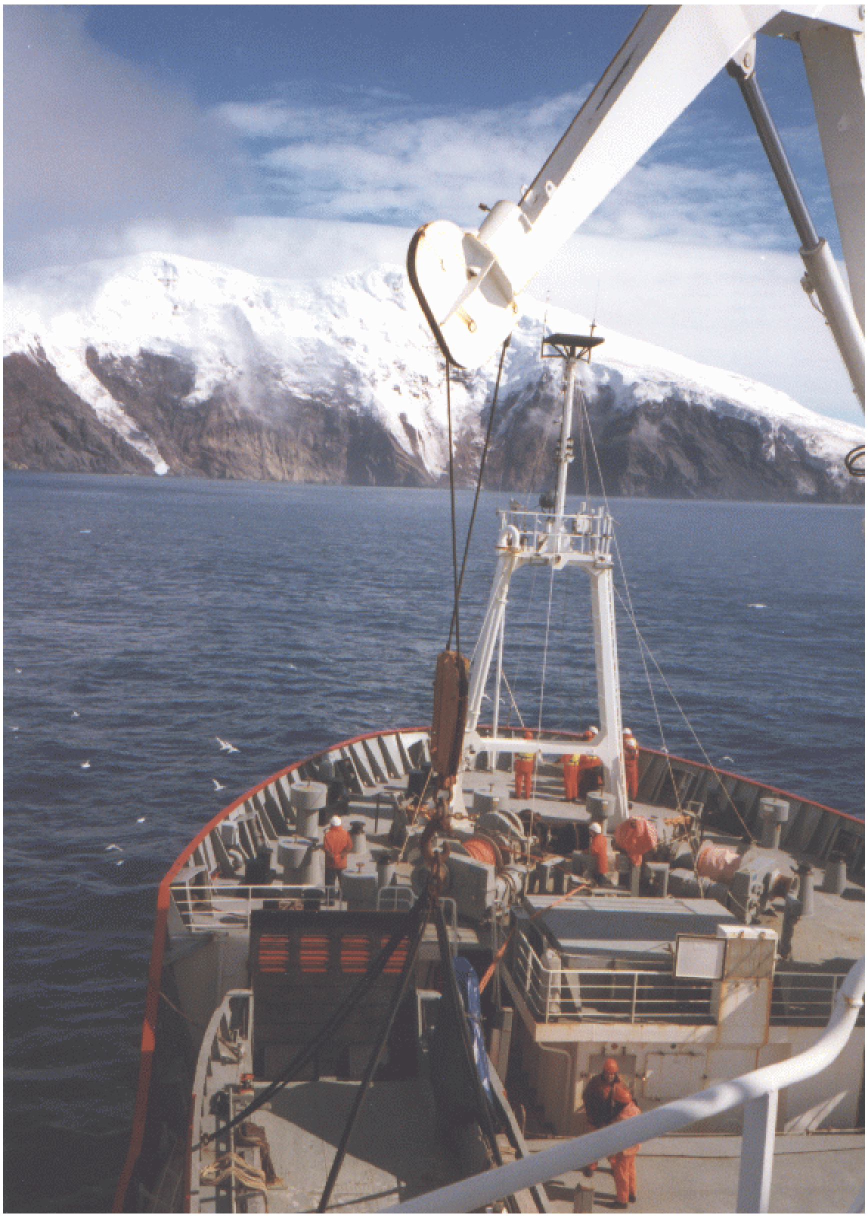
JR18 CRUISE REPORT



Draft - Nov 2000

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1 Summary

Cruise JR18 was mainly devoted to controlled-source seismic investigations of the South Sandwich island arc. These investigations were part of the Sandwich Lithospheric and Crustal Experiment (SLICE), an integrated geological and geophysical study of the structure, geodynamics and composition of the arc. The cruise departed from Port Stanley on 13th January 1997 (day 013) and returned 51 days later on 5th March (day 064).

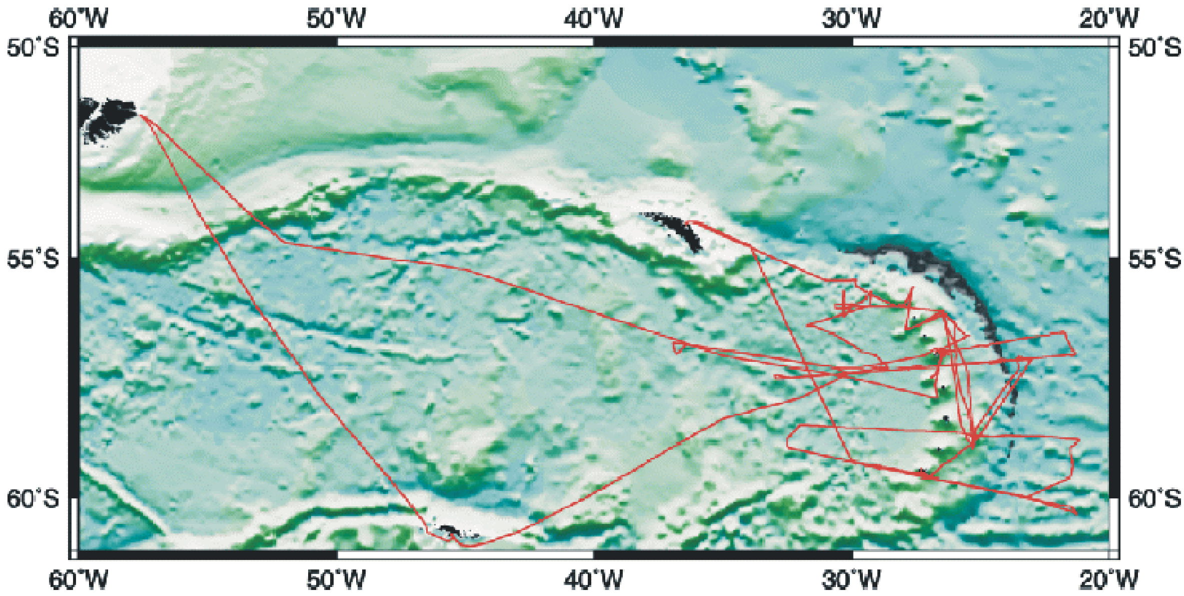


Fig 1 JR18 cruise track

The main objective of the cruise was to collect 4 long multichannel seismic reflection profiles across the trench, arc and back-arc basin, recording wide-angle seismic data on ocean-bottom seismometers along 2 of these profiles. This was achieved. Three short multichannel seismic lines were also collected over a segment of the East Scotia Ridge where data from cruise JR09a (1995) had revealed the presence of a magma chamber. Magnetic (mainly shipboard three-component magnetometer) and gravity data were collected along all seismic profiles and passage tracks. Ocean-bottom seismometers were also deployed to augment a temporary local network of seismic stations set up on the islands by colleagues. This exercise was also carried out successfully.

A secondary objective of the cruise was to collect a large number of dredges and wax cores from targets on the submarine flanks of the arc and the back-arc spreading centre. This objective was only partially achieved because uplifting field parties from Candlemas Island by boat proved more time consuming than expected. In the event, uplift of field parties from both Candlemas Island and Thule Island were noteworthy successes, but not ones we would recommend any attempt to repeat.

Technical successes included the first use of the full capabilities of the ship's compressors and airgun deployment facilities, the first use of ocean-bottom seismometers on a BAS geophysical cruise, interfacing of the NERC multichannel hydrophone streamer with seismic recording equipment from the University of Glasgow, and use for a second time of the BAS-built three component magnetometer and Racal 'Skyfix' differential GPS navigation.

2 List of Personnel

2.1 Scientific and Technical (18)

R.D. Larter	BAS	Chief Scientist
N.J. Bruguier	BAS	Geophysicist
A.P. Cunningham	BAS	Geophysicist
P. Morris	BAS	Geophysicist/Database Manager
L.E. Vanneste	BAS	Geophysicist
R. Shipp	Cambridge Univ.	Geophysicist
D.K. Smythe[1]	Glasgow Univ.	Geophysicist
S.F. Bremner	BAS	Mechanical Engineer
J.A. Crawshaw	BAS	Computing Engineer
M.O. Preston	BAS	Electronic Engineer
D.J. Richmond	BAS	Computing Engineer
A.M. Tait	BAS	Mechanical Engineer
D.G. Booth	RVS	Electronic Engineer
D. Dunster	RVS	Mechanical Engineer
G. White	RVS	Electronic Engineer
D.C. Abensour[1]	Glasgow Univ.	Electronic Engineer (seismic recording)
R.J. Iuliucci	Geoforce	Ocean-Bottom Seismometer Engineer
A. Polkey	BAS	Doctor

2.2 Scientific and Support Personnel in Transit (10)

P. Bucktrout[3,4]	BAS	Photographer
P. Convey[4]	BAS	Biologist
E.C. King[4]	BAS	Geophysicist
P.T. Leat[4]	BAS	Geochemist
A. Morton[4]	BAS	Field Assistant
B. Newham[4]	BAS	Field Assistant
W.C. Quayle[5]	BAS	Field Assistant
A.M. Reading[2]	BAS	Geophysicist
D. Rycerz[2]	BAS	Field Assistant
J.L. Smellie[3,4]	BAS	Volcanologist

[1] Participated until mid-cruise break at Grytviken, South Georgia.
[2] Uplifted from Thule Island by boat, 22nd February.
[3] Transferred to HMS *Endurance* by helicopter, 17th January.
[4] Uplifted from Candlemas Island by boat, 28th February.
[5] Disembarked at Signy Island, 15th January.

2.3 Ship's Officers (14)

C.R. Elliott	Master
J.R. Harper	Chief Officer
B. McJury	2nd Officer
A.P. Wallis	3rd Officer
D.J. Cutting	Chief Engineer
W.R. Kerswell	2nd Engineer
G. Tyrer	3rd Engineer
R.J. Macaskill	3rd Engineer
N. Thomas	Electrical Officer
K.R. Olley	Catering Officer
S.J. Mee	Radio Officer
J.W. Summers	Deck Officer
D. Trevett	Deck Engineer
C. Lowe	Cadet

2.4 Crew (15)

R. Watson	Bosun
C. Lang	Bosun's Mate
J. Dodd	Seaman G1
A.M. Bowen	Seaman G1
G. Dale	Seaman G1
D. Watson	Seaman G1
D. Taylor	Seaman G1
S. F. Smith	Motorman
B. D. Smith	Motorman
D. McManamy	Chief Cook
J. Carney	2nd Cook
R. Heeney	2nd Steward
D. McLean	Steward
L. Jones	Steward
T. Macaskill	Steward

3. Introduction

Cruise JR18 formed part of the "Sandwich Lithospheric and Crustal Experiment" (SLICE), an integrated geological and geophysical investigation of the structure, geodynamics and composition of the South Sandwich island arc. In addition to the marine geology and geophysics carried out on this cruise, SLICE also involved surveys by HMS *Endurance* and geological and geophysical field parties working on the South Sandwich Islands. Earlier in the season a geophysical field party had also spent several weeks at King Edward Point, South Georgia installing a permanent, broadband seismic station, named "HOPE". The success of SLICE depended on close coordination of all these different activities.

An important part of SLICE was a controlled-source seismic investigation which was the most extensive yet carried out by BAS, consisting of 4 long transects across the South Sandwich Trench, the island arc and the East Scotia Sea back-arc basin. This involved use of the largest airgun array yet deployed from RRS *James Clark Ross* (14 airguns with total volume 98 l), and was the first occasion on which BAS had used ocean-bottom seismometers. Signals from the airgun array were also recorded at land stations set up on Candlemas and Thule islands by the field parties, and by disposable sonobuoys. Multichannel seismic reflection data were recorded by interfacing the NERC multichannel hydrophone streamer with seismic recording equipment borrowed from the University of Glasgow. This equipment allowed recording of data on 8 mm high-density magnetic data cartridges, in contrast to the half-inch 9-track tapes used on all previous BAS seismic cruises, resulting in an enormous reduction in the physical volume of data tapes generated on the cruise. This more convenient form of data storage also facilitated demultiplexing, so all of the multichannel seismic data recorded were demultiplexed on board, the first time this has been achieved on a BAS geophysics cruise.

In addition to the controlled source seismic work, cruise JR18 also extended a temporary local network of earthquake seismic stations on the islands by deploying ocean-bottom seismometers at two locations in the forearc for a cumulative period of 4 weeks. Furthermore, some local earthquakes were recorded on the lines of ocean-bottom seismometers deployed for controlled-source recording, providing a very interesting set of earthquake observations.

It was intended that a large number of dredges and wax cores would be collected during cruise JR18, from targets on the submarine flanks of the arc and on the back-arc spreading centre. In the event the planned programme of dredging and wax coring was drastically curtailed because the time required to uplift field parties from Candlemas Island by boat was much greater than had been anticipated. Field parties had been input to Candlemas and Thule islands by HMS *Endurance* helicopters, but HMS *Endurance* had to leave the area at the start of February. Therefore uplift had to be effected by boat from RRS *James Clark Ross*. In the light of this season's experience it is recommended that any future field parties visiting the South Sandwich Islands should not be left dependent on boat landings for uplift.

4. Scientific Objectives

The overall objectives of SLICE were to improve understanding of crustal growth, geodynamics and geochemical processes associated with subduction. Specific objectives of cruise JR18 were to collect marine geophysical data and sea-floor samples which would enable us to:

1. **Determine crustal and upper mantle structure across the complete forearc, arc and back-arc system.**
2. **Determine the main structural differences between the northern and southern halves of the arc and try to explain these.**
3. **Accurately define the shape of the outer rise and determine the flexural rigidity of the subducting oceanic lithosphere.**
4. **Image structures in the lower forearc, thus providing evidence concerning the balance between accretion and tectonic erosion at this relatively sediment-starved active margin.**
5. **Look for evidence of diapiric structures in the forearc, analogous to features observed in the Mariana forearc.**
6. **Determine seismic velocities beneath the forearc, and test the feasibility of the existence of extensive serpentinised mafic bodies at depth which could account for forearc diapiric activity.**
7. **Look for evidence of forearc volcanism, analogous to that found in the Izu-Bonin Arc.**
8. **Look for evidence of ancient crustal remnants in the forearc, which may have formed part of the Pacific margin of Gondwana (this is a possible origin for the mid-slope high in the southern forearc).**
9. **Determine the age and origin of forearc basement exposed in fault scarps at the trench slope break and consider the implications for arc evolution.**
10. **Test the hypothesis that the present arc is built upon oceanic crust formed during the earliest stages of East Scotia Sea spreading.**
11. **Investigate the seismic reflection characteristics and velocity structure of the lower crust beneath the island arc: is it layered like many areas of continental lower crust?**
12. **Investigate whether or not there are changes in the back-arc relating to north–south changes in the arc and forearc structure (particularly the change at about 58°S).**
13. **Investigate the seismic reflection characteristics of oceanic crust formed in a back-arc setting. In recent years it has been shown that normal oceanic crust contains low-angle reflectors which cut right through the crust and are thought to be produced close to the spreading axis. Do similar reflectors occur here?**
14. **Determine the volume of the volcanogenic sediment apron on the western flank of the arc: this will be a valuable quantity for estimating the volcanic output of the arc.**
15. **Determine the seismic velocity structure and thickness of the back-arc crust. Is it in any way different from standard oceanic crust?**
16. **Look for any fragment of remnant arc on the western flank of the East Scotia Sea.**

5. Achievements

A complete track plot for cruise JR18 is shown in Fig. 1, and a detailed track chart showing the locations of seismic profiles, ocean-bottom seismometer stations and sample sites in the East Scotia Sea is shown in Enclosure 1.

Multichannel seismic reflection data were collected on four 600–900 km long profiles across the trench, arc and back-arc basin. Additionally, 3 short multichannel seismic profiles, totalling 110 line-km, were collected over East Scotia Ridge segment E2, where previously collected 4-channel seismic data revealed a magma chamber reflector. On these short profiles and two of the long profiles the data quality is excellent. On the other two long profiles severe sea conditions made it difficult to control the towing depth of the hydrophone streamer with the result that the seismic refection data are somewhat degraded. However, with careful data processing it should be possible to produce a useful record even from these lines. Inspection of shipboard data plots already reveals evidence of major extensional structures in the forearc.

Wide-angle seismic data were collected along two of the long profiles using ocean-bottom seismometers. Of the 24 ocean-bottom seismometers deployed along the controlled-source seismic lines, 23 were successfully recovered and recorded useful data. Wide-angle recording of signals from the airgun array at land stations on Candlemas and Thule islands was also successful. A total of 11 disposable sonobuoys were deployed and 7 of these recorded satisfactorily out to 24 km range.

The ocean-bottom seismometers deployed to augment the local network of earthquake seismic stations on the islands were successfully recovered and had recorded useful data for the intended period. Seven local earthquakes with body wave magnitudes ≥ 4.2 occurred at times when a whole line of OBSs had been deployed for controlled-source recording, and the data recorded from these earthquakes should provide new constraints on the seismic velocity structure at depth beneath the island arc.

Gravity and magnetic data were collected on all seismic profiles and passage lines. However, damage to a magnetometer cable during the first long seismic profile showed that it was not safe to tow a proton precession magnetometer sensor at the same time as a full airgun array, given the current towing arrangements on RRS *James Clark Ross*. Therefore magnetic data on subsequent seismic lines was obtained just from the shipboard three-component magnetometer.

9 dredges and 1 wax core were carried out during the cruise. 7 of these samples include certain or probable *in situ* material. Although this is a much smaller number of samples than originally planned, these samples are expected to provide important evidence concerning geochemical variations with distance from the trench, the nature of the forearc basement exposed at the trench -slope break, possible arc migration, and geochemical variation with depth along the axis of the E1 segment of the East Scotia Ridge.

6. Timetable of Events

1997

January

7 Scientific party arrives in Falkland Islands on flight from Brize Norton via Ascension I.
8-12 Mobilisation.
13 Ship departs from FIPASS at 07:00 GMT, bound for Signy I.. First STCM calibration manoeuvre at 09:00, then deploy total field magnetometer sensor and start scientific echo sounders.
14 Passage to Signy I.. STCM calibration manoeuvre.
15 Recover total field magnetometer sensor on approach to Signy I.. Weather and visibility poor, so ship anchors outside Factory Cove. Wendy Quale disembarks. Redeploy magnetometer sensor on departure from Signy.
16 Passage to East Scotia Sea. STCM calibration manoeuvre in early morning.
17 STCM calibration manoeuvre. Recover total field magnetometer sensor. Helicopter transfer of John Smellie and Peter Bucktrout to HMS *Endurance*. Deploy multichannel hydrophone streamer to assess buoyancy.
18 Recover multichannel hydrophone streamer, then large swell limits options.
19 Passage to start position of seismic survey over E2 segment of East Scotia Ridge. Add lead to multichannel hydrophone streamer during deployment. Deploy airguns. Commence seismic acquisition on line BAS967-31, across ridge axis.
20 Complete line BAS967-31 and also acquire another line across ridge axis (BAS967-32) and one along axis (BAS967-33). Deploy prototype reusable sonobuoy on latter line. Deploy far-field hydrophone to test towing characteristics. Recover multichannel streamer and airguns. Recover prototype reusable sonobuoy. Deploy total field magnetometer sensor.
21 Passage to OBS1 site, 65 km ENE of Zavodovski I.. Recover total field magnetometer sensor, deploy OBS1, redeploy magnetometer sensor and start passage to OBS2 site.
22 Search for suitable site for OBS2 in area approx. 75 km E of Bristol I.. Recover total field magnetometer sensor, deploy OBS2, redeploy magnetometer sensor. Passage to OBS14 site, 220 km E of Candlemas I., the easternmost OBS site along a line running approx. E-W between Candlemas and Saunders Is.. Recover magnetometer sensor, deploy OBS14, move 30 km W and deploy OBS13, then move another 73 km W and deploy OBS12. 'Skyfix' differential GPS activated.
23 Proceed W and deploy 9 more OBSs (OBS11 - OBS3), on average approx. 30 km apart.
24 Passage to start position of seismic line. Deploy multichannel hydrophone streamer and airguns. Deploy total field magnetometer sensor. Commence seismic acquisition on line BAS967-34 (line through OBS sites 3 - 14).
25-26 Continue line BAS967-34 in poor weather conditions. Recover total field magnetometer sensor after two days because it is tangled with airgun umbilical.
27 Complete line BAS967-34. Recover starboard airguns to correct problems.
28 Redeploy starboard airguns and commence seismic acquisition on line BAS967-35, heading west toward Candlemas I. Deploy far-field hydrophone for second trial. Deploy first sonobuoy successfully.
29 Continue line BAS967-35, passing north of Candlemas I.. Deploy 4 sonobuoys: 3 successful, 1 failed.
30-31 Continue line BAS967-35 in deteriorating weather conditions.

February

1 Complete line BAS967-35. Recover multichannel streamer and airguns. Deploy total field magnetometer sensor and start passage to OBS3 site.
2 Recover total field magnetometer sensor on approach to OBS3 site. Ahead of schedule, so carry out opportunistic wax corer drop on axis of E5 segment of East Scotia Ridge.
3 Recover OBS3 - OBS7.
4 Recover OBS8 - OBS12. Fail to find OBS13.
5 Recover OBS14. Return to vicinity of OBS13 site and search area. Deploy total field magnetometer sensor for passage to OBS2 site. Recover magnetometer sensor on approach to OBS2 site. Measure acoustic ranges to OBS2 from 3 positions. Recover OBS2. Deploy OBS15 at same site. Deploy 2 XBTs, both failed. Redeploy magnetometer sensor and start passage to OBS1.
6 Recover magnetometer sensor on approach to OBS1 site. Measure acoustic ranges to OBS1 from 3 positions. Recover OBS1. Deploy OBS16 at same site. Passage to proposed dredge sites between Leskov I. and Zavodovski I.. Search for suitable dredge target.
7 Carry out two dredges on ridge between Leskov I. and Zavodovski I.. Fail to recover any rock and lose dredge bag and pipe dredge. Passage to proposed dredge site 70 km north of Zavodovski I.. Carry out local sounding survey to identify target. Carry out dredge. Recover good haul of volcanic rocks but lose pipe dredge and damage dredge bag beyond repair. Passage to Protector Shoal, then carry out local sounding survey to identify dredge target on its SE flank.
8 Carry out dredge on SE flank of Protector Shoal. Recover good haul of volcanic rocks. Passage to E1 segment of East Scotia Ridge. Carry out two dredges. Recover good haul of volcanic rocks from first dredge and a single volcanic rock from second one. Deploy total field magnetometer sensor and start passage to South Georgia.
9 Recover magnetometer sensor on approach to Grytviken. Ship tied up at Grytviken jetty at 19:00 GMT. Stop scientific echo sounders.
11 Ship departs from Grytviken jetty at 09:00 GMT. Start scientific echo sounders. Deploy total field magnetometer sensor over South Georgia shelf. Start passage to OBS17 site,
12 Recover magnetometer sensor on approach to OBS17 site, 135 km W of Southern Thule, the westernmost OBS site along a line running approx. W-E and passing to south of Southern Thule. Deploy OBS17.
13 Proceed E and deploy 8 more OBSs (OBS18 - OBS25), on average approx. 30 km apart. STCM calibration manoeuvre at OBS24 site.
14 Continue E and deploy 3 more OBSs (OBS26 - OBS28). Deploy XBT at OBS26 site. Deploy PES fish. Passage to start position of seismic line. Carry out STCM calibration manoeuvre, then deploy multichannel hydrophone streamer and airguns. Commence seismic acquisition on line BAS967-36 (line through OBS sites 28 - 17).
15 Continue line BAS967-36. Deploy 5 sonobuoys: 2 successful, 3 failed.
16 Continue line BAS967-36.
17 Complete lines BAS967-36 and BAS967-37. Commence line BAS967-38.
18-19 Continue line BAS967-38, passing between Montagu and Bristol islands.
20 Deploy sonobuoy (successful). Complete line BAS967-38. Recover multichannel streamer and airguns. Deploy total field magnetometer sensor and start passage to OBS28 site.
21 Recover magnetometer sensor and PES fish on approach to OBS28 site. Recover OBS28 - OBS26. Deploy spare total field magnetometer sensor between OBS27 and OBS26 sites, to test it. Trial deployment confirms sensor is defective.
22 Recover OBS25 - OBS22. Enter Douglas Strait and deploy Cargo Tender and Humber to

uplift Thule I. field party. Recover OBS21, then return to Douglas Strait to recover Cargo Tender and Humber, with Thule I. field party. Recover OBS20 and OBS19.

