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UNIVERSITY of LEICESTER
Department of Geology

R.R.S. CHARLES DARWIN

CRUISE REPORT 8/85

R.R.S. CHARLES DARWIN CRUISE 8-85

Dr. I. A. Hill

Geology Department
Leicester University
Leicester LE1 7RH

GEOPHYSICAL STUDIES OF THE CAPE VERDE ARCHIPELAGO

8th October to 12th November 1985

Mindelo, Cape Verde Islands

to

Funchal, Madeira

SUMMARY

This cruise forms part of a multidisciplinary geological investigation of the Cape Verde archipelago. Previous land studies have defined the geochemical nature of the island volcanism. The geophysical studies are aimed at determination of the structure of the island volcanic centres, the underlying oceanic crust and the upper mantle. The marine geophysical investigation was started on Shackleton cruise 83/1, but curtailed by industrial action.

The principal scientific aim of this cruise was to investigate the oceanic crustal structure around the islands, particularly with regard to flexure of the crust due to the loading effect of the islands. This required the collection of gravity, bathymetry, magnetic and seismic profiling data on a systematic grid enclosing the islands.

The cruise was beset by a series of problems. Firstly the seismic streamer was damaged on the previous cruise, and the supply of oil for repairs was critically short. Both compressors for the airgun supply failed while under test in port before the start of the cruise. Equally seriously several members of the ships company contracted dysentery in Mindelo. These combined problems led to an initial cruise leg of 10 days with no seismic capability, followed by a portcall to collect spares. Unfortunately as the ship docked, a generator control motor failed. Two sick crew members were hospitalised. Five days were lost in port before spare parts and replacement officers could be supplied to allow the ship to sail. Of the remaining scientific time, nearly all was spent in collecting seismic reflection data, mostly using the multichannel system.

Despite the problems the cruise has been surprisingly productive. While the seismic system was disabled, magnetic survey and a dredging program were progressed. The range of methods used on the cruise meant that with a little ingenuity, it was usually possible to perform useful work despite the technical breakdowns. 2150 km. of multichannel reflection data have been recorded, less than was planned, but hopefully sufficient to resolve the major objectives of the study. Magnetic survey has been about 70% completed, and the dredging programme also about 70% completed. After the portcall the cruise was blessed with very good weather conditions and few equipment failures. Details of the scientific achievements of the cruise are given in chapter 4.

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SHIPS COMPANY

OFFICERS

Master	G. Long
Mates	M. Putnam, B. Richardson, R. Chamberlain
Engineers	C. Storier, R. Hagger, G. Gimber(D. Anderson)
Elec. Eng.	P. Parker
R. O.	J. Baker

CREW

Bosun	R. Macdonald
Cook/Stew.	W. Hawkins
Seamen	P. Biggs, G. Crabb, D. Buffery, S. Francis, A. Quick
Stewards	D. Chattaway, C. Peters, J. Osborn
Cook	C. Hubbard
Motorman	M. Williams

LEICESTER SCIENTISTS

P.S.O.	Ian Hill
Scientists	Rob Young, Paul Hill, Jaafar Ali, Colin Cunningham, Gavin Ward, Neil Peake

RVS TECHNICIANS

Electronics	Steve Jones, Chris Paulson, Dave Booth
Mechanical	John Taylor, Russell Griffiths, Herbie Herbert
Computer	Ed Cooper, Robert Lloyd, Linton Wedlock

SCIENTIFIC OBJECTIVES

The long term purpose of the investigation of the Cape Vedre Islands is to provide information about the conditions within the mantle of the earth, at depths of 70 to several hundred kilometers, which give rise to intra-plate volcanic areas such as the Cape Verdes. This infromation is only obtainable by inference from measurments on the relavitely near surface rocks and structures. Particulat lines of study and itemised below in order of priority:

1) To investigate the thermal heating of the oceanic lithosphere by the activity of the Cape Verde Hotspot. This can be achieved by observing the "depth anomaly" of the oceanic crust and the "flexural rigidity". These studies require knowledge of the age of the ocean crust from magnetic anomaly dating, the sediment thicknesses from seismic reflection, and gravity field observations.

2) To determine the relationship between oceanic fracture zones and the position of volcanic centres. This requires a combination of magnetic field and seismic reflection data.

3) To complete an investigation of the geological structures underlying the shallow submarine ridge between the islands of Maio and Boa Vista

4) To investigate the local island structure in the vicinity of Fogo, the active volcanic centre.

5) To obtain dredged rock samples for geochemical analysis of volcanic rocks from outlying seamounts as well as the island volcanic centres.

6) To record sea-surface gravity data along a Seasat repeat orbit on the passage from the work area to Madeira to provide "ground truth" checking of satelite-derived grvity data.

7) To perform a magnetic survey to the southwest of the archipelago to investigate previous reports of strong lineated magnetic anomalies lying within the "Cretaceous Quiet Zone".

SCIENTIFIC NARRATIVE

Mindelo, Cape Verde Islands

The scientists, technicians and relief officers flew from Heathrow on Thursday 3rd October with SAA and after an overnight stop at Sal flew on to Mindelo with TACV. The ship arrived on the 5th. the handover period until the 8th was useful since there was a complete change of RVS technical personnel. The major problem was the breakdown of one of the compressors during the previous cruise. Spares arrived by airfreight on the 7th, but by this time tests had revealed similar faults in the second compressor.

During the period of the portcall some personnel, mostly from those who had stayed in the Porto Grande Hotel started to develop symptoms of dysentery. Most passed in a couple of days, but some people, particularly Taylor and Gimber had persistent symptoms. Also during the portcall the ships supply of freshwater was depleted, and it was essential to set tracks outside the 50 mile limit in order to make more water.

