Ref. JR39B

No.D1

DRAFT

RRS *James Clark Ross*
February - March 1999
Cruise JR39b

Completed 11/3/99

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RRS *James Clark Ross*
February - March 1999
Cruise JR39b

R.A. Livermore, Chief Scientist
10th March, 1999

C.R. Elliott, Master
11th March, 1999

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1. Abstract

JR39b completed a varied programme of investigations into the East Scotia Ridge spreading centre. This ridge, forming the boundary between the Scotia and Sandwich plates, is one of the world's longest-lived back-arc spreading systems, having been active for more than 15 Ma, during which time it has created about 300,000 km^2 of east Scotia Sea floor. The entire East Scotia Ridge was mapped for the first time during cruise JR09a in 1995, using the HAWAII-MR1 towed sonar. This revealed nine distinct segments, dubbed E1 to E9. Seismic reflection profiling and detailed rock sampling were completed on selected segments of the ridge in 1996 during cruise JR12, and a set of deep crustal seismic profiles with ancillary wide-angle recording was obtained in 1997 during JR18.

The present cruise completed work under the present 'Oceanic Active Margins' programme, by carrying out deep-towed sonar mapping, seismic reflection and wide-angle surveys, as well as completing systematic geochemical sampling of almost all ridge segments. In addition, water column investigations were carried out using a CTD, and a limited amount of video footage was acquired using a deep-sea camera system.

The cruise objectives were met comfortably, including the detection of three hydrothermal plumes within the water column. It was not possible, however, to locate the vents responsible for these plumes with sufficient precision to justify deep-sea camera work. A surprisingly rugged sea floor morphology was imaged at the mermaid's purse, rising to depths some 300 m shallower than expected from earlier mapping, while a 300 m deep caldera was imaged at the summit of E9.

After some initial problems, the Southampton Oceanography Centre's deep-towed sonar, TOBI, completed two successful deployments, on E2 and E9. The deep-sea camera system, SHRIMP, also suffered some early teething problems, before providing good quality video ground truth on E2. A set of five ocean bottom hydrophones, supplied by GEOMAR (Kiel), performed well during two deployments, although with two recording failures, and provided high-quality data. Once again, the 'rock chipper' was used to obtain fresh glass samples from pillow basalts at more than twenty five sites, with a success rate of over 90%.

2. List of Personnel

Scientific and Technical

LIVERMORE Roy A	Ch.Scientist	BAS
BRUGUIER Nigel J	Geophysicist	BAS
CUNNINGHAM Alex P	Geophysicist	BAS
MORRIS Peter	Data Manager	BAS
GERMAN Christopher	Geochemist	SOC
FRETZDORFF Susanne	Geochemist	U.Kiel
MALDONADO Andres	Geophysicist	C.S.I.C / U.Granada
EAGLES Graeme	Research Student	U.Leeds
AUDLEY Neil	Mech.Eng	BAS
TAIT Andrew	Mech.Eng	BAS
LENS Peter	Comp.Support	BAS
COOPER Patrick	SonoR Support	BAS
DOMASCHK Urte	OBH Support	GEOMAR
HUNTER Christopher	Equip. Support	RVS
PAULSON Christopher	Equip. Support	RVS
ROUSE Ian	TOBI Support	SOC
WHITTLE Steven	TOBI Support	SOC
EDGE David	SHRIMP Support	SOC

Ship's Officers and Crew

ELLIOTT Christopher R	Master
PATERSON Robert C	Ch/Off
KILROY Robin T	2nd/Off
LIDDLE Andrew R	3rd/Off
SUMMERS John	Dk/ Off
HAIGH Thomas	Cadet
WADDICOR Charles C	R/O
CUTTING David J	Ch/Eng
KERSWELL Wiliam R	2nd/Eng
JONES Roger S	3rd/Eng
EADIE Stephen J	4th/Eng
WRIGHT Simon A	Deck Eng
THOMAS Norman E	Elec
GIBSON James S	Cat/Off
BROOKES Martin	Bosun
DODD Jonathon M	Bosun Mate
COSSEY Peter A	SG1
GRAHAM Roderick	SG1
O'SULLIVAN Neil B	SG1
DAVIS Raymond A	SG1
WATSON David N	SG1
SMITH Sidney F	MG1
ROBINSHAW Mark A	MG1
FOX Roy W	Ch Cook
BAILEY David R	2nd Cook
CLANCY John A	2nd Stwd
DIXON Tony N	Stwd
BALDWIN-WHITE L B	Stwd
HADGRAFT Simon D	Stwd

3 Timetable of Events

February 1999

10 Mobilisation of TOBI and SHRIMP commences, three seismic beams rigged.

11 Ship departs FIPASS at 19:30, STCM compensation loops completed at 20:50; magnetometer towfish deployed at 21:25; main bearing problem causes ship to slow to 4 kts briefly at 21:40.

12 Transit eastward to fill gap in magnetic data coverage.

14 Retrieve magnetometer at 15:00 and arrive King Edward Point, South Georgia at 17:00.

15 Depart King Edward Point 09:30; move to head of Cumberland Bay for trial deployments; SHRIMP deployed at 12:00, recovered at 12:30; TOBI deployed at 13:45, recovered 15:00; SonoR deployed at 15:30, recovered 16:00; OBH deployed at 16:15, recovered 16:35; depart Cumberland Bay 16:45; arrive CTD station 1 at 21:45; magnetometer deployed at 22:45.

16 Manetometer towfish recovered at 18:45; TOBI deployed at mermaid's purse 19:05, but power failure at 20:30, depressor recovered but problem is with umbilical: TOBI recovered by 22:40.

17 Deployed OBHs 1 to 5 along line S101, plus CTD at mermaid's purse; airguns and seismic streamer deployed by 14:00 and magnetometer streamed; SonoR released at 16:30.

18 Line S101 completed and seismic gear recovered; all OBHs recovered and OBH 6 to 9 deployed along axis of E2 ridge segment.

19 OBH 10 deployed and seismic gear deployed; line S102 commenced.

20 Line S103 completed, gear recovered; all OBHs recovered successfully; TOBI deployment attempted again with spare umbilical at 21:00, but failure again at 22:40; turns out to be umbilical fault again.

21 CTD completed on mermaid's purse, but no plume signal detected; return to TOBI deployment site for another attempt; TOBI deployment commences 16:15, once again failure and TOBI recovered; move to SHRIMP deployment site on mermaid's purse; SHRIMP deployed at 19:45, fails at 20:00 and recovered; wax coring commenced.

22 Wax coring programme underway, sites WX42 to WX44 sampled successfully; return for fourth TOBI deployment at 16:00, this time with scratch umbilical with coaxial bable tied to outside of aramid tow cable, now working, and cross-axis lines run.

23 E2 TOBI survey continues with N-S lines, good results from sidescan.

24 Strong winds (> 40 knots) make it impossible to stay on course, turn to wind and steam N; later, tow cable is shortened and ship returns to way points on E2 axis.

25 TOBI survey completed 22:30 and TOBI recovered.

26 SHRIMP deployed on mermaid's purse; only video available but good images recorded of pillow basalts on summit of E2; SHRIMP recovered at 12:10; Nephelometer signal detected on TOBI MAPR, ship moves to site for CTD; bad weather forces ship to heave to at 21:00.

27 Move to CTD station 7; followed by WX45

28 Wax core sites WX46 to WX51 on ridge axis

March

1 Wax core sites WX52 to WX 54

2 Wax core sites WX55 to WX 59

3 Wax core sites WX60 to WX64; TOBI deployed on E9 at 062/18:20

5 TOBI recovered and small bathymetric survey of 'Nigels Hole' completed; continue wax coring (WX65, WX66)

6 Wax Cores WX67 to WX69

7 Steam for ridge segment E10 - WX70, WX71(no recovery). Deployed proton magnetometer. Set course for Stanley

11 Arrive FIPASS

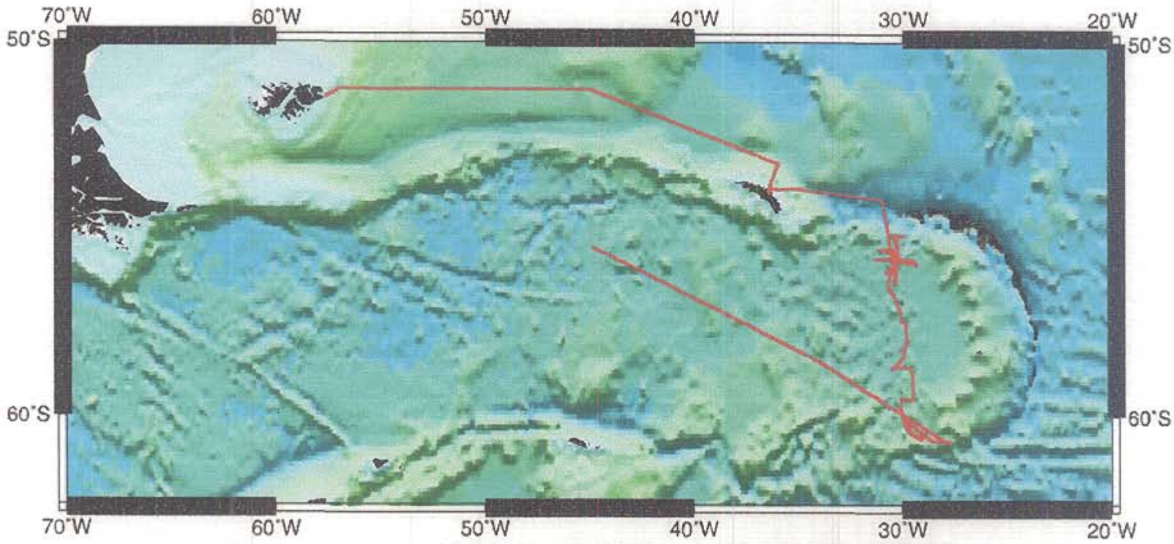


Figure 1 Track of RRS James Clark Ross during cruise JR39b

4 Introductionn

Cruise JR39b completed a program of deep-towed sidescan and bathymetric mapping, seismic reflection profiling, wide-angle recording and rock sampling on the East Scotia Ridge spreading centre.

