International Indian Ocean Expedition
RRS Discovery
Cruise 2 Report

Geology and Geophysics in N.W. Indian Ocean

23 August to 4 December 1963

Prepared on behalf of the British National Committee for Oceanic Research

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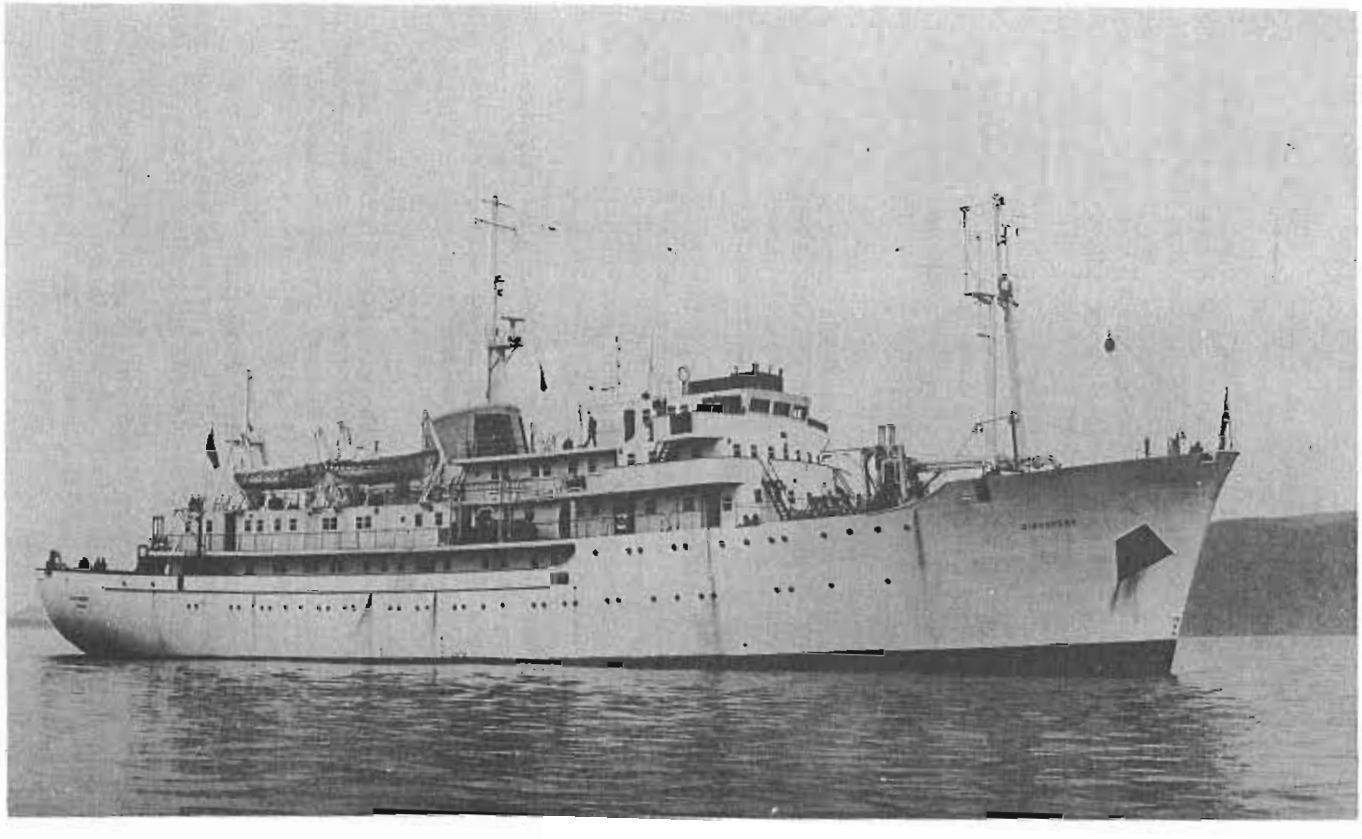


1. Introduction

This report gives a comprehensive general description of the scientific activities of Cruise 2 of R.R.S. 'Discovery'. These were largely geological and geophysical and were part of the British contribution to the International Indian Ocean Expedition. In addition to the thirteen geophysicists and geologists on board, there were five scientists involved in ocean chemistry, temperature measurements and ornithology making continuous observations - their accounts are also included. The report of a geological expediton ashore in the Seychelles is given in section 6.

The scientific personnel on the cruise is shown in table 7. Although every scientist had individual tasks to perform and particular equipment to service, co-operation was absolutely necessary especially in the larger operations. Thus the success of the cruise was due to the united efforts of many people.

This cruise report has been compiled by Dr M.N. Hill; the note on geological work in the Seychelles was prepared by Dr D.H. Matthews. No attempt has been made to present detailed results nor to advance hypotheses; the report is limited to a descriptive account.

Most of the original objectives of the cruise were attained. Moreover, there was sufficient flexibility in the programme to permit making appropriate new experiments on board. This helped to give extensive coverage to areas found to be of unusual interest, and necessitated keeping as up to date as possible in the interpretation of scientific results.

Statistics for the cruise are included in the station list (table 5) and a good general indication of the work done may be obtained from figure 1. A second chart (figure 2) shows the tracks of all U.K. ships which have made geological and geophysical measurements in the Indian Ocean between 1961 and 1963.

The new ship proved very suitable for our operations. At no time, was work impeded through lack of any facility, and personal comfort was at a high level. The bow-propeller proved its worth in all station work and must be considered as an essential for future research ships.

The weather was uniformly good and few rough seas were encountered. Cruise 2 lasted for 103 days of which 12 were spent in port. A total of 136 stations were occupied and the ship steamed 15000 miles.

On a personal note, we were always very hospitably received in port, and our visits to outlying islands - Ile des Noeufs and Bird Island - provided a pleasant break from our normal routine.

1.1 Acknowledgements

The Work was supported by the D.S.I.R., and O.N.R. contract No. N62558-3542 with the University of Cambridge.

The co-operation of the National Institute of Oceanography in providing time on the ship, all its facilities and some of the scientists was invaluable.

The captain of 'Discovery', Captain C. Alexander, D.S.C., and the Chief Engineer, Mr T. Humphrey, provided every assistance possible and contributed in large measure to the success of the cruise. The officers and crew gave us cheerful and unfailing support.

The captain, officers and crew of H.M.S. 'Owen' co-operated magnificently with 'Discovery' in the complex two-ship seismic operations. The charts of previous surveys by H.M.S. 'Owen' helped greatly in planning experiments.

The continuing practical interest of the Hydrographer of the Navy is acknowledged gratefully.

In the Seychelles, the help provided by M. Guy Lionnet, a Director of the Department of Agriculture, greatly facilitated geological operations.

2. Leg 1 - ADEN TO MOMBASA - 23 August to 12 September 1963

2.1 Narrative

The ship arrived in Aden after the first cruise on 20 August 1963 and, after lying at anchor for a few hours while the asdic plate was removed, she came alongside the Admiralty jetty. The scientists leaving the ship at the end of cruise 1 went ashore on 21 August and 13 newcomers joined; 5 remained from cruise 1. Before sailing, a daily variation magnetometer which had been run by the school at Aden during the 'Owen' cruise was once again put into action.

The ship sailed from Aden at 1630 on 23 August and in the moderate-to-strong SW monsoon set off eastwards down the Gulf of Aden. A diversionary run with the magnetometer and sounder had been arranged to provide a new track across the Gulf towards what is believed to be the continental-like rocks on the southern side. The magnetometer record confirmed the results previously obtained and, after violent magnetic and topographic relief over the region of the postulated median valley, typical continental smoothness developed.

A course to the south of Socotra was set and thence to a large non-magnetic seamount at about 10° 25'N 56° 07'E. On the way the ship passed over a deep water area where a water bottle station was occupied; the maximum depth out of

three casts was 3500 m. In this deep water area, all pressure casings on the after main warp were successfully tested. Apart from a minor failure, all the casings were watertight.

The non-magnetic seamount was reached on 27 August where a dan-buoy (I) was laid in 450 m of water. From the track during the previous night it appeared that there was a considerable westerly set; this was confirmed by the direction of the pellets relative to the force 6 to 8 wind after the buoy had been laid.

A site for dredging was selected which enabled the ship to move slowly up-slope and also to fall back over the dredge if it fouled the bottom. The first dredge station was a failure; the weak link had been incorrectly secured to one arm of the dredge and was free to slide down the arm. It is likely that the dredg was, throughout, towing sideways over the bottom. A second dredge station was attempted and, after a number of bites, heaving started. Just as the dredge was coming off the bottom there was a short period of time - a matter of 10 seconds - when the tension rose from about 2000 kg to between 5000 and 6000 kg; then the dredge apparently broke clear of the rocks. In fact, the chain between the end of the warp and the dredge had parted and 50 m of chain and the dredge had been lost. There is no doubt that the bits of chain and the shackles joining them were too weak for dredging in this shallow depth, where the snatch comes suddenly if the dredge becomes hitched to the bottom. The breaking strain of the shackles joining the lengths of chain was less than 2000 kg. This had not been realized until after the dredge had been lost.

While making up another dredge, a short survey run was made. Howeve it was soon apparent that time was so short for station keeping that we should abandon this seamount and proceed to area 4A (mid-Carlsberg Ridge) as soon as possible. The dan-buoy was recovered shortly before midnight and course was set for area 4A.

During the run, the magnetometer and precision echo sounder were operated. The latter worked well, but the former produced an aesthetically unsatisfactory though readable record. However, no appreciable proportion of the recording time was lost.

On 29 August area 4A was reached and late in the evening dan-buoy II was laid. Owing to overcast weather, there had been no evening star fix and it was therefore with some uncertainty that the position was approached. However the splendid bathymetric and magnetic charts made by H.M.S. 'Owen' earlier in 1963 soon enabled a precise fix to be obtained; these charts were also invaluable in subsequent operations in the area. The buoy contained the recorder and equipment for measurement of the daily variation of the Earth's magnetic field. After a brief survey around the buoy to confirm its position, a camera station revealed outcrops of rock in an area which was regarded as suitable for coring.

Until 3 September after laying dan-buoy II, intensive station work was

carried out in area 4A and a survey was made to the NW of the area to find where the median valley lay. Dan-buoy III was laid to the south of the second dan-buoy. As the topmast, radar reflector and light of the magnetic variation buoy (II) had carried away, a simple dan-buoy (IIa) was attached to the same moorings on 2 September. An excellent record of the daily variation had been obtained.

While in area 4A, the following stations were occupied:

4 camera	-	all successful
11 dredge	-	from which 3 provided good hauls
5 coring	-	from which 4 cores were obtained as well as 2 heat flow measurements

1 complete water bottle station of 3 casts.

Throughout the period in area 4A, strong SW winds were experienced with a strong northerly set of 1 to 2 knots.

After lifting dan-buoys IIa and III, course was set for area 4C on the south-western flanks of the Carlsberg Ridge. Meanwhile, it was realized that time for station work was so short that the programme should be modified. It was arranged to reach Mombasa one day late and to approach there in a straight line instead of diverting towards the northern boundary fault of the Seychelles.

Area 4C was reached in the early afternoon of 4 September and a simple dan-buoy (IV) was laid with its moorings at about 4000 m. Once again the quality of the chart provided by 'Owen' greatly assisted position identification for buoy laying and subsequent manoeuvres in the area.

From 4 to 7 September, intensive station work was carried out in the area working on dan-buoys IV to VII and the following stations were occupied:

4 camera	-	all successful
6 dredge	-	from which 3 good hauls were obtained
2 coring	-	from which good cores and heat flow measurements were obtained

1 complete water bottle station of 3 casts.

On 8 September, while en route to Mombasa, a successful coring and heat flow measurement station was occupied.

The strong northerly set, similar to that which existed in area 4A, resulted in the loss of two dan-buoys which dragged their moorings into deep water and foundered. The other two were recovered after considerable shifting of position. The last one laid had its moorings in about 4000 m. It was given 10% scope, it was on the upstream side of a seamount, and there were twelve pellets to support the wire. On recovery, there were no pellets above the surface although the moorings were in considerably shallower water than where they had been laid. In a region of no current, 5 or 6 pellets should have been

visible. The current at the surface was between 1 and 2 knots and must have extended deep in order to pull the pellets under in this way and shift the moorings. (for dan-buoy VII, these consisted of two bundled lengths of old chain each weighing about 50 kg and one square concrete sinker of the same weight. Various moorings had been tried in order to avoid dragging).

While in area 4C it appeared that the monsoon might be ending, but on passage to Mombasa the wind again rose to force 5 to 6. The maximum wind met during this leg of the expedition was force 8 though it only persisted for a short time; there was only one day during which the wind remained below force 4. It was hot, with much sunshine, and many periods of tropical rain.

At the outset of the passage from area 4C, the magnetometer was streamed. The wire almost immediately parted; both the preamplifier and the tail-end fish were lost. It was decided not to use the spare while on passage, particularly in view of previous tracks in the area and the need to preserve the magnetometer for detailed surveys later in the cruise.

The towed echo-sounder 'fish' was satisfactory throughout; the fibre-glass fish was more stable at speed than the bronze fish.

At the start, the pingers did not provide adequate bottom reflexions for wire control. Later, their performance was improved and full control of distance from the seafloor provided. Each pinger became partially flooded on one occasion; repairs to the electronics were not difficult.

2.2 Dredging

(a) Method. On all dredge stations, tight control of the ship's position had to be maintained by radar fixing on the appropriate dan-buoy and continuous watch was maintained on the stress in the warp. The ship's track was always such that immediately the dredge fouled the bottom it was possible to come back over the wire. Before every dredge station, a course and speed was determined which maintained the ship in a fixed position relative to the bottom; where the strong currents did not correspond with the wind directions, this was made possible by the bow propeller. The usual dredging speed was 0.3 kn.

(b) Results in area 4A. The three successful dredge stations in area 4A were made on the ridge of seamounts which extends about 25 miles in a NNW direction from 05° 25'N 61° 50'E. This ridge is bounded on the west by an escarpment interpreted as a fault scarp, and to the south by the median valley of the Carlsberg Ridge.

At station 5106 (near 05° 36'N 61° 51'E, depth ca. 2200 m), 20 cobbles of altered lavas and 2 manganese nodules were collected on the upper part of the eastern slope of the Ridge. The volcanic

rocks have a thin film of manganese. They are soft greenish rocks which appear to be altered (chloritised) basaltic lava and tuff. The alteration may resemble that of the rocks collected from Swallow Bank in the Iberian Abyssal Plain, unless the rocks have been dynamically metamorphosed. A nearby camera station (5109) showed similar material, devoid of foliation.

Station 5123 was 2 miles south of 5106 in a similar locality. It yielded three cobbles; one was a brick-shaped piece of fresh, strongly foliated, chlorite schist. The others were thick slabs of manganese, enclosing shreds of rotten green schist. If these three rock specimens prove to be identical when seen under the microscope, it is likely that they are not erratics. No metamorphic rocks of this grade have previously been reported from the oceans. Photographs, taken 8 miles SSW of the seamount at the southern end of the ridge, showed boulders and outcrops with conspicuous markings on their surfaces which suggest that the rocks exposed there are schists.

Station 5111 (at 05° 28'N 61° 50'E, depth 2400 m) yielded manganese encrusted specimens of fresh vesicular olivine basalt, and included two pieces torn from the reddened glassy top of the lava flow.

