I.O.S.

R.R.S. DISCOVERY

CRUISE 101

10 APRIL – 6 MAY 1979

GEOPHYSICAL INVESTIGATIONS IN THE SW INDIAN OCEAN AND AROUND THE NORTHERN MASCARENE PLATEAU

CRUISE REPORT NO 94

1980

INSTITUTE OF OCEANOGRAPHIC SCIENCES

NATURAL ENVIRONMENT RESEARCH COUNCIL

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On citing this report in a bibliography the reference should be followed by the words UNPUBLISHED MANUSCRIPT.

R.R.S. DISCOVERY CRUISE 101

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Geophysical Investigations in the SW Indian Ocean and around the Northern Mascarene Plateau

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Institute of Oceanographic Sciences,
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DATES

Departed Cape Town - 10 April, 1979

Arrived Port Victoria - 6 May, 1979

SCIENTIFIC PERSONNEL

D.G. Roberts	(Principal Scientist).	IOS
M.L. Somers		IOS
D.G. Bishop		IOS
J. Langford		IOS
R.B. Kidd		IOS
D. Masson		IOS
C. Flewellen		IOS
B. Barrow		IOS
G. Rothwell		IOS
C. Jacobs		IOS
P. Hunter		IOS
A.R. Stubbs		IOS
A. Gray		IOS
B. Knowles		IOS
P.R. Miles		IOS
M. Beney		RVS
S. Jones		RVS
T. Colvin		RVS

SHIP'S OFFICERS

M. Harding	Master
D. Norden	Chief Officer
J. Seymour	Second Officer
G. Harries	Third Officer
A. Coombes	Chief Engineer
N. Wilson da Rose	Second Engineer
J. Richardson	Third Engineer
D. Hornsby	Fourth Engineer
L. Wilson	Electrical Officer
T. Stevenson	Radio Officer
R. Gridland	Purser/Catering Officer
A. Greenham	Junior Engineer
R. Owens	Junior Engineer

SUMMARY OF CRUISE INTENTIONS

Following the successful application of the long-range side-scan sonar (GLORIA Mk II) to studies of the continental margins off north western Europe during R.R.S. Discovery Cruises 84 and 90, it was planned to make a study of selected margins of the western Indian Ocean utilising the technique of producing sonograph mosaics of substantial areas with acquisition and preliminary interpretation of bathymetric, gravity, magnetic and seismic reflection measurements. It was planned to concentrate the main effort of the cruise in the vicinity of the Mascarene Plateau but, en route to this area, to examine the continental margin off South Africa, and the southern part of the Transkei and Mozambique Basins. The principal objectives in each of these areas were as follows:

(a) The Mascarene Plateau, Mascarene Basin and Amirantes Ridge and Trench

The northern part of the Mascarene Plateau or Seychelles Bank is underlain by Pre-Cambrian granites and is considered to be a microcontinent thus bearing in some measure a similarity to the Rockall Plateau that has been studied in detail by IOS. In the northwest, the Seychelles Bank is adjoined by the arcuate Amirantes Ridge and Trench of enigmatic origin but considered by some to be an inactive subduction complex. Between the Amirantes Ridge and the Farquahar group of atolls lies the Amirantes Passage through which Antarctic Bottom water flows into the Somali Basin. Studies in the Amirantes Passage by Woods Hole Oceanographic Institution have demonstrated active erosion of the sediments by this flow.

Prior to this cruise, the only available geological and geophysical data were collected during the international Indian Ocean Expedition or during the study of the Amirantes Passage made by Woods Hole Oceanographic Institution. The principal objectives of the survey were twofold:

1. To examine the structure of the margins of the Seychelles Bank and their relationship to the structure of the Amirantes Ridge and Trench.
2. To examine the distribution of erosional channels and bedforms in the Amirantes Passage and to obtain a number of cores at selected points on these features.
3. To examine the influence of sedimentary processes on the morphology of the margins of the Seychelles Bank.

(b) Continental Margin off South Africa

To optimise on the transit to the Mascarene Plateau, it was intended to occupy

a GLORIA traverse between Cape Agulhas and Port Elizabeth parallel to the long Agulhas Fracture Zone that strongly influences the morphology of the margin. Specific objectives of the traverse included an examination of any structures related to the fracture zone that might be present and observations of bedforms on the slope produced by the Agulhas Current. It was also intended to examine the distal parts of the Zambezi Fan using GLORIA and seismic reflection profiles whilst in transit across the Transkei Basin.

The programme of studies outlined above was to be made using GLORIA, multichannel seismic reflection profiles, 2 kHz seismic profiles, gravity and magnetic measurements. Disposable sonobuoys would also be used to obtain velocity data in the thicker sedimentary sequences and short range sonar data would be obtained wherever possible.

OTHER PROJECTS

1. Seismic signal processing and digital recording of multichannel seismic data

It was planned to generate random seismic pulses using the 2 kHz profiler and 5 cu. in. airgun to test the feasibility of improving the resolution of the seismic system. It was also planned to continue development of the digital data logging system for the multichannel seismic data during the cruise.

2. Short-range sonar

A series of torque tests were planned to aid in the design of a new azimuthmeter.

NARRATIVE

The scientific party arrived in Cape Town on 4th April, well in advance of the sailing date to fit out Discovery for the leg to the Seychelles. Between 5th and 8th April, the scientific party were fully occupied in loading the ship for cruises 101 and 102 from containers shipped out from the U.K. No help was provided by the crew because of a singularly ill advised decision by the Chief Officer to give them leave until the day before sailing. To avoid delaying the sailing date the scientific party loaded the ship unaided for these two cruises with obvious attendant safety risks. Even on 9th April, little help was available from the crew who were largely occupied in loading stores. It is strongly recommended that port and starboard watches in port are kept by the crew to assist the scientific party when it is necessary to load large quantities of equipment.

R.R.S. Discovery finally sailed from Cape Town at 1215Z (100) delayed by some 3½ hours because of the late arrival of a corer and 2 kHz pulse generator. At

1540Z (100) the PDR fish and side-scan sonar pod were deployed and between 1612Z and 1900Z torque tests were made on the side-scan sonar. During this period the hydrophone drum was mounted on the capstan. At 1900Z (100) passage was resumed although data logging was delayed until 2338Z by tripping of the air conditioning system in the computer room. Moderately rough seas prevailed overnight and the side-scan sonar pod rotated at 0321Z. After adjustments to the sonar pod, Discovery continued southward to cross the shelf break south of Cape Agulhas. At 1230Z (101) course was altered to 111° and at 1337Z speed was reduced to deploy GLORIA. Deployment was complete at 1347Z and shortly afterwards the magnetometer and multichannel airgun system were deployed. GLORIA transmissions began at 1600Z and we commenced a GLORIA traverse parallel to the ENE-WSW trending Agulhas Fracture Zone that controls the linear margin off South Africa. Persistent problems with the magnetometer were apparently caused by a faulty plug and high temperatures in the plot, but these faults were cleared up by 2200Z. At 2003Z we altered course to 071° to parallel the slope and examine structural features and any bedforms that might be associated with the Agulhas current. At 0602Z (102) a fault developed on the starboard transmission of GLORIA and at 0500Z transmissions to starboard were stopped to trace the fault. Logging of magnetic data started at 0806 and 2 kHz profiling using the new transmitter began at 0841Z. GLORIA starboard transmission were resumed to port at 0930 and to starboard at 1100Z, the fault having been traced to a faulty plug socket. However, white dot and white band interference remained troublesome. At 1310Z (102), course was altered to 041° to cross the upper part of the slope. Airgun seismic profiler quality deteriorated throughout the day and the array was recovered at 1840Z. The fault was traced to broken wires in channel 2 and a break in the decklead to channel 3. During the day, the side-scan sonar began to lose oil at 10 litres a day. Our progress during the day was considerably hampered by the Agulhas current - speeds of 4 knots were calculated from the navigation data at one point. Despite the intermittency of GLORIA, the GLORIA mosaic of the slope showed evidence of linear basement ledges as well as abundant linear bedforms oriented parallel to the foot of the slope. A large submarine slide was observed on the slope to the south of Port Elizabeth. At 0200Z (103) seismic profiling (airgun and 2 kHz) began again and course was altered eastward to cross the Cape Basin and Mozambique Ridge. At 0410Z, the side-scan sonar system was shut down to conserve oil and IOS was advised of the problem. Throughout the dull and overcast day, excellent seismic results were obtained that included a particularly good traverse of the Zambezi fan in the