This spreading centre is one of a special class of 'back-arc' ridges, i.e. it lies not in a mid-ocean setting, but in a marginal basin associated with the South Sandwich volcanic arc. Its present rate of opening, 65 to 70 km Ma^{-1}, puts it in the intermediate class of spreading centres, and makes it particularly sensitive to small changes in the supply of magma.

Mapping in 1995 with the HAWAII-MR1 sonar showed that two segments, one at either end of the ridge (E2 and E9), have a form suggesting a greater than normal magma supply. This is seen in their shallower axial depth (~2500 m versus ~3500 m for the other segments), and the existence of topographic highs at their centres, contrasting with the rifted median valleys seen elsewhere. These segments were the prime targets for detailed mapping with TOBI, and for the search for hydrothermal plumes and vents.

This was the first time that either a deep-towed sonar or deep-sea camera system had been deployed from *James Clark Ross*, although a 10,000 m conducting cable has been fitted to the ship since launch

5 Scientific Objectives

The objectives of the cruise were:

i. to image two anomalous ridge segments, E2 and E9, the former exhibiting a 600 m high, narrow, linear ridge known as the 'mermaid's purse', beneath which seismic profiling had previously demonstrated the presence of a lens of melt,

ii. to locate hydrothermal plumes on the ridge using optical sensors to detect particulates formed at sea floor vents and incorporated into rising plumes,

iii. to determine whether a seismic low-velocity zone exists beneath E2, by recording airgun signals using ocean-bottom hydrophones,

iv. to obtain representative rock samples on all ridge segments (in conjunction with previous *R/V Polarstern* dredging).

6 Achievements

E2 TOBI and SHRIMP Survey

Two TOBI passes were achieved over most of E2, (Fig.2), including the overlap with E3 at the southern end, and a linear ridge beyond the northern end. Maximum sidescan swath width of 6 km was achieved in most places, except where high relief features caused shadows. The rough texture of the apex of the mermaid's purse was clearly observed, contrasting with the very smooth sea floor, presumably caused by extensive volcanic flows, which surrounds it. Numerous volcanic seamounts were imaged and recorded for the first time.

The highlight of the survey is the presence of narrow, rugged, and very steep-sided ridges flanking the E2 axial high, although these are absent adjacent to the apex itself.

E2 Seismic Survey

Seismic lines were acquired along and across the axis of segment E2, centred on the 'mermaid's purse' feature (Fig. 3). A source of eleven airguns with total capacity of 7330 cu in was used to shoot into an array of five ocean bottom hydrophones. The aim was to establish whether a low seismic velocity zone exists here, indicating the presence of small amounts of melt in the mantle surrounding the magma lens previously observed here. Results indicate that such a zone does, indeed, exist.

E9 TOBI Survey

One N-S and three W-E seismic profiles were acquired, in order to examine the structure of oceanic basement created during an abrupt change in plate motions. These profiles show a remarkable change in basement structure, from rough and high-relief to the north, to smooth and deeply-buried beneath the kink itself. An extensive magnetic grid was acquired (Fig. 3), which demonstrates that a W-E trend of magnetic isochrons was maintained during the 15 Ma or so duration of the change.

E2 - E9 Rock Sampling

During transit down the ridge from E2 to E9, the opportunity was taken to complete the sampling of basaltic glass from the active spreading zone on each segment of the ridge. Dredging by Professor Colin Devey and his group aboard *Polarstern* last season, together with previous BAS dredging and wax coring, had left two segments still unsampled, and several only scantily represented. These omissions were filled with thirty new wax cores.

Technical Achievements

Both TOBI and SHRIMP were operated successfully for the first time aboard RRS *James Clark Ross*.

A new hydrophone and recording configuration, used for the first time on JR39a, was employed with success on two new lines over segment E2. This comprised a short, twelve-channel streamer, formed from spare sections of the Teledyne multichannel cable, and the new, Geometrics, seismic recording system.

A set of five GEOMAR ocean bottom hydrophones was deployed and recovered on two seismic lines. Data quality was good although two tapes failed to record.

The BAS re-usable sonobouy was deployed for more than 16 hours and recovered successfully. The signal to noise ratio of the recording needs to be improved.

The modified rock chipper worked well, with a good success rate in both the head and collar cups.

7 Equipment Performance

A complete summary of equipment operation is shown diagrammatically in Table 1.

7.1 Navigation (PM)

Navigation for Geoscience cruises is now carried out exclusively using GPS. There is a variety of different systems around the ship

1. Leica system - differential GPS used by ships officers for navigation purposes

2 Ashtech - differential GPS in ship's dynamic positioning (DP) system

3 Ashtech - second differential GPS in DP system

4 Trimble - differential GPS used as main scientific positioning system

5. Glonas - 'GPS' system using Russian satellites

6. Ashtech 3D GPS (not working on JR39b)

7. Simple GPS system on TOBI console

8. Simple GPS system providing time for OBHs

9. Simple GPS system on recoverable sonobuoy

Despite the fact that no two of these instruments give the same position, navigation is not currently a serious problem. Accuracy sufficient for all normal purposes is readily available at all times providing that there is an adequate constellation of gps satellites visible from the vessel. This, unfortunately, has not been the case on a number of occasions during this cruise. Such a situation causes more problems on the bridge when the ship is under dynamic positioning , or being steered along a precise course, than it does to scientific positioning where post processing can be carried out to obtain more realistic fixes. On most occasions when conventional differential gps has dropped out GLONAS continued to give a reasonable, if slightly less accurate, alternative for scientific positioning purposes.

7.1.1 Trimble GPS

No obvious problems

7.1.2 Ashtech 3D GPS /
TSS Motion Sensor (PM)

As it is desirable to include roll and pitch information in the correction of STCM data, the performance of these two instruments was monitored. As is normal, the Ashtech only worked intermittently. The TSS instrument has a history of problems. The original model fitted never worked correctly and was replaced in 1997. The new instrument had a tendency to go unstable and introduce 90° rolls. This was returned to the manufacturers for checking in spring 1998. It is obvious from the records obtained this cruise that despite this the problem has still not been solved (Fig. 6a). The true roll signal frequently is contaminated with low frequency noise, and the instrument goes unstable on occasion taking several minutes to recover. By contrast the pitch signal is good and correlates very well with that from the Ashtech (Fig. 6b). The TSS obviously is still in need of some serious repair.

7.2 Bathymetry

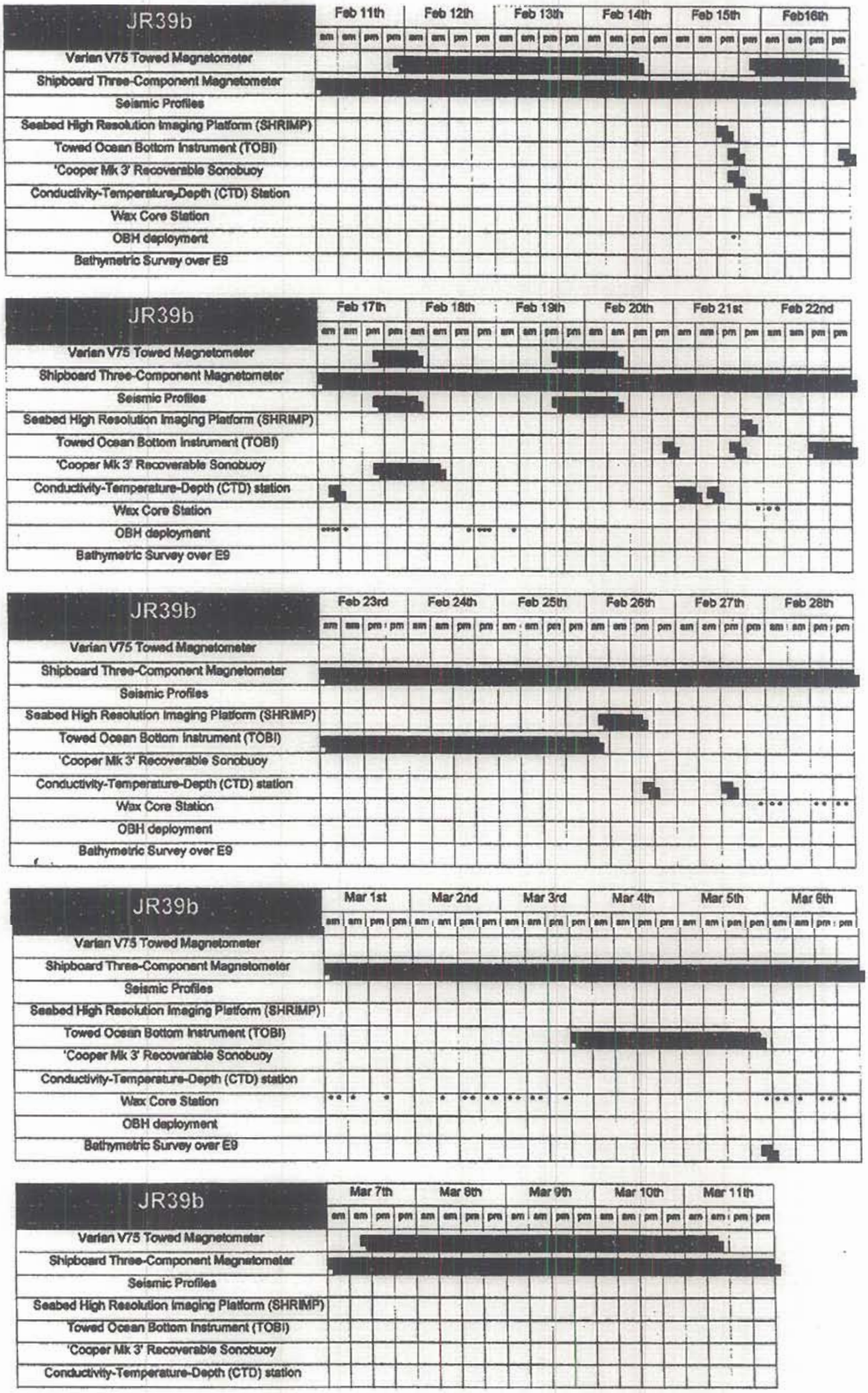
7.2.1 Simrad EA500

Worked reasonably throughout the cruise. As usual the instrument fails to lock on to the bottom reflection during rough weather leading to a loss in digital recording.

