/08/95 13:00	03/08/95 23:00	
16	M 24	40 25.61	12 49.51	665	5249	31/07/1995 1226	31/07/95 12:10	01/08/95 12:00	flooded
17	W 215	40 26.72	13 00.23	460	5269	31/07/1995 1337	01/08/95 13:00	01/08/95 19:00	disk corrupted
18	B19	40 27.62	13 10.74	260	5277	31/07/1995 1700	01/08/95 13:00	03/08/95 07:39	
19	D E	40 28.56	13 21.77		5285	31/07/1995 1819	01/08/95 13:00	03/08/95 23:00	
20	M25	40 29.83	13 32.36		5288	31/07/1995 1928	31/07/95 19:00	06/08/95 01:15	
21	D A	40 30.94	13 42.97		5288	31/07/1995 2043	01/08/95 13:00	01/08/95 13:00	failed to record

M = MiniDOBS
B = Bullard old DOBS
W = Wormley DOBS
D = Dalhousie DOBS

TABLE 4: SECOND OBS EXPERIMENT

posn	dobs	Lay Latitude	Position Longitude	Depth (u/c m)	lay date, time	recording starts	recording ends	comments
2	W215(60/80)	40 51.46N	12 42.7W	5262	06/08/95 18:14	08/08/95 15:00	08/08/95 21:29	disk corrupted
3	M20	40 48.84	12 14.12	5212	06/08/95 20:18	08/08/95 09:00	17/08/95 09:00	
4	D C	40 47.52	12 00.31	5100	06/08/95 21:51	08/08/95 15:00	13/08/95 03:00	
5	B16(64)	40 46.06	11 46.35	4986	06/08/95 23:32	09/08/95 11:00	12/08/95 18:12	
6	D F	40 45.01	11 34.53	4908	07/08/95 01:00	08/08/95 15:00	13/08/95 03:00	
7A	B17	40 34.43	11 36.26	5093	07/08/95 02:30	08/08/95 15:00	10/08/95 10:02	
7B	W165	40 34.36	11 36.47	5094	07/08/95 02:48	10/08/95 10:55	14/08/95 00:03	
8	M21	40 35.7	11 49.09	5144	07/08/95 04:07	08/08/95 09:00	14/08/95 09:00	
9	D B	40 37.14	12 01.9	5191	07/08/95 09:08	08/08/95 15:00	13/08/95 03:00	
10	M23	40 38.31	12 16.03	5231	07/08/95 10:41	08/08/95 09:00	13/08/95 23:00	
11	D A	40 27.51	12 17.68	4908	07/08/95 12:09	08/08/95 15:00	08/08/95 16:00	recording failed
12	M25	40 26.21	12 03.6	5191	07/08/95 13:43	08/08/95 09:00	15/08/95 04:00	some noise spikes
13	D D	40 25.0	11 50.14	5161	07/08/95 15:02	08/08/95 15:00	13/08/95 03:00	
14	B12(64) tube	40 24.12	11 38.11	5128	07/08/95 16:15	08/08/95 23:00		not recovered
15A	B13 tube	40 13.17	11 39.57	5100	07/08/95 17:57	09/08/95 03:00	10/08/95 14:12	
15B	W55	40 13.26	11 39.91	5100	07/08/95 17:33	10/08/95 18:55	10/08/95 18:55	disk corrupted
16	W56	40 14.38	11 51.75	5141	07/08/95 19:16	09/08/95 01:00	09/08/95 19:28	disk corrupted
17	M22 (24)	40 15.85	12 05.6	5172	07/08/95 20:32	08/08/95 09:00	15/08/95 00:30	clock jump

M = MiniDOBS
B = Bullard old DOBS
W = Wormley DOBS
D = Dalhousie DOBS

and hauled over the rail by hand, taking care to keep the instrument upright as it came aboard.

Instrument #24 was obviously 1/4 full of water and was opened very quickly. Surprisingly little damage had occurred to the electronics even though the water was up on top of the battery compartment, and nothing was sealed. All boards were washed in fresh water immediately, and the hard disk connected to the PC. It had run for 24 hours, after which it had struggled for 12 hours to reboot the ADC and then died completely before shooting started. A glass chip had broken out around one top connector, completely across the sealing face. It is impossible to know when water entered, as the total weight of water in the sphere would not have materially altered its ascent rate. The ADC may have failed because a little water shorted the ADC power in the pre-amp box in the bottom of the instrument, but it is possible that the two are unconnected and inundation occurred during ascent and recovery.

The other four instruments were still recording on recovery, and had clocks reading approximately the correct time. One was subsequently found to be about 250 ms adrift, which may be the result of a clock jump. The disks contained data covering the entire shooting period, but one (#20) was somewhat noisy, which was traced to a hydrophone that had flooded through a small crack. Sample record sections from each instrument were replayed during recovery and before redeployment and all data (about 300 Mb in total) transferred to PC and Sun. On recovery, almost all of the releases had one or two rusted pivot pins - obviously made of mild steel or very inferior stainless. We had the two original releases and were just able to remake another three using good pivots.