23 Recover OBS18 and OBS17. Deploy total field magnetometer sensor for passage back to Southern Thule, then recover sensor on approach to Douglas Strait. Bad weather precludes 4-channel seismic profile through Douglas Strait, so redeploy magnetometer sensor for passage to OBS15 site. Recover magnetometer sensor on approach to OBS15 site. Measure acoustic ranges to OBS15 from 3 positions.

24 Recover OBS15. Deploy total field magnetometer sensor for passage to Candlemas I. or OBS16 site. Weather deteriorates. Recover magnetometer sensor and heave to.

25 Passage to OBS16 site. Measure acoustic ranges on OBS16 from 3 positions. Recover OBS16. Passage to proposed dredge site on inner trench slope. Deploy dredge.

26 Recover dredge haul of volcanic and epiclastic rocks. Passage to Candlemas I.. Anchor in Kraken Cove and deploy Cargo Tender and Humber in unsuccessful attempt to uplift field party. Recover Cargo Tender and Humber.

27 Weather deteriorates. Leave Kraken Cove and heave to E of Candlemas I.. Passage to proposed dredge site NW of Saunders I. Deploy dredge.

28 Recover dredge haul of volcanic rocks together with a variety of biological material. Passage back to Candlemas I.. Anchor in Kraken Cove and deploy Cargo Tender and Humber to uplift field party. Recover Cargo Tender and Humber, with Candlemas I. field party. Passage to proposed dredge site SW of Saunders Island.

March

1 Carry out dredge. Poor dredge haul - doubtful if any *in situ* samples recovered. Deploy total field magnetometer sensor and start passage to Falkland Islands. ‘Skyfix’ differential GPS deactivated.

2-4 Passage to Falkland Islands.

5 Recover total field magnetometer sensor and switch off scientific echo sounders on approach to Port Stanley. Arrive FIPASS at 12:15 GMT.

7. Scientific Narrative

7.1 Mobilisation

The multichannel hydrophone streamer winch and the gravity meter had been installed in Grimsby at the start of the season. Even given this head start four full days were required in port to mobilise the ship for seismic work. The areas of most intense work were the aft deck and the Underway Instrumentation and Control (UIC) room. On the evening of 10 February the NERC Chief Executive, Prof. John Krebs, visited the ship. He was surprised to be told that most of the equipment he was shown on the aft deck and in the UIC room had been installed in the previous 2 days.

7.2 Passage and Transfers of Personnel

RRS *James Clark Ross* left Port Stanley at 0700 GMT on day 013. A couple of hours later a shipboard three-component magnetometer (STCM) callibration manoeuvre was carried out, then a course was set for Signy Island. A visit to Signy to take Wendy Quayle to the BAS base there was a late change to the sailing instructions for the cruise. The end of the cruise had been put back one day to compensate for the extra passage time involved. At 1400 on day 015 the ship anchored outside Factory Cove, as visibility was poor and there were strong winds, and Wendy was taken ashore in the work boat. On departing from Signy a course was set for the East Scotia Sea. Our next task was to rendezvous with HMS *Endurance* to transfer John Smellie and Pete Bucktrout. Through radio communication with HMS *Endurance*, a provisional rendezvous was agreed for the afternoon of day 017, somewhere west of Candlemas Island. A helicopter from HMS *Endurance* reached RRS *James Clark Ross* at 1730 on day 017 and a helicopter transfer was effected by winching John and Pete up from the foredeck.

7.3 Streamer Balancing and E2 Survey

Immediately after HMS *Endurance* departed, work was started on balancing the multichannel hydrophone streamer. The ship headed slowly north-west, into the sea, while the streamer was deployed. Once fully deployed the streamer towed fairly well, although it was clear that some extra weight would have to be added. The streamer was fully recovered by 1030 on day 018, but bad weather prevented any further balancing work for the rest of the day. Work recommenced at 1130 on day 019, and in the meantime the ship had manoeuvred into a position east of the E2 segment of the East Scotia Ridge. The intention was to test all the multichannel seismic equipment, before we started deploying ocean-bottom seismometers, by collecting some short lines over the E2 segment. Some 4-channel seismic lines we had shot over this segment on cruise JR09a had revealed a magma chamber reflector, so this seemed a good opportunity to test the equipment and obtain some useful data at the same time. 0.5 kg of lead was taped to each section of the streamer as it was deployed. Once fully deployed it towed well, so the airguns were deployed. Three beams carrying three airguns each and one airgun on a separate umbilical were available. Work on preparing the fourth beam was still in progress. Once the available airguns had been deployed, recording of the first seismic data of the cruise began at 0050 on day 020.

Three short seismic lines were collected over the E2 segment, two running across the ridge axis and one running along it (BAS967-31 to BAS967-33). The prototype re-usable sonobuoy which Pat Cooper had developed was deployed on the last of these lines. Seismic recording was stopped at 1814 on day 020, and after recovering the streamer and airguns we went to search for the re-usable sonobuoy. By the time the ship had reached the area where the device was deployed it was dark and had started snowing. However, as we came within about 20 km of the sonobuoy we started picking up its transmissions again and were able to go directly to the GPS position it was sending.

7.4 First Set of OBS Deployments

The trial survey confirmed that all elements of the multichannel seismic system were working satisfactorily, so we were able to start deploying ocean-bottom seismometers (OBSs) in preparation for shooting the first long seismic transects. The first priority was to deploy the two instruments which would augment the temporary local earthquake seismometer stations which had by now been set up on the islands. The first of these was deployed 65 km ENE of Zavodovski Island at 1509 on day 021. There was then a long transit south before the second of these OBSs was deployed 75 km east of Bristol Island the following morning. Another 12 OBSs were then deployed on an east-west line running between Candlemas and Saunders islands. The first of these was deployed 70 km east of the trench axis and the last was deployed on the west flank of segment E5 of the East Scotia Ridge 30 hours later. The ship then continued westward to reach the designated start position of the first long seismic profile (BAS967-34).

7.5 Northern Seismic Profiles

Deployment of the multichannel hydrophone streamer started on 0700 on day 024. Once this was complete the full airgun array was deployed and recording was started at 1818. There was a problem with the tail of the streamer towing too shallow, but as the RVS technicians were due a rest period, and the OBSs were all deployed with the clocks on their timed releases running, the decision was taken to continue. During the following day a strong following sea developed, and this made the streamer towing characteristics even worse. However, by this time the conditions were too bad to attempt to recover the equipment. When it was decreed safe to go on deck again, the magnetometer cable was found to be tangled with one of the airgun umbilicals. The magnetometer sensor was recovered, revealing significant damage to the cable. Weather conditions started to improve on day 027, and the streamer started towing well again for the last part of the profile. Recording was stopped at 2128 on day 027 and the starboard airgun beams were recovered to fix problems with two airguns.

Work on the airguns continued through the night, and meanwhile the ship transited slowly northwards to the designated start position of the next seismic profile (BAS967-35), which would pass through the South Sandwich Islands just to the north of Candlemas Island. As the streamer was towing well now that the conditions were reasonable once again there seemed to be no reason to recover it. Recording on line BAS967-35 started at 1247 on day 028. Later that day the first disposable sonobuoy of the cruise was deployed. 4 more sonobuoys were deployed on day 029 as we approached Candlemas Island, and 3 of these operated successfully. Weather conditions deteriorated again during the evening of day 030 and the option of recovering the seismic equipment was considered. However, the forecasts available indicated that conditions were unlikely to become worse than during the storm we had weathered on the previous line, so it was decided that we would continue. The forecasts were wrong and 35-40 kt ESE winds produced a strong following sea on day 031, with similar adverse effects on the towing characteristics of the streamer as before. Fortunately we had already crossed the East Scotia Ridge by this time, so the most important parts of the line had already been completed. The main concern now was that if conditions did not moderate quickly we might not be able to recover the streamer and airguns in time to return to the OBS stations before the times set for them to release. To add to our problems, the RVS clock which controlled seismic shooting and recording jumped forward by a whole minute twice on day 031. Fortunately the weather did moderate on day 032. Recording was stopped at 1500 and the streamer and airguns were recovered with plenty of time in hand to return to the nearest OBS before its scheduled release time. During recovery of the streamer 0.5 kg of lead was added to alternate sections from sections 2 to 22.

7.6 First Set of OBS Recoveries

The ship reached to first OBS station well ahead of schedule, so the spare few hours were used to collect an oppotunistic wax core from the axis of the E5 segment of the East Scotia Ridge, which was just a few kilometres to the east. The first OBS release fired on schedule at 0000 on day 034, and the instrument was recovered at 0145. Subsequent OBS recoveries went according to plan, until we reached the penultimate instrument on the line (OBS13). No acoustic signal was detected from the instrument at the scheduled release time (2100 on day 035) and nothing was seen at the surface, even after the ship had remained on station for about an hour after the OBS was expected to reach the surface. We recovered the last OBS on the line without any difficulty and then returned to the previous station to carry out a further search. Nothing was found and a course was set to the southern earthquake OBS station. The earthquake OBSs were fitted with both acoustic and timed releases. The acoustic release on the southern one was triggered at 1726 on day 036 and it was recovered about 50 minutes later. Another OBS was then deployed in its place to record for a further two weeks. The northern earthquake OBS was recovered and replaced in a similar way on day 037.

7.7 First Set of Dredges

Having completed the OBS recoveries there was now an opportunity to attempt some dredges around the northern part of the island arc and back-arc before heading to South Georgia. The first dredge target was the submarine ridge linking Zavodovski and Leskov islands. Two dredges were attempted here early on day 038. The first was unsuccessful (DR159) and the second resulted in the loss of the bag and pipe (DR160). While a new dredge bag was being rigged we moved to another target north of Zavodovski Island. The result of this dredge was loss of the pipe and irreparable damage to the bag, but at least we suceeded in recovering some samples. Three more dredges using a third dredging rig were carried out on day 039. The first was on the southeast flank of Protector Shoal and recovered an excellent haul of samples (DR162). The next two were on the E1 segment of the East Scotia Ridge (DR163 and DR164). The first again resulted in excellent recovery and the second recovered just a single piece of fresh glassy basalt. Once the dredge had been recovered after the last of these dredges at 1840 on day 039, the towed magnetometer sensor was deployed and we set course for South Georgia. RRS *James Clark Ross* arrived at Grytviken at 1900 on day 040 for a mid-cruise break, and departed again at 0900 on day 042. Dave Smythe and David Abensour disembarked at Grytviken, as planned, and eventaully returned to the Falklands on M/V *St Brandon*.

7.8 Second Set of OBS Deployments

After leaving South Georgia the first priority was to deploy 12 OBSs on a line passing just to the south of Southern Thule, in preparation for shooting the southern long seismic transects. The first of these was deployed on the western flank of the E8 segment of the East Scotia Ridge 2054 on day 043 and the last was deployed about 65 km east of the trench 33 hours later. The ship then continued eastward to reach the designated start position for the next long seismic profile (BAS967-36).

7.9 Southern Seismic Profiles

Deployment of the multichannel hydrophone streamer started at 1130 on day 045. Once this was complete the full airgun array was deployed and recording started at 2026. All of the seismic equipment worked well and everything continued to run smoothly for the next three days. Five disposable sonobuoys were deployed on day 046, but only 2 of these worked satisfactorily. Weather conditions deteriorated during day 047, but the wind direction was from the southwest and the streamer continued to tow well in the head sea this generated. As everything continued to work well when we reached the end of this line on day 048, we continued recording on the northward transit to the start of the next line.

Later on day 048 we started the last long seismic profile, which passes between Montagu and Bristol islands. By this time the swell was from the northwest, and the tail of the streamer started towing too shallow once the ship had straightened up on the new course. Streamer depth control continued to be a problem all along this line, even after the conditions improved. It was subsequently discovered that three of the depth controllers had malfunctioned, two leaving their fins uncontrolled and the other leaving its fins fixed in the 'surface' position. As no wide-angle recording was planned on this line, the nominal shot interval was reduced from 100 m to 50 m, thus giving the compressors a thorough work out. Recording was stopped at 1740 on day 051, and the airguns and streamer were fully recovered by 2245. The towed magnetometer sensor was deployed and a course set for the easternmost OBS, which was scheduled to release earliest.

7.10 Second Set of OBS Recoveries and Uplift of Field Party from Thule Island

The ship reached the first OBS station with an hour to spare before it released at 1100 on day 052. This instrument was recovered successfully and subsequent OBS recoveries also went according to plan. Late on day 052 it became clear the weather conditions the next day, when we would pass close to Thule Island, would be the best encountered during the whole cruise, presenting an opportunity to uplift the geophysical field party from the island which could not be ignored. However, at our closest approach to Thule Island there would still be another 5 OBSs to recover, with the releases scheduled to fire at 4-hourly intervals. It was decided that we would attempt to interleave uplift of the field party with the OBS recovery operations. Thus, after OBS22 was recovered from a position about 15 km southeast of Thule Island at 1138 on day 053, the ship went into Douglas Strait and deployed the cargo tender and a humber. The new hydrographic survey carried out from HMS *Endurance* during the previous month was used to navigate a save route into and out of Douglas Strait. The ship went to recover OBS21, reaching its station about 20 km southwest of Thule Island after the instrument had released from the sea floor, but before it reached the surface. OBS21 was recovered at 1445, and then the ship returned to Douglas Strait to collect the cargo tender and humber, which had by this time effected the uplift of the field party.

8. List of Scientific Equipment used

8.1 Seismic Reflection Equipment

Teledyne 96-channel analogue hydrophone streamer, 2400 active length	[RVS]
8 x Teledyne depth sensors and digital depth display model 28950	[RVS]
13 x Syntron RCL-2 cable levellers	[RVS]
6 x Syntron retrievers and floats	[RVS]
Water-break hydrophone and Kalamos water-break amplifier	[RVS]
14 x Bolt 1500C airguns with chamber sizes 1.97-11.47 l (120-700 in^3)	[RVS]
4 x NERC airgun umbilical winches and beam towing systems	[BAS/RVS]
Ref Tek 43A gun controller and gun depth monitor	[RVS]
Ref Tek 70 seismic source solenoid power supply	[RVS]
4 x Hamworthy 555 m^3 /hr (327 ft^3 /min) compressors	[BAS]
DMW clock	[RVS]
RVS extended header and timing control system	[RVS]
RVS seismic header interface and parallel interface to level A	[RVS]
12V power supply normally used for Sercel SN358	[RVS]
Kalamos M4 signal testing and conditioning system	[RVS]
Seismic Engineering Co. 104-channel DSS-V interface	[BAS/RVS]
120-channel Texas Instruments DFS-V (modified not to use 9-track tape)	[UG]
4 x Exabyte 8500XL drives mounted in 120 MHz Pentium PCs	[UG/BAS]
Seismic data capture and demultiplex software for Windows95	[DCA]
2 x Waverley model 3710 thermal linescan recorders	[RVS]
ProMax seismic processing software on Sun UltraSparc 1	[BAS]
MicroMax seismic quality control and processing software on 486 PC	[BAS]
Oyo GS612 thermal plotter attached to MicroMax PC	[BAS]

8.2 Wide-angle Seismic Equipment

15 x analogue recording ocean-bottom seismometers	[GSC]
Odetics GPStar model 335 time and frequency receiver	[DU]
11 x Ultra Electronics SSQ906/907 disposable sonobuoys	[BAS]
2 x ICOM communications receiver IC-R7000	[RVS]
BAS digital 4-channel marine seismic data recording system	[BAS]
Prototype re-usable sonobuoy	[BAS]

8.3 Potential Field Equipment

LaCoste and Romberg gravity meter (S84)	[RVS]
2 x Varian/Scintrex V75 proton-precession magnetometers and parallel interface	[RVS]
Shipboard three-component magnetometer	[BAS]

8.4 Echo Sounders

IOS 10/12 kHz Precision Echo Sounder MkIV and Waverley linescan recorder	[BAS]
IOS 3.5 kHz high resolution profiler and Raytheon linescan recorder	[BAS]
Simrad EA500 (Bridge navigational echo sounder)	[BAS]

8.5 Rock Sampling

3 x dredging rigs (dredge bag, pipe dredges, weak links, pingers etc.)	[RVS]
IOS Rock Chipper (wax corer)	[BAS]
30-ton traction winch	[BAS]

8.6 Navigation

Trimble 4000DS GPS receiver	[BAS]
Skyfix differential GPS demodulator (input to Trimble receiver)	[RACAL]
Ashtech GPS+GLONASS receiver	[BAS]
Ashtech 3D GPS receiver	[BAS]
TSS300 heave, roll and pitch sensor	[BAS]
Chernikeeff Aquaprobe Mk5 electromagnetic speed log	[BAS]
Sperry doppler speed log	[BAS]

8.7 Data Logging

RVS ABC system used for logging navigation and potential field data	[BAS]

The letters in square brackets at end of each line indicate the source of the equipment. The sources of equipment not owned by BAS are as follows:
DCA = D.C. Abensour (as sub-contractor to Glasgow University)
DU = Dalhousie University, Nova Scotia, Canada
GSC = Geological Survey of Canada, Atlantic (via Geoforce Consultants Ltd)
RACAL = RACAL Survey Ltd, Aberdeen
RVS = Research Vessel Services, Southampton Oceanography Centre
UG = University of Glasgow

9. Equipment operation summary

9.1 10 kHz Precision Echo Sounder and 3.5 kHz Sub-Bottom Profiler

Continuously operating from 013/09:30 to day 064/09:30, with the following exceptions:
During deployment and recovery of OBSs.
015/13:00 to 015/15:25 - anchored off Signy Island.
040/16:45 to 042/10:58 - alongside at Grytviken, South Georgia.
055/23:20 to 056/09:35 - hove to during persistent westerlies (Simrad EA500 operating).
057/14:45 to 058/18:35 - anchored in Kraken Cove, Candlemas Island, then subsequently moved offshore but stayed within area already surveyed with HAWAII-MR1 on JR09 (Simrad EA500 operating).
059/02:00 to 059/23:30 - return visit to Kraken Cove coincident with previous track; anchored in Kraken Cove during uplift of field party (Simrad EA500 operating).

Total line-km collected: 15235

9.2 Gravity Meter

Continuously operating and logging from day 013 to day 064.

Total line-km collected: 15729

9.3 Shipboard Three-Component Magnetometer

Continuously operating from day 013 to 039/14:00, when sensor fixings sheared.
Continuously operating from 043/16:30 to 056/11:00, when problems with the instrument were judged to be terminal (see section 10.4.2).

Total line-km collected: 11717.7

9.4 Proton Magnetometer

Operating during the following periods:
013/10:18 to 015/04:42 - then interrupted because of instrument problems.
015/06:11 to 015/11:36 - then sensor recovered on approach to Signy Island.
015/16:51 to 017/17:12 - then sensor recovered prior to rendezvous with HMS *Endurance*.
Magnetometer sensor not towed during acquisition of seismic lines BAS967-31 to BAS967-33.
021/02:06 to 021/13:19 - then sensor recovered before deployment of OBS1.
021/15:44 to 021/18:15 - then interrupted because of instrument problems.
021/19:40 to 022/06:52 - then sensor recovered before deployment of OBS2.
022/07:45 to 022/17:51 - then sensor recovered before deployment of line of OBSs.
024/22:56 to 026/19:58 - then sensor recovered after entanglement (line BAS967-34).
Magnetometer sensor not towed during acquisition of seismic line BAS967-35.

033/01:34 to 033/19:21 - then sensor recovered before recovering of line of OBSs.
036/05:18 to 036/15:05 - then sensor recovered before OBS2 recovery & OBS15 deployment.
036/19:12 to 037/12:08 - then sensor recovered before OBS1 recovery & OBS16 deployment.
039/19:02 to 040/16:12 - then sensor recovered on approach to Grytviken, South Georgia.
042/12:03 to 043/18:56 - then sensor recovered before deployment of line of OBSs.
Magnetometer sensor not towed during acquisition of seismic lines BAS967-36 to BAS967-38.
051/23:01 to 052/09:27 - then sensor recovered before recovering line of OBSs.
054/07:33 to 054/14:13 - then sensor recovered on approach to Douglas Strait.
054/15:51 to 054/23:01 - then sensor recovered before OBS15 recovery.
055/03:02 to 055/23:20 - then sensor recovered as ship hove-to in bad weather.
060/08:19 to 064/09:30 - then sensor recovered on approach to Falkland Islands.

Total line-km collected: 8222

9.5 Multichannel Seismic Acquisition

Continuously collecting seismic data during the following periods:
020/00:50 to 020/18:14 - lines BAS967-31 to BAS967-33, segment E2 of East Scotia Ridge.
024/18:18 to 027/21:28 - line BAS967-34, S of Candlemas Island.
028/12:47 to 032/15:00 - line BAS967-35, N of Candlemas Island.
045/20:26 to 051/17:40 - lines BAS967-36 to BAS967-38, across S part of island arc.

Total line-km collected: 3017

10 Equipment performance

10.1 Seismic Systems

10.1.1 Teledyne Streamer (DGB/RDL)

A 96-channel hydrophone streamer with associated equipment was supplied by RVS and installed on the ship in August 1996. The hydrophone streamer consisted of:

Tow Cable (99m outboard)
4off Spring Sections (50m ea.)
24off Active Sections (100m ea.)
Spring Section (50m)
Tail rope & buoy

Depth sections placed in front of sections 1, 5, 8, 12, 15, 19, 22 and behind section 24 (each 1m long).
Water Break in front of Dep. 1 (1m).

Note all section reference numbers are counted from the front of the streamer.

The depth sections were calibrated during each deployment. Birds (depth controllers) were placed in front of every odd numbered section and behind section 24. Retrievers and Floats were placed in front of sections 4, 8, 12, 16, 20 and 24. Bunching of diaphragms in the Birds posed a probelm at the start of the cruise (all the birds had been rebuilt and tested prior to sailing).

The hydrophone sections were approximately balanced when being serviced by RVS prior to the cruise. A balancing deployment (day 017) was carried out and showed that the streamer was slightly too positively buoyant. It was decided to add 0.5 kg of lead to the centre of each section during the next deployment (day 019).

With the additional lead the streamer towed at reasonable depths except at times when there was bad weather and a following sea (i.e. most of line BAS967-34 and the last part of BAS967-35). At such times most of the streamer towed at shallower depths than desired. More lead (0.5 kg) was added to alternate sections just in front of the birds (except Birds 1 and 13) during recovery at the end of line BAS967-35. The streamer towed at reasonable depths during line BAS967-36, but the hydrophone depths became shallower again as a strong following sea developed toward the end of line BAS967-37. On line BAS967-38, although the weather improved, the hydrophone depths remained stubbornly shallow, except for the front ¼ of the streamer. On recovery Birds 5, 6 and 8 were found to have broken driving rods for the fins and bird 7 was found to have a jammed diaphragm. The failure of the rods can only be attributed to the preceding very bad weather.

During line BAS 967-35 bad weather caused the tow cable to be damaged by one of the port airgun beams. This damage was repaired by taping the damaged areas.

On servicing the retrievers at the end of the cruise it was discovered that two units had developed small leaks and the batteries had corroded causing gas to be formed inside the casing. The cases have been damaged so badly that they will need replacing.