(c) Results in area 4C. Three dredge stations yielded bottom samples. At station 5133 (near 02° 45'N 60° 02'E, depth ca. 4300 m), 10 rounded manganese nodules of about 8 cm diameter were collected. One was opened and had a non-calcareous white core of about 3 cm diameter; this is probably montmorillonite pseudomorphing palagonite. At station 5136 (near 02° 47'N 59° 53'E, depth 3400 m), some slabs of manganese encrustations up to 10 cm thick were collected. These specimens were evidently ripped from outcrops, but they included no rocks. Finally at station 5138 (near 02° 48'N 59° 52'E, depth 3050 m), 34 rounded cobbles were collected in which a 12 mm thick layer of manganese enclosed a core of palagonite tuff which is more or less completely altered to montmorillonite.

Nodules, thickly encrusted boulders and outcrops entirely smothered in manganese figure largely in the photographs. There is probably rather little material suitable for dredging.

2.3 Underwater photography

A total of 358 photographs were taken at 8 stations, divided equally between areas 4A and 4C.

In area 4A, it was unfortunate that where photographs were taken dredging was unsuccessful. All but one station showed a high proportion of massive bedrock and large boulders encrusted with manganese concentrated on the peaks and on local steep cliffs on the sides. On the flanks of the southern seamount near to the fault scarp, many of the rocks have lineations suggestive of schistosity beneath a thin manganese encrustation. Between the positions showing bedrock and boulders, there were areas of sediment-covered basins and slopes. Many photographs showed striking sand ripples and scour. The sediments were most commonly found near the bottom of the slopes.

In area 4C, dredge samples were obtained of the main types of rock seen in the photographs. Again massive bedrock was found at the peaks and on short steep slopes but, in contrast to area 4A, they were commonly extremely rounded and smooth as if encrusted with a layer of manganese (cf. dredge sample at 5136). On the slopes in some sediment regions, there were great concentrations (about 200/m^2) of manganese nodules of about 8 cm diameter. No current ripples were observed.

In both areas there is comparatively little life, other than that indicated by the mounds, burrows and tracks in the sediment. Fauna included several sea pens, sea lilies, sea urchins, a crinoid, some gorgonians and about four different fish species.

2.4 Coring and heat flow

(a) Method. A free-fall gravity corer, with a core barrel 3.7 m long was used and this device incorporated a new hydraulic release mechanism which prevented premature releases and never failed to trigger. The heat flow apparatus consists of three heat sensitive elements on outriggers at various distances down the core barrel and a potentiometer recorder mounted above the lead weights. The rig is satisfactory and no damage to the probes or the recorder was experienced.

(b) Cores. Eight cores were obtained ranging in length from 2.5 to 3.5 m. Five of these cores were obtained from the central part of the Carlsberg Ridge, two on the SW flanks and one en route to Mombasa. All were in areas of localized ponding of sediments, presumably deposited at a rapid rate owing to winnowing from surrounding peaks and the bottom mass transport of sediment from the slopes of these peaks. Three closely spaced cores exhibit a similar sequence of pelagic and, possibly, turbidic current deposits.

(c) Heat flow. Five successful recordings of heat flow were obtained, 2 in area 4A, 2 in area 4C, and 1 en route to Mombasa. Assuming an average thermal conductivity, no high values of heat flow have been revealed and the results in the individual areas have been consistent.

2.5 Water bottling

(a) Method. It was possible to make shallow casts from the for'ard hydrographic winch during dredging operations, but deep casts appeared to be too hazardous. Complete series of 3 casts were made each week in areas 4A and 4C.

(b) Chemical work. After leaving Aden, 4 chemical stations were worked. Nitrate and nitrite determinations were carried out for the whole water column while ammonia and albuminoid nitrogen were determined in the upper 150 m.

As might have been expected, the most northerly station was shown to be far richer in nutrients in the upper layers than the more southerly stations which were completely devoid of available nitrogen above the thermocline. Salinity and dissolved oxygen determinations were carried out on each sample.

(c) Trace metals. The object of the work was to determine the concentration and variation of trace metals in solution and in suspension in sea water. After leaving Aden, sea water samples from the surface to 2000 m were obtained. Each sample was filtered to retain suspended matter and the resulting filtered sea water was treated by a method of co-crystallization. The filters and solutions will be analysed at Liverpool for copper, lead, cobalt, nickel, manganese and zinc.

2.6 Ornithology

The central regions of tropical oceans are usually relatively barren, except where they are crossed by equatorial currents. Nevertheless, the number of birds seen in the central Arabian Sea was unexpectedly high. South-east of Socotra, a barren area was crossed; however, south of about 9° N, birds were seen regularly even though in small numbers. The average total was about 20 birds a day. The species associated with the upwelling areas of the Arabian coast were mostly missing except for small numbers of Jouanin's petrel and the blue-faced booby. Instead, there were species usually associated with the equatorial regions of the Indian Ocean, such as the sooty tern, a species of frigate bird and the red-footed booby. The black-bellied storm-petrel was probably one of the most common species and this has rarely been recorded in the Indian Ocean. Another small dark petrel was also seen quite frequently and was thought to be Bulwer's petrel, known to breed in the Pacific. It has previously been recorded once on the Maldive Islands. On the passage from 03° N 60° E to Mombasa, sooty terns increased in numbers and several large flocks, which probably contained birds dispersing from the breeding colonies in the Seychelles, were seen.

Unexpectedly, land birds were also seen in the central Arabian Sea: a whimbrel and a swallow at 05° N 62° E, and a curlew sandpiper when about 250 miles ENE of Mombasa; whether these were drifted migrants or birds on course to Africa from Asia is not known.

3. Leg 2 - MOMBASA TO MOMBASA - 14 September to 23 October 1963

3.1 Narrative

At Mombasa, R.R. Butler left the 'Discovery' to return to the U.K. and E.J.W. Jones joined the ship. The ship left her anchorage off Mombasa in the mid-morning of 14 September and about an hour later tied up alongside the R.N.A.D. jetty to take on board explosives and ancillary pyrotechnics. After completing this in the early afternoon, the ship sailed down past Mombasa to the open sea. Only the slave radar was functional at this time. This situation was worrying, but it was decided not to delay the cruise to await spares reported to be available in Nairobi. The risk proved worthwhile since, in spite of continual difficulties, the slave remained functional until the ship first met 'Owen' when there was temporary total failure. Fortunately, through the skill of the Radio Officer and with the aid of the scientists on board, the set was patched up.

En route to the Seychelles, the following stations were occupied:

5 water bottle
8 coring and heat flow
6 camera
2 dredge
9 seismic refraction profiles
5 bottom seismic profiles
5 seismic reflexion profiles

All stations provided valuable results except for one seismic refraction profile at position 4. One bottom seismic profile was not successful as a hydrophone cable was caught round the screw during lowering; its retrieval so delayed operations that it was impossible to lower to the bottom in time.

On the way to the Seychelles, the weather was generally calm, but on the day when we met 'Atlantis II', it was blowing hard enough to prevent the lowering of boats. However, a saluting charge was fired at an appropriate range, and two empty wooden cable drums which were required aboard 'Atlantis' were floated across together with various other objects and devices to indicate friendliness and esteem. As 'Atlantis' was having trouble with the stranding of her stainless steel wire and had only one length in reserve, 6000 m of wire were deposited with the agent in Port Victoria.

Throughout the cruise to the Seychelles, there was concern about the coring winch which showed increasing signs of the drum spreading. Although use of the winch was continued, eventually the spread was such as to preclude its use.

After visiting the Seychelles, course was set southwards to Fred Mount where a magnetic and topographic survey was made. A seismic station on the top was attempted, somewhat unsuccessfully as the ground waves were of very low amplitude.

After leaving Fred Mount a small desert island, called Ile des Noeufs, in the Amirantes group was approached. The ship passed over the fringing reef and anchored close inshore. The island is famed for its colony of sooty terns; as can be seen from section 3.8, the numbers are spectacular. A party of 4 men, including the ornithologist, went ashore for about 3 hours.

As shown in figure 1, the ship then made to the west. In anticipation of seismic profiles with 'Owen' additional to those originally planned, the position of profile 4 was occupied. It was in this position that 'Owen' had made an unsuccessful attempt to obtain the shallow seismic structure. On this occasion, all went well, and a long profile was shot by the single-ship method.

'Owen' met the ship on the evening of 16 October, in the position of profil 3. The Captain of 'Owen' (Cdr D.R. Haslam, R.N.) came aboard 'Discovery' together with some equipment brought out from the U.K. After discussing future operations, Cdr Haslam and Dr D.H. Matthews from 'Discovery', who was to organize the first stages of the charge firing, returned to 'Owen'. During the previous day, 'Discovery' had layed a dan-buoy and made a surface-to-bottom seismic run with the motor boat. Not only did this provide interesting results from the bottom receiver, but it also gave an opportunity to test all systems that were subsequently used while working with 'Owen'.

Before reaching Mombasa, 4 profiles (one more than originally conceived were shot in conjunction with 'Owen'. The additional profile was close inshore and was possible through making the line at the position of profile 3 single ended. The ship arrived in Mombasa on 23 October and 'Owen' was tied up alongside (thus providing a good opportunity to exchange information and gear).

Between the Seychelles and Mombasa, the following stations were occupie

4 water bottle
4 coring and heat flow
3 camera
1 rock dredge
6 bottom seismic profiles
4 two-ship seismic refraction profiles
2 single-ship seismic refraction profiles
2 surface current measurements

1 grab
2 Indian Ocean standard net
1 shore collection

3.2 Underwater photography

From nine camera stations were produced 243 monochrome and 20 colour photographs. In 7 stations, the camera height above the bottom was 4·6 m, in one it was 1·4 m and in the other it was 12 m. The latter successfully used the new 700 joule flash and obtained a remarkable series of 50 overlapping photographs on the side of Fred Mount.

All six stations made on the Lamu-Seychelles line at profile positions 2 to 6 were consistent in showing only mud disturbed by benthos. There were no manganese nodules. One station in area 4D showed rocky outcrops and large rounded boulders on an elongated abyssal hill. The long range photgraphs on Fred Mount showed a few rock outcrops heavily coated with sediment, a dyke-like ridge and large areas of well developed ripple marks.

3.3 Coring and heat flow

(a) Cores. ~~Sixteen~~ Twelve coring stations were occupied, all of which were successful. Nine cores from the six seismic stations between Mombasa and the Seychelles (three were repeated) consisted of highly foraminiferal blue-grey terrigenous mud with, at the three easternmost stations, intercalated turbidity layers of shallow origin. Two cores from area 4D and one from south of the Seychelles Bank consisted of highly calcareous pink foraminiferal clays interbedded with a large proportion (30 to 50%) of graded turbidity deposits of mainly organic calcareous composition, presumably derived from the Seychelles Bank or the slopes of local seamounts.

(b) Heat flow. Twelve heat flow stations were occupied. Six in a straight line from the Kenya coast to the edge of the Seychelles Bank and two in area 4D were completed before arriving in the Seychelles. On the return passage, three successful heat flow stations out of four were completed; one in the area of Fred Mount and the other two repeating stations 4 and 2 of the outward passage. The values around the Seychelles Bank obtained so far appear to be lower that those near the Kenya coast.

3.4 Seismic refraction profiles

On this section of the cruise, fifteen stations (of which only one was entirely unsuccessful) were completed in 36 days. The method of seismic refraction using sono-radio buoys was employed in conjunction with self-recordin buoys which have substantially improved signal-to-noise ratio on seismic records

by eliminating the radio link between buoys and ship. Both the radio buoys and the self-recording buoys operated satisfactorily.

The main purpose of seismic investigations was to determine the crustal structure beneath the gently sloping ocean floor between Lamu and the Seychelles, since there is geophysical evidence (gravity and magnetic) that this area, though deep ocean in general, is not 'typically oceanic' in conforming to a well-established pattern reported for other oceans by many observers. Seven reversed profiles at equal spacings of medium length (48 km) were completed and three of these were also shot to long ranges (96 km) with the assistance of H.M.S. 'Owen'.

3.5 Seismic reflexion profiles

Five attempts were made to obtain sub-bottom profiles, four of them on the Lamu-Seychelles line and one in area 4D. In the last line 85 charges were fired over a line about 32 km long.

An extremely good hydrophone slackening technique was developed that could be used at 5 km while giving very low hydrophone noise. Charges of 0.5 kg were first fired without floatation, later on a 3 m string below a balloon and thirdly on a 1 m string. The latter system gave a very much cleaner pulse and much better resolution of such sub-bottom echoes as were observed.

Recording gave the greatest difficulty; owing to the extremely slow paper movement, the paper dried up, and this was never completely overcome. The helix triggering arrangements worked excellently. The latter three stations were also recorded on tape being played back at different gains and in different frequency bands.

No very obvious sub-bottom reflexions were found in any of the stations even with the high signal-to-noise ratio; though the technique adopted seemed satisfactory, it was concluded that the soundings were in areas without a high contrast layer at shallow depth.

3.6 Bottom seismic profiles

In table 1 are shown the number and type of bottom seismic profiles attempted and the quality of the records obtained.

Notes on type (a). One of these stations was abandoned as a result of a deep hydrophone cable becoming foul of the ship's screw. This interfered with the timing schedule and the recording apparatus could not be lowered in time. The other 4 stations gave interesting records with complicated groups of first arrivals. No analysis of these results has yet been attempted.

Table 1. Bottom seismic profiles

Stations attempted	Station numbers	Type	Records obtained	Record quality
5	(5146 (5156A (5164 (5174 (5182	(a) 2.25 kg bottom charge	4	4 good
2	(5162 (5192	(b) 2.25 kg surface charge (from motor boat)	2	1 excellent 1 good
4	(5197 (5198* (5200 (5203	(c) near surface depth charge (with 'Owen')	5*	1 excellent 2 good 1 not good 1 poor

* Two recordings made at station 5198

Notes on type (b). This type of station had not previously been tried with the bottom seismic apparatus. During the 20 minutes of recording time available, the ship's motor boat fired a 2.25 kg charge every 2 minutes; starting at a range of 6 km and going out to 9 km.

The first analysis of one of these stations has shown the method to have great potential. Preliminary velocities of 2.7 and 4.5 km/s were obtained at the position of profile 5.

Notes on type (c). In the long range work with 'Owen', from which a depth charge was fired every 30 minutes, the bottom recorder was switched on for about 3 minutes to record each shot, and switched off between shots by means of a mercury tilt switch.

The signal-to-noise ratio was not generally good (partly due to strong currents and poor dan-buoy control), although at profile 1 the ground wave arrivals were noticeably clearer than those recorded by the sono buoys. No analysis of the records has yet been achieved.

3.7 Chemistry

Nine water bottle stations were worked after leaving Mombasa and at each the water column was sampled at 22 depths down to 1000 m. Analysis of these samples has been carried out with special reference to the ammonia and

albuminoid nitrogen concentrations. In all cases ammonia was found to be low, of the order of 1 μg/litre; albuminoid nitrogen was in general 3 to 4 times this concentration. Concentration of both were erratic down the water column, whether using filtered or unfiltered samples. A well defined thermocline was present, causing almost complete depletion of nitrate in the surface layers while below the discontinuity it increased rapidly to > 30 μg/litre at 1000 m.

