D154:

RRS Discovery
Antarctic Peninsula and Weddell Sea Marine Geophysics and Marine Geology
December 1984 - April 1985

UNIVERSITY OF BIRMINGHAM

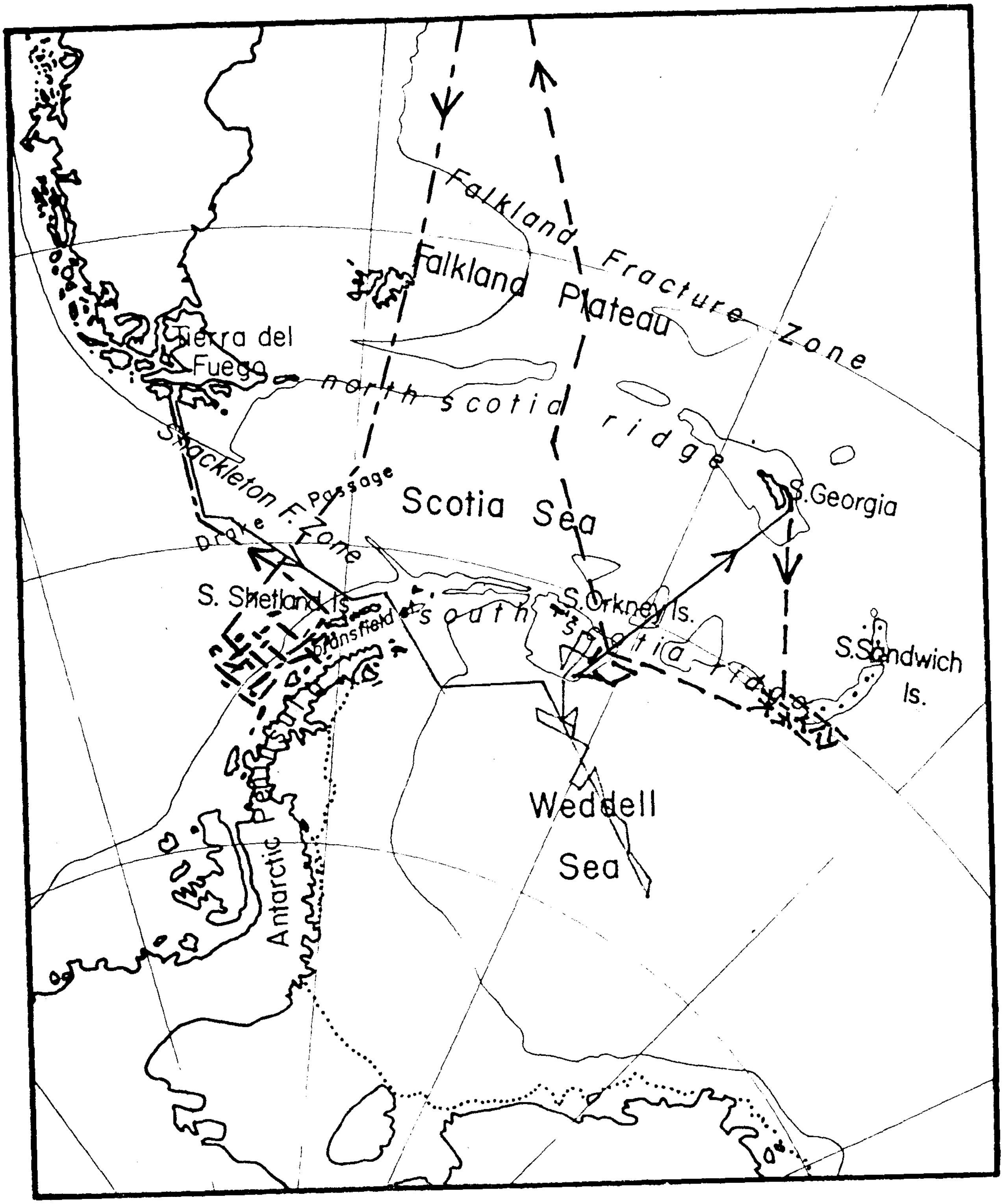
ANTARCTIC MARINE GROUP

Cruise Report

RRS Discovery Cruise D154
December 1984 to April 1985

Marine Geophysics and Marine Geology
Antarctic Peninsula and Weddell Sea

May 1985



Cruise D154
Birmingham Univ - BAS
Scotia and Weddell Sea Region

Legs 1 and 2
Leg 3
Leg 4

SUMMARY

Discovery Cruise 154 started from Gibraltar late on 8 December and arrived Montevideo 11 April 1985 (124 days), via Port Stanley, Punta Arenas and Grytviken (S. Georgia). The main projects for the 3 working legs (after Port Stanley) were:

1. study of young ridge crest-trench collisions at the Pacific margin of the Antarctic Peninsula
2. investigation of factors controlling Weddell Sea floor sedimentation, with particular interest in the effects of Weddell Sea Bottom Water
3. reconnaissance of a young intra-oceanic ridge crest-trench collision zone directly south of the S. Sandwich island arc and trench.

An additional objective, linked to 2 above, was to provide site survey for proposed Ocean Drilling Program drill sites on the S. Orkney block and in the northern Weddell Sea.

The ship undertook seismic, magnetic, bathymetric, gravity and shallow sidescan sonar survey, dredged and cored. Heat-flow measurements were made by a Woods Hole/UT at Austin/Trieste group. The principal innovation however was the new digital multichannel seismic acquisition system (DMCSAS), purchased with BAS funds and operated by RVS.

DMCSAS trials immediately before cruise 154 revealed several deficiencies in the system, mainly in the type and quality of data being recorded on the tape headers, but also in control and deployment of the seismic source and in the streamer. These were tackled energetically during passage south, but the system was not fully usable until 13 January, when HMS Endurance fired 2 short expanded-spread profiles into the array off Anvers I., as part of project 1, and it is unfortunate that so much time on this cruise had to be devoted to bringing the DMCSAS into service. The DMCSAS was subsequently used on all 3 legs, and about 3700 km of 50m-shot, 24-fold data were acquired. The main limitations of the system now lie in gun array size, deployment and monitoring, and compressor power. All 3 projects and the ODP site survey went well, although the coring suffered from bad weather (stern coring off Antarctica is not smart) and equipment loss (piston corer) and unreliability (box corer).

After changes to her subsequent programme, the ship headed directly back to the UK from Montevideo, and is due to arrive in the Clyde on 12 May 1985.

RRS Discovery Cruise 154

Birmingham University Antarctic Marine Group

November 1984 to April 1985

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C. Woodley

INTRODUCTION

This cruise marked a new phase in the UK's marine geophysical and geological investigation of British Antarctic Territory and surrounding areas. The Birmingham University group is now funded by a BAS contract with the University, and BAS paid for the ship time and for purchase of the new digital multichannel seismic acquisition system (DMCSAS) which had its first use on this cruise. The programme of research of which this cruise was the beginning builds on the understanding of regional tectonic evolution developed by the Birmingham group over the past decade, but branches out into palaeo-oceanography and sedimentology, and into the detailed study of tectonic processes particularly well-displayed in the region.

One of the three main components of the new phase of investigation, a study of the southern margins of the Weddell Sea aimed towards understanding the earliest stages of Gondwana break-up, could not be started in the 1984-5 season, since it requires the use of an ice-strengthened ship. The other two are (a) the study of ridge crest-trench collision and (b) investigation of the controls on Weddell Sea sedimentation, concentrating particularly on the influence of Weddell Sea Bottom Water.

The subduction of a spreading centre is a virtually inevitable component of the history of a long-lived subducting margin, with probably profound effects on the geology of the over-riding plate. Yet its study is neglected, because of a lack of young examples, where such effects may best be isolated and examined. We now know that BAT contains perhaps the majority of young examples of simple geometry, along the South Scotia Ridge and the Pacific margin of the Antarctic Peninsula. This cruise included a study of the 3 youngest collision zones off the Peninsula, during Leg 2, and a reconnaissance of the youngest collision zone in the contrasting intra-oceanic environment directly south of the South Sandwich arc during Leg 4.

Most of Leg 3 was devoted to a coring transect from the centre to the northern edge of the Weddell gyre to examine the effects on sedimentation of Weddell Sea bottom water (WSBW). Antarctic Bottom Water (AABW) is one of the two main components of Southern ocean circulation. It drives the southern hemisphere's north-south circulation, and influences sedimentation as far away as the western North Atlantic. It is renewed from beneath, mainly at present in the Weddell Sea, essentially by the sinking of brine produced beneath forming sea ice, under certain poorly known conditions. Its production is therefore intimately related to the glacial state of Antarctica so that,if its sedimentary signature could be deciphered, Antarctic glaciation could be studied.

Previous attempts to study AABW by drilling farther north have failed, but the opportunity is coming to examine Weddell Sea sediments directly, with an ODP drilling leg to the region, planned for early 1987. This drilling requires a conceptual model for WSBW effects on sedimentation which does not yet exist. Our coring transect was intended to provide the statutory site survey for drilling but, more importantly, was aimed at gaining insights into the controls on modern sedimentation in the Weddell Sea which could be applied to sediments recovered during drilling. We also undertook ODP site survey for a suite of drill sites across the southeastern margin of the South Orkney block, aimed at examining the evolution of intermediate-depth water masses in the Weddell Sea. Such drilling would also provide control for single and multichannel seismic lines on the South Orkney block and thus reveal the block's response to a 20Ma-old ridge crest-trench collision. One of the heat-flow transects undertaken by Dr. L.A. Lawver and Dr. B. Della Vedova, funded by a NSF-DPP research grant to Prof. R. von Herzen of Woods Hole Oceanographic Institution, was located nearby in Jane Basin and should also throw light on aspects of the collision history of this margin.

The DMCSAS played a prominent part in the work of the cruise, particularly during Legs 2 and 3. Because so many problems remained after DMCSAS trials (which, unfortunately, came immediately before the start of this cruise) we have been responsible for setting up much of what could become the routine operating mode of the system. The part of this report which deals with equipment performance contains rather a long section on the DMCSAS including a description of the operating mode and a series of recommendations on how the system may be improved. We hope that RVS and future users of the DMCSAS will find this section useful.

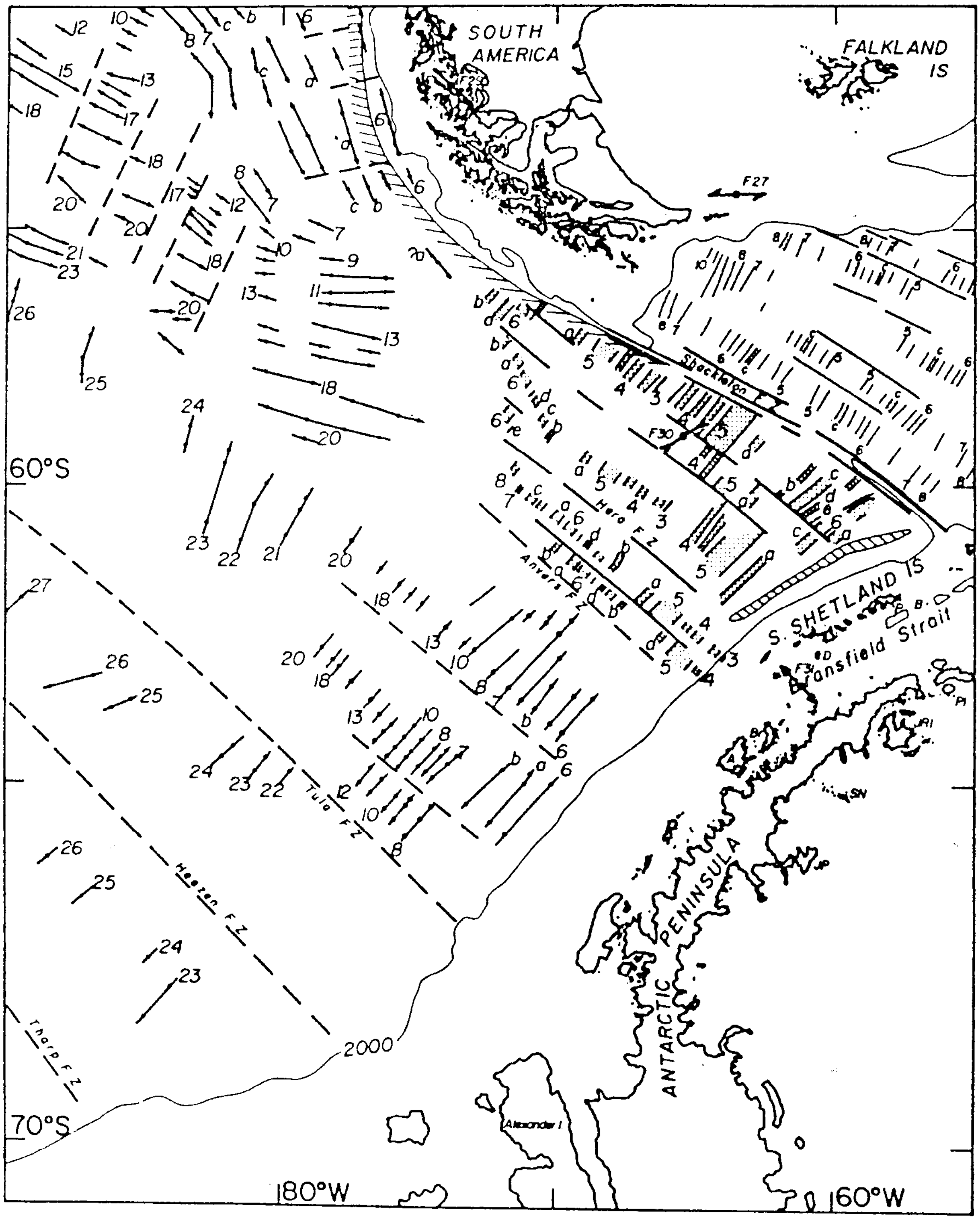


Fig. 1. Magnetic anomalies young towards Antarctic Peninsula margin (except off S. Shetland Is), indicating a series of ridge crest-trench collisions, at times becoming more recent towards the northwest.

SCIENTIFIC NARRATIVE

Leg 1

RRS Discovery sailed from Gibraltar in the evening of 8 December on the first leg of her Antarctic cruise, $1\frac{1}{2}$ days late because of an extension to the preceding DMCSAS trials cruise. Of the scientific party now aboard, 5 RVS technicians (ARC, GL, DT, BB, DL), Richard Phipps of IOS and 2 Birmingham scientists (RDL, PFB) had taken part in those trials. The continuity was important, since this first leg was mainly straightforward passage and most of the available man-hours had to be spent in making good the deficiencies which trials had revealed (see DMCSAS sections). We attempted only a small amount of marine geophysical data acquisition lasting 5 days in all, near the Cape Verde Is (but outside 200 nm limits) for Dr. I.A. Hill (Leicester) and from there to 4°S (ditto) for Dr. EJW Jones (U.C. London). In addition, Colin Woodley (IOS) deployed expendable bathythermographs (XBTs) for Dr. W.J. Gould of IOS (also outside 200 nm limits). XBT deployment continued throughout the cruise, normally one every 12 hours. The ship made excellent time through the Atlantic, crossing the Equator (ceremoniously) on 18 December and reaching Port Stanley on 30 December. Thanks to the ship's engineers we had averaged 11.5 knots for the passaage from Gibraltar, and recovered all but a half day of the time originally lost.

At Stanley we took on fuel and water from the Cunard tanker Lumiere anchored in Port William, then anchored ourselves in Stanley Harbour. Martin Dougherty and Skip Pelletier, the Woods Hole heatflow team, joined the ship the following day.

Leg 2

The ship left Port Stanley in the evening of January 1st, en route for the western margin of the Antarctic Peninsula. The aim of this Leg's work was to study the tectonic processes involved in subduction of a spreading centre. Along the Peninsular margin (Figure 1), a series of such ridge crest-trench collisions have taken place, at times ranging from 50 Ma ago in the far south to only 4 Ma ago off Smith I and northern Brabant I. Off the South Shetland Is, moreover, spreading and subduction have both stopped (or almost stopped) without the ridge crest having reached the trench, thus offering the chance to examine the margin as it was before a collision. We wanted to define better the timing of collisions and extent of each collision zone, by straightforward magnetic and bathymetric mapping of the oceanic area. Also however, we wanted to assess the effects of collision on the geology of the continental shelf and margin. A number of theoretical studies had predicted that uplift, regional thermal metamorphism, the cessation of arc volcanism, ophiolite obduction, back-arc extension and tectonic erosion of the fore-arc should all accompany collision, but none of these hypotheses had been tested.

Because it was likely that exposure would be better there, and the processes of interest less overprinted by later events, we had chosen to concentrate on the youngest collision zones ($6\frac{1}{2}$ Ma and 4 Ma) off Smith I and Brabant I. There we wanted to obtain multichannel seismic profiles across the shelf and margin, so as to learn about the history of vertical movement. The same profiles, with dredge stations up the margin, would reveal the extent of any tectonic erosion. However, because these younger zones were narrow, and perhaps affected by uplift associated with back-arc extension in nearby Bransfield Strait, we had sited a 2-ship expanding spread seismic experiment (ESSEX), with HMS Endurance as shooting ship, farther to the southwest off Anvers I. The need to locate ESSEX lines precisely attracted reconnaissance tracks into the same area. Also, the effects of a heat impulse at the base of the Peninsula plate, which a ridge crest-trench collision should provide, would take time to reach the surface. The heat flow transect was therefore also located off Anvers I in a region where the collision occurred 18Ma ago.