Transkei Basin. The first flying fishes were sighted in the afternoon and a wandering albatross kept company with us for several hours. Throughout day 104 we continued eastward across the Transkei Basin and observed lava flows on the seismic records. The sonar continued to lose oil at about 15 litres per day. Overnight (103/104) we continued our traverse of the Transkei Basin slowly passing over the western margin of the Mozambique Ridge; spectacular sediment waves associated with erosion down to basement were observed. At 0930Z (105) there was a complete failure of the ship's propulsion and electrical system. Power was not regained until 0950 during which time GLORIA sank to 950 ft. The only damage was to the depth sensor in the hydrophone. The power failure was caused by a faulty resistance. To guard against further failures an ancillary generator was kept switched on. At 1454 (105) computer logging was restarted following a much delayed satellite fix. At 0033Z (106), an eye in the airgun towing bridle failed but was repaired by 0120Z. At 0642Z (106), after passing over a very prominent series of eroded waves east of the Mozambique Ridge, speed was reduced to recover all geophysical gear. For the period 0748-0801Z (106) Discovery lay to allow the engineers to replace the resistance control on the main propulsion. At 0801Z, the sonar pod was retracted and the magnetometer and 2 kHz hydrophone streamed at 0836 and 0842Z and speed was increased to full ahead. At full speed, however, heavy thrumming of the PDR fish was observed. The PDR fish was therefore brought aboard for repairs at 1140Z when we switched to the hull transducer. Speed was then increased again for our traverse around Madagascar towards the Mascarene Plateau. Excellent penetration of 75-100m was obtained with the 2 kHz profiler at speeds of 13 knots. During day 107, we traversed the Madagascar Ridge occupying a gravity profile across the seismic refraction profiles occupied by Scripps and Cambridge. Between 0724 and 0900Z (107) we steamed at various engine speeds to enable the engines to be balanced. At 1418Z (108) the traverse of the Madagascar Ridge was completed and we set course 014° for Bardin Seamount. At 0558Z (109), the 2 kHz hydrophone was lost apparently because of failure of the lead-in joint. We continued northwards throughout day 109 recording only magnetic, PES and gravity data. At 0600Z (110) the magnetometer became very noisy and was brought onboard at 0701 when we also reduced speed to tension the new main warp placed onboard in Cape Town. The opportunity was also taken to test the new dynamometer system. About 8827m of wire was paid out before hauling in to retrieve the warp and drouge at 1152Z; the warp stretched by 135m. The opportunity was taken to stream the multichannel hydrophone to calibrate the depth sensors. At 1354Z (110) the magnetometer was

streamed and speed was increasedto 13 knots. At 1730Z (110) the computer failed due to a typewriter malfunction and was not brought on line until 1942Z (110). Passage to the Amirantes area continued and at 1346Z (111), we crossed Bardin Seamount altering course northward to make the Amirantes Passage. Throughout day 112, high temperatures in the labs proved a problem resulting in malfunctioning of the magnetometer and Micronova. At 0930Z (112) we reduced speed to stream the PDR fish which had been fitted with a spoiler. The new arrangement proved very effective and eliminated thrumming at speeds of up to 13 knots. At 1100Z (112) we arrived in the Amirantes Passage area and between 1102Z (112) and 0306Z (113), core stations 10005 to 10007 were occupied in a traverse of the Amirantes Passage. The core taken at station 10005 yielded Maestrichtian sediments. Whilst on station 10005, the ship's doctor caught a small shark. Two small squid were also caught at night and were preserved in formalin.

On completion of station 10007, an attempt to lower the sonar at 0331 (113) failed and it remained retracted for the remainder of the cruise. At 0353Z (113), we reduced speed to commence deployment of GLORIA, the multichannel seismic system and magnetometer. The airgun was deployed with a weight of 180 lbs attached to the clamps. All outboard gear was deployed at 0557Z when speed was increased to 8 knots. At 0945Z and again at 1736Z (113), the airgun failed due to air leakage caused by the chain. After the second leakage, the weight was removed and profiling continued thereafter without major interruption. The first traverse across the Amirantes Passage yielded echoes at maximum range to both port and starboard and clearly showed the linear ridges reported by Atlantis II. Between 1136Z (113) and 0141Z (113) a series of traverses of the Amirantes Ridge and Amirantes Passage were made. The seismic profiles showed little evidence in support of the Amirantes Ridge and Trench being a subduction complex. At 0141Z (115), we altered course to 061° to complete a transit to the Seychelles Bank via Amirantes Ridge. The Amirantes Ridge was crossed at 1600Z and at 2010Z course was set to 034° to make the Seychelles Bank. Sonobuoy station 10018 was occupied between 0705 and 0900Z (116). During our transit from the Amirantes Ridge to the Seychelles Bank, remarkably little penetration was observed on the seismic records. A reduction in speed to 6 knots to assess the effects of noise did not result in improved penetration. The effective range of GLORIA was also markedly reduced in this basin presumably due to different propagation conditions. At 1519Z (116), an attempt was made to ripple fire the small 5 in^3 airgun which failed because of poor towing arrangements and gun failure. At 0325Z (117) we altered course parallel to the south margin of the Seychelles Bank and southward again at 0450Z (117).

Two sonobuoys launched at station 10009 between 0555Z and 0654Z (117) failed due to entanglement of the hydrophones and weak signals. At 1100Z (117), speed was reduced to recover the multichannel hydrophone. On recovery, the hydrophone was found to be severely twisted, the tail rope had unravelled and the tail buoy was partly filled with water. A 4-inch split was also found in one section. At 1222Z (117) the IOS array was streamed and speed was increased to 9 knots for a return traverse across the Mascarene Basin. Sonobuoy Station 10010 was successfully occupied between 1436 and 1600Z (117). We continued southwestward across the Mascarene Basin overnight. At 0953Z (118) the compressor air line jammed and at 1157Z the airgun started to leak. To avoid losing critical data on the Amirantes Ridge, we circled back to our original position pending repairs to the airgun which were completed at 1458Z when course was resumed. At 2158Z (118) course was altered to 340° to begin a return traverse across the Amirantes Trench. At 0234Z however, the airgun again became intermittent and finally failed at 0415Z. Although repairs were completed by 0533Z, the airgun subsequently failed at 0921Z, 1049Z and 1455Z (119). Between 1622Z and 1743Z, sonobuoy station 10011 was occupied on the Amirantes Ridge. Airgun repairs were finally completed at 2024Z shortly before beginning a further traverse across the west flank of the Amirantes Ridge. The cause of the repeated airgun failures was uncertain. At 2230Z, we passed within radar range of Alphonse Island on the crest of the Amirantes Ridge. At 0044Z (120) the compressors tripped due to a blown fuse and were not brought back on line till 0223Z (amperage less than specified by the manufacturer) although profiling was further delayed until 0457Z because of an airgun failure. On completion of the airgun repairs, sonobuoy station 10012 was occupied in the Amirantes Trench between 0558Z and 0718Z (120). At 0826Z, we altered course to 045°T to cross the sill connecting Alphonse Island and the main Amirantes Group. The traverse revealed evidence of buried reefs as well as active sediment movement across the sill. At 1046Z (120) Discovery passed through a tide rip of breaking waves oriented 020-200°T to overlap one of our earlier traverses of the Mascarene Basin. This northeastward traverse showed a steady northward thickening of sediments towards the Seychelles Bank with hints of fault blocks at depth. Between 1336Z and 1800Z (121) we saw Mahe Island in the distance before altering course at 1800Z to run northwestward parallel to the margin of the Seychelles Bank. Between 1817Z and 1830Z (121) the D.C. compressor failed. We continued our northwestward traverse overnight crossing a series of box shaped canyons and occupying en route sonobuoy station 10013 between 0600Z and 0830Z (122). In the early afternoon, we passed