3.8 Ornithology

Throughout the whole area, bird numbers were very variable and remarkably patchy. A conspicuous increase of numbers was noted in the middle seismic stations 2, 3 and 4, compared with either end of the line, although the little tern was noticeably more common close to the African coast. On returning to this area in October, there had been a noticeable decrease in the number of birds which may represent a movement to the south of such species as the sooty tern, black-bellied storm petrel, red-footed booby and the frigate-bird.

Within 320 km of the Seychelles, area 4D to the north and the magnetic seamount to the south-east were both much richer in birds than any area to the west. The latter area, lying relatively close to the breeding colonies on the Amirantes was exceedingly rich in birds. The wedge-tailed shearwater, white-tailed tropic-bird, blue-faced booby, and the sooty tern, all species nesting in the Amirantes, were more common there than elsewhere.

Unusual observations were of the red-footed booby, which is rarely recorded so far north, but which was quite common to the west of the Seychelles, and a species of Oceanodroma, probably a race of the sooty storm petrel from the Far East which was seen quite frequently, especially to the north of the Seychelles.

A visit to Isle des Noeufs where about two million pairs of sooty terns breed, showed that the end of the breeding season was approaching. There was little evidence of starvation and all the fledgings were at the same stage of development, and would have been ready to fly after a week or two. Three neuston net samples from the vicinity of the island suggested that the water is richer to the west, so upwelling may occur to the west of the Amirante Bank where the north-west flowing current moves away from the island. Several landbirds, principally waders, were seen at sea. The turnstone, in particular, was ubiquitous in small numbers, but a few whimbrel and curlew sandpipers were also seen.

3.9.1 Neuston net samples

On this section of the cruise, fourteen hauls were made; one at each of the seismic lines, except for line 4 where two were taken, one at area 4D and three around Ile des Noeufs. The volume of plankton was generally low except for the hauls taken in the vicinity of Ile des Noeufs. There seemed to be no significant difference in the volumes at any of the seismic lines although the ones

close in to the African coast may have been slightly richer than the others, while one taken in area 4D contained about three times as much plankton as the average elsewhere. The hauls in the open ocean have almost always been of the same type, containing fair numbers of a blue Copepod, and smaller numbers of a blue Decapod. Few fish have been caught, probably because all the hauls have been taken in daylight.

3.9.2 Bathythermograph

Between 7 and 9 September, while crossing the Equator, bathythermograp sections were taken at 2-hourly intervals; the results, plotted as continuous isotherms, have been forwarded to the National Institute of Oceanography. At other times, 6-hourly observations were taken while on passage and once or twice daily at seismic stations. After 23 August 110 observations were made. On 19 October, a bathythermograph and 550 m wire were lost when the wire parted after having been in continuous use since late July for some 300 dips. The wire was replaced by 3 mm wire given by 'Owen' which limited the length to 365 m.

3.9.3 Secchi disk

Observations were taken at all water bottle stations carried out in daylight. The results show little departure from a mean of about 22 metres.

3.9.4 Currents

Every opportunity was taken to measure currents by navigational fixes, sono buoy movement and, in a few cases, log ship observations against anchored dan-buoys.

4. Leg 3 - MOMBASA TO ADEN - 26 October to 14 November 1963

4.1 Narrative

'Discovery' and 'Owen' sailed from Mombasa on 26 October on passage to one of the more easterly positions for 2-ship seismic profiling; a core and heat flow stations was occupied by 'Discovery' en route. Before the shooting began on 29 October, Lt. Cdr Bhardwaz (of the Indian Navy) and Mr T. Reilly (a geologist from Nairobi) were transferred to 'Discovery' as observers. The usual procedure was followed with 'Discovery' laying the appropriate buoys with 'Owen' acting as firing ship.

The seismic shooting was at the positions of three profiles previously occupied for short-range work by 'Discovery'. A fourth line of great length - 170 km - was shot on the Seychelles Bank. Previous attempts by other ships had failed to achieve results at long-range owing to the difficulty of measuring

the range between the firing ship and the recording ship. However, by using the taut wire gear in 'Owen', ranging was entirely satisfactory. Even so, it was necessary to extrapolate the distances beyond 155 km from the speed of 'Owen' for the last two shots since, at this distance, no wire was left on the drum. On the completion of the long-range shooting, 'Discovery' made a reversed profile with her own shots and the 5 sono-radio buoys which had been laid for the work with 'Owen'. In all, 18 depth charges and 26 smaller shots were fired.

This seismic station took over 24 hours to complete; in the early morning of 3 November, the two observers on 'Discovery' returned to 'Owen'. The latter steamed into Port Victoria while the former started the collection of 6 grab samples of the sediments from the bank to the SW of Mahé. Subsequently on the same day, a further 18 grab samples were obtained to the north of Mahé, and towards Bird Island. Bird Island had a tern colony, as did the Ile des Noeufs, and it was decided that a visit was ornithologically desirable. For the first and last time during the cruise, the ship lay-to during the night and at 0530 on 4 November came to anchor $2\frac{1}{2}$ km from the island. The fifty or so inhabitants received the boat from 'Discovery' and the manager, having arranged for a guide for the shore party, was shown over the ship. At about 1000, the landing party was back on board and the vessel was underway; a report of the landing party's activities is given below.

Two towed magnetometers were lost during the earlier part of the cruise, but components for the reconstruction of a third had been flown out to Mombasa. This work, which involved building a fibre-glass fish and electronics gear in the ship, was completed soon after leaving the Seychelles Bank.

Thence the ship sailed for Mount Error at the northern end of the Carlsberg Ridge. Bathythermograph results were taken at $\frac{1}{2}$-hourly intervals on this passage, and the usual on-passage observations were made. As the gearing in the winch stripped on 6 November, further bathythermograph measurements were not possible.

Late in the evening of 8 November, a dan-buoy was laid above Mount Error; it immediately dragged and was recovered. A second attempt was made, but the moorings parted before the buoy was over the side. At the third attempt, the dan-buoy was successfully moored. On each occasion, the moorings consisted of 110 kg of old chain and a 27 kg anchor.

On the top of the seamount, two successful dredge hauls were obtained, a seismic station with 59 shots was occupied, photographs were taken, while surveys and a magnetometer heading correction run were made. Finally, on the flanks, the dredge became hitched to the bottom where the wire eventually broke. Losses consisted of two dredges, one length of chain, a pinger and 260 m of crippled wire.

The dan-buoy was recovered and a course set for the Gulf of Aden. On the way, one core and heat flow measurement was obtained. In the Gulf, three

more such measurements, on a line across the central axis, were successful. Early in the morning of 14 November, the ship arrived alongside the Admiralty Jetty at Aden.

Between Mombasa and Aden, the following stations were occupied:

1 water bottle
7 coring and heat flow
4 camera
2 bottom seismic profiles
3 twin-ship seismic refraction profiles
1 single-ship seismic refraction profile
5 surface current measurements
5 grab
4 rock dredge
1 shore collection
1 magnetic heading correction

4.2 Underwater photography

The four camera stations occupied gave 146 monochrome pictures. At two of these stations, the 700 joule flash was used at 12 m though at the second of these the flash fired for only half the time. On one station, the camera was 2 m above the bottom.

The most rewarding stations were on the edge of Mount Error and showe rocky outcrops quite unlike those on volcanic seamounts. They could be interpreted as an eroding or decaying coral limestone. In the Gulf of Aden, a statio was taken of the central rough topography, surprisingly, no rocks or boulders were seen in the pictures.

4.3 Surface seismics

Four complete seismic profiles were shot on this leg, two being in oceanic depths and two in comparatively shallow water. The former two completed the eastern end of a line of seven seismic stations between Lamu on the Kenya coast and the Seychelles Bank. In each case, depth charges were fired by H.M.S. 'Owen' on courses 040 and 220 from the ship and buoys out to a range of about 80 km; the records confirm the picture obtained from the earlier shorter-range single-ship lines.

The next line was shot on the Seychelles Bank in 54 m of water, shots being fired by both ships. The buoys were laid approximately 32 km SW of Mahe 'Owen' fired 20 depth charges on a line 110° from them for 170 km and then 'Discovery' completed the shooting with close range shots on the same side and shots out to 30 km range in the direction 290°. As sound waves could not be received through water at ranges greater than about 32 km, 'Owen' used taut-wire measuring gear to give her range from a moored dan-buoy on which the

free-floating sonobuoys were continuously fixed visually and by radar. Excellent arrivals were obtained out to maximum range, a layer three-type velocity being found to underlie the essentially granite bank.

The last seismic station was shot over Mount Error, a non-magnetic seamount (at 10° 17'N 56° 04'E), the flat top of which extends approximately 24 by 9½ km and lies between 360 and 420 m deep. The buoys, laid at the NE end of the mount during the shooting, were carried along its whole length to the SW by a current of nearly 2 knots. Lines were shot on both sides of the buoys parallel and perpendicular to the length of the bank, 56 shots being fired in all with excellent results.

On all these stations, five buoys were launched: three radio-sonobuoys and two of the internally recorded type. The Mount Error station completed the seismic operations of the cruise.

4.4 Bottom seismics

The apparatus was used in the shooting of profiles 5 and 6 with 'Owen', but not for the Seychelles Bank profile (the third and final profile with 'Owen' on this leg) as the water depth was only about 54 m.

Time was not available to work more stations either with bottom charges or with surface charges from the ship's motor boat.

Profile 5, 29 October 1963. The record is extremely noisy in spite of calm weather conditions and good dan-buoy control. Ground waves were recorded from the first 3 shots only. The reason for the absence of signals from the hydrophones for the remaining shots has yet to be solved.

Profile 6, 31 October 1963. Only the first 3 shots produced ground waves. It seems likely that the loss of signal at this stage was due to a pressure effect on the hydrophone cables, as the system worked properly under test when back on deck.

The apparatus was lowered again for the reverse leg of this profile. After recording the first three shots reasonably well, the 35 mm camera jammed.

4.5 Ornithology

The transect from Mombasa to the Seychelles Bank showed an even greater reduction in bird numbers, presumably due to a southward migration, than was observed at the beginning of October. Only small numbers of sooty terns, frigate-birds and red-footed boobies were seen; one sooty storm-petrel was seen. Another interesting observation was of two probable Arctic skuas migrating southwards, presumably to South Africa.

On the Seychelles Bank, there were many local concentrations of birds

feeding from fish shoals close to the islands. The most common species were common noddies, white terns, and Audubon's shearwaters, with smaller numbers of sooty terns and wedge-tailed shearwaters. It was somewhat surprising to see a few small parties of Wilson's storm-petrels so far north at this season.

On 4 November, when leaving the Seychelles Bank, a shore party landed on Bird Island, where sooty terns were the only seabirds breeding in any numbers. The only other resident seabirds were white terns and common noddies which nest in the trees in the centre of the island. Northern waders were common, and the most abundant of these were turnstones and whimbrels. At least three species of migrants seen had not previously been recorded on the Seychelles: the Temminck's stint, the Pratincole, and a bird which was probably a race of the common swift.

A quick transect north towards Socotra showed that this area also had been markedly depopulated since the beginning of September. Around the equator, sooty terns were seen in quite large numbers, with very small numbers of blue-faced boobies and sooty storm-petrels; the sighting of a Wilson's storm-petrel was surprising. To the north, no more of these species were seen, but at about 6° N, Jouanin's petrel was seen and, at the non-magnetic seamount at 9° N, both this species and the red-billed tropic-bird were seen in small numbers. Surface plankton samples were taken along this line and their volumes indicate that the equatorial region was several times more productive than the open sea to the north, a fact well in accordance with the bird distribution.

4.6 Bird Island, Seychelles

A party of five landed on the west coast of Bird Island soon after dawn on 4 November and were met by the local inhabitants on the beach; no problems of any sort were encountered on landing and the party set off to find the colony of 'goelettes', the local name for the sooty tern.

The whole of the interior of the island, 1600 m by 800 m, is planted with coconuts interspersed with a few small maize plantations. Most of the thatched huts were centred around the manager's house on either side of a wide avenue of coconut palms. Here and there chickens (and a donkey) foraged together with turnstones, wading birds from the Arctic which are normally associated with rocky and desolate shores. Small ground doves and the bright scarlet fody, both introduced from Mahé, were observed in the bushes, but the most obvious bird was the white tern. Soon the avenue of tall Casuarina trees broadened near the shore and, after passing through the tall dense bushes fringing the beach, the party came to the sooty tern colony situated in a tiny corner of the island just to the east of the north point. The whole colony, estimated to comprise between twenty and fifty thousand birds, covered an area of only a few acres and, while impressive, this must be a mere fraction of the numbers that were present at the beginning of the century. Almost all the birds were juveniles which were nearly ready to fly. Adults were present in small numbers and rose at our approach, but it seems likely that most would have been out at sea feeding.

The nesting area was only just above the beach and apparently was sometimes covered with water during gales. This may be the explanation of the lateness of the breeding season, for earlier attempts at breeding may have been unsuccessful. As at other islands in the colony, egg collecting is allowed up to a certain date and this again could be a contributory factor, if not the main one. In the last century, the island was covered with phosphatic guano, but by 1905 all this had been removed as fertiliser. However, before then, the raised central plateau may have afforded some protection from the gales.

The breeding season now is comparatively very late since, in 1905, the birds were reported to have left by September. Even in November 1963, the birds showed no signs of having a diminished food supply. There is the possibility that, because the birds have a late breeding season enforced on them by egg-collecting, there is less food available for the young and so now the island is able to hold far fewer birds than formerly; only thirty thousand instead of a hundred thousand before. However, this reduction could be due simply to the lack of space following the planting of the coconuts.

Unlike Ile des Noeufs in the Amirante Islands, there were no noddies among the sooty terns. Instead, small numbers of noddies were seen on the coconut palms in the interior where they apparently nest. Passing north from the tern colony, there was a long sand spit which may be of relatively recent formation. It was devoid of all vegetation and was inhabited only by parties of migrant crested terns with small numbers of wading birds including the strange crab plovers, a long-legged bird with a huge beak adapted for breaking open the carapace of crabs.

Moving southwards, along the eastern shore, the party used a track behind the fringing bushes which really gave the impression of lush tropical secondary growth. The vegetation in the interior was both thick and of great variety and on the western side it was so dense as to be impenetratable. The party returned aboard about 1000 hours.

4.7 Coring and heat flow

(a) Cores. Of the seven coring stations attempted, only one was unsuccessful. The two cores that were taken between Mombasa and the Seychelles consisted in the main of a greenish to bluish grey ooze, but in one core there were two thin layers of a sandy turbidite. A core from the Somali Basin south of Socotra also contained sandy layers, evidently the product of turbidity current deposition. In the Gulf of Aden, grey-green muds were collected, one core also contained small shell fragments; the other two cores were mottled in appearance with small dark patches.

(b) Heat Flow. Seven heat flow stations were occupied: 2 between Mombasa and the Seychelles, 1 just north of the Seychelles, 1 south of Socotra and 3 in the Gulf of Aden. The values of the first two stations confirmed

previous results; on the third, no core was obtained. The fourth was average and the last three are high confirming previous American work. The apparatus worked very well on this part of the expedition with no failures in either probes or recorder.

5. Leg 4 - ADEN TO PLYMOUTH - 16 November to 4 December 1963

5.1 Narrative

'Discovery' sailed from Aden in mid-morning of 16 November. The intention was to obtain a series of 9 core and heat flow measurements, to determine, as far as possible, the difference in heat flow between the median disturbed area and its flanks. At each heat flow station, a water bottle cast was made.