7.2.2 3.5 kHz Echo Sounder

This instrument is in a very bad state of repair. A replacement is urgently required.

Table 1 - Instrument Usage



7.3 Magnetics

7.3.1 Varian V75 Proton Precession Magnetometer S/No. 244 (CP)

The V75 Proton precession magnetometer consists of a sensor bottle containing a coil, Jet A1 airplane fuel (or similar) and pressure compensation bellows, connected to the polarization and counting electronics located in the UIC room via a 600 foot tow cable and inboard lead. The coil is polarized every 6 seconds and the exponentially decaying precession signal derived is multiplied by the proton constant (23.4875) and displayed as a frequency in Hz equivalent to the total field intensity in nanotesla.. The data are displayed both on an analogue recorder (two LSD) and also converted via a parallel interface into a serial string where they are recorded on the shipboard ABC system.

Operational Difficulties

The sensor bottle reterminated during leg JCR 39A was deployed shortly after leaving Stanley, initially this worked fine but the analogue trace became increasingly more noisy and eventually the bottle failed prior to arriving in Cumberland Bay , South Georgia. This was traced to water ingress into both the inboard cable connector and the connector on the sensor tow cable causing low impedance between coil conductor. These connectors were remade and the spare bottle was deployed after TOBI, SHRIMP, and CTD trials during transit and seismic lines with good results. It must be noted that the relatively short tow cable (600 foot from stern to sensor) can cause noise and heading errors and ideally a cable which can provide at least 800 foot of tow should be used for a vessel the length of *RRS James Clark Ross* (99.9m), i.e 2.5 times the ship length.

7.3.2 BAS Shipboard Three-component Fluxgate Magnetometer (PM)

Two three component magnetometers were in operation during JR39. The first is the original BAS instrument which has been run on all geoscience cruises since JR12 in 1996. The sensor mounting and outdoor electronic package for this STCM were improved for the 1997 - 8 season and have not been changed since. The second instrument is one of a batch constructed by BAS in 1998 and was installed on the JCR in Stanley immediately before sailing on JR39a. It was hoped that with two independent sensors located in different parts of the ship it would be possible to get better compensation. The ships magnetisation should affect the two instruments differently whilst true field changes would be the same for both.

Magnetometer 1 behaved impeccably during JR39b, just as it had done on the previous leg of the cruise (JR39a). Magnetometer 2 never worked satisfactorily during JR39a and the problems continued through JR39b. The sensor was positioned on the rail on the deck immediately below the old instrument.

The calibration coefficients found for the new STCM were always poor compared with those for the old instrument even though they were derived from exactly the same calibration loops.. Fig ** shows a typical piece of record from the two instruments, together with the corresponding proton magnetometer record. The old instrument tracks the proton data very well whereas the new instrument is considerably noisier and shows numerous unexplained jumps and drifts. The new STCM obviously needs a major overhaul before next season. Also it would be useful to have software available so that both instruments could be logged by a single PC thus saving on computer requirements and desk space.

As an active programme of calibration turns had been carried out on the preceding leg JR39a only one more was made on JR39b:

1 11/2/99 20:32:02 - 21:07:59 51.616S 57.592W

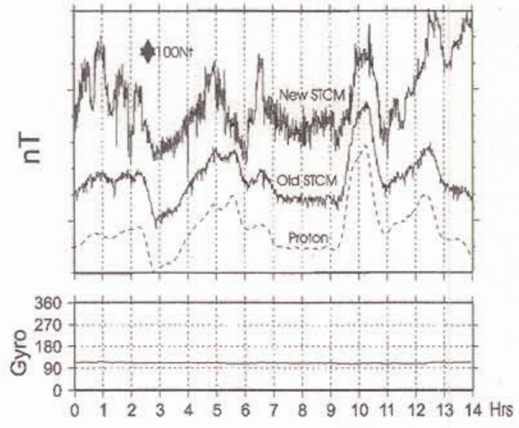


Figure 4 Magnetometer Comparison - Day 045

7.4 Seismic Reflection

7.4.1 Airguns (NA)

Introduction

The majority of the seismic equipment was already set up in position on the Aft deck, having been used on the earlier JR39a cruise. The only change was to use an extra two single airguns from two single umbilicals running from another single distribution board. Prior to leaving port the Engineering Technology shipping container was removed from the aft deck and stored in the forward hold. This extra deck space gave provision for the installation of the Southampton Oceanography Centre shipping container, used to support the TOBI. All times given in this document are local to the ship (The Falklands Islands are +3 hours to GMT). Arrival at the ship was made at 18:00 on 9 February 1999.

Equipment

RVS 12 Channel Hydrophone
BAS Air-gun handling System

System Components

Umbilical Winch (3 off)
Beam Crane (2 off)
7 Metre towed Air-Gun Beam (3 off)
Bolt 1500 c Airguns with the following chamber sizes (in cubic inches)
120 (1 off), 160 (2 off), 300 (2 off), 400 (2 off), 466 (4 off), 600 (1 off), 1000 (1 off)
Towed Hippo Buoy (3 off)

Recording and Firing system

Reftek Gun Controller
Geometrics strataview RX96 acquisition system

JCR fixed equipment

Hamworthy air compressors
Ship hydraulic system
JCR Gilson Winch (c/w 12mm diameter 7x19 ss wire)
JCR Port & Starboard Effer Cranes

Pre-cruise preparations and departure

During Julian days 041 and 042, the two single airguns were set up on the aft deck. The starboard single airgun to be used was fitted with a 600ci chamber and the port single airgun fitted with a 1000ci chamber. The three single umbilical lines were layed out along the starboard deck for checking and selection. The two selected lines were attached to the airguns and installed on the aft deck. The discarded umbilical was stored away in the aft hold. The solenoid to the 1000ci airgun was stripped for inspection and the coil found to be slightly 'sticky'. This was rectified, reassembled and refitted to the airgun. The two single airguns were set up on the deck, the umbilicals attached and secured. The goose-neck supply was moved from the starboard to the port side and connected to the stand-alone distribution board.

The beam/airgun chamber size (always referred to in cubic inches) configuration was as shown below;

Beam	Forward	Centre	Aft
Outer Starboard	400	120	466
Inner Starboard	300	160	466
Port	300	160	466
Starboard single	600		
Port single	1000		

Final setting up of the airguns and beams were made when underway following testing of the SHRIMP, the TOBI, and the OBHs in Cumberland bay at South Georgia.

First deployment

The first deployment of the airguns commenced at 05:30 on 17 February 1999 and was carried out in the usual manner of using the two Effer cranes to deploy the beams over the ship's sides, the starboard crane being used to deploy both beams on that side. The inner starboard beam was deployed first followed by the port beam and then the starboard outer beam. All the beams are deployed by paying out the Effer crane winch and the umbilical winch together leaving three complete turns of the umbilical on the winch drum. There is a marker at this point to show the appropriate position and allow it to be accurately repeated. This also acts to show any stretch or movement of the umbilical relative to the winch drum. At this stage the winch drum was also marked to show any possible 'creep' of the umbilical drum relative to the winch frame.

Next the 600ci airgun was deployed followed by the 1000ci airgun, both being deployed over the aft end using the stern gantry and the Gilson winch. The winch cable was secured to the airgun by it's rear mounting bolt hole to a shackle and the other end of the cable was secured to the deck of the ship once it was fully deployed.

All the airguns were satisfactorily sealed using 400 psi prior to paying-out the umbilical winch together with the Effer crane. The 120ci airgun was initially reluctant to seal when pressurised at the lower sealing-pressure of 400psi and continued to leak even with increased pressure. Experience has shown that often a sharp blow with a heavy hammer on the end of the main pressure housing would enable the shuttle to seal and so this method was used and the gun immediately sealed correctly. The only other problem that was noted during the deployment of the airguns occurred when deploying the single 1000ci airgun. As the full weight of the airgun, taken by the Gilson winch, and the strain-relief cable was being payed-out the umbilical had to be payed-out by hand over a roller block that was mounted on the bulwark gate. As the full weight of the umbilical became bias overboard it payed out very rapidly and was totally uncontrollable, only stopping when the electrical cable became trapped between the rotating roller and its mounting frame - this could have been very dangerous. This was clearly caused by the operation of the winch paying out the strain relief too fast. The cable was freed by hand and upon inspection it fortunately showed that only the outer sheath had been cut and all the conductor insulations were still intact. The sheath was repaired using self-amalgamating tape and insulation tape.

No other problems were encountered during deployment and when all the guns were out at full distance the supply pressure to all the guns was increased to the full operating pressure of 2000psi. All eleven airguns were running satisfactorily by 10:00.

At approximately 11:00 it became apparent that the starboard outer umbilical winch drum was paying out very slightly by itself due to the drag of the beam and buoy in the water as a marker we used to indicate full deployment was approximately 450mm further out than previously noted. The winch drum was hauled back to the correct position and the hydraulic supply isolated. The drum position was then continually monitored for any further creep but the problem did not recur.

All the airguns continued to operate satisfactorily throughout the duration of deployment. Compressor watches followed. During the 20:00 watch it was discovered that the No.3 compressor had automatically shut itself off due to running at too high a temperature. This did not have any immediate detrimental effect to the operation of the airguns but the Deck Engineer was duly informed of the problem.

The operation of the airguns continued to run until they were shut down at 23:45 hours 17 February 1999 in preparation for recovery.