While further spares and advice were sought from Hamworthy (the manufacturers of the compressors), the ship sailed on time from Mindelo at 1000 on the 8th for a gravity and magnetic survey to the south-west of the islands. This survey had a low priority in scientific work, but was one task for which seismic data was not essential, and the survey was almost exclusively outside the 50 mile limit so that the evaporators could be run.

October 8th-11th (J.D. 281-284)

The ship sailed south in calm weather from San Vicente to a point to the southwest of the island of Fogo making bathymetric, magnetic and gravity measurements. At latitude 14 S the ship turned west to begin a series of tracks parallel to the spreading direction of the ocean crust to measure magnetic and gravity data. The magnetic anomalies studied are the young end of the M-sequence of anomalies and the margin of the Cretaceous quiet zone. Six parallel tracks were completed.

At this time there was still no definate news of arrival of spares in Mindelo, so it was decided to continue at sea and start the dredging programme. This would not be affected by the lack of seismic capability, and the eastern dredge sites were outside the 50 mile limit to allow more water to be made. It was decided to include a brief survey of the area around the island of Fogo "en passant".

Course was set to the north to perform a detailed bathymetric and magnetic survey around the island of Fogo.

October 12th (J.D. 285)

During the day the ship steamed a grid survey between the islands of Fogo and Brava. The objective was to investigate the likely geological connection between the two islands. Fogo is an active volcano, but Brava is currently experiencing seismicity indicative of volcanic events.

In the evening the ship headed to the southwest of Brava and a dredge site (D885/1) was selected on a steep southern slope of a bank rising to 1700 metres. The active weight dredge was rigged and deployed at 2228Z. The dredging operation seemed to proceed well, with several good "snatches" until the dredge snagged and a pull of 9 Tonnes was registered on the tensionmeter. On recovery the weak links were found to have parted and the dredge was lost.

A conventional pattern dredge was rigged and deployed at 0316Z on the 13th. This haul was successful in recovering samples of volcanic rock.

October 13th-16th (J.D. 286-289)

Course was set to the east to collect magnetic, bathymetry and gravity data on passage to the next dredge site. This was reached at 2300Z on the 13th. After an initial box survey over the seamount rising to 1500 metres depth, a dredge site was selected and three hauls were made on day 287. Hauls were generally small with little volcanic rock so operations were continued until a reasonable quantity of rock was obtained which would be suitable for geochemical analysis.

The pattern of fast passage between seamount dredge sites continued until day 289. Hauls were genreally small, except for dredge 885/5 which contained several hundred kilos of useful volcanic rock samples and blocks of conglomerate. On each dredge the standard pattern dredge buckets were deformed, on one occasion the welds on the mouth frame being broken. Two further dredges were lost. There appeared to be little consistency in the shear strength of the weak links used. Some hauls were ended after snatches over 6 Tonnes with the expectation that weak links would have sheared, only to find the dredge completely intact. On other occaisions the dredge was lost on what were apparently lesser snatches. On each occaision allowance was made for the varying weight of warp at that time.

October 17th-19th (J.D. 290-292)

Having completed a proportion of the dredging program, the objective was to arrive in Mindelo early on the morning of Friday 18th to take on board the spares for compressors and the supply of oil for the seismic streamer, which we were informed would be awaiting us. Gimber and Taylor had not recovered from the suspected dysentery and there was increasing concern over their health. Other personnel had recurring short bouts of the same symptoms.

The passage to Mindelo was arranged to incorporate a magnetic survey to determine the exact sequence of M-sequence anomalies to the north of the north-western islands.

October 19th-23rd (J.D. 292-296)

The ship arrived off Mindelo at about 1000Z and anchored off the main quay in the hope that the stores would be delivered by launch. By late morning it was arranged that the ship had to move to an alongside berth. The doctor who was requested to see Taylor and Gimber came aboard immediately the ship docked and took the two patients to the local hospital for observation. As the ship moved alongside a control motor in one of the generators burnt out. The ship was unable to sail because of the failure of one generator and the lack of a third engineer.

Arrangments were made to fly out spare parts for the generator and a relief engineer (D. Anderson), but this was not possible before Wednesday 23rd. The intervening period was spent alongside with the ships company being somewhat reluctant to eat ashore. The only good aspects of this wasted scientific time were that the spares for the compressors arrived and the compressors were returned to working condition, the oil for the seismic streamer was taken on board, and three days were spent in removing the seismic streamer from its drum and curing electrical faults along its length. These were mostly due to salt water ingress to sections damaged during the previous leg, where the punctures to the skin had been repaired, but residual salt water had migrated to electrical connectors and caused corrosion and short circuits.

October 23rd-27th (J.D. 296-300)

Eventually the relief engineer arrived at about 1800 on the 23rd and the ship sailed immediately. One lasting effect of the long stay in Mindelo was that the ship's water supply had reached a critically low level, and it was essential that the ship move outside the 50 mile limit from the islands so that the evaporators could be operated. It was possible to proceed directly to the start of the multichannel seismic lines, but since most of the multichannel lines lay within the island group, it was essential to stock up with fresh water before engaging on this part of the survey. This requirement dictated the exact scientific courses followed, and the ship made a circuitous route, staying 50 miles away from the islands, towards the start of the multichannel seismic profiling lines at DSDP Site 367.

Along these tracks single channel profiles were obtained, and the opportunity was taken to run-in the repaired compressors, and to experiment with gun deployment and array types. It was immediately discovered that the twin-channel seismic streamer had only the leading channel operative, and that the capstan used for deployment had no brake. The latter deficiency makes controlled deployment of the streamer very difficult. Although the airgun depth measurement system had been checked and calibrated with the ship stationary in Mindelo, the depths read from the system were suspiciously deep. The airgun array used for the multichannel work was of five guns 1000, 300, 300 with wsk, 40 and 40 cu. ins. This array was up to the theoretical maximum capacity of the compressors and in view of their past frailty it was considered unwise to overload them.