The ship reached the work area on 5th January, having headed first south and then southwest from Port Stanley (See Figure 2). At this time we had a week before the ESSEX lines were due to be shot, and yet several components of the DMCSAS were not completely ready, or had not been tested. We decided to spend the next 3 to 4 days undertaking reconnaissance survey for the ESSEX lines, using magnetics, gravity and a single-channel seismic system comprising one 40 cu inch gun and a 30 m Geomecanique Streamer. This system could be towed at 8 knots, but only because BAS had agreed to underwrite any resulting gun damage (an RVS-imposed 5.5 knot limit was in force, following gun damage on IOS Gloria/seismic cruises off the US margin aboard Farnella: in the event, no damage could be detected). The single channel system was not ideal, giving only limited penetration on the continental shelf and none on the slope, but it served its purpose in this instance.

Over the next 3 days (5th to 8th January) we achieved a reasonable knowledge of the shallow structure off Anvers I, allowing us to locate the two ESSEX lines precisely along the regional strike and within recognisably different geologic provinces. This was done in poor weather, and included most of a day virtually hove to into a NE gale. On the 8th we met HMS Endurance in western Orleans Strait to transfer Malcolm Lonsdale and the shot recording gear for ESSEX. (This early transfer, 5 days before ESSEX, and the extra passage it required, were chosen because of the wealth of unsolved problems associated with the DMCSAS: we wanted to be able to devote a solid block of time to final preparation, without having to recover and redeploy the streamer to fit in with a tighter schedule for transfer, closer to the experiment, at what might be an inconvenient time). The weather was still poor, and all were impressed by the abilities in those conditions of Endurance's helicopter crews. On leaving the rendezvous to spend time preparing the DMCS streamer, we were again forced to head slowly into a NE gale, towards the lee side of Deception I where on 9 January the ship anchored for several hours while damage to the engineroom monitor/control console (from a wave through the skylight the previous evening) was assessed and repaired.

By the morning of 10 January the wind had dropped sufficiently for us to consider deploying the DMCS streamer, to complete the streamer balancing which had been started during trials. By mid-afternoon the ship had reached the end of a magnetics line directly SW of the Hero fracture zone (see Figure 3) and could start streaming, at the same time removing those amounts of lead from each streamer section that had been agreed upon at the end of trials. Towards the end of this deployment a PVC jacket on the patch section linking the tow leader and spring section split in the cold weather and had to be replaced by Neoprene hose of the same diameter, fortunately available from ship's stores. Given that the streamer itself was entirely Polyurethane-skinned, brittle PVC was an odd choice for the patch section.

With the agreed amount of lead removed, the streamer should have been ideally balanced, according to the Teledyne manuals aboard. Instead, however, it towed very deep. After much discussion we decided to recover the streamer and find out the thermal expansion coefficient of the streamer oil. During recovery the after end of the streamer sank to at least 200 feet, and the tail buoy came in with both tanks imploded. Using oceanographic tables aboard ship we were able to establish that no account had been taken in constructing the Teledyne buoyancy tables of streamer oil density changes, while the reply to our telex enquiry showed that the expansion coefficient of the oil was four times that of water (even away from the 0°C density maximum of salt water).

This subject is discussed further in the section of the report which considers equipment performance. Suffice to say here that we calculated the loss in buoyancy due to oil contraction, the next night and morning (11/12th) filled the streamer with the amount of oil estimated to correct for it (12 litres per active section, 7 litres per spring section) and constructed a makeshift tail buoy using plastic fenders and a dahn buoy. Fortunately, since 12th January was the day originally planned for the start of ESSEX, R.M. Captain Simon Scott's extremely useful firing order for ESSEX specified 13 January as the starting date, which gave us the 12th to complete preparations. Discovery was by this time in deep water about 50 miles NW of the start position of ESSEX I, and on the afternoon of the 12th HMS Endurance came out to meet us, firing 4 test shots at decreasing range to permit checks of recording arrangements aboard both ships and of inter-ship communications. This completed, our airguns were streamed and 2 very short trial DMCS lines were shot overnight (27 second shot interval, 16-fold cover) to test the complete DMCS system, on the way to the ESSEX start position.

The first ESSEX line was shot with Endurance heading 237°T, Discovery 057°T (this choice keeping the shots farther from penguin rookeries on and around Anvers I). One test shot was fired 10 minutes before the ships came abeam, the remainder (33 on the first line) at increasing separations, the largest charge (100lb) being fired at a greatest range of 63 km. There was only one misfire and only one other shot missed through a recording error. The camera records showed an excellent signal-to-noise record on all streamer channels and mantle velocities occurred much earlier than expected, indicating an abnormally thin crust in the outer fore-arc (ESSEX I was only about 5 miles inshore from the shelf break). The morning was calm, but as the day progressed the weather deteriorated and we were pessimistic about Endurance's wanting to fire the second ESSEX line the same day. When the time came, however, Capt. Maclaren was willing to go ahead. ESSEX II was shorter, because we lacked the necessary explosives to shoot both to full range, and the final shot, the 25th, was of 100 lb fired at only 43 km. Again, and despite the worsening weather, the record quality appeared excellent. The line finished late on the 13th so the streamer was recovered only after breakfast on the 14th in more sheltered waters off southern Anvers I, prior to closing sufficiently with HMS Endurance for Malcolm Lonsdale and the recording equipment to be returned (again in bad weather) by helicopter.

After the transfer the ship headed east to the head of Flandres Bay, in an attempt to extend the marine gravity into the network of gravity measurements made onshore over several years by BAS. This done, the DMCS streamer was deployed overnight, some lead being removed en route. The guns were then streamed and the gun synchronisation system proved. A makeshift far-field hydrophone was constructed and an attempt made to make it swim directly beneath the guns (40m away) at 50 m depth. DMCS line 3 (the first real, long, 50m-shot-interval line) was then started; it ran through ESSEX lines I and II and off the shelf edge into deep water, ending once typical oceanic basement could be seen on the single channel monitor.

At about this stage the limitations of Discovery's after end became apparent. With a safe separation of streamer and the 4-gun array created, most of the width of the after end was in use: the far-field hydrophone, which was not very satisfactory in operation, could only be towed from the starboard quarter. The magnetometer could only be streamed on the port quarter where it was uncomfortably close to the seismic streamer. Because of the way that the ship drifted downwind in a crosswind and because the seismic streamer's great length gave it a longer memory of turns than those of the shorter wires, it was necessary to increase the separation between seismic gear and magnetometer, and to ensure that the magnetometer could be towed from either quarter. Moreover, the existing ship's booms could not be used, being so far forward that there was a risk of whatever was being towed from them tangling with the ship's propellor (as had happened on a previous cruise). It was decided to abandon the far field hydrophone to create space on the starboard quarter, and to rig an 8 foot boom on the port quarter, an arrangment which worked well thereafter.

Over the next 4 days (16-19 January) we shot 6 more seismic lines, mostly crossings of the shelf and margin in the 18 Ma, 6.5 Ma and 4 Ma collision zones, with pauses for bad weather or the threat thereof, for engine repairs, gun failure, alternator breakdown and SERCEL power failure. Also, these lines provided the density of cover in shallow water which brought home the value of the IOS sidescan sonar in the study of shelf glacial processes.

At the end of DMCS line 9 near ESSEX II, we recovered the seismic gear and headed northwest onto ocean floor of age 22 Ma for the first heatflow station. The weather worsened to a NE gale and we were hove to for 8 hours. On arrival at the nominal heatflow site we found the weather not yet good enough to start, so spent 10 hours on magnetic reconnaissance before returning to the site to take a preliminary (and for us practice) piston core. Penetration was poor, and the 3.5 kHz records unattractive, so we headed west for about 10 miles to a more favourable location.

A suite of 6 penetrations of the heatflow probe at the 22 Ma site was followed by a shift 60 nm inshore to a 19 Ma site close to the margin. After 7 penetrations at this site we moved to a region of hummocky topography close to the foot of the continental slope. This region and the (very steep) slope itself were considered important parts of the transect, but clearly it was not going to be easy to achieve successful measurements. The ship spent 16 hours among the hummocky topography and on the slope: a probe barrel was bent and there were heater problems. Of 10 attempted penetrations at 3 sites, only 2 were successful, and the attempt was finally abandoned in favour of measurements on the shelf. It was recognised that heat flow measurements on continental shelves are subject to disturbance from changing seawater temperatures and variable sedimentation, but as the Peninsular shelf is deep and the water temperature changes small, the attempt was thought worth the risk. From existing 3.5 kHz profiles, 2 sites were found near the southwest end of ESSEX I, a trough of depth 540 m and an adjacent bank of least depth 450 m. On the way to these sites the ship passed over the position (63°57'S 66°17'W) of a 70 m shoal reported by HMS Endurance (found by her on 12th January on her way to fire ESSEX test shots). The reported shoal lay very close to the shelf edge and we were interested in it as a potential dredge site, since the general depth at the shelf break is 300 to 500 metres. However, we found the reported position to lie offshore from the shelf break, in an area where the generally very steep slope is interrupted by a bench at about 580 metres. It seemed possible that, in a province where bottom echoes could easily be lost, the true depth could be 70m plus once around the duty cycle of an echo sounder.

Through most of 23rd January, the heatflow probe made several successful penetrations at firstly the bank site and then the basin site, with a pause between sites to straighten a bent bail (suspension eye) on the core head. In the late evening the DMCSAS was deployed for the start of line 10, a strike line northeastward along the shelf to connect all of the shelf-margin crossings shot so far. In worsening weather the line was ended early and the ship cut southeast of Smith I looking for a lee where the gear could be recovered. This done we ran a magnetics reconnaissance line offshore in the youngest (4 Ma) RC-T collision zone before starting to dredge.

All the dredge sites chosen lay on the generally steep, 045°-225° striking margin of the 4Ma collision zone. Seven sites were dredged over the next 48 hours. From 4 shallow sites (between 3000m and 1000m) we collected obviously in situ rocks, largely indurated volcanic conglomerates.

Such rocks probably form part of the seaward-dipping sequences found beneath the shelf edge on virtually every seismic profile. Three dredge sites below 3500 m, however, provided only unconsolidated sediment and obvious glacial dropstones. Thus the possibility of ophiolite obduction at RC-T collisions remains untested.

At the end of the dredge programme, we tried out the box corer in 700 m of water, in preparation for the next leg. The trial was not too successful, however; on the first lowering, the hydrostatic safety release pin did not shear so that the jaws failed to close, and on the second the no-load delay did not work because salt-water corrosion products had blocked a fine hole used to equalise pressure.

We then headed for the northern side of the S. Shetland Is, into West Hero Bay, for the start of a DMCS profile northwestward across the S. Shetland Is. shelf and margin. In this region, subduction stopped (or almost stopped) about 4Ma ago, well before the spreading centre had reached the trench: the age of ocean floor at the margin ranges from 13 Ma to 23 Ma. This margin therefore provides a useful example of how the Antarctic Peninsula margin farther to the south-west would have looked a little time before RC-T collision.

The seismic line (line 12) was shot in worsening weather, and parts of its NW (oceanic) end may not be worth processing, because of degradation in the quality, repeatability, and regular spacing of the seismic records resulting from rapid fluctuations in ship speed. However, the contrast in the nature of the margin between this and other profiles (even on the single-channel monitor record) is startling. The entire lower fore-arc seen on the South Shetland profile is missing farther south. It provides convincing support for the notion of tectonic erosion.

After recovering the DMCS streamer and air guns in the forenoon of 29 January, the ship headed (via a FCO waypoint) for Bahia Cook to pick up a Chilean pilot to help the ship navigate 220 scenic miles of the Patagonian Channels to Punta Arenas. Streamed gear was recovered outside the 12 mile limit on 31 January and only the gravimeter (for a gravity tie in Punta Arenas) and the bridge navigational echo sounder were kept running. The ship tied up alongside at Punta Arenas at about 8 a.m. on 1 February.

In Punta Arenas we took on fuel, water and fresh provisions, and took a look around southernmost South America. More startling to those who stayed, was the change over of virtually half the ship's company: all officers except Marc Taperell, all RVS technicians, the heatflow team and all but Colin Woodley from IOS had gone and been replaced. In particular, we welcomed the new heat flow team Larry Lawver from UT Austin and Bruno Della Vedova from the Oceanographic Institute at Trieste. The handover was brief, and made briefer by our being directed out to anchor on the second day, to allow the recovery of a crane which had gone for a swim while servicing the ship ahead of us. As a result of this also, we had only a brief meeting with Dr. J.B. Anderson of Rice University, Texas, who had been coring along the Antarctic Peninsula and on the western South Orkney block aboard USCGS Glacier.

Leg 3

The plan for the entire cruise had left undecided the order in which the two principal remaining investigations should be tackled, to be resolved nearer the time on the basis of satellite ice reports. While in December the Weddell Sea had been quite full of ice, January's reports had shown a quite rapid retreat of the ice edge, so that both field areas (northern/central Weddell Sea and southern S. Sandwich arc and trench) were ice-free by the time the ship left Punta Arenas. Lest ice advance at the end of the season be unusually early, it was decided to work in the Weddell Sea in Leg 3 and in the more northerly South Sandwich area in Leg 4.

The main task of Leg 3 was thus the investigation of Weddell Sea sediments. We planned a DMCS and 3.5 kHz profile southeastward from the northern margin (somewhere south of the South Orkney Is to avoid the fracture zone topography which dominates the Weddell Sea floor farther east) followed by a coring programme back northwestward along it. This transect would therefore run from the edge to the centre of the Weddell gyre and the cores would be expected to sample sediments laid down under a range of bottom current speeds. Previous studies farther south had shown that there the dominant mode of deposition was from turbidity currents, so we wanted in addition to run a cross line, in a NE-SW direction, to sample the expected proximal (S and SW) to distal (NE) range of turbidite deposition. We thought we would achieve about 20 core stations with a box core and a piston core at each, which meant an approximate 60 km to 100 km average core spacing, although the actual core distribution, and the position of the cross line, would be decided only after an initial profile had been acquired. The ship sailed from Punta Arenas at 2 p.m. on 4th February (day 035) after a series of small delays through the morning. We reached the Pacific through the Patagonian Channels by the same route as on the inward journey, slightly delayed by strong winds and poor visibility. The PES, 3.5 kHz and magnetometer fish were streamed outside the 12 mile limit on the afternoon of 5 February (036) and parallel passage to the way in continued to 59°15'S. From there we ran southeast to the South Shetland margin, avoiding fracture zones to obtain an uninterrupted magnetic profile. The ice reports were by now suggesting a quite abnormal freedom from ice in the northern Weddell Sea, so it was decided to route passage to the southern S. Orkney block via the northeastern end of the Antarctic Peninsula to take advantage of the rare chance to run a DMCS line across it. That having been decided, it was clearly useful also to stream the DMCS gear before the South Shetland trench was reached, to obtain a second crossing of the fore-arc to augment the one obtained at the end of Leg 2. Streamer and guns were deployed on 7th January at about 61°S, for Line 13. This line did not delay the ship very much, since the next 24 hours were largely foggy, which would have reduced her speed anyway.

A burst airline ended line 13 on 8 February (039), but repairs were made in time for the start of line 14, which crossed Bransfield Strait and the shelf northeast of the Antarctic Peninsula. We encountered intermittent fog for much of this line also, but no ice except for one or two grounded bergs where our track grazed the 100 fm line. Towards the end of the line, as we were running into deeper water, the 300 cu inch gun hose split, which left us underpowered and perhaps therefore unable to detect oceanic basement. The line was ended on the morning of 10 February (041) when stringers of pack ice were encountered. As recovery started the gun drogue was found to be wrapped around the streamer tow cable, possibly as a result of the recent course alteration: both were recovered slowly together and some superficial damage to the tow cable was repaired. After all had been recovered we tried a box core, in about 3000 m of water. The first attempt failed, because the hydrostatic shear pin did not shear: the second attempt, without a shear pin, succeeded in recovering 0.5 m of mud. The ship then headed ENE at best speed for the southern margin of the South Orkney block. While deploying the DMCS streamer in preparation for the long southeastward line into the Weddell Sea, we removed one pound of lead from most active sections to allow for a further reduction in seawater temperature, compared with the western Antarctic Peninsula shelf. DMCS line 15 started in the basin at about 3500 m depth, south of the South Orkney block, soon stepping down to about 4300 m onto Weddell Seafloor "proper". The line was about 450 miles long, took more than 3 days to complete and ended at 68°12'S, a farthest south for the ship. the weather was good and the seismic record quality excellent. The 3.5kHz records, moreover, were perhaps the most interesting we had seen on the cruise, and the only difficulty appeared to be in deciding which coring opportunities to reject. Eventually we picked 15 sites, to study 3 aspects of Weddell Sea sedimentation.

Firstly, we chose to core the northern levee of a large complex channel close to the southern end of the line. Four more sites were chosen around 66°30'S to sample the full range of variability of the 3.5 kHz profile in what were thought would be distal turbidites. A further four were to be located near 64° 30'S to look at the effects of fracture zone topography on local sedimentation. A final six were devoted to the study of a hemipelagic drift-like feature with exceptional (up to 100 m) 3.5 kHz penetration and lying between 64°S and 64°30'S, in the hope of seeing Antarctic Bottom Water effects. Actual events over the next few days are described in detail to convey the flavour of Weddell Sea coring.

We started station 004 with a box corer deployment late on 15 February (046). On recovery the box corer had not released because an end screw on the no-load damper had been over-tightened and had closed off the bleed channel. The piston corer was lowered next: we tried 2 barrels and recovered 4m. Then, early on 16 February, we got underway for the next site, 13 hours away, but the weather worsened and we were hove to for about 10 hours. On arrival on site, on the morning of 17th February (048) we found the weather still too bad to core, but seemingly improving. We undertook a small 3.5 kHz survey, but the weather did not improve sufficiently to permit coring until about 8 p.m. Piston core 005 recovered only 1.6 m, and came back bent: over-ambition in marginal weather perhaps, but we had no guarantee that the average weather conditions would be better. The

Weddell Sea is no place to be coring from that part of a ship which moves up and down the most.