Tests prior to streamer deployment on day 024 revealed a leakage fault affecting a block of channels. This was traced to the connector between sections 16 and 17. The problem was solved by cleaning the connector and replacing the seal. The depth electronics failed after two depth channels developed shorts on day 024, shortly after the start of line BAS967-34. Once the displays for these channels had been switched out the remaining units continued to work. The leakage on the two faulty depth channels decreased without any intervention and when they were switched on again on day 027 they were found to work. During streamer deployment on day 045 it was found that the connector between sections 10 and 11 was leaking oil while under pressure on the winch, requiring replacement of the seal.

During the very bad weather around days 031/032 the tail buoy light and radar reflector were lost.

Table 1 Streamer deployments, balance adjustments and performance.

Deployment	Day	Line Numbers	Comments
1	017		Balancing streamer.
2	019		0.5 kg lead added to every section.
	020	BAS967-31/2/3	Towed OK in good conditions.
3	024		Leakage - connector 16/17 seal replaced.
	024-027	BAS967-34	Too shallow for most of line in bad weather & following sea. OK on last part of line as conditions improved.
	028-032	BAS967-35	Towed OK for most of line in fine conditions. Too shallow on last part of line in bad weather and following sea. Tail buoy light and radar reflector lost. Tow cable damaged by airgun beam. Some birds sticking when recovered.
	032		0.5 kg lead added to alternate sections.
4	045		Oil leak - connector 10/11 seal replaced.
	045-048	BAS967-36	Towed OK in moderate conditions.
	048	BAS967-37	Became too shallow near end of line.
	048-051	BAS967-38	Too shallow in bad weather and following sea, and remained too shallow when conditions improved. Birds 5, 6, 7 & 8 found to be damaged when recovered.

10.1.2 Airguns and airgun handling system (AMT/SFB)

10.1.2.1 Introduction

The seismic system was installed on RRS *James Clark Ross* while alongside at FIPASS (Port Stanley, FI) between 8th January 1997 and 12th January 1997.

Staff:

- S. F. Bremner (BAS)
- A. M. Tait (BAS)
- D. Dunster (RVS)

Equipment:

- RVS 4-channel seismic system*
- BAS airgun handling system

Airgun handling system components:

- Umbilical winch (4 off)
- Beam crane (2 off)
- 7-metre towed airgun beam (4 off)
- Bolt 1500c airguns with the following chamber sizes (in cubic inches):
  120 (2 off), 160 (3 off), 200 (1 off), 400 (2 off), 460 (2 off), 600 (2 off), 650 (1 off), 700 (4 off)
- Towed Hippo buoy (4 off)
- JCR Gilson winch (c/w 12mm diameter 7x19 ss wire)
- JCR port & starboard Effer cranes

Recording and firing systems:

- Teledyne 96-chan. streamer (RVS)**
- Geomechanique streamer (RVS)*
- DSS-V interface (BAS/RVS)
- DFS-V recording system (Glasgow)
- RefTek 43A airgun controller (RVS)
- EDMOSEIS recording system (BAS)

JCR fixed equipment:

- Hamworthy air compressors
- Ship hydraulic system

* Equipment installed but not used
** Equipment already installed in UK.

10.1.2.2 Installation

Preliminary installation went well with most of the equipment in position and bolted down by the end of the first day. The ISG mechanical equipment container was in position on the after deck by mid-morning. Containerisation of the equipment was a great success and ensured that we were in a good position to start building up the airgun system the following day. As space was limited the container was moved a few days later to the forward hold, but due to the improved container layout we were not unduly hampered.

A custom built container flat was used this year to transport the beam cranes and umbilical winches. This proved very successful, not only in the handling of the equipment but also in considerably reducing the risk of damage. Thus no damage was incurred this year and the hydraulics were plumbed in and tested with minium delay.

The bulk of the installation was completed on schedule with only one or two minor faults in the system. These were rectified and the system was fully tested satisfactorily. The ship sailed at 06:00 on Monday 13th January 1997. Outstanding items were completed while underway.

10.1.2.3 Beam mounted airgun system

The majority of the handling system was supplied from the BAS Geoscience equipment pool. The airguns, multichannel hydrophone streamer and two umbilical winches were supplied by RVS. The four umbilical winches were positioned on either side of the aft deck allowing the inboard and outboard beams to be deployed over the stern quarters and aft side rails. Each beam was assembled with the following gun configurations.

Beam	Fwd	Centre	Aft
Stbd Inboard	400	120	600
Stbd Outboard	300	160	700
Port Inboard	466	120	600
Port Outboard	300	160	650
Stbd Single	700		
Port Single	700		

Shotphones were positioned directly above each gun, inside the beam. Depth sensors were also placed inside the beams and positioned at each end.

10.1.2.4 Deployment and Recovery

The beams were deployed in the usual manner, using the beam cranes connected to the aft port and starboard Effer cranes. The starboard inboard beam was deployed first, followed by the outboard beam, then the procedure was repeated for the port beams in the same manner. Finally the two single guns were deployed over the stern bulwark.

There were two airgun configurations used on the cruise as follows:

Configuration 1 - consisted of both stbd beams, the port inboard beam and the stbd single airgun (c/w a 300 cu. in. chamber).

Configuration 2 - all beams and singles were used as indicated in the table above.

The basic procedure was as follows:

The beam was raised over the bulwark. The Hippo buoy was connected to the aft end of the beam by 8 metres of 24 mm polypropylene rope. Each gun was then primed to 200 PSI (ca 14 bar). The beam was lowered into the water by means of the winch mounted on the beam crane, whilst simultaneously paying out the umbilical.

The umbilical, which was towed through a fairlead (fixed to the end of the airgun booms for the outboard beams, and fixed on the stern quarter bulwark for the inboard beams), was paid out until there were only approximately three turns left on the winch drum. Because of the different positions of the umbilical winches and the different lengths of umbilical between the winches and the stern, this resulted in varying lengths of umbilical deployed beyond the stern, ranging from about 50 m to about 80 m. Wire on the beam crane winch was paid out until slack and then tied off on the bulwark, to enable the strain to be taken on the umbilical. The remaining strain wire was then removed from the beam crane (for the inboard beam) and a new wire was wound on and connected to the outboard beam for its deployment in the same way. The guns were then charged to 2000 PSI (ca 138 bar). The port side deployment was carried out in the same way. Recovery in both cases was the reverse of the deployment.

The single airguns were connected by a strain wire via a block on the stern gantry to the Gilson winch. The airgun was lifted outboard of the ship using the stern gantry and Gilson winch, where it was primed to 200 PSI (ca 14 bar). The strain wire was then paid out until the umbilical (which was passed over a roller block on the stern bulwark) took the strain and the strain wire itself became slack. The wire was then tied off and a separate wire was used in the same manner to deploy the second single gun. Recovery in both cases was the reverse of the deployment.

10.1.2.5 Operational Problems

Lines BAS967-31, BAS967-32 & BAS967-33 (19th–20th Jan 97)

Deployment (airgun configuration 1). During the first deployment there were a number of small problems which were quickly rectified. All guns sealed and the starboard inboard and outboard beams were deployed without any problems. During the deployment of the port inboard beam, the removal of the electrical cables to the umbilical winch was overlooked, causing the cables to be severed. The operation was halted and the wires removed before completing the deployment. The electrical cables for the port outboard beam were used as a temporary measure while repairs were carried out.

Starboard outboard beam. Gun 3, 700 cu. in.
Symptom: gun would not fire after being switched off prior to start of line.
Action: stopped firing guns on stbd side, reduced air pressure down to 700 PSI (ca 49 bar) and fired the gun manually.
Result: gun started firing and was placed on line.

Starboard inboard beam. Gun 3, 650 cu. in.
Symptom: gun stopped firing.
Action: stopped firing guns on stbd side, reduced air pressure down to 700 PSI (ca 49 bar) and fired

the gun manually.
Result: gun started firing and was placed on line.

Starboard single. 300 cu. in. gun.
Symptom: shotphone produced a weak signal which made it impossible to synchronize with the other guns.
Action: gun was turned off.
Result: on recovery the shotphone was found to be faulty and was replaced.

Recovery. All beams were recovered successfully. Starboard beam crane suffered a hydraulic problem which prevented it from holding the beam without the operation of the haul lever. This was later found to be related to a restricted flow caused by recently fitted quick release couplings. This was removed and the pipe work was then connected directly to the crane which rectified the fault.

Line BAS967-34 (24th–26th Jan 97)

Deployment (airgun configuration 2). All guns sealed, on the two singles and the starboard and port beams. These were then deployed and brought on line without any problems.

Starboard single. 700 cu. in. gun.
Symptom: poor signal from shotphone.
Action: investigated the signal received by firing equipment and located a faulty amplifier card.
Result: a new card was used and the signal was fine.

Port single. 700 cu. in. gun.
Symptom: suspected of auto-firing.
Action: the gun was turned off.
Result: on recovery the solenoid was serviced and the plunger was discovered to have a broken firing seal.

Recovery. Initially the single guns were brought in first as they were connected directly to the ¼ turn valves on their respective inboard umbilical winches, which prevents them from being rotated. Due to recent bad weather the two single guns had become tangled together so they had to be recovered as a single item. The starboard outboard beam and the two port beams were recovered without any problem. It was apparent that while retrieving the starboard inboard beam the recovery wire had broken and the normal method of retrieval was not possible. It was therefore necessary to bring the beam up on the umbilical as far as the fairlead would allow. From here it was possible to pass a lifting strop below the first gun and attach it to the Gilson winch. The beam was then paid out into the water and its weight taken on the Gilson winch. The beam was then brought up using the stern gantry clear of the water the guns were bled down before it was landed on the aft deck. Once there, it was possible to re-terminate the recovery wire and the beam could be lowered back in the water and recovered in the normal way.

Having retrieved all the guns the following work was under taken:

Starboard inboard beam. All guns were removed and stripped down as they had been flooded during recovery.

Starboard & port single airguns. Damaged air hoses were replaced and their shotphones repositioned further back from gun to reduce their signal levels.

Line BAS967-35 (28th Jan–1st Feb 97)

Deployment (airgun configuration 2). On deployment of starboard inboard beam, gun 2 (120 cu. in.) refused to seal. After several attempts to resolve the fault the gun was replaced and the deployment continued. All other beams and single guns were deployed without any problems.

Starboard single. 700 cu. in. gun.
Symptom: gun stopped firing.
Action: gun was turned off. No attempt was made to restart it as this would have interfered with data collection.
Result: on recovery no fault was found.

Recovery. Single guns retrieved without any problems. Starboard beams retrieved without any significant problems. Port outboard beam had major retrieval problems. The retrieval wire had broken near the beam crane winch during the survey. The beam was brought alongside and the wire was grabbed using a grappling hook. The wire was then rewound onto the winch, the guns discharged and the beam recovered as normal. Port inboard beam was brought to the surface where it was discovered that the wire was tangled with the centre 120 cu. in. gun. The wire had significant damage and was cut through down to 2 strands. During the process of untangling the gun and beam, the wire broke. The retrieval method used was to bring the beam to the rail using the umbilical winch. The beam was then secured to the rail and the guns were discharged in the normal way. A new wire was connected to the beam and wound onto the winch. The beam was then lowered into the water and retrieved in the normal way. During this process the airguns were completely flooded with water. During replacement into the beam stands the ship rolled and forced the beam athwartships, sending the beam towards the ship side. Care must be taken when positioning the beams athwartships as this can cause excessive forces on the stands, due to the ship's tendency for rolling.

Lines BAS967-36, BAS967-37 & BAS967-38 (14th–20th Feb 97)

Deployment (airgun configuration 2). All guns sealed (only the 120 cu. in. guns requiring additional help). They were then deployed as normal with no further problems.

10.1.2.6 Comments and Recommendations

1) The new style umbilicals proved to work exceptionally well on this cruise. Their ridged round construction provided the ideal design to spool evenly onto the winch while providing maximum protection to the gun hoses and cables. Even in heavy weather uniform spooling of the umbilical was possible, thus preventing the necessity to re-spool the winch once recovery was complete. These new umbilicals will certainly reduce costly repairs in the future and extend the useable life of the umbilical.

2) The trial of new style airgun beams proved a great success compared to the older traditional style ones. Both types of beam were used side by side and allowed a good comparison. The new beams with their quick release side panels proved very effective, allowing quick access to hoses and cables.

This allowed running repairs to take place with the minimum of down time.

3) The servicing of all the airguns by Dave Dunster at RVS prior to the cruise was a major factor in their reliability. The guns in general required the minimum of attention while data was being acquired. Most of the subsequent breakdowns and damage during the cruise, had been as a result of bad weather. The unpredictability of the weather and the time taken to recover the gun array, makes it impractical to retrieve equipment before conditions deteriorate to a state where damage will occur.

10.1.3 Seismic Firing and Recording Control, Timing, RefTek Airgun Controller and Associated Equipment (DGB)

The main timing for the multichannel seismic system was derived from a free-running DMW master clock. This master clock, located in the Main Lab, drove slaves both in the OBS container and in the UIC room. The clock was synchronised to a GPS clock signal from the Odetics GPStar system prior to the start of each OBS seismic line. The drift of the master clock relative to the GPS clock was noted at intervals throughout the cruise and is shown graphically in Figs X and Y. The time error in milliseconds is the absolute error from the GPS time (positive values = ahead of GPS).

A PC was used to control the 'start' and 'fire' commands. Normally this PC also provides the Sercel extended header data. Figure Z shows the timing sequence. The PC time of the 'start' command, together with position number and hydrophone depths, were logged onto 3½" floppy disks labelled "RVS Sercel Log", which were supplied to the Principal Scientist at the end of the cruise. An output also provided data to a Level A, giving the 'fire' command time on the DMW clock (least significant digit of seconds followed by decimal fraction of a second) and the least significant two digits of position number, time stamped with the full 'start' command time. The data from this Level A were logged to a file called 'sercel' on Level C, and these data confirm that the 'fire' command always occurred precisely on a whole second on the DMW clock, exactly one second after the 'start' command. Note that the airguns were synhcronised to fire 100 ms after the 'fire' command by the RefTek airgun controller, so the shot instants were actually 1.1 seconds later than the 'start' command times.

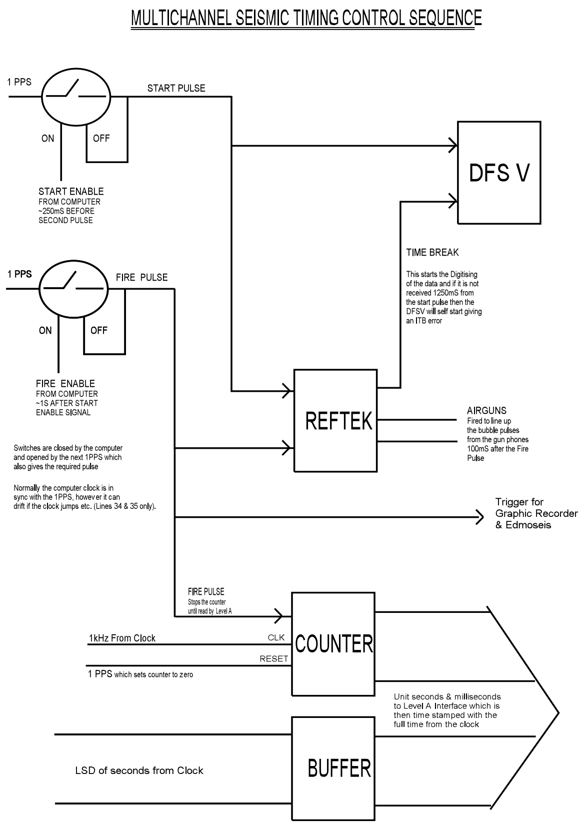


Fig. ZZ. Multichannel seismic system timing control sequence.

The PC time was synchronised to the DMW master clock approximately every 12 minutes.

Unfortunately the DMW clock jumped forward by unit minutes six times during the cruise. Clock jumps occurred on day 020 (after completion of line BAS967-33), twice on day 031 (during line BAS967-35), on day 045, day 048 (BAS967-37) and day 053. For the jump during line BAS967-35 the PC identified the jump forward and used its own time. Drift of the PC clock eventually resulted in one second pulses from the DMW clock falling outside the normal time windows for the 'start' and 'fire' commands. This resulted in 'internal time breaks' on the DFS5 recording system (indicating that it was not receiving actual 'time break' signals from the RefTek) and shot intervals that were occassionally one second longer than the intended cycle time (the PC clock was running slow). For intervals of several minutes every shot was recorded with an 'internal time break' and then the system would start recording normally again, presumably once the PC clock had drifted near enough to a whole second for the timing sequence to function as intended once more. The times logged by the Level A remained correct until it was reset (the level A continued to use the DMW clock as its time reference, but ignored the whole minute jump). When the Level A was reset (0100/031 and 1632/031) the logged time jumped to the new DMW time over a series of shots.

For the last group of seismic lines (BAS967-36 to BAS967-38) the software in the PC was modified so that when a clock jump occurred the milliseconds of the PC time continued to be synchronised but the minutes were not updated. As a result of this modification the DMW clock jump on day 048 did not cause any recording problems.

The RefTek system provided the firing pulses for the 14 airguns. Apart from a problem with an amplifier at the start of the cruise, and a locking up twice on day 047 during line BAS 967-36, the firing system performed very well. The usual problem with shot phones and depth sensors becoming damaged on-line caused a few problems, but did not prevent the airguns being fired staticly. Note the airguns were set to fire 100ms after the 'fire' command pulse was received by the RefTek.

An interface unit was constructed to provide an additional contact closure which was used to trigger the BAS 4-channel seismic recording system ('Edmoseis'), which was modified to accept this. Contact closures are used to isolate the triggering systems which helps to prevent noise on the data channels.

10.1.4 Seismic reflection data processing (APC/JC)

10.1.4.1 MicroMAX seismic processing system

The MicroMAX seismic processing system was assembled during JR18 mobilisation and consisted of the following:

Compaq 486 CPU and VGA monitor
StorageTek 2925 0.5 inch tape drive
Exabyte 8505XL 8mm tape drive with Pertec interface
Oyo GS-612 thermal plotter

During JR18, the MicroMAX system was principally used for seismic data plotting. MCS data were copied from ProMAX to MicroMAX via 8 mm Exabyte tape, and plotted using the Oyo GS-612 thermal plotter. In general, the MicroMAX CPU and peripherals functioned reliably during the cruise. The Exabyte 8 mm tape unit behaved erratically when first connected to the system. However, subsequent tests showed that the SCSI tape device within the unit was functioning normally, and the fault was traced to connectors on the Pertec interface. The unit functioned normally after the connectors were reseated.

10.1.4.2 ProMAX seismic processing system

ProMAX version 6.1 was installed on UltraSPARC1 'jrue' at the start of the cruise from an Exabyte tape supplied by Landmark Graphics Corporation. When BAS purchased a ProMAX licence for use at BAS HQ, an agreement was secured which permits installation of a second copy of the software for use offshore, for a period not to exceed 2 months per calendar year. A fee of $500 is payable each time this facility is exercised. In order to exercise this facility a temporary licence must be requested from Landmark before the cruise, and the host-id of the system on which the software is to be used must be supplied.

10.1.4.3 Seismic Processing Sequence

The processing of JR18 MCS reflection data involved data testing, quality control and the development of strategies for the processing of common-mid-point (CMP) data. These activities are described below.

Unprocessed MCS shot gathers were initially read into ProMAX from trace-sequential SEG-Y field tapes (Exabyte 8505XL 8mm data cartridges). During SEG-Y input, MCS data were usually anti-alias filtered and resampled from 2 to 4 ms to conserve computer disk space. Initial examination of unfiltered shot records showed considerable variation in data quality due to the presence of swell and towing noise. In particular, data channels recorded on hydrophone groups which towed at shallow depths showed very high levels of noise. Shot gathers also showed coherent low-frequency towing noise which propagated laterally from shallow sections of the MCS streamer. Data channels contaminated with instrumental noise (50 Hz and octaves) were also apparent. Instrumental noise apparent on line BAS967-35 data channel 61 was traced to a faulty board in the DFS-V acquisition system which was subsequently replaced. However, the same noise problem reappeared on line BAS967-36, so the faulty DFS-V board was probably not the root of the problem

Filtered near-trace gathers were plotted for all MCS profiles acquired during JR18. These plots provided an informative view of the near-surface geology, and were used to gauge the quality and content of each profile. Near traces were read from SEG-Y field tapes, filtered and plotted on the Oyo GS-612 thermal plotter. Processing procedures applied to near-trace gathers included spherical divergence correction, bandpass filter (corner frequencies 8–220 Hz) and statistical deconvolution before stack (operator length=350ms, gap=24ms, whitening=0.1%). Near trace gathers were typically plotted with an additional display gain of 4dB.sec^{-1}.

Seismic geometry information. During JR18, shot times were recovered from SEG-Y trace headers to determine live station locations. Field file identifier (FFID) and shot time (as per RVS clock) were extracted directly from trace headers using an executable program *scan* provided by D.C. Abensour. An additional FORTRAN program *geom* was used to calculate live station numbers and coordinates, and this information was output in ASCII columns, a format suitable for loading into the ProMAX 2D geometry spreadsheet.

Processing of MCS profile BAS967-31. A series of plane wave stacks of MCS profile BAS967-31 were generated. The plane wave technique applied to these data involved the application of linear moveout in the time-offset domain to simulate the steering of wavefronts from a line source. Plane wave stacks generated during the cruise were encouraging, and showed that this procedure may enhance deep, dipping structure on the east-west SLICE transects.

Processing of MCS profile BAS967-32. Seismic parameter tests were carried out on shot records acquired along MCS profile BAS967-32 to determine an optimum processing strategy. Initially, spectral analyses were computed to assess the frequency characteristics of noise apparent in the water column. Power spectra were computed over 2000 traces using a 2 sec window above the sea-floor reflection. These tests showed a peak in the spectrum of the water layer at ~3 Hz which was attributed to swell and towing noise. Prominent spikes were also apparent at 50 Hz (and octaves) which were attributed to noise generated by the ship's cathodic protection system. Analyses computed on near-surface reflections showed that the JR18 MCS airgun source impulse had a broad-band power spectrum with a notch at ~59 Hz resulting from free-surface cancellation (equivalent to a source depth of 12.5 m).

Tests were carried out to determine an appropriate filter to suppress low-frequency towing noise apparent in unfiltered shot records. Low-cut filters with corner frequencies of 6-12 Hz were applied to near traces and plotted in a series of test panels. These tests showed that an 8 Hz filter had the lowest corner frequency which effectively suppressed noise in the water column. As a consequence, an 8 Hz low-cut filter has been applied before stack to all MCS data processed during JR18.

Testing was also undertaken to determine appropriate deconvolution parameters. Autocorrelations were computed using a 3 second window of near-surface primary reflections to assess periodicities in the reflected data. The autocorrelations showed prominent peaks at 110 ms, 220 ms and 330 ms lag which were attributed to residual bubble pulse reverberations. The second zero crossing on the autocorrelations (incorporating source and receiver ghosts) was measured at ~24 ms lag. On these grounds, a predictive deconvolution operator was chosen with an operator length=350 ms, gap=24ms and 0.1% whitening. This operator was applied before stack to all MCS data processed during JR18.

Following these initial tests, geometry was assigned to BAS967-32 shot gathers using the ProMAX 2D geometry spreadsheet. The source-near group offset was estimated by measuring direct wave arrival times on shot gathers, and by using independent estimates of tow cable/umbilical lengths deployed beyond the stern of the ship. These estimates showed an offset of 270 m for profiles BAS967-31 to -33, and an offset of 275 m for profiles BAS967-34 to -38. Live station locations were calculated using the *scan* and *geom* executables described above, and the MCS data were binned with a CMP bin interval of 12.5 m to maximise spatial resolution (equivalent to 24-fold CMP coverage).

