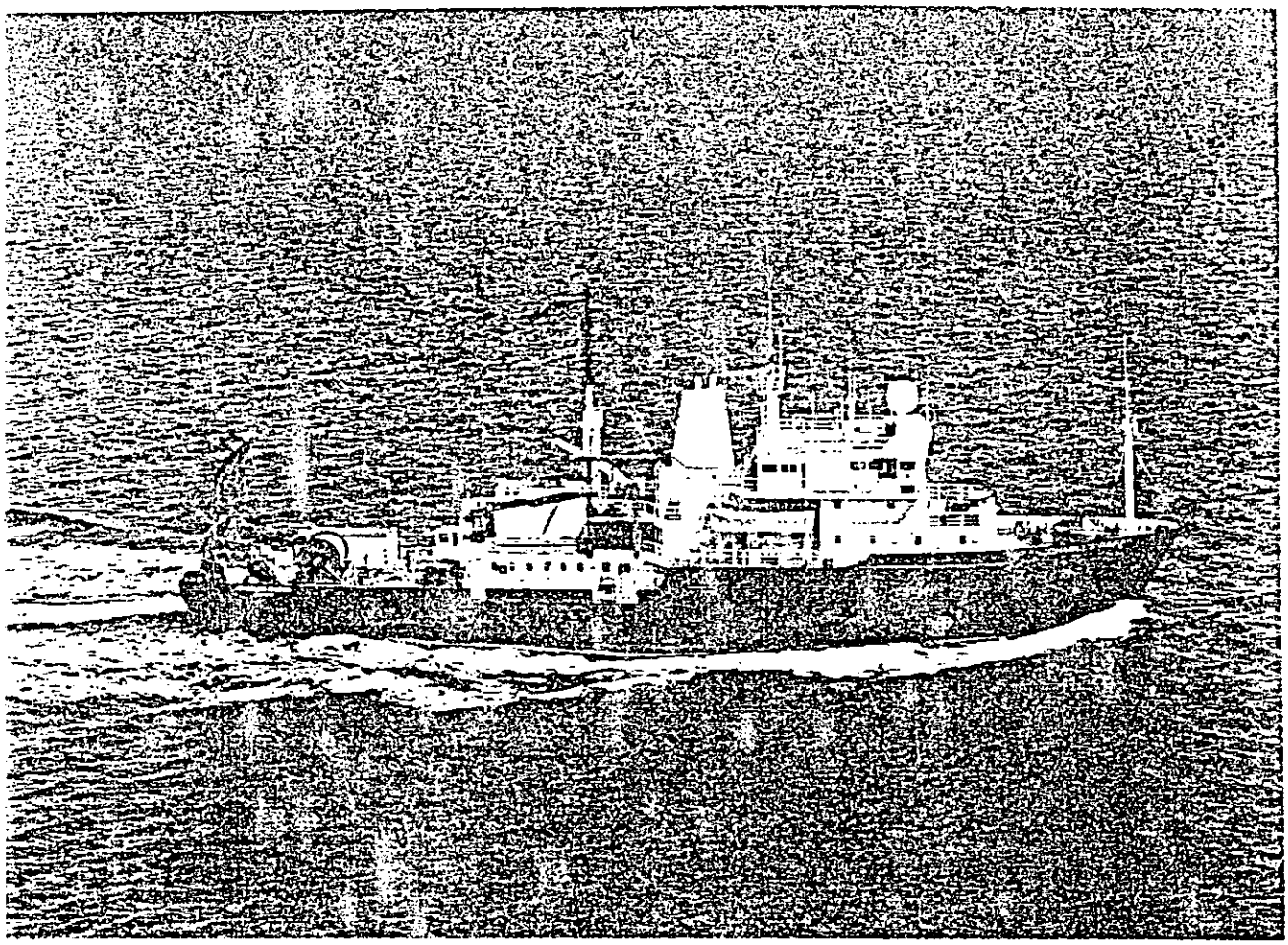
RRS CHARLES DARWIN

Cruise 28

REPORT



Conducted under NERC Grant GR3/6480

Report on

RRS CHARLES DARWIN

Cruise 28

Muscat, The Oman
27th September 1987

to

Mauritius
1st November 1987

R A Scrutton
Grant Institute of Geology
University of Edinburgh

CRUISE OBJECTIVES

Work was carried out within the area of intra-plate deformation in the Central Indian Ocean Basin (Fig 1) which includes long and short wavelength folds and closely-spaced faults, all striking east-west. The deformation of the lithosphere extends from 6S to at least 6N and from 76E to 90E, with another, smaller, area on the east side of the Ninetyeast Ridge. Only a relatively small part of this enormous area could be studied on the cruise, and the southwestern part was chosen in view of the availablity of previous work there by American scientists and the Ocean Drilling Programme (ODP).