Second Deployment

During the first deployment we established that instrument #22 had damaged ADC chips for which we had not spares, and we were not confident that the CPU was entirely right. We were able to used the ADC boards, CPU and MIO boards from #24 in instrument #22, and reclaim its original sphere from the SOBS. The CPU retained its instrument number to the second deployment, so the instrument was #22 alias 24. The minidobs program was changed for the second deployment to servo the long term average value to 6 bits in the compaction algorithm to enhance data resolution, and the pre-amplifiers of all instruments except #20 were modified to increase gain from about 3.5 to about 15 to improve signal-to-noise ratios in the light of the amplitudes recorded in deployment 1.

Hard disks from deployment 1 were not reused, and instead new 540 Mb Quantum Maverick drives were fitted to all instruments. The minidobs were all programmed to start recording at 0900 on Julian day 220. On recovery, all the instruments had stopped recording, but the clocks were still running. Only #23 was not capable of being reset and run without opening the sphere. This instrument required the sphere to be opened and auxiliary power to be applied, and then showed a reasonable clock time. There was no sign of leakage and very little spalling of the sphere edges, although one hemisphere had a small crack in the edge where it had been banged during assembly. The modified releases showed no sign of corrosion.

IOSDL Digital Ocean Bottom Seismographs (Bob Whitmarsh and David White)

Four Digital Ocean Bottom Seismographs (DOBS) were used during the cruise. The Teledyne Portable Digital Acquisition System (PDAS) within each DOBS, as used up to 1994, had hard disks with a recording capacity of 40 Mb, which was insufficient for the objectives of the cruise. Therefore during late 1994 and 1995 tests were conducted to replace the old hard disks with 540 Mb disks, as had already been done by Durham and Leicester for their own PDASs. New disks were purchased from Quantum (Model LP540S), together with SCSI host adapters to speed up data transfer. At the same time MSDOS 5.0 was installed in each PDAS, to enable a single partition of 525 Mb to be used, as was Teledyne's latest operational program version 1.73.

A single new system (PDAS number 165) was extensively bench tested to ensure that it could record continuous data on four channels at 100 samples/second. The tests were successful and other parameters (higher sampling rates and various file sizes) were also tried. As a result it was concluded that the new system was adequate to meet the requirements of the cruise. At this point the remainder of the hard disks were purchased. There was a choice between the `lightning' (a low power model), the `prodrive' (the relatively high power model we used for testing and that BAS had used in the field), and the `maverick', a medium power model. We naturally wished to use a low-power version and therefore chose `lightnings'. PDAS 165 fitted with a `lightning' disk was then run for 2 days logging four channels at 100 samples/second without a problem.

Unfortunately, for reasons that are still not completely clear, the performance of the four PDASs at sea did not match the expectations we had following the bench tests ashore. Each DOBS was deployed twice. All four PDASs had been programmed identically for continuous recording on four channels at 100 samples/second. Three failed after about the same length of time, during the third write to disk and after 6 hours of recording. The fourth PDAS (055) recorded for 18 hours and failed during the 25th write to disk.

A number of tests were carried out on the first two instruments recovered (PDASs 165 and 056) to investigate the failures and to discover what parameters would work for the second deployment. The faulty behaviour could be replicated on the bench and appeared to be the result of a program crashing (Norton Utilities indicated software rather than hardware failures) possibly as a result of a too-long overhead on the CPU whilst writing the disk. In the short time available before the next set of deployments it appeared that the disk overhead could be reduced by reducing the size of the disk partition, by writing smaller files and by reducing the number of channels. We were able to rule out low-temperature effects and battery supply as a cause of the problems.

Thus for the second deployment three PDASs (055, 065 and 165) were set to record one channel continuously at 100 samples/second. The fourth PDAS (215) was set to record 2 channels on a regular time schedule (60 seconds every 80 seconds) for operational reasons. On recovery we found that PDAS 165 had worked perfectly but PDASs 055, 056 and 215 had crashed in the same manner as before.

Since the cruise, we have been told by Teledyne that the `lightning' disk has never been reliably interfaced with a PDAS; no explanation has been provided for this incompatability. Teledyne also recommend using small partitions and a relatively small number of data files.

<u>**Dalhousie Ocean Bottom Seismographs**</u> (Keith Louden)

Six ocean bottom seismometers from Dalhousie University were used during the cruise, with independent financial support from the National Science and Engineering Research Council of Canada. The instruments can be deployed in depths up to 6 km and are released from their anchor by a 12-kHz acoustic command system with an independent backup timed-release unit. Recovery aids include RDF beacon and strobe. The instruments include 16-bit digital recording of 3-axis, 4.5 Hz geophones and broadband hydrophone. Maximum recording length depends on the digitization rate which is selectable from 43 Hz to 5 kHz. The rate used during these deployments was 174 Hz which yields a total recording period of approximately 4.5 days. The internal clock in each unit is synchronized to GPS time before deployment with an accuracy of <1 usec. After retrieval, clock drifts are determined to an accuracy of 0.1 msec. Total drifts for each deployment were never greater than 22 msec, or approximately 1 digital sample.