BAS967-32 data were corrected for spherical divergence, bandpass filtered, deconvolved and sorted into 24-fold CMP gathers. Stacking velocity functions were then picked along the line at 1.25 km intervals. During velocity analyses, it became apparent that CMP gathers lying beyond the flanks of the East Scotia Ridge contained few primary reflections, and therefore provided poor estimates of seismic velocity. As a consequence, a series of constant velocity stacks were produced to help to identify primary reflections, and to gauge the sensitivity of the stack to adjustments in stacking velocity. These tests showed that the stack was fairly insensitive to variations in stacking velocity above 2750 $m.s^{-1}$. Finally, a velocity function with interval velocities comparable to those beneath the ridge axis was extrapolated beyond the ridge flanks, and the CMP gathered traces were then corrected to zero offset and stacked.

The CMP stack data were imaged using a Stolt FK time migration algorithm. Trial migrations showed that the semblance-derived stacking velocity field had discontinuities at depth which resulted in spurious dips in the time-migrated data. To rectify this, a smoothing operator was applied to the stacking velocity field (smoothing window of 100 CMPs and 500 ms TWT) before migration. Profile BAS967-32 was then time migrated using 90% stacking velocity and a Stolt stretch factor of 0.6.

Figure 5 shows a section of the final time migration of BAS967-32 extending across the axis of the East Scotia Ridge. These data show a well-defined magma chamber reflection at ~4.8 s TWT beneath the summit of the ridge (described in RRS *James Clark Ross* cruise JR09 Report).

10.1.4.4 Recommendations.

The ProMAX seismic processing system functioned reliably during JR18. However, the large volumes of MCS data acquired during the cruise placed heavy demands on computer disk space, and the 9 Gb hard disk reserved for MCS data processing was frequently full. Therefore, it would be desirable to add further disk space to the UNIX network before the next MCS cruise.

During JR18, MCS data were plotted by screen dump on the UNIX network, or transferred to the MicroMAX and plotted on the Oyo GS-612 thermal plotter. In future, it would be desirable to plot MCS data directly from ProMAX using CGM+ seismic data plotting software. This could be achieved by configuring the Oyo GS-612 plotter as a UNIX network device, or by installing CGM+ to Postscript conversion software which would permit the plotting of ProMAX files on the HP650c plotter.

Table 2 Details of multichannel seismic lines

Line number	Day/time	Latitude	Longitude	Distance from start of line (km)
BAS967-31	020/0050	56° 00.52' S	30° 11.04' W	
	020/0349	56° 00.47' S	30° 36.51' W	26.6
BAS967-32	020/0527	56° 06.16' S	30° 34.86' W	
	020/0847	56° 06.10' S	30° 05.08' W	30.7
BAS967-33	020/1153	56° 15.35' S	30° 19.12' W	
	020/1814	55° 44.83' S	30° 19.34' W	56.5
BAS967-34	024/1818	57° 35.94' S	32° 41.51' W	
	027/2128	57° 02.91' S	21° 21.06' W	690.6
BAS967-35	028/1247	56° 38.76' S	22° 09.17' W	
	029/1643	57° 01.73' S	26° 18.89' W	258.2
	029/1937	56° 58.49' S	26° 45.40' W	285.7
	029/2243	57° 06.82' S	27° 04.45' W	314.9
	030/1453	57° 22.05' S	29° 39.38' W	467.5
	030/2100	57° 22.07' S	30° 39.51' W	527.6
	032/1500	56° 51.82' S	36° 56.70' W	911.5
BAS967-36	045/2026	60° 08.49' S	21° 51.24' W	
	048/1549	58° 59.66' S	32° 28.11' W	613.8
BAS967-37	048/1604	58° 58.91' S	32° 28.99' W	
	048/1815	58° 49.62' S	32° 29.61' W	17.4
	048/2236	58° 33.16' S	31° 58.99' W	60.8
BAS967-38	048/2239	58° 33.14' S	31° 58.46' W	
	051/1740	58° 50.40' S	21° 10.52' W	626.5
Total number of line-km collected				3017.0

10.2 Ocean-Bottom Seismometers (RJI)

10.2.1 Introduction

The *British Antarctic Survey* (BAS) arranged with the *Geological Survey of Canada* (GSC) for use of the GSC's ocean-bottom seismometers (OBS) for the Sandwich Lithospheric and Crustal Experiment (SLICE), an integrated geological and geophysical exploration of the South Sandwich arc and back-arc in the Scotia Sea, southeast of the Falkland Islands. *Geoforce Consultants Ltd.*, Dartmouth, Nova Scotia, the private company which services and provides ocean-bottom seismometer logistics and field personnel to the GSC, was contracted to provide those services to BAS in support of the SLICE project.

In early October 1996 Geoforce Consultants shipped to the UK, from its Dartmouth, Nova Scotia facility, a containerized OBS workshop, complete with the instrumentation and consumables required for a 28 station OBS programme. It arrived in the UK and was trans-shipped to Port Stanley, Falkland Islands. BAS had the 28 OBS plate anchors required for the project fabricated in the UK to Geoforce's specifications and shipped them South with other BAS equipment aboard the RRS *James Clark Ross,* which departed from Grimsby in September 1996.

Geoforce Consultants' OBS field operator, Robert Iuliucci, departed Nova Scotia for the UK on 4 January 1997, met with the BAS cruise JR18 scientific personnel in Cambridge on the following day, and travelled with them on a RAF flight via Ascension Island to Port Stanley to join the ship.

Fig 6 OBS ready for deployment

During the period, 8–12 January at Port Stanley, the 20 foot OBS container/workshop was placed on board the RRS *James Clark Ross* and secured to the aft deck. The ship's electrical, communications, and fire-safety services were installed, and the OBS equipment was mobilized for the start of cruise JR18.

RRS *James Clark Ross* departed Port Stanley on 13 January 1997 and began the marine seismic activities of the SLICE project in the East Scotia Sea with streamer balancing on 17 January. An extensive seismic reflection, refraction and earthquake monitoring programme, including 28 OBS deployments, was carried out over the next 40 days. The RRS *James Clark Ross* departed the East Scotia Sea survey area on 1 March for transit to Port Stanley. During the transit the OBS container was demobilized and after arrival at Port Stanley on 5 March it was off-loaded and set dockside to await forwarding.

The OBS program had two components - earthquake monitoring and controlled source refraction. Two OBS's set to record for two weeks were deployed on 21 and 22 January at locations in the forearc, east of the South Sandwich Islands, to monitor earthquake activity. They completed a local network which also included land seismometers on Zavodovski, Candlemas and Thule Islands. These

OBS's were recovered and replaced on 5 and 6 February by two others set for two more weeks of recording to give a total coverage of 4 weeks monitoring at those locations. The other 24 deployments were along two east–west controlled-source seismic lines, 12 OBS's per line. The first set of 12 OBS's was deployed between 22–24 January on the northern of the two refraction lines (BAS967-34) and recovered between 3–6 February. OBS "C" deployed at Station BAS967-OBS13 failed to respond or surface at the programmed recovery time. The second set of 12 OBS's was deployed between 12–14 February on the southern refraction line (BAS967-36) and recovered 21–23 February.

10.2.2 Description of Equipment

10.2.2.1 Ocean-Bottom Seismometers

The GSC ocean-bottom seismometers were developed at the Atlantic Geosciences Centre, Bedford Institution of Oceanography, in Dartmouth, N.S., in the early 1980's primarily for use in seismic refraction studies and for seismic monitoring. The GSC had 20 instruments built by the Canadian Marconi Company in 1986. In 1989 Seastar Instruments Ltd. acquired the commercial rights to the OBS design and subsequently built a number of replacements for units lost over the years. The OBS's have been used for numerous studies and experiments for GSC, other countries' geological surveys, universities, research institutions, and oil companies.

An OBS consists of the seismometer instrument package housed in a 6000 metre depth-rated pressure cylinder, a flotation assembly on which glass buoyancy spheres are mounted, a hydrophone, and recovery aids. When deployed at an OBS station the instrument package cylinder is clamped to the flotation assembly and mated via an electro-mechanical release to an expendable steel plate anchor. The OBS is deployed by lowering it over the side of the ship to the water line and then releasing it to free-fall to the bottom. The anchor's weight sinks the OBS to the ocean bottom and holds it in contact with the sea-floor during data collection. Descent and ascent times are approximately 1 metre/second.

The anchor release mechanism is activated by two independent, programmable timers, one in the OBS circuitry in the main pressure cylinder, and a second separately housed in a small pressure cylinder attached to the flotation package. Each of these circuits is attached to a wire with a corrodible monel-metal loop at the end. The monel loop is attached to a lace which holds a tensioned nylon rod in place. This nylon rod is the sole link between the instrument cylinder/float assembly and the anchor. When either circuit gates a current to the monel loop at the end of its "burn-wire" the loop electrolytically dissolves releasing the lace, allowing the nylon rod to let go of the anchor, and the positively buoyant instrument package/ flotation assembly returns to the surface. Recovery aids attached to the flotation package are a VHF radio beacon, a strobe light, and a 25 metre length of 6 mm diameter rope, which unfurls from a canister as the OBS lifts off the anchor. Four of the flotation assemblies incorporate *Benthos* acoustic releases in the assembly's central glass sphere which, in addition to enabling the OBS to be released from the bottom by an acoustic command from a deck unit, allow for range-location of the OBS on the bottom.

The OBS instrument cylinder houses the main electronics/geophone assembly, the tape recorder, and alkaline battery power packs. One cylinder end cap has a pinger, the other end cap has through-connectors linking the internal electronics to the external hydrophone, the primary release burn wire, and a serial communication port to allow for clock calibrations and CPU programming when the cylinder is closed.

The main electronics/geophone assembly contains the digital and analog electronics, a 1 MHz clock/oscillator, a geophone sub-assembly, and the sockets to and from the sensors, tape recorder, pinger, and power supplies. The OBS onboard microprocessor is an RCA 1802 which performs time keeping and time code generation, pinger, tape transport, and release time control, and operator interface/serial communication.

The OBS sensors are a 2-component gimballed geophone package located in the OBS instrument cylinder and a hydrophone which is fastened to the flotation assembly. Specifications are:

Geophones:
Geospace - Model HS1
4.5 Hz
1.14v/in/sec sensitivity
+100 db amplifier gain - fixed

Hydrophone:
OAS - Model ES2D
3–20 Hz
87 db re 1V/microbar
+71 db amplifier gain - fixed

Data is recorded on an analog, 4-channel, 4-deck, cassette tape recorder, with geared-down tape drives which allow a standard 120 minute audio cassette to record up to 7 days' data. The decks can be configured to run in any combination from all 4 at once for 1 week to sequenced individually for 4 weeks.

10.2.2.2 Time Reference

The SLICE project OBS time reference was provided by an *Odetics GPStar, Model 335, Time and Frequency Receiver* which BAS leased from *Dalhousie University*, *Dept. of Oceanography*, Halifax, Nova Scotia. The *GPStar* provides an accuracy to 100 nanoseconds of UTC.

The receiver can perform navigationing functions and gives an output of the ship's position, course, and speed. Its primary use is as a precision timing device with the capability to time tag events, time trigger events, output 1 pulse per second, and act as a frequency standard at 1MHz, 5MHz, and 10MHz.

10.2.3 OBS Data Collection

10.2.3.1 BAS OBS Station Identification

All JR18 OBS stations were numbered sequentially by the BAS designation BAS967-OBS1 through BAS967-OBS28. Four of these stations (OBS-1, OBS-2, OBS-15, OBS-16) were designated for earthquake monitoring. Stations OBS-3 through OBS-12 were on the northern of the two seismic reflection/refraction lines (BAS967-34) and OBS-17 through OBS-28 were on the southern reflection/refraction line (BAS967-36), the numbers running low to the west and high to the east. **Table** 3 gives deployment location, deployment and recovery times, water depth, clock calibration and drift, and general comments for all OBS stations.

All OBS assemblies have letter ID's, A through T to identify the various components. Since their construction a complete performance and service record has been maintained for each OBS assembly. This enables the operator to choose the most reliable units and selectively assign them according to the Principal Scientist's priorities. 18 OBS assemblies were aboard the RRS *James Clark Ross*: A, B, C, D, E, G, H, I, J, K, L, M, N, P, Q, R, S, T. While some effort is made to keep the individual components with letter designations together as a complete assembly it is frequently necessary to substitute components for a deployment. In the case of mixed components for an OBS station the letter ID of the main electronics/CPU is used to identify the OBS for that site.

10.2.3.2 Data Recording

Experience with OBS deployments has shown that running of 2 of the 4 tape recorder decks in tandem to record each week of deployment results in the highest likelihood for complete data recovery for the time period. The running of more that two tapes at a time during shorter deployments introduces an unacceptably high noise level from tape motor rumble while not substantially increasing data recovery.

For SLICE the tape decks were configured to run in tandem mode to provide 2 weeks of recording with full backup. The four data channels were set up to record:

Channels 1 & 4 - Time code
Channel 2 - Vertical Geophone
Channel 3 - Hydrophone

Data from each OBS deployment consists of four *SONY* HF120 audio tapes, one from each tape deck in the tape recorder assembly of the OBS. Each tape is labelled with a sticky paper label in the following format:

OBS letter ID (A through T)
BAS967-OBS Station # (1–28)
Tape Deck # (1 through 4)
As Drive # (1 or 2)

In the event of the loss of the paper label the time code channels contain the time, date, and OBS ID which will identify the data. The four decks of each OBS tape recorder assembly are operator selectable to sequence in any order. The Tape Deck # refers to the physical location of that deck in the tape recorder assembly and does not indicate a location in time of the data on the tape. The location in time is given by the "As Drive #" which indicates the sequence of that deck in the data recording. For each BAS OBS deployment there are two data tapes indicating they ran "As Drive 1" and two tapes "As Drive 2". Drive 1 contains the first week of data recorded, from the time the tape deck was turned on, and Drive 2 the second week. The SLICE north and south reflection/refraction lines (BAS967-34 and BAS967-36) were shot so that the data from those lines will be wholly contained on the Drive 1 tapes. Data from the parallel reflection line to the north of each reflection/refraction line will start on the Drive 1 tape and continue onto the Drive 2 tape. Since the tape decks are continuously recording, any earthquake activity occurring from the time they landed on the bottom until they were released, should be recoverable from the tapes. For mechanical reasons some of the tapes did not advance properly. Refer to **Table 3** for a preliminary assessment of the data quality.

10.2.3.3 OBS Clock Calibration

Time Code - Using the 1 Mhz oscillator as its frequency base the OBS clock is generated by the RCA1802 microprocessor in the form of a BCD and hexadecimal code which is written to the data tapes. This "time code" contains the time of day, the Julian date, and OBS letter ID. The faceplate of the OBS main electronics assembly has a BNC output from which the operator monitors the time code. The initial pulse of the time code string beginning on the minute is the OBS time for that minute.

"One Shot" or "Minute Printing" Time - Since the OBS time code BNC connector is inaccessible when the instrument is bottled in its pressure case for deployment the OBS has a software selectable switch which allows the operator, by selecting *"minute printing on"*, to put a time pulse on the serial communication line. A serial port is available through a pressure-proof connector on the OBS end cap. This enables the operator to make the final pre-deployment time calibration with the OBS on deck ready for deployment and upon recovery prior to opening the pressure case. As a result of internal delays this so-called *"one-shot"* time is not the same as the time code. To correct to time code or OBS time, 22 milliseconds is added to the "one-shot" time (i.e. the one-shot time lags time code time by 22 milliseconds.

UTC Time - The OBS clocks are not designed to be started from an outside source such as the *GPStar* event trigger, so they cannot be synchronized to exact UTC at the start of a deployment. The OBS clock is set to the GPS clock visually by inputting the Julian day, hour, minute, and second to the OBS's microprocessor through an RS-232 interface and terminal keyboard. The OBS time code from the BNC output is fed into the *GPStar* time tag input port through a *Dalhousie University signal conditioner*. The OBS time is then adjusted by incrementing or decrementing tenths of seconds through keyboard keystrokes to within the nearest tenth second (100 ms) match of UTC. This time was tagged prior to the OBS being inserted into the pressure cylinder. Subsequently, one or more calibrations of the "one-shot" may have been made prior to deployment. The final of these is recorded as the *OBS pre-drop time code - time tag* which is reported on the attached **OBS Deployment Summary**. On recovery of the OBS after a station the clock was calibrated prior to opening the cylinder using the "one-shot" and after opening using the time code BNC.

Regardless of whether the final method of calibration was directly off the time code BNC or off the serial line "one-shot" the number reported in the OBS Deployment Summary is corrected to time code time.

Note that the *GPStar*, when tagging the OBS or the DMW clock (see below), is establishing the time of the incoming event in UTC. This is extremely accurate at the microsecond level but of no use in determining the difference in seconds, minutes, or hours that the clock being tagged thinks the time is. It is up to the operator, either by visually reading the clock, or in the case of the OBS by using the "one-shot", to compare the UTC time with the clock being calibrated.

To calculate the drift per day the following convention was used. A "+" or positive symbol indicates the OBS clock is ahead or in advance of the GPS time reference. Likewise, a "-" or negative symbol means that the OBS was behind or lagged UTC. The average drift, expressed in milliseconds/day on the **OBS Deployment Summary** (Table 3) and on the **Clock Drift/Day Spreadsheet Calculation** (Table 4) follows this same convention.

N.B.: Data reduction/digitization personnel should **not** mistake the + and - symbols as indications of time to be added or subtracted to compensate for clock drift.

The **OBS Deployment Summary** (Table 3) and **Clock Drift/Day Spreadsheet** (Table 4) contain the OBS clock calibration information. These files and the original *GPStar* time tags from which they were compiled were supplied to the Principal Scientist on a 3½" floppy disk (2 copies) labelled "BAS967/JR18/SLICE". The *GPStar* OBS time tags are located in ASCII files in 3 subdirectories under the directory \BAS967\BAS967\OBSCAL. The subdirectories are \EARTHQKE, \NORTHLNE, and \SOUTHLNE, the last two of which each have subdirectories \DEPLOY and \RECOVER. The \SOUTHLNE\DEPLOY directory contains two filetypes: ".DEP" and ".FIN".

10.2.3.4 Airgun Shot Clock Calibration

It had been proposed that the *Odetics GPStar* be used as the firing clock. This proved to be impractical, in part because the *GPStar's* event trigger pulse at 1 microsecond was too short for the airgun system to recognize, and in part because of the complications of mating a variety of systems with different input requirements.

It had also been planned to create a shot log using the *GPStar* and *Dalhousie University* software. For reasons still not entirely clear this turned out to be a non-starter as well.

The arrangement that was settled on was the Research Vessel Services (RVS) clock, a *DMW Associates Type 520/1310,* would fire the airguns according to their usual setup. At the beginning of each refraction line the *DMW* clock was synchronized to UTC using the *GPStar* 1 pps output. The *DMW* 1 pps output was then monitored and tagged on a twice/day basis by the *GPStar.* The drift of the *DMW* clock was consistent at approximately +600 microseconds/day (i.e. the *DMW* clock was ahead or in advance of UTC). These calibrations are on the "BAS967/JR18/SLICE" 3½" floppy disk under the directory \BAS967\BAS967\CLOCKCAL. The subdirectories \NORTHLNE and \SOUTHLNE cover the time periods for the north and south sets of reflection/refraction lines. The files are listed as DMW(julian day)(julian hour) so that DMW04910 is the time tag for Julian day 49, 1000 hours. Note that the RVS clock randomly jumped whole minutes of time. These jumps cannot be identified on the *GPStar* calibrations. The *GPStar* does verify that the microsecond drift of the clock was unaffected by these jumps.

10.2.3.5 Deployment/Recovery

The seismometer cylinders were prepared in the OBS workshop container and carried to the water bottle annex where they were placed on anchors, mated to flotation assemblies, the release configured, and recovery aids made up. The availability of the annex with its push-button "garage door" opening, which enabled OBS's to be lifted directly off the 4 x 4 anchor blocks for deployment, was a much-appreciated luxury. Being able to make up the OBS assembly in a warm, well-lit, dry environment greatly eased the demands of ensuring that all preparations were carefully and correctly done.

Recoveries of the OBS were made at the same location using the midships gantry. All of the deployments and almost all recoveries went exceedingly smoothly. On 24 of the 27 recoveries the OBS was on deck within 15–20 minutes of surfacing. On only three recoveries, one in rough seas, one in dense fog, and one where the retrieval stray line failed to deploy, was more than one pass required for pickup.

During the running of the seismic lines the OBS beacon frequencies were monitored by radio receivers in the OBS container, the UIC room, and on the Bridge. This procedure was carried out in an effort to prevent any prematurely surfacing OBS from getting away.

10.2.4 Results and Conclusions

With the exception of the loss of OBS C at Station BAS967-OBS13 the deployment and recovery of the OBS's on the SLICE project was a very smooth and uneventful operation.

When an OBS is lost conjecture always abounds as to the cause. In this case, the ship was on location well in advance of the OBS release from the bottom and for an ample amount of time afterwards to be certain that the OBS did not surface at the planned time. The pinger was not seen which could indicate failure of the CPU, either by resetting or flooding, and the consequent failure of the OBS internal or primary release. The fact that the unit did not surface would indicate a second failure, either of the external release or of the flotation. This dual-failure scenario, while possible, is considered unlikely. At 5200 metres this was the deepest deployment of the cruise, and there is the possibility that catastrophic failure of the flotation could have damaged the main cylinder electronics, causing the observed effect.

The other explanation for the observed non-events at the scheduled release time is that the OBS was no longer on the bottom at the station, that it released early and drifted away. This could happen for a number of reasons: misprogramming, mechanical failure of a burn-wire loop or lace, CPU reset causing the primary release to activate, or a bad landing on the bottom causing the OBS to shift and release from the anchor plate. To guard against this possibility the OBS beacon frequencies are monitored by shipboard receivers in the hope that if an OBS prematurely surfaces the transmissions from its radio beacon locator will be detected and the unit can be recovered. In the case of OBS13, it was 4½ days from the time the unit was deployed to when it was passed over during the refraction line and then another 9 days before the attempted recovery at the location, enough time for the unit to drift out of the 8–10 mile range of the radio beacons. There was some indication of a response in the frequency range of the Chan. 72 (156.625 MHz) radio beacon associated with this OBS at the time of the ship's pass during the refraction line, but it could not be positively confirmed by the various receivers on board. Signal detection in that range was complicated by a steady background signal which was generated by a harmonic of the ship's 10 GHz radar. When trying to detect signals in that frequency range the Bridge cooperated by shutting down the radar while the search was conducted. The radar was secured during the investigation surrounding the spurious signal which, in retrospect, may have been OBS13. The suspicious signal could not be confirmed to be from an OBS beacon so suspension of the seismic line to conduct a physical search, which would require recovery of the streamer and airguns and at minimum a full day of ship time, was not justified.

Other than the loss of data represented by the loss of Instrument C at station OBS13, 100% coverage of the recording period was achieved. 7 tapes (with 4 decks per OBS for 27 deployments there were 108 tapes recorded in total) lost portions of the recorded interval when the tape adhered to and wrapped around the capstan roller. Since all decks were backed up in a tandem recording mode no data was lost as a result of these failures.

On the GSC's ECSOOT OBS programme which preceded SLICE, an electronic interference problem developed in some of the OBS. A low frequency signal, which could only have been internally generated by the OBS, was found recorded on the hydrophone and geophone data channels. This signal appeared only during deployments, when the OBS was in the water, and could not be seen on the bench or while the instrument was in its pressure case on deck. On ECSOOT the problem was thought to have been traced to some miswired main battery supplies in which the digital and analog grounds were reversed. It was thought that this miswiring set up some sort of ground loop which caused the problem. Unfortunately, the OBS technicians ran out of time on the ECSOOT cruise before they could confirm this theory.

At the beginning of JR18, when the ship stopped briefly at the BAS base at Signy Island to discharge some scientific equipment and personnel, an over-the-side test of two of the affected instruments, OBS's G & H, was conducted. The test proved inclusive when OBS G produced a clean record and OBS H did not. Pending further opportunity to test it , H was not deployed during SLICE.