within sight of African Island, the northernmost member of the Amirantes Group. This traverse across the northernmost part of the Amirantes Ridge was completed at 1325Z (122), when we altered course northeastward to begin a series of traverses across the northwest margin of the Seychelles Bank. Between 1400Z and 1700Z (122) the 5 in^3 airgun was tested for signal processing studies. These studies were completed at 1720Z when speed was increased to 9 knots. Traverses across the northwest margin of the Seychelles continued without incident throughout the day (123) and revealed a striking series of NNW trending ridges and troughs. At 0830Z (124) all GLORIA amplifiers tripped and did so again at 1425Z. Repeated attempts to execute repairs failed and the fault was traced by the morning of day 125 to overheating in the GLORIA Portakabin. For the remaining period of the cruise a series of traverses were made of the northeast margin of the Amirantes Ridge until 1152Z (125) when speed was reduced to recover the geophysical gear. All gear, except the magnetometer was recovered and at 1237Z when course was set for Mahe, Seychelles. Watchkeeping of gravity, magnetics, PDR and side-scan sonar (deployed for the traverse across the Seychelles Bank) continued until 0500Z (126). During the passage to Port Victoria, the spare GLORIA cable was broken out and the old cable wound off the GLORIA davit. Discovery docked Mahe, Seychelles at 0930 LT Day 126.

This was a most successful cruise. Approximately 3800 mls of good quality GLORIA and seismic profiles were occupied as well as a number of sonobuoy and core stations. The most persistent problem was caused by the poor functioning of the ship's air conditioning equipment which resulted in uncomfortable conditions in the laboratories and the occasional overheating of several items of equipment.

It is a pleasure for me to record my thanks and appreciation for the support and help of Captain M. Harding, the officers and crew. In particular, I would like to thank the scientific party for their hard work at sea.

D.G.R.

PROJECT REPORTS

1. The Mascarene Plateau, Mascarene Basin, Amirantes Ridge and Trench

The region between 3 ^{o}S and 10 ^{o}S, and 56 ^{o}E and 52 ^{o}E was surveyed during the latter part of the cruise. Available bathymetric data included charts from the TOE Atlas and unpublished charts for the Amirantes Passage prepared by D. Johnson of Woods Hole Oceanographic Institution and made available for the cruise. Survey tracks were chosen to run parallel to the margins of the Seychelles Bank and oblique to both the Amirantes Ridge and Trench and features the Amirantes Passage.

Within the Amirantes Passage, a number of unexpected features were found. Much of the 'basement' topography, here thinly mantled by sediments because of erosion by Antarctic Bottom Water, as dominated by linear ENE-WSW ridges lying orthogonal to a more closely spaced set of ridges resembling the topography of a mid-ocean ridge. In the northern part of the passage, the sediment cover becomes thicker often accumulating in the lee of the more prominent ridges. These trends bear no obvious relation to the Farquhar group to the west but seem to terminate at the Amirantes Ridge. The seismic profiles across the Amirantes Trench and Ridge do not show any immediately obvious thrusting that would otherwise indicate it might be a fossil subduction complex. To the north, the Amirantes Ridge and Trench merge with a series of Northerly trending ridges and troughs off the northwest margin of the Seychelles Bank. The Southern margin of the Seychelles Bank is remarkably linear and may be a fossil transform fault although a more detailed analysis of the data will be required to confirm this speculation. Sediments within the basin between Amirantes Ridge and Seychelles Bank average 1 to 1.5 seconds - thickness, and rest on a flat lying basement of equivocal origin.

D.G.R.

2. Continental Margin off South Africa

A GLORIA traverse was occupied parallel to the continental slope off South Africa between Cape Agulhas and Port Elizabeth. Basement trends typically parallel the NE-SW trend of the Agulhas Fracture Zone. At the foot of the slope, sediments were typically thin or absent or comprised thin highly reflective (condensed) sequences. Several prominent sediment drifts were observed as well as a large slump feature off Port Elizabeth. Within the Transkei Basin distal lobes of the Zambezi fan were crossed at several points and were revealed on the GLORIA sonographs as distinctive changes in scattering and in the 2 kHz profiles by a distinctive microtopography. Prominent migrating sediment waves often associated with erosion were observed on either side of the Mozambique Ridge.

D.G.R.

3. Sediment Coring

A 24-hour period was to be devoted to sediment sampling in the Amirantes Passage. Since this was to occur prior to any profiling in the area by 'Discovery', sampling sites necessarily had to be chosen based upon previous WHOI surveys (1).

Johnson & Damuth's sediment facies map based upon 3.5 kHz profiling records (2) depicts three 'widespread' facies that we could hope to identify and trace specially using GLORIA and 2 kHz high resolution profiling. These are:

(a) stratified channel deposits

(b) sediment wave fields - here it might be possible to recover cores from wave crest and wave trough locations.

(c) background pelagic sediments, likely to be above the local CCD and possibly less influenced by bottom water flow.

The aim was to recover a representative sample for each of these facies.

A single core head loaded with 4 lead weights was rigged for the Calvert 10 cm diameter stainless steel corer. Two 2 metre length barrels and two 3 metre length barrels were prepared each with liner, cutter and catcher rigged. This would allow rapid changing of barrels, so reducing 'turnaround' time: up to six coring attempts might be necessary in water depths of 3500-4500 metres and transit time between sites needed to be allowed for. One of the 2 metre barrels could be rigged with the Southampton-design core catcher whereas the others relied upon conventional finger-type catchers supported by plastic 'skirts'.

Coring operations began at 1300, Sunday 22nd April and terminated 0800 the next day. The three sites lay on an east-west transect at around latitude 09°30'S (Table).

Station 10005 was occupied above a topographic high that stands between the "Western" and "52°20'" channels. A 2 metre barrel was used fitted with the Southampton catcher.

On recovery it was found that both the core catcher and corehead valve compartment contained sample but that the barrel contained no sediment core. The core catcher sample contained an 11 x 7 x 3 cm manganese nodule broken to reveal a 0.5 cm thick crust over a creamy yellow and black interior sediment. Smear slides show this interior sediment to be altered tephra with manganese oxide granules. This manganese nodule was associated in the catcher with over 40 small pieces of manganese crust of punice. The sample from the corehead contained three complete but smaller manganese nodules, about 12 pieces of manganese crust or altered tephra and up to 30 pieces of stiff white nanno ooze/chalk. The ooze/chalk is clearly Quaternary and probably Recent, based upon nannofossil and foraminiferal assemblages. However, smear slides of the altered zeolitic tephra show that its carbonate is recrystalised making nannofossil identification impossible. Globorotalid type foraminifera were washed from the tephra which will require accurate identification but are possibly upper Cretaceous in age.

Since it was clear that the corer had obviously encountered a 'hardground', this sample was considered the best we were likely to get at this site.

Station 10006 was located above the centre of the Western Channel. Again the 3 metre barrel with Southampton core catcher was used now fitted with a new plastic valve unit.

No outer barrel sediment smear was visible on recovery and much water and sediment was lost from the top of the core because of the necessity to lay the core on deck. (This was due to restricted movement of the crane - now unable to reach the steps to the next deck up) Nevertheless, a core 105 cm long was retrieved in the plastic liner and capped. The core catcher sample also contains about 10 cm of core that was extruded from the base of the liner tube during capping.