October 27th-29th (J.D. 300-302)

Single channel profiling ended at 14 N. 21 20'W. and the ship made a quick passage at full speed towards DSDP Site 367, slowing to begin deployment of the Multichannel streamer when 30 miles short of the required line.

Despite the work done on the streamer in Mindelo, the deployment was not a quick process. Further electrical faults were found during deployment and it was decided to correct them before commencing recording. This involved some time-consuming fault tracing but finally resulted in a completely functional streamer apart from channel 56, which had high leakage and was switched out, and an intermittent fault on the readout on depth sensor 2. With the streamer successfully deployed, a towing trial showed that it was well balanced and towing stably under control from the birds. Course was altered towards the start of the seismic line.

As airgun deployment started it was found that the electrical pressure sensors for the airgun supply, and the depth measurement had developed faults. Additionally several airguns failed to seal on initial deployment. With all these delays, the ship overran the start of the seismic line before the system was operational and it was necessary to make a large circle while these problems were overcome. Data recording started at 0130 on day 302.

October 29th-November 8th (J.D. 302-312)

Line 01 was recorded as a link between DSDP Sites 367 and 368 to provide a reference to which the remainder of the survey could be tied. The equipment worked well apart from Tape Deck "A" which was a continuing source of write errors, usually following insertion of a new tape. On one occasion one particular tape produced continuous errors from deck "A", and it was suspected that the tape was faulty. The tape was mounted on the level "C" shipboard computer where no faults were found. It was returned to stock and sucessfully recorded. The exact cause of the poor performance of deck "A" is not understood.

Considerable efforts were made to rig a far-field hydrophone. A working system (as described in chapter 3) was devised and recorded sucessfully for about 80% of the line mileage.

During the initial line the ship's engineers ran both evaporators and produced record amounts of water, such that by the time the ship entered the 50 mile limit again there was a sufficient supply to last throughout the remaining scientific time.

The seismic system proved much more robust and reliable than had been expected. It was used continuously for 10 days until all the scientific time had been exhausted. No fresh faults developed until several days had passed, and it was only on the last two days that any complete channels were lost, possibly as a result of a fish attack on the turn between lines 05 and 06. The quality of the data was good with the EPC display of channel 2 showing good penetration of the sedimentary section, low noise levels and considerable stratigraphic detail.

November 8th-12th (J.D. 312-316)

At 0230 the scientific time was exhausted and the multichannel system was retrieved. It was found that several sections had bad punctures in the form of jagged tears or neatly cicular holes which were attributed to fish attacks. As damaged sections were recovered they were drained of oil in the area around the holes so that the outer sheath could be repaired by welding, and the welded repairs securely taped over. Despite this proceedure at least one of the repairs burst under pressure on the winch drum. The recovery was completed by 1000, the process having been much delayed by the necessary repair work.

The ship immediately turned to a course of 023 at full speed and proceeded to Madeira. It had been arranged that the seismic line ended at a point on a SEASAT satellite track which could be followed towards Madeira. Gravity, magnetic and bathymetric measurements were made until 0800 on the 10th when the ship entered the 200 mile limit of the Canary Islands and scientific watches were discontinued. The data collected will be used to check on the free air gravity values calculated from the SEASAT altimeter data. The ship slowed briefly to recover the PES fish and magnetometer bottle then continued at full speed to Madeira, arriving off the coast in the early hours of the morning of the 12th, then moving alongside the quay at about 0900.

The Leiceter equipment was packed during the passage and stowed in Explosive store No. 1, to be left there for collection when the ship reaches a U.K. port.

EQUIPMENT PERFORMANCE

1. NAVIGATION

The Magnavox Satnav worked without faults, and seems to be a very good system, but it would be useful to have access to more data about the fixes, specifically the course and speed used to compute the fix, and the geometry of the fix (N,S and E,W). This information is necessary in order to adjust the fix position for incorrect speed and heading input.

The E.M. log failed early in the Cruise due to water ingress, and failed a second time soon after rewiring. The spar was deformed and it was written off until a replacement could be provided in Funchal. The doppler log was used as a substitute and worked well except for sudden apparent speed surges, probably due to large concentrations of plankton encountered south of 14 degrees N. It did develop an unexplained intermittent fault on the final passage to Madeira. With the E.M. log failure, and the inability of the data-logging system to interface to the Doppler log, there was no accurate log data for the second leg of the cruise. Approximate fore/aft speed data were recorded by connecting a voltage calibrator to the EM-log Level"A" interface and adjusting its value to give a value on the level "B" monitor which matched the Doppler log output. Heath Robinson was a great man.

It is important that the interfacing of the Doppler log be accomplished as quickly as possible, to provide a backup log system. Indeed it is argueable that the doppler log should be the primary log system for scientific navigation.

NNSS satellite navigation is inadequate for multichannel seismic aquisition. A high priority should be assigned to purchasing a GPS receiver.

2. SEISMIC SYSTEM

A) Compressors and Air supply.

The two Hamworthy compressors distinguished themselves by both failing while under test in Mindelo, before the Leicester party had moved aboard the ship. The fault, identical in both compressors, was in the third stage where the valves failed to seal. Eventually this fault was solved by the supply of replacement cylinders and valves for the third stage on both compressors. It is interesting that the fourth stages had already had a similar rebuild by Hamworthy engineers. It seems likely that there is a design fault that may be causing progressive faults in the various stages.

Because of this compressor failure it was not possible to do any seismic work in the first ten days at sea, before the spares were collected from Mindelo.

Once running, the compressors proved quite reliable though they did need constant attention because of the rapid build up of water in the humid conditions experienced, especially south of 14 degrees N. A rigid high pressure pipe developed a leak at a union and had to be replaced by a flexible one.

The seismic source is one of the weak points of the total system, and an increase in air capacity should be a priority. To obtain this it would be better to have more compressors of a similar size than to have bigger compressors. This would provide a more flexible and resilient system.