On the first set of 14 deployments during JR18, two instruments, OBS's N and S, neither of which had been reported to have this problem during ECSOOT, exhibited it. OBS N exhibited the problem for the entire deployment and it appeared on OBS S for the latter part of its 2-week deployment at an earthquake monitoring location. Other instruments, such as OBS G, which had been reported with problems on ECSOOT were OK this time. This eliminated ECSOOT's miswired battery packs, sea-water activated ground loop theory as the cause.

The corrupting signal recorded to the tapes is a < 1 Hz variable frequency, 2–2½ volt amplitude, asymmetrical spike appearing in reverse polarity on the hydrophone and geophone channels. Considerable time was spent prior to the last set of deployments in an unsuccessful effort to reproduce the problem on the bench. Inability to reproduce it on the bench makes the problem virtually impossible to isolate. The only devices in the OBS's which produce a variable pulse are the tape drive motors, which generate a pulsing -4.5 volt back EMF at a frequency of about 4–5 Hz. The backs of these motors were insulated to prevent the possibility of arcing from the motor power leads to the recorder case. All solder joints were re-examined and cleaned up to reduce the possibility that the cold, moist bottom conditions were working on bad solder joints to produce the noise.

The second set of 14 deployments showed noise spikes on instruments N, R, G, and P. Other than G (BAS967-OBS25), data on which appears to be corrupted beyond use, data should be recoverable from most of the rest of the recordings. Instrument R, which had no problems during the first deployment, developed noise spikes 9 days into the recording. Instrument S, which had problems on the first deployment, was fine this time. The cause and cure for this electronic interference remain unresolved at the end of SLICE.

Data recovery for SLICE is preliminarily estimated to be at around 90%.

10.2.5 Acknowledgements

Ocean-bottom seismometry is inherently a team effort. The SLICE project is the first time a

programme of this magnitude, 28 deployments, has been attempted with a single OBS operator. This would have been impossible without the cooperation and assistance of many others in the BAS group. Rob Larter went to great lengths to accommodate the scheduling of OBS operations as best he could within the time pressures operating on him, and was up and around to coordinate all the OBS deployments and recoveries. Nigel Bruguier was assistant OBS operator for the entire cruise, took responsibility for the preparation of all recovery aids, made up many of the OBS for deployment, and assisted in most of the deployments and recoveries. He faithfully carried out many of the time-consuming repetitive jobs which are difficult because their simplicity requires little thought yet much alertness.

The *RRS James Clark Ross* is a superb ship for OBS operations, having excellent equipment and maneuverability, highly skilled officers who can handle the ship, and a crew sensitive to the necessity of handling scientific equipment with care.

Table 3 Ocean-bottom seismometer deployment summary.

Station BAS967-	OBS ID	Time (z) Deployed	Time (z) Recov'd	Location S & W	Depth meters	Pre-drop TC-time tag	Post-drop TC-time-tag	Drift/day msec	Comments
OBS-1	S	21/1508	37/1604	56 09.95 26 30.46	3140	21/14:26:00:0795	37/17:30:02:1359	-127.74	Developed noise spikes on all tapes data channels towards end of week 1. Week 2 very noisy.
OBS-2	J	22/0713	36/1815	58 53.78 25 15.00	1340	22/04:20:00:0028	36/19:26:02:1811	-150.13	All tapes data good.
OBS-3	I	24/0038	34/0145	57 29.89 30 20.09	3100	23/22:42:00:0103	34/02:13:00:6020	-58.78	All tapes data OK.
OBS-4	A	23/2133	34/0407	57 28.99 29 57.31	2882	23/19:30:00:0969	34/05:32:01:9990	-184.09	All tapes data good.
OBS-5	M	23/1846	34/0924	57 27.69 29 26.03	3550	23/18:28:00:1007	34/09:39:01:3917	-121.42	All tapes data good.
OBS-6	Q	23/1232	34/1728	57 23.47 27 48.00	3338	23/07:49:00:0619	34/17:49:02:5595	-218.77	All tapes data good.
OBS-7	R	23/1031	34/2117	57 21.98 27 15.01	3160	23/05:47:00:0619	34/21:37:59:4094	56.96	Deck 4 tape wrapped around capstan. Data good otherwise.
OBS-8	B	23/0829	35/0109	57 20.61 26 44.92	2596	23/03:50:00:0207	35/01:39:02:0006	-166.25	Deck 1 no data. All others data good.
OBS-9	T	23/0657	35/0412	57 19.66 26 22.94	2553	23/02:50:00:0416	35/04:36:01:9367	-156.96	Deck 2 wrapped around capstan Other decks data noisy.
OBS-10	N	23/0445	35/0825	57 18.33 25 49.80	3530	23/00:55:00:0060	35/08:45:59:5990	34.72	Data poor all decks. Noise spikes on data channels.
OBS-11	E	23/0226	35/1228	57 16.73 25 16.91	3885	23/00:15:00:0794	35/12:53:03:1777 Note:clock may have reset	-247.34 Reset?	Data good decks 1, 2 & 3 Deck 4 only OK. Carefully check seismic returns against clock.
OBS-12	G	23/0010	35/1640	57 15.37 24 41.66	4170	22/18:59:00:0842	35/17:19:02:3901	-178.33	Data OK decks 2 & 3. Decks 1 & 4 poor with crosstalk.
OBS-13	C	22/2015	LOST	57 11.97 23 29.89	5210	22/16:49:00:0601	LOST	-----	OBS was not recovered.RIP.
OBS-14	L	22/2030	36/0249	57 11.01 22 59.94	4875	22/16:59:59:9981	36/03:17:59:2230	57.54	All tapes data good.

Table 3 Ocean-bottom seismometer deployment summary (continued).

Station BAS967-	OBS ID	Time (z) Deployed	Time (z) Recov'd	Location S & W	Depth meters	Pre-drop TC-time tag	Post-drop TC-time-tag	Drift/day msec	Comments
OBS-15	R	36/1833	55/0225	58 53.78 25 15.05	1328	36/14:32:00:1121	55/03:13:59:1138	53.88	Deck 1high noise level on hyd. Occassional noise spike. Deck 2 & 3(2nd week of deploy) start off as Deck 1 then noise spikes obliterate data. Deck 4 wrapped around capstan.
OBS-16	J	37/1624	56/1510	56 09.99 26 29.97	3165	37/11:19:00:0363	56/15:3303:0220	-155.70	All tapes data good.
OBS-17	T	43/2054	54/0715	59 17.04 29 59.34	3045	43/18:38:00:0623	54/07:41:01:7298	-158.15	Noisy hyd. all tapes. Deck 2 wrapped around capstan after about 5 days.
OBS-18	N	44/0045	54/0311	59 22.42 29 19.52	3015	43/19:52:59:9988	54/03:27:59:5943	39.21	Data poor all decks. Noise spikes on data channels.
OBS-19	E	44/0352	53/2312	59 24.82 28 47.03	2785	44/02:11:00:0542	53/23:33:02:3117	-228.25	Data good Decks 1, 2 & 3. Deck 4 wrapped around capstan.
OBS-20	B	44/0625	53/1952	59 27.50 28 17.69	2435	44/05:05:00:0318	53/20:15:01:6584	-168.88	All tapes data good.
OBS-21	M	44/0914	53/1445	59 31.89 27 40.94	1845	44/07:45:00:0850	No end calibration	-----	All tapes data good. Pinger worked on way up. Reset on deck
OBS-22	L	44/1138	53/1138	59 35.51 27 11.02	1420	44/10:03:59:9515	53/12:05:59:3932	61.45	All tapes data good.
OBS-23	Q	44/1416	53/0852	59 38.39 26 39.85	2215	44/11:53:00:0455	53/09:20:02:0301	-223.15	All tapes data good.
OBS-24	I	44/1644	53/0710	59 41.59 26 09.99	2335	44/15:26:00:1018	53/07:41:00:6402	-62.05	All tapes data good.

Table 3 Ocean-bottom seismometer deployment summary (continued).

Station BAS967-	OBS ID	Time (z) Deployed	Time (z) Recov'd	Location S & W	Depth meters	Pre-drop TC-time tag	Post-drop TC-time-tag	Drift/day msec	Comments
OBS-25	G	44/1916	53/0201	59 45.01 25 35.97	2685	44/18:13:00:1110	53/02:20:01:6272	-181.84	Data not good. Noise spikes obliterate data channels all tapes.
OBS-26	K	44/2149	52/2249	59 48.71 24 58.46	4730	44/21:12:00:1126	52/23:14:00:9749	-106.66	Data good decks 1,2 &3. Deck 4 tape wrapped around capstan after 1 1/2 days.
OBS-27	P	45/0312	52/1649	59 55.90 23 49.03	5075	45/02:05:00:0738	52/17:14:01:5603	-194.79	Decks 1, 2 & 3 very noisy with spikes. Deck 4 data obliterated by noise spikes.
OBS-28	S	45/0547	52/1228	59 59.89 23 13.10	4165	45/04:32:00:0650	52/12:50:00:9896	-125.87	All tapes data good.

Table 4. Ocean-bottom seismometer clock drift/day calculation

OBS Station	OBS - ID	start day	start hour	start min	Julian hour start	correction start	end day	end hour	end min	Julian hour end	correction end (ms)	elapsed hours (total)	elapsed days	correction (ms) (total)	drift/day
1	S	21	15	8	519.13	-79.5	37	17	30	905.50	-2135.9	386.37	16.10	-2056.4	-127.74
2	J	22	7	13	535.22	-2.8	36	19	26	883.43	-2181.1	348.22	14.51	-2178.3	-150.13
3	I	24	0	38	576.63	-10.3	34	2	13	818.22	-602.0	241.58	10.07	-591.7	-58.78
4	A	23	21	33	573.55	-96.9	34	5	32	821.53	-1999.0	247.98	10.33	-1902.1	-184.09
5	M	23	18	28	570.47	-100.7	34	9	39	825.65	-1391.7	255.18	10.63	-1291.0	-121.42
6	Q	23	7	49	559.82	-61.9	34	17	49	833.82	-2559.5	274.00	11.42	-2497.6	-218.77
7	R	23	5	47	557.78	-61.9	34	21	37	837.62	590.6	279.83	11.66	652.5	55.96
8	B	23	3	50	555.83	-20.7	35	1	39	841.65	-2000.6	285.82	11.91	-1979.9	-166.25
9	T	23	2	50	554.83	-41.6	35	4	36	844.60	-1936.7	289.77	12.07	-1895.1	-156.96
10	N	23	0	55	552.92	-6.0	35	8	45	848.75	422.0	295.83	12.33	428.0	34.72
11****	E***	23	0	15	552.25	-79.4	35	12	53	852.88	-3177.7	300.63	12.53	-3098.3	-247.34
12	G	22	18	59	546.98	-84.2	35	17	19	857.32	-2390.1	310.33	12.93	-2305.9	-178.33
13	C	22	16	49	544.82	-60.1					OBS not recovered				Lost
14	L	22	16	0	544.00	1.9	36	3	17	867.28	777.0	323.28	13.47	775.1	57.54
15	R	36	14	32	878.53	-112.1	55	3	13	1323.22	886.2	444.68	18.53	998.3	53.88
16	J	37	11	19	899.32	-36.3	56	15	33	1359.55	-3022.0	460.23	19.18	-2985.7	-155.70
17	T	43	18	38	1050.63	-62.3	54	7	41	1303.68	-1729.8	253.05	10.54	-1667.5	-158.15
18	N	43	19	52	1051.87	1.2	54	3	27	1299.45	405.7	247.58	10.32	404.5	39.21
19	E	44	2	11	1058.18	-54.2	53	23	33	1295.55	-2311.7	237.37	9.89	-2257.5	-228.25
20	B	44	5	5	1061.08	-31.8	53	20	15	1292.25	-1658.4	231.17	9.63	-1626.6	-168.88
21	M	44	7	45	1063.75	-85.0					No end cal. reset				Reset
22	L	44	10	3	1066.05	48.5	53	12	5	1284.08	606.8	218.03	9.08	558.3	61.45
23	Q	44	11	53	1067.88	-45.5	53	9	20	1281.33	-2030.1	213.45	8.89	-1984.6	-223.15
24	I	44	15	26	1071.43	-101.8	53	7	41	1279.68	-640.2	208.25	8.68	-538.4	-62.05
25	G	44	18	13	1074.22	-111.0	53	2	20	1274.33	-1627.2	200.12	8.34	-1516.2	-181.84
26	K	44	21	12	1077.20	-112.6	52	23	14	1271.23	-974.9	194.03	8.08	-862.3	-106.66
27	P	45	2	5	1082.08	-73.8	52	17	14	1265.23	-1560.3	183.15	7.63	-1486.5	-194.79
28	S	45	4	32	1084.53	-65.0	52	12	50	1260.83	-989.6	176.30	7.35	-924.6	-125.87

****Note: OBS Station 11, OBS E, Unit may have reset prior to end calibration. Check apparent drift carefully against seismic returns.

10.3 Gravity (APC/RDL)

10.3.1 Data Acquisition

LaCoste and Romberg marine gravity meter S84 was supplied by RVS and was installed by Chris Paulson in August 1996. The meter was installed on a wooden plinth on the starboard side of the Gravity Meter Room, instead of on the purpose-built plinth at the aft end of the room. The latter is too close to the aft bulkhead to allow the meter to be installed there with adequate space for cables, unless the meter is installed back-to-front (as on JR04).

The gravity meter operated throughout the cruise. Gravity data were smoothed by a 5-minute hardware filter and filtered values were logged by the 'ABC' system at 6 s intervals. The data files written to the gravity meter PC during the first half of the cruise (days 013 to 044) were backed up to a zip disk and then deleted from the hard disk. This was done to prevent the PC hard disk filling up, which would have interrupted data logging.

Some large rolls on day 049 exceeded the gyro-stabilisation capabilities of the gravity meter platform, resulting in apparent deflections of > 350 mGal between 10:30 and 14:00. There was some concern that this event might have caused a tear in the gravity data, but this now seems unlikely in view of the very small instrumental drift during the cruise (see below). Analysis of gravity mis-ties at track cross-overs also shows no evidence of a tear.

Gravity data were processed onboard using the level C 'prograv' program (see Data Logging section).

Instrumental drift was constrained by base ties at FIPASS, Port Stanley before and after the cruise. Unfortunately, base ties at FIPASS can not be made in the normal way because FIPASS is a floating structure, precluding use of a land gravity meter on the quayside. Base ties are made by assuming that the local free-air gravity gradient is zero and using a base station at the landward end of the FIPASS bridge, 200 m south of the berths (RRS *Discovery* Cruise 172 Report). At the start and the end of the cruise the ship was berthed in approximately the same place, near the western end of FIPASS, so these base ties should accurately constrain the drift during the cruise. Low drifts obtained between Port Stanley and other ports during previous cruises suggest that the absolute values of gravity derived from FIPASS base ties are accurate to within 0.5 mGal. Base ties were also carried out at Grimsby, before the ship departed from the UK and after it returned, and at Grytviken, South Georgia during the cruise.

10.3.2 Gravity Base Ties (APC)

Gravity meter	: S84
Meter calibration constant	: 0.9967

Grimsby gravity base tie day 239/1996

Day/time	: 239/1100
Meter reading (meter units)	: 12608.5
g at meter on ship (mGal)	: 981370.42

FIPASS gravity base tie day 010/1997

Day/time : 010/1620
Meter reading (meter units) : 12451.3

Estimate of g at marine meter S84:
An estimate of the value of g at meter S84 was made by measuring the height difference between the meter and the gravity base station established on the concrete pillar at the west side of the bridge abutment (RRS *Discovery* Cruise 172 Report). Measurements to the water line indicated that the gravity meter was 2.05 m below the FIPASS base station (g=981227.66 mGal, RRS *James Clark Ross* Cruise JR12 Report). The ship was assumed to be moored 200 m north of the base station (RRS *Discovery* Cruise 172 Report).

Free-air correction (FA)
FA = 0.3085 * 2.05 = 0.63 mGal

Latitude correction (LA)
Assuming a north-south gravity gradient of 0.79 $mGal.km^{-1}$ (RRS Charles Darwin Cruise 37 Report) and a 200 m north-south separation between meter and base station:
LA = -0.79 * 0.2 = -0.158 mGal

Estimated g at marine meter S84
g = FIPASS base value + FA + LA
= 981227.66 + 0.63 - 0.16
= 981228.13 mGal

Drift (Grimsby-FIPASS)

δg at marine meter from Grimsby
= 981228.13 - 981370.42 = -142.29 mGal

Difference in meter reading
= 12451.3 - 12608.5 = -157.2 meter units
= -156.68 mGal (S84 cal. const. 0.9967)

Drift from day 239/1996
= -14.39 mGal in 137.2 days
Drift rate = -0.105 $mGal.day^{-1}$

Grytviken gravity base tie day 041/1997

Day/time : 041/2000
Meter reading (meter units) : 12732.3

Estimate of g at Grytviken Jetty:
The S84 meter reading was tied to an existing gravity base station at King Edward Point (KEP) using Worden gravity meter 647. The KEP gravity base station lies on the concrete base of the radio mast near Discovery House (the mast has since gone). Gravity measurements were obtained on land at the eastern end of Grytviken jetty, where the (western) edge of the jetty walkway meets the shoreline. The measurements were then tied to the KEP base station (g=981505.4, SOC data sheets) using the measurements shown in Table XX.

Table 5 Worden measurements used in Grytviken to King Edward Point gravity tie.

Time	Position	Worden meter reading	Mean time (GMT)	Mean reading
1915	Jetty	504.0		
1915	Jetty	504.3	**1919**	**504.1**
1920	Jetty	504.1		
1925	Jetty	504.1		
1955	KEP station	514.4		
1957	KEP station	514.3	**1959**	**514.1**
2000	KEP station	513.9		
2002	KEP station	513.7		
2030	Jetty	504.5	**2033**	**504.5**
2035	Jetty	504.4		

Worden drift = 504.5 - 504.1
= 0.4 meter units in 74 minutes
Drift rate = +0.005 meter units.min^{-1}

Drift corrected KEP base station meter reading (1959 GMT)
= meter reading - (mins after 1st reading * drift rate)
= 514.1- (40 * 0.005)
= 513.9 meter units

Initial meter reading at Grytviken jetty (1919 GMT)
= 504.1 meter units

Worden meter calibration constant
= 0.1044 mGal.div^{-1}

Difference in g between KEP base station and jetty
δg = (504.1 - 513.9) * 0.1044 mGal
= -1.02 mGal

g at Grytviken jetty
= g at KEP base station + δg
= 981505.4 - 1.02 = 981504.38 mGal

Estimate of g at marine meter S84:
Correcting for differences in height and latitude between the shoreline station at the eastern end of the jetty and the marine meter S84.

Free-air correction (FA)

Measurements to and from the water line indicated that the marine meter was located approximately 0.25 m above the shoreline station at the edge of the jetty, so:

FA = -0.3085 * 0.25 = -0.08 mGal

Latitude correction (LA)
Measurements indicated that the marine meter was located approximately 34 m north of the shoreline station at the eastern end of the jetty.
Assuming a latitude correction of 0.77 $mGal.km^{-1}$ at 54.28°S:
LA = -0.77 * 0.034 = -0.03 mGal

Estimated g at marine meter S84
g = g at Grytviken jetty + FA + LA
= 981504.38 - 0.08 - 0.03
= 981504.27 mGal.

Drift (FIPASS-Grytviken)

δg at marine meter from FIPASS (day 010)
= 981504.27 - 981228.13 = +276.14 mGal

Difference in ship's meter reading
= 12732.3 - 12451.3 = +281.0 meter units
= +280.07 mGal (S84 cal. const. 0.9967)

Drift from day 010
= +3.93 mGal in 31.1 days
Drift rate = 0.126 $mGal.day^{-1}$

FIPASS gravity base tie day 065

Day/time	: 065/1450
Meter reading (meter units)	: 12451.5

Estimate of g at marine meter S84:
Measurements to the waterline indicated that the marine gravity meter was located 2.15 m below the FIPASS base station (g=981227.66, RRS *James Clark Ross* Cruise JR12 Report).

Free-air correction (FA)
FA = 0.3085 * 2.15 = 0.66 mGal

Latitude correction (LA)
Assuming a north-south gravity gradient of 0.79 $mGal.km^{-1}$ (RRS *Charles Darwin* Cruise 37 Report) and a 200 m north-south separation between meter and base station:
LA = -0.79 * 0.2 = -0.158 mGal

Estimated g at marine meter S84
g = FIPASS base value + FA + LA
= 981227.66 + 0.66 - 0.16
= 981228.16 mGal

Drift (Grytviken-FIPASS)

δg at marine meter from Grytviken

Recommendations

1. The TSSHRP appears to be producing data that is very similar to that from the Ashtech and is probably valid. It is also distorting this data horribly. It seems unlikely that this is intentional so there is probably something wrong with the instrument or the way in which it is set up. Given the potential use of the device a thorough check/overhaul by the manufacturers is needed to ascertain what exactly is going on and to set it up correctly.

2. The present RVS level A logging setup is rather crude. An instrument theoretically capable of producing data 50 times a second can only be sampled every 2 seconds. The present level A unit should be replaced with a PC to permit 1 second, or even more frequent, sampling.

10.6 Dredging (RDL)

9 dredges were carried out using the 30-tonne traction winch and steel 'coring' warp, with the warp running through a block on the Stern Gantry (Table XX). 4 dredge bags, together with pipe dredges, weak links, swivels and other dredge rigging equipment were supplied by RVS. The dredge was rigged in the standard manner: pipe dredge attached to dredge bag by short chains, dredge bag bridle arms secured by 1-tonne weak links, bridle joined to length of heavy chain by 3-tonne weak link, dredge bag also joined to chain by strangler wire which by-passes 3-tonne weak link, heavy chain joined to 100 m of 13 mm pennant by 5-tonne weak link and swivel, and pennant joined to main warp by a hammer lock and another swivel. During deployment the 100m pennant was transferred to the main warp from a handling pennant which was attached to the starboard Gilson Winch, and this procedure was reversed for recovery. This type of dredging rig is illustrated in the JR12 Cruise Report. A pinger was attached to the main warp 150 m above the dredge.

The equipment supplied by RVS included about 7 m of heavy chain for linking the dredge bag bridle to the 100 m pennant. The links of this chain were initailly thought to be too wide to pass through any block available on the ship, presenting a problem for deployment and recovery. Furthermore, as there was only one length of this chain, any failure of the 5-tonne weak link would have terminated dredging for the cruise. Both of these problems were solved by cutting the chain into two lengths. This made it possible to swing the dredge bag onto the deck using the articulated arm of the Stern Gantry without the chain having to pass through the wide-throated block on the arm, and also allowed us to keep a length of chain in reserve.

The second dredge attempted (DR160) resulted in loss of the dredge bag and pipe dredge, both the 3-tonne weak link and strangler wire having failed. The 3-tonne weak link failed again during the next dredge (DR161). On this occassion another pipe dredge and the mouth of the second dredge bag were lost. The bag itself, and the haul of rock samples it contained, were saved by the strangler wire, but this bag could not be used again. The third dredge bag, used for all the subsequent dredges, had fixed bridle arms, so no 1-tonne weak links were required. Bolts fabricated from stainless steel rods on board were used in the '3-tonne' weak link for the remaining dredges, increasing their breaking load to about 4 tonnes. This appears to have been a successful innovation, as there were no subsequent failures of this weak link.

10.7 Rock Chipper (RDL)

The Rock Chipper, first used by BAS on cruise JR12, was only deployed once during JR18, on day

033 (Table 7). It was deployed using the 30-tonne tractions winch and steel ‘coring’ warp, with the warp running over a block on the Midships Gantry. A pinger was attached to the main warp 100 m above the Rock Chipper, which was then lowered at 80 m/min until it was 40 m above the sea floor. It was then left to stabilise for a few minutes before lowering at a rate of 120 m/min until impact. It was raised to 45 m above the sea floor and then lowered at 120 m/min again for a second impact. The Rock Chipper was recovered and the wax-filled cups were found to have collected a small, but useful, quantity of basalt particles. The whole operation took only 2 hours once some initial problemd with the winch system had been overcome.