This core was subsequently split in the shipboard laboratory into 'working' and archive half sections. It contains a soft to firm undisturbed sediment sequence of silicious foram. nanno ooze. The only structural changes downcore are variations in the amount of bioturbation (mostly Zoophycos-type burrowing). Lithologic changes reflect changes in the amounts of coarse fractions; this mostly foraminifera, radiolarians and diatomis.

This is clearly a current winnowed pelagic sediment, the silicious fossil content reflecting the equatorial high productivity zone and also, perhaps, local upwelling in the sill region. Smear slide analysis shows that the detrital terrigenous sediment component is particularly low. Nannofossil and foraminiferal identification suggest that the section is entirely Quaternary with possible Pleistocene at the base. Reworked overgrown Tertiary discoaters occur in trace amounts.

Station 10007 was chosen to examine the sediment wave field thought to exist to the west of the Western Channel (2). The echo sounder approach showed isolated small hummocks but no large-scale sediment waves (subsequently GLORIA - coverage confirmed a restricted area of small-scale waves). Without transponder navigated coring it clearly would not be possible to locate cores on separate wave crests and troughs.

Two attempts were made to obtain a sample over this site. The first was with the 3 m barrel and finger type core-catcher. Here sediment had obviously entered the barrel but had not been retained since the top valve seating had shattered around its edge destroying the seal. The fingers of the core catcher had been turned inside out by the rush downwards of sediment and water.

The second attempt with a refurbished valve unit, a 2 metre barrel and a

finger-type core catcher was also unsuccessful except for a small amount of fine pelagic sediment in the plastic catcher shirt. The core cutter edge had been dented but there was no evidence of significant penetration. Freefall distance, height of pinger off bottom and wire out all suggest that the corer should have penetrated. Our conclusion was that it had failed to penetrate a sandy lag deposit or another hardground.

This station was abandoned because of the above possibility and likely further damage to coring equipment. No time was available to locate and make an attempt at another site.

References

(1) DAMUTH, J.E. & JOHNSON, D.A. The Amirantes Passage in the Western Indian Ocean: I Physiography, Microtopography and Regional Sediment Distribution. Marine Geology (In press).

(2) JOHNSON, D.A. & DAMUTH, J.E. The Amirantes Passage in the Western Indian Ocean: II. Modern Deep Thermohaline Flow and Current-Controlled Sedimentation. Marine Geology (In press).

R.B.K.

4. GLORIA Operations

The vehicle was launched at 1300 GMT on Day 101 after the usual system checks, but because of the depth of water and the need to vary speed for the seismic hydrophone tests not all the cable was veered until 1600. As soon as the system was fully deployed tape recording was started and continued until the gear was recovered at 0730 GMT on Day 106 at the end of the work in the first area. There were several minor and intermittent problems with the receiving electroncis and the power amplifier protective trips, the latter as far as could be ascertained due to noise on the trip circuitry power supply.

The passage across the Madagascar Basin and the station work afforded an opportunity to go carefully through the system, replacing some faulty components on the Starboard No. 4 power Amplifier.

The system was relaunched at the start of the second survey at 0400 GMT on Day 113, and worked at maximum range until Day 121 when a change was made to the 20 second pulse repetition interval giving half the maximum range, and this was used until the final recovery on Day 125. The second survey was marked by very high temperatures and towards the end consistent trouble with the power amplifier safety trips. The problem was not satisfactorily resolved, but was probably indirectly caused by the high temperature making the trip points more

noise sensitive. This problem was the cause of a number of irregularities and gaps in the sonar records.

In all during Cruise 101 some 400 hours of recording was achieved at a service speed of 9 knots.

It was decided at the end of the cruise to change the cable although there was no indication of malfunction. This was mainly to ensure as far as possible that the quick re-shipment scheduled for when Discovery returns to the U.K. will not be complicated by the need to do a cable change. It would also ensure that if the old cable was in some unknown way responsible for tripping the power amplifiers, the next cruise would not be plagued with this problem.

M.L.S.

5. Short Range Sonar and Platform

Torque Tests

Directly after leaving Cape Town the Sonar Pod was deployed, two spring balances were fitted to arms attached to the training shaft and the power switched off. The shaft was trained manually to various angles and at each angle the force required to hold the pod was noted at speeds of 6, 8 and 10 knots. From these figures curves of torque versus angle were calculated for each speed to enable the design of a new azimuth motor to be checked.

Oil Leak

Whilst changing transducers at Cape Town it was realised that there was an oil leak in the assembly, probably in the azimuth motor, but no cure could be effected. At sea it was soon apparent that the leak was serious and to ease the situation the hydraulic oil pressure was reduced from 800 to 650 psi and the servo system only switched on when actually required to control the plates. At the start of the cruise the rate of oil loss was about 10-15 litres per day, but this eventually increased to 40-50 litres per day.

Pod Deployment

As mentioned above the pod was deployed for the torque tests but two later attempts were unsuccessful. After the first attempt the failure was thought to be due to a sticking solenoid but the second attempt (within a few hours of docking in the Seychelles) showed this was not so. The reason for the non-operation was not discovered.

Echosounding

For most of the cruise the water depth was too great for conventional side-scan working so the starboard side was used with the transducer switched to the square beam and pointing vertically downwards. Fortunately the starboard plate

assumed this position with no power present - the ship's motion was small enough not to need stabilisation of the plate.

Side-scanning

This facility was only used on a few limited occasions, all but one being on seamounts, ridges or the edges of the banks where the depths lay between 1000 and 2500 metres and consequently the tilt angles were large (i.e. greater than 60°). The starboard side was used for this with the transducer switched to the fan beam.

The remaining occasion was at the end of the cruise whilst steaming across the Seychelles Bank to Mahe Island where the average depth was about 60 metres. Due to the fact that the pod could not be deployed the records obtained were of inferior quality calling for careful interpretation.

A.R.S.

6. Seismic Reflection Profiling

On day 101, the IOS 2-channel array and 160 ins^3 airgun were deployed. At an average speed of 9 knots, nearly 1000 n.m. of seismic data was recorded. Later on day 102, channel 2 of the array went open circuit. On inspection, both wires of this channel had broken in the first spring section. These wires were interchanged at the back of the socket with those for channel 3. Towards the end of this run on day 105 there was a ship's engine failure. This resulted in the forward depth sensor of the array sinking below its maximum depth rating causing permanent damage.

On reaching the main survey area, the Mascarene Plateau, on day 113, the multichannel array and a 300 in^3 airgun were deployed. As an experiment to get the airgun towing deeper, 3 short lengths of chain weighing in total about 300 lbs were suspended from the bottom of the chamber towing clamp. This unfortunately upset the balance of the airgun on firing, resulting in distortion of the chamber seal and its subsequent disintegration. The experiment was tried twice with the same result. The chain was removed and the gun deployed. Further leaking problems with this gun suggested that the main housing may have been badly damaged and it was therefore replaced.

This system was run until day 117 at 8 knots, covering 800 n.m. of track. Because of the lack of deep sedimentary layers it was decided that there was nothing to be gained from using multichannel techniques at slow speeds. The array was recovered, during which time it was noticed that one of the active sections had a 4" split in the plastic tubing. This underwent a temporary repair.

On the same day, 117, the I.O.S. array was redeployed enabling the survey to

be carried out at the higher speed of 9 knots, and was used for the remainder of the cruise recording a further 1800 n.m. of seismic data.

D.G.B.

7. Generation of Random Acoustic Pulses

The 2 kHz high resolution profiler and 5 in^3 airgun were used to generate a random or sub-optional series of acoustic pulses. One object of the experiment was to determine if the resolving power of the seismic reflection profiling system could be improved by using a small airgun and compensating for its lack of acoustic output by firing the airgun several times.