First Recovery

The first recovery of the airguns commenced at 00:00 on 18 February 1999. The order and sequence of recovery was always the reverse of the deployment. Upon haul of the first airgun, the 1000ci single airgun, both the single airguns appeared together having become entwined. It was apparent that this had occurred at some stage during firing by the way the air-hose of the that airgun had been stretched. Both the airguns had to be brought in-board together and were layed on the deck and separated manually. A new hose was added to the air supply hose to ensure it would not be stretched again.

The three airgun beams were all recovered satisfactorily and placed in their stands. The 400ci airgun had flipped over the top of its beam and was hanging down the other side. This was manually lifted over the beam and allowed to drop down the other side once the beam was safely secured on deck in its stands. This occurrence had bent the swivel bolts on the beam to airgun hose/cable strain-reliefs. This made the removal of the strain-relief blocks very difficult.

Recovery was completed by 02:00.

All the airguns were washed down with hot fresh water, had the shuttles greased and re-set and the exhaust ports taped up to keep moisture out.

Second deployment

This deployment commenced at 12:00 on 19 February 1999. Again, the 120ci airgun was reluctant to seal initially until it was sealed using the same method as described earlier in the first deployment.

When all the beams and guns were fully deployed a check of the shot-phones showed that the 120ci airgun was auto-firing, ie firing continuously. The pressure to that airgun was backed off to 300psi and then returned to 2000psi, the problem disappeared and did not re-occur. Deployment was completed by 13:45. Compressor watches followed.

All the airguns continued to operate satisfactorily throughout the duration of their deployment.

Second Recovery

This recovery of the airguns commenced at 05:45 on 20 February 1999 in the same reverse order as before. The single airguns were recovered first and this time they were not entwined - using the winch cable on the same bracket as the hose strain-relief with a spacer was obviously beneficial.

The port beam had the lifting cable caught around it but this was easily corrected with careful manipulation of the Effer crane and umbilical controls. The same problem occurred with the starboard outer beam and again was corrected in the same way.

The recovery was completed by 07:30.

The solenoid to the 120ci airgun that initially was auto-firing was dismantled for inspection. The coil was found to be a bit 'sticky' within it's housing. This was cleaned, regreased and reassembled and appeared fine. This was then re-introduced to the airgun.

All the airguns were washed down with hot fresh water, had the shuttles greased and re-set and the exhaust ports taped up to keep moisture out. All the guns were subsequently dismantled, serviced and rebuilt. No significant damage or wear was apparent.

7.4.1.2 Deployment and Recovery.

7.4.2 Seismic Air Compressors (SAW)

The *James Clark Ross* is equipped with four air compressors for seismic operations. They are Hamworthy four stage water cooled machines. The four machines are controlled in cascade to generate compressed air over the range 138 - 155 bar. This is supplied to the guns from the common reservoirs via a regulating valve which governs the supply pressure to 135 bar (2000 psi). The requirements of this cruise required two machine to be run during 40 second firing rate periods and three during 20 second periods (ie during calibration). In both cases the final machine in the sequence was only on load for a short period of time.

Problems

None of the problems affected the operations in any way due to the over capacity of the system for operations of this nature. However during the initial periods there were a few minor faults which is only to be expected with equipment that can only be run for extended periods infrequently.

7.4.3 Seismic recording (CP)

The new RVS seismic recoding system uses the *Geometrics* StrataView RX96 as the acquisition system and a PC, running the *Geometrics* Marine Controller Software, to record the data which is stored on a pair of DAT drives. A second pair will automatically take over when the first drives get full. Two Printrex printers provide on-line hard copies of the near field gather and a shot "camera".

Compressed shot gathers were repeated after every line.

The Teledyne Hydrophone is directly connected to the Strataview. The Hydrophone was configured to give 12 channels with 25 m spacing. Two depth sensors were also fitted, one to the front of the first active channel and the other to the back of the last channel.. Hydrophone depths were logged onto Zip Drive via the logging PC.

The Hydrophone was extensively balanced on JR39a, the balancing configuration being retained for JR 39b

The synchronizing of the airguns was achieved by the Reftek firing system situated in the main Laboratory . The guns were fired a nominal 50 ms (+/- 2ms) after the fire pulse received from the firing control box in the UIC room. Exact times of the fire pulse were logged on a Level A. The position number and the exact delay times and amplitudes of the individual guns were monitored and logged onto a Zip Drive via the logging PC situated in the UIC room.

The overall fire timing of the system was tied to a 1 pulse per second obtained from an Ashtek G12 GPS receiver. A crystal delay unit provided a time delay which then allowed the next 1pps received to fire the guns, start the seismic recording system and reset the delay unit. The enable pulse also provided the pre-trigger required by the Reftek to digitize the depths of the airguns. Gun depths were recorded on the logging PC.

Geometrics Setup Parameter Summary

Number of Data Channels	12	
Active Spacing	25m	
Active Channel gain	24dB	
Aux Channel 1 gain	24dB	Not Used
Aux Channel 2 gain		Not Used
Aux Channel 3 gain		Not Used
Aux Channel 4 gain		Not Used
Transconductance	34 uv/ubar	
Sample Rate	4mS	
Delay	0S	
Record Length		
	12 S	
Recorded Data Bandwidth	0.3 - 103 Hz	103 Hz is the Anti-alias frequency for a 4mS sampling rate.
Display / Print Bandwidth	10 - 103 Hz	
Firing Rate	40 Secs	Synchronised to the exact minute, 20 Sec or 40sec GPS time

Hydrophone Configuration

Tow Cable	48.5m	Measured from Stern Roller - Max length = 150m
Boot	2m	
Spring	50m	un-stretched
Depth	1m	
Active	100m	4 x 25m groups
Active	100m	4 x 25m groups
Active	100m	4 x 25m groups
Depth	1m	
Spring	50	un-stretched
Rope	100m	Monkey's fist as drogue

Gun Configuration

GUN No.	Beam	Position	Size (Cubic Inches)
1	Starboard (Outer)	Forward	400
2	Starboard (Outer)	Middle	120
3	Starboard (Outer)	Aft	466
4	Starboard (Inner)	Forward	300
5	Starboard (Inner)	Middle	160
6	Starboard (Inner)	Aft	466
7	Single Tow	Astern (Stbd)	600
8	Single Tow	Astern (Port)	1000
9	Port	Forward	300
10	Port	Middle	160
11	Port	Aft	466

Total firing volume :7330 cubic inches

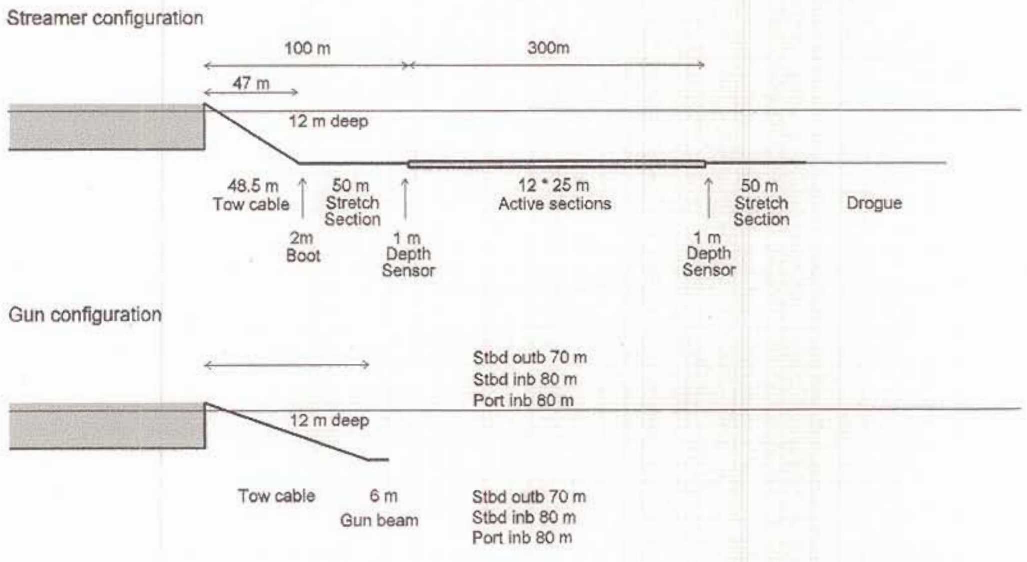


Fig 6 Streamer and Gun Array Configuratio

7.4.3 Operational problems

All eleven guns fired throughout lines BAS 989 - S101 to BAS 989 - S102, due in large to R.Phipps on leg JR39a, who discovered that certain gun solenoids failed to operate at high pressure and manufactured a rig to test them. The depth sensor on the 600 cubic inch gun began to fail towards the end of line BAS 989 - S102 possibly due to a flooded connection. Line S101 acquisition had to be restarted when one of the DAT drives failed to read a file , commenced to write to hard disk and then transfer writing to the standby drives 3 and 4. The line was terminated , the DAT drives reloaded and the line restarted with no further problems.

7.4.4 Seismic data processing (APC)

During cruise JR39b, seismic reflection data obtained on the cruise (lines BAS989-S101 and BAS989-S102) was processed with ProMAX 2D software mounted on UNIX workstation JRUE.

Navigation data

UKOOA shotpoint records were generated for the two profiles. During seismic acquisition, shots were triggerred by the ship's Ashtech G12 GPS receiver at 40s intervals (equivalent to a shot interval of c. 100m at 4.9 knots), and the observer's logs show no gaps in shooting (usually indicated by discrepancies between FFID and position number). As a consequence, shot times were simply incremented at 40 s intervals from the start of the line and a FORTRAN program jr39b_2.f fas used to relate seismic station number s directly to geodetic position via time. A correction of -48 s (equivalent to c. 120m at 4.9 knots, estimated from source geometry described elsewhere in this report) was applied to compensate for the offset between the GPS navigation antenna (c. 60m ahead of the stern of the ship) and the centre of the airgun array.

These data were also used to compute the recording windows and offsets of traces reconstructed from continuous data streams recorded by the GEOMAR ocean bottom hydrophones. In this case, an aditional 50ms was added to the shot times to reproduce the airgun synchronisation delay applied by the REFTEK seismic controller.