The need to crop the wire and straighten a barrel slightly delayed deployment of the next piston core (006), at a site nearby. On the first lowering, the pyro release would not switch on, on command. The pinger command card was changed with the corer at the rail, and the attempt to core repeated: this time, it worked. We got 4m of core and another bent barrel.

The next core (007) was located close to the site of PC005 in an effort to improve recovery, which it did, to 6m. It was followed by a deployment of the box corer, which eventually was found to have pre-triggered, having been towed around for some hours while the ship regained the position of the piston core. The box core lowering was therefore repeated but failed to trigger because too long a screw in the drain hole of the no-load delay device had clamped the piston. We gave up and headed for the next site (008). Here, early on the 20th February (051), a piston corer lowering recovered only a trigger core sample and a piston core catcher sample: the pyro had failed to fire despite a clear response signal from the release transducer. We moved to the next site, which however we could not occupy for an iceberg and growlers. At another site nearby we recovered more than 6m of piston core (009), after problems with deck hydraulics and the release command housing.

So far, at every piston core lowering, more of the barrel had been muddy on the outside than there was core on the inside. There was much discussion on the correct length of the wire running from the trigger arm to the piston, to ensure that the piston stayed at the seabed as the corer descended (give or take up to 6m vertical motion of the after end, in 10 seconds or less at times). It seemed clear however that the wire was too short, and accordingly it was lengthened, generally to book value plus 5 feet. Core recovery increased forthwith, but also the weather improved slightly!

By now, having decided at the start of coring that the cross line could not be located until a few cores had been collected, we were concerned to complete the coring plan for the existing line, since core stations were taking much longer than planned, because of repeats, box core failures and bad weather. We decided to make fewer attempts with the box corer, and to move on to the second topic, of seamount/fracture zone effects. Accordingly, at about noon on 21st February (day 052, 5½ days after coring had started) we got underway for the area around 64°30'S, where we had originally crossed two elevations thought to be fracture zones. On returning there, further survey showed that one was a fracture zone and the other probably an isolated seamount. The 3.5kHz records provided very clear guidance as to where we might be able to sample proximal and distal facies of debris flows/turbidites from the seamount, and where, on the edge of the sediment drift to the north, these effects might disappear. We tackled this problem fairly successfully over the next four days (21-25th February, days 052 to 056), with the same mixture of good and bad weather (the latter spent in reconnaissance survey), a fruitless box corer deployment, unpredictable drift, pre-triggering and bent barrels, but with the additional ingredients of 8 to 11 m cores, a seamount dredge, and the loss of one core head and 3 barrels. This last happened on core station 013 on 25th February (056): the corer pre-triggered, within a minute of the pyro release having fired, with the pilot core head still 44m above bottom. The wire parted at the base of the clamp on the trigger head, so that the trigger arm, release pinger and trigger corer were all recovered. There was no obvious explanation for what happened.

We next collected 2 long piston cores (014 and 015) on the southern margin and in the middle of the hemipelagic drift which floors the northernmost Weddell Sea in this area. On the next (016) near the northern margin, the core again pre-triggered shortly after the acoustic release had fired. This time, fortunately, the wire did not part, but the pyro release pinger appears to have slid right out of its clamps, when the wire rebounded as the core weight came off it, and was left behind on the seabed. After this had happened, because the only sign aboard ship was a spike on the dynamometer trace which may have had other causes, the corer was lowered gently onto the seabed and raised again, acquiring a trigger core and very short pseudo- gravity core.

Since our second pyro release housing had leaked earlier , we now had the choice of continuing coring either with a piston corer totally unprotected against pre-triggering, or using the same head and barrels as a gravity corer. Choosing the latter, we tried GC017 close to PC016 on 27th February (058), recovering 2.8 metres and bending 2 barrels. The ship next headed southeast for 2 cores close together on a local (basement-controlled) rise within the drift, but bad weather set in, with the barometer down to 950 mb and a full gale blowing. It was decided to abandon Weddell Sea coring for this leg, to allow time for the ODP site survey of the southeastern South Orkney block to be completed.

The bad weather continued, and DMCS gear could not be streamed until 2 March (061). This was a long day of problems with streamer and airguns, so that DMCS line 16 only started about 14 hours after the start of deployment, and even then without the 20 cu inch gun. The line ran southward close to the axis of a sedimentary basin known from older single-channel data, and ended at the southern margin. Line 17 started only after another 14 hour gap, which involved gun repairs, a major fault on the Sercel, and some uncertainty finally about the suitability of the weather for DMCS work. The line intersected line 16, running first east and then south towards the 3 provisional drilling sites. However, the gun drogue and streamer tangled, as had happened on 10th February: as then, damage was very minor, but on recovering the guns some damage from other causes was discovered, so there was a 6 hour delay before shooting continued, again heading south through the drill sites on line 18, with an overlap to line 17 at the start.

The DMCS line ended on 5th March (064) and the ship headed virtually directly for Grytviken, a 2½ day passage. The last few days had seen a considerable effort by the mechanical engineers in streaming, recovering and repairing the airgun array under extremely difficult conditions, and it was not certain just how fit the array now was for any further work. After some discussion it was decided to use the passage to and from Grytviken to re-rig the array completely: the gun umbilical and towing chain were stripped right down and rebuilt, fortunately in reasonable weather. the design was slightly different to permit free interchange of guns should a particular airline or trigger lead fail, and to make handling over the stern easier.

The coring gear was also limping rather, and it was decided to straighten and shorten as many barrels as possible in order to be able to carry out a minimal gravity coring programme as necessary on the final leg (the coring component of the S. Orkney ODP site surveys had not yet been attempted, because of delays with the DMCS profiling component).

The ship arrived at King Edward Cove at 11 a.m. on 8th March (067) having earlier that morning responded to a BAS request to check on an incommunicado field party in St. Andrews Bay. We took on 133 tons of fuel at KEP, less than we expected, or wanted, but all we could have since the last tanker to visit had been unable to discharge because of bad weather. We shifted to the Grytviken whaling station on 9th March for water and stayed there. A surprisingly large number of people took advantage of the opportunity to stretch their legs and get away from the ship. The army were detached but friendly, although a proposed

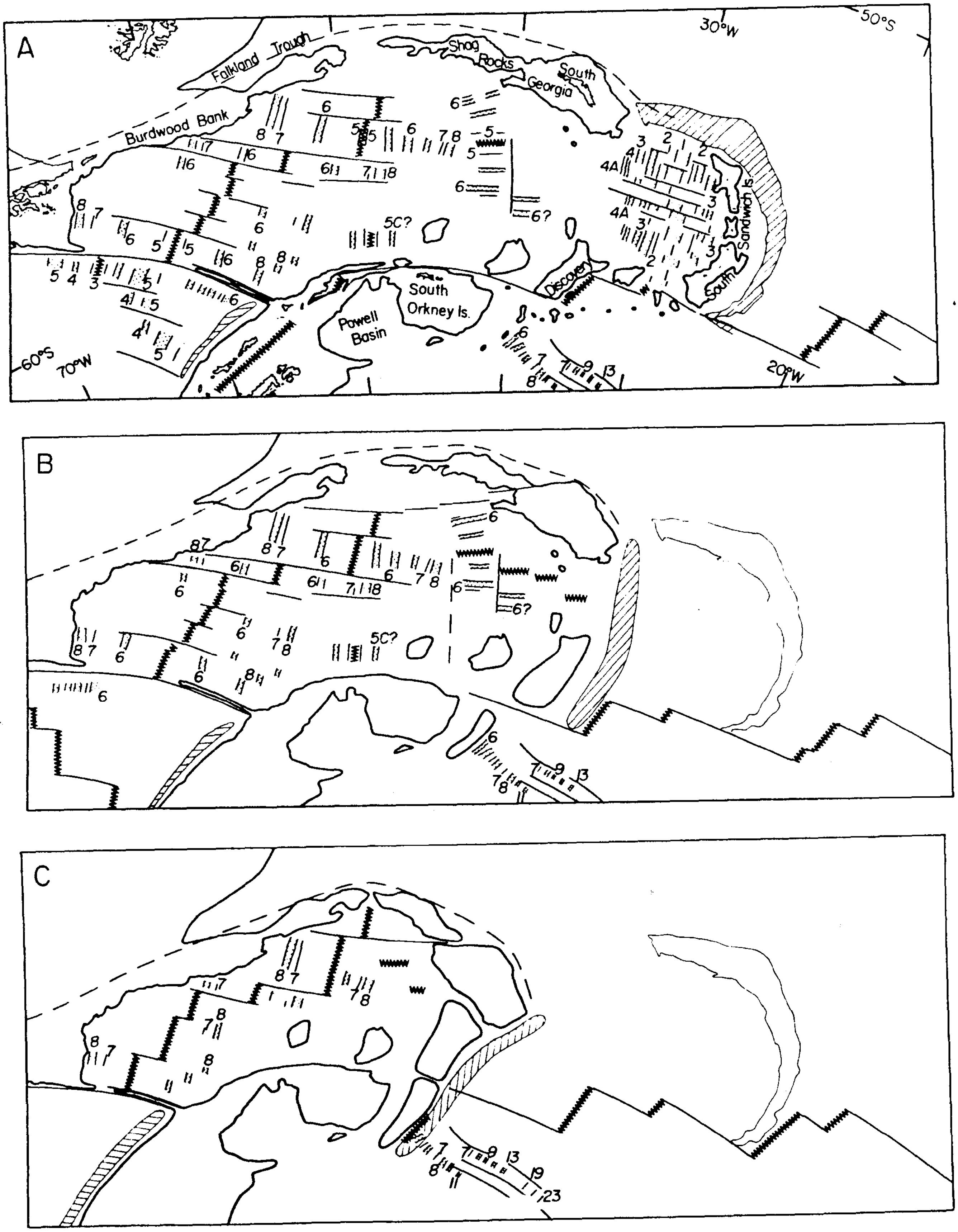


Fig. 3. The S. Scotia Ridge has seen a series of collisions between ridge crest sections of the SAM-ANT plate boundary and ancestors of the South Sandwich trench. The situations now, 10Ma and 20Ma ago are shown. If present motions persist, another collision will take place 5 Ma from now.

football match was cancelled because "the ball had been packed" - a relief being imminent.

Leg 4

Sailing from Grytviken was delayed until 1530 on 10th March (069) in the hope of receiving mail via the Sir Percivale which docked at KEP about 1330. (The paucity of mail on arrival at South Georgia had been remarked upon by the ship's company). The ship headed east out of Cumberland Bay, then SSE for the southern end of the South Sandwich Island arc on clearing South Georgia early on 11th March (070).

Most of Leg 4 was to be devoted to reconnaissance survey of an intra-oceanic ridge crest-trench collision in an area directly south of the present South Sandwich arc and fore-arc. We had speculated originally that in the past the slowly east-west-spreading ridge forming the South America-Antarctic plate boundary east of the S. Sandwich arc (Figure 3) had been longer, extending much farther west in the northern Weddell Sea. It had been shortened by collisions with ancestors of the east-moving Sandwich plate. In pursuit of this speculation, our 1980-81 Shackleton cruise had looked for and found a 20 Ma-old ridge crest-trench collision at Jane Bank, east of the S. Orkney block. Our attempts to study collision processes there, however, had been hampered by 20 Ma of subsequent sedimentation. It seemed inherently more promising to study as young an example as possible, and the youngest had to lie directly south of the present South Sandwich fracture zone and somewhere off the southern end of the present South Sandwich arc. Very little was known of this region, so the objectives of leg 4 were really 2-stage: firstly, to map the area and secondly to describe and understand the characteristics of the collision zone which must lie within it. We had originally been offered GLORIA, which would have been an ideal reconnaissance tool, but that offer was later withdrawn. We proposed to undertake fast magnetic and bathymetric survey initially (single-channel seismics in this area was not feasible with the gear available on board), switching to DMCS profiling of the intact S. Sandwich arc and fore-arc (as a reference line) as soon as weather permitted, and dredging similarly in weather windows and as soon as critical sites were recognized. Within the survey area we could hope to recognize fragments of back-arc, fore-arc and ocean floor, although not perhaps immediately since onshore geochemical analysis of dredge hauls was likely to be important in diagnosis.

The other components of the leg were to be a heatflow programme and further coring. As for the Antarctic Peninsula margin, the delay necessary before any heat impulse injected at the base of the crust by RC-T collision would have propagated to the seabed argued against heatflow measurements in a very young collision zone. In addition the rough topography and absence of sediments in the young collision zone made a thorough heatflow study there impracticable. It was decided to concentrate the heatflow measurements in the region of the 20 Ma-old collision, east of the South Orkney block, where also the coring component of the ODP site survey remained to be done.

The ship reached the South Sandwich survey area on the afternoon of 12th March (071) and, since the weather was calm ('though foggy intermittently), the DMCS gear was streamed for a profile eastward at 60°S across the intact back-arc, arc and fore-arc, to serve as a reference profile for subsequent work in the collision zone. As the guns were being streamed an airline blew on deck at foot level, at about 600 psi air pressure (perhaps because of knife damage during the stripping of a few days previously). An additional new airline was taped on to the umbilical and the seismic line commenced finally early on 13th (072). Later that morning the gun array was partly recovered to check the 160 cu inch gun, then restreamed, and the line continued to the next morning. Then, because the weather appeared to be worsening, the DMCS gear was recovered rather than a second reference line being shot. Three leaks in the streamer were taped, but one section contained much seawater and would be replaced on the next deployment. Reconnaissance gravity and magnetic survey of the collision zone started with a long E-W line.

Reconnaissance continued for the next four days to map the bathymetric grain (largely east-west) and to look for oceanic magnetic anomalies (subdued and not obvious), for heat flow sites (very sparse sediments) and for dredge sites (plentiful). Late on 18th March (077) we headed back onto the intact S. Sandwich fore-arc to a position on the DMCS reference line to undertake a trial/reference heatflow measurement. This ended on only the fourth penetration when the probe broke at the joint between the two 3-metre sections: the ship moved back into the collision zone to the first dredge station (D107). Most of the steep, clean scarps we had found were oriented approximately east-west and probably were either an original oceanic fracture zone lineation or the result of strike-slip detachment of the collided arc and fore-arc from the surviving S. Sandwich arc and fore-arc, or related dissection. Shorter scarps were more likely to have been older and were generally more difficult to dredge.

After 4 dredge stations, 3 of which yielded obvious in situ rocks, the weather became too rough for anything other than more reconnaissance magnetic survey. On 21st March (080), after a day of survey, we dredged up the downwind (NE) flank of a shallow (280 m) seamount on the very southern margin of the existing S. Sandwich arc. In improving weather we then headed for a second, even shoaler volcanic peak originally crossed by Bransfield in 1979, which we mapped and successfully dredged. The least measured depth on this feature, which continues precisely the curve of the present subaerial volcanic arc, was 85m. Having crossed what appeared to be a crater on the approach line, we deployed the sidescan and launched an XBT on a cross-track after dredging, but without much success: the temperature profile was probably unreliable after the XBT hit the seabed, although the temperature did increase, and the sidescan picture, in marginal weather, showed nothing obviously crater-like.

One more dredge station on 22nd March (081) was followed by DMCSAS deployment, starting from a tie with the earlier reference profile on the intact fore-arc near the heatflow station. Over the next 35 hours the ship zig-zagged across the collision zone, to examine the acoustic character of the various topographic elements mapped previously. Very little or no penetration of the seabed could be seen on the single channel monitor record. Certain sections of these profiles should be processed before pronouncing a final verdict, but it is not obvious at present that large areas of well-sedimented fore-arc survive within the collision zone, unless uplift and erosion have changed their character.

Following DMCSAS recovery, three more dredge sites were occupied in the western part of the collision zone, which was originally thought to be back-arc but which was anomalously non-magnetic. The more elevated dredge sites from this region yielded volcanic pebble conglomerates, but whether from back-arc or fore-arc is at present uncertain. These dredge stations completed the collision zone reconnaissance. The region had proved rather more complicated than we had expected, being unlike the 20 Ma-old Jane Bank collision zone, with no obvious oceanic magnetic lineations, no prominent palaeo-trench and no thick penetrable sedimentary sequences. The key probably lies in the dredge hauls, nearly all of which contain clearly in situ rocks, but since the arc, colliding oceanic ridge and back-arc could all yield basalts largely indistinguishable in hand specimen or thin section, XRF geochemical analysis (using the Birmingham machine) will be needed to make further progress.

The ship left the survey area early on March 25th (084) heading west for the Jane Basin to start a heatflow transect. Drs. Lawver and Della Vedova had decided to concentrate on Jane Basin because heatflow measurements in back-arc basins are scarce. Additionally, it was hoped to extend the transect eastward onto Jane Bank, the palaeo-arc, and westward onto the remnant arc of the eastern South Orkney block. Measurements commenced on 26 th March (085) along an E-W Bransfield 801 single-channel seismic profile at about 61°50'S. The first two transects, involving 22 penetrations, covered the central and eastern Jane Basin. The third and fourth in the western basin were offset southward to 62°10'S: the third was terminated prematurely by the loss of the lower half of the probe, so that the fourth, after running repairs,used only a 3m probe. Late on 29th March (085) the fourth transect ended, to be followed by the first of three gravity core stations (GC018, 019,020), on the tentative locations of ODP drill sites W6, W7 and W8, in 3000 m, 1250 m and 700 m of water respectively.