Another objective was to see if the penetration and resolution of a high resolution system such as the 2 kHz or 3.5 kHz pulsed system could be improved by the generation of suitable acoustic pulse trains.

Sub-optimal series of differing lengths and sequences were produced from a Nova computer and used to drive the 5 in^3 high resolution profiling systems. Each of the sequences were recorded along with a corresponding section of returning seismic data. The seismic data will have to be processed at IOS before the effectiveness of the technique can be gauged.

J.L.

8. S.R.P. Data Logging

At the start of the cruise the interfacing between the micro-Nova computer and the tape and analogue circuits had been tested and only a few further modifications needed to be made. Both S.E. labs. digital tape-decks had been serviced as had the Silent 700 terminal. However, considerable frustration was suffered as various, usually unrelated, hardware faults cropped up. The main source of trouble seems to be connectors, though most of the Data General chips involved in interfacing to the I/O bins had to be changed before a working combination was achieved.

Software development was fairly straightforward though not helped by the limited nature of the micro-Nova's monitor program. Ultimately it was possible to log up to sixteen channels with trace leader (initially blank) while monitoring one channel prior to recording. A replay routine was written to check the data and this worked satisfactorily. With the second transport connected up the end of tape change over was demonstrated.

Although there are still many weak points in the software, especially in the interrupt structure, the two channels available were logged overnight on two occasions. Unfortunately on both occasions the program stopped sometime in the

early morning without any corruption of program or data. It is suspected that this was due to radio interference and could be solved by improved mains filtering.

It is hoped that a floppy disc system can be obtained so that an operating system and a high level language may be supported and thus ease the next stage of development - i.e., the generation of tape and trace leader information, improving communications with the operator and the increasing of the logger's flexibility.

C.F.

9. Disposable Sonobuoys

Seven sonobuoys were deployed in occupying six stations. All buoys used had been gain adjusted - 20dB using the calibration of 3v Peak-Peak and operated well. Lost transmissions from one buoy may have been caused by entaglement with towed instruments in a strong cross current. The main objective of the station was to obtain refraction velocity data. This was achieved on five stations and in particular refracted arrivals were monitored to over 30 km on station 10013. Some sediment velocity interval data was obtained from two stations 10010, 10012.

In an attempt to extend sonobuoy reception range, the first experiments were made to receive sonobuoy transmissions from a dipole aeriel supported by a parafoil kite at 50 metres elevations. The experiment was unsuccessful possibly owing to signal loss down an inefficient kite-ship co-ax cable. The sonobuoy receiving and recording console operated well but on board play back opportunities were limited. It was noticed that the Record Signal Level control should be adjusted for the + 3dB signal level to avoid the use of an attenuator on playback.

P.R.M.

10. Revells VHP 36 Compressors

All 3 compressors were run at various times, mostly driving a 160 cu. in. airgun For 45 hours running the 300 cu. in. gun was used and required 2 compressors to be run together. This caused a balancing problem because one compressor worked harder than the other.

The containerised D.C. compressor worked well with only a few minor mechanical breakdowns (i.e. pipe joint leaks and blocked third stage pressure gauge). The main problem was caused by blown fuses. On investigations by L. Wilson (Ship's Electrical Officer) two separate fuse boxes were found, each containing two 200 amp fuses. The compressor motor current was measured and found to be 200 amp

approximately. This complies with the factory test certificate. The No. 1 AC compressor in upper aft hold was reliable except for minor leaks, the fourth stage relief valve and pressure maintaining valve leakage.

The No. 2 AC compressor had two major faults. The first was overheating which was cured by replacing the fresh water pump. The second was oil pressure. This M/L compressor has always had a low oil pressure but as the oil became hot (68 °) the pressure dropped to dangerously low values. On inspection of the oil pump and pipes two joints were tightened so curing the problem.

Average ambient temperatures	35 °C
Average seawater for cooling two A.C. M/CS	29 °C
Average final air temperature	64 °C (cut out 70 °C)

A.W.G., B.K.

11. Magnetometer

Problems with the magnetometer was as follows:

a) Overheating

The extreme temperatures in the plot, particularly with no air conditioning, caused erratic measurements. The circuit board rack was cooled with a fan, that was the best solution in warm conditions.

b) Pen Recorder

The ink supply system was not up to operating in the temperatures encountered. An alternative electro-sensitive recorder was used but itself suffered from noise due to overheating and lack of recording paper.

c) Magnetometer Fish

Wormley fish 'B' is now unserviceable, being very noisy. The cable was stripped by 3 m and reconnected but the improvement was not sufficient. The data was then recorded using one of the RVS fish requiring a compatible connector.

d) Missing

Wormley magnetometer fish 'A' is missing being neither onboard or at Wormley.

P.R.M.

12. Gravimeter

After analysis of data logger tapes, LaCoste and Romberg suggested adjustment of the gain of one of the cross coupling components by altering an input (gain adjust) resistor to 36K. The result of the change could not be fully tested during Cruise 101 since sea conditions were mostly flat. The most obvious effect is experienced during rough sea conditions, especially during the pitching.

During the cruise the only down time on the meter was caused by 3 mains failures, the first due to preferential trips switching off the DC to the rotary transformer, the second two, due to a complete black-out of the ship.

This resulted in a total down time of 6 hours (2 hours to stabilise meter), no tape was evident when the meter was back on line.

Unfortunately only four valid cross ties were made and these resulted in differences of less than 2 m gal. on average, despite the fact of suspect navigation due to currents and occasional failure of the Sat. navigation (high channel drop out).

S.J.

13. Dynamometer System

A new dynamometer system was temporarily fitted in parallel with the existing system. The new system comprises a main control unit and a series of digital displays. Data is transmitted from the control unit to the displays via a serial digital data link.

The system was used during coring stations and while tensioning the main warp and operated satisfactorily over a period of 24 hours. A few minor modifications will be carried out on the system before it is fitted permanently during the next refit.

J.L.

14. Shipboard Computer

In view of the expected climatic conditions it was thought that many problems of overheating would exist; however, even with the temporary loss of one of the three air-conditioning units the computer system functioned well even though parts of the computer room had temperatures in excess of 37 deg. C. With all three air-conditioning units working the temperature was maintained at a comfortable 30 deg. C. with a low humidity, for an outside air temperature of 28 deg. C.

Standard navigational meteorological and geophysical data were logged throughout the cruise.

Total 'down-time' of the 1800 computer system amounted to nine hours, of which seven and half were due to the loss of ship's A.C. power (and subsequently waiting for the Gyros to stabilise), and the remainder due to a key board fault.

The prime navigational aid was the magnavox satellite navigator but in the equatorial area the frequency of satellite passes was at a minimum, with intervals of up to nine hours between acceptable fixes. Difficulties were experienced

with the high channel losing lock, the aerial cable being the prime suspect.

Data editing was performed on a midnight to midnight GMT basis with the aim of producing a 1:250,000 track chart as soon as possible to enable GLORIA sonographs to be corrected.

Annotations along the track of the geophysical data were plotted daily. Certain profiles along the track were produced and here it is worth mentioning that in the plot specification the angle of plotting is the direction of positive values counter-clockwise from due east. The scale parameter is still of uncertain definition.

To ease the process of data editing a new program 'limit' was written which extracts the track chart limits and the maximum and minimum values of any logged data. A separate listing of data spikes and their values is optional.

This program is particularly useful in final checking of edited data.

M.B., T.C.

15. Meteorological Observations

There was no difficulties with any of the meteorological instruments. The thermometers were checked every day and distilled water was added to the wet thermometers if it was needed. The bridge barometer functioned very well.

There was a slight problem with the solarimeter due to the face that there was a shortage of silica-gel onboard, but this was remedied by borrowing some from the sonobuoys.

Readings correlated well with thos taken by the onboard computer.