Processing of BAS989-S101 and BAS989-S102

Twelve channel seismic reflection profiles BAS989-S101 and BAS989-S102 were acquired and processed during cruise JR39b. These normal incidence data were obtained whilst shooting into an array of GEOMAR ocean bottom hydrophones and consequently have a wide shot interval of 100m. Measurements taken on deck during the cruise suggest that the offset between the centre of the airgun array and the near channel was c 40m (Fig 7 - plan view of source array). However examination of the raw shot gathers for the two profiles showed that the direct water wave reached the near channel between 10 and 18 ms after each shot, which implies a smaller source to near channel offset of c. 20m (possibly due to a shortened tow cable). CMPs were assigned so that CMP number on the stacked sections can be related directly to the shot (station) number logged in the UKOOA navigation files using the relationship:

CMP = (8 * (shot station - 1)) +1000

The processing scheme applied to these data includes the following steps:

1. Trace sequential SEG-D input (12 channels,4ms sample interval, 12 s record length)

2. Geometry assignment (CMP bin width = 12.5m)

3 -50ms static (to remove REFTEK airgun synchronisation delay)

4 Partial gain recovery (1500 ms-1 spherical divergence correction)

5 Bandpass filter (corner frequencies 8 , 100 Hz)

6 Prestack deconvolution (operator length = 350 ms, operator gap = 24ms, whitening = 0.1%, 4s design window including the sea floor reflection)

7 CMP sort

8 Normal moveout correction (applied using the subsurface velocity profile described in the JR39a cruise report)

9 CMP stack (1 or 2 fold)

10 Kirchoff post-stack time migration (applied to profile BAB989-S101 using smoothed 100% stacking velocities)

11 Time- variant filtering

F1 corner frequencies 4 and 70 Hz
F2 corner frequencies 4 and 30 Hz
F1 applied between 0 STWT and sea floor + 0.5 STWT
F2 applied between sea floor reflection and + 1 STWT and 12 STWT

12 Weighted 3-trace mix (trace weights 1:2:1)

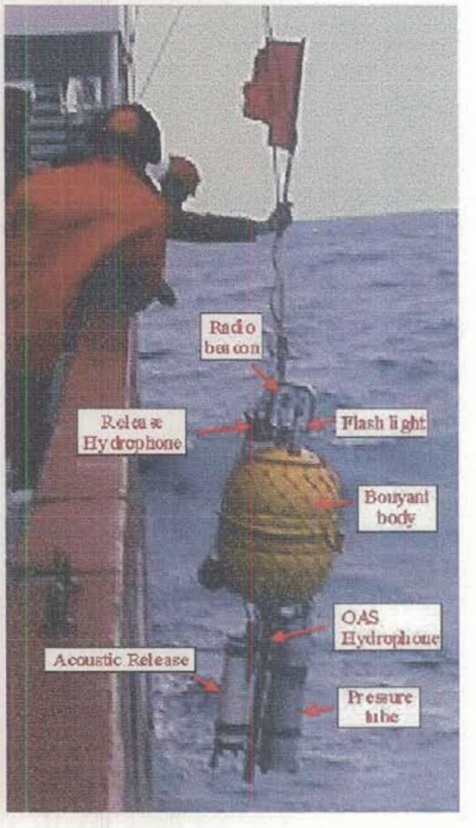
Raw shot gathers with geometry, prestack processed CMP gathers, stack and time migrated stack data were then archived to DAT tape in 32 bit floating SEG-Y format. A plot of the stacked and time migrated data (shown in Figs **** and ****) was produced using SU seismic processing software.

7.5 Ocean Bottom Hydrophones (UD)

The Instruments

The first GEOMAR Ocean Bottom Hydrophone (OBH) was built in 1991 and tested at sea in January 1992. A total of 5 OBH instruments were available for JR39b. This type of instrument has proved to have a high reliability; with more than 800 successful deployments.

Plate II GEOMAR OBH deployment



The principal components of the instrument are shown in Plate II, The design is described in detail by Flueh and Bialas (1996). The system components are mounted on a steel pipe which also incorporates the buoyancy body. The buoyancy is made of syntactic foam and is rated, as are all other components of the system, for a water depth of 6000 m, except for the pressure cylinders holding the recording electronics, which is limited to a depth of 3500 m. Attached to the buoyant body are a radio beacon, a flash light, a flag and a stray line for retrieving from aboard the vessel. The hydrophone for the acoustic release is also mounted here. The release transponder is a model RT661CE made by MORS Technology. Communication with the instrument is possible through the MORS transducer system. For anchors, pieces of railway tracks weighing about 40 kg each are used. The anchors are suspended 2 to 3 m below the instrument. The sensor is an E-2PD hydrophone from OAS Inc., and the recording device is a Methusalem recorder of DELTA t, which is contained in its own pressure tube and mounted below the buoyant body opposite the release transponder (see Plate *). The Methusalem consists of a preamplifier (26 dB), a highpass and antialias filter, a 13 bit A/D converter and a core memory of 0.768 MB. Signals are sampled at 800 Hz, and after FIR-decimation filtering, a resolution of 14 to 15 bits is achieved. Data are stored as 16 bit integers on a DAT cassette, which is run in audio-mode to save power consumption, and which can store about 1.1 GB of data. The power supply is from alkaline batteries for long term deployments. The instrument can be programmed before deployment through an RS232 interface. Up to 4 channels with different amplifications and sampling rates can be recorded.

Procedure

A DTCXO (0.05 ppm accuracy) is checked against GPS time before and after deployment. The DAT cassettes are read from a playback system, which simulates a SCSI interface, to a workstation for data reduction and analysis.

The initial data file is one continuous SEGY-trace in time of recording. For data analysis, this has to be divided into traces as long as shot interval in the shot window of the airguns. An UKOOA file with shot time and position information is used to do this. It is also possible to apply a reduction velocity for a clearer presentation. After relocating the OBH position, the data are plotted in shot distance to instrument position versus reduced time.

A total of 10 sites were occupied during the JR39b (Fig. 9). These were at segment E2, 5 along the ridge axis and 5 across. A bandpass filter of 4/7-16/40 Hz was applied to improve the signal to noise ratio. Good data quality is observed, and first arrivals are easy to identify up to 35 km offset (Fig. 10).

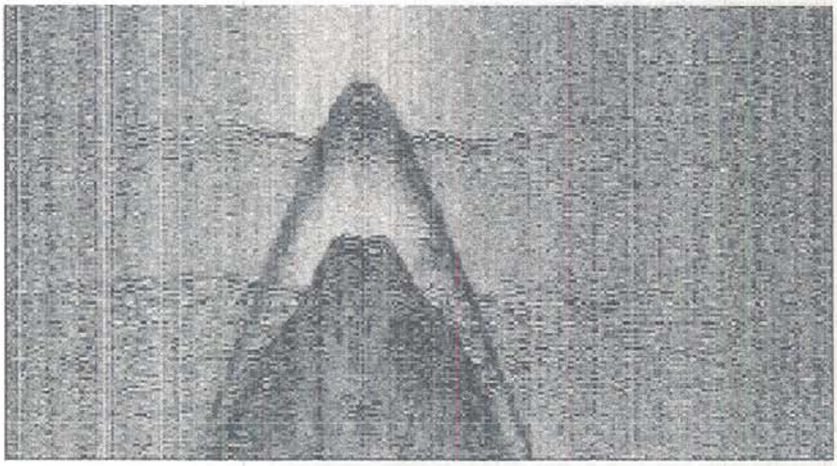


Fig 10 OBH Record from site 3 (Mermaids Purse)

7.6 Re-useable Sonobuoy (SonoR) (PC)

The SonoR system has been developed to provide additional data during seismic survey. SonoR consists of a ruggedised floating platform about 1.2m diameter (Plate *). A watertight central core contains the battery pack and electronics unit. External enclosures house the radio transceiver, power amplifier and release system. The electronics unit is equipped with two CMF8680 single board PC's, a 16 channel A/D converter, radio modem, GPS and other devices.

SonoR is activated using an external watertight connector. One CMF8680 processor boots and monitors the radio modem for commands. Positional data and status information are transmitted to the ship every 40 seconds. As soon as the GPS is tracking in 3D mode (usually after 2 minutes) then SonoR can be deployed.

Deployment will normally be carried out when all the seismic system is already in the water. This means that SonoR has to be deployed with the ship moving at 5 knots and as far outboard as possible to minimise colliding with the air gun array. However, SonoR has been built to withstand such an encounter.

The "greasy pole" approach to releasing devices will not work when the ship is moving. SonoR weighs 250kg and presents considerable drag when in the water. The solution was to use an ex RMT net release device. This is electrically operated and has two release jaws that operate sequentially. A three button control box has been wired to ensure that two buttons must be pressed to activate either release. This safety measure was enhanced by having two short release strops on the SonoR frame connected to each release jaw.

The SonoR and release system were tested off South Georgia in calm seas. SonoR was not powered for this trial but all went smoothly. Recovery was straightforward. A proper test of the complete system occurred on Day 48. SonoR was deployed in a moderate sea using the port Effer crane. SonoR responded to commands to enable the logging system and a further command to release the Hydrophone. This cable for this sensor is normally wrapped around the SonoR body which provides protection should any collisions occur.

Positional and status information was received for about 45 minutes after which the signal strength was not sufficient for the data to be properly decoded by the packet radio system. This is largely due to the fact that the antenna is not mounted in an optimum position. It is hoped that fixed antennae can be provided before the next seismic cruise. The bridge were able to continue reception of the RDF system for about 3 hours (15 miles).

On return, after 17 hours, a clear position transmission was received at a range of six miles. Recovery was quite easy. The recovery rope was threaded through lengths of plastic pipe to prevent it getting tangled. This worked well although a bit more experimentation is required. Once on deck the battery voltage was checked and found to be around 11.8V. This indicates that the system would have carried on working for at least another 6 hours, which was its designed endurance.