Table 7. Wax core and dredge sites.

No.		Date	Time (GMT)	Latitude	Longitude	Corrected Depth (m)	Comments
WX41		97/033	21:35	57° 30.0'S	30° 08.0'W	3865	Small quantity of *in situ* basalt recovered.
DR159	Start	97/038	03:11	56° 31.30'S	27° 54.12'W	1512	Recovered only mud in pipe dredge.
	End		04:12	56° 31.88'S	27° 53.99'W	1316	
DR160	Start	97/038	07:33	56° 30.67'S	27° 52.53'W	1296	Lost dredge bag.
	End		09:54	56° 32.47'S	27° 52.67'W	738	
DR161	Start	97/038	17:15	55° 39.19'S	27° 36.56'W	1404	Recovered lavas and pumice, probably *in situ*.
	End		17:48	55° 39.51'S	27° 37.06'W	1355	
DR162	Start	97/039	00:56	56° 01.85'S	28° 07.84'W	1532	Excellent recovery of lavas, pumice and pyroclastic
	End		01:57	56° 01.53'S	28° 08.51'W	1335	rocks.
DR163	Start	97/039	12:16	55° 37.96'S	29° 47.11'W	3550	Excellent recovery. Large haul of basalt.
	End		13:35	55° 37.75'S	29° 47.92'W	3449	
DR164	Start	97/039	16:42	55° 30.53'S	29° 50.98'W	4735	One piece of fresh pillow basalt rim recovered.
	End		17:35	55° 30.06'S	29° 50.03'W	4765	
DR165	Start	97/056	22:47	56° 42.00'S	25° 27.95'W	4592	Excellent recovery of lavas and epiclastic sedimentary
	End		23:45	56° 42.00'S	25° 29.01'W	4257	rocks.
DR166	Start	97/058	23:53	57° 33.91'S	26° 52.99'W	1022	Recovered volcanic rocks, some possibly *in situ*.
	End	97/059	01:00	57° 34.59'S	26° 54.62'W	675	
DR167	Start	97/060	06:30	57° 59.90'S	26° 41.75'W	1625	Only recovered a few pebbles and mud in pipe dredge.
	End		07:34	57° 59.91'S	26° 43.22'W	1267	Doubtful if any of pebbles were *in situ*.

10.8 Echo Sounders

10.8.1 Simrad EA500 (RDL*)*

The digital depth read out from the Simrad EA500 (the ship's 'navigational' echo sounder) was logged throughout the cruise with the water velocity parameter fixed at 1500 m/s. Unfortunately, interference from the 3.5 kHz sub-bottom profiler and 10 kHz precision echo sounder prevented the Simrad EA500 from tracking the sea floor except in shallow water depths or where the sea floor was relatively smooth. It was decided that the advantages of having sub-bottom profiler and precision echo sounder records in the UIC Room generally outweighed the benefits of having automatically-determined water depths from the Simrad EA500. However, depths from the EA500 were used in the merged geophysical data file in very shallow water areas because of concern about the lack of calibration of the array depth control on the 10 kHz precision echo sounder. It is recommended that the possibility of having a duplicate Simrad EA500 console in the UIC Room should be investigated. The scientific watch keeper would then be able to see when the system is providing digital depth readings. It might also be possible to arrange for control of the EA500 to be switchable between the UIC Room and the Bridge, allowing the system to be used routinely for scientific echo sounding, but enabling the Bridge to take control when the system is needed for navigational purposes in shallow water areas. However, a higher priority must be the provision of a swath bathymetry capability: swath bathymetry is now an essential tool for all types of marine geoscience and for studies of deep-water benthic biology and physical oceanography.

10.8.2 3.5 kHz Sub-bottom Profiler (MOP*)*

Attention is drawn to previous JCR cruise reports as all that can be said about this equipment has been said before. This piece of equipment is a disgrace to a modern scientific vessel. It suffers from many problems, including poor build quality, poor/incomplete documentation, faulty power amplifier or transducers, poor initial design and incomplete spares.

Although this piece of equipment is dearly loved by some members of BAS Geoscience Division for its simple unprocessed output it is recommended that it should be replaced.

Due to the lack of proper documentation a fault has persisted with the equipment for several years. The power of the output pulse produced is controlled by a rotary switch on the power amplifier. If the power is increased to -6 db or above then a monitoring circuit inside the amplifier shuts the unit down indicating a transducer mis-match. This situation could arise for two reasons: 1) a fault in the mis-match detection circuitry, or 2) a genuine mis-match.

The necessary information on the specification of the transducers and the setup of the mis-match circuitry is not available, so a diagnosis is not possible. Due to the importance placed on the equipment an experimental approach has not been adopted as it would be easy to damage the equipment further. With poor documentation and incomplete spares available this situation may result in the equipment being rendered inoperable which is obviously undesirable. For this reason no further attempt has been made to repair the equipment and bring the available power output back up to original specification, for fear of inflicting further damage.

The poor build quality, incomplete spares and poor documentation will eventually lead to this important piece of data gathering equipment failing in the middle of a cruise, jeopardising the objectives of a very expensive science project.

Apart from a change of styli in the Raytheon line scan recorder the 3.5 kHz profiler worked to the limit of its capabilities for the duration of the cruise.

10.8.3 10 kHz Precision Echo Sounder MkIV (MOP, RDL)

All the comments levelled at the 3.5 kHz sounder about spares, build quality, documentation and design are also true of the 10 kHz, only more so. This equipment is more complex and has more controls, therefore it operated in an even more illogical, temperamental manner. Some of the controls interact with each other. For instance the 'array depth' control has a subtle but definite effect on the sequence of the gating. These two controls should be entirely and utterly independent of each other, one having absolutely no effect on the other. Again limitations in the documentation and 'fear' of making things worse have prevented further investigation.

The 10 kHz echo sounder cannot be relied upon in shallow water because the 'array depth' control has never been calibrated. Comparison of the echo sounder records with digital depths from the Simrad EA500 suggested that identical depths are obtained if the 10 kHz 'array depth' control knob is turned to its maximum depth compensation setting.

The above aside, the 10KHz echo sounder provided a bathymetric record for the duration of the cruise.

For a supposedly world-class scientific research vessel it seems preposterous that the 'navigational' echo sounder on the Bridge (Simrad EA500) is a far more advanced piece of equipment than the echo sounder installed for scientific work. If a duplicate Simrad EA500 console could be fitted in the UIC Room, as suggested in an earlier section, the archaic precision echo sounder would be redundant. However, provision of a swath bathymetry capability should be a higher priority.

10.5 Navigation Instruments (DJR/JC)

10.5.1 Trimble 4000DS GPS unit

This operated in differential location mode from day 022 23:50 until day 060 23:59. The differential corrections were derived from a Racal Skyfix unit via an Inmarsat feed and applied in real time by the GPS receiver. The position fixes calculated by the GPS unit were logged via the ABC system and raw calculation data was logged to a PC using the Trimble "LOGST" program. While the unit was operating in differential mode it was used as the primary navigation data source for the program "bestnav" which was run on the LevelC. During the rest of the cruise period the unit operated in standalone GPS mode and was used as the secondary navigation data source, the Ashtech GG24 GPS/GLONASS receiver being used in preferenc

10.5.2 Ashtech GG24 GPS/GLONASS unit

This was operated throughout the cruise and was found to produce fixes which were more accurate than those of the standalone GPS receivers. Therefore when differential GPS was not available this unit was used as the primary navigation data source. However, the unit was found to suffer from some problems. The first of these was that the power supply the unit had been fitted with was not sufficiently highly rated to allow the unit to operate properly, this was rectified by temporarily replacing the original power supply with a bench unit. It was then found that the unit appears to be susceptible to interference from the ships satellite transmitter, fixes were lost during any periods that the transmitter was operating. Sometimes the unit restarted normal operation when the transmission had finished but at other times it was necessary to power cycle it and restart the unit. It also appears to have a tendency to fail when the ship is turning, this *may* be due to the positioning of the antenna on the bridge wing. In this position large areas of sky are swept out by the ships funnel and mast when the ship is turning. There may also be a problem with the unit itself in that it does not always appear to restart normal operation after one of these failures without manual intervention. This appears to be the first release of the unit

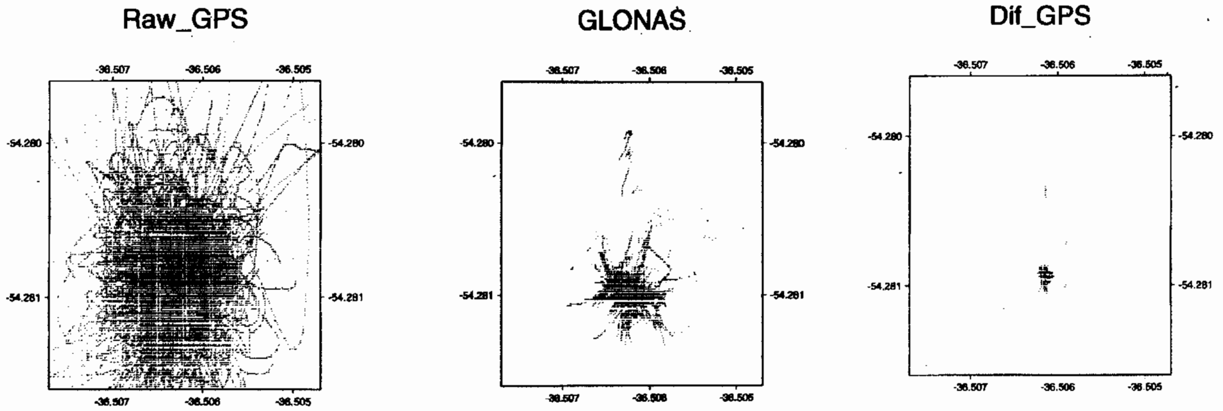


Fig 6 Comparison of GPS positions recorded over 24 hour period at Grytvyken jetty. Accuracies are Raw GPS: ~100m GLONAS: ~ 10m Differential GPS: ~ 1m

10.5.3 Ashtech 3D GPS and TSSHRP (PM)

The main reason for logging these instruments on JR18 was to provide pitch and roll information for correcting STCM data. Unfortunately the quality of data from both is, at the moment, on JR09A this was seen to correlate well with the gyro sensors of the Japanese STCM run on that cruise. Ideally a pitch and roll value should be obtained every second. About 20% of the readings, however, are zero. This does not just represent odd 'dropouts'; there are often several minutes at a time with no, or just a few, one second readings. This may well be due to the instrument not seeing a sufficient number of good satellites.

The alternative is the TSSHRP. Judging by the manual this is a quite sophisticated piece of equipment which should easily be able to provide the desired pitch and roll information required. Unfortunately it does not currently appear to be performing to specification. During the course of the cruise some investigations were made into what exactly was being output.

A power spectral analysis of the 'roll data' shows two peaks, one corresponds to a wavelength of about 10 seconds (the dominant roll period of the JCR), the other which is several times greater corresponds to an event with a period between 90 and 100 seconds. This dominating low frequency event, which is also present on the pitch and heave signals, was first observed on JR09A in 1995 and does not appear to have changed much since then. An hour's worth of pitch and roll signals were filtered using a high pass filter with a 20 second cut off. This appeared to be reasonably effective in separating out the true roll signal (10 second period) from the 100 second noise. When the filtered signal was compared with the Ashtech data there was an obvious similarity except that the TSSHRP data appears to be delayed by about 20 seconds. The same is true for pitch. It is not too difficult to find a source for the 20 second delay as this can be introduced if post-processing of the heave data is requested. As far as can be ascertained however this option was not requested in our setup of the instrument.

Cross plots between Ashtech and TSSHRP pitch and roll show that the relationship between the two instruments is still not as linear as might be hoped for. In particular the high pass filter used to remove the 100 second signal seems to have removed higher amplitude events from the TSSHRP data. It is nevertheless a step in the right direction and is encouraging in that it suggests that useful data is being generated somewhere within the TSSHRP.

There is an option available on the TSSHRP setup menu to apply a filter to the pitch and roll channels if very high sampling rates are not required. A one second filter was set up for JR18.

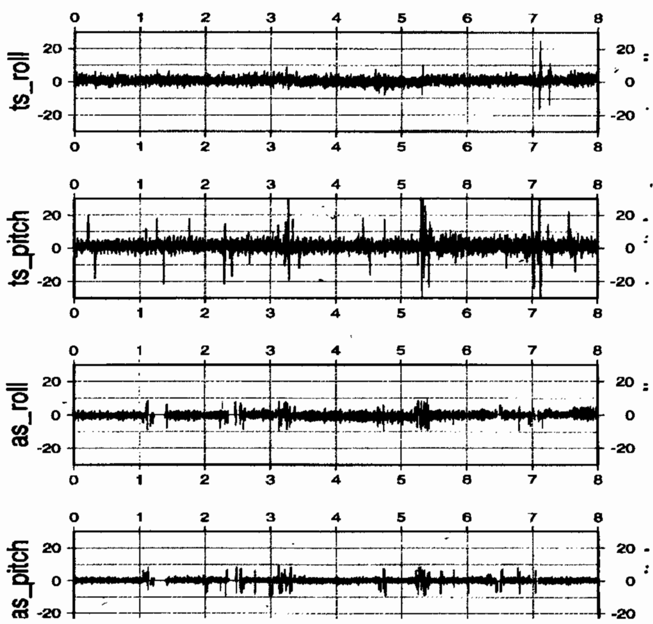


Fig 8 T ypical 8 hour sample of Ashtec and TSSHRP pitch and roll records.

10.9 Disposable Sonobuoys (NJB)

The sonobuoy recording system consisted of the following components:

Ultra Electronics SSQ-906/907 disposable sonobuoys (x11)
VHF aerials (x3)
ICOM IC-R7000 receivers (x2)
BAS 4-channel digital recording system
Iomega zip drive

The three VHF aerials were installed prior to leaving Port Stanley. One aerial was mounted on the middle yard arm of the main mast and the remaining two were mounted on the rail at the rear of the Monkey Island. Cables were run from the aerials down to the UIC room, where the ICOM VHF receivers, supplied by RVS, were installed. Since only two receivers were available, these were connected to the main mast and the port side Monkey Island aerials. The outputs from the VHF receivers were then connected to the BAS 4-channel digital recording system.

Two modifications to the recording system were necessary, and these were made by Dave Booth once the ship was underway. Firstly, the recording system was modified to accept a contact closure rather than a +5V pulse as a trigger from the firing system. This was accomplished by the addition of two sockets on the rear of the unit, one connected to the +5V supply, and one to the trigger input. A contact closure between these two sockets resulted in a +5V pulse on the trigger input. A 1.5 kΩ resistor was also required between the trigger line and the ground. Secondly, the ICOM VHF receivers produced an output signal on the order of several volts, whereas the BAS 4-channel recording system requires the maximum input signal to be +/- 300 mV. A simple potential divider circuit consisting of a 100 Ω resistor and a 500 Ω pot was therefore inserted in the leads connecting the receiver to the recording system in order to attenuate the input signal to the desired level. Unfortunately, these modifications were not completed until after the initial seismic lines were completed, and this meant that no sonobuoys were deployed over the E2 segment of the East Scotia Ridge.

Prior to deployment of each sonobuoy, the flipper plate and parachute were removed, the hydrophone depth was set to 30m, and the maximum transmitting time of 6 hours was selected. During cruise JR12 sonobuoys were deployed by hand from the Boat Deck or Monkey Island, and a number of failures occurred soon after launch due to damage by the airgun array. Consequently, for this cruise all but one of the sonobuoys were deployed at a greater distance from the ship using the aft crane, following the technique previously used on cruise JR05 consisting of a ‘greasy peg’ pulled from the deck. This proved highly successful, with no sonobuoy losses due to collision with the airguns. However it is a fairly time consuming process requiring a ships crewman to drive the crane, and the possibility of building a sonobuoy launcher should be investigated. The last sonobuoy used (No. 29) was launched by hand from the Bridge Wing.

The data were recorded at a 2 ms sample rate with an 8 s record length. The programmable gain was initially set at 2 and was increased with distance up to 64 to keep the signal level above 50% of maximum. Similarly, the time delay was initially set at 0 s and was increased in 2 s steps so as to keep the direct arrival within the 8 s recording window. The two receivers allowed two sonobuoys to be recorded simultaneously, which was done on several occasions. When only a single sonobuoy was active, both receivers were tuned in to provide two copies of the data.

A bug in the seismic acquisition software meant that the shot times were only updated when in the first menu and stayed constant when the second menu was selected. This problem was recognised previously on cruise JR09A and had been subsequently solved, but a new version of the acquisition software, which allows data to be recorded on an Iomega zip drive, appears to have resurrected this bug. To overcome this problem, changes to the second menu were made as briefly as possible, and the system was left in the first menu at all other times. However in some cases this was not possible and consequently some times recorded in the SEG-Y headers may be incorrect. The recording system used its own PC clock as the time reference for times written to the trace headers. This was manually synchronised with the ships master clock immediately before each period of recording.

A major limitation of acquisition software became apparent during this cruise. The record length is limited to a maximum of 8 s, and the recording delay is similarly limited to 8 s, giving a maximum possible recording time of 16 s. This meant that the direct water wave arrival, which is used to calculate the shot-receiver range, disappeared off the end of the record at a distance of only 24 km. It also made it extremely difficult to record two sonobuoys simultaneously when their arrivals were more the 8 s apart. Fortunately, no significant data were lost during the cruise but this was more through luck than judgement. The limitation of the maximum record length to 8 s seems unnecessary, and the real restriction should be the maximum number of samples that can be recorded per trace, which would allow longer records to be recorded at a lower sample rate. It is recommended the maximum record length be increased to at least 8000 samples, allowing recording for 16 s at 2 ms, or 32 s at 4 ms sample rate.

The Iomega zip drive was installed as drive D on the acquisition PC. This allowed data to be recorded directly onto zip disks with a maximum capacity of 100 Mb per disk, much more than required for a single sonobuoy profile. The data were written in 16-bit SEG-Y format as two files: one containing the binary reel header, and one containing binary trace headers and data. An additional file containing the EBCDIC reel header was copied from the PC hard disk onto the zip disk. The data files were transferred onto the Unix network via a second zip drive installed in the Data Preparation Room. The three files were concatenated to produce a standard SEG-Y disk image file which was then read into the ProMax seismic processing system. Basic processing consisted of increasing the trace length to 16 s, recovering the time delays, and calculating source-receiver offsets using a nominal shot spacing of 100 m. Preliminary record sections were plotted to assess data quality, and the data were archived onto an exabyte tape.

A total of 11 sonobuoys were deployed during the cruise (see Table XX). Of these, 7 recorded satisfactorily out to 24 km range, giving a success rate of ~60%. Of the 4 failures, one transmitted no data at all and appears to have been faulty, and the rest probably collided with the multichannel streamer or tailbuoy and had their hydrophone cables severed. Data quality is generally good with refracted arrivals visible on several of the records, out to a maximum distance of over 20 km for SB22.

Table 8. Disposable sonobuoy deployments.

No.	Type	Chan.	Frequency MHz	Depth m	Deployment Time	Latitude	Longitude	Comments
19	SSQ-906	19	164.125	30	028/21:08:32	56° 45.7' S	23° 22.7' W	
20	SSQ-906	30	172.375	30	029/10:09:28	56° 56.8' S	25° 20.1' W	failed immediately
21	SSQ-907	78	153.250	30	029/10:32:50	56° 57.2' S	25° 23.3' W	
22	SSQ-907	96	160.000	30	029/13:03:50	56° 59.0' S	25° 46.3' W	
23	SSQ-907	68	149.500	30	029/23:31:14	57° 07.5' S	27° 16.8' W	
24	SSQ-907	78	153.250	30	046/02:00:52	60° 03.0' S	22° 43.9' W	failed at 02:10
25	SSQ-906	97	160.375	30	046/02:33:20	60° 02.5' S	22° 48.8' W	
26	SSQ-907	94	159.250	30	046/11:06:00	59° 53.9' S	24° 08.5' W	
27	SSQ-906A	79	153.625	30	046/12:34:00	59° 52.3' S	24° 21.5' W	failed at 12:52
28	SSQ-907	84	155.500	30	046/13:18:00	59° 51.1' S	24° 27.9' W	failed at 13:37
29	SSQ-907	97	160.375	30	051/14:31:15	58° 49.0' S	21° 40.8' W	

10.10 Prototype Re-usable Sonobuoy (MOP)

10.10.1. Description and Overview

'Sonic' is a free-floating marine sonobuoy data acquisition instrument. It is designed to work with a remote marine seismic source (e.g. a towed airgun array) and records low frequency acoustic information generated by the seismic source. It has the potential to out perform, in all aspects, the disposable type of sonobuoy currently being used. The short comings of the disposable type are numerous and are listed below by way of comparison.

At the heart of the sonobuoy is a low power IBM PC/XT CPU module with hard and floppy drives, serial ports, a parallel port and on-board CRT and keyboard interfaces. The PC controls the data logging (analogue hydrophone data and digital GPS positions), communications link and hydrophone deployment. Operational program, boot program and data are all stored on the hard disk. The communications link is made up of an MFJ TNC2 packet radio controller, an ADI corp. 2 metre hand held radio transceiver and a model P-335 RF power amplifier to increase range. The antenna used is a Procomm CXL 70-1 LW.

The ship end of the communication link uses an identical setup with the antenna mounted on a spare antenna tube on the Monkey Island aft port quarter. All work on the ship was done in consultation with the ship's Radio Officer and cable from this antenna was run around the superstructure and entered the lab spaces through the starboard gland in the Main Lab, where the radio equipment was situated.

10.10.1.1 Shortcomings of Disposable Sonobuoys

1. The hydrophone deploys immediately, risking entanglement with air gun beams and the streamer.
2. Hydrophone data it transmitted by the sonobuoy and recorded on-board the seismic vessel. As separation between the ship and sonobuoy increases, data quality degrades and eventually disappears at approximately 18 km.
3. The exact position of the sonobuoy is not known. Winds and currents can take the unit several miles, even within it's limited useful life.
4. The instrument costs £300 and is usable only once.
5. As the unit is not recovered it constitutes a source of marine pollution.

All of the above issues are addressed even in the first prototype: the instrument being discussed.

10.10.1.2 Benefits of the Re-usable Sonobuoy

1. Sonic deploys its hydrophone as and when commanded to. This is achieved using a digital command transmitted over a VHF packet radio link.
2. Hydrophone data is digitised and recorded within the sonobuoy, thereby removing data quality degradation with distance, and should in future permit higher quality data recording.
3. Sonic also has built in a 12 channel GPS receiver enabling precise position data to be recorded with the data set. Position data is also transmitted to the ship enabling fast accurate, all weather, day or night recovery.
4. Although more expensive initially, the re-usable aspect alone should provide a cost saving in a small number of years.
5. Due to the recoverable nature this unit is not a source of any type of marine pollution.

10.10.1.3 Disadvantages of Re-usable Sonobuoys

1. The sonobuoys have to be recovered. This may seem obvious but if the ship's track was not going to take it back along the seismic line just shot then extra time will be needed to recover the instruments.

10.10.2 Development Status

The available development lead time on this project was very short considering the potential complexity of the desired instrument. Bearing this in mind and the very 'unfinished' nature of the software and electronic systems on board, everything performed, for the most part, exactly as desired. The trial deployment was the first time the electronics package had ever been mated with the mechanical and flotation elements. Very little testing of any parts of the system had been possible at all.

10.10.3 Deployment

The instrument was assembled on deck outside the Water Bottle Annex, as this was the largest un-used space available. Concern had been voiced as to how best to lift the device, and to this end John Summers, ship's Deck Officer, constructed a polypropylene rope 'cradle'. This was built such that Sonic was held together from the bottom upwards, rather than hanging from a high lifting point. The harness also had a trailing grapple line with a monkey's fist at the end to facilitate recovery. Deployment was to be carried out with the 10-ton aft crane. This enabled the unit to be deployed as far off the port side as possible so as to avoid entanglement with the seismic equipment already in the water. The sonobuoy was lifted from the Water Bottle Annex and placed on the hatch of the scientific hold awaiting the correct deployment time. It was there that the submersible connector (functioning as an on/off switch) was inserted. Radio communications were checked with the base station in the Main Lab. The release mechanism consisted of a 'greasy pin' and rope loop affair. This worked quite well, in as much that the unit was released successfully, however it took several solid dips in the sea before the pin was able to be withdrawn. A quicker, more positive method of release is needed if trauma and possible damage is to be avoided. A summary of information pertinent to the deployment is shown in the table below.