TABLE 1

GLORIA and Seismic Reflection Profiler Traverses

(all profiles were also run with 2.0 kHz profiler, gravity and magnetics)

(all times in GMT)

Profile No. and dist. (nm)	Equipment	Start	End	Latitude From	Longitude	Latitude From	Longitude To	Depth Range CM	Comments
1 (38)	GLORIA 160 in^3 airgun IOS array	1550/101	1953/101	36°41.4'N	21°11.3'E	36°54.4'S	21°51.9'E	314-3461	Agulhas arch and Agulhas Fracture Zone
2 (168)	GLORIA 160 in^3 airgun IOS array	2003/101	0130/103	36°58.13'S	21°58.0'E	35°18.7'S	25°13.4'E	848-4354	Traverse parallel to Agulhas Fracture Zone
3	GLORIA 160 in^3 airgun IOS array	0130/103	0642/106	35°18.7'S	25°13.4'E	32°11.4'S	38°19.9'E	1278-5175	Agulhas slope to Mozambique Basin via Transkei Basin
4 (158)	GLORIA 160 in^3 airgun RVS 6-ch array	0712 (113)	0025 (114)	09°20.55'	51°44.2'S	08°22.5'S	53°34.1'E	1126-5164	Amirantes Passage
		0035 (114)	0350 (114)	08°22.4'S	53°35.1'E	08°36.3'S	53°56.8'E	3827-4105	
5 (180)	GLORIA 160 in^3 airgun RVS 6-ch array	0406 (114)	2200 (114)	08°38.0'S	53°56.8'E	09°47.5'S	51°42.3'E	3100-5166	Amirantes Passage
		2226 (114)	0141 (115)	09°50.6'S	51°41.9'E	10°09.9'S	51°58.8'E	3847-4383	
6 (390)	GLORIA 160 in^3 airgun RVS 6-ch array	0141 (115)	2010 (115)	10°09.9'S	51°58.8'E	09°01.8'S	54°10.0'E	2640-4784	Amirantes Passage to Seychelles Bank
		2010 (115)	2050 (116)	09°01.8'S	54°10.0'E	06°26.9'S	55°58.3'E	3116-4069	
		2050	03.5	06°26.9'S	55°58.3'E	05°34.5'S	56°02.9'E	3050-3306	

7 (324)	GLORIA 160 in^3 airgun IOS array	0456 (117)	1054 (117)	05°29.6'S	55°49.1'E	06°12.6'S	55°28.2'E	2560-3397	Seychelles Bank - Amirantes Ridge
		1054 (117)	1645 (117)	06°12.6'S	55°28.2'E	06°11.2'S	54°39.4'E	2441-3646	
		1653 (117)	0810 (118)	06°11.2'S	54°39.4'E	08°04.2'S	55°18.6'E	2930-4023	Amirantes Ridge - Amirantes Passage
		0818	2219	08°04.2'S	55°18.6'E	08°42.1'S	52°00E	2267-5170	
8 (113)	GLORIA 160 in^3 airgun IOS array	2219 (118)	0101 (119)	08°42.1'S	52°00'E	08°20.0'S	51°52.2'E	3980-4240	Amirantes Passage - Amirantes Ridge
		0101 (119)	1254 (119)	08°20.0'S	51°52.2'E	07°34.1'S	53o07.2'E	883-5140	
9 (70)	GLORIA 160 in^3 airgun IOS array	1254 (119)	1455 (119)	07°34.1'S	53°07.2'E	07°16.1'S	53°03.8'E	3485-3941	Amirantes Ridge - Amirantes Passage
		1455 (119)	2038 (119)	07°16.1'S	53°03.8'E	07°43.2'S	52°21.1'E	2609-5120	
10 (101)	GLORIA 160 in^3 airgun IOS array	2038 (119)	0307 (120)	07°43.2'S	52°21.2'E	06°48.8'S	52°35.2'E	2935-5116	West Flank of Amirantes Ridge
		0307 (120)	0826 (120)	06°48.8'S	52°35.2'E	06°05.5'S	52°15.7'E	2893-5020	
11 (92)	GLORIA 160 in^3 airgun IOS array	0826 (120)	1544 (120)	06°05.5'S	52°15.7'E	06°45.4'S	53°05.2'E	1580-4960	Amirantes Ridge
		1544 (120)	1852 (120)	06°45.4'S	53°05.2'E	07°14.8'S	53°06.5'E	3790-3933	
12 (170)	GLORIA 160 in^3 airgun IOS array	1852 (120)	1344 (121)	07°14.8'S	53°06.5'E	05°04.9'S	54°52.7'E	2004-3940	Amirantes Ridge - Seychelles Bank
13 (40)	GLORIA 160 in^3 airgun IOS array	1344 (121)	1800 (121)	05°04.9'S	54°52.7'E	05°21.3'S	55°30.4'E	1779-2360	Margin of Seychelles Bank

14 (165)	GLORIA 160 in^3 airgun IOS array	1800 (121)	1948 (121)	05°21.3'S	55°30.4'E	05°34.5'S	55°20.8'E	2039-2770	Seychelles Bank - Amirantes Ridge and Trench
		1948 (121)	2100 (122)	05°34.5'S	55°20.8'E	03°54.1'E	53°42.6'E	1174-4440	
15	GLORIA 160 in^3 airgun IOS array	2100 (122)	0357 (123)	03°54.1'E	53°42.6'E	03°15.4'	54°41.8'E	1914-4162	N.W. Margin of Seychelles Bank
		0357 (123)	0655 (123)	03°15.4'E	54°41.8'E	03°36.2'	55°00.0'E	1576-3498	N.W. margin of Seychelles Bank
		0655 (123)	1239 (123)	03°36.2'E	55°00.0'E	03°34.7'	54°14.3'E	1883-3941	N.W. margin of Seychelles Bank
		1239 (123)	2100 (123)	03°34.7'	54°14.3'E	04°01.0'	53°34.0'	1927-3878	N.W. margin of Seychelles Bank
		2100 (123)	0348 (124)	04°01.0'	53°34.0'	04°55.7'S	53°43.5'E	1660-3136	N.W. margin of Seychelles Bank
16	GLORIA 160 in^3 airgun IOS array	0348 (124)	0706 (124)	04°55.7'S	53°43.5'S	04°49.4'S	54°10.8'E	1506-3136	Traverses between the Seychelles Bank and Amirantes Ridge
		0706	1025	04°49.4'S	54°10.8'E	04°59.5'S	54°36.2'E	1292-2024	
		1025	1442	04°59.5'S	54°36.2'E	05°27.6'S	54°14.7'E	1783-3410	
		1442	1945	05°27.6'S	54°14.7'E	05°08.12'	53°29.2'E	3004-3394	
		1945	2100	05°08.15'S	53°29.2'E	05°17.8'S	53°29.6'E	2704-3004	
		2100 (124)	0218 (125)	05°17.8'S	53°29.6'E	05°38.2'E	54°09.1'E	2500-3000	
17	160 in^3 airgun IOS array	0218 (125)	0727 (125)	05°38.2'E	54°09.1'E	05°53.8'E	53°23.7'E	1800-3400	East Flank of Amirantes Ridge
		0727 (125)	1151 (125)	05°53.8'S	53°23.7'E	06°21.8'S	53°36.0'E	1800-3700	