One camera station was occupied in the middle of the Red Sea; the photographs all showed flat sediments.

The stations occupied in the Red Sea were as follows:

6 coring and heat flow
1 camera
1 water bottle

On completing this station work, a course was set for Suez where the ship anchored in the early morning of 22 November. The northbound convoy was joined in the morning of 23 November and 'Discovery' left the canal in the late evening. Thence, at full speed she headed for Gibraltar. Three days from Port Said, strong to gale force head winds were encountered which, at times, considerably reduced the ship's speed.

On 29 November, the last station of cruise 2 of R.R.S. 'Discovery' was occupied. This was a water bottle station with the large bottles. Deep water from the western Mediterranean was required for standardization purposes by the N.I.O.

The passage back to the U.K. was at full speed with the strong to gale force wind abeam or astern. The ship entered Millbay Docks on the evening of 4 December.

5.2 Underwater photography

One camera station near the centre of the Red Sea gave 26 pictures of dull sediment.

5.3 Red Sea cores and heat flow

(a) Cores. Six coring stations were occupied, five of which were successful and one partially successful. The two shallowest stations yielded a pink to grey foraminiferal mud and the deeper stations banded muds of varying yellow, grey and brown colour tones. All cores contained significant quantities of pteropod remains which were occasionally abundant. With the exception of the southernmost core, all contained a layer of close-packed, hard, jagged calcareous concretions, sometimes tailing off downwards into a sporadically occurring, more crumbly variety. The partially successful station provided a small sample of these concretions.

(b) Heat flow. Six heat flow stations were attempted in the Red Sea, the first, second and fourth of which were successful. On the fifth station, the trigger weight failed to go off and only the bottom probe penetrated the sea bed. On the third and fourth stations, a layer of closely packed concretions ripped the bottom fin from the core barrel and on the sixth these same concretions caused an early conclusion to the heat flow stations by stripping off all three fins leaving a solitary broken Jubilee clip. A preliminary examination showed that the values of heat flow obtained in the Red Sea appear to be high.

6. FIELDWORK FOR STUDIES OF ROCK MAGNETISM IN THE SEYCHELLES

6.1 Objectives

The inner islands of the Seychelles group are granite; most of them are formed of late pre-Cambrian granite, but the remnants of an alkaline (syenitic) ring - complex of Tertiary age are preserved on Silhouette Island. The plutonic rocks are cut by dolerite dykes. Specimens of the dyke rocks collected by scientists from H.M.S. 'Owen', during 1961-62 have been dated in Cambridge. The results show that there are two suites of dykes, corresponding in age to the granites and syenites: ca. 650 and ca. 50 million years, respectively (Baker and Miller 1963). Dykes of the two suites cannot be distinguished in the field. Magnetometer traverses carried out at sea by 'Owen' during 1961-62 showed that the central area of the Seychelles Bank is characterized by total field anomalies of more than 1000 γ. These anomalies have been tentatively attributed to the magnetic effects of the dolerite dykes. Measurements of Natural Remnant Magnetism (NRM) made by H. R. Spall on specimens of these rocks collected in 1961-62 have shown that some of them are unusually strongly magnetized, with intensities in excess of 0.1 e.m.u./cm^3.

The objectives of the present fieldwork were twofold:

(a) To establish the direction and intensity of magnetization of the dykes with a view to quantitative interpretation of the magnetometer traverses made at sea;

(b) To measure the remanent magnetization directions of the pre-Cambrian and Tertiary dykes and compare the results with those obtained on rocks of similar ages in East Africa, in order to find out whether the Seychelles have moved relatively to Africa.

6.2 Personnel

The work is being carried out jointly by the Department of Geodesy and Geophysics, Cambridge, and by the Department of Physics, Royal College, Nairobi (Professor A.N. Hunter). The field work has been done by Dr D.H. Matthews, Cambridge and Mr T.A. Reilly, Nairobi (under the supervision of Professor P.M.S. Blackett). Geological maps and advice were provided by the Director, Department of Mines and Geology, Kenya (Dr B.H. Baker).

6.3 Narrative

Matthews reached Mahé on 27 October 1963 aboard s.s. 'Kampala'. During the first week, arrangements were made for visiting the more distant islands and collection on Mahé was started. Reilly arrived on 3 November aboard H.M.S. 'Owen'. During the following week, collections were made on Praslin, Cousine, La Digue, Marianne and Felicité. The remaining days were spent collecting on Mahé. The party left aboard s.s. 'Karanja' on 21 November.

The majority of the dykes shown on the geological map were sampled. As it was usually impossible to find suitable exposures inland, it was concluded that only exposures in the foreshore were likely to be profitable. In all 71 blocks were taken from 40 separate dykes. Each block was orientated by two dips measured with an Abney level on a three-legged template placed on the rock. The azimuth of the template was measured with a Wild TO compass-theodolite. The magnetic bearings given by the theodolite were checked for errors arising from the magnetic effect of the dyke by taking bearings and altitudes of the sun, and/or of distant islands. Attempts were made to take core samples of the dykes on Mahé using portable drilling machinery developed in Nairobi, but the diamond bit cut too slowly into the fresh dolerite.

6.4 Disposal of material and results

The 71 specimens were left in Nairobi where facilities are available for cutting thin sections and for measuring the direction and intensity of magnetization of cores cut from the blocks in the usual way. Measurements of NRM will be made on a newly constructed astatic magnetometer. Facilities for thermal demagnetization exist and a.c. 'washing' techniques were expected to be available.

The magnetic work is under the supervision of Dr A. Mussett and Professor A.N. Hunter. The thin sections are to be compared with Dr Baker's material in Nairobi. If the results of this work suggest that further age determinations are necessary, material will be sent to Cambridge. Initial publication of result will be in Nature in early 1964.

There proved to be little opportunity for general geological observations during the fieldwork. A few hand specimens of unusual rocks were collected (notably on Ile Longue, at Pte. Vareur on Silhouette Island and at Anse aux Poules Bleues and Sunset Hotel on Mahé). In general, Dr Baker's map and monograph seemed very accurate, but for a few minor points.

6.5 Comments

The physical difficulties of the work were somewhat underestimated. The rainy season had set in before the start and the high humidity coupled with temperatures of 85 to 90° F were trying. Land-slipped blocks, thick vegetation and steep slopes combined to impede progress on land: a rate of a few hundred metres per hour was the best that could be achieved away from the path. At this time of year (October/November), a small boat would have assisted the fieldwork. With less than three in the party, the rate achieved would have been far less.

It is hoped that a report on the Seychelles will be prepared incorporating the magnetic results with additional petrological and petrofabric studies and making a comparison with other parts of the Mozambique Belt.

Reference

Baker, B.H. & Miller J.A. 1963 Nature. Lond., 199, 346-348.

Table 2. Summary of Cruise 2

23 August 1963 to 4 December 1963

		Station (days)	On Passage (days)
Leg 1.	Aden to Mombasa	9.0	10.5
Leg 2.	Mombasa to Mombasa	27.0	7.2
Leg 3.	Mombasa to Aden	10.6	7.7
Leg 4.	Aden to Plymouth	0.8	17.7*
		47.4 d	43.1*

Total time at sea 90.5 days

Total time at port 12.5 days

Distance steamed on passage	12,610 miles	23, 430 km
Distance steamed on station	2,720 miles	5060 km
Total distance steamed	15,330 miles	28, 490 km

* This includes one day at anchor awaiting the canal convoy at Suez.

Table 3. Station summary

Total number of stations occupied - 136

Bottom seismics	13
Seismic reflexion	5
Single-ship refraction seismics	14
Two-ship refraction seismics	7
Rock dredge	26
Underwater camera	22
Core and heat flow	33
Grab	6
Water bottles	26
Miscellaneous	11

Table 4. Key to station list

N.N.	Neuston net
I.O.S.N.	Indian Ocean standard net
D.L.H.	Large heavy dredge
D.C.	Conical dredge
U.C.	Underwater camera
W.B.	Water bottles
C.H.F.	Core and heat flow
C.M.	Current measurement
G.	van Veen grab
S.S.	Seismics - surface refraction
S.B.	Seismics - bottom refraction
S.S.B.	Seismics - surface and bottom refraction
S.R.	Seismics - reflexion
S.D.	Secchi disc
M.H.C.	Magnetic heading correction
U.C.F.	Uncorrected depth in fathoms (800 fm s^{-1})
C.F.	Corrected depth in fathoms (Matthews)
D.B.	Dan-buoy
L.M.T.	G.M.T. + 4h

NOTES

(i) In seismics, the mean centre of the buoy line is given if Discovery moved during the station. In two-ship seismics, the mean position of the centre of the line is given. In general this coincided approximately with Discovery's position.

(ii) Heat flow; all probes worked unless otherwise stated.

(iii) Depths are to the nearest five fathoms.

(iv) Distances are to the nearest nautical mile when above ten miles (1 n. mile = 1 minute of arc).

(v) Dan-buoy number is given when used on station.

(vi) Maximum depth in water bottle stations is the greatest depth to which a bottle was lowered according to the meter.

Table 5.

Station list

tion ıber	Type	Date	Time (L.M.T.)	Position	D.B.	Depth UCF	Depth CF	(m)	Comments
02	W.B.	26/8	1130-1536	11° 10.5' N 55° 03.2' E	-	2130	2190	4010	Four successful casts, maximum depth 4000 m.
					MOUNT ERROR				
03	D.L.H.	27/8	0848-1257	10° 25.1' N 56° 11.1' E	I	210-490	220-505	400-925	One piece of dead coral. Weak link slid down arm.
04	D.L.H.	27/8	1335-1500	10° 24.5' N 56° 08.4' E	I	220-260	230-270	420-495	No collection. Dredge and half the chain lost.
					AREA 4A				
.05	U.C.	30/8	0118-0332	05° 35.5' N 61° 48.1' E	II	1655-1720	1695-1760	3110-3220	Forty good pictures at 4.6 m range of mud and one rocky outcrop.
.06	W.B. D.L.H. D.C.	30/8	0800-1236	05° 36.3' N 61° 53.4' E	II	1190	1220	2240	Two successful shallow water bottle casts (200 m depth). Prolific haul of 21 altered basalt cobbles in D.L.H.
.07	Core	30/8	1336-1654	05° 37.8' N 61° 47.5' E	II	1790	1835	3360	No core. (Trigger had released correctly.)
.08	D.L.H.	30/8	1830-2330	05° 36.0' N 61° 47.2' E	II	1535-1775	1575-1820	2890-3340	No collection. Chain snarled up. Small collection of ooze from the dredge frame.
109	U.C.	31/8	0048-0442	05° 35.7' N 61° 51.2' E	II	1270-1360	1300-1395	2380-2560	Sixty-two pictures at 4.6 m range of boulders, bedrock, ripple-marked sand and mud.
110	C.H.F.	31/8	0612-0930	05° 47.5' N 61° 47.4' E	II	2150	2210	4050	No heat flow result. Core of foraminiferal ooze.
111	D.L.H.	31/8	1402-1818	05° 27.6' N 61° 50.4' E	III	1260-1500	1290-1540	2360-2820	Five fresh-looking basalt cobbles.
112	C.H.F.	31/8	1955-2218	05° 34.4' N 61° 57.1' E	-	1900	1950	3580	No heat flow result. Core of foraminiferal ooze.
113	U.C.	01/9	0024-0420	05° 26.2' N 61° 49.0' E	III	940-1130	965-1155	1770-2120	Fifty pictures at 4.6 m range of rocky outcrops, boulders and sediment.
114	D.L.H.	01/9	1548-0918	05° 25.3' N 61° 50.0' E	III	1070	1095	2010	Dredge arms parted at the weak link.

Table 5.

ıtion mber	Type	Date	Time (L.M.T.)	Position	D.B.	Depth U.C.F.
:15	D.L.H.	01/9	0942-1248	05° 26.5' N 61° 49.3' E	III	1040
116	C.H.F.	01/9	1354-1636	05° 34.5' N 61° 57.1' E	II	1900
117	D.L.H. N.N. W.B.	02/9	1706-1054	05° 26.6' N 61° 53.3' E	III	1450
118	D.L.H.	02/9	1354-1806	05° 30.2' N 61° 47.1' E	III	1400
119	D.L.H.	02/9	1954-2154	05° 28.3' N 61° 47.2' E	III	1165
120	D.L.H.	02/9 03/9	2205- 0005	05° 28.4' N 61° 46.9' E	III	1045
121	U.C.	03/9	0052-0442	05° 28.3' N 61° 47.1' E	III	1050- 1220
122	C.H.F.	03/9	0640-0906	05° 34.5' N 61° 56.3' E	-	1895
123	D.L.H.	03/9	0954-1300	05° 34.0' N 61° 51.5' E	IIa	1275- 1465
124	D.L.H. I.O.S.N.	03/9	1340-1639	05° 37.0' N 61° 50.2' E	IIa	1090- 1320
				AREA 4C		
125	C.H.F.	04/9	1542-1848	02° 44.6' N 60° 14.8' E	IV	2550
126	D.L.H.	04/9	1955-2230	02° 49.0' N 60° 20.9' E	IV	2200
127	U.C.	04/9 05/9	2336- 0338	02° 47.5' N 60° 20.7' E	IV	2100- 2230
128	U.C.	05/9	0400-0622	02° 47.8' N 60° 21.4' E	IV	2055

Station list (Continued)

Depth CF	(m)	Comments
1065	1950	No collection.
1950	3580	Heat flow result. Core of foraminiferal ooze and turbidity material.
1485	2720	No collection. Three successful water bottle casts, maximum depth 2000 m. 2 ml of plankton and one flying fish in net.
1435	2630	No collection.
1195	2190	No collection.
1070	1960	No collection.
1075- 1250	1970- 2290	Fifty-two pictures at 4.6 m range of bedrock, boulders and ripple-marked sand.
1945	3560	Heat flow result. Core of foraminiferal ooze and turbidity layers.
1305- 1505	2390- 2760	Three manganese encrusted metamorphic cobbles.
1120- 1350	2050- 2470	No collection. Medium sized haul in net.
2630	4830	Heat flow result. Core of foraminiferal ooze and turbidity layers.
2260	4150	Station abandoned because of difficulty of heaving to.
2160- 2290	3960- 4200	Thirty-five pictures at 4.6 m range of manganese nodule massive bedrock and ooze.
2115	3880	Twenty pictures at 4.6 m range of massive bedrock and conglomerates.

Table 5.