I suspect that the air supply lines to the A-frame distribution box are of too small diameter. It is noticable when trying to seal guns when deploying, that on opening the quarter turn valves with a static pressure of 500 psi, the pressure drops quickly to about 200 psi and takes over ten seconds to recover to 500 psi, even if the gun seals instantaneously. We had considerable trouble in persuading guns to seal during deployment and I suspect the constricted air supply is a major contributing factor to this. It is interesting that Graham Westbrook made similar comments after cruise 2/85.

The air supply box on the aft A-frame is very useful but has disadvantages when used with multiple guns. Because the lines used for air supply and venting are common to all guns, it is impossible to vent one failed gun while others are firing. Obviously such a modification would result in a more complex system, but providing it was well designed and labelled, I cannot believe it would be inherrently less safe. Such a modification is essential to allow maintenance of airgun arrays without interrupting data collection.

B) Airguns

The Bolt airguns worked well and proved reliable, as expected. Once the desired array was streamed and operating for the multichannel work, the 1500C guns worked continuously for 10 days, while the two 600B guns only had two failures, one due to an abraded hose. On recovery it was found that the 300 in. gun with waveshape kit had broken all of its firing seal springs, but was still sealing correctly.

The problems here are the unsatisfactory towing arrangements and limited range of chamber sizes. The 1000 cu. in. chambers are recognised to be inefficient, and chamber sizes between that and 300 cu. ins. are needed. There are many preferences for gun deployment, but most seem untidy. RVS should take the initiative and produce a subarray carrying three 1500C airguns and allowing flexibility of chamber sizes, with a single integrated towing/umbilical cable. The relatively small number of guns should make such an array manageable on the other ships less well endowed with aft deck space than Darwin. All the towing problems have been experienced and solved by the commercial contractors and it is important that their experience is tapped to produce an efficent, safe and economical solution to this problem.

C) Streamer

The teledyne streamer worked well, was relatively easy to deploy and was reliable. 40 hours were spent in fixing electrical faults during initial deployment, but once deployed it performed well. It was fortunate that the previous cruise had spent time balancing it for the local water conditions. Persistant faults were leakage on channel 56, and intermittent operation of depth sensor 2. Towards the end of the ten days of deployment three channels of data were lost completely, and the tail of the streamer started to tow rather deep and the bird depth settings had to be progressively altered.

On recovery, several sections were found to have serious splits or holes, all attributed to fish attack. These were repaired as well as possible by draining the sections and welding the splits, with patching where necessary. Despite this at least one repair burst under pressure on the winch drum. The streamer will need comprehensive maintenance before its next deployment.

D) Sercel system

The Sercel itself proved a reliable and easy to use device. The same cannot be said for the tape decks. Deck "A" provided a constant source of anxiety, and H32's. Deck "B" provided far fewer faults, mostly parity errors and synchro errors. Throughout our cruise the 5 v. supply for the tape switching unit was provided by two laboratory power supply units, one of them suspended with string from the deckhead. It somehow typifies the frailty of the tape deck situation. A spare tape deck with associated switching and power supply is essential as backup. If these decks are to continue in service a microswitch on the tape flap with a warning light on the case would be a useful reminder to watchkeepers.

On the preceeding cruise John Jones reported having trouble with 3M tapes instead of the RVS standard Memorex. We have used 150 3M tapes and have had no problems, although we have played safe and used most of them on deck "B". Checking of the Executive reports has reavealed that the 3M tapes may be associated with an increase in parity and synchro errors, but this has not been rigorously proved. Further detailed checking will be carried out.

It is highly undesirable that four parallel numbering systems are used for shotpoint and record numbering, these being the Shot Counter, BBC Position Number, Sercel Record Number and Event Log Number. Only the Position Number and Sercel Record Number are needed. The BBC should produce the Position Number to place in its extended header, and the event logger should read the Position Number and Sercel Record Number and log both against time and position. The shortcomings of the BBC software in terms of user-friendliness are highlighted by the problem of Position Numbers not incrementing, and the burying of often-updated variables in Menu 5, which should be directly accessible. Despite these criticisms the BBC header sytem will be very useful, when it is finished.

E) Twin channel streamer

Apart from the fact that channel two was u/s at the beginning of the cruise, and was never operational, this streamer worked well and provided good quality data. Its deployment from the capstan is not a good system, principally due to the lack of a brake and fine speed control on the capstan, but also due to the difficulty of obtaining a fair lead to the stern.

F) Hard copy display

The EPC's worked well and the EPC delay box was very useful. The batch of paper which was not EPC's own brand was unsatisfactory, giving highly variable grey scales across the page for a constant "contrast" setting. It was difficult to print a legible record without some areas being burnt. If this is an economy measure, it is not a satisfactory one.

G) Sonobuoys

The compact self-inflating units (Ultra SB109) were used. The radio ranges achieved were noticably less than those using the older pattern sonobuoys in the same area two years ago, even though the sea conditions for this present cruise were noticably calmer. The radio range is the limitation of these buoys since a good acoustic signal was obtained until radio reception was lost. We did not perform the gain modification to any of the buoys deployed.

I have difficulty understanding why RVS supply a sonobuoy system comprising sonobuoys, receiver, filters, tape-deck, EPC's but fail to provide a high-gain, well-sited aerial. I did not bring my own aerial on this cruise because I was told one would be supplied. I was not satisfied with the performance of the aerials fitted and suspect that they are a major factor in the poor ranges achieved by our sonobuoy lines.

Despite long and earnest consultation with the Mates and Master we could not devise a foolproof method for deciding from which side to deploy the sonobuoy when the multichannel array was towed. We lost three sonobuoys by collision with the tailbuoy. Some kind of simple launcher which could shoot the sonobuoys several tens of metres away from the ship would be very useful.