Table 9 'Sonic' deployment summary.

Date	20/1/97
Latitude	56° 12.0"
Longitude	30° 19.0"
Time deployed	12:33
Time hydrophone dropped	12:36
Course	359°
Speed	5 kts
Depth	3170 m
Set	2 Port
Wind speed (true)	7 kts
Wind direction (true)	240°
Sea state	2
Sea surface temperature	2.6 C

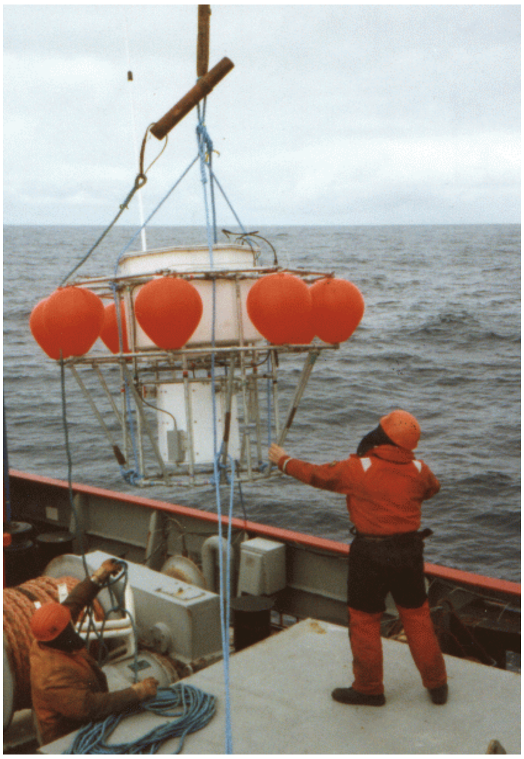


Fig 9 Deploying 'Sonic'

10.10.4 Radio Communications and Tracking

Since the effective communication range of the radio link was an untested parameter, I was keen for the hydrophone to be released sooner rather than later, in case Sonic drifted beyond communication range before the release command was issued. To this end it was decided to release the hydrophone just after the sonobuoy had passed the airguns and not to wait for it to pass the end of the streamer. The command was issued successfully and as expected the sonobuoy acknowledged the command and began relaying its GPS position to the ship. These positions were recorded and plotted to estimate drift and therefore position, should the radio link fail or the unexpected happen. At 14:26:40 the ship received 56° 10.8867' S and 30° 18.4683' W as last positions before Sonic passed radio communications range. Radio communication was still being attempted, but signal strength prevented successful decoding of the data, and therefore the link was effectively broken. The ship's position at this point was 56° 02.66' S 30° 19.86' W, giving a communications range of approximately 20 km.

Seismic line BAS967-33 was completed and the airgun beams and hydrophone brought back on board. At this point the ship set course to the point where the drift plot predicted Sonic would be. One potential problem became obvious at this point. If, for whatever reason, the ship did not receive new GPS positions from Sonic then the ship would be searching a considerable area of sea at night for a small unlit buoy. As the ship steamed to the search area it also started to snow, reducing visibility and vastly reducing the range of the ship's search lights. At approximately 11:30 the radio link re-connected and the position of 56° 07' S 30° 21.6' W was transmitted to the ship. The ship altered course to the new position. The ship slowed as it converged on the GPS position and at approximately 0.75 of a mile the small amount of metal on Sonic was visible on the ships radar.

10.10.5 Recovery

Out of the gloom and snow slowly came the sonobuoy. The ship's speed had, by this time, slowed to a knot or so, the monkey's fist was easily recovered and by 01:30/021 Sonic was lifted back on deck again using the aft 10 ton crane.

10.10.6 Recovery and Analysis of Data

Later that day the octagonal polypropylene container, containing the electronics, was removed and brought into the lab. There the top was removed and the data (some 40 Mb) was interlinked to a networked PC for onward linking to the ship-board level C Unix machine. The structure of the data record is shown in Appendix 1, raw and filtered data are shown in Figs XX and YY.

10.10.7 Conclusions

The experiment was considered to be a great success. The problem associated with data quality ie. radio transmissions interfering with the recorded data was unfortunate but will be easy to solve.

10.10.8 Beta Model Development

Sonic, as it stands, performed better than expected considering the development status of the instrument. If the concept is to be expanded to a fully functioning, market ready piece of equipment then much work needs doing.

10.10.8.1 Essential Improvements

1. The final instrument needs to be substantially smaller and lighter. If a reasonable number of these are to be deployed then there will be a considerable shortage of space on deck if the instrument is anywhere near as large as the prototype. If the instrument is at most a comfortable two man lift then moving them around, securing for sea and deployment all become much easier.
2. A xenon strobe and independently powered radio beacon should be included for safe recovery.
3. Start logging, stop logging and park hard disc commands should be available over the radio link for safer launch and recovery.
4. Separate batteries should be included for powering the PC and radio.
5. PC power management system is necessary with safe shut-down on battery discharge.
6. Ability to turn on and off, charge batteries, and dump data without disassembly of the electronics package.
7. Improved hydrophone release mechanism.

10.10.8.2 Desirable Improvements

1. Instrument status available on the ship.
2. Analogue data channel to relay seismic data as a data quality indicator.
3. Each sonobuoy would act as a relay for others 'down the line' so a sonobuoy could still be in digital communication hundreds of kilometres from the ship.
4. Internal moisture sensor to detect ingress of water before damage occurs.

10.10.8.3 Physical

The general plan consisting of central electronics surrounded by flotation with hydrophone release below is good. However the size of the whole instrument needs reducing considerably. Ten of the present design would take a huge amount of deck space. A taller, narrower design would take less space on deck and would be more stable in the water, especially if heavier items like batteries are contained low down beneath the water line. Having individual round floats proved very successful, not only for buoyancy but also as fenders when deploying and recovering the device. It took, without problem, several collisions with the side of the ship during recovery that would have been quite serious if it had not been for the floats. Undue shock must be avoided as there is a spinning hard drive on-board.

Drift of Prototype Re-usable Sonobuoy

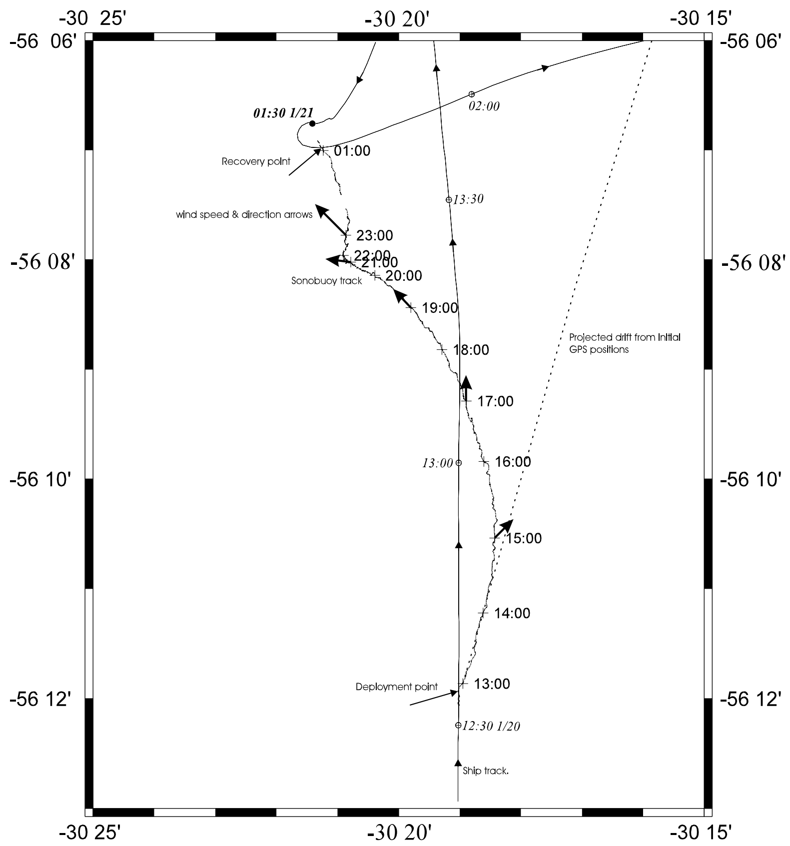


Fig 10

= 981228.16 - 981504.27 = -276.11 mGal

Difference in marine meter reading
= 12451.5 - 12732.3 = -280.8 meter units
= -279.87 mGal (S84 cal. const. 0.9967)

Drift from day 041
= -3.76 mGal in 23.8 days
Drift rate = -0.158 $mGal.day^{-1}$

The S84 meter readings obtained at FIPASS on days 010 and 065 are very similar, casting doubt on the accuracy of the KEP base station. As a consequence, gravity meter drift has also been calculated using only FIPASS ties at the start (day 010/1997) and end (day 065/1997) of the cruise. If the S84 meter drift was as low as the FIPASS ties suggest, then the gravity readings obtained at Grytviken and KEP during JR18 may provide an improved estimate of g at the jetty and the KEP base station (see below). Further ties are needed to check and refine this new estimate before it can be used for constraining marine gravity meter drift.

Drift (FIPASS-FIPASS, 010-065/1997)

δg at marine meter from FIPASS (day 010)
= 981228.16 - 981228.13 = +0.03 mGal

Difference in marine meter reading
= 12451.5 - 12451.3 = +0.2 meter units
= + 0.20 mGal (S84 cal. const. 0.9967)

Drift from day 010/1997 (ignoring Grytviken tie)
= +0.17 mGal in 54.9 days
Drift rate = +0.003 $mGal.day^{-1}$

Revised estimates of g at Grytviken Jetty and KEP base station assuming drift of +0.002 $mgal.day^{-1}$

Estimated δg from FIPASS (day 010), assuming no marine meter drift
= meter reading difference * meter constant
= (12732.3 - 12451.3) * 0.9967
= +280.07 mGal

Correction for drift at +0.003 $mGal.day^{-1}$
= estimated δg - (elapsed days * 0.003)
= 280.07 - (31 * 0.003) = +279.98 mGal

Revised estimate of g on the shoreline at Grytviken Jetty

g = g at FIPASS (010) + 279.98 + FA + LA
= 981228.13 + 279.98 + 0.08 + 0.03
= 981508.22 mGal

Revised estimate of g at KEP base station

g = g at Grytviken Jetty + δg measured
= 981508.22 + 1.02
= 981509.24 mGal

Grimsby gravity base tie day 147/1997

Day	: 147
Meter reading (meter units)	: 12596.0
g at meter on ship (mGal)	: 981370.56

Drift (FIPASS-Grimsby)

δg at marine meter from FIPASS (day 065)
= 981370.56 - 981228.16 = +142.40 mGal

Difference in meter reading
= 12596.0 - 12451.5 = +144.5 meter units
= +144.02 mGal (S84 cal. const. 0.9967)

Drift from day 065/1997
= +1.62 mGal in 82 days
Drift rate = +0.020 $mGal.day^{-1}$

10.4 Magnetics

10.4.1 Proton Precession Magnetometer (DGB)

Two systems were provided by RVS:

Consoles - Varian V75 S/No 208
Scintrex V75 S/No 2401

Several problems occurred during the cruise with the magnetometer systems. On initial deployment it was discovered that the fuse in the main power supply had blown. The fuse was replaced and the power supply caused no further problems during the cruise. The digital data cable need to be rewired, and breaking wires caused several problems during the cruise. The first sensor used became very noisy on day 015 and was replaced by the spare unit. This in turn became noisy on day 021 and a fault was traced to the deck cable inboard connector (sea water contamination). The deck cable was replaced with the spare and the original cable repaired.

During the multichannel seismic line BAS967-34 (day 026) the sensor cable became tangled around one of the two airguns that were being towed on separate umbilicals (i.e. not on a beam). On recovery the cable showed considerable damage to the outer sheaving but fortunately minor damage to the strength wires. The cable damage was taped up and survived the remainder of the cruise. It was however agreed that while the seismic equipment was being towed there was insufficient space to safely tow a magnetometer sensor

During a magnetometer line on day 051 a resistor (R201) in the console arian) burnt out. The console was replaced but the spare unit needed the PLL boards 1&2 replacing before a turned signal could be obtained. The data connections on the two consoles are different so an adaptor cable was manufactured.

During one of the short passage lines between OBS recoveries (day 052) the original sensor was deployed but still remained too noisy to use. It will need to investigated further on return to RVS.

On the passage into Stanley the signal became very noisy. Electrical leakage could be detected between the screen & the sensor wires. Cleaning the connector did not fully clear the fault for any length of time although the leakage had disappeared. The changing over of consoles did not give a vast improvement. The signal improved with time. The problem may have been caused by condensation in the deck connector. (The air temperature had noticeably increased when the fault started)

Every time the magnetometer was deployed the level A had to be reset, after switching the system on, in order to start data logging.

The original Servoscribe chart recorder became jittery and was replaced by a spare.

Although all the equipment was fully serviced before leaving the UK, it is becoming unreliable due to its age and a new system should be invested in.

10.4.2 Shipboard Three Component Magnetometer (PM)

10.4.2.1 Data Acquisition

The STCM really proved its worth on this cruise by being able to provide a usable magnetic record during the frequent intervals when the proton magnetometer was unavailable, either because of malfunction or because limited space behind the ship during seismic acquisition precluded normal magnetometer deployment. The instrument behaved impeccably during the first half of the cruise but some serious problems developed later. The first of these, which may well have led to the others, was mechanical. The layout of the equipment had changed slightly since JR12 with the control box being moved up a deck and mounted on the lower end of the alloy pole holding the detector. This pole was in the same position as on JR12; fastened to the railings of the Monkey Island, behind the funnel. The thin aluminium strips used to hold the pole to the rail were inadequate and sheared on day 039, and the whole assembly swung around for some time before it was noticed that the records were peculiar. Unfortunately it is not always obvious from the PC screen display if something is wrong. This only becomes apparent when the records have been processed, an operation which was carried out daily. Some new more solid clamps were fabricated and the instrument was restored in place. Subsequently however the record showed many more noise spikes and regularly 'dropped out', often for hours at a time, before returning to normal. The vertical axis appeared to be the most affected. Eventually the instrument died on day 056.

10.4.2.2 Calibration

7 calibration runs were made during the cruise; 5 before the detector mountings broke and 2 after (Table XXX). During this procedure the vessel sails round a fairly tight figure of 8 course. From the STCM readings recorded during this time a set of calibration constants is calculated which are used to remove the magnetic effect of the ship from the raw STCM data. Remounting the detector head changed the alignment of the detectors slightly which meant that the first 5 calibrations were then inappropriate. The next 2 calibrations did not provide a robust set of correction coefficients but fortunately it appears that the correction coefficients calculated from the first 5 runs can still be used to calculate total field variations which track the proton magnetometer anomalies very well. There is however an offset of several thousand nT between the absolute proton and STCM anomaly levels. The STCM anomaly base level also becomes extremely dependent on the ship's heading.

10.4.2.3 Processing

As on JR12, STCM processing was carried out using software obtained from Dr Y. Nogi (Meteorology Research Institute, Japan) on JR09A (See JR09A cruise report for details). Various in house modifications have been made to the programs to make input and output operations simpler but the essential algorithms remain unchanged. The lack of reliable pitch and roll data remains a problem and no corrections for these variables were applied (see Ashtech/TSS RP section of this report). The main interest was in calculating a total field anomaly to infill important portions of record where no proton magnetometer data is available. Infilling a few hours in the proton magnetometer record is straightforward if the ship has held a constant course but problems arise over longer periods. The STCM readings show long term non-linear drift. This could be caused by instabilities within the instrument itself or by the changing attitude of the ship as a result of wind, currents etc. On the long seismic traverses where no proton magnetometer was run there were always some sections of the line close to an old cruise track with magnetic data which could be used to determine the STCM drift. Various types of filtering and polynomial trend removal were investigated as possible methods of drift removal but eventually it was decided that it was more effective to design a smooth drift curve by hand which could be subtracted from the STCM anomaly to give a reasonable fit to any fragments of available proton data.

10.4.2.4 Recommendations

1. The STCM should now be considered as an essential fixture on the JCR.

2. The sensors and control box need a permanent installation and not the temporary type of lash up which they have at the moment. There should be absolutely no possibility of the sensors moving relative to the ship.

3. A long term test of the instrument onshore would be useful to determine if there are any stability problems which need addressing.

4. The calibration constants determined for the JR12 and JR18 cruises are not greatly dissimilar. This suggests that if the detector head is mounted somewhere permanently it should be possible to use some average sort of coefficients to allow approximate real time compensation for the ship's magnetisation to be carried out, given the availability of gyro and hopefully roll and pitch information. This would make it much easier to determine if the instrument was operating correctly.

5. A proper supply of roll and pitch information needs to be made available. If this cannot be done from the TSSHRP or Ashtech then some simple, foolproof, roll and pitch sensors need to be obtained and connected to the system.

Table 6 STCM calibrations.

Day	Latitude	Longitude	Start time
97/013	-51.73	-57.55	08:25
97/014	-56.00	-53.17	08:08
97/016	-60.04	-41.99	01:56
97/017	-58.00	-32.00	08:49
97/021	-56.17	-26.53	14:00
97/044	-59.69	-26.17	16:52
97/045	-60.30	-21.25	11.13

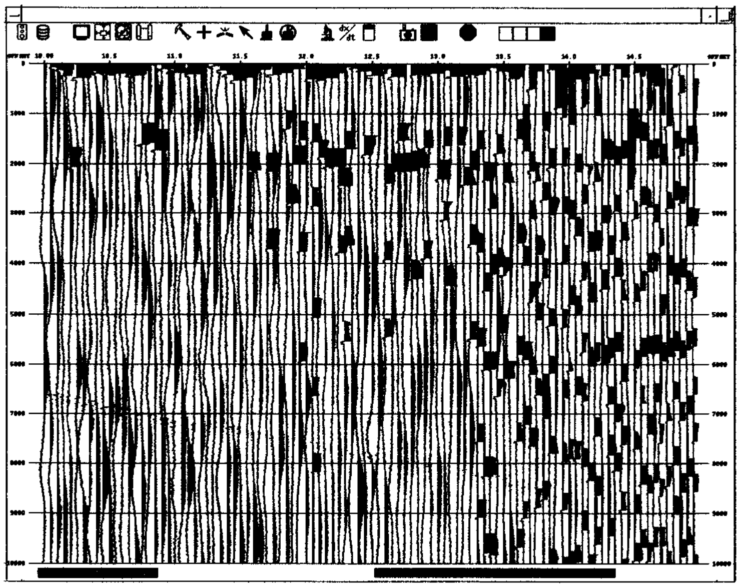


Fig. 11a. Example of raw sonobuoy data. Distance increases from 10 to 15 km left to right, time from 1-10s downwards. Note radio interference.

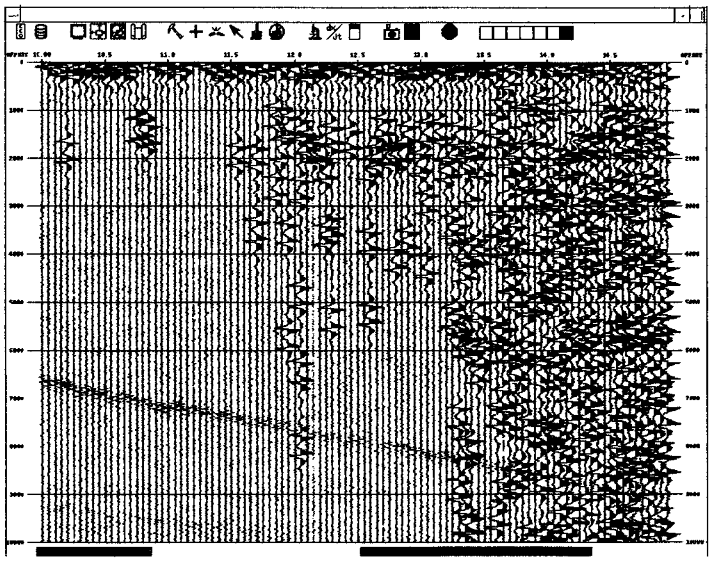


Fig. 11b. Same data shown in Fig.11a with bandpass filter 3–30 Hz applied. Seabed reflection can be seen between 7–9 s. Arrival is obscured by radio interference beyond 14 km range

10.11 Data Logging (DJR/JC)

10.11.1 Recording

The logging equipment performed well and no major problems were encountered. However, during most of the cruise the LevelB was running on only one disk. Attempts to repair this disk on the fly were unsuccessful and so it is assumed to be unfixable. The LevelB was also overheating significantly although this did not degrade performance. These problems are simply age related, the hardware in question being about six years old and in need of refurbishment This was carried out at the end of the cruise. Initially the spare LevelB chassis unit was fitted with new disk and tape drives, however the ethernet interface on this unit appeared to be faulty. This fault may simply be a simply be due to clogged fan intake filters and requires investigation.

Table 10 JR18 ABC SYSTEM DATA LOGGING		
LEVELA APPLICATION	**DATA FILE**	**INSTRUMENT**
BAS_STCM	stcm	Shipborne three component magnetometer, BAS developed.
GPS_ASH	gps_ash	Ashtech 3DF GPS receiver.
GPS_GLOS	gps_glos	Ashtech GG24 GPS/GLONASS receiver.
GPS_NMEA	gps_nmea	Trimble 4000DS GPS receiver.
MAGNET	magnet	RVS supplied Varian V75 proton magnetometer.
TSSHRP	tsshrp	Ships TSS heave, roll and pitch sensor.
GYROSYNC	gyro	Ships gyrocompass.
SERCEL	sercel	RVS supplied Sercel airgun control system.
ANEMOM	anemom	Ships ultrasonic anemometer.
WINCH	winch	Ships Seametrix winch data logging system.
SIM500	sim500	Ships Simrad EA500 bathymetric echo sounder.
OCEANLOG	oceanlog	BAS developed environmental data logging system.
EM_LOG	em_log	Ships Chernikeef electromagnetic speed log.
GRAV_84	gravity	RVS supplied LaCoste and Romberg gravity meter, serial number S84. Meter constant 0.9967.
DOP_LOG	dop_log	Ships Sperry doppler speed log.
none	rawdep	Manually logged depths from 10kHz echo sounder.

The processed navigation file 'bestnav' was produced as follows: When differential GPS was not available, the Ashtech GG24 combined GPS/GLONASS unit was used as the primary source of position fixes. When DGPS was available, the Trimble 4000DS unit was used as the primary source instead.

Position fixes from these sources were fed through the LevelC program 'gps_av', which was using a 1 minute 30 second averaging window, and this produced the 'gps_av' file of fixes. This file was then fed into 'bestnav' along with the relative motion file, 'relmov', which was derived from speed and heading information in the 'em_log' and 'gyro' files (N.B. 'bestnav' ignores data in 'relmov' when the 'gps_av' data stream is continuous).