Station list (Continued)

Station number	Type	Date	Time (L.M.T.)	Position	D.B.	Depth U.C.F.	Depth CF	(m)	Comments
5129	W.B.	05/9	1036-1218	02° 48.2' N 60° 19.6' E	V	2140	2200	4030	A successful cast. Maximum depth 1000 m.
5130	D.L.H.	05/9	1242-1554	02° 48.1' N 60° 20.1' E	V	2120	2180	4000	No collection. Evidence that D.B. V was adrift while dredge on the bottom.
5131	W.B. S.D.	05/9	1518-1634	02° 47.3' N 60° 20.4' E	V	ca.1870	ca.1920	ca.3520	Shallow and deep casts. Deepest sample at 2500 m. Maximum depth 3500 m.
5132	U.C.	06/9	0150-0527	02° 46.2' N 60° 02.5' E	VI	2000-2080	2055-2140	3770-3920	Fifty-one pictures at 4.6 m range of manganese nodule and massive bedrock.
5133	D.L.H. D.C.	06/9	0613-0930	02° 45.4' N 60° 02.8' E	VI	2110-2170	2170-2230	3980-4090	Manganese nodules in both dredges. A prolific haul.
5134	D.L.H.	06/9	1015-1030	02° 46.0' N 60° 03.1' E	VI	2000	2050	3760	Station abandoned when D.B. VI sank.
5135	C.H.F.	06/9	1430-1730	02° 55.3' N 59° 52.8' E	VII	2495	2570	4700	Heat flow result. Core of foraminiferal ooze and turbidity layers.
5136	D.L.H.	06/9	1856-2345	02° 46.6' N 59° 52.8' E	VII	1845-1940	1890-1990	3460-3640	Many large manganous nodules.
5137	U.C.	07/9	0045-0445	02° 46.0' N 59° 53.0' E	VII	1900-2160	1950-2220	3560-4060	Forty-nine pictures at 4.6 range of ooze and two of rounded boulders and bedrock.
5138	D.L.H.	07/9	0535-0915	02° 47.9' N 59° 52.1' E	VII	1775-1840	1815-1895	3330-3470	Manganese nodules, nuclei of palagonite tuff.
				PASSAGE TO			MOMBASA		
5139	C.H.F.	08/9	0912-1218	01° 54.0' N 56° 10.5' E	-	2550	2630	4800	Heat flow result. Core of foraminiferal ooze.
				LAMU -			SEYCHELLES LINE		
				PROFILE 1					
5140	S.S.	16/9	0700-1336	01° 53.3' S 42° 09.6' E 18 miles 030°	-	1310-1390	1340-1420	2450-2600	Two buoys, nine shots. Successful testing run.

Table 5.

Station list (Continued)

Station number	Type	Date	Time (L.M.T.)	Position	D.B.	Depth U.C.F.	Depth CF	Depth (m)	Comments
5141	W.B. ✓	16/9	1728-2000	01° 40.6' S 42° 19.1' E	-	1225	1255	2300	Three successful casts but deepest bottle triggered at 1500 m not 2200 m.
5142	S.R.	16/9	2105-2400	01° 46.5' S 42° 12.0' E 13 miles 230	-	1240-1270	1270-1300	2320-2380	Twenty-one shots at 5 minute intervals. Hydrophone slacking worked well.
5143	S.S.	17/9	0652-1800	01° 41.0' S 42° 05.5' E 21 miles 040° 28 miles 214°	-	1040-1190	1065-1220	1950-2230	Profile 1. Four buoys, twenty-three shots. Results confirmed those of 5140.
5144	C.H.F.	17/9	1900-2145	01° 41.0' S 42° 13.4' E	-	1205	1235	2260	Corer dragged while in the bottom owing to dynamometer failure. No heat flow result. Core of mottled foraminiferal ooze.
5145	S.R.	17/9 18/9	2218-0045	01° 41.4' S 42° 20.1' E 10 miles 105°	-	1140-1470	1170-1500	2140-2740	Twenty-two shots at 5 minutes intervals. No sub-bottom echoes.
				PROFILE 2					
5146	S.B. W.B.	18/9	1054-2100	02° 22.3' S 43° 22.8' E	VIII	1880-2100	1930-2160	3530-3950	Four charges fired, two of these showed ground waves. Three successful water bottle casts, but bottom triggered at 1000 m not at 3500 m.
5147	S.R.	18/9 19/9	2145-0112	02° 23.5' S 43° 20.5' E 16 miles 205°	-	1860-1885	1905-1965	3480-3600	Twenty-two shots at 5 minute intervals. Sub-bottom echoes absent.
5148	S.S.	19/9	0520-1515	02° 33.5' S 43° 30.8' E 19.5 miles 040° 14 miles 216°	-	1885-1940	1925-1990	3520-3640	Four buoys, nineteen shots. Poor radio reception, correlated noise.
5149	C.H.F.	19/9	1728-2024	02° 24.3' S 43° 24.4' E	-	1895	1945	3560	Heat flow result. Core of foraminiferal ooze.
5150	U.C.	19/9	2030-2242	02° 25.8' S 43° 23.5' E	-	1885	1930	3530	Twenty-one pictures at 4.6 m range of soft bottom and tracks, also submarine cable (?).

Table 5.

Station list (Continued)

Station number	Type	Date	Time (L.M.T.)	Position	D.B.	Depth U.C.F.	Depth CF	(m)	Comments
				PROFILE 3					
5151	S.S.	20/9	0924-1750	02° 29.5' S 44° 58.3' E 14 miles 044° 18 miles 223°	-	2200-2250	2260-2310	4140-4230	Four buoys, twenty-five shots. Lack of direct sound.
5152	C.H.F.	20/9	1755-2112	02° 31.8' S 44° 55.7' E	-	2220	2280	4170	Heat flow result. Mottled foraminiferal ooze.
5153	U.C. W.B.	21/9	2112-2354	02° 33.6' S 44° 55.6' E	-	2220	2280	4170	Twenty-five pictures at 4.6 m range of soft bottom showing tracks. Big bottle 30 m above camera.
5154	N.N.	21/9	1400-1418	02° 47.8' S 47° 02.4' E	-	2550	2630	4810	At least 1 ml of plankton.
5155	C.H.F.	21/9	1600-1917	02° 48.2' S 47° 02.5' E	-	2550	2630	4810	Heat flow result. Core of foraminiferal ooze and thi turbidity layers.
5156A	S.B.	21/9 22/9	2000-0245	02° 47.3' S 47° 01.8' E	IX	2555	2635	4820	Eight charges laid. Hydrophone cable fouled screw s experiment abandoned for lack of time.
5156B	W.B.	22/9	0320-0530	02° 48.8' S 47° 03.2' E	-	2550	2630	4810	Four successful casts. Pinger used on deep bottles. Maximum depth 4800 m.
				PROFILE 4					
5157	S.S.	22/9	0639-1230	02° 54.7' S 47° 00.0' E	-	2555	2635	4820	Five buoys, only two shots fired. Station abandoned due to excessive radio noise.
5158	U.C. W.B.	22/9	1300-1518	02° 55.3' S 47° 02.1' E	-	2555	2635	4820	Twenty-four pictures at 4.6 m range of soft bottom. Water bottle attached to camera wire and collected sample at 4700 m.
				PROFILE 5					
5159	S.S.	23/9	0715-1822	03° 26.5' S 49° 36.5' E 25 miles 040° 19 miles 225°	-	2665-2680	2750-2765	5040-5060	Five buoys, forty-three shots. Good arrivals with radio range to 30 miles.
5160	C.H.F.	23/9	2007-2330	03° 30.0' S 49° 40.1' E	-	2670	2760	5050	Heat flow result. Core of foraminiferal ooze and turbidity layers.

Table 5.

ation mber	Type	Date	Time (L.M.T.)	Position	D.B.	Depth U.C.F.
161	S.R.	23/9 24/9	2340- 0242	03° 31.5' S 49° 40.6' E 13 miles 220°	-	2645- 2675
162	S.B.	24/9	0800-1250	03° 31.8' S 49° 43.0' E 6.6 miles 294°	X	2670
163	U.C. W.B.	24/9	1330-1624	03° 30.7' S 49° 40.2' E	-	2675
164	S.B.	24/9	1758-2336	03° 30.6' S 49° 36.3' E 1.8 miles 302°	X	2670
165	C.H.F.	25/9	1200-1648	03° 32.5' S 51° 28.7' E	-	2705
				PROFILE 6		
166	U.C. W.B.	25/9	1700-2000	03° 31.6' S 51° 29.5' E	-	2650
167	W.B.	25/9 26/9	2115- 0200	03° 31.4' S 51° 30.5' E	-	2665
168	S.S.	26/9	0605-1711	03° 32.0' S 51° 31.0' E 20 miles 041° 20 miles 226°	-	2630- 2700
169	N.N.	27/9	1354-1418	02° 16.8' S 54° 44.5' E	-	2300
				AREA 4D		
170	S.S.	28/9	0518-1643	02° 12.0' S 57° 20.1' E 45 miles 111°	-	2315- 2400
171	C.H.F.	28/9	1807-2050	02° 09.8' S 57° 24.5' E	-	2335

Station list (Continued)

Depth CF	(m)	Comments
2730- 2760	5000- 5050	Thirty-one charges at 5 minute intervals. No sub-bottom echoes.
2755	5045	Ship's boat fired nine shots on course 294° from ship. Good arrivals recorded by hydrophones and geophone.
2760	5050	Twenty-five pictures at 4.6 m range of featureless so bottom. Bottle 30 m above the camera.
2755	5045	Five shots recorded on geophone. No ground waves.
2790	5100	Heat flow result. Core of foraminiferal ooze and thi turbidity layer.
2730	5000	Twenty-four pictures at 4.6 m range of featureless s bottom. Big water bottle 30 m above camera.
2750	5040	Three successful casts. Maximum depth 5000 m.
2710- 2790	4960- 5100	Five buoys, thirty-one shots. Good records.
2360	4320	½ ml of plankton.
2380- 2470	4360- 4520	Five buoys, twenty-four shots. Good records.
2400	4390	Heat flow result. Core of foraminiferal ooze with several turbidity layers.

Table 5.

ation mber	Type	Date	Time (L.M.T.)	Position	D.B.	Depth U.C.F.
172	U.C. W.B.	28/9 29/9	2050- 0050	02° 08.2' S 57° 24.8' E	XI	2245- 2350
173	W.B.	29/9	0055-0710	02° 07.4' S 57° 25.7' E	XI	2280
174	S.B.	29/9	0800-1622	02° 10.8' S 57° 22.9' E	XI	2340
175	D.L.H. D.C.	29/9	1715-2236	02° 06.3' S 57° 22.9' E	XI	2210- 2345
176	S.S.	30/9	0546-1800	02° 11.7' S 57° 16.1' E 48 miles 291°	XI	2340- 2375
177	C.H.F.	30/9	1824-2118	02° 11.6' S 57° 19.8' E	XI	2345
178	S.R.	30/9 1/10	2242- 0039	02° 22.0' S 57° 10.2' E 27 miles 055°	-	2310- 2340
179	D.L.H.	01/10	0555-1018	02° 07.9' S 57° 24.5' E	XI	2260- 2340
				FRED MOUNT		
180	C.H.F.	06/10	0612-1100	06° 39.3' S 54° 16.2' E	-	2035
181	W.B.	06/10	1406-1755	06° 18.0' S 54° 07.9' E	XII	1960
182	S.B.	06/10 07/10	1840- 0242	06° 19.6' S 54° 07.6' E	XII	1960
183	S.S.	07/10	0440-1732	06° 16.0' S 54° 08.8' E 43 miles 270°	XII	1720- 1980

Station list (Continued)

Depth CF	(m)	Comments
2305- 2415	4220- 4420	Forty pictures at 4.6 m range showing exposed rock, boulders and pelagic ooze. Big bottle 30 m above the camera.
2340	4280	Forty pictures at 4.6 m range showing exposed rock, boulders and pelagic ooze. Big bottle 30 m above the camera.
2400	4390	Six out of six shots recorded.
2270- 2410	4150- 4410	Two rocks, mud in the D.C.
2410- 2445	4410- 4470	Five buoys, twenty-seven shots. Good results.
2410	4410	Heat flow result. Core of foraminiferal ooze with turbidity layers.
2375- 2405	4350- 4400	Thirty-one shots, 3 m below surface, thirty shots 1 m below surface and twenty-four shots on the surface Feeble sub-bottom echoes.
2320- 2405	4250- 4400	One rotten manganese nodule, mud in D.C.
AREA		
2090	3820	Heat flow result. Core of foraminiferal ooze and several turbidity layers.
2015	3690	Three casts successful except that the lower two big bottles did not trigger at correct depth. Maximum depth 3550 m.
2015	3690	Five charges recorded. Shot 1 fired early.
1760- 2030	3220- 3720	Five buoys, twenty-five shots. A line to the east abandoned because a seamount encountered. Poor ground waves.

Table 5.

Station number	Type	Date	Time (L.M.T.)	Position	D.B.	Depth U.C.F.	Depth CF	(m)	Comments
5184	U.C.	09/10	2148-2300	06° 12.6' S 54° 22.2' E	XIII	310	320	585	Colour film. Sediments only.
5185	D.L.H. D.C.	10/10	1330-1800	06° 06.5' S 54° 26.4' E	XV	1340- 1710	1370- 1750	2510- 3200	No collection in dredges.
5186	U.C.	11/10	0012-0225	06° 12.0' S 54° 19.7' E	-	730- 770	750- 790	1370- 1450	Fifty pictures at 12 m range of rocky outcrops, a dyke, boulders and sand ripples.
					ILE DES NOEUFS				
5187	G.	11/10	1435-1500	06° 13.5' S 53° 01.9' E	-	30	30	55	Shelly coral sand.
5188	Shore Collection	11/10	1420-1705	06° 14.0' S 53° 03.0' E	-	-	-	-	Party sent ashore in rubber dinghy, explored the island and collected ornithological specimens.
					PROFILE 4				
5189	W.B. ✓ ~~S.C.~~ I.O.S.N.	13/10	0900-1440	02° 50.5' S 46° 58.5' E	-	2495	2570	4700	Three successful casts. Maximum depth 4550 m. Secchi disc to 20.5 m. Deep hydrophone pressure-tested on deep cast. Medium haul in I.O.S.N.
5190	C.H.F.	13/10	1500-1800	02° 51.3' S 47° 00.7' E	-	2550	2630	4820	Heat flow result. One probe damaged in lowering. Core of foraminiferal ooze and thin turbidity layer.
5191	S.S.	13/10 14/10	1955- 1424	02° 55.3' S 47° 02.6' E 50 miles 222°	-	2540- 2550	2615- 2625	4800- 4810	Good records.
					PROFILE 3				
5192	S.B.	15/10	1330-1708	02° 31.0' S 44° 52.3' E 4.6 miles 144°	XVI	2200	2270	4150	Thirteen shots recorded. Lifeboat firing surface charges (2.25 kg). Strong ground waves from layer 1.
5193	U.C.	15/10	1810-2245	02° 33.0' S 44° 52.6' E	XVI	2210	2270	4150	Twenty-four pictures at 1.4 m range of soft bottom. Bottoming weight fell off while lowering and had to be replaced.

Station list (Continued)

Table 5.