H) Far-field Hydrophone

This is an important part of any multi-gun array system for gun synchronisation and processing. A system was improvised by using the hydrophone from a disposable sonobuoy, deployed from the ORE fish towed from the Rex-Roth winch via the starboard A-frame. The signal was carried from the hydrophone to the wet lab by an armoured cable taped to the Rex-Roth wire. With this arrangement the hydrophone would tow at a depth of about 55 metres vertically below the gun array in a fore/aft direction, but offset about 4 metres outboard from the ship's starboard side. This arrangement is not ideal, but is adequate.

A much better system could be made from an old PDR fish, a suitable hydrophone, 150 metres of CTD wire and a small slip-ring winch. Most of these components are probably available at Barry.

3) MAGNETOMETER

The old Varian units worked well. The only loss of data was caused by noise in the inboard cable from Main Lab to Plot. For the latter part of the cruise data were collected by having the magnetometer electronics in the Main Lab and the chart recorder in the Plot. This is obviously unsatisfactory for watchkeeping.

Eventually a major source of noise was discovered to be the air blower fan motor for the seismic compressor compartment, to which the magnetometer inboard cable had been taped. The length of the inboard cable is likely to be a continuing source of poor signals. If the magnetometer is to run in the Plot then some preamp. in the Main lab. area will be necessary.

4) GRAVIMETER

The Lacoste-Romberg meter S.40 performed without any faults. Its drift was low and was well determined by the repeat occupation in Funchal. Details of all Base ties are in Appendix 3.

5) DATA LOGGING

The new computer system with level A/B/C units was very reliable and seemed to be efficient. There is a lack of documentation of exactly what is done to each data type in terms of sampling and especially filtering. This problem was highlighted when we tried to check the gravimeter performance by examining crossover errors. Distinct step functions were found in the processed free-air anomaly data, with amplitudes of 3 to 20 mgal. The source of these is the sudden change in course and heading at the time of satellite fixes introduced by the unsophisticated treatment of D.R. errors between fixes. The navigational computation is degrading the gravity data. We did suspect that the problem may be linked to the lack of an EM log for part of the cruise, but the problem occurs in all the navigation, regardless of the source of speed data. I find this navigational algorithm unacceptable and will recompute all navigation after the cruise. One impediment to doing this thoroughly is the lack of parameters of each satellite fix supplied by the MX1107 Satnav to the Level "A" (see comments in Navigation above).

This problem would have been discovered much earlier if there was a simple utility available to plot logged variables against time or distance for each 24 hour period. A linear plot is much easier to check for noise spikes and distortion in the data than the annotated track plots which are the only graphical output currently available. A program to plot fence diagrams along tracks was developed during the cruise.

The event logging facility for seismic shot points is a useful feature but should be enhanced (see comments under SERCEL system).

6) DREDGING

The coring warp was used in lieu of a dredging warp, and led via diverter sheaves to the aft A-frame. Its main characteristic was its relative lack of elasticity compared to the dredging cable.

The active weight dredge was tested on deck and appeared to work well, but was lost on the first deployment (see narrative Day 285). This was extremely regretable. After its loss, conventional pattern dredges were used, but often deformed and in one case the welds on the mouth frame broke. I remain convinced that the active weight principle is a great advance in dredge techniques.

Some trouble was experienced with the remote winch control units and their socket points on the after-deck. This appears to be the result of a system design problem which will need an early solution. It was esential to work from the Main Lab when dredging, the Plot being too remote from operations.

7) THE SHIP

In general I have been impressed by the facilities and comfort provided by the Darwin. I offer the following observations:

a) For our cruise the Plot turned out to be an airy and spacious watchkeeping area. However despite the sea state always being less than Force 3, two of the scientific watchkeepers were seasick. I would not like to use the plot for scientific watchkeeping in rough weather. The position of the Plot is very convenient for the PSO, but not for other scientists, for moving equipment, or for communication with operations on the afterdeck.

The installation of the SERCEL in the Plot is inconvenient for supplies of tapes, for testing the streamer, and for tuning the airgun array.

In my view the Plot should be used as just that, for plotting and analysing data, not as an electronics lab.

b) Before the cruise I only became aware of the restrictions imposed on use of the ship's evaporators within 50 nm. of land during a chance conversation. This was a serious logistic problem for this cruise, and will probably cause more trouble in other areas, particularly the Mediterranean. It would be sensible if PSO's were at least made aware of this constraint before cruises began.

c) The sharing of the main lab between electronics and airgun maintenance is clearly unsatisfactory. I repeat my request made during the Summer, that the Main lab be divided by a partition so that the port side can be kept as relativley clean working space. This would provide an analogue to the Rough Lab/ Wet Lab / Main Lab arrangement which worked so well on Shackleton.

The distribution of fixed equipment in the Main Lab (and also Plot) is irrational. The satnav repeater monitor, TV camera monitor, EM log repeater, gyro repeater and winch repeaters should be grouped closely together to form a natural centre for watchkeeping or operations on station. The present arrangement demonstrates the lack of planning in the layout of laboratory space.

d) The afterdeck is an excellent working area, and with the extremely good weather encountered on our cruise we experienced no water on deck. The mounting points in the deck are a great convenience. The large stern roller made deployment and recovery of the seismic streamers easy as well as reducing wear and tear on the streamers. The layout of the spaces at the stern to either side of the A-frame should be modified to ease deployment of airguns, and ideally should be capable of deploying arrays of guns.

I can see little advantage in the flush hatch since for all of our cruise it was an empty area with a guard rail around it. An easy, and all weather communication from the labs to the hold should be provided which will allow movement of cases of dimension 1 metre cubed.

e) There is no adequate visibility onto the afterdeck from the bridge. With the multichannel streamer winch in place the field of view of the video camera is very restricted. The rear conning position makes a good bicycle store. The safety problems of lack of rear vision might most easily be solved by additional cameras, one mounted on the A-frame looking forwards across the blind areas of the aft-looking ones. A workable rear conning position with a clear view of the afterdeck (above the emergency generator?) would be very useful for such operations as recovery of the multichannel streamer.

f) The floodlighting of the working decks is inadequate. I understand this deficiency is already well recognised.