First Deployment

Six instruments were deployed (DA at posn 21, DB at posn 13, DC at posn 8, DD at posn 15, DE at posn 19, and DF at posn 10). Instrument DA did not record for unknown reasons. All other instruments recorded successfully for the entire line, although instrument DE developed a serious electronic fault before recovery. This fault could not be corrected at sea and the instrument was not used on the second deployment.

Second deployment

Five instruments were deployed (DA at posn 11, DB at posn 9, DC at posn 4, DD at posn 13, and DF at posn 6). Instrument DA only recorded during a short interval (220/1600-1700) at the start of shooting. All other instruments recorded successfully during the period 220/1500 to 225/0430).

General comments

(1) Data quality appears good with particularly high SNR on the geophone channels. A preliminary record section produced at sea from instrument DC on line 1 show clear wide-angle reflections and refracted phases out to ranges in excess of 30-50 km. There are very strong seabed multiple phases.

TABLE 5: SONOBUOYS

Sonobuoy	Deployed (GMT)	Latitude	Longitude	SAQ tape no.	Frequency (MHz)	Channel	Comments
1	13:33:35/214	40 20.96N	12 02.70W	4	163	2	
2	17:19:37/220	40 16.96	12 19.40	5	169	10	
3	03:24:35/221	40 41.63	12 01.24	6	164.5	4	
4	05:19:28/221	40 31.45	12 02.90	6	168.25	9	lost after 4 minutes
5	12:51:36/221	40 20.95	11 50.63	7	172.75	15	
6	14:44:26/221	40 30.78	11 45.89	7	167.125	23	receiver noise problems
7	13:56:07/222	40 26.95	12 11.41	8	163.01	2	
8	15:55:03/222	40 25.82	11 57.60	8	168.25	9	lost after 20 minutes
9	16:31:54/222	40 25.41	11 53.31	8	172.375	30	crosstalk problem
10	22:53:30/222	40 34.36	11 35.73	9	164.5	4	
11	00:44:24/223	40 36.28	11 54.76	9	168.625	25	
12	05:30:27/223	40 39.43	12 27.01	10	163.375	18	lost after 10 minutes
13	06:27:03/223	40 39.99	12 32.91	10	172.375	30	
14	09:15:50/223	40 42.3	12 50.66	10, 11	167.125	23	
15	13:28:12/223	40 50.88	12 36.36	11	163.75	3	crosstalk problem
16	15:13:16/223	40 49.85	12 24.43	11, 12	171.625	29	crosstalk problems solved
17	12:59:45/223	40 30.99	11 56.00	12	166	6	lost after 20 minutes
18	01:30:01/225	40 31.02	11 55.78	13, 14	170.5	12	wind force 6+
19	05:34:39/226	40 23.25	12 14.66	none	163	2	wind force 7+, no acoustic signal

(2) Preliminary analysis of the far-field airgun waterwave suggests that it is peaked at approximately 10 Hz with a bandwidth of 3 Hz. There are prominent harmonics at 20 and 30 Hz.
(3) The acoustic release system worked very well. Use of the ship's dual frequency echo sounder (at 12 kHz) was particularly helpful in confirming release from the bottom, as our separate receiving system was too noisy to reliably hear the acoustic returns in deep water.
(4) Recovery of the instruments proved difficult at times because the stray lines did not properly deploy. This problem was caused by use of rope with somewhat inferior quality. However the calm seas and good handling of the vessel and successful retrieval efforts by the ship's officers and crew resulted in no damage to the instruments during recovery.

DISPOSABLE SONOBUOYS

Nineteen Sparton Electronics AN/SSQ-57A sonobuoys were deployed on the cruise, one during the first OBS deployment and the remainder during the second (Table 5). Signals were received on three ICOM IC-R700 VHF receivers, using the permanently installed direction-finding aerial and two other aerials installed on the main mast, and low loss cabling down to the Main Lab. Signals were filtered and digitally recorded on two independent systems: the RVS SAQ four-channel acquisition system, recording in SEGY format on 2400' magnetic tapes, and a PDAS data logger borrowed from British Antarctic Survey, recording on a hard disk. The SAQ was set up to record 35 s records, while the PDAS recorded continuously. In principle the sonobuoy data could be inspected immediately after acquisition using Promax, but in practice this was rarely possible due to the competing demand for Promax to process the multichannel data. Data were displayed on an EPC and a Waverley recorder. The SAQ data suffered from cross-talk between the different channels. In general, on-board display showed ground waves out to ranges of 15-20 km only.