Station list (Continued)

Station number	Type	Date	Time (L.M.T.)	Position	D.B.	Depth U.C.F.	Depth CF	Depth (m)	Comments
5194	C.H.F.	15/10 16/10	2245- 0130	02° 34.2' S 44° 52.7' E	XVI	2210	2270	4150	Mechanical failure in heat flow apparatus. No result. Core of foraminiferal ooze and thin turbidity layers.
5195	W.B. ✓ I.O.S.N.	16/10	0145-0708	02° 35.3' S 44° 53.7' E	XVI	2220	2280	4170	Two successful casts. Maximum depth 2050 m. I.O.S.N. lost when wire parted.
5196	C.M.	16/10	0830-1020	02° 31.3' S 44° 52.0' E	XVI	2210	2270	4150	0.5 knots 274°.
5197	S.S.B.	17/10	0537-1748	02° 33.2' S 44° 53.5' E 57 miles 039°	XVI XVII	2245- 2310	2305- 2375	4220- 4350	Four buoys, eight depth charges, two ranging shots. Surface hydrophone poor, mid-water hydrophone satisfactory.
				PROFILE 2					
5198	S.S.B.	18/10 19/10	0555- 0717	02° 41.6' S 43° 26.6' E 46 miles 040° 60 miles 220°	XVIII	1890- 1980	1940- 2030	3550- 3720	Four buoys, seventeen depth charges, one ranging shot Surface hydrophone picking up ship noise. Mid-water hydrophone used for one leg only. Good ground waves on first four shots of each leg recorded by bottom hydr phones.
5199	W.B. ✓	19/10	1448-1826	02° 18.7' S 42° 46.0' E	-	1735	1775	3250	Three successful casts. Maximum depth 3200 m.
				PROFILE 1					
5200	S.S.B.	20/10	0237-2000	01° 46.0' S 42° 10.0' E 61 miles 040° 43 miles 220°	-	1075- 1200	1100- 1230	2015- 2250	Four buoys, eleven depth charges, two ranging shots. Surface hydrophone poor. Ten shots recorded on the bottom and showed ground waves.
5201	C.H.F.	21/10	0915-1115	01° 42.0' S 42° 15.0' E	-	1095	1120	2050	Heat flow result. Release gear failed and got double core of foraminiferal ooze.
				PROFILE 0					
5202	C.M.	21/10	2000-2118	02° 12.6' S 41° 26.5' E	XX	500- 570	515- 585	945- 1070	1.7 knots 038°.

Table 5.

Station list (Continued)

Station number 5203	Type S.S.B.	Date 22/10	Time (L.M.T.) 0030-1200	Position 02° 07.3' S 41° 30.2' E 41 miles 037° 32 miles 215° (latitude and longitude is centre of line, not centre of buoys)	D.B. -	Depth U.C.F. 470-775	Depth CF 480-795	(m) 880-1450	Comments Twelve shots by 'Discovery' followed by eleven from 'Owen'. Three ranging shots. Good records. Bottom hydrophones recorded ground waves from four shots.
				PROFILE 5					
5204	C.H.F.	28/10	1742-2112	03° 31.3' S 48° 23.3' E	-	2605	2685	4910	Heat flow result. Two probes shattered on the bottom. Core of foraminiferal ooze and turbidity layers.
5205	C.M. S.S.B.	29/10	0525-2300	03° 31.3' S 49° 36.2' E 46 miles 040° 47 miles 220°	XXI	2650-2700	2730-2785	5000-5100	0.4 knots 090°. Five buoys, twelve depth charges. Disappointing arrivals. Ground waves from the first three shots recorded on the bottom. Low frequency hydrophone gave poor response.
5206	W.B.	29/10 30/10	2330-0300	03° 28.9' S 49° 38.8' E	-	2665	2755	5040	Three casts successful except that the lower two big bottles did not trigger at the correct depth. Maximum depth 5050 m.
				PROFILE 6					
5207	C.H.F.	30/10	1330-1653	03° 33.5' S 50° 29.1' E	-	2690	2780	5090	Heat flow result. One probe smashed. Core of foraminiferal ooze and several turbidity layers.
5208	U.C.	31/10	0235-0543	03° 34.3' S 51° 25.9' E	XXII	2655-2665	2740-2750	5020-5030	Thirty-eight pictures at 12 m range of featureless sediment.
5209	C.M. S.S.B.	31/10 01/11	0053-0658	03° 35.0' S 51° 30.0' E 49 miles 040° 69 miles 220°	XXII	2560-2795	2640-2885	4840-5280	0.65 knots 175°. Five buoys, fifteen depth charges. Mid-water hydrophone used. First three shots on both legs recorded on bottom.
				SEYCHELLES BANK					
5210	C.M. S.S.	02/11 03/11	0630-0559	04° 46.5' S 55° 03.6' E 106 miles 110° 20 miles 290°	XXIII	ca.30	ca.30	ca.55	0.5 knots 358°. Five buoys, twenty depth charges; twenty-four 'Discovery' shots.. Taut wire measuring gear used to 90 miles by 'Owen'. Good arrivals.

Table 5.

tation umber	Type	Date	Time (L.M.T.)	Position	D.B.	Depth U.C.F.	Depth CF	(m)	Comments
5210A	G.	02/11	1030	04° 48.8' S 55° 03.5' E	XXIII	ca.30	ca.30	ca.55	
5211	G.	03/11	0742-1016	04° 49.4' S 55° 00.8' E 12 miles 223°	-	20-30	20-30	35-55	Six grabs at approximately $2\frac{1}{2}$ miles apart yielded coarse shelly coral sands.
5212	G.	03/11	1428-2040	04° 30.6' S 55° 25.3' E 41 miles 352°	-	20-35	20-35	35-65	Sixteen grabs stations, 2 to 4 miles apart yielded shelly coral sand and mud away from land.
				BIRD ISLAND					
5213	G.	04/11	0750-0753	03° 43.0' S 55° 11.3' E	-	ca.30	ca.30	ca.55	Variegated coarse coral sand.
5214	Shore Party	04/11	0540-0930	03° 43.0' S 55° 12.5' E	-	-	-	-	Landed in rubber dinghy. Inspected tern colony on island.
5215	C.H.F.	04/11	1900-2200	02° 24.5' S 54° 45.0' E	-	2320	2385	4360	One probe out of action and another did not penetrate. Poor heat flow result. Trigger mechanism failed. Short core fell out on hoisting inboard.
				MOUNT ERROR					
5216	C.M.	09/11	0205-0311	10° 16.5' N 56° 03.3' E	XXV	200	205	375	1.7 knots 240°.
5217	G.	09/11	1055-1230	10° 16.6' N 56° 00.3' E	XXV	210	215	395	No sample.
5218	D.L.H.	09/11	1300-1440	10° 16.0' N 55° 59.2' E	XXV	215	220	405	Eight cobbles and one sponge. Cobbles were of hard fine-grained pink calcareous rock. Abundant samples of bottom living organisms.
5219	D.L.H.	09/11	1515-1645	10° 17.1' N 55° 59.3' E	XXV	210	215	359	One cobble as at 5218. Small black coral, one echinoid, one sponge.
5220	U.C.	09/11	1705-1908	10° 15.9' N 55° 58.7' E	XXV	200-360	210-370	385-675	Seventy-five frames yielding thirty-two pictures at 12 m range while drifting over a cliff.

Table 5.

Station list (Continued)

Station number	Type	Date	Time (L.M.T.)	Position	D.B.	Depth U.C.F.	Depth CF	Depth (m)	Comments
5221	D.L.H.	09/11	1955-2112	10° 15.5' N 56° 00.0' E	XXV	240-270	245-275	450-505	No collection.
5222	U.C.	09/11 10/11	2145-0007	10° 15.8' N 56° 00.3' E	XXV	205-250	210-260	385-475	Thirty-four pictures at 2 m range of outcropping rock.
5223	M.H.C.	10/11	0045-0430	10° 18.1' N 56° 05.2' E	XXV	220	230	420	Ship's track was in the form of a rose pattern. Magnetometer towed 90 and 170 m astern.
5223A	C.M.	10/11	0526-0618	10° 19.8' N 56° 09.0' E	XXV	220	230	420	1.6 knots 245°.
5224	S.S.	10/11	0636-1621	10° 16.8' N 56° 04.4' E 12 miles 066° 8 miles 260°	XXV (off mount:	200-230 480	205-240 495	375-440 910)	Five buoys, fifty-six shots. Buoys were laid in an L-shaped pattern which drifted along the seamount. Two reversed lines at right angles. Good records.
5225	D.L.H. D.C.	10/11	1700-2154	10° 12.9' N 56° 01.1' E	XXV	545-640	560-655	1025-1200	Dredge jammed. Wire parted by steaming off ship. Dredges, chain and pinger lost.
5226	C.H.F.	11/11	1040-1400	11° 07.2' N 54° 02.8' E	-	2145	2205	4040	Heat flow result. Core of foraminiferal ooze alternating with turbidity layers.
				GULF OF ADEN					
5227	C.H.F.	13/11	0245-0424	11° 39.0' N 47° 50.0' E	-	1015	1040	1905	Heat flow result. Core of foraminiferal ooze.
5228	U.C.	13/11	1014-1242	12° 28.5' N 47° 06.5' E	-	880-900	900-925	1650-1695	Forty pictures at 4.6 m range. All show pelagic ooze.
5229	C.H.F.	13/11	1325-1515	12° 28.9' N 47° 02.0' E	-	1145	1170	2140	Heat flow result. Core of foraminiferal ooze.
5230	C.H.F.	13/11	2015-2150	12° 56.0' N 46° 35.5' E	-	875	895	1640	Heat flow result. Core of foraminiferal ooze and two sandy layers.
				RED SEA					
5231	C.H.F. W.B.	17/11	1800-2025	15° 58'N 41° 31'E		925	950	1740	Heat flow result. Core of mud containing organic remains and silty clay. One successful bottle cast for temperature-salinity profile, 1100 to 1700 m.

Table 5.

Station number	Type	Date	Time (L.M.T.)	Position	D.B.	Depth U.C.F.	Depth CF	Depth (m)	Comments
5232	C.H.F. W.B.	18/11	1245-1448	18° 24'N 39° 47'E	-	805	825	1510	Heat flow result. Core of mud containing organic remains and layer of calcareous concretions. Two successful casts, sixteen bottles at 100 m intervals.
5233	C.H.F. W.B.	19/11	0118-0338	19° 42'N 38° 41'E	-	1385	1420	2580	Two probes damaged on entry. Heat flow result possible. Core of foraminiferal ooze, layer of concretions, volcanic ash (?). Two successful bottle casts over 400 to 2300 m range.
5234	C.H.F. W.B.	19/11	1020-1130	20° 27'N 37° 55'E	-	460	475	870	One probe lost, other two damaged. Heat flow result. Core of foraminiferal mud and layer of concretions. One successful cast - ten bottles at 100 m intervals.
5235	U.C.	19/11	1717-1845	21° 30'N 38° 08'E	-	780	823	1510	Twenty-six pictures at 4.6 m range, all showing flat sediment.
5236	C.H.F. W.B.	19/11	1930-2057	21° 36'N 38° 11'E	-	710	730	1340	Release gear failed, small penetration. Core of mud and concretions. Two successful bottle casts over range 0 to 1300 m.
5237	C.H.F. W.B.	20/11	0200-0300	22° 24'N 38° 23'E	-	310	320	585	All probes and fins lost. Core of foraminiferal mud and layer of concretions. One successful cast of seven bottles from 0 to 550 m.
				WESTERN			MEDITERRANEAN		
5238	W.B.	29/11	1000-1107	37° 11'N 30° 50'E	-	1270	1320	2420	Water sample (18 l) collected from 2200 m.

Table 6. Dan-buoy positions

lumber	Date	Area or Profile	Latitude	Longitude	Remarks
	27/8	Mount Error	10° 21.4' N	56° 11.1' E	Probably dragged.
I	29/8	4A	05° 35.5' N	61° 47.5' E	Magnetic variation; replaced by simple dan-buoy (IIa) on 2/9.
II	31/8	4A	05° 26.7' N	61° 47.4' E	
V	04/9	4C	(i) 02° 49.4' N	60° 16.7' E	Dragged and finally sank in
			(ii) 02° 46.4' N	60° 17.3' E	position (ii).
	05/9	4C	(i) 02° 48.7' N	60° 17.6' E	Dragged and recovered in
			(ii) 02° 46.4' N	60° 19.7' E	position (ii).
I	06/9	4C	(i) 02° 47.6' N	60° 00.1' E	Dragged and sank approx-
			(ii) 02° 46.4' N	60° 02.0' E	imately in position (ii).
II	06/9	4C	(i) 02° 50.8' N	59° 53.4' E	Dragged. Recovered in
			(ii) 02° 49.8' N	59° 54.3' E	position (ii).
III	18/9	Profile 2	02° 22.9' S	43° 25.0' E	
X	21/9	Profile 4	02° 49.7' S	47° 32.5' E	
	23/9	Profile 5	03° 29.6' S	49° 37.6' E	
I	28/9	4D	02° 09.7' S	57° 22.4' E	
II	06/10	Fred Mount	06° 20.7' S	54° 09.2' E	
III	08/10	Fred Mount	06° 16.0' S	54° 23.0' E	Dragged 000°, 9.7 km.
IV	08/10	Fred Mount	06° 04.6' S	54° 15.3' E	Magnetic variation.
					Dragged 350°, 5.7 km.
V	08/10	Fred Mount	06° 06.1' S	54° 25.8' E	Laughton special.
					Dragged 010°, 4.3 km.

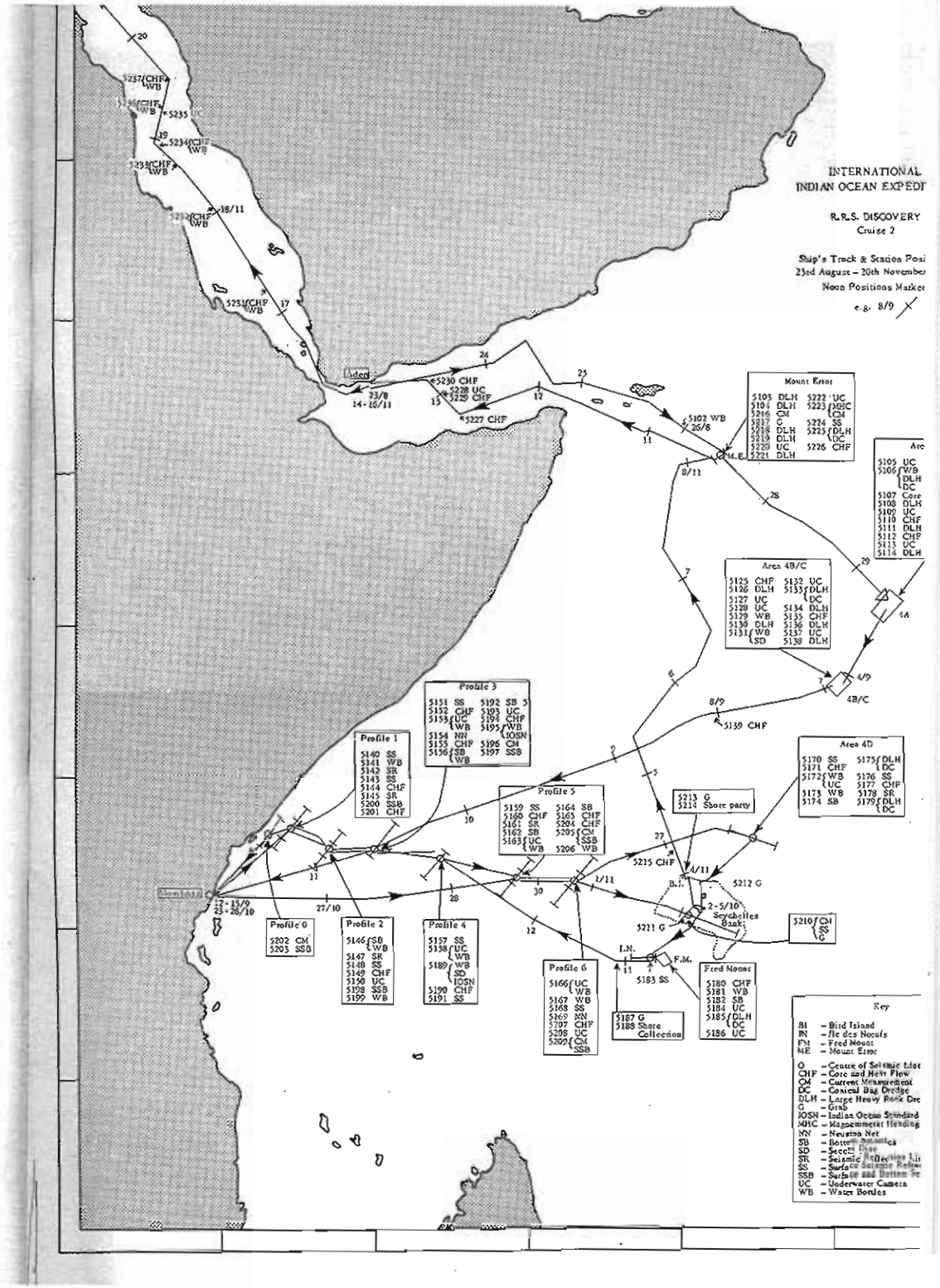
Table 6. (Continued)