SCIENTIFIC RESULTS

The scientific fortunes of the cruise varied from disastrous to good. The start was very depressing when the compressors were u/s, and the five lost days in Mindelo seriously damaged the scientific program. The necessitity of spending time more than 50 miles from land in order to make fresh water was a constant worry, and caused many tracks to be placed away from the optimum scientific position. The scientific results can best be described with reference to the cruise objectives listed on Page 1.2.

1) The investigation of the thermal anomaly.

The gravity and magnetic data collected during this cruise were less than anticipated because of the lost shiptime. However the magnetic data close to the islands completes most of the pre-cruise plans. The gravity data is more problematic. While the distribution of data is good, if restricted in quantity, there is a query about the quality of the navigational data for the second half of the cruise when the E.M. log was u/s. It is not yet clear whether this will degrade the corrections for the gravity data to a significant extent.

The quantity of single channel seismic data is much less than intended because of the compressor failures. Most tracks of the first ten days would have been profiled if the equipment had been servicable. The quality of the data which were recorded is however good. The multichannel seismic acquisition was a definite success. Despite problems during the deployment of the gear, the record quality is good and the reliability of the gear exceeded expectations. We were fortunate in having excellent weather conditions and that the streamer did not suffer from fish attack until the last seismic line.

The combination of the above data should allow accurate dating of all the ocean floor surrouding the archipelago, the determination of the "depth anomalies" in oceanic Layer 2 and the calculation of more precise flexure models. The seismic stratigraphy within the Tertiary sedimentary sequence on the seismic reflection records holds great promise of revealing the pattern of uplift of the Cape Verde Rise, and hence provide time constraints on the growth of the Hotspot. For such detailed analysis the multichannel data will have to be fully processed.

2) Relationship of volcanic centres and fracture zones.

Despite the lower quantity of data this objective should be attained with the combination of these and previous data. It has been possible to identify magnetic reversal anomalies very close to the islands and hence closely constrain the positions of possible fracture zones.

3) Investigation of the Maio-Boa Vista ridge.

This objective was a victim of the combination of the loss of time, and the requirement to spend time over 50 miles from land.

4) Investigation of the Fogo area.

This survey was completed, though with less seismic profiling than desired. The interpretation of the results is not immediately clear, but it is apparent that there is a topographic ridge connecting the islands of Fogo and Brava, passing through the Islas Secos. The significance of this ridge will be clearer after full interpretation of the gravity and magnetic data.

5) Rock Dredging.

This task was persued with vigour during the first ten days of the cruise while the seismic compressors were u/s. Sites were dredged on four seamounts and useful rock samples were obtained from at least one haul on each seamount. Hauls were however somewhat disappointing as regards the recovery of unaltered volcanic rock, except for one where over 100 kg. was recovered. These patchy results are probably a fair reflection of the difficulty of dredging in this type of terrain. Two further dredge sites to the northwest of the islands were not attempted.

Geochemical analysis of the samples will take a considerable time, but should be scientifically valuable whether they confirm the current expectation, or produce surprises.

6) Ground Truth gravity for a Seasat track.

Data was collected from 18 to 26 degrees North on passage to Funchal. Because of the lack of time the most desirable "repeat" track could not be used since it lay over a hundred miles to the west. The gravity data is slightly suspect because of the degraded quality of navigational data. Comparison of the collected data with that from Seasat has not yet been carried out.

7) Magnetic survey of the Cretaceous Quiet Zone.

This survey was completed in preference to those with higher scientific priority because it allowed the ship to make fresh water. The magnetic data show several lineations parallel to the "M" sequence anomalies but lying within the "Quiet zone". The origin of these anomalies as either genuine reversal features, or topographic effects has to be established by further detailed study of the data.

In summary, the multichannel seismic acquisition was sucessful, but all other objectives were victims of the series of problems which beset the cruise.

APPENDIX 1: CRUISE STATISTICS

	Days	hrs.	NM.	km.
Total Cruise length (8th Oct.-12th Nov.)	35	00	5047	9347
Days alongside (Mindelo)	5	10	....	....
Passage time (26 N. to Funchal)	2	00	400	741
Time lost to breakdowns	0	00	0000	0000
Total scientific time	27	11	4647	8606
Time on station (14 dredge hauls)	1	23	....	....
Underway Geophysics (Magnetics, Gravity, Bathymetry)	25	12	4647	8606
Single channel seismic	4	10	583	1080
Multichannel seismic	10	10	1168.6	2164
Time not available for seismic work (compressors u/s)	10	3		
Scientific downtime (multichannel streamer and airguns)	1	2		

APPENDIX 2: STATION LIST AND DREDGE SAMPLE DESCRIPTION

SONOBUOY STATIONS

No.	Day	Time	Lat.	Long.	Cse	Spd	EoR	Chan.
885/1	297	0959	15 38.7	25 26.9	193	5.7	1120	20
885/2	297	2212	14 31.5	25 45.6	185	5.7	2313	20
885/3	299	0401	13 59.3	23 18.7	090	5.9	0520	16
885/4	302	0436	12 31.6	20 02.3	310	4.9	0536	17
885/5	305	1012	17 30.6	21 53.3	274	5.0	1137	17
885/6	306	1930	16 04.1	23 45.8	191	5.1	1945	16
885/7	306	2004	16 01.0	23 46.5	192	4.9	2022	05
885/8	307	1625	14 21.6	24 09.5	186	5.0	1844	10
885/9	308	1902	15 29.8	24 35.2	009	5.1	2038	10
885/10	309	1334	15 43.5	23 13.6	087	5.1	1451	10
885/11	309	1455	15 43.6	23 06.8	087	5.0	1618	20
885/12	310	1653	16 11.3	21 32.0	283	4.9	1719	10
885/13	311	1656	16 40.8	23 32.3	294	5.0	1826	10