The end of the final leg was now not far off. It was decided to spend the remaining time trying to extend and enhance the main, 61°50'S heatflow traverse of central and western Jane Basin. We would firstly core the western margin (i.e. eastern S. Orkney block) to see if it was suitable for heat flow penetrations then (quickly, in daylight) cross Jane Basin and make heatflow measurements on Jane Bank overnight. We would then core back across the basin and, if time remained and the sediments were suitable, make heatflow measurements back up the S. Orkney block margin.

The first part of this program went according to plan : the ODP sites were cored within a day, and 4 other cores obtained (not without bending barrels 'though) on an EW line down the S. Orkney margin by early morning on 31st March (090). The run from there across to Jane Bank took longer than planned because of an easterly head wind. There was no clear alternative to this passage, however, because sediments on the South Orkney margin were sandy, and thus unlikely to allow reliable heatflow probe penetration. On arrival at Jane Bank, the 3.5 kHz records suggested a hard seabed there also, so some time was spent finding a more promising site. Even so, the first penetration was only partial and it seems that the slack wire coiled neatly in a hitch around the protruding probe, because on pullout some thermistors were damaged and the probe came to the rail tangled and upside down. After some deliberation it was decided to use the remaining time (concurrently being reduced by revised bridge estimates of the time needed to reach Montevideo on schedule) to obtain 3 cores back across Jane Basin. These were collected without mishap, and at 8 pm on 1st April (091) the final core came inboard and the ship headed for Montevideo.

A ship track towards Montevideo was chosen which filled in a few gaps in our knowledge of the Scotia Sea, crossed the deepest section of the N Scotia Ridge and offered the chance of assessing the 3.5 kHz echo character of several provinces of the Scotia Sea and Falkland Plateau. Data acquisition (apart from XBT launches) would stop at 48°S. The weather was calm for two days, but on 4th April (094) a force 9-10 northerly gale slowed the ship to 2 kts. However, a 20° course alteration off the wind permitted an increase to 5kts, and the ship was able to recover her exact course as the weather improved. 48°S was crossed on 6th April (096). On 8th April the DMCS streamer was deployed so that oil could be drained from each section as a protection against over-expansion on the drum on passage through the tropics and as a step towards balancing for the next cruise. The ship arrived in Montevideo early on 11th April, a day ahead of schedule. An attempt to occupy the gravity base station in the Port area at Montevideo (the last base station occupied had been Punta Arenas) failed because of military intervention, and the RVS technicians involved were nearly arrested. It will be necessary to try again, we hope more successfully, when the ship returns to Glasgow on 12th May.

CRUISE STATISTICS

a.	Cruise length, Gibraltar to Montevideo	123.6	days
	time in port or at anchor	7.7	days
	time on passage, no Birmingham/BAS acquisition (i.e. N of 48°S, Chilean channels etc)	27.8	days
b.	Working time, passage plus survey plus stations	88.1	days
	distance steamed, all cruise 18,850 miles		
	distance steamed, working 11,590 miles		
c.	total bathymetry time (PES, 3.5 kHz inc. stns)	87.7	days
	underway bathymetry time	65.0	
	underway gravity time	65.0	
	total magnetics time	56.1	days
	" DMCS time	16.3	days
	" " distance 3,770 km		
	" single-channel time	2.8	days
	" sidescan sonar time	17.9	days
	ESSEX shooting time	0.3	days
d.	time hove to or at anchor for weather	2.0	
e.	total station time	20.7	
	coring time	9.8	
	no. of stns. 28		
	dredging time	4.7	
	no. of stns. 19		
	heatflow time	6.2	
	no of stns. /transects 84/13		
	XBT launches	169	

Notes: 1. magnetics time is less than underway bathymetry and gravity time mainly because there were short periods of steaming between dredge or core stations (not included in station time) where it was not worthwhile streaming the magnetometer (or where we already had magnetic data), but also because for two days during Leg 2 it was not possible to stream the magnetometer while the DMCSAS was deployed.

2. The average underway speed, while we were working, was 7.4 kts. The reduction from the nominal 10kt 2-engine cruising speed was caused by:

(a) 5.0 to 5.5 kt DMCS profiling
(b) 8kt single-channel seismic profiling
(c) DMCS streaming and recovery at 0 - 5kts
(d) 5 kt steaming during the hours of darkness while south of the Antarctic Convergence (RVS regulation).

We <u>were</u> south of the Convergence for virtually all of the working part of Legs 2,3 and 4, and darkness varied between 4 and 11 hours. We tried where possible, however, to be on station or on a DMCS profile during darkness, to minimise the loss of profile which this caused.

5 EQUIPMENT PERFORMANCE

(A) MULTICHANNEL SEISMIC SYSTEM

Cruise 154 was the first time the NERC's Sercel 358 system had been used to collect multichannel seismic data, excepting the two tapes recorded on DMCSAS trials. The first leg of the cruise down to the Antarctic and a portion of the second leg were devoted to ironing out many of the problems which came to light during trials.

The seismic system has three components (a) the Sercel 358 and peripheral instrumentation located in the Plot; (b) the streamer and depth control system; (c) the airguns and compressors. The performance of each component is discussed below and a few improvements are suggested.

(a) Sercel 358 and Peripheral Instrumentation

(a) (i) Sercel SN358 Digital Seismic Recording Instrument

The Sercel was found to be unusually reliable for a new piece of equipment. A number of faults did occur and these had two sources.
Instrument Faults: These included two power supply failures and several tape transport problems. The power supply failures were unrelated and were repaired by RVS technicians. The fault with the tape transport was intermittent and grew progressively worse during the second leg. It usually started with an H32 inhibit and attempts to restart the system brought up a collection of inhibits until the system froze. It was found that by powering down and restarting the Sercel the fault would disappear. This however was an unsatisfactory solution as twenty or more shots were lost on each failure. At the start of the third leg fans were incorporated into the tape deck boxes as it was felt the problem was heat-related. At the same time a chip was replaced on the tape control board in the logic unit. After these measures had been taken, there were no more tape transport failures due to instrument faults.
Operator Error: About 90% of the inhibits were caused by operator error. These usually took the form of a H32 inhibit (data not read by read processor) caused by either failing to reload the tape deck or leaving the flap above the tape heads up. Recovery was sometimes possible by pressing RESET. Otherwise Mode 44 was used to rewrite a burst. The other common error was a H19 ("stickers found") inhibit caused by trying to write too many records on the occasional short tape. The recovery procedure for this error depended on which tape transport the offending tape was on. If it was on deck 'A' it was necessary to rewrite the burst on the new tape using Mode 44. However, if

the tape was on deck 'B' recovery was possible by just pressing RESET.

Overscaling on the Auxiliary Input: It was found that significant overscaling of the signal on the auxiliary channels caused glitches to appear on the record. The gain on these channels was controlled by presetting the auxiliary gain in the Sercel Header (Mode 00) and/or by adjusting a variable resistor on the input to the Sercel auxiliary channels.

Recommendations:

Excessive data loss was often a result of not observing an inhibit on the Sercel display panel when it first occurred. It would be a good idea to have an audio warning, like the 'no burst status' bleeper, when an error inhibit appears.

The air conditioning system in the plot on Discovery was inadequate. The solution on this cruise was to leave the doors of the Forward Rough Laboratory open. The Sercel, particularly the tape transport, performs better in an airconditioned environment. So if it is possible, an airconditioning system similar to that in the Computer Room should be set up.

(ii) BBC Extended Header Program

The BBC Extended Header Program was written and interfaced with the Sercel on the way down to the Antarctic during leg one. [Appendix 2 gives a users' guide to the program.] The extended header provides a complementary set of recording parameters and an incrementing Position Number as well as the ship's time. Thus if for some reason the Sercel did not record a shot, then the Position Number would increment whilst the Sercel Record Number would remain the same. The BBC Position Number was found to be unreliable. It occasionally incremented by more than one per shot, thus jumping ahead of the Sercel Record Number. The number of these spurious events increased as the cruise progressed, so that during the recording of the last multichannel lines on leg four, the Position Number was jumping ahead at least once per tape. On analysis of some of the Headers on the recorded tapes, using the MCDSAS Program on the ship's computer [Appendix 3], it was found that there were two causes for the Position Number jump. Firstly, a straight jump in Position Number was probably caused by electrical noise. Secondly, a jump in Position Number took place if the time between shots was greater than the set 'cycle' time. (eg: if the airguns were set to fire every 18 seconds from the Trigger Unit and the airguns fired at say 22 seconds then the Position Number would increase by two). The 'cycle' time, usually set at 17 or 18 seconds, in fact ranged between 10 and 36 seconds, although for 95% of the time, the set cycle time was observed. Another consequence of the

Position Number jumping was that it sometimes caused automatically triggered camera records to be skipped.

Recommendations:

The Position Number and cycle time should be made the most reliable feature of the recording system, as it enables the data to stack properly. Having a reliable Position Number will also reduce data processing time and hence costs.

(iii) Camera Records

The BBC extended header has an option to have a monitor record automatically played out every 'n' shots. Sometimes, as mentioned, the jumping Position Number affected this option. On a few occasions when a line was started or a value in the extended header was changed mid-line, this had the effect of causing a camera record to appear every shot. When this happened camera records were taken manually.

For 95% of the camera records fired automatically, the first two or three hundreds milliseconds of the record were missing, lost in the camera start up.

Recommendation:

It would be desirable if the camera could be started by the same pulse that starts the Sercel tape transport.

(iv) Water-break recording

On all D154 seismic lines the water-break hydrophone signal was recorded on auxiliary channel 3 on the Sercel. However, the recorded signal is modified by the anti-alias filter of the Sercel and therefore lacks resolution.

To determine an accurate value of water-break time the signal was patched through to the Aft Rough Lab. where it was compared to the gun solenoid firing pulses on a dual channel digital storage oscilloscope. It is recommended that this procedure be carried out at the beginning and end of every line while the ship is still travelling at survey speed. This will enable any inelastic stretch in the stretch sections to be detected.

In the long term it would be useful if an automated water-break monitoring system could be developed. This should measure the time offset between the key pulse and the time at which the water-break hydrophone signal exceeds a set theshold. BCD output should be made available for display in the Plot and for automatic entry into the BBC extended shot headers.

(b) Streamer and Depth Control Systems

On the whole the streamer functioned well and it was only towards the end of the cruise that electrical leakage or excessively noisy channels started to appear. Even then only two channels had electrical leakage and channel 13 was noisy due to salt water getting into that section. Over the entire cruise, only 2 active sections were changed.

(i) Emergency Stop of Seismic Winch

There are emergency stop buttons fitted within easy access of people deploying or recovering the streamer. These are of dubious value because they switch off the motor, which can only be restarted by the controls in the Winch Room. If someone became entangled in the streamer on the drum during recovery it would be more effective to wind him out quickly but gently from the Winch control position. Further, from the Winch control position on Discovery it is not possible to see where the streamer winds onto the winch. Better positions for the winch control would be directly aft, on either side of the platform.

(ii) Streamer Sleeve

As pointed out by Bruce Harrick, the SSL consultant, in his report on the DMCSAS trials, the streamer sleeve is too thin. A new leak appeared on the majority of times the streamer was used. These were generally easily patched and water intake into the streamer was minimal, except for section 7 which was replaced due to excessive sea water intake.

The sleeve on the adaptor section between the spring sections and the lead-in cable was unsuitable for the cold conditions encountered. It was made from PVC, which becomes brittle at low temperatures. The sleeve cracked early in the cruise and there was no spare on board. Fortunately an adaptor was fashioned from a segment of Neoprene firehose and proved more than adequate.

(iii) Streamer Buoyancy

Three days of data acquisition were lost as a result of having to balance the streamer. The oil used in the streamer (Isopar L) has a volume coefficient of thermal expansion (0.00072) four times that of water. Isopar L is not one of the 2 streamer oils recommended by the manufacturer, but was recommended by Kalamos in view of its ready availability in Europe. The coefficients for all paraffins are high however so there is no question of the oil being an unfortunate choice in this respect. We were able to show, using oceanographic tables, that the buoyancy tables in the Teledyne manual took no account whatever of temperature changes in streamer oil density.

This problem was overcome in a gross sense (that is to the extent that 6 depth sections over 2400m of streamer could monitor the balance) after it had been correctly diagnosed. However it was ascertained that the streamer sections had been filled originally outside on the grass at Barry, over a series of hot days in August. Approximately the same volume of oil was put into each, but at what temperature? Also, several sections are noted in the filling log as having leaking valves, presumably a result of thermal expansion after filling. It is clear that the streamer balance can only be approximate until the sections are emptied and refilled.

Recommendation: When the opportunity arises all the oil should be drained out of the sections and they should be refilled at a controlled temperature. At the same time a "streamer log book" should be established in which a record is kept of the filling, bleeding, weighting and repair history of each section. For reskinning, a thicker skin should be used.

(iv) Birds

Once the streamer was properly balanced, the birds were successful in raising and lowering the streamer, within limits. However, for work of a reconnaissance nature, where the ship moves between different areas on the same cruise, a precise balance will often not be achieved. This means that the birds have to be overdriven to achieve correct depths, and that towing speeds are constrained. Additional birds should accompany any additional depth sections incorporated (see above). The recommended life of the bird batteries was fifty operations. This is worth remembering if the streamer is deployed for a significant length of time.

(v) Tail Buoy

The purpose built aluminium tail buoy was pulled down and crushed at depth, during recovery after the first Antarctic deployment (see buoyancy discussion). For the remainder of the time a large plastic buoy without a radar reflector had to suffice. We think a tail buoy made out of scaffolding and polystrene, similar to ones used by the commercial companies, which is robust enough to be thrown off the ship, would suit the purpose better than an expensive aluminium one built from flotation tanks. A radar reflector is highly desirable, since it permits measurement of "feather" and provides an assurance that the tail buoy survives.

(vi) Streaming the Magnetometer when the Streamer is Deployed

The optimum position for streaming the magnetometer when the streamer was out depended on the wind direction and was usually the windward side. A boom was rigged on the port side which made deployment and recovery of the magnetometer very simple. Deploying the magnetometer on the port side also had the advantage that it was further away from the airguns. On a few occasions the magnetometer drifted near or wrapped around the streamer, resulting in interference with the magnetometer signal.

****

XBT # 88 T- 7 PROBE

TIME 12:00 Z DAY 44

LAT: 64 DEG 52 MIN 30 SEC (S)

LON: 38 DEG 26 MIN 30 SEC (W)

TAPE FILE NAME 788P

****

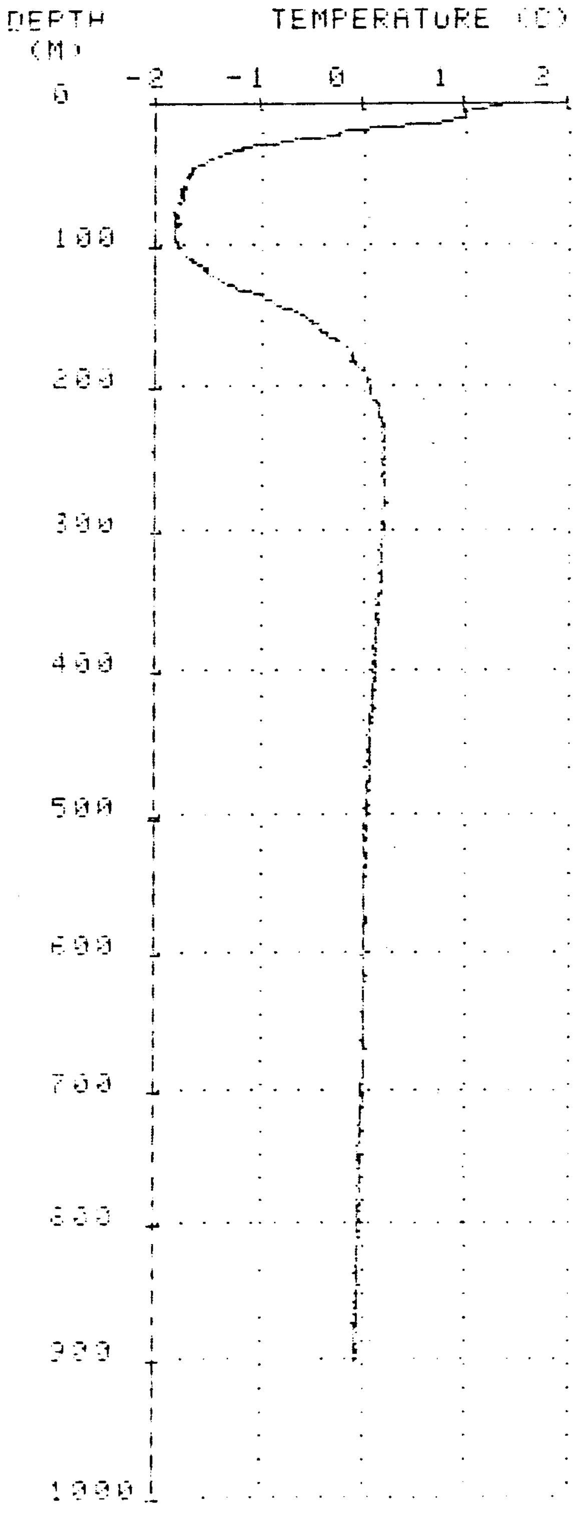


Fig. 4. This XBT profile shows a sharp temperature drop at shallow depth, typical of Antarctic waters. Even after the streamer was balanced for towing at 30ft at 5 kts, it could sink during recovery (slow speed, bird weight). Then it would cool, grow denser and tend to continue to sink.

(vii) Stretch Sections

Accurate measurement of the water-break time compared to measured lengths on the streamer suggested that, at 5kts, the three 50m stretch sections at the front of the streamer stretched by 10-12%.