There were three principal objectives (Fig 2).

i) To collect multichannel seismic, single channel seismic and sediment velocity data in the vicinity of ODP Leg 116 sites. These were to contribute to an understanding of the structural setting of the drill sites and will be worked up for publication in the Leg 116 Proceedings Volume.

ii) To study the three dimensional form of the sediment and basement deformation in the area of folding and faulting around 5S, 80E. Single and multichannel profiling and disposable sonobuoy data were to be collected. Gravity and magnetic data were also to be acquired to contribute to an understanding of crustal thickness and tectonic setting. A structural analysis will follow from this.

iii) To sample basement and sediments on Afanasy Nikitin Seamount and collect enough magnetic, gravity and seismic profile data to allow an integrated geological - geophysical study of the seamount. It is hoped to date the formation of the seamount, which may have provided a critical load on the lithosphere to promote deformation.

Ojective i) was a substitute for the original objective of collecting seismic data to establish a better crustal cross section northwards from the Afansay Nikitin Seamount into the thicker parts of the Bengal Fan. Curray et al. (1982) have published a rough section that does not show the deformation. This objective was abandoned when the ship was rescheduled to avoid calling at Colombo and some working time was lost.

The objectives of multichannel seismic work were placed in jeopardy by the non-availability of the Sercel digital acquisition system and the 48-channel streamer. A 12-channel system with analogue recording was provided by RVS, and at the time of writing it remains to be seen what results have been obtained.

EQUIPMENT USED

12-channel analogue-recording (multichannel - MCS) seismic profiling system, based on Geomechanique array and Racal Store 14 tape recorder.

4-channel analogue-recording (single channel - SCS) profiling system based on Geomechanique array and Racal Store 4 tape recorder.

Ultra disposable sonobuoys and analogue recording on Store 4 tape recorder.

Airgun array sound sources of various dimensions.

3.5kHz bathymetry and sediment profiler (on loan from IOS).

LaCoste and Romberg Air-Sea gravimeter.

Barringer proton-precession magnetometer.

Digital logging and processing system (Levels A,B,C) for navigation, bathymetry, gravity and magnetic data.

NAVSAT and GPS position fixing navigational aids.

Piston coring and rock dredge bottom sampling equipment.

SCIENTIFIC PERSONNEL

From Edinburgh University

Dr R A Scrutton (Principal Scientific Officer)

Mr J M Bull (Research Student - Tied Studentship attached to Grant GR3/6480)

Mr P J Condon (Research Student)

Mr R R Hillis (Research Student)

From Research Vessel Services

Mr A Cumming (Base Signal Group)

Mr J Wynar (Base Signal Group)

Mr P Mason (Shipborne Computer Group)

Mr J Taylor (Base Engineering Group)

Mr J Strangward (Base Engineering Group)

Mr A Poole (Base Engineering Group)

NARRATIVE OF DAY-TO-DAY OPERATIONS

27th September. The sailing time from Muscat was delayed from 1200 (all times in this Report are local) until 1430 to await air freight containing a spare gyro for the gravimeter and a replacement Store 4 tape recorder. Both were essential: the spare gyro on board had just been used, and the existing Store 4 was operating on only three channels.

Only a few hours after sailing the RVS BEG technicians discovered that what appeared to be a simple case of a faulty valve requiring replacement on one of the Hamworthy compressors was a serious problem of warp in the valve housing. Two compressors were essential for the multichannel work, so immediately the possibility of calling at Colombo for spare parts was raised. Over the next few days the technicians were to spend much of their time trying to compensate for the warp to avoid a call at Colombo.

Another problem that came to light soon after leaving Muscat was that the ship could only make 9-9.5kts through the water due to growth on the hull. As the cruise objectives and logistics had been planned on the basis of 11kts (the nominal speed on passage) this had serious implications for the working time available.

At this time Pete Mason found that he could not load the UNIX operating system onto the Level C computer, although this particular problem was eventually overcome.

Despite a gloomy outlook in many respects, spirits were high as we settled down for a lengthy transit to the working area.

28th September - 1st October. These days were spent on passage southeastwards across the Arabian Sea in excellent weather conditions. A northwesterly breeze and current produced 10-10.5kts over the ground. Equipment was prepared for scientific work and efforts continued to repair the compressor (unsuccessful) and the Level C (successful). On 1st October the decision was made to divert to Colombo to pick up compressor spares, that could be there by air freight p.m. 4th October.