DREDGE STATIONS

No.	Day	Time	Lat.	Long.	Depth	Remarks
885/1	285	22/02	14 37.0	24 54.0	2500	Active weight lost.
885/1A	286	03/06	14 37.0	24 54.0	2500	Rock recovered
885/2	287	00/04	14 45.0	22 29.0	3100	Dredge empty
885/2A	287	06/10	14 45.0	22 29.0	3000	Rock recovered
885/2B	287	12/16	14 45.0	22 29.0	3200	Rock recovered
882/3	288	07/10	15 17.3	21 53.2	1300	Dredge lost
885/3A	288	11/12	15 17.4	21 53.2	1100	Rock recovered
885/4	288	13/16	15 18.2	21 50.4	1600	Rock recovered
885/5	288	17/19	15 18.7	21 50.6	850	Good rock recovery
885/6	289	11/14	17 05.5'	21 59.7'	2000	Dredge broken, few rocks
885/6A	289	14/16	17 06.2	21 59.3'	2000	Rock recovered
885/7	289	17/18	17 08.8	21 57.7'	600	Dredge haul small
885/7A	289	19/20	17 09.3	21 57.3'	380	Dredge haul small
885/8	289	20/22	17 07.7'	21 56.5'	900	Dredge lost

DREDGE RECOVERY - BRIEF DESCRIPTIONS.

885/1A Medium haul of altered balsltic rocks.

885/2A About 15 kg. of rock samples, all pillow rinds and hyaloclasites. Most very altered.

885/2B About 20 kg. of rock. One lange (400mm.) section of pillow rind cored with hyaloclasite. Other smaller samples of similar type

885/3A Large haul, but mainly of coral fragments and shells. Some oyster shells which may be of shallow water origin, and hence of interest. Some small blocks of altered basalts.

885/4 Some small altered basalt samples.

885/5 Large haul with 4 large blocks of basaltic rock greater than 500mm diameter, containing vesicles up to 3mm diameter. 16 further samples in the range 150-500mm of mixed basaltic and conglomeratic lithology. One bag of smaller fragments of similar lithology.

885/6A 2 basalt samples 150mm, and a few smaller fragments. Some solitary coral material.

885/7A Small haul of coral and shell debris with some small (50mm) basaltic samples.

APPENDIX 3: GRAVITY BASE STATION TIES AND DRIFT CALCULATIONS.

Drift of Lacoste-Romberg meter S.40:

Passage from Falmouth to Funchal = +0.07 mgal/day

1) Base at Funchal 29/8/85
   At bollard £18 on Commercial Pier using value:
   32 38.4'N 16 54.7'W = 979769.8 mgal.

   Meter reading = 8030.0
   Meter 3 metres below quay wall.
   g = 979769.8 + (3 x 0.3085)
   = 979770.7

2) Mindelo Base from MS6
   On main quay, established using two marine gravimeters
   = 978731.7 mgal.

   Meter reading = 06982.8
   Meter 2.2 m. below quay wall.
   g = 978731.7 + (2.2 x 0.3085)
   = 978732.4

   Drift Funchal - Mindelo:
   = Base at Funchal-(meter diff. x 0.9917)
   = 979770.7 - ((8030.0-6982.8) x 0.9917)
   = 978732.2
   Drift = 978732.4 - 978732.2
   = 0.2/39
   = - 0.005 mgal/day

3) Provisional Base tie at Funchal gives a total drift between Funchal readings of approx. -0.01 mgal/day.
   This is to be confirmed by Steve Jones after the Leicester party had left Funchal.

SEISMIC RECORDING FORMAT AND TAPE USAGE

Channels	48
Group interval	50 m.
Pop interval	50 m.
Nominal fold of cover	24
Nominal streamer depth	10 m.
Nominal gun depth	10 m.
Sample interval	4 msec.
Record format	SEGB, extended headers.
Record length	5 sec(Lines 1,2);6 sec(Lines 3,4,5,6)
Record delay	Variable 0-5 secs.
Filters:	
Anti-alias	77 Hz. 36dB/octave
Locut	8 Hz. 36 dB/octave
Notch	out.
Auxilliary channels:	
1	Waterbreak Hydrophone
2	Far field Hydrophone
3	Sonobuoys
4	Not used.

Tape Usage (1200ft. tapes at 1600 bpi NRZI):

Line No.	Tape Numbers.
01	001 - 146
02	147 - 198
03	199 - 303
04	304 - 353
05	354 - 443
06	444 - 529

2) ANALOGUE RECORDING (Store 4)

Item	Tape No.	Tp. count.	Remarks
SB01	1	0000-0396	
CSP	1	0397-2828	continues from SB01
SB02	1	2829-3375	
CSP	2	0000-0335	Precedes SB03
SB03	2	0336-1320	continues as CSP only
SB04	2	1356-1921	
CSP	2	1937-3400	CSP following SB04
CSP	3	0000-0030	Precedes SB05
SB06	3	0030-0344	SB06 lost on multichannel tailbuoy
SB07	3	0344-0551	SB07 lost on multichannel tailbuoy
SB08	3	0570-1886	
SB09	3	1921-2837	
SB10	4	0000-0745	
SB11	4	0789-1575	
SB12	4	1634-1881	SB12 lost on multichannel tailbuoy
SB13	4	1902-2759	

CHART ROLL INDEX

) PES Rolls

No.	Start Time	End Time
1	1100/281	2208/283
2	2210/283	0450/286
3	0452/286	1818/288
4	1818/288	0350/291
5	0354/291	0950/291
6	2020/296	2128/298
7	2135/298	1036/301
8	1040/301	0408/302
9	0418/302	2214/303
10	2216/303	1139/306
11	1142/306	2327/308
12	2330/308	0825/311
13	0828/311	2045/313
14	2047/313	0800/314

) Magnetometer Rolls.