XVI	15/10	Profile 3	02° 31.4' S	44° 53.1' E	
XVII	16/10	Profile 5	02° 31.4' S	44° 52.7' E	
XVIII	18/10	Profile 2	02° 42.5' S	43° 23.9' E	
XIX	20/10	Profile 1	01° 45.0' S	42° 05.4' E	Dragged 145°, 30.5
XX	21/10	Profile 0	02° 13.1' S	41° 25.5' E	Dragged 040°, rapid
XXI	29/10	Profile 5	03° 30.1' S	49° 37.1' E	
XXII	31/10	Profile 6	03° 34.0' S	51° 30.0' E	
XXIII	02/11	Seychelles Bank	04° 47.9' S	55° 02.8' E	
XXIV	08/11	Mount Error	(i) 10° 21.0' N	56° 06.3' E	Dragged. Recovere
			(ii) 10° 18.6' N	56° 02.5' E	position (ii).
XXV	09/11	Mount Error	10° 16.8' N	56° 04.4' E	

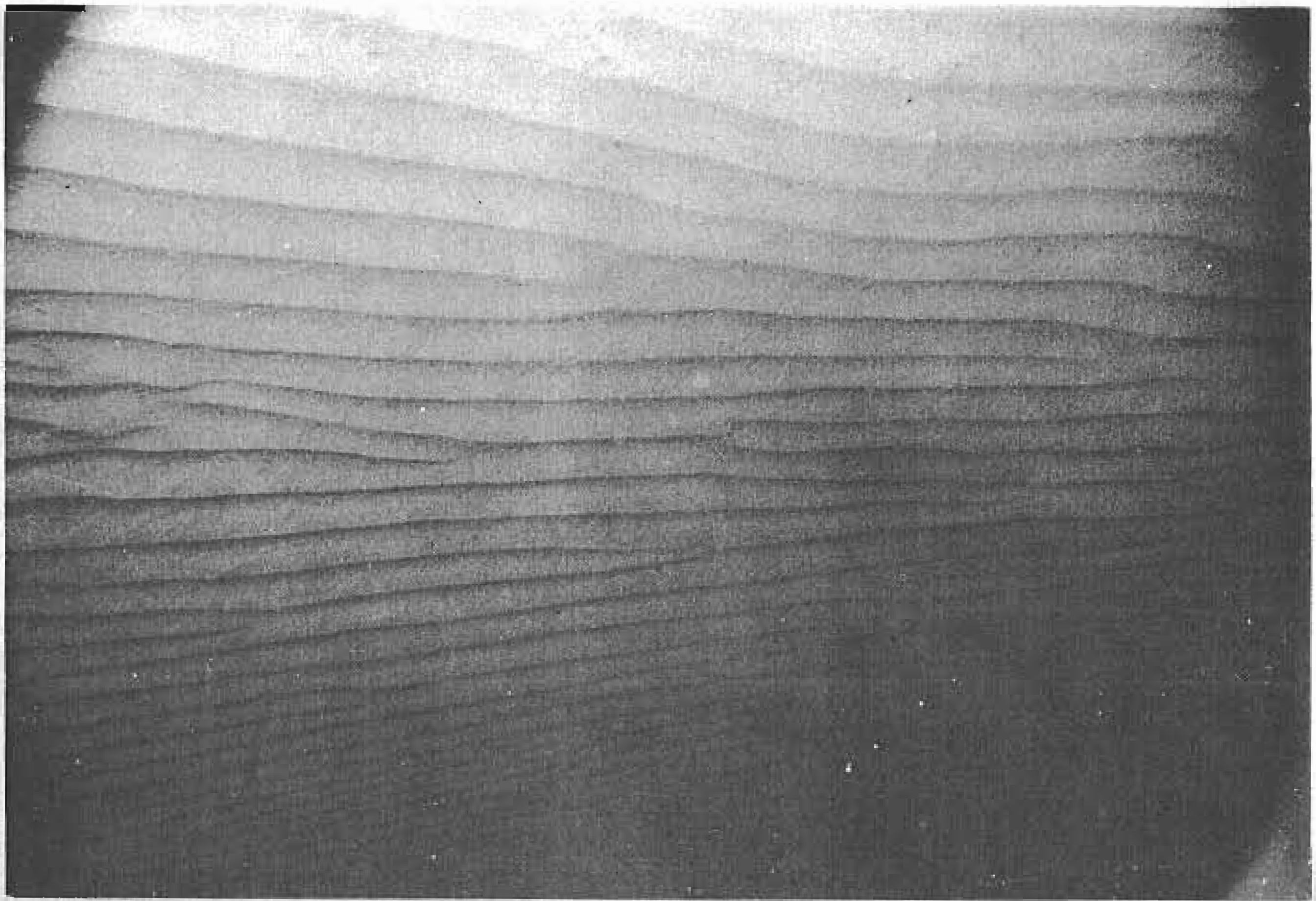
Table 7. Scientific Staff

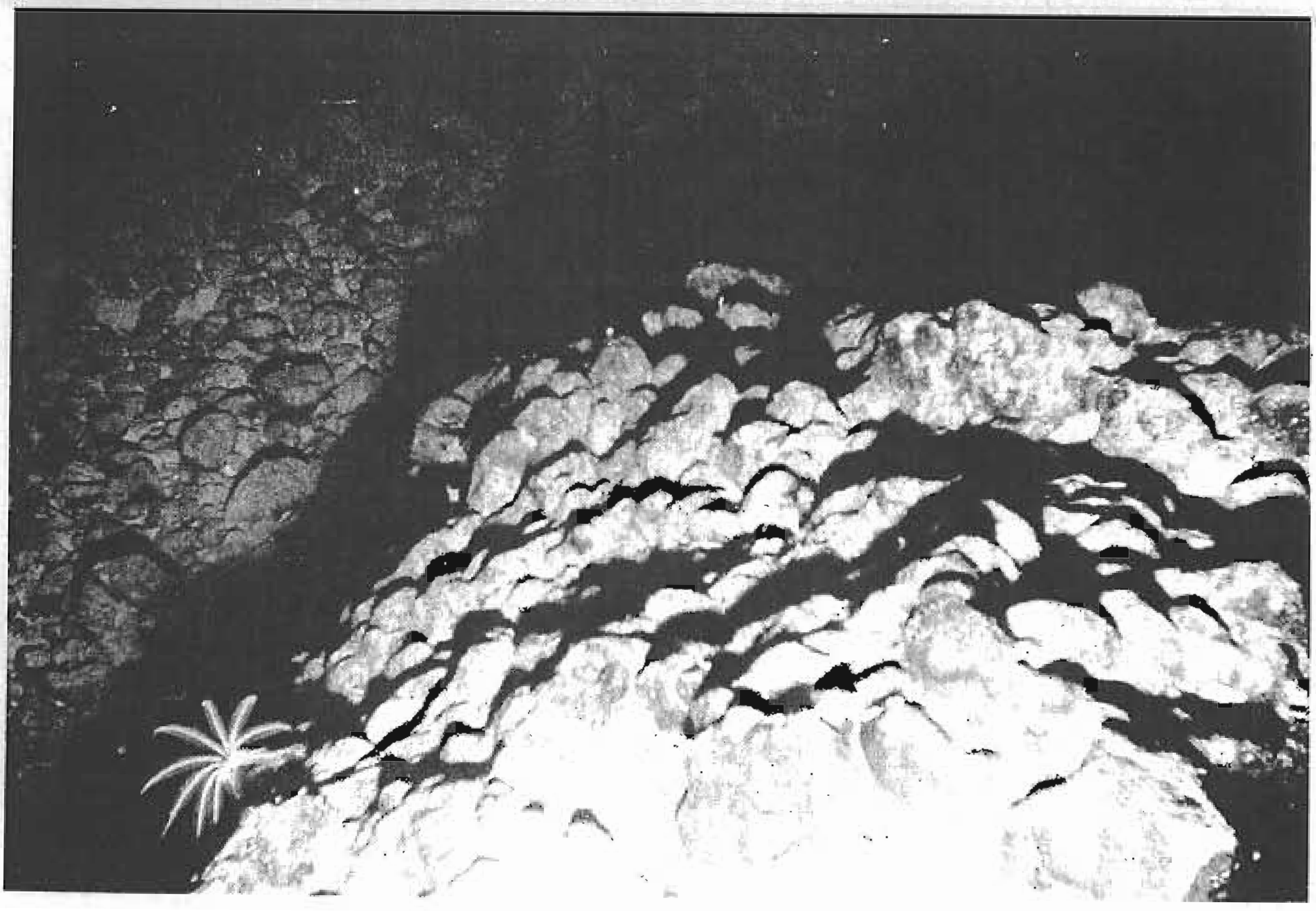
M.N. Hill	Principal Scientist	Cambridge*
A.S. Laughton	Senior Scientist	N.I.O.+
D.H. Matthews	Senior Scientist	Cambridge*
R.A.G. Nesbitt		Hydrographic Dept.
R.S. Bailey	Ornithology	Oxford‡
R. Belderson		N.I.O.+
P.G. Brewer	Chemistry	Liverpool University
J.C. Cleverly		Cambridge*
D. Davies		Cambridge*
T.J.G. Francis		Cambridge*
E.J.W. Jones		Cambridge*
J.M. Jopling		N.I.O.+
J.G. Sclater		Cambridge*
J.M. Shorthouse		Cambridge*
G. Topping	Chemistry	Liverpool University
T. Vertue		N.I.O.+
R.B. Whitmarsh		Cambridge*

* Department of Geodesy & Geophysics, University of Cambridge
\+ National Institute of Oceanography, Wormley, Surrey
‡ Edward Grey Institute of Field Ornithology, University of Oxford