(c) Airguns and Compressors

The source part of the multichannel system is the area where improvements will have to be made. Most of the problems with the airguns were due to the poor provision of lifting equipment and lack of after deck space on Discovery. We had a selection of airguns to choose from. The majority of lines used 4 guns, of chamber sizes 20, 40, 160 and 300 cu inch. An array of guns including the 1000 cu in (1220 cu inch total) would only be fired on a 17 or 18 second cycle at reasonable pressures if all 4 compressors on board were running simultaneously, so that the seismic line would be at the mercy of a compressor malfunction. A 1000 cu in chamber and an array of smaller guns were used successfully on the first two short lines on D154, but at the expense of longer cycle times (~27 seconds) and reduced fold of cover (to 16).

(i) Compressors

There were four compressors on board, two located in the winch room and two in a container secured on the main deck. For an array of airguns whose total capacity was 520 cubic inches the two compressors in the winch room were capable of supplying air for a firing rate of 18 seconds. However, to maintain a steady firing pressure three compressors were run, since the installed compressors time-dumped. The compressors performed reasonably well throughout the cruise, with those in the winch room being the more reliable.

(ii) Airguns

Gun Deployment: The method used to deploy the guns was unsatisfactory. A team of people were required to manoeuvre the umbilical (the name given to the airhoses and trigger leads), and the Hiab on the crane davit was used to lift the guns over the side. This often resulted in kinking and scuffing of the airhoses, and the bigger guns often swung and struck the edge of the deck when they were lifted over the side. Once deployed, the drogue occasionally became entangled with the streamer. These tangles were sorted out by hauling in the streamer and the guns simultaneously until the drogue could be reached from the poop deck and disentangled. The lead-in was slightly damaged by the drogue wires on one of these occasions, and afterwards the vulnerable area was bandaged with a thick layer of sea tape for protection. Perhaps the possibility of using buoys to support the gun array and dispensing with the drogue should be investigated further. More importantly, however, if the gun array is going to grow, as seems likely (the present source is the weakest part of the system) then some kind of deck rig to assist deployment and recovery will have to be produced. The industry has invented several solutions to this problem, which RVS should investigate. Unlike industry rigs, however, this rig should be removable, since it would otherwise occupy too much prime after deck space during cruises where it was not needed. Nor should its use be confined to one ship.

Airgun Umbilical: The airhoses and trigger leads were taped together. There was little protection from wear caused by repeatedly striking the chain and airguns and suffering their blast. When a leak occurred this arrangement made it difficult to repair. A strong plastic sleeve housing for the air-hoses and trigger leads would give them some protection and make repair easier. When not in use the umbilical was left lying along the shelter deck. It would be better to store the umbilical on a drum similar to the streamer. This would make deployment easier and prevent kinking. It would also help prevent damage if the airguns were strung from a boom.

Gun Synchronization: It was often only possible to synchronize the 300 and 160 cubic inch guns to ± 3ms as the firing instant (detected by the gun solenoids) drifted and/or jumped. The 20 and 40 cubic inch guns could be fired to within ± 0.5ms. Sometimes the guns mistriggered or suffered from multiple triggering, apparently due to wear of the gun solenoids. If it is possible, adjustments should be made so that the airguns can be synchronized accurately.

With the present gun monitoring system (using a dual channel digital storage oscilloscope) it is only possible to monitor 2 guns at any one time, and unless someone is watching the guns continuously it is not possible to keep them properly synchronized. A high priority should be given to the development of a computer-controlled gun monitoring and control system such as is used in industry. Such systems monitor gun firing times by detecting when the gun solenoid signal rises above a threshold, then synchronize them by adjusting the firing delays to individual guns.

Far Field Hydrophone: It had been hoped to deploy a far field hydrophone to record the airgun signature. Unfortunately the weight intended to be used to sink the hydrophone was thrown overboard on the journey south. Another weight was improvised but was unable to hold the hydrophone vertically under the airguns, so the airgun signature was not recorded.

Gun depth. See Addendum at back of report.

PROCEDURE FOR SHOOTING A MULTICHANNEL SEISMIC LINE

(i) Firstly the streamer was deployed, with the ship moving at four to five knots. The continuity and leakage of all the channels was checked first using the Kalamos Line Tester. During deployment, each depth section was calibrated and the Bird tested on the platform by commanding it to dive and surface firstly from the platform and then from the Plot. All Birds were set to surface initially. The leakage was tested again once the streamer was out. The lead-in was padded with rope where it makes contact with the "doughnut". This padding also served as a marker so that the streamer was wound out by the same amount on each deployment.

The towing lead was generally brought towards the outboard (port) side of the drum for towing, by paying out extra and slewing the ship to port while this extra was recovered. This position increased the separation between streamer and airguns.

(ii) After the streamer was deployed the airguns were put out. This was done with the ship moving at five knots.

(iii) Whilst the streamer was being deployed the daily instrument tests were run on the Sercel and the tapes were put on and bursts written on them using Mode 44.

(iv) The relevant data were entered into the Sercel and into the BBC Header. The BBC Header information was saved and the program re-run, so that in the event of a power failure the new parameters would survive.

(v) The Sercel was put into tape bypass mode and the airguns switched on when ready. The airguns were switched on at both the Trigger Unit in the Plot and the Firing Unit in the After Rough Laboratory. The airguns were then synchronized. Putting the Sercel in tape bypass allowed manual camera records and an EPC single channel record, before tape recording need start.

(vi) When it was time to start the line (i.e. the streamer was straight and towing at the correct depth) a noise record was taken first. To take the noise record, the guns were turned off in the Plot and the Rough Laboratory. The Sercel was then put into shot Mode 03 and the start button pushed. A manual camera record was taken. Before the noise record was taken the Sercel Record Number was set to 9999 so that the Noise Record Number was zero.

(vii) To record the shots, the shot counter was set to zero. [This counter was intended to be used to produce an oscillograph record of the gun solenoids, but in fact was used to keep a check on the Position Number.] The airguns were switched on in the Rough Laboratory and then switched on at the Trigger Unit in the Plot. At the same time the BBC Extended Header Program was set running.

(B) CORING EQUIPMENT

1. Piston/Gravity Cover

1.1 Core cutters

Uniformly excellent, showing no signs of damage even when coring sands and gravels.

1.2 Core catchers

The short length of polythene tube used in addition to the tulip-type core catcher was probably unnecessary, since the lowest sediments cored were in most cases so stiff that the petals of the catcher were jammed open. The catchers worked well except in two cases: i) the spot-welding gave way while coring a thin (1cm) sand bed in a mud section, and the petals of the catcher moved bodily up the liner for several metres: considerable core disturbance resulted from their removal ii) one petal broke off while coring a gravelly sand. Most gravelly sands tended to mangle the core catchers so that each could only be used once or twice.

1.3 Core barrels and collars

We bent most available barrels, slightly or severely, generally by trying to core a hard bottom. Stainless steel barrels are expensive and cannot always be straightened satisfactorily (see below). We would suggest a look at the use of mild steel barrels, either painted or galvanised to reduce corrosion. Mild steel is cheap and barrels could be treated as more expendable items than at present. Note that to fit the same liners the barrels should be machined to a slightly larger internal diameter to allow for paint or galvanising. Stainless steel is appropriate for the collars since these very rarely suffer damage.

The method of assembly with 8 Allen screws per collar is satisfactory.

1.4 Liners

Polycarbonate core liners performed very well, remaining intact even when the enclosing core barrel had been bent through some 50^{o} and then straightened. Removal of a liner full of sediment from a slightly bent barrel can be difficult, but is facilitated by drilling a small hole within 1cm of the end of the liner: a hook-knife or small screwdriver can then get a grip on the otherwise smooth plastic. This comment also applies to core catchers.

1.5 End-caps

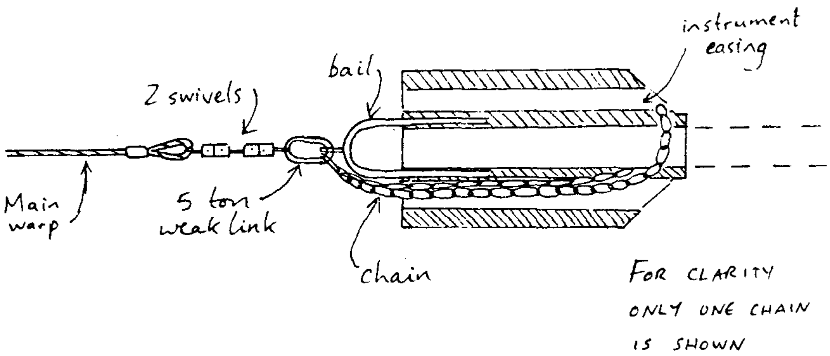
The red flanged end-caps were not satisfactory. They were a very tight fit on the liners, and were tapered, so that when sawn in half the end-cap fell off. The flange made it very awkward to tape half-end-caps in position. The yellow type of end-cap which has parallel sides and no flange would have been much more useful. When splitting cores we abandoned the red end-caps altogether and used yellow tape instead. A small number of internal end caps would be useful, particularly when removing liners from bent barrels.

1.6 Core head and bail

The bail suffered damage while the core head and heat-flow probe were being pulled out of the seabed sideways. The more times a stainless steel bar is bent and straightened the weaker it becomes: This also applies to the welds joining the bail to the core head. These welds are inaccessible and cannot be inspected for damage. Recommend replacement of the welded bail by a large U-bolt which can be readily removed, inspected for damage, and if necessary straightened under more controlled conditions than a sledgehammer on the deck.

We rigged a pair of safety chains (supplied by the bosun) on the core head thus:

Luckily the bail did not break. The breaking strain of each chain and its shackles was 2 tons.



1.7 Pilot/Trigger Corer

This never failed to achieve a core but we are concerned that the most soupy sediment, at the seabed, may escape through the top of the corer before the weight actually comes to rest in the mud. There might be less risk of this if the pilot corer barrel were made longer, say 1.5 to 2m instead of the present 1.2m. The base of a 2m long, relatively light pilot corer would probably come to rest in the sediment before all the water was expelled from the top of the barrel: the trigger mechanism of the piston would operate as designed, when the load came off the trigger chain. Furthermore, a better seabed sample would be obtained if the pilot core were kept vertical in a stand on deck, rather than rolling into the scuppers as presently happens (when the soupy part of the sediment gets thoroughly mixed).

1.8 Release Mechanism/Pyros etc

Somewhat unreliable. Several pyros were rejected as unfit for use. Twice the release mechanism failed to work and the corer had to be brought to the rail. Twice it pre-triggered immediately the pyro fired, losing one complete corer and one release mechanism. This reduced us to gravity coring.

2. General

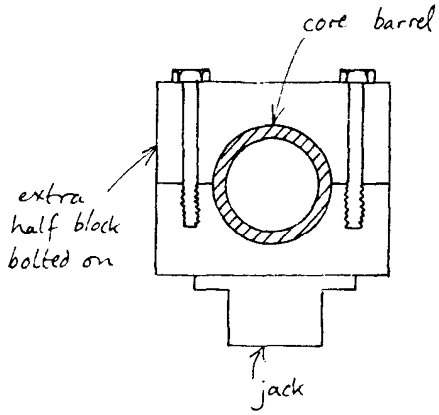
2.1 It is inconvenient not being able to rig the piston corer until the end of the main coring warp is available. If it could be rigged with a pennant which is subsequently bent on to the main warp considerable time could be saved, as a box core or even a dredge could be in progress while the piston corer was being rigged.

2.2 The core head bucket was very effective except towards the end of the coring programme when the hydraulic pump failed twice and the core head had to be hauled inboard with a chain block attached to the crane davit. The crane davit, small davits and capstan all worked well. In general the deck handling of the corer is very efficient. Even when the barrels came up bent they were brought inboard with remarkably little grief.

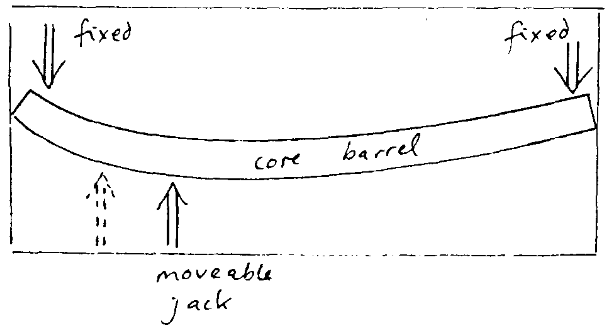
2.3 A pinger was attached 50m above the core head so that we could see on the P.E.S. how far the corer was above the bottom. In only one case did the pinger fail and luckily this occurred one minute <u>after</u> pull-out. A chart recorder in the plot recorded wire tension and this was entirely satisfactory (much better than the digital read-out of tension).

2.4 Straightening machine

The basic idea is good and undoubtedly saved our coring programme. We suggest the following improvements. a) the blocks which support the barrel should enclose it completely. Barrels pushed from one side only tend to become elliptical.



b) the central block which is jacked up should be moveable to one end of the machine. With the present arrangement it is impossible to straighten the very end of a barrel.



3. Core Lab

The following operations were done in the lab.

1. sawing core liners to 1.5m sections (or shorter), removing the caps, taping ends.

2. splitting liner lengthways with circular saw.
3. splitting core with cheese-wire.
4. cleaning surface with electro-osmotic knife.
5. describing - grain size, colour, sedimentary structures, fossil content etc; macroscopically and with the aid of smear slides.

6. photography, all cores in black and white, some in colour, using Hasselblad camera.

7. sampling - for palaeomagnetic studies, grain size analysis and x-ray diffraction.

8. sieving of coarse fractions. Sediment from the core cutter of every core was wet-sieved through a 0.2mm mesh. In addition, sediment cleaned from the surfaces of sandy cores (see 4. above) was treated in this way.

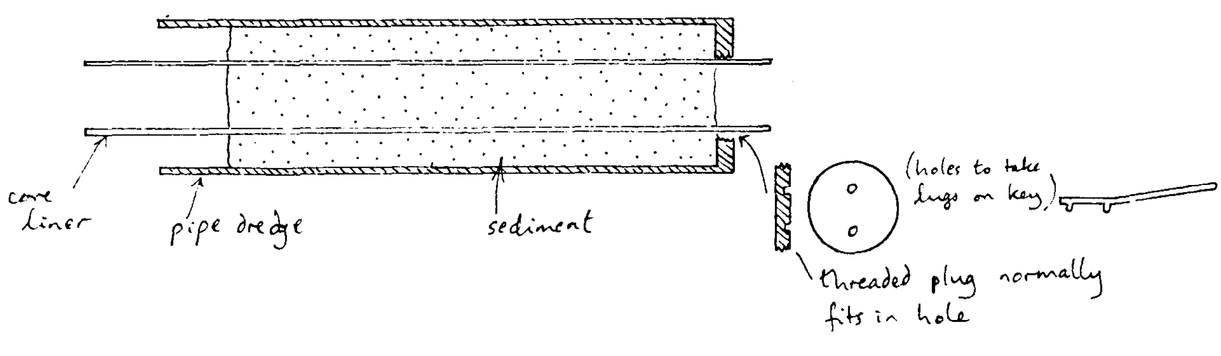
9. The cores were wrapped in cling-film and enclosed in lay-flat plastic tubing sealed at either end, prior to storage in the cold room next to the scientific hold. Corrugated plastic supported on wooden battens was used to separate layers of split cores and this was satisfactory.

All the core lab. experiment worked all the time. Thanks go to Roy Wild who made the sieve and the guide for the circular saw, and to Bruno who supplied fishing line.

Pipe Dredge Samples

The contents of the pipe dredge were emptied on to the deck and a short(2') length of core liner was used to sample the resulting heap of mud. It would be easier to empty the pipe dredge if it had a removable plug at the bottom end, say $1\frac{1}{2}$" in diameter, to allow entry of air (hence exit of mud).

In fact if it had a 3" diameter hole you could push a core liner all the way through without needing to empty out the mud.



Scientific chest freezers

4 chest freezers were installed in the scientific hold, and we were told that these had been set in Falmouth to 2-4^{o} above freezing as we had requested. When examined on the way from Gibraltar however, all proved to be set below zero, which we did not want, and could not be reset. If we had collected more cores we would have exceeded the capacity of the scientific cold store, which we were forced to use.

(C) SINGLE CHANNEL SEISMIC REFLECTION

A small amount (3 days) of single-channel seismic reflection work at 8 kts was undertaken at the start of Leg 2 to ensure that the ESSEX lines were properly located. The system comprised 1 40 cu inch airgun and a 30m Geomecanique streamer, feeding into a matching amplifier, through Kronhite filter onto an EPC recorder. The system was adequate for this purpose, but could not be used elsewhere during the cruise: it gave sparse penetration on the continental shelf and none in deeper water. We do not think the 30m hydrophone was up to the task and would recommend future users to try to obtain a larger streamer.

There was in force an RVS ban on airgun towing above 5.5 knots, which was only waived because BAS agreed to make good any gun damage which occurred. No damage could be detected, and there seems no reason why the ban should remain in force, provided that RVS technicians are onboard the ship in question to ensure that prudent towing arrangements are organised and adhered to.