It was intended to recover the data using Interlink. Bench tests had shown this software to be reliable but for some reason it would not work properly. The electronics unit had to be removed and the system set-up on the bench. After several hours, all the hydrophone and GPS positional data had been extracted, converted from its binary format and stored on the network.

Plate III SONOR deployment

The hydrophone data is sampled and stored in an array every 4mS. After 29750 samples (1min 59 seconds) the array is written to disk and the program waits for the next second pulse from the GPS. This technique provides for virtually continuous data logging with less than 10minutes of data lost over the whole 18 hour period. The data files totalled over 33Mb.

Hydrophone data were converted to SEG-Y format and then filtered to show surface and bottom returns. The resulting picture was poor but we had already seen from previous sea trials that this would be the case until some form of sensor damping was employed.

A 3-axis accelerometer package (AX3) with similar characteristics to the hydrophone was constructed. AX3 was first deployed over the side of the ship using 30m of cable linked directly to a 3 channel A/D converter. The motion of the sensor was clearly visible, especially when I simulated wave movement by hauling on the cable. The next test was to add a conical sea anchor near to the sensor and several lengths of bungee cord to the rest of the cable. The bungee cord created loops in the main cable and the idea was that these would absorb much of the wave motion.

The second deployment over the side showed great improvements in all three axes but the change in the Z (vertical) axis was quite dramatic. Several spikes were present but these were probably due to the bungee cable being completely stretched.

This was very encouraging and I transferred the damper system from AX3 to the actual hydrophone cable ready for the next full deployment. As luck would have it, we ran out of time and no further use was made of the seismic system.

Hopefully, there will be another opportunity to test SonoR again during JR42 in May. On the bright side we now have a proven recoverable floating platform that can be adapted to many different projects. The addition of an Argos transmitter would increase the likelihood of recovery. Various power saving changes can be made to increase deployment life and now that solid state memory is more affordable the hard drive can be replaced

7.7 **TOBI Deep-towed Sonar** (IR)

Plate IV TOBI

System Description

TOBI - Towed Ocean Bottom Instrument - is Southampton Oceanography Centre s deep towed vehicle. It is capable of operating in 6000m of water. The maximum depth encountered during the TOBI surveys was around 4000m.

Although TOBI is primarily a sidescan sonar vehicle a number of other instruments are fitted to make use of the stable platform TOBI provides. For this cruise the instrument complement was:

1. 30kHz sidescan sonar (Built by IOSDL) with swath bathymetry capability

2. 7.5kHz profiler sonar (Built by IOSDL)

3. Three axis fluxgate magnetometer. (Ultra Electronics Magnetics Division MB5L)

4. CTD (Falmouth Scientific Instruments MicroCTD)

5. Gyrocompass (S.G.Brown SGB 1000U)

6. Pitch & Roll sensor (G + G Technics ag SSYO091)

7. CTD logger and lOOm LSS light scattering sensor string (WS Oceans)

An AutoHelm ST5O GPS receiver provides the TOBI logging system with navigational data.

The TOBI system uses a two-bodied tow system to provide a highly stable platform for the on-board sonars. The vehicle weighs two and a half tonnes in air but is made neutrally buoyant in water by using syntactic foam blocks. A neutrally buoyant umbilical connects the vehicle to the 600kg depressor weight. This in turn is connected via a conducting swivel to the main armoured coaxial tow cable. All signals and power pass through this single conductor.

For this cruise the ship'54s winch system was used for towing with separate deck-mounted launch and umbilical winches. During the TOBI surveys the winch was controlled from a remote station in the UIC laboratory.

The deck electronic systems and the logging and monitoring systems were set up along the port side of the UIC laboratory, giving both watchkeepers and scientists a clear view of the incoming data. The data are recorded onto magneto-optical (M-O) disks.

TOBI Deployments

TOBI was launched and recovered a total of 6 times during the cruise. The times are listed below along with relevant comments:

Deployment	Start time/day	End time/day	Comments
1	14.00/046	15.00/046	Short test deployment.
2	19.40/047	23.00/047	Curtailed due to 0/C umbilical.
3	21.45/051	23.00/051	Curtailed due to S/C umbilical.
4	16.34/052	1800/052	Curtailed due to S/C umbilical.
5	1332/053	0200/057	Run 1.
6	1855/062	2000/064	Run 2.

The M-O disks used and their relevant numbers, files and times are listed in JCR TOBTIMES.DOC.

The James Clark Ross is equipped with a large stern mounted hydraulic 'A frame capable of deploying and recovering TOBI in its normal athwartships mode. The main sheave was used for deploying and recovering both the TOBI vehicle and the depressor weight as well as towing during the survey.

Data Recording and Replay

Plate V TOBI console

Data from the TOBI vehicle is recorded onto 1.2Gbyte magneto-optical (M-O) disks. One side of each disk gives approximately 16 hours 7 minutes of recording time. All data from the vehicle is recorded along with the ship position taken from the GPS receiver. Data was recorded using TOBI programme LOG.

In order to generate correctly scaled sidescan images, a ship track plot was generated and the TOBI vehicle laybacks calculated from the wire-out and depth readings every half an hour. The positions of the TOBI vehicle were then plotted and vehicle distance run measurements taken for each half an hour. These were then used by ERASDISC to produce correctly scaled digital images that were then reproduced using DISSCRAY onto a Raytheon thermal recorder. These hard copies were made into a mosaic by pasting them onto the vehicle track plot. BLOWUP was used to generate large images of areas of interest.

The profiler data was corrected for the depth of the vehicle and replayed in programme PROFRAY.

Data from the M-O disks were copied onto CDROMs for archive and for importation into image processing systems. A program called TOBIEXRACT was used to strip off CTD and magnetic data from the raw data files and store it in ASCII format for direct importation into a spreadsheet.

Instrument Performance

The majority of problems with the TOBI system came from the umbilical cable. Two main fault modes appeared to occur. The first was a necking or kinking of the coaxial cable due to a Chinese finger effect of the kevlar strain member. The kevlar grips the coaxial cable tight at one point while the rest of the cable stretches and hence the neck occurs on the coax causing the failure. It is recommended that in future all new umbilicals be streamed under tension prior to their use with TOBI to reduce this problem.

The second failure mode was a shorting of the cable at the underwater joint between the plug and the umbilical. This appeared to be due to tracking or arcing compounded by the pre-glued heat shrink used in the join. Whether the glue was conducting under combined effect of high pressure and the 350V voltage applied is not known yet but it was highly suspicious that the short circuits encountered all had been made using this type of heat shrink. It is therefore recommended that only
normal heat shrink be used for making high voltage underwater joints in future.

The sidescan sonar worked well throughout with minimal interference from other instruments on the vehicle. Full range 6km swath widths were produced everywhere the terrain allowed.

The swath bathymetry system performed well, regularly giving phase data out to beyond half range. Given the complex terrain this is a good achievement. The vehicle phase measuring program crashed occasionally, the most likely cause being noise spikes upsetting the signal acquisition multiplexer.

Due to the rocky terrain, the profiler sonar did not reveal any sediment layers. It did, however, fulfil its other role of vehicle altimeter admirably well. The top end display program was altered slightly to give a greater range of gain.

The magnetometer functioned well throughout. An incorrect of the x value was observed every 12 seconds, which may be explained by the asynchronous nature of the A/D converter for the unit leading to readings during a sonar transmission.

The gyrocompass appeared to have an offset of some 200. 10.10 may be explained by the mechanical mounting of the unit in the vehicle, the rest by the offset caused by latitude error. This offset is constant and can be deduced from the data by comparing the gyro reading with the course of the ship over a long, straight line.

The CTD unit itself worked well with a good indication of the top inversion layer found on other CTD stations done in the area. There was a problem with the computer in the vehicle that takes the serial gyro and CTD data and puts it into the telemetry chain. This computer crashed every 9 minutes or so and needed rebooting. This problem could not be stimulated when the vehicle was on deck and could not therefore be traced during the cruise. The consequence of this is that the gyro and CTD data have jumps in them when the computer was rebooted. The LSS logger worked well and provided evidence of hydrothermal activity in both work areas. Due to the problem with the gyro and CTD interface computer, real-time readings from the logger were not available during the cruise.

Summary

After a somewhat stuttering start to TOBI operations caused by the umbilical the system itself gave very few problems. Firsts on this cruise include, furthest south TOBI survey ever, first use of the LSS string, first time no vehicle electronics tubes were needed to be opened and first use on the James Clark Ross, the tenth different research ship to operate TOBI from.

7.8 **Seabed High Resolution IMaging Platform (SHRIMP)** (DE)

SHRIMP successfully completed a major milestone in its development during the cruise, and provided the first ever video footage of the East Scotia Ridge. This cruise provided the first opportunity to operate SHRIMP in deep water with its latest video developments. The subsea components comprised a stainless steel frame

Plate VI SHRIMP deployment

vehicle of dimension 3m x 1m x 1m complete with two video cameras, a colour CCD and a monochrome SIT, twin 250W quartz halogen lamps, a dual Hi8 video recorder, altimeter, pressure sensor, 5 pressure balanced 24V batteries, photographic camera and 1200J flash gun. A coaxial conducting tow cable provided a communications path for control and monitoring of the vehicle and supply of supplementary power. The TOBI compatible cable and electrical slip ring simplified cable transfer between vehicles.

Plate VII SHRIMP CONTROL CONSOLE

An initial trial in Cumberland Bay, South Georgia, before heading to the work area provided time to fine tune the communication modems to the conducting coaxial tow cable. All pressure housings, cables and connectors showed they were secure from water ingress. The camera / flash cable was found intermittent and the lack of a spare required a temporary repair which later proved unsuccessful.

Deployment and recovery of SHRIMP was conducted from the midships A-frame (Plate VI). Midship operation of the vehicle assists in reducing the effect of ship heave which in turn results in a more controllable operational vehicle altitude. The midships CTD annexe 'garage' facility provided valuable weather protection especially when removing electronic components from their water tight pressure housings during deck testing.