Table 11 LEVELC PROCESSED DATA FILES

FILE NAME	DESCRIPTION
gps_av	This file was produced from GPS fixes from both Trimble 4000 and Ashtech GG24 units using the "gps_av" LevelC program. The data in this file is the raw GPS data smoothed by use of a 1 minute 30 second averaging window.
relmov	This is the relative motion file produced from the em_log and gyro files by use of the "relmov" LevelC program.
bestnav	This is the final navigation file produced by the LevelC program "bestnav" using the GPS fix files and the relative motion file.
bestdrf	This file contains the drift vectors produced by bestnav.
promag90	This is a file of processed magnetics produced from the raw data in the file magnet. It uses the 1990 IGRF reference field.
prodep	This is a file of Carter corrected depths produced using depths from the file rawdep.
prograv	This is the processed gravity data file. The raw gravity data was processed using data from the files bestnav and prodep. The base station tie-in was carried out at FIPASS on 10/01/97. The values were: Gravity at Base Station: 981228.33 Base Station Meter Reading: 12451.3 Meter Calibration Constant: 0.9967

Appendix 1. Format of Prototype Re-usable Sonobuoy Data Record (MOP)

-9 -8 -16 -4 -8 -8 -4 -9 -8 -5 -8 -8 -7 -17 -2 -4 -9 0 -9 -2 -17 -8 -15 -9 -4
-4 -4 0 -4 -9 -13 -17 -1 -9 -9 -5 -9 -9 -4 -13 -13 -9 -13 -17 -9 -2 -4 -9 -1 -1
-5 -4 0 -13 0 -1 -13 0 -2 -13 0 -1 -9 0 0 0 -2 -2 0 -1 -5 -1 0 3 -3
0 0 -2 3 -5 -2 0 -1 2 -1 0 0 0 -2 0 -1 0 3 8 3 3 3 0 1 6 -1 16
8 -1 7 0 16 1 0 7 1 7 7 1 7 8 16 -1 12 12 3 11 15 8 16 8
5 43 108 111 112 123 112 $GPRMC,190500,A,5608.3979,S,03019.8606,W,0.000,0
*.0,200197,8.3,W*6C*
End of data record

Start of data record
96 96 81 87 80 81 87 71 80 87 83 79 88 75 87 87 92 79 71 79
80 82 80 79 80 80 72 80 76 80 76 75 67 72 80 70 69 71 65 59
75 76 80 79 63 73 67 80 75 63 78 73 68 67 78 80 79 71 67 78
75 63 80 75 77 76 67 74 72 76 -459 -734 -820 -767 -820 -905 -768 -961
-909 -828 -768 -909 7 15 18 9 16 15 16 16 23 16 23 20 19 18 15 1
1 15 16 15 24 15 7 14 15 18 23 16 15 19 15 11 11 11 23 17 11
Data remover here for clarity
-16 -8 -17 -8 -21 -6 -17 -8 -21 -9 -17 -19 -7 -9 -9 -8 -13 -9 -12 -16 -16 -12 -
9 -9 -21 -10 -9 -4 -16 -17 -9 -21 -17 -8 -16 -8 -16 -13 -11 -13 -16 -21 -16 -10
-9 -17 -13 -21 -9 -13 -13 -4 -9 -8 -10 -19 -16 -17 -13 -17 -13 -25 -16 -6 -21 -8
-12 -21 -21 -19 -21 -16 -16 -10 -17 -9 -10 -8 -10 -13 -17 -10 -17 -9 -8 -17 -17
-17 -11 -16 -5 -12 -7 -8 -8 -4 -17 -2 -8 -2 -9 -15 -17 -9 -8 -5 -2 -12 -8 -7 -9
-15 -2 -15 -2 0 -2 0 -1 -8 -4 -7 -4 -10 -17 -5 -9 -7 0 -9 -13 $GPRMC,190520,
*A,5608.3975,S,03019.8662,W,0.598,211.6,200197,8.3,W*60*
End of data record

Start of data record
103 91 107 104 96 95 103 103 104 96 96 108 96 108 95 96 105 10
7 112 98 99 112 104 112 111 99 106 99 112 108 107 99 103 112 11
1 111 112 104 107 112 105 111 112 103 120 112 99 95 107 120 113
103 105 103 120 115 112 119 120 111 112 111 120 111 120 119 -773
-734 -845 -767 -884 -905 -905 -901 -1 0 -2 26 23 20 11 13 16 23 22 11

Appendix 2. MGD77 Files (PM)

The RVS level software has a utility for writing an MGD77 file from the cruise data. This needs to be treated with some discretion and the following notes may be of use to anyone who needs to use this facility.

The file written by the RVS command 'mgd77' has a header of 24lines of 80 characters followed by the cruise data on 120 character records. Because it does not explicitly state in the MGD77 specification that an end of record character should be included at the end of each line RVS maintain that they are not required and their file consists of one single continuous record. To convert an RVS type MGD77 file (mgd77.old) to a more standard type (mgd77.new) use the UNIX command.

```
dd if = mgd77.old bs=80 skip=24 | fold-120 > mgd77.new
```

This strips off the header records and converts the remainder of the file to conventional 120 character records.

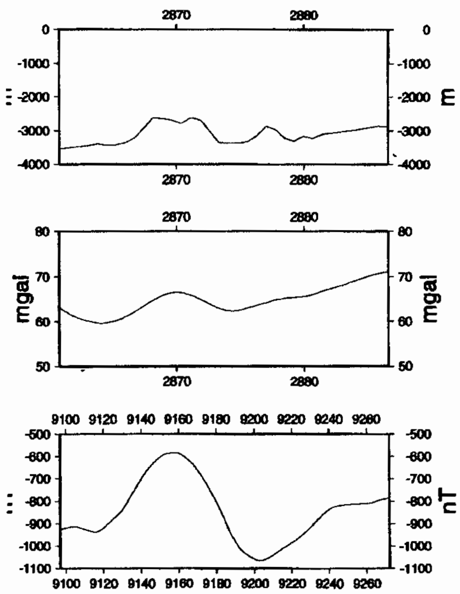
One should also be aware that the RVS MGD77 program will happily pick up values marked as bad from Level C files and write them into the mgd77 file so there is little point in editing the Level C data on the assumption that this will produce a good mgd77 file. Also if any value is too big for its alloted number of characters it will expand into the next columns of the record. This is particularly liable to happen with residual magnetics where negative noise spikes or zeros in the total field can easily produce a residual requiring more than 6 characters to display.

It follows that a certain amount of post processing of mgd77 files produced using the RVS command is usually going to be required.

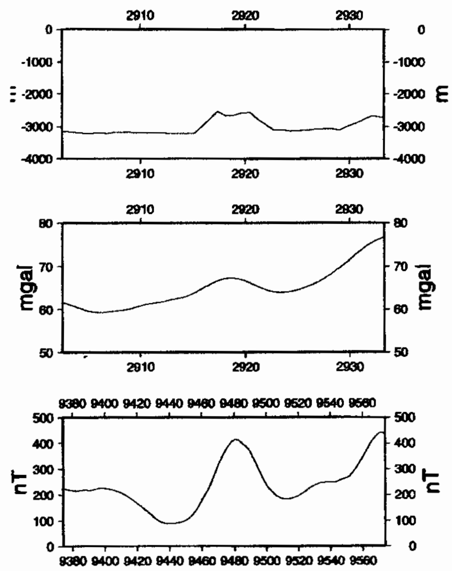
Appendix 3

Plots of Bathymetry, Free Air Gravity anomaly and Magnetic anomaly along seismic lines

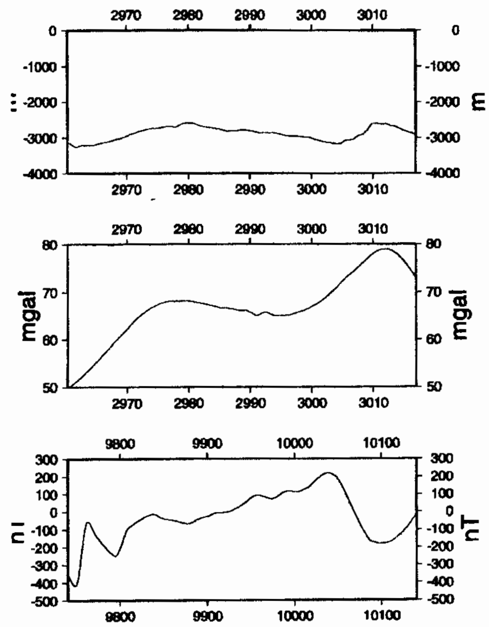
BAS967-31



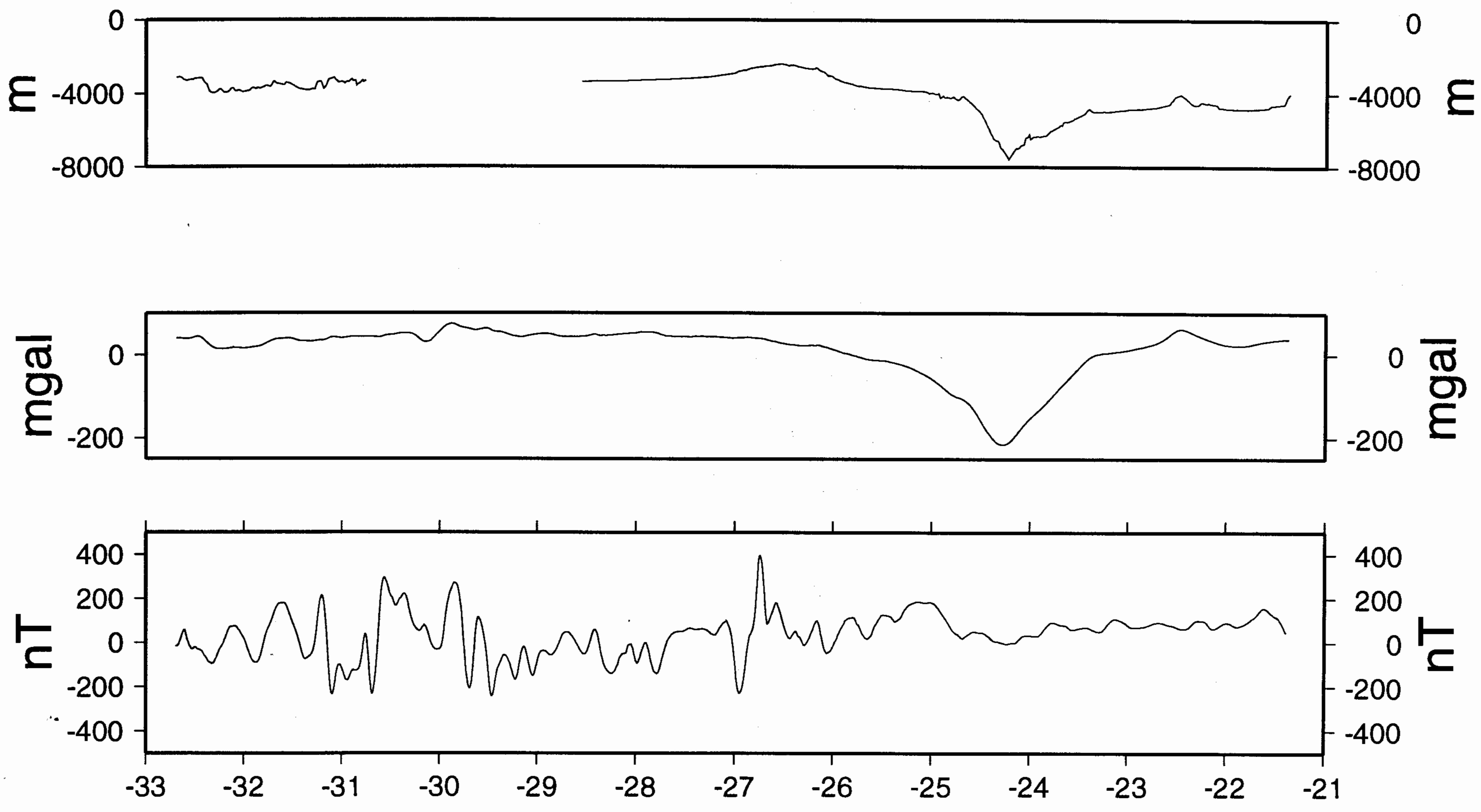
BAS967-32



BAS967-33

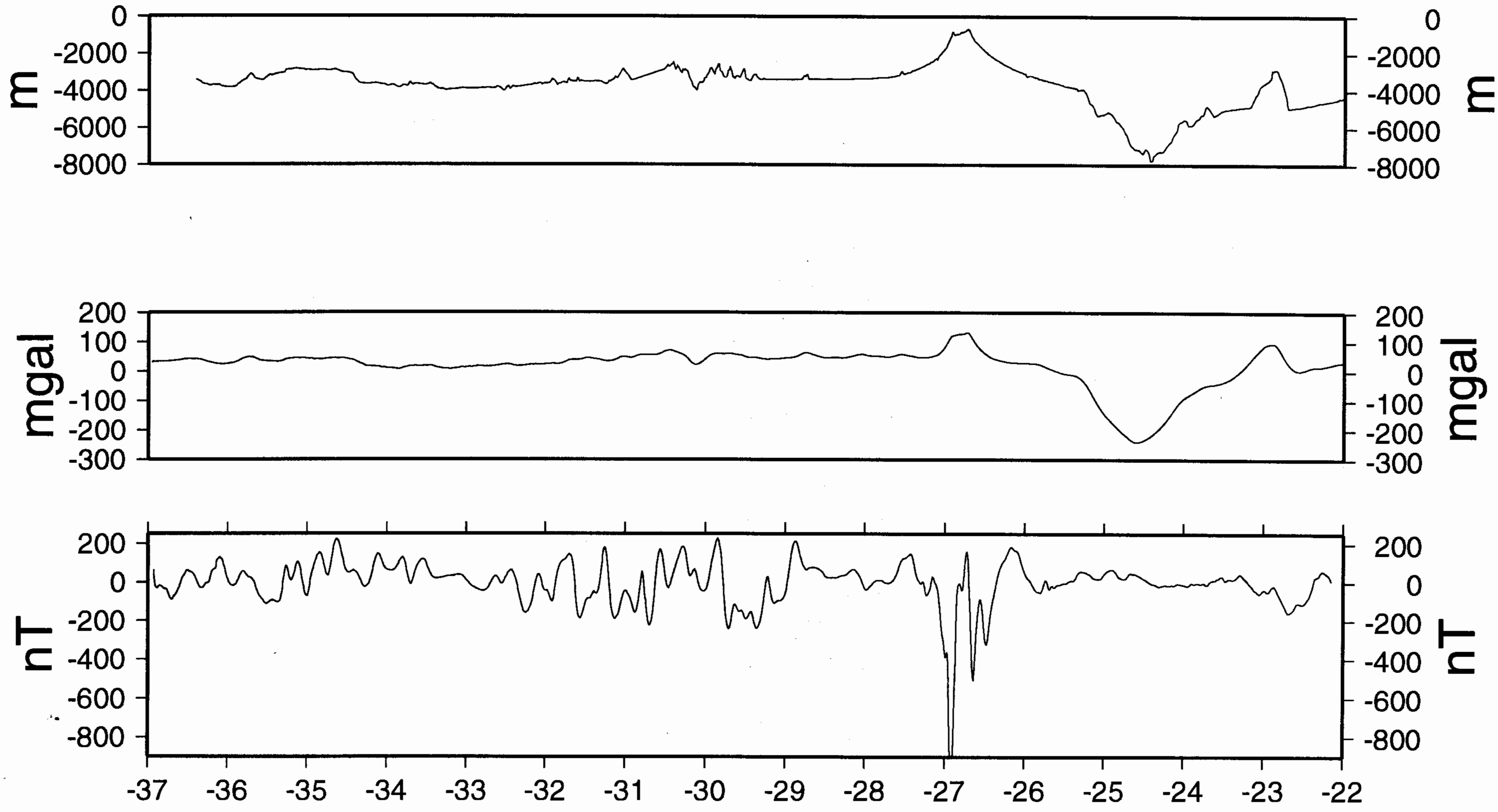


Line 967-34



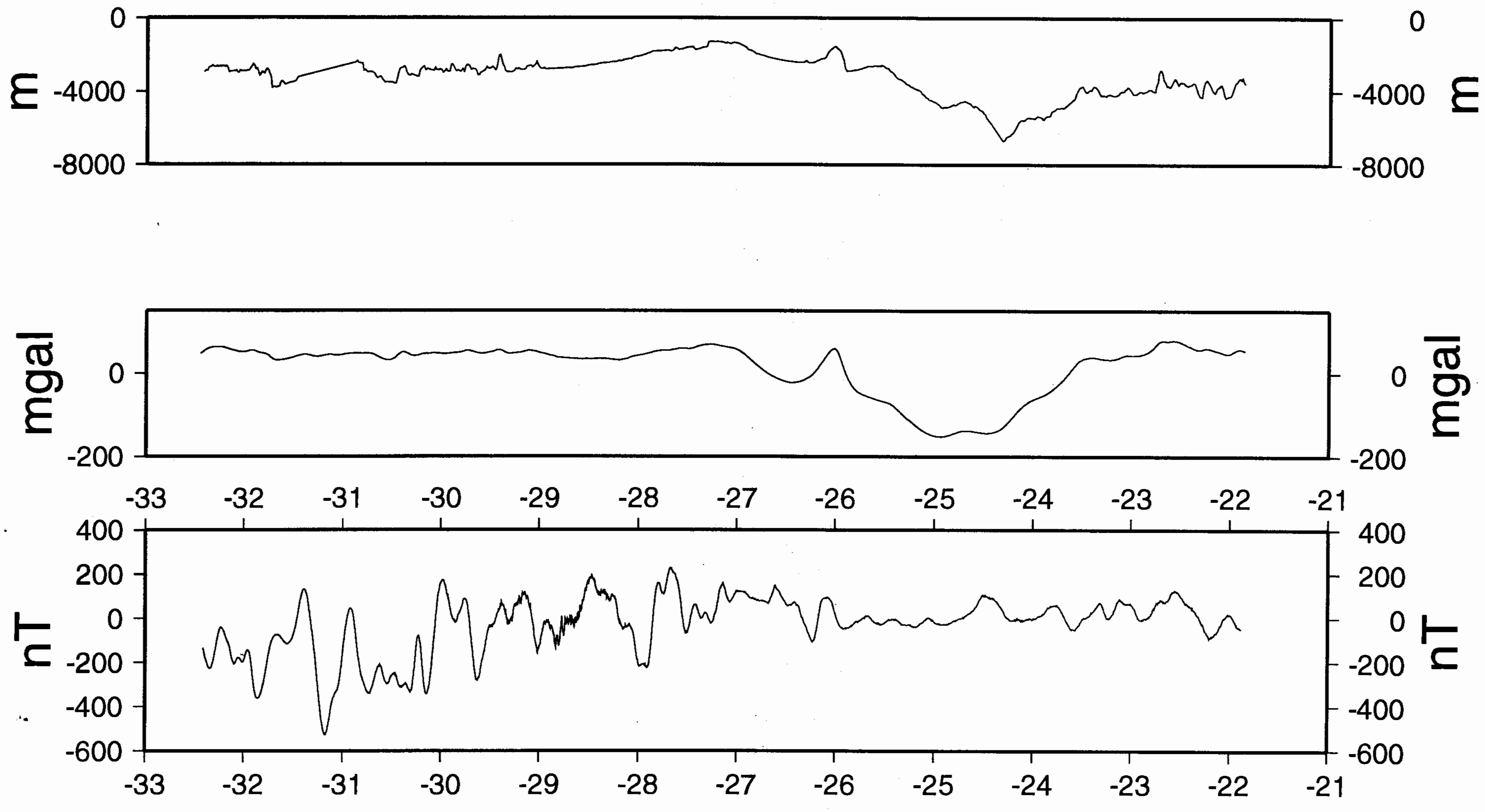
0
-4000
-8000
m
mgal
0
-200
nT
400
200
0
-200
-400
-33
-32
-31
-30
-29
-28
-27
-26
-25
-24
-23
-22
-21

Line 967-35



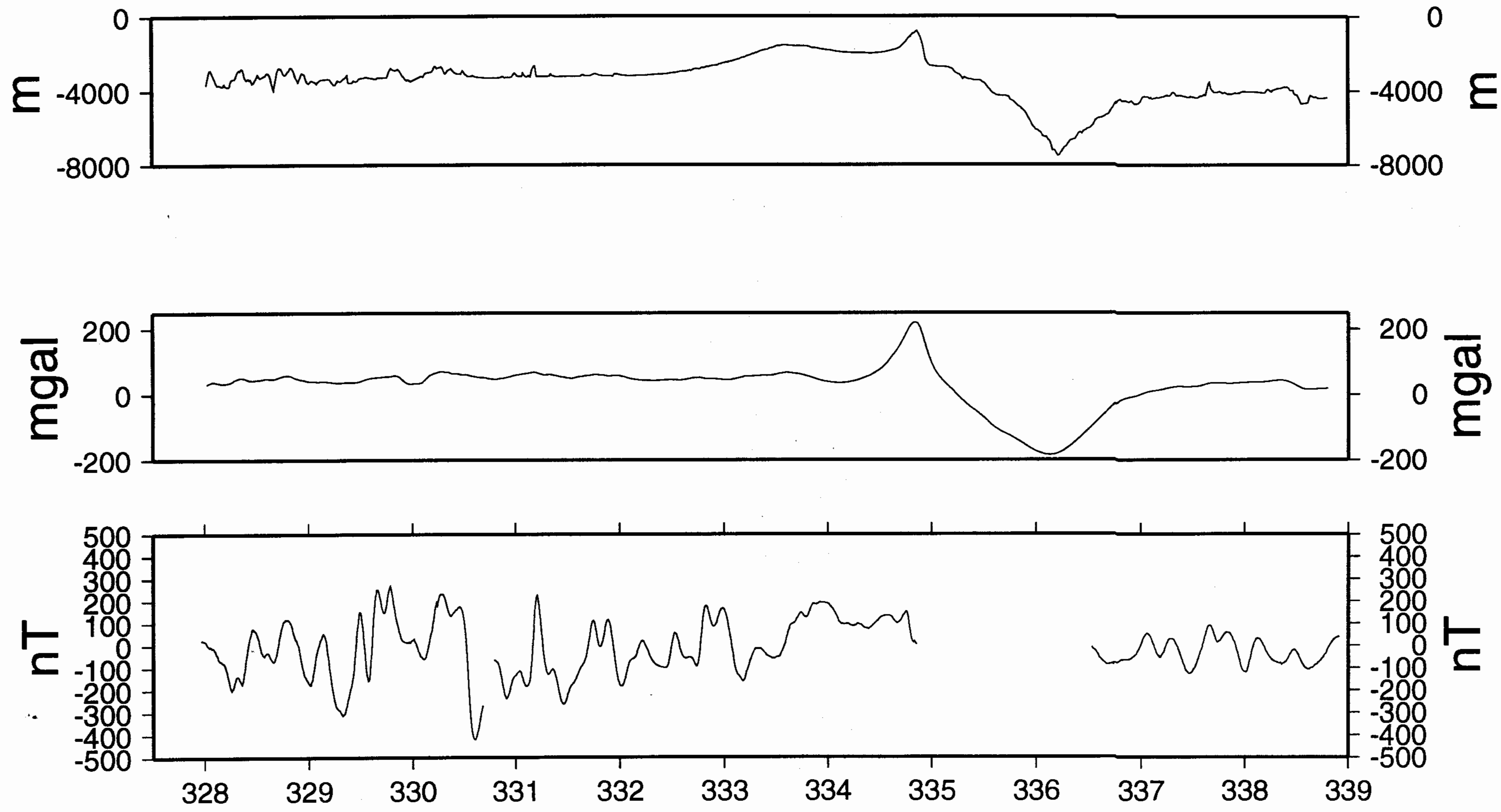
0
-2000
-4000
-6000
-8000
m
200
100
0
-100
-200
-300
mgal
200
0
-200
-400
-600
-800
nT
-37
-36
-35
-34
-33
-32
-31
-30
-29
-28
-27
-26
-25
-24
-23
-22

Line 967-36



m
0
-4000
-8000
mgal
0
-200
nT
400
200
0
-200
-400
-600
-33
-32
-31
-30
-29
-28
-27
-26
-25
-24
-23
-22
-21

Line 967-38



m
0
-4000
-8000
mgal
200
0
-200
nT
500
400
300
200
100
0
-100
-200
-300
-400
-500
328
329
330
331
332
333
334
335
336
337
338
339