(D) ESSEX

On 13 January we recorded shots fired by HMS Endurance along 2 lines off the Antarctic Peninsula near Anvers I. We used the DMCSAS system to detect and record the shots, initiating each record manually at a time after the "charge dropped" signal appropriate to the nominal fuse length. On the Sercel anxiliary channels we recorded time (from ship's master clock), transmitted shot instant from a towed hydrophone and the DMCS waterbreak detector signal. We also recorded the same hydrophone, transmitted voice and clock on an analogue Store 4 system. Aboard Endurance, Malcolm Lonsdale recorded hydrophone, a geophone, a second precision clock and voice on a second Store 4 borrowed from BGS. This system in theory permitted the experiment to continue in the event of communication breakdown by use of calibration between the clocks. It is fortunate that this was not needed (communications, on 3600 kHz and 3800 kHz, were very good) because Discovery's clock stopped after Malcolm had left: we could have recovered the situation by transmitting clock pulses for intercomparison, using NNSS timing signals or any other commonly received transmission, but it would have been rather complicated, and difficult to decipher afterwards.

(E.) PES, 3.5kHz, Sidescan

These all worked very well throughout the cruise. The sidescan had only the starboard transducer installed, which was unfortunate since we were obtaining excellent records on the Antarctic shelves, provided the weather was reasonable. The transducer was only stabilised against roll so that record quality deteriorated in a head sea, or if the roll was excessive.

(F) MAGNETICS, GRAVITY

The magnetometer was towed either from a boom on the port quarter, or through a fairlead on the starboard quarter (see DMCSAS section).

The gravimeter performed well throughout, although there was some uncertainty expressed through the cruise about the behaviour of the cross-coupling computer, based on the presence of short-period energy in the gravity trace on the chart recorder. Base stations were occupied at Falmouth, Gibraltar, Punta Arenas and South Georgia. Some of these were unreliable and it will be necessary to make a connection to the UK network again when the ship returns.

(G) HEAT FLOW

The heatflow equipment was provided by Professor R. von Herzen of Woods Hole Oceanographic Institution and was operated on the first leg by a WHOI team, on the second leg by a UTA/Trieste team (see Scientific Narrative). The heat flow probe, initially 6m long, was attached to the RVS piston core head, which weighed 1 ton. The probe was sometimes recovered bent, and on two occasions the lower half broke off. Whether there was a fault in manufacture, or whether repeated bending and straightening had weakened the probe, was uncertain. Undoubtedly on occasions the weather was marginal and, in shallow water particularly, the probe was pulled out obliquely because of ship drift during the ~15 minutes it had to remain in the seabed. As for coring, midships is a much more stable heatflow position than the stern.

Details of heat flow stations form part of Appendix 1.

(H) DREDGING

We dredged using the trawl warp from the crane davit on the starboard quarter. Usually we deployed a box dredge, with a pipe dredge for sediments attached to one corner and a balance weight to the other. Otherwise the rig was standard for the ship: about 7m of chain to weigh down the dredge mouth, 5 ton, 3 ton and 1 ton weak links, and a 50m pennant so that the dredge could be transferred to the auxiliary winch for recovery [because the rig was too long for the distance, davit to tension rollers]. A pinger was usually located 150m above the dredge, and the wire tension displayed on a Servoscribe chart recorder. Nineteen dredge stations were occupied (see Appendix 1 for positions and water depths). Usually it was possible to manoeuvre the ship upslope by putting the wind on one or other bow and varying the forward speed.

(I) NAVIGATION

For the first half of the cruise, the bridge and plot navigation systems were identical, using the same satellite receiver (abaft the bridge) and the same antenna (mainmast). For the second half the plot (and data logger) used a receiver in the computer room and the foremast antenna. Both systems had input from the em log (fore- and aft positive component) and gyrocompass. The data logger in addition recorded the em log athwartships component and a true fore and aft component if the ship went astern.

The bridge system had better reception in marginal conditions, perhaps because of its shorter antenna down-lead, but otherwise the two were equivalent.

The em log fore-and aft component read about 10 per cent low, throughout the cruise. This was inconvenient if there were frequent course changes, since the satellite navigation programme was calculating a compensatory "current" which it expected still to exist after the course change. We did not modify the system, however, having no chance to run a measured mile and no other way of making better than an arbitrary adjustment.

(J) DATA LOGGER AND COMPUTER

The system operated reliably throughout, with little loss of logged primary data. At the very end of the cruise the Calcomp plotter failed but this was not serious. Our main complaint was against the software, which in places appeared archaic. The dead-reckoned navigation, for example, updates position at a satellite fix (but is extremely undiscriminating about fix quality) but does not then compute a "current" between the last fix pair and apply it to newly arriving data. DR positions are therefore permanently unreliable to a much greater extent than they need be. Again, one cannot apparently specify exact scales for dependent parameters on the plotter. Also, the IGRF being used to correct new data appeared out of date, and gave residuals about 100 γ low. Again, one could not on board have data output at a stage earlier than the final, fully merged state (although Adrian Lewis has since made such data available to us, working at Barry). If this system is to remain in use, perhaps some time could be spent in updating it.

(K) SEARCHLIGHT

A fixed-beam searchlight, similar to RRS Bransfield's, was bought by BAS and mounted on Discovery's foremast, to help spot and avoid bergy bits during darkness. It was hardly used on Leg 2, when nights were short, but was used regularly during the longer nights of Legs 3 and 4, so presumably was of some value. Its use did not, as we had hoped, decrease the adjudged length of the "hours of darkness" during which ship speed was restricted, compared with other cruises. It is worth noting, however, that the PES and 3.5kHz fish and magnetometer were streamed all the time during passage and survey, and nothing whatever was even damaged by ice, let alone lost.

(L) WEATHER FORECASTING (or, come back Danny Borland, all is forgiven)

For about 5 days during Leg 2 when HMS Endurance was nearby, we received a reasonable short-term weather forecast. Intermittently during Legs 3 and 4 we would hear that Bransfield or Biscoe, operating to the west of us, was enjoying good or atrocious weather which therefore we could expect to see ourselves a day or two later, to a certain extent. Apart from that our weather forecasts were limited to the occasional (never when we really wanted one) weather map of very dubious reliability transmitted from Buenos Aires. I had not appreciated that in these days of weather satellites, we could be so bereft of information on which to base the planning of the next day or week's work. It is particularly galling to spend six hours deploying the DMCSAS or surveying a core site, to have the weather blow up, or to abandon a line or station and then have a threatened gale come to nothing. As our science becomes more sophisticated it generally becomes more weather-dependent. Money spent on a shipborne satellite receiver to track depressions, or on a local weather forecasting network, would be well-spent. And whatever happens to all those met. observations which the mates record, and the RO transmits to the Met.Office several times each day?

ACKNOWLEDGEMENTS

Cruise 154 was a success: we completed more of the programme than we could reasonably have expected, given the likely weather, the ship limitations and the newness of the DMCSAS. This success is due mainly to the efforts of the entire ship's company, who kept the ship running and endured uncomfortable and cramped conditions, and responded generously and cheerfully to the demands of the scientific programme.

We were also helped considerably by BAS and MOD staff who arranged the supply of fuel and water at Stanley and Grytviken, without which there would have been much more passage and less science. Particular thanks are due to Miriam Booth, who became unpaid adopted ship's agent in Stanley.

We would also like to thank those unsung shore-based members of RVS and IOS who helped to get the ship to sea and keep it there doing science, at times when that is becoming progressively more difficult to achieve.

With the exception of the NSF/DPP funded heat flow programme, the entire cruise was funded by BAS, including ship "charter" initial purchase of the DMCSAS and the research contract with Birmingham University. We are grateful for this act of faith, and pleased that the success of the cruise appears to justify it.

APPENDIX 1

RRS. DISCOVERY CRUISE 154 CORING STATIONS

LATITUDE SOUTH	LONGITUDE WEST	CORE NUMBER	DEPTH (M)	CORE LENGTH	DAY	TIME	STATIOI NUMBER
63 23.00	67 56.00	845.PC001	3483	01.0	85021	0939	11193
		845.TC001		01.2			
63 10.00	63 54.00	845.BC002	720	00.0	85028	0056	11206
64 10.00	51 09.00	845.BC003	2975	00.6	85041	2319	11207
67 57.00	30 28.00	845.BC004	4541	00.0	85047	0100	11208
67 56.00	30 26.00	845.PC004	4546	04.0	85047	0651	11208
		845.TC004		01.			
66 20.00	34 52.00	845.PC005	4685	01.6	85049	0239	11209
		845.TC005		01.2			
66 20.00	34 42.00	845.PC006	4694	04.0	85049	1928	11210
		845.TC006		01.2			
66 20.00	34 51.00	845.PC007	4686	03.0	85050	0539	11211
		845.TC007		01.2			
66 20.00	34 50.00	845.BC007	4689	00.0	85050	1540	11212
66 12.00	35 18.00	845.PC008	4692	00.0	85051	0250	11213
		845.TC008		01.2			
65 55.00	35 47.00	845.PC009	4727	06.0	85051	1254	11214
		845.TC009		01.2			
64 38.00	39 01.00	845.0PC10	4802	08.3	85052	2020	11215
		845.TC010		01.2			
64 27.00	39 41.00	845.PC011	4788	10.8	85053	1040	11216
		845.TC011		01.2			
64 29.00	39 28.00	845.BC012	4794	00.0	85053	1845	11217
64 29.00	39 34.00	845.PC012	4795	09.3	85054	0056	11218
		845.TC012		01.2			
64 30.00	39 28.00	845.PC013	4801	00.0	85056	1043	11220
		845.TC013		01.2			
64 21.00	39 55.00	845.PC014	4718	10.9	85056	1957	11221
		845.TC014		01.2			
63 57.00	40 55.00	845.PC015	4537	11.2	85057	0648	11222
		845.TC015		01.2			
63 30.00	41 43.00	845.PC016	4510	02.8	85058	1107	11223
		845.TC016		01.2			
63 31.00	41 43.00	845.GC017	4545	02.8	85058	1818	11224
62 30.00	42 14.00	845.GC018	3000	04.7	85089	0706	11240
62 15.00	43 15.00	845.GC019	1176	02.4	85089	1507	11241
61 54.00	42 57.00	845.GC020	650	01.6	85089	1840	11242
61 52.00	42 56.00	845.GC021	650	00.8	85089	2019	11243
61 35.00	42 39.00	845.GC022	823	02.6	85090	0119	11244
61 35.00	42 29.00	845.GC023	712	01.8	85090	0354	11245
61 36.00	41 56.00	845.GC024	873	00.8	85090	0828	11246
61 41.00	41 24.00	845.GC025	1550	02.3	85090	1310	11247
61 51.00	39 20.00	845.GC026	3211	03.4	85091	1137	11248
61 47.00	40 08.00	845.GC027	3470	04.5	85091	1645	11249
61 40.00	40 47.00	845.GC028	3621	04.7	85091	2153	11250

RRS. DISCOVERY CRUISE 154 LEG 2 HEATFLOW STATIONS

ST. NO.	LATITUDE SOUTH	LONGITUDE WEST	DAY/TIME	PES.	CORRECTED DEPTHS	
101	63 23.10	68 26.50	850211605	3585	3541	22 MY. OCEAN FLOOR
201	63 23.40	68 26.90	850211838	3531	3487	
202	63 23.00	68 25.60	850211924	3580	3536	
203	63 22.50	68 24.80	850212006	3582	3538	
204	63 21.80	68 24.60	850212054	3583	3539	
205	63 21.40	68 25.00	850212148	3584	3540	
206	63 21.00	68 25.00	850212232	3584	3540	
301	63 40.00	66 36.60	850220857	3352	3307	19 MY. OCEAN FLOOR
302	63 40.00	66 37.00	850220953	3350	3305	
303	63 40.40	66 36.10	850221046	3348	3303	
304	63 41.30	66 36.60	850221151	3348	3303	
305	63 41.80	66 33.90	850221256	3393	3349	
306	63 41.60	66 32.30	850221418	3383	3339	
307	63 41.30	66 31.80	850221446	3375	3330	
401	63 45.83	66 25.22	850221750	3298	3253	CONTINENTAL SLOPE
501	63 45.30	66 24.60	850222016	3300	3255	
502	63 45.20	66 24.80	850222035	3265	3220	
601	63 48.90	66 20.80	850222359	3117	3072	
602	63 49.00	66 20.70	850230018	3100	3055	
603	63 50.20	66 17.30	850230206	2890	2845	
604	63 49.88	66 17.39	850230213	2865	2820	
605	63 50.01	66 17.18	850231226	2710	2666	
606	63 50.40	66 16.70	850230243	2696	2650	
607	63 50.90	66 15.00	850230358	2470	2427	
701	64 22.40	66 46.70	850231117	0462	0448	ANVERS ISLAND SHELF
702	64 22.54	66 46.14	850231148	0470	0456	
703	64 22.59	66 45.99	850231200	0470	0456	
704	64 22.63	66 45.82	850231224	0473	0459	
705	64 22.66	66 45.80	850231300	0475	0460	
706	64 22.75	66 45.40	850231325	0480	0466	
707	64 22.83	66 44.75	850231413	0500	0486	
708	64 23.25	66 44.00	850231452	0516	0501	
709	64 22.30	66 37.10	850231813	0545	0530	
710	64 22.30	66 36.80	850231834	0545	0530	
711	64 22.20	66 36.40	850231900	0537	0522	
712	64 22.10	66 36.00	850231915	0536	0521	
713	64 22.20	66 38.40	850231936	0538	0523	
714	64 22.10	66 38.60	850231956	0536	0521	
715	64 22.10	66 39.30	850232017	0538	0823	
716	64 22.10	66 39.60	850232037	0537	0522	
717	64 22.10	66 39.90	850232102	0537	0522	
718	64 22.10	66 40.20	850232131	0540	0525	
719	64 22.10	66 40.30	850232138	0541	0524	

RRS. DISCOVERY CRUISE 154 DREDGE STATIONS

ST. NO.	START LATITUDE SOUTH	START LONGITUDE WEST	END LATITUDE SOUTH	END LONGITUDE WEST	START DEPTHS	END DEPTHS	DAY/HOUR
98	63 04.19	64 08.06	63 04.37	64 04.09	2340	1500	8502523
99	63 03.86	64 07.14	63 04.13	64 05.17	2450	1680	8502604
100	63 06.32	64 06.99	63 06.44	64 05.87	1140	930	8502609
101	63 04.79	64 08.94	63 05.47	64 06.46	2420	1700	8502612
102	62 50.13	63 59.38	62 50.36	63 58.03	3930	3790	8502618
103	62 42.17	63 50.13	62 41.59	63 47.70	4270	4030	8502701
104	62 49.69	63 39.64	62 51.90	63 36.31	2865	2300	8502709
105	62 56.43	64 05.08	62 57.04	64 04.17	3850	3720	8502718
106	64 30.86	39 24.96	64 31.20	39 25.12	4240	4120	8505601
107	60 31.28	27 37.13	60 32.80	27 36.03	2400	1785	8507811
108	60 43.55	27 36.66	60 43.97	27 37.17	3215	3000	8507820
109	60 55.61	27 36.95	60 55.51	27 37.71	2940	2940	8507903
110	60 57.68	27 10.48	60 58.12	27 10.84	3120	2415	8507911
111	60 17.34	28 10.52	60 17.63	28 11.13	575	483	8508015
112	59 40.17	28 09.36	59 41.65	28 13.54	785	330	8508101
113	60 32.01	27 06.51	60 30.98	27 06.69	2200	1910	8508114
114	60 41.09	29 21.88	60 40.44	29 21.58	1770	1200	8508315
115	60 31.17	29 56.88	60 31.09	29 55.36	2750	2425	8508322
116	60 44.45	30 09.80	60 44.92	30 09.24	1790	1315	8508406

RRS. DISCOVERY CRUISE 154 LEG 2 HEATFLOW STATIONS

ST. NO.	LATITUDE SOUTH	LONGITUDE WEST	DAY/TIME	PES.	CORRECTED DEPTHS	
101	63 23.10	68 26.50	850211605	3585	3541	22 MY. OCEAN FLOOR
201	63 23.40	68 26.90	850211838	3531	3487	
202	63 23.00	68 25.60	850211924	3580	3536	
203	63 22.50	68 24.80	850212006	3582	3538	
204	63 21.80	68 24.60	850212054	3583	3539	
205	63 21.40	68 25.00	850212148	3584	3540	
206	63 21.00	68 25.00	850212232	3584	3540	
301	63 40.00	66 36.60	850220857	3352	3307	19 MY. OCEAN FLOOR
302	63 40.00	66 37.00	850220953	3350	3305	
303	63 40.40	66 36.10	850221046	3348	3303	
304	63 41.30	66 36.60	850221151	3348	3303	
305	63 41.80	66 33.90	850221256	3393	3349	
306	63 41.60	66 32.30	850221418	3383	3339	
307	63 41.30	66 31.80	850221446	3375	3330	
401	63 45.83	66 25.22	850221750	3298	3253	CONTINENTAL SLOPE
501	63 45.30	66 24.60	850222016	3300	3255	
502	63 45.20	66 24.80	850222035	3265	3220	
601	63 48.90	66 20.80	850222359	3117	3072	
602	63 49.00	66 20.70	850230018	3100	3055	
603	63 50.20	66 17.30	850230206	2890	2845	
604	63 49.88	66 17.39	850230213	2865	2820	
605	63 50.01	66 17.18	850231226	2710	2666	
606	63 50.40	66 16.70	850230243	2696	2650	
607	63 50.90	66 15.00	850230358	2470	2427	
701	64 22.40	66 46.70	850231117	0462	0448	ANVERS ISLAND SHELF
702	64 22.54	66 46.14	850231148	0470	0456	
703	64 22.59	66 45.99	850231200	0470	0456	
704	64 22.63	66 45.82	850231224	0473	0459	
705	64 22.66	66 45.80	850231300	0475	0460	
706	64 22.75	66 45.40	850231325	0480	0466	
707	64 22.83	66 44.75	850231413	0500	0486	
708	64 23.25	66 44.00	850231452	0516	0501	
709	64 22.30	66 37.10	850231813	0545	0530	
710	64 22.30	66 36.80	850231834	0545	0530	
711	64 22.20	66 36.40	850231900	0537	0522	
712	64 22.10	66 36.00	850231915	0536	0521	
713	64 22.20	66 38.40	850231936	0538	0523	
714	64 22.10	66 38.60	850231956	0536	0521	
715	64 22.10	66 39.30	850232017	0538	0823	
716	64 22.10	66 39.60	850232037	0537	0522	
717	64 22.10	66 39.90	850232102	0537	0522	
718	64 22.10	66 40.20	850232131	0540	0525	
719	64 22.10	66 40.30	850232138	0541	0524	