5109.29



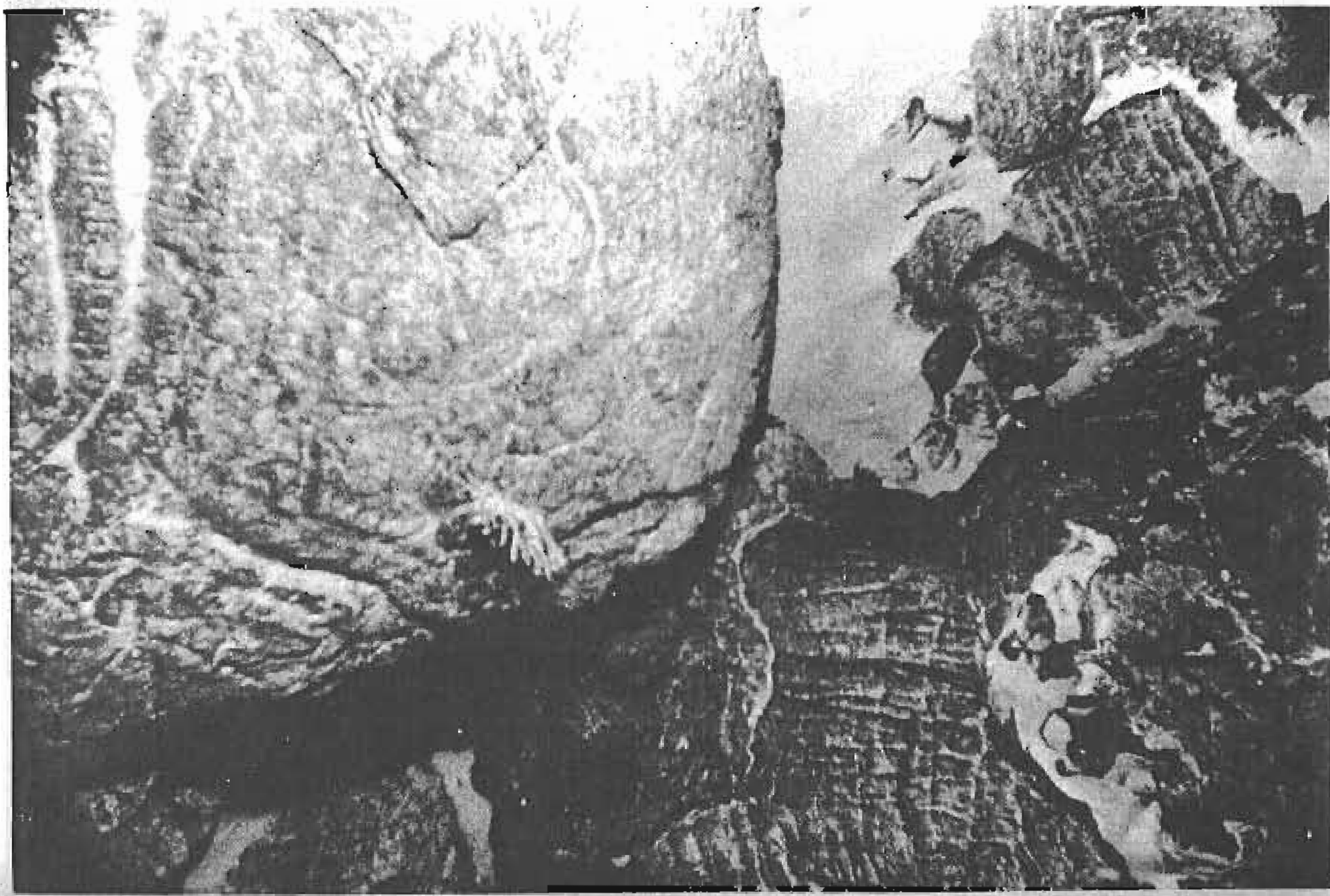


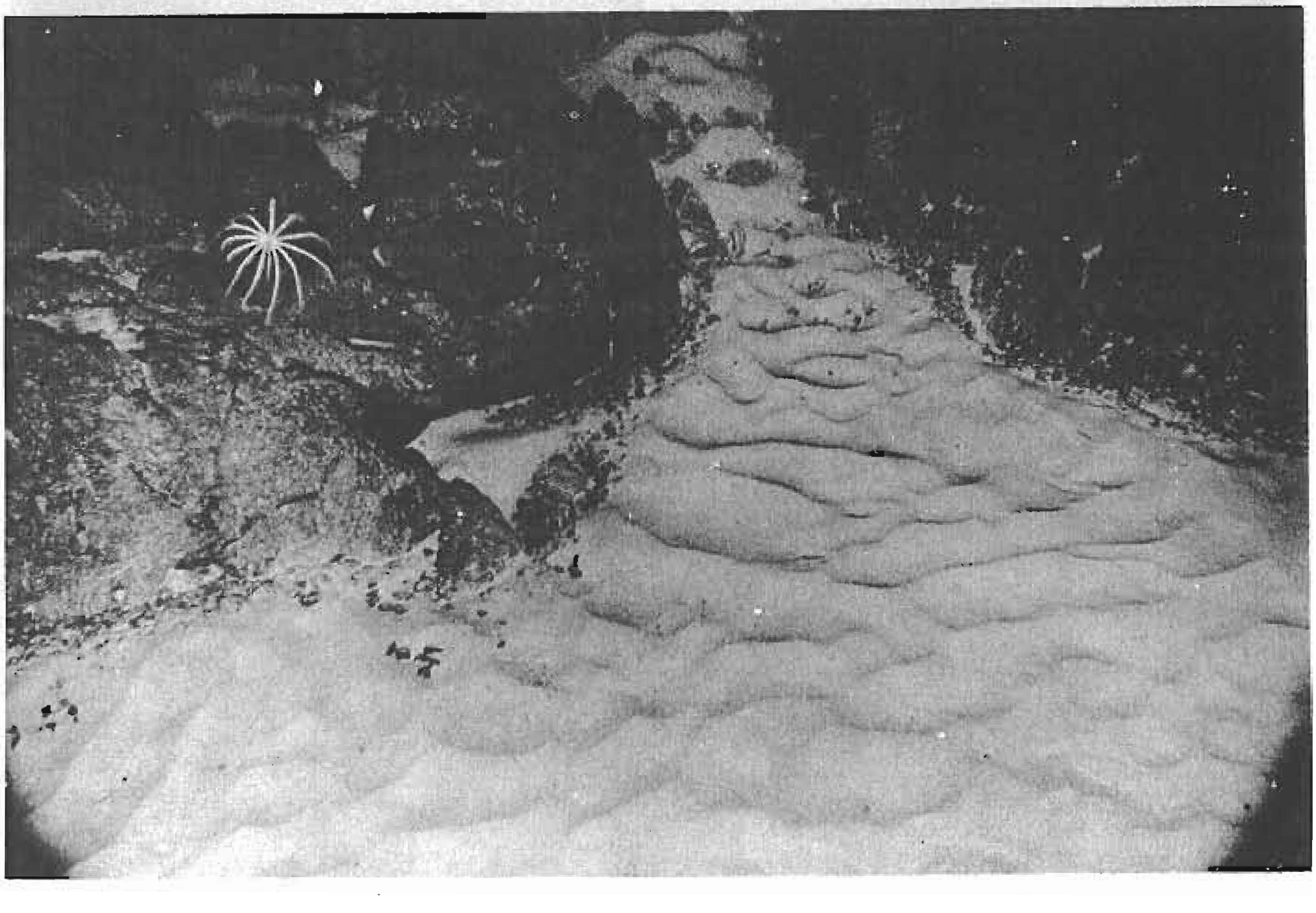
5109.3
Seamount near centre of Carlsberg Ridge (area 4a).
Area of picture 3 x 4 m.
Outcrop of volcanic breccia standing above an accumulation of loose boulders.

05°36'N 61°51'E
Depth 2420 m
1320 fm.

5113.1
Seamount near centre of Carlsberg Ridge (area 4a).
Area of picture 2 x 2 m.

05° 26'N 61° 49'E
Depth 1800 m



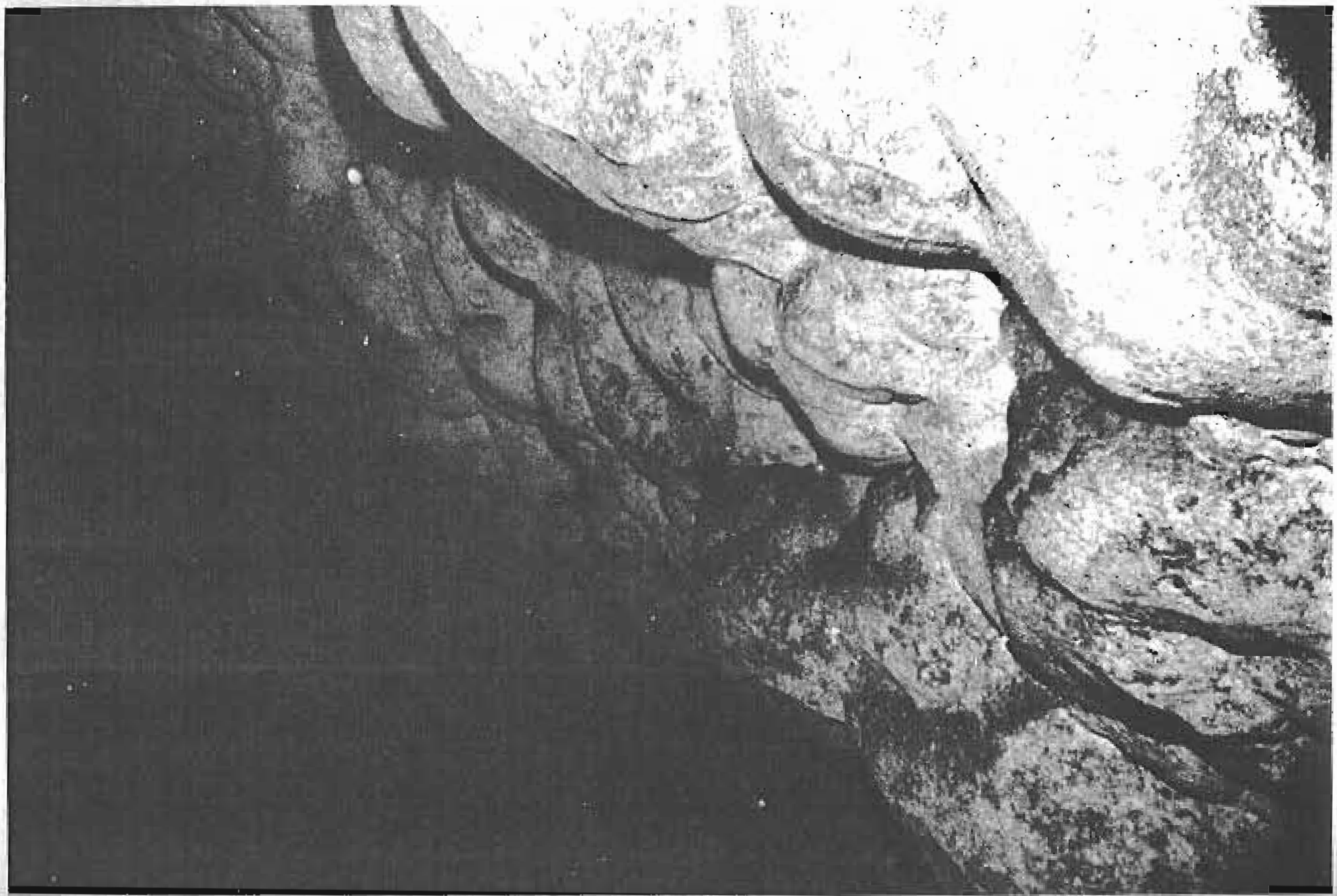


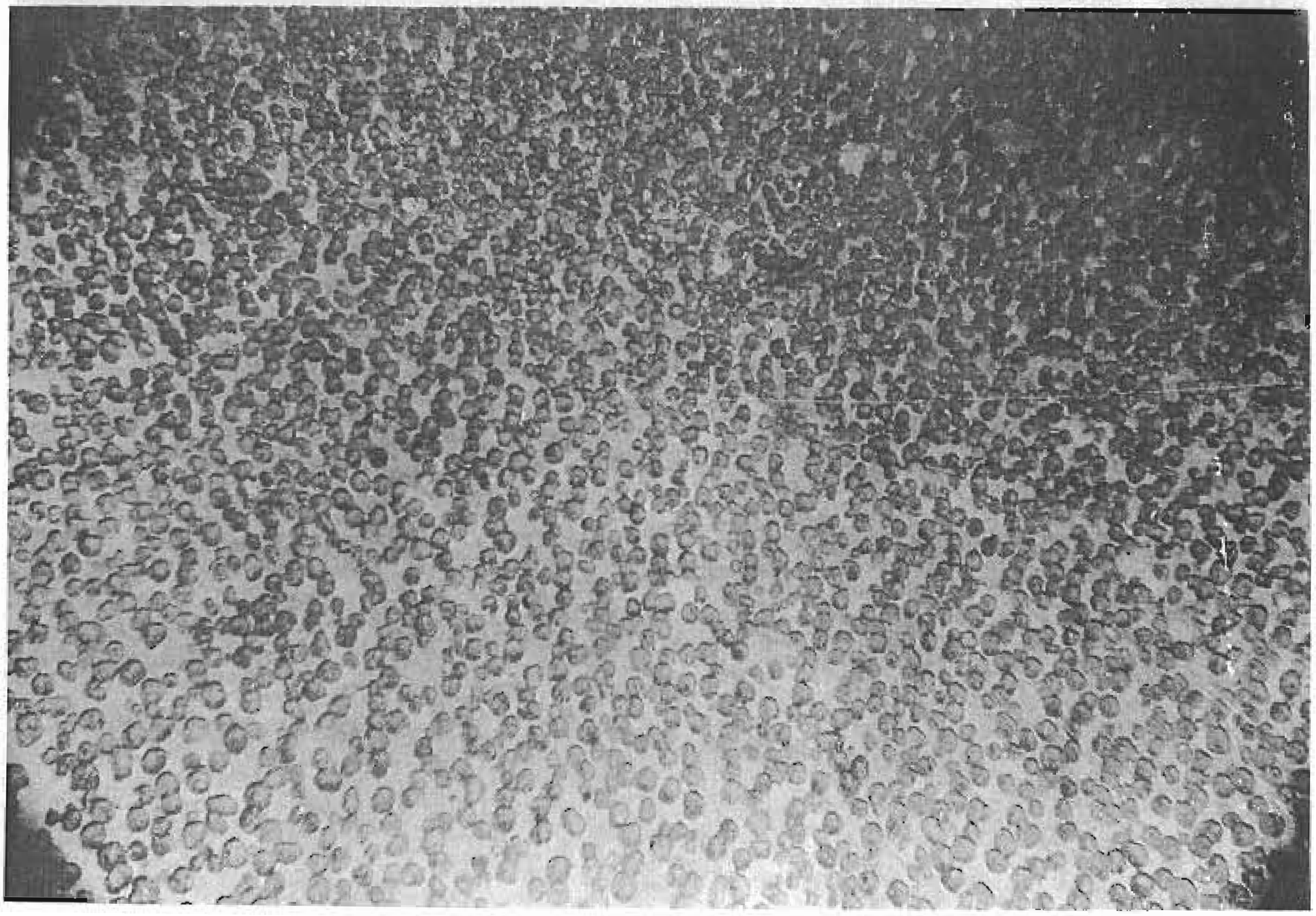
5109.35
Seamount near centre of Carlsberg Ridge (area 4a).
Area of picture 3 x 4 m.
Ripple marks (20 cm wavelength) in calcareous sand due to current funnelling

05° 36'N 61° 51'E
Depth 2500 m
1370 fm.

5132.48
Seamount of the southern flanks of the Carlsberg Ridge (area 4c).
Area of picture 3 x 4 m

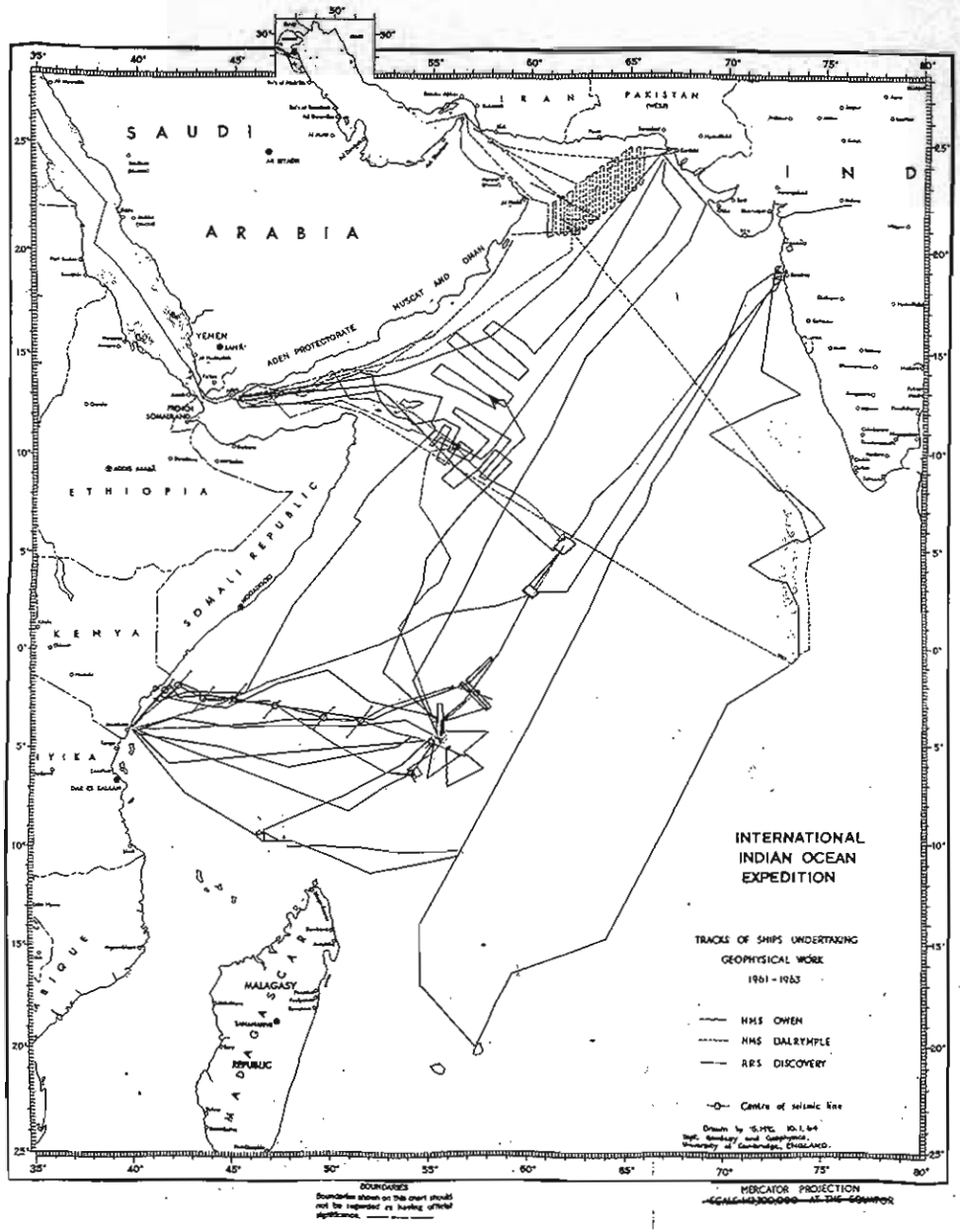
02° 46'N 60° 02'E
Depth 3950 m





5127.2
The edge of a seamount on the southern flanks of the Carlsberg Ridge (area 4c).
Area of picture 3 x 4 m.

02° 47'N 60° 21'E
Depth 4250 m
2320 fm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TRACKS OF SHIPS UNDERTAKING
GEOPHYSICAL WORK
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H.M.S. DALRYMPLE
R.R.S. DISCOVERY
Centre of seismic line
MERCATOR PROJECTION