2nd October. Since at present speed the ship would arrive Colombo 14hrs before the spares it was decided to spend the day balancing and testing the 12-channel hydrophone array, a job that was necessary before work commenced anyway. 12hrs were spent around 8N, 74E ironing out several problems, the main one being that the array was clearly too heavy. Sea surface temperatures were anomalously high (29C as opposed to 26-28C quoted for the area) reducing the density of the surface waters and thus the array buoyancy. 5 litres of oil had to be pumped into each array section and one weight and one depth section were removed. Depressors were not deployed during the test to see if the array could be used without them, as they had attracted sharks in the past, but it was found necessary to use them (and risk the sharks!).

3rd October. Steaming east to Colombo all day. The sad news of the death of Jon Taylor's father came through. Jon decided to stay with the ship, for which we were extremely grateful.

4th October. Dropped anchor off Colombo at 1400. The spare compressor parts were on board by 2000 and the ship was underway again by 2100. By 2300 the compressor was repaired and running well. Tribute must be paid to the BEG technicians.

5th October. On passage south with the weather still fine. A disposable sonobuoy test was carried out successfully with reception strong to 20km.

6th October. In the morning scientific watches were begun on PES, 3.5kHz profiler, magnetometer and gravimeter to allow watchkeepers a chance to familiarise themselves with these before the additional work of seismic profiling started. Subsequently, on all survey tracks, this suite of instruments was used. We continued on passage southwards at 8-9kts. At 2100 the SCS profiling system was streamed to begin work in the area of the ODP Leg 116 sites. 2x160cu.in. airguns were used to provide enough low frequency energy for sonobuoy work.

7th & 8th October. After some experimenting with airguns and wave-shape kits we began and completed a number of east-west profiles in the vicinity of the Leg 116 sites (Fig 3&4). These profiles, along strike, were intended to compliment the largely north-south data set over the area and also allow sonobuoys to be run parallel to structure. Two longer profiles crossed a fracture zone. Six successful sonobuoy profiles were obtained. The weather remained warm and fair but with occasional heavy rain and an annoying, persistent swell from southeast.

9th October. Overnight the SCS system was replaced with the MCS system. Repairs to splits in a spring section of the array and in an

air hose to the airguns delayed the start of profiling but by 0930 everything was working. At 1100 we began a long MCS profile southwards. An array of 700+466+300+160cu.in. guns was used firing at 1700psi every 18sec (=50m). The temperature in the compressor room was 49C!

Trouble with recording time pulses on one channel of the Store 14 tape recorder eventually lead to not being able to record them at all. Subsequently, all MCS data were recorded without any time base on the tapes, since we had already dispensed with a flutter correction signal to record 12 channels of data.

10th October. The swell worsened during the day and caused an increase in noise on the MCS data. An investigation of the distribution of the noise along the array suggested that the depressors, mounted on the front of the odd channels, were dragging the array out of the horizontal. Nothing was done to cure this at this time. We proceeded to profile southwards.

11th October. A breezy day, but the swell had died down. We finished the MCS profile at 1230, with a sonobuoy over the last 25km. This buoy was the third tried, the first two having almost certainly snagged the 12-channel array. After a change to SCS profiling, which took six hours, we proceeded northeast to Afanasy Nikitin Seamount at profiling speed, 6kts, making sure to traverse a spectacular example of intra-plate faulting crossed at the southern end of the MCS line. Two 40cu.in. airguns were deployed for this profiling in order to obtain reasonably good resolution on records over the seamount. The very high sea surface temperatures were now forcing the 4-channel array to tow deep and the weight section was removed.

12th October. Profiling over the southern part of the seamount complex. With the reduced ship's speed on passage it was now necessary to calculate how much time might be spent sampling on the seamount in order to leave enough time to complete the bulk of the proposed work and reach Mauritius on time. A maximum of three days sampling was possible. A strategy for site selection was decided.

13th October. The weather was still fine with some swell and modest breeze as we arrived over the top of the seamount in mid-afternoon and commenced a sampling site survey using an old Soviet bathymetric map as a guide. Some trouble was experienced with erratic SATNAV updates and an EM log error, but the old data and the new suggested the northeastern slopes of up to 25-30 would be best for dredging. In the late evening we steamed to the nearest deep water (to the east) to tension the main warp, and collect more magnetic and gravity data as we went.

14th October. Warp tensioning took longer than anticipated and on return to the northern slopes of the seamount a 3.5kHz box survey was abandoned to save time. Dredging commenced at 1530 and the first effort was successful, recovering large, up to 0.3m, pieces of pillow basalts. Subsequent dredge stations were less successful. See Fig 4 for dredge station details.

15th October. At 0100 the ship became anchored on the second dredge station and the dredge was eventually lost