TABLE II

STATION POSITIONS - CORES

STATION NO.	CORE NO.	STATION DATA			FREEFALL LOCATION		RESULTS
		LAT. °S	LONG °E	DEPTH (Corr.m)	LAT. °S	LONG °E	(Calvert 10 cm diam. Gravity Corer)
10005	1	ST. 09°34'.4	52°25'.9	3702	09°34'.3	52°27'.7	In core catcher and core head manganese nodules associated with altered tephra, plus Quaternary stiff ooze and copper Cretaceous chalk. No core.
		END 09°34'.6	52°28'.9	3625			
10006	1	ST. 09°27'.9	52°05'.0	4253	09°30'.0	52°03'.2	Sediment core 105 cm length plus core catcher containing approx. 10 cm length extruded in handling core comprises quaternary siliceous foram nanno ooze. Only downcore lithologic changes relate to varying coarse. Fraction percentages. Base may be Pleistocene
		END 09°30'.7	52°02'.4	4255			
10007	1	ST. 09°27'.5	51°57'.0	4236	09°27'.1	51°57'.9	Top value seal shattered. No. recovery
		END 09°27'.6	51°58'.0	4236			
10007	2	ST. 09°27'.7	51°58'.0	4234	09°27'.6	51°57'.9	Core cutter dented. Sediment smear inside catcher. No other evidence of penetration. No recovery
		END 09°27'.7	51°58'.3	4249			

TABLE III

STATION POSITION LIST

Stn No.	Type	Start	End	Latitude Longitude START	Latitude Longitude END	Depth Range UCM	Depth Range CM	Comments
10008	DSB	0705 (116)	0900 (116)	07°42.0'S 54°55.7'E	07°30.3'S 55°05.6'E	3390-3695	3398-3696	Successful
10009	DSB	0620 (117)	0654 (117)	05°36.3'S 55°46.1'E	05°43.8'S 55°43.7'E	3080-3217	3076-3213	Signal lost due to hydrophone failure.
10010	DSB	1436 (117)	1600 (117)	06°12.3'S 54°59.4'E	06°11.3'S 54°46.9'E	3585-3640	3584-3641	Successful, incoherent low frequency noise.
10011	DSB	1622.5 (119)	1743 (119)	07°23.2'S 52°52.6'E	07°29.6'S 52°42.4'E	3052-3540	3046-3538	Successful
10012	DSB	0558 (120)	0718 (120)	06°26.6'S 52°25.5'E	06°15.2'S 52°50.1'E	4872-4985	4899-5016	Successful
10013	DSB	0600 (122)	0820 (122)	04°57.3'S 53°55.3'E	04°51.8'S 53°38.3'E	3180-3046	3176-3041	Successful. Good refraction arrivals

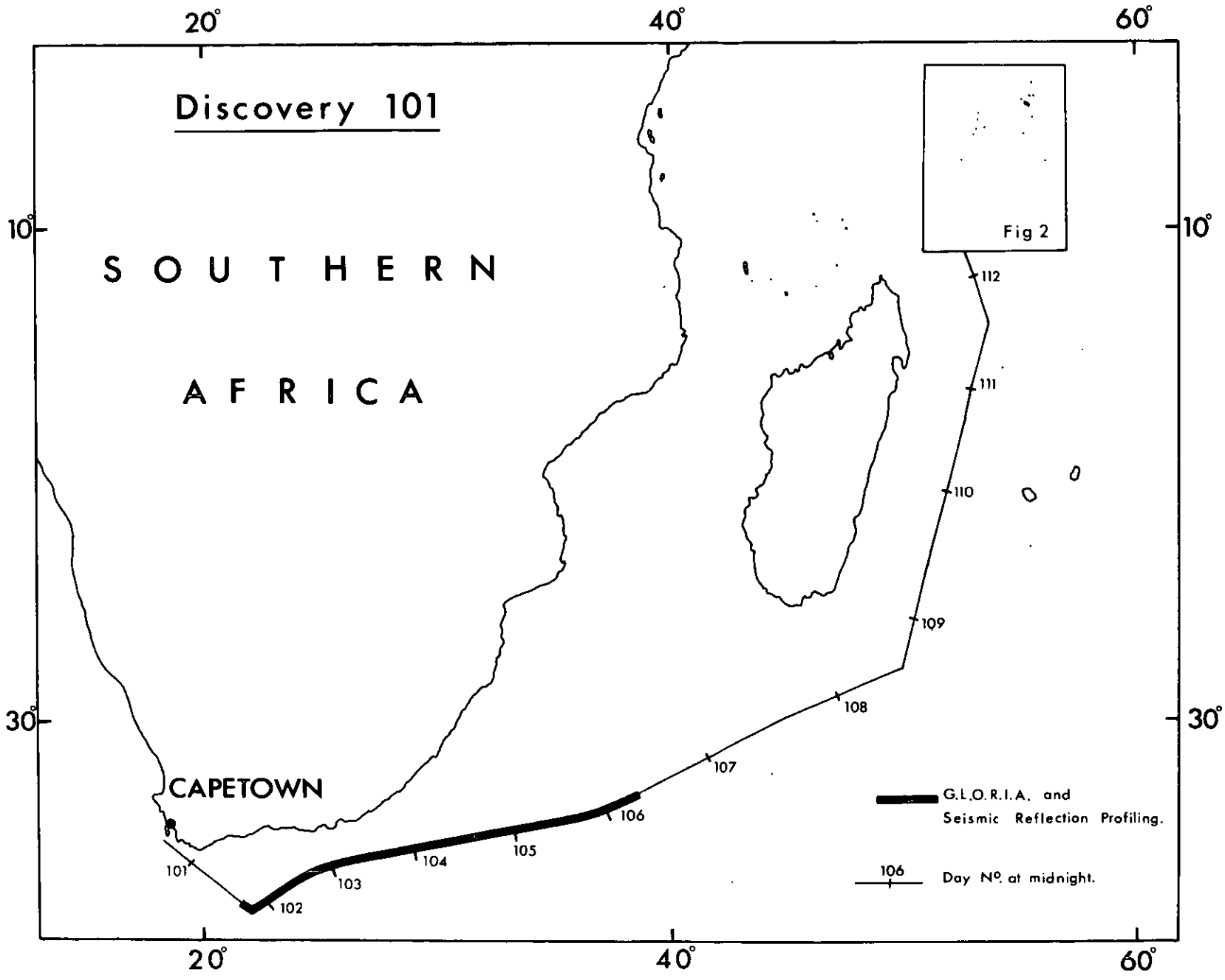
20°
40°
60°
10°
30°
Discovery 101
SOUTHERN
AFRICA
Fig 2
CAPETOWN
101
102
103
104
105
106
107
108
109
110
111
112
G.L.O.R.I.A. and
Seismic Reflection Profiling.
106
Day N° at midnight.