RRS. DISCOVERY CRUISE 154 LEG 4 HEATFLOW STATIONS

ST. NO.	LATITUDE SOUTH	LONGITUDE WEST	DAY/TIME	PES.	CORRECTED DEPTHS	
101	60 10.70	27 09.50	850780126	1727	1684	SOUTH SANDWICH FOREARC
102	60 10.90	27 10.70	850780221	1710	1667	
103	60 11.30	27 11.90	850780315	1710	1667	
104	60 11.60	27 13.40	850780419	1680	1638	
201	61 48.00	39 57.30	850852226	3495	3441	JANE BASIN
202	61 47.50	39 59.70	850860010	3505	3452	CENTRAL TRANSECT
203	61 47.10	40 02.20	850860212	3522	3468	HEADING WEST
204	61 47.30	40 04.80	850860354	3525	3472	
205	61 47.30	40 07.30	850860525	3532	3479	
206	61 47.50	40 09.30	850860650	3517	3463	
207	61 47.60	40 11.00	850860806	3540	3487	
208	61 47.60	40 12.70	850860919	3530	3477	
209	61 47.50	40 14.30	850861033	3520	3466	
210	61 47.30	40 18.70	850861219	3538	3485	
211	61 47.50	40 18.90	850861248	3539	3486	
301	61 49.60	39 44.50	850861838	3455	3397	JANE BASIN
302	61 49.90	39 41.10	850862009	3430	3376	EAST TRANSECT
303	61 50.10	39 36.30	850862149	3428	3373	HEADING EAST
304	61 49.60	39 33.60	850862332	3416	3561	
305	61 49.50	39 31.60	850870100	3405	3350	
306	61 49.80	39 30.50	850870225	3415	3361	
307	61 50.60	39 29.10	850870350	3430	3376	
308	61 50.90	39 26.50	850870530	3330	3275	
309	61 50.60	39 23.20	850870706	3330	3275	
310	61 50.80	39 19.60	850870842	3288	3233	
311	61 51.10	39 16.40	850871009	3150	3096	
401	62 09.60	41 32.70	850872135	3465	3411	JANE BASIN
402	62 09.70	41 28.60	850872327	3496	3442	WEST TRANSECT
501	62 09.00	41 27.80	850880405	3500	3447	JANE BASIN
502	62 09.30	41 24.60	850880535	3468	3414	WEST TRANSECT
503	62 09.40	41 21.30	850880709	3470	3416	HEADING EAST
504	62 09.90	41 18.00	850880838	3460	3406	
505	62 10.10	41 13.30	850881026	3452	3398	
506	62 10.20	41 09.50	850881201	3420	3366	
507	62 10.10	41 06.30	850881325	3365	3311	
508	62 10.60	41 04.50	850881442	3375	3321	
509	62 11.00	41 03.30	850881549	3385	3330	
510	62 11.60	41 01.50	850881658	3395	3341	
511	62 12.40	40 59.50	850881809	3420	3366	
512	62 13.20	40 57.70	850881922	3435	3380	
601	61 55.00	38 45.10	850910455	1680	1638	JANE (SAND) BANK

R.R.S. DISCOVERY CRUISE 154 EXPENDABLE BATHYTHERMOGRAPH STATIONS

ST. NO.	LATITUDE SOUTH	LONGITUDE WEST	YEAR/DAY/TIME
1	-11 06.66	24 37.00	843501318
2	-10 33.00	24 47.00	843501801
3	-09 13.00	25 19.00	843502354
4	-08 08.00	25 45.25	843510559
5	-07 20.00	26 02.00	843511019
6	-06 52.00	26 12.00	843511300
7	-05 56.00	26 33.66	843511800
8	-04 48.00	26 47.33	843520000
9	-03 39.00	26 46.00	843520600
10	26 30.00	41 39.33	843591159
11	27 34.00	42 14.50	843591759
12	28 45.00	42 51.00	843600000
13	30 37.00	43 54.50	843600938
14	31 15.00	44 11.00	843601300
15	32 08.00	44 35.00	843601800
16	33 08.00	45 13.50	843610000
17	34 42.00	46 07.25	843610900
18	35 23.00	46 28.00	843611300
19	36 16.50	46 58.50	843611900
20	37 22.50	47 54.50	843620200
21	38 33.00	48 36.50	843620959
22	38 48.88	48 44.75	843621143
23	39 18.33	49 00.50	843621507
24	40 15.66	49 24.88	843622113
25	41 05.00	50 05.50	843630300
26	42 00.00	50 46.50	843630900
27	42 57.50	51 28.25	843631500
28	43 57.50	52 06.75	843632100
29	44 53.50	52 45.75	843640300
30	45 56.50	53 31.00	843640900
31	47 06.00	54 19.75	843641500
32	48 18.50	55 02.00	843642100
33	49 21.00	55 58.50	843650300
34	53 18.00	58 11.50	850020900
35	55 40.75	58 40.66	850022102
36	56 48.50	59 04.00	850030300
37	56 49.00	59 04.00	850030311
38	57 37.00	60 19.88	850030900
38	58 28.00	61 45.75	850031500
39	59 15.50	63 11.00	850032100
40	59 57.50	64 25.75	850040300
41	60 28.50	65 21.75	850040900
42	61 16.00	66 50.75	850041500
43	62 06.00	68 13.00	850042100
44	62 56.50	68 11.50	850050300
45	63 36.25	66 45.15	850050900
46	63 33.00	65 56.50	850072105
47	62 32.00	64 27.75	850101506
48	61 52.00	64 44.50	850111235
49	63 23.00	68 01.50	850121341
50	63 50.50	66 38.00	850122359
51	64 04.75	65 54.25	850131200

52	62	56.50	68	52.50	850210300
53	63	22.75	68	25.75	850211500
54	63	41.75	66	35.00	850221300
55	63	48.75	66	20.75	850230000
56	64	22.50	66	48.25	850231214
57	64	22.13	66	38.50	850232000
58	62	47.00	64	12.50	850251800
59	62	49.33	64	01.33	850261800
60	62	49.50	63	40.50	850270600
61	62	56.13	64	05.33	850271800
62	61	49.50	61	28.50	850290000
63	61	02.50	62	45.00	850291159
64	60	38.75	63	31.25	850291800
65	60	07.50	65	06.00	850300000
66	59	31.50	66	41.75	850300600
67	58	52.00	67	56.25	850301200
68	57	56.50	68	33.50	850301759
69	56	58.00	69	13.00	850310000
70	55	49.75	70	08.50	850310909
70	56	38.00	69	14.00	850370142
71	57	20.50	68	43.50	850370600
72	58	21.50	67	55.75	850371200
73	59	08.50	66	49.75	850371800
74	59	08.75	66	43.50	850371810
75	59	29.50	64	54.75	850380000
76	60	14.00	63	29.50	850380600
77	60	47.50	61	50.50	850381200
78	61	08.25	60	56.25	850381800
79	61	30.50	60	11.50	850390000
80	61	51.75	55	50.00	850400200
81	64	13.50	51	51.50	850411159
82	64	10.50	51	07.25	850411848
83	63	49.00	48	07.00	850421200
84	63	31.00	46	05.25	850421813
85	63	16.75	44	14.00	850430017
86	63	23.00	42	01.50	850431200
87	64	11.75	40	16.25	850440019
88	64	52.50	38	26.50	850441200
89	65	39.75	36	30.25	850450000
90	66	26.00	34	30.25	850451200
91	67	05.50	32	26.75	850460000
92	67	51.75	30	26.25	850461200
93	67	35.00	31	10.00	850471200
94	66	20.75	34	46.50	850481200
95	66	17.75	34	54.25	850501200
96	64	39.50	39	57.25	850521200
97	64	03.75	39	19.50	850551859
98	64	00.00	40	39.00	850571159
99	63	30.00	41	43.00	850581159
100	62	29.00	43	35.25	850601159
101	61	49.75	43	27.50	850601724
102	62	12.50	44	09.25	850621159
103	61	45.50	42	42.50	850632100
104	62	35.25	43	41.75	850641200
105	61	13.00	41	47.00	850650000
106	60	14.00	39	35.00	850651200
107	59	22.50	38	26.50	850651800
108	58	39.00	37	42.50	850660013
109	57	22.00	36	36.00	850661200
110	56	21.00	36	13.00	850661800
111	55	27.50	35	51.00	850670000
112	55	55.00	34	39.00	850701200
113	56	49.00	33	59.00	850701800

114	57	36.00	33	31.75	850710000
115	58	59.00	32	40.50	850711200
116	59	54.00	31	53.00	850711800
117	59	55.75	30	40.00	850720000
118	60	05.00	28	05.00	850721500
119	60	19.00	26	29.00	850730000
120	60	28.50	24	30.00	850731200
121	60	57.75	26	27.00	850740000
122	60	35.00	28	04.00	850741200
123	60	46.00	26	12.75	850751159
124	60	35.75	30	15.00	850761200
125	60	54.00	29	34.50	850771200
126	60	31.50	27	35.75	850781200
127	60	57.25	27	09.75	850791200
128	60	18.00	28	09.00	850801200
129	59	41.50	28	11.00	850810527
130	59	41.50	28	11.00	850810535
131	60	46.75	28	12.25	850821200
132	60	27.50	29	34.00	850831200
133	60	58.00	30	54.00	850841200
134	61	53.25	37	25.00	850851200
135	61	50.50	39	32.00	850851800
136	61	50.75	39	39.00	850862059
137	62	07.75	41	39.50	850872000
138	62	13.50	40	57.50	850882000
139	61	41.25	40	25.00	850901800
140	60	22.00	42	36.00	850921200
141	59	26.00	43	38.00	850921800
142	58	39.00	44	36.00	850930000
143	56	56.00	46	35.00	850931500
144	56	21.00	47	14.00	850931900
145	55	42.00	47	47.00	850940000
147	54	06.00	48	11.00	850941215
148	53	34.00	47	59.00	850941800
149	53	01.00	47	52.00	850950000
151	51	41.00	47	55.00	850951200
152	50	57.00	48	13.00	850951800
153	50	01.00	48	41.00	850960000
154	49	03.00	49	01.00	850960601
155	48	10.00	49	15.00	850961200
156	47	17.00	49	27.00	850961800
157	46	27.00	49	42.00	850970000
158	45	45.00	49	48.00	850970600
159	45	01.00	49	47.50	850971200
160	44	09.00	50	00.00	850971817
161	43	21.00	50	19.00	850980000
162	41	58.00	50	44.00	850980830
163	41	26.75	50	47.50	850981200
164	41	02.00	50	42.00	850981800
165	40	48.00	50	46.50	850990000
166	40	21.00	50	47.50	850990600
167	39	23.00	51	09.50	850991200
168	38	22.00	51	25.00	850991800
169	37	27.00	51	51.25	851000000

APPENDIX 2

USERS GUIDE TO
R.V.S. EXTENDED HEADER INPUT PROGRAM, "SERCEL" PLUS NOTES ON EXTENDED RECORD HEADER FORMAT

1. Description

"SERCEL" is a BBC micro program that takes input of and formats seismic record extended header information. This information is stored in an area of memory from which it may be fetched by the SERCEL SN 358 seismic acquisition system when required.

2. History

The program was developed on RRS Discovery during cruise D154. It was written by A.R. Lewis (R.V.S.) to a specification laid down by R.D. Larter (University of Birmingham). Later modifications were made by J. Price (R.V.S.).

3. Format of the extended header

In deciding on an extended header format three main aims were kept in mind:

(1) to fulfil the immediate requirements of D154,

(2) to arrive at a header format that would be acceptable to other potential users,

(3) to allow scope for future developments to be incorporated without re-organisation of the extended header.

Although it is somewhat archaic, BCD format was chosen for most of the extended header variables because it seems to be standard in the seismic industry and adhering to this standard should facilitate use of the extended header information in processing centres.

4. Overall Program Structure

Several header parameters are monitored automatically by the program. The values of these parameters are updated each second and they are grouped together at the start of the extended header.

Other parameters are entered via the BBC keyboard. A main menu gives access to any one of five sub-menus for speed of access to any individual parameter. The parameters most likely to change during a line are grouped together wider sub-menu 5 ("miscellaneous").

5. Loading the Program

To load the program insert the floppy disk containing the SERCEL program into drive 0. Then hold down the SHIFT key, press the BREAK key, and finally release the SHIFT key. After a successful loading the main menu should appear on the screen (eventually).

6. Program operation

To access one of the sub-menus from the main menu just type the number of the sub-menu (no need to press RETURN). Similarly, to access one of the parameters within a sub-menu just type the number of the parameter. The prompt "Enter new value:"will appear on the screen. Type the new value of the parameter and then press RETURN. To return to the main menu press "P" (for "proceed") when the "Enter parameter:" prompt is showing.

To initiate monitoring of the automatically monitored parameters at the start of a seismic line, press "P" when the main menu is showing on the screen. This should be done after the SERCEL has been switched to "remote" and the key Pulse Generator has been switched on. If a noise record is to be taken at the start of a line the operator should wait until this has been taken before pressing "P". The message "RUNNING" and the position number count then appear on the screen, with the position number set to 1.
Note that at any time between records the position number showing on the screen is that which will be written onto the header of the next record , in contrast to the record number on the SERCEL, which is the number written on the header of the previous record.

To access the main menu at any time during a line press the ESC key. The procedure for changing a parameter is then just the same as described earlier. Pressing "P" when the main menu is showing should return the "RUNNING!" message and the position number count to the screen. Neither the monitoring of automatically monitored parameters nor the position number count should be affected by interrupting the program in this way as long as no more than 1 record is taken during the interruption. Once the header parameters have been set up for the start of a line it is advisable to take advantage of the "save header and exit" option. This is put into operation by typing "E" when the main menu is showing. The set parameters will then be restored if the program should have to be reloaded in the middle of a line due, for example, to a temporary power failure.

7. Automatically Monitored Parameters

At present these are:

position number
julian day
time (hour, minure, second)
hydrophone array depths (ft)
gun depth (m)
manifold pressure

Position number should update once per cycle irrespective of whether or not the guns fire successfully and whether or not a record is taken on the SERCEL. However, complete reliability has not yet been achieved and this greatly reduces the value of position number in locating missed records. It has been observed that position number occasionally increments by 2 or even 3 at the end of a cycle. It is important that the reason for this malfunction be determined and that it be eliminated.

Space has been allocated in the extended header for up to 10 gun depth values and up to 10 hydrophone array depth values. Space has also been allocated for a strain gauge value, although at present the streamer does not include a strain gauge. Hydrophone array depth values are entered in the header in feet while gun depth values are in metres. This is the form in which the values are supplied by external systems and there seemed little to be gained by converting one to the other.

It is hoped that other parameters may eventually be monitored automatically. Obvious candidates are water-break, time, ship's heading and water speed (currently updated via keyboard). Another useful addition would be the time interval between the key pulse and the main firing pulse for each gun (not yet allocated extended header space since the monitoring system does not yet exist).

8. Keyboard Input

The main menu gives access to 5 suit-menus :

1) General information
2) Recording parameters
3) Streamer configuration
4) Source configuration
5) Miscellaneous

8.1 General Information

The 4 parameters in this section are entered in the header as ASCII characters. Everything else in the extended header is in BCD. The line information parameters are:

1. Ship identification mnemoric (2 characters).
2. Cruise number (up to 3 characters).
3. Line ID (up to 10 characters)
4. Line type mnemoric (2 characters)

It is suggested that the ship identification mnemoric be "DI" for "Discovery" and "CD" for "Charles Darwin". It is suggested that the following mnemoric be used for line type:

NI - Normal incidence
CO - Constant Offset
ES - Expanding spread

8.2 Recording Parameters

These are:

1. Anti-alias corner frequency (Hz)
2. Low-cut corner frequency (Hz)
3. Low-cut roll-off (dB/oct)
4. Polarity (1 or 0)
5. Auxiliary channel gains

The low cut filter on the SERCEL has a fixed corner frequency (8Hz) and roll-off (36 dB/oct). The only control of the filter is whether it is in or out, and this is recorded in the standard SERCEL header. In view of this it was suggested that these values should be inserted into their memory locations and rendered inaccessible. However, this seems to have been overlooked in the programming.

A similar suggestion was made with respect to polarity, which has been hardwired so that an increase in pressure results in a negative number on tape. It was suggested that the value "1" be used to represent this condition and that it should be unchangeable, but this too seems to have been overlooked.

It is suggested that the values held in the SERCEL configurator mode, parameters X 1 to X4, be entered in the space for auxiliary gains (i.e. a value of n represents a gain of 2^n).

8.3 Streamer Configuration

Parameters:

1. Group centre separation (m)
2. Measured distance of centre of nearest group from stern of ship (i.e. without any correction for stretch of stretch sections).
3. Distance from ships datum to stern (m)
4. Number of depth sections
5. Positions of depth sections
6. Number of depth controllers
7. Positions of depth controllers
8. Number of water-break hydrophones
9. Positions of water-break hydrophones

Both the positions of depth sections and the positions of depth controllers are entered via a sub-sub menu.It is suggested that in both these cases position in the streamer be indicated by entering the number of the following group (so position 1 is in front of group 1 and the position after group 48 is position 49). The same convention has been used for water-break hydrophone position(s), but space in the extended header has been allocated only for two water break position values, so a sub-sub menu was not required.