The first SHRIMP operation was unsuccessful. Just after deployment, the shipborne power supply showed an abnormal high current value so the vehicle was recovered. Immediately the fault was traced to an electrical breakdown of the vehicle power / communications connector. The second SHRIMP operation provided over 5Hrs of seabed video footage with video frames transmitted and displayed on ship every 5 to 10seconds. From the video images obtained it could be seen that a wider flood lamp reflector would be needed to match the cameras field of view. It is planned to introduce superior lighting on return to SOC. From the results obtained during this cruise I would expect that operation with the light sensitive SIT camera would comfortably provide an operational vehicle altitude up to 20m.

7.9 Water Column Investigations (CRG)

Introduction

Hydrothermal research represents an important component of the study of marine geochemistry because, together with riverine input, hydrothermal circulation through young oceanic crust dictates the balance and residence time of geochemical tracers in the oceans. To fully understand the relative importance of hydrothermal activity with respect to riverine inputs, two questions must be answered: a) what are the processes active at any given vent-site? and b) what is the global distribution of hydrothermal venting on the seafloor? To answer the second question requires a sysematic study of a range of different mid-ocean ridge environments, including back-arc spreading centres. Only then will it be possible to make geologically intelligent predictions concerning the likely frequency of occurrence of hydrothermal venting around the global MOR system. Additionally, studies of vent biogeography around the global MOR have revealed distinct differences between fauna from the N.Atlantic and Pacific Oceans. A study of the E.Scotia Ridge was also of importance to vent biologists, therefore, because identification of high-temperature venting in such an isolated and relatively young mid-ocean ridge setting would provide an intriguing setting for follow-up colonisation and evolutionary biology investigations.

Plate VIII LSS optical back scattering sensor string being prepared for deployment, suspended beneath TOBI

Instrumentation

Three approaches were used to investigate the distribution of hydrothermal venting along the E.Scotia Ridge. Our primary tool was a new hydrothermal sensor string suspended beneath the SOC's TOBI deep-towed sidescan sonar vehicle. The sensor string comprised a WS Ocean Systems UMI2 Marine Monitor data-logger with Conductivity, Temperature and Pressure sensors together with 5 SeaTech LSS optical back-scattering sensors, set in high-gain. One of these instruments was mounted directly upon the body of the TOBI vehicle, adjacent to the CTD/data-logger. The further 4 sensors were deployed at depths of 25m, 50m, 75m and 100m below the vehicle attached to a rope which was kept taut by deploying a 20kg lead weight at its far end (Plate VIII). With a pre-programmed logging frequency of 5 readings/minute a total of 5 days' continuous recording from all 8 channels (C, T, D and 5 x LSS) can be logged internally for subsequent data retrieval following recovery inboard of the TOBI vehicle. By comparing time-stamped light scattering sensor anomalies with the co-registered sidescan sonar imagery and bathymetry an accurate understanding of the geological setting in which hydrothermal activity is set can be developed. This same approach has previously been successful in identifying the presence and tectonic/volcanic setting of hydrothermal actvitiy on the northern Mid-Atlantic Ridge near the Azores Triple Junction (German et al., 1996) and along the SW Indian Ridge (German et al., 1998a).

In addition to our TOBI/sensor string operations, another mode of hydrothermal exploration utilised routinely throughout the cruise was deployment of a NOAA-PMEL MAPR instrument (Baker and Milburn, 1997). The MAPR is a self-logging instrument which comprises a temperature and pressure sensor and data-logger all interfaced with a SeaTech high-gain LSS instrument (Plate IX). This instrument was routinely deployed at all wax-coring stations between segments E2 and E9. Instrument failure prevented data collection at the final wax coring station in segment E10. The instrument was routinely attached at a height of either 110m or 200m up the tapered trawl cable from the BAS rock-chipper depending on whether a station involved placement of an acoustic bottom-detecting pinger on the wire at 100m above the corer, or not, respectively. The methodology employed here followed that used previously along the SE Indian Ridge as described by Scheirer et al. (1998).

The third system available to us was the use of the BAS Seabird 9/11+ CTD and water-bottle rosette which was augmented by interfacing with a Chelsea Instruments AquaTracka III 25cm path-length transmissometer. The advantage of this system was that it also contained a suite of twelve 10L Niskin bottles for water column sampling which allowed seawater samples to be taken for subsequent laboratory analysis of total dissolvable Mn concentration - a diagnostic tracer of submarine hydrothermal plumes.

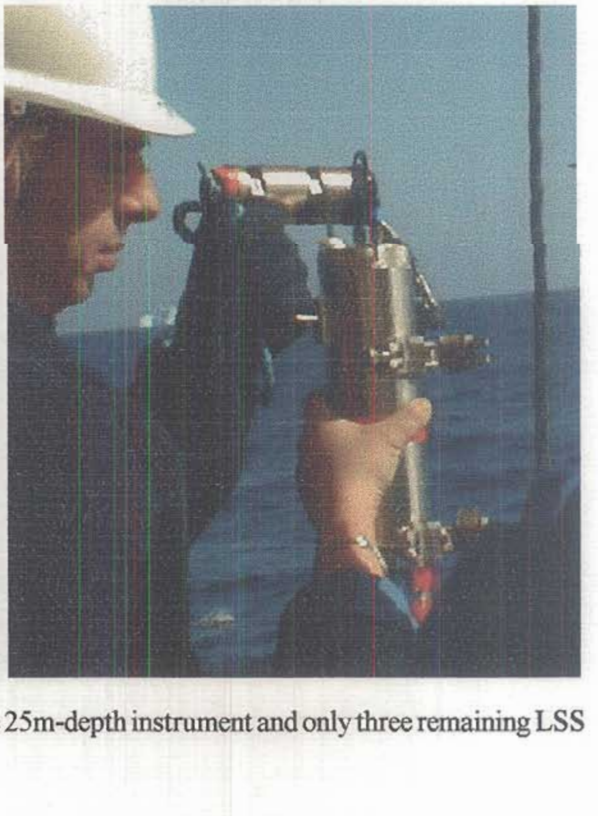


Plate IX NOAA-PMEL's Miniature Autonomous Plume Recorder (MAPR) .

Deployments

The TOBI sensor string was deployed as part of both TOBI runs which collected double-swath sidescan sonar data along segments E2 and E9 (see Figs. 2,3 earlier). The sensor string performed well throughout this deployment with the exception that excessive electrical noise was observed during and following the 4kt tow of the deep-tow vehicle to regain our survey line on the morning of 24 February (JD 055). Severe vibration on the vehicle appeared to cause subsequent intermittent failure of electrical connections between individual sensors and the data-logger. In one exception, the sensor on the TOBI vehicle itself was irreversibly damaged as a result of this operation. For the second TOBI deployment, therefore, this sensor was replaced by the 25m-depth instrument and only three remaining LSS sensors were deployed below the vehicle at 50m, 75m and 100m below the TOBI deep-tow frame. All four surviving sensors performed satisfactorily throughout the entire E9 segment and the electrial connection problems experienced during the E2 survey were not seen to recur under more normal TOBI towing-conditions.

The NOAA-PMEL MAPR was deployed routinely upon the trial cable for all Wax Coring stations from WX 42 to WX 69 with the exception of station WX55 where battery failure precluded data collection. Locations of individual wax coring stations are detailed elsewhere (see section 7.8). Following this approach, a total of 26 vertical profiles of optical back-scatter data were collected from targetted rock-coring stations along the length of the E.Scotia Ridge from segment E2 to segment E9.

Table 2 JR39b CTD Station Locations

Series No.	Lat	Lon	Depth (m)
CTD01	56° 04.72'S	30° 19.13'W	2620
CTD02	55° 56.92'S	30° 19.15'W	2976
CTD03	55° 49.64'S	30° 19.13'W	3061
CTD04	56° 12.94'S	30° 19.56'W	3158
CTD05	56° 21.02'S	30° 20.00'W	3537
CTD06	** Failed - 500m of CTD cable removed & reterminated **		
CTD07	55° 57.00'S	30° 16.80'W	3224
CTD08:			
Start	60° 02.90'S	29° 55.84'W	2768
End	60° 03.48'S	29° 57.94'W	2709
CTD09	60° 03.07'S	29° 58.47'W	2445

A total of 9 CTD stations were also occupied during the cruise. Stations CTD 1-5 were occupied early in the cruise along the ridge of the E2 AVR coincident with the positions of the OBH hydrophones and at a spacing of approximately 10km one from another. Following the first TOBI survey through the same area an aborted CTD station (CTD06) was followed by a full water column profile at the same station (CTD07) to investigate a deep-water transmissometer anomaly at this site which may have been due to sediment resuspension. A suite of 12 samples for TDMn analyses were collected from the same depths at which TOBI LSS data had previously identified a high back-scattering signal. Two further CTD stations were occupied toward the end of the cruise following the second TOBI survey lines in segment E9. The first, CTD08, started due East of the central AVR and included a tow-yo toward and descending into the axial caldera where a profile of 11 water column samples for TDMn were collected (Niskin bottle 9 failed to fire on this deployment). A final station, CTD09 was also occupied approximately 1km NW from the caldera atop the central AVR. Locations of all CTDs together with water depths are listed in Table 2 below and illustrated in Fig. 12

Preliminary Results

First evidence for hydrothermal activity along the East.Scotia Ridge was identified at three different locations. In segment E2 two crossings of the central magma chamber and associated volcanic ridge, together with the adjacent NW-striking "basalt curtain", yielded plume particulate anomalies on 3 or 4 of the 5 available LSS sensors. Maximum anomalies were observed close to the crossing point of these two lines providing good resolution of the site of venting to within approx 2km.