No.	Start Time	End Time
1	1224/281	0430/284
2	0433/284	2132/285
3	0708/286	2318/286
4	1723/287	0700/288
5	1842/288	1046/289
6	2229/289	0900/291
7	2100/296	2022/297
8	2224/297	0904/300
9	0955/301	1712/301
10	1718/301	1600/304
11	1606/304	1624/307
12	1632/307	1100/310
13	1105/310	1609/312
14	1612/312	0800/314

3) Gravimeter Rolls.

No.	Start Time	End Time
1	1000/281	1412/282
2	1412/282	2336/283
3	2336/283	1334/285
4	1336/285	0336/287
5	0340/287	1410/288
6	1418/288	0447/290
7	0448/290	1307/291
8	2030/296	1006/298
9	1007/298	0042/300
10	0049/300	1403/301
11	1404/301	0055/303
12	0103/303	1555/304
13	1600/304	0625/306
14	0630/306	2118/307
15	2123/307	1030/309
16	1034/309	2150/310
17	2153/310	1018/312
18	1020/312	1930/312
19	1936/312	0800/314

4) EPC chart Rolls.

No.	Start Time	End Time	EPC No.	Sweep(s)
1	0003/297	0031/300	1	4
2	0003/297	0031/300	2	8
3	0003/297	0031/300	3	8
4	0003/297	0031/300	4	4
5	0200/302	1630/303	4	4
6	1630/302	1620/305	4	4
7	2231/308	0116/305	1	4
8	2231/308	0330/312	2	8
9	1625/305	0330/312	4	4
10	0156/312	0338/312	1	4
11	0145/302	2139/308	2	8
12	Sonobuoy Records		3	8

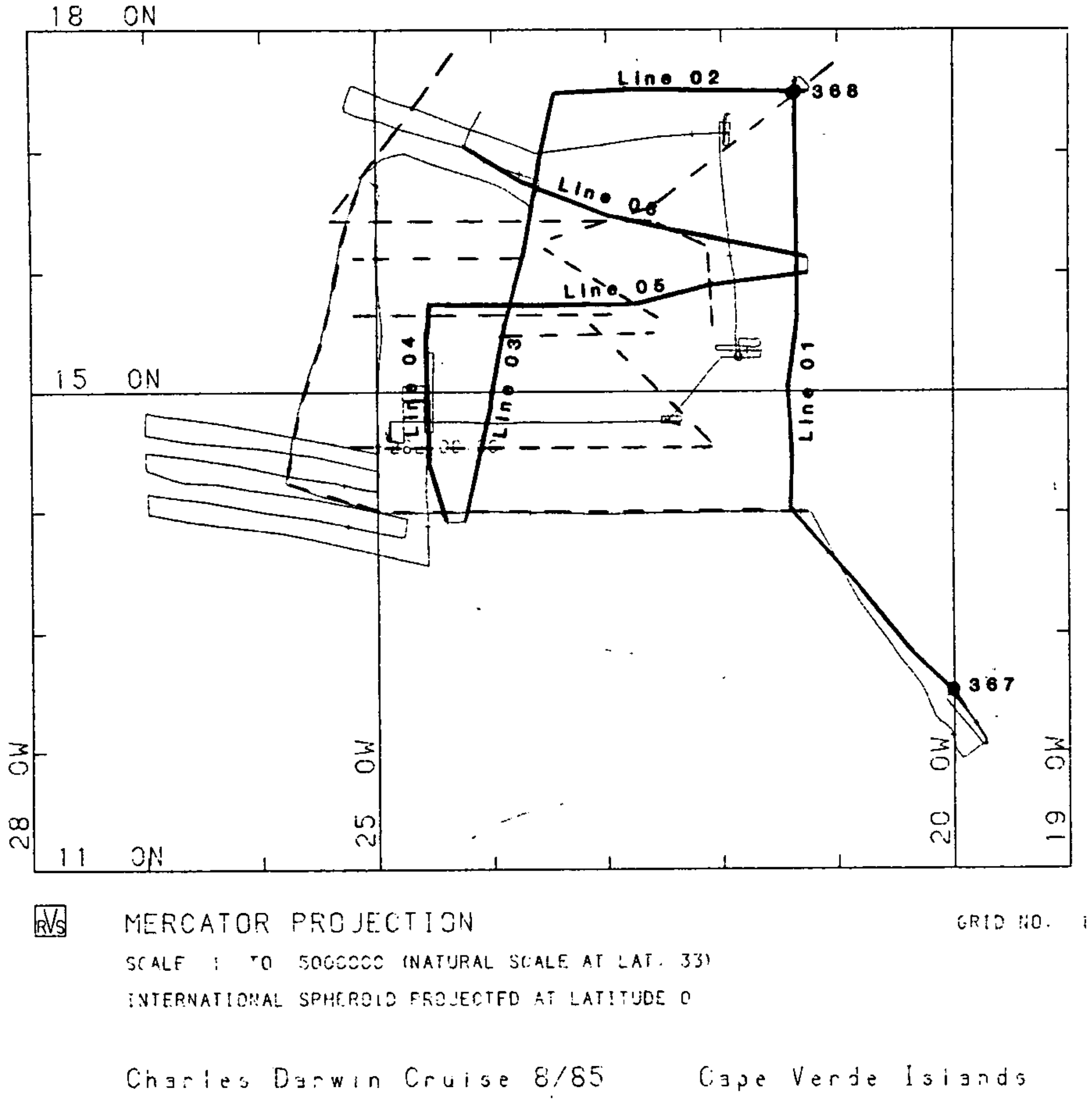

Figure 1. Seismic reflection Lines in the Cape Verdes area. (Multichannel lines solid: Single channel dashed: Line numbers refer to multichannel lines: 367, 368 are DSDP drill Sites).