Distance from ship's datum (principal navigational antenna)to stern may be a useful parameter in areas where precise navigation systems such as SYLEDIS and PULSATE are available.

8.4 Source Configuration

Parameters:

1. Source type
2. No. of guns
3. Gun capacities (cu. ins)
4. Distance of nearest gun from stem (m)
5. Spacings between guns (m)
6. Intended shot interval (m)
7. Gun sync. delay after key pulse (ms)

It is suggested that the following convention be used to indicate source type:

1 = airguns

2 = waterguns

3 = explosives

Gun capacities and gun spacings each have a sub-sub menu. It is suggested that both are entered starting from the front of the string of guns. If there is more than one string of guns then enter the distance of the gun from the stern of the ship for the first gun in each new string; this should be a value too large to be confused with inter-gun spacings.

By "gun sync. delay", is meant the nominal delay after the key pulse to which the gun firing pulses are meant to be synchronised.

8.5 Miscellaneous

This menu includes all the parameters that are likely to require modification during a line.

Parameters:

1. Record length(s)
2. First seismic block length (s/10)
3. Water break time (ms)
4. Water speed (kts/10)
5. Tail buoy bearing (degrees true)
6. Ships heading (degrees true)
7. Intended course (degrees true)
8. Shots per print

Tenths of the normal units have been used for first seismic block length and water speed to economize on the use of header space in the one case and to avoid complications with real numbers in the other.

The shots per print parameter does not go into the extended header but controls the frequency with which the BBC micro triggers the camera. The automatic camera triggering was never satisfactory on D154 because it invariably missed the first couple of hundred milliseconds of a record and therefore missed most of the information on the auxiliary channels.

9. Extended header byte allocation

Some of the following byte allocations may seem a little illogical at first sight and they certainly make header dumps obtained from the SERCEL using MODE 47 slightly confusing. The confusion stems from the fact that both the BBC and SERCEL store two byte values, backwards i.e. with the least significant byte in the high order position. This is a standard feature on many computers and the header should be easily read by another computer even though it makes the header dump difficult to understand (see report on RVS Multi-Channel Seismic Tape Analysis program "MCDSAS").

Byte No.	Contents
1 - 58	SERCEL standard header
59 - 60	Position number
61	Most significant byte of Julian Day
62	Year
63	Hour
64	Least significant byte of Julian Day
65	Seconds
66	Minutes
67	Depth of array depth section 2 (ft)
68	Depth of array depth section 1 (ft)
69	Depth of array depth section 4 (ft)
70	Depth of array depth section 3 (ft)
71	" " " " 6 (ft)
72	" " " " 5 (ft)
73 - 76	Array depth sections 7-10 (ft)
77	Gun depth 2 (m)
78	Gun depth 1 (m)
79 - 86	Gun depths 3-10 (m)
87 - 88	Compressor manifold pressure
89 - 90	Strain guage reading
91 - 92	Ship identification mnemonic (ASC11, reversed)
94,93,96	Cruise number (ASC11 - in order specified)
95,98,97,100,99,102,101,104, 104,106	Line identifier (ASC11, in order specified)
105, 108	Line type mnemonic (ASC11, order specified)
107	Anti-alias corner frequency (least sig. byte)
109	Low cut corner frequency (Hz)
110	Anti-alias corner frequency (most sig. byte)
111	Polarity
112	Low cut roll-off (dB/oct)
113	Gain on auxiliary channel 2 (power of 2)
114	Gain " " " 1 "
115	" " " " 4 "
116	" " " " 3 "
117	Least sig. byte of distance from stern to centre group 1 (m)
118	Group centre separation (m)
119	Distance from ships datum to stern (m)
120	Most sig. byte of distance from stern to centre group 1 (m)
122	Number of hydrophone array depth sections

Byte No.	Contents
121	Position of array depth section 1
123	Position of hydrophone array depth section 3
124	" " " " " " 2
125	" " " " " " 5
126	" " " " " " 4
128	" " " " " " 6
127,129,130,132	" " " " " " 7 - 10
131	Number of hydrophone array depth controllers
133	Position of depth controller 2
134	Position of depth controller 1
135-142	Position of depth controllers 3-10
143	Position of WB hydrophone 1
144	Number of WB hydrophones
145	Source type (1 = airguns, 2 = waterguns 2 = explosives)
146	Position of WB hydrophone 2
147	Least sig. byte of gun 1 capacity (cu. ins)
148	Number of guns
149	Least sig. byte of gun 2 capacity(cu. ins)
150	Most sig. byte of gun 1 capacity (" ")
151	Least sig. byte of gun 3 capacity(" ")
152	Most sig. byte of gun 2 capacity(" ")
153	Least sig. byte of gun 4 capacity(" ")
154	Most sig. byte of gun 3 capacity (" ")
155-166,168	Other gun capacities (up to 10 total)
167	Distance of nearest gun to stern (m)
169	Gun 2 - Gun 3 spacing (m)
170	Gun 1 - Gun 2 spacing (m)
171	Gun 4 - Gun 5 spacing (m)
172	Gun 3 - Gun 4 spacing (m)
173-176,178	Other gun spacings (up to 9 total)
177	Intended shot spacing (m)
179	Record length (s)
180	Gun sync. delay (ms)
181	Least sig. byte of water break 1 time (ms)
182	Length of first seismic block (s/10)
183	Least sig. byte of water break 2 time (ms)
184	Most sig. byte of water break 1 time (ms)

Byte No.	Contents
185	Water speed (kts/10)
186	Most sig. byte of water break 2 time (ms)
187 - 188	Tail buoy bearing (degrees true) absolute
189 - 190	Ships heading (degrees true)
191 - 192	Intended course (degrees true)
193 - 256	UNALLOCATED

APPENDIX 3

USERS GUIDE TO
R.V.S. MULTICHANNEL SEISMIC DATA TAPE ANALYSIS PROGRAM "MCDSAS"

1. Description

"MCDSAS" is a PDP-11 program to read multichannel seismic tapes recorded on the SERCEL SN 358 seismic data acquisition system and output selected information from the tapes to a video terminal or to a file.

2. History

The program was originally written by R.B. Lloyd at the Research Vessel Base, Barry. A number of modifications were made by A.R. Lewis on cruise D154. Some of these modifications were designed to output information from the newly designed extended record headers in an easily readable format*. Others, at the request of the University of Birmingham staff, resulted in the provision of an option for a more concise output format, listing only a few key parameters from each shot header.

(* see Appendix 2)

3. Running "MCDSAS"

Arrange a mutually convenient time with R.V.S. computer personnel, explaining that you will require the use of the User System tape deck, one video terminal logged into the User System and the lineprinter.

The procedure for loading the tape and the mechanics of running the program are adequately dealt with in R.V.S. Shipborne Computer Group document SCG/MCDSAS/01 by R.B. Lloyd and A.R Lewis. Here the options provided by the program will be discussed in greater detail. After initiation the program conducts an interactive question-answer session. First of all it prompts the operator for the tape number. This is merely a convenience so that the tape number can be written automatically at the head of the output. The number entered has no effect on the running of the program.

The second prompt is:

"Print long or short headers [S/L]?

If "long" headers are requested all the information on the headers is output in an explicit format. The next page contains an example of this form of output. This format has the disadvantage that it is very uneconomical in use of paper if print-out is requested (see later). The alternative "short" format was devised to conserve paper and provide neat concise output of the most important information in the header.

Tape Number: 21

RN	PN		TIME	TI	MP	GD	ARRAY DEPTHS					
437	440	15	9:30:24	0	4845	8	28	44	54	63	53	45
438	441	15	9:30:44	20	2219	8	28	44	54	63	54	45
439	442	15	9:31: 4	20	6259	8	28	44	54	63	54	45
440	443	15	9:31:24	20	699	8	28	44	53	64	55	45
441	444	15	9:31:44	20	1815	8	28	43	53	64	55	46
442	445	15	9:32: 4	20	196	8	28	43	53	65	56	46
443	446	15	9:32:24	20	7171	8	26	42	53	65	56	45
444	447	15	9:32:44	20	4443	8	26	42	53	66	56	46
445	448	15	9:33: 4	20	7880	8	28	42	53	65	57	46
446	449	15	9:33:24	20	803	7	28	42	53	65	57	47
447	450	15	9:33:44	20	9693	8	28	42	52	65	58	48
448	451	15	9:34: 4	20	8076	8	28	41	52	65	58	48
449	452	15	9:34:24	20	7170	8	26	41	52	65	59	50
450	453	15	9:34:44	20	5047	8	26	40	51	65	59	50
451	454	15	9:35: 4	20	8578	8	28	40	51	64	60	51
452	455	15	9:35:24	20	2219	8	28	40	51	64	60	51
453	456	15	9:35:44	20	2219	8	28	40	50	64	60	51
454	457	15	9:36: 4	20	9692	8	28	40	50	63	60	51
455	458	15	9:36:24	20	6262	8	28	40	50	63	60	51
456	459	15	9:36:44	20	6362	8	28	39	50	63	60	52
457	460	15	9:37: 4	20	9189	8	28	39	49	63	60	52
458	461	15	9:37:24	20	8785	8	28	40	48	63	60	53
459	462	15	9:37:44	20	7166	8	28	40	48	63	60	53
460	463	15	9:38: 4	20	3833	8	28	41	48	63	59	54
461	464	15	9:38:24	20	1841	8	28	40	48	62	59	54
462	465	15	9:38:44	20	7873	8	40	41	48	63	58	54
463	466	15	9:39: 4	20	1511	8	42	41	48	62	58	54
464	467	15	9:39:24	20	2219	8	42	42	48	63	58	54
465	468	15	9:39:44	20	605	8	42	43	49	62	58	54
466	469	15	9:40: 4	20	7975	8	42	43	49	62	59	54
467	470	15	9:40:24	20	6562	8	42	43	49	62	59	54
468	471	15	9:40:44	20	9289	8	42	44	51	62	59	53
469	472	15	9:41: 4	20	8679	8	42	44	51	63	59	53
470	473	15	9:41:24	20	98	8	40	44	51	63	59	53
471	474	15	9:41:44	20	8577	8	40	44	52	63	59	52
472	475	15	9:42: 4	20	7574	8	40	43	53	64	59	52
473	476	15	9:42:24	20	4040	8	40	44	53	64	59	53
474	477	15	9:42:44	20	7371	8	42	44	53	65	59	53
475	478	15	9:43: 4	20	1713	8	42	45	53	66	60	53
476	479	15	9:43:24	20	2422	8	42	45	53	66	60	54
477	480	15	9:43:44	20	397	8	42	45	54	66	61	54
478	481	15	9:44: 4	20	7572	8	42	45	54	67	61	54
479	482	15	9:44:24	20	4945	8	42	45	54	67	61	55
480	483	15	9:44:44	20	8578	8	42	45	54	68	62	55
481	484	15	9:45: 4	20	1011	8	42	45	54	68	62	56
482	485	15	9:45:24	20	9893	8	42	45	54	68	63	56
483	486	15	9:45:44	20	6357	8	44	45	54	69	63	57
484	487	15	9:46: 4	20	5958	8	44	46	54	69	64	58
485	488	15	9:46:24	20	6351	8	44	46	55	70	64	58
486	489	15	9:46:44	20	8583	8	44	46	55	70	65	58
487	490	15	9:47: 4	20	9371	8	44	46	54	71	65	58
488	491	15	9:47:24	20	98	8	44	47	55	71	66	59
489	492	15	9:47:44	20	8578	8	44	47	55	71	66	59
490	493	15	9:48: 4	20	398	8	44	46	55	72	66	60
491	494	15	9:48:24	20	9190	8	44	47	55	71	67	61

It consists of one line of output per header (see example). The information listed, from left to right is: record number, position number day and time (hours: minutes, seconds), time increment (seconds) compressor manifold pressure (psi) gun depth (metres) and hydrophone array depths (feet). The time increment is calculated by the program as the difference between the times in successive headers. By scanning this column of times missed records can be spotted at a glance. It provides an independent check on position number, with which there remain some unsolved problems that prevent it from being used as an instant locator of missed records (see Appendix 2)

Third prompt:

List to terminal of file [T/F]?

This option allows the operator to send output to a file for later viewing or for printing. The alternative is to have the information flash across the screen as the program reads through the tape, allowing no second chance to see it without rewinding the tape and re-running the program. On the VT 100 terminals it is possible to use the "NO SCROLL" key to stop and start scrolling, thereby allowing oneself more time to digest information.

Fourth prompt:

Print Every 'N' header blocks with 'M' data scans? [n. m]

By typing '1' for 'N' the operator can choose to have output from every header block on the tape. Typing '2' instead would produce output from every other header block, typing '4' every fourth header block, and so on. Entering a value other than zero for M results in each header being followed by output of M scans from the associated data block.

Obtaining Print-out

1. In order to obtain print-out it is essential that file output be selected (by typing 'f' in response to the third prompt - see previous section).
2. Make sure the lineprinter is switched to "ON-LINE"
3. When the program ends type the following command:

   pip sercel. tmp/sp

   Printing should commence immediately.

```
Tape Number: 835

** SERCEL header information:

Record 218        Type=SHOT         Sample rate=4    2 Data Blocks   Fixed gain=4
                  No.Chans=48       Shot no.230      Ident    1540358 Tape no.13
                  Date 2-3-85       Delay 0          Filters-Lowcut OUT Notch OUT

** Extended header information:

Ship/cruise: DI154       Line: AMG 845 16          Type: NI

Position number: 221               Date: 1985 061 23:29:58
Array depths: 29 35 37 39 35 35 0 0 0 0
Gun depths: 3 0 0 0 0 0 0 0 0 0
Manifold pressure: 2115            Strain: 0
Anti-alias corner frequency: 77 Low-cut: 8       Roll-off: 36
Polarity: 1      Auxiliary gains: 1 1 1 1        Group separation: 50
Dist to 1st group: 309             Dist satnav-stern: 35
No. of depth sections: 6           Positions: 1 11 21 31 41 49
No. of birds: 6                    Positions: 1 11 21 31 41 49
No. of water-break hydrophones: 1          Positions: 1
Source: AIRGUNS           No. of guns: 4  Sizes: 300 160 40 20
Dist. to 1st gun: 36               Gun spacings: 203 1 0 0
Intended shot interval: 50                 Gun sync delay: 40
Record length: 8                   1st seismic block length: 3
Water brk time after gun sync: 215                Water speed: 5.0
Tail buoy bearing: 0    Ship's heading: 180      Intended course: 180

** SERCEL header information:

Record 227        Type=SHOT         Sample rate=4    2 Data Blocks   Fixed gain=4
                  No.Chans=48       Shot no.239      Ident    1540358 Tape no.13
                  Date 2-3-85       Delay 0          Filters-Lowcut OUT Notch OUT

** Extended header information:

Ship/cruise: DI154       Line: AMG 845 16          Type: NI

Position number: 230               Date: 1985 061 23:32:39
Array depths: 19 30 36 37 35 36 0 0 0 0
Gun depths: 3 0 0 0 0 0 0 0 0 0
Manifold pressure: 1930            Strain: 0
Anti-alias corner frequency: 77 Low-cut: 8       Roll-off: 36
Polarity: 1      Auxiliary gains: 1 1 1 1        Group separation: 50
Dist to 1st group: 309             Dist satnav-stern: 35
No. of depth sections: 6           Positions: 1 11 21 31 41 49
No. of birds: 6                    Positions: 1 11 21 31 41 49
No. of water-break hydrophones: 1          Positions: 1
Source: AIRGUNS           No. of guns: 4  Sizes: 300 160 40 20
Dist. to 1st gun: 36               Gun spacings: 203 1 0 0
Intended shot interval: 50                 Gun sync delay: 40
Record length: 8                   1st seismic block length: 3
Water brk time after gun sync: 215                Water speed: 5.0
Tail buoy bearing: 0    Ship's heading: 180      Intended course: 180

* SERCEL header information:
```

5. Unsolved problems

On cruise D154 it was discovered that the program was unable to cope with tapes which had been recorded with a first seismic block and a delay before the main block. This would seem to be due to the fact that such tapes contain a physical gap between the two seismic blocks. The problem is being studied by A.R. Lewis and it is hoped that it will be solved in the not too distant future.

Any sort of error on a tape causes MCDSAS to produce the prompt :

Enter 'exit' or 'continue'

Typing 'e' in response to this prompt will end the program. Type 'c' or simply press the RETURN key to continue. However, on every occasion the program detected an error on a D154 tape it was found that continuing only caused a re-occurrence of the "exit" or "continue" prompt. If file output was requested the file will have been written up to the point at which the error was detected.

Another program called "QDP" may enable problem tapes to be investigated further (see Shipborne Computer Group document "SCG/MCDSAS/01", section 2.2). No attempt was made to use this program on cruise D154.

Addendum

Gun depth (refers to page 33). Gun depths were measured using an open-ended air line attached to the umbilical and bleeding low-pressure air. The bleed pressure as measured in the line varied with the towing depth. Unfortunately the pressure drop outboard of the pressure sensor was significant, and the measurement was therefore flow-dependent. This dependence was reduced considerably by inserting a Venturi between source and sensor, but was still significant. The sensor could be crudely calibrated by lowering an identical air line with weight attached over the side with the ship stationary. Despite this, there were periods when the gun depth, as displayed in the plot (and written to the extended header) seemed very suspect, suggesting a non-linear drift of some kind. A more direct measurement of ambient pressure near the guns seems necessary.