We can be confident that these signals are the result of hydrothermal venting from the ridge crest because the plume signals are observed at a depth of approx. 2150m and, hence, significantly shallower than the source of sediment resupension, identified as such, which occurs further north within the E2 segment at

>3000m water depth. The magnitude of the anomalies observed here and, indeed, at all stations remain small when compared to those measured close to an active vent site (cf German et al., 1998b). Nevertheless, as preliminary indicators of hydrothermal activity within the vicinity, the signals here are directly comparable to the preliminary indications reported previously from the northern MAR and SWIR using the same approach (German et al., 1996, 1998a). This is illustrated in Fig. 13 where the anomalies recorded by the middle LSS instrument on the TOBI sensor string above the E2 magma chamber (top) are compared to those recorded previously by a MAPR instrument from the strongest plume-source of the SW Indian Ridge.

A second site of hydrothermal activity was identified from a single wax-core and MAPR profile at station WX48 (for location see Fig.14). Although lack of additional stations or high-resolution seafloor imagery precludes accurate identification of the site of active venting within this E5 segment the anomaly is again significant w.r.t. previous SWIR MAPR anomalies and is clearly in excess over the background profile measured further south within the same segment at station WX49.

The third site at which evidence for hydrothermal activity was observed was adjacent to the Axial Volcanic Ridge and associated caldera at the centre of segment E9. All 4 operating LSS sensors on the TOBI string identified a strong optical back-scattering anomaly immediately adjacent to the caldera but at a depth some 250-300m shallower that the apex of the ridge-crest suggesting that the source of venting must lie north or south along the ridge crest and not be associated with the floor of the 300m-deep axial summit caldera. This was apparently confirmed by the absence of any strong transmissometer anomaly in the CTD08 station occupied directly within and above the caldera, although better spatial resolution of the source of venting at this site could not be resolved due to lack of time available for further CTD operations. This will be a key priority for vent-site identification, as will the comparable plume-signal area in segment E2, in any future ridge-crest studies of the E.Scotia Ridge.

Fig. 12 Location of CTD stations 01-05 and 07-09 during RRS James Ckark Ross cruise JR39b, Feb-Mar 1999. (NB Map under construction by Graeme Eagle).
Fig. 13 Plots of LSS (optical back-scatter instrument) voltage and pressure recorded by the TOBI vehicle in hydrothermal plumes a) directly above the E2 magma chamber and b) along the SW Indian Ridge. Note the near constant (±2mV) background voltages recorded by both instruments in clear oceanic deep-water when compared to the higher back-scattering signals indicative of particle-rich lenses in the water column at a) approx 04:30z and b) approx 22:45z.

References

E.T.Baker and H.B.Milburn. MAPR: A new instrument for hydrothermal plume mapping. Ridge Events 8, 23-25, 1997.

C.R.German, L.M.Parson and the HEAT Scientific Team. Hydrothermal Exploration at the Azores Triple-Junction: Tectonic control of venting at slow-spreading ridges? Earth Planet. Sci. Lett. 138, 93-104, 1996

C.R.German, E.T.Baker, C.A.Mevel, K.Tamaki and the FUJI Scientific Team. Hydrothermal activity along the South West Indian Ridge. Nature 395, 490-493, 1998a.

C.R.German, K.J.Richards, M.D.Rudnicki, M.M.Lam, J.L.Charlou & the FLAME Scientific Party. Topographic control of a dispersing hydrothermal plume. Earth Planet. Sci. Lett 156, 267-273, 1998b.

D.S.Scheirer, E.T.Baker and K.T.M.Johnson. Detection of hydrothermal plumes along the Southeast Indian Ridge near the Amsterdam-St. Paul Plateau. Geophys. Res. Lett. 25, 97-100, 1998.

7.10 Wax Corer (Rock Chipper) (SF)

Wax coring is a simple technique to recover rock samples from the sea floor. The wax corer consists of a weighted 2m steel column (Plate *) with a cutting head containing five detachable hardened steel cups. The wax corer was modified with 6 additional cups on rods around the stem, to collect samples as it falls over and new tapered cups are used to prevent wax slipping out during the recovery. The steel cups are filled with cold water surfing wax and the Wax Corer is dropped onto the bare rock surface in order to collect volcanic glass / rock fragments which adhere to the wax.

Operation (RAL/SAW)

A deck frame was supplied, into which the Wax Corer could be fitted for changing heads and was fixed to the deck outside the water bottle annexe on the starboard side of the JCR. The Wax Corer was deployed by means of the midships gantry on the 16.8 mm steel coring warp on the 30t traction winch. It was attached to the warp via a swivel, and deployed with the winch in six driven sheaves mode to provide the best control at the ship's side. After installing the prepared head and placing wax cups on the side, a 10 kHz pinger at 100m and a nephelometer at 110m were attached to the wire. The Wax Corer was then lowered at a rate of 78m/min until 200m from the sea floor as indicated by the PES and was left to stabilise for at least 2 min before dropping at a rate of 110m/min until impact. Based on good experience during the wax coring campaign on JR12, generally two drops were performed to increase the yield of rock fragments. After the 14th deployment it was decided to leave the pinger off, as, owing to rough weather conditions, no bottom reflection could be observed. The nephelometer was then attached at 200m on the wire. To make sure that the Wax Corer hit the bottom, approximately 150m more cable than water depth was lowered.

Plate X Wax Corer deployment

Following deployment and recovery, the cutter head and cups on the side were detached and immediately replaced ready for redeployment. The head was then taken to the Preparation Laboratory, where the larger fragments were removed from the wax with tweezers, smaller fragments were dug out with a spatula, bottled and numbered. In those cases where significant amounts of sediment were returned, this was also bottled and labelled. To clean the rock fragments, they were placed into glass beakers which were then filled with water. These were placed in a microwave oven for two minutes to melt the wax. The beaker was cooled and the wax removed. The sample was then washed with ultra pure water taken from the Millipore Water System and dried in the oven at 100°C.

The first three deployments on the centre of the E2 segment were very successful, even cups on the side of the Wax Corer were filled with volcanic glass fragments, thus the sampling strategy was retained. Altogether thirty sites were cored all along the segments from E2 up to E10 (Table 4, Fig. 12). Good recovery was achieved on the majority of deployments, only on two sites (centre of E6, E10) did it fail to recover any worthwhile sample.

7.11 Winches (SAW)

7.11.1 TOBI" & "SHRIMP" Traction Winch Operations (SAW)

Ships Equipment Used:

Thirty Tonne Traction Winch
Rochester Cable Design A301241 - Deep Tow Coaxial Cable
Stern Gantry (TOBI)
Midships Gantry (SHRIMP)
Other winches included; RVS Deployment & Umbilical Winches.

Observations

TOBI was towed on the ships large conducting cable with up to and over 6000 m of wire out depending on required vehicle depth and worked well with the winch only "seeing" a maximum of four tonnes outboard weight which is well within the identified limits of this cable and winch system.
SHRIMP was operated on the same cable, but over the midships gantry to give the best control ability of the package during flights. Despite the delays built into the system the winch worked well during the one six hour deployment.

Problems

The only problems that occurred where during the TOBI deployments lasting several days as the winches cable monitoring system Seametrix crashed once on each of the deployments for no explained error apart from some system fault. On both occasions the system was recovered by rebooting and the line out read remained correct. No.2 storage winch pump caused a problem when it tripped during one tow closing the winch system down temporarily. This is an intermittent fault that was solved by running both storage pumps as a safe guard until time allowed a fuller investigation.

Plate XI Successful Wax Corer recovery

7.11.2 "Rock Chipping" Traction Winch Operations

Equipment Used:

Thirty Tonne Traction Winch
Steel Tapered Trawl Warp - ⌀14.5 mm [3 x 12(9/3) 1960 RH ORD]
(Deployment depth only used this section of the warp)
Midships Gantry

Method

This warp was preferred over the usual coring warp as it allowed quicker and safer changes for the conducting cable, by eliminating some of the reeving normally required in the winch room.

The Chipper was attached to the warp via a swivel. The Chipper was deployed with the winch in six driven sheaves mode to provide the best control at the ship's side. The wire out was zeroed at the surface and deployed initially to 100 m before attaching the Pinger and a Nephelometer 10 m above this, later due to several failures the Nephelometer was moved to 200m and the pinger removed to allow greater over run of wire. From this point four driven sheaves were used with the speed being regulated to 80-85 m/min until 200 m from the sea bed. The final 200 m were operated at the winch's maximum speed of 110 m/min. The winch was brought to a halt at a wire out value decided before the final high speed descent.

Problems

No significant problems occurred with this method and the only time lost to science was the two hours required to change between the conducting and trawl cables. This was a little longer than would usually be expected due to the limitation and care required to ensure that the electrical termination on the conducting cable was not damaged in anyway.

7.12 Data Logging (PM)

Scientific data were recorded during the cruise using the ABC logging system. This performed well with few problems being encountered.

Along-track data was extracted from the differential GPS, Simrad EA500 and proton magnetometer records. Noise was removed from the depth and magnetic data using the Geosoft Oasis editor. The data were then resampled to 1 minute intervals, Carter and IGRF corrections being applied as appropriate, before being merged into a MGD77 format cruise file.

8 Recommendations

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Table 4: Logged datastreams

Instrument	Measurement	Mnemonic	Streams logged	Recording Interval
GPS (Trimble) (differential gps)	position	gps_nmea	lat lon gq svc hdop dage dbase	1 sec
GPS (Glonas)	position	gps_glos	lat lon utc type svc alt cmg smg vvel pdop hdop vdop tdop	1 sec
GPS (Ashtech) (3D gps)	position,roll,pitch	gps_ashlat	lon roll pitch sec hdg mrms brms attf	1 sec
Gyro	heading	gyro	heading	1 sec
Simrad 500	water depth	sim500	uncdepth rpow angfa angps	~9sec
TSS	roll,pitch,heave	tss	roll pitch heave hacc vacc	1 sec
Proton magnetometer	magnetic field	proton	magfld	5 sec
Old STCM	magnetic field components	stcm	X Y Z	1 sec
New STCM	magnetic field components	new_stcm	X Y Z	1 sec
Seismic system	shotpoint	shot	shot_no	20 sec
Winch	winch data	winch	cabltype,cableout rate,tension,btension comp,angle	5 sec

Appendix

Summary of Seismic Reflection Lines