Fig 1

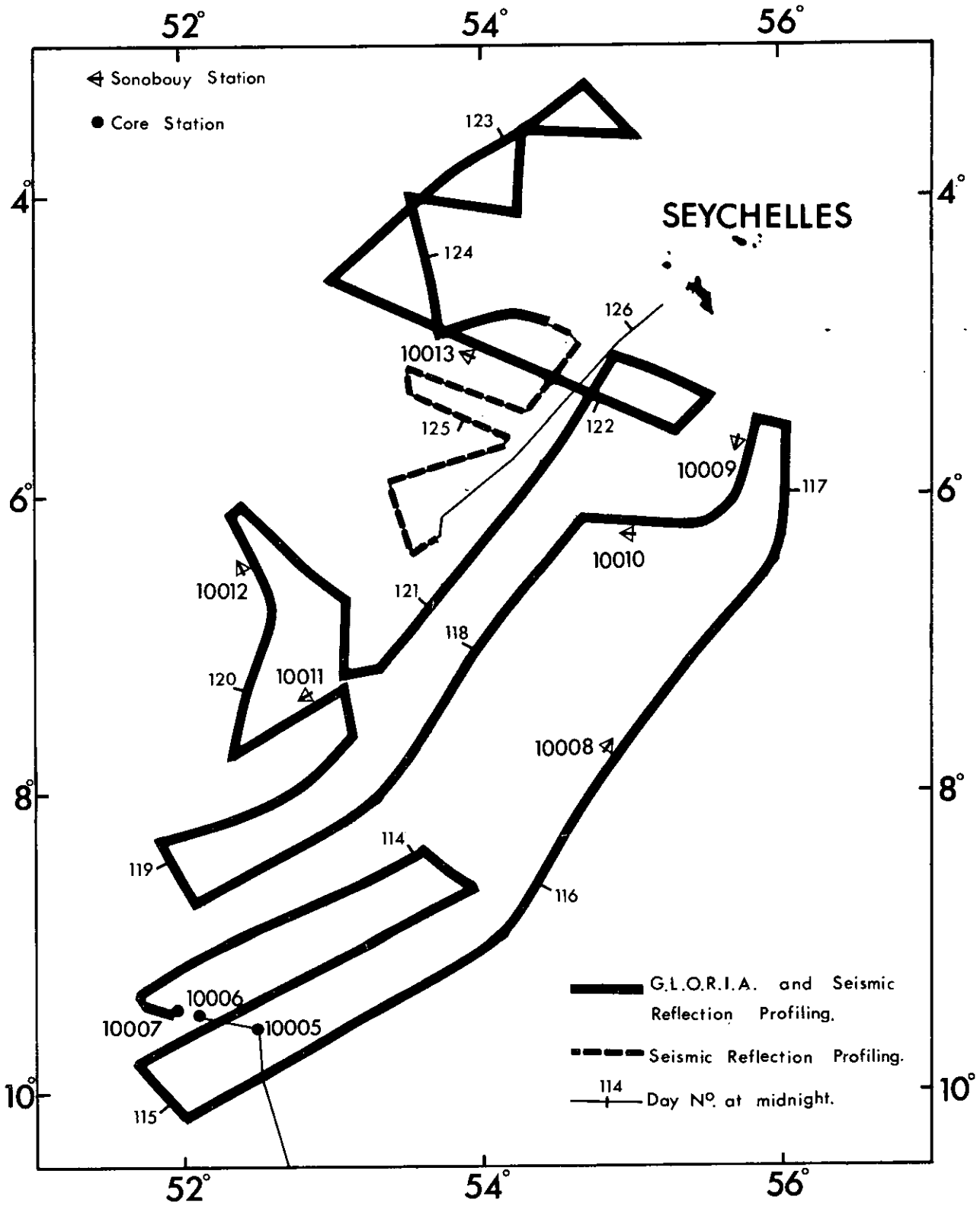
52°
54°
56°
4°
6°
8°
10°
Sonobouy Station
Core Station
SEYCHELLES
123
124
126
10013
125
122
10009
117
10010
10012
121
118
120
10011
10008
114
119
116
10006
10007
10005
115
G.L.O.R.I.A. and Seismic Reflection Profiling.
Seismic Reflection Profiling.
114
Day N°. at midnight.

Fig 2

CRUISE REPORTS

RRS "DISCOVERY"

CRUISE NO.		REPORT NO.
1	JUN — AUG 1963	1*
2	AUG — DEC 1963	2*
3	DEC 1963 — SEP 1964	3*
		NIO CR**
4	FEB — MAR 1965	4
TO	TO	TO
37	NOV — DEC 1970	37
38	JAN — APR 1971	41
39	APR — JUN 1971	40
40	JUN — JUL 1971	48
41	AUG — SEP 1971	45
42	SEP 1971	49
43	OCT — NOV 1971	47
44	DEC 1971	46
45	FEB — APR 1972	50
46	APR — MAY 1972	55
47	JUN — JUL 1972	52
48	JUL — AUG 1972	53
49	AUG — OCT 1972	57
50	OCT 1972	56
51	NOV — DEC 1972	54
52	FEB — MAR 1973	59
53	APR — JUN 1973	58
		IOS CR***
54	JUN — AUG 1973	2
55	SEP — OCT 1973	5
56	OCT — NOV 1973	4
57	NOV — DEC 1973	6
58	DEC 1973	4
59	FEB 1974	14
60	FEB — MAR 1974	8
61	MAR — MAY 1974	10
62	MAY — JUN 1974	11
63	JUN — JUL 1974	12
64	JUL — AUG 1974	13
65	AUG 1974	17
66	AUG — SEP 1974	20
68	NOV — DEC 1974	16
69	JAN — MAR 1975	51
73	JUL — AUG 1975	34
74/1 + 3	SEP — OCT 1975	35
74/2	SEP 1975	33
75	OCT — NOV 1975	43
77	JUL — AUG 1976	46
78	SEP — OCT 1976	52
79	OCT — NOV 1976	54
82	MAR — MAY 1977	59
83	MAY — JUN 1977	61
84	JUN — JUL 1977	60
86	SEP 1977	57
87	OCT 1977	58
88	OCT — NOV 1977	65
89	NOV — DEC 1977	67
90	JAN — MAR 1978	68
91	MAR 1978	69
92	APR — MAY 1978	70
93	MAY — JUL 1978	71
94	JUL — SEP 1978	74
95	OCT — NOV 1978	77
96	NOV — DEC 1978	79
97	DEC 1978	77
98	DEC 1978 — JAN 1979	75
99	JAN 1979	78

CRUISE DATES	REPORT NO.
RRS "CHALLENGER"	
AUG — SEP 1974	IOS CR 22
MAR — APR 1976	IOS CR 47
MAR — MAY 1978	IOS CR 72
APR — 1979	IOS CR 81
MV "CRISCILLA"	
NOV — DEC 1978	IOS CR 73
RV "EDWARD FORBES"	
OCT 1974	IOS CR 15 X
JAN — FEB 1975	IOS CR 19
APR 1975	IOS CR 23
MAY 1975	IOS CR 32
MAY — JUN 1975	IOS CR 28
JUL 1975	IOS CR 31
JUL — AUG 1975	IOS CR 36
AUG — SEP 1975	IOS CR 41
FEB — APR 1976	IOS CR 48
APR — JUN 1976	IOS CR 50
MAY 1976	IOS CR 53
AUG — SEP 1977	IOS CR 64
RRS" JOHN MURRAY"	
APR — MAY 1972	NIO CR 51
SEP 1973	IOS CR 7
MAY — APR 1974	IOS CR 9
OCT — NOV & DEC 1974	IOS CR 21
APR — MAY 1975	IOS CR 25
APR 1975	IOS CR 39
OCT — NOV 1975	IOS CR 40
AUG — OCT 1975	IOS CR 42
OCT — NOV 1976	IOS CR 53
MAR — APR 1977	IOS CR 66
JUL — SEP 1978	IOS CR 76
NC "MARCEL BAYARD"	
FEB — APR 1971	NIO CR 44
MV "RESEARCHER"	
AUG — SEP 1972	NIO CR 60
RV "SARSIA"	
MAY — JUN 1975	IOS CR 30
AUG — SEP 1975	IOS CR 38
MAR — APR 1976	IOS CR 44
MAR 1977	IOS CR 63
RRS "SHACKLETON"	
AUG — SEP 1973	IOS CR 3
JAN — FEB 1975	IOS CR 18
MAR — MAY 1975	IOS CR 24
FEB — MAR 1975	IOS CR 29
JUL — AUG 1975	IOS CR 37
JUN — JUL 1976	IOS CR 45
OCT — NOV 1976	IOS CR 49
JUL 1977	IOS CR 62
JUL 1979	IOS CR 80
MV "SURVEYOR"	
FEB — APR 1971	NIO CR 38
JUN 1971	NIO CR 39 X
AUG 1971	NIO CR 42 X
DE "VICKERS VOYAGER" AND "PISCES III"	
JUN — JUL 1973	IOS CR 1

* Reports 1 to 3 were published and distributed by the Royal Society following the International Indian Ocean Expedition.

** NIO CR: National Institute of Oceanography, Cruise Report.

*** IOS CR: Institute of Oceanographic Sciences, Cruise Report.

X Not distributed

Printed by NERC/SRC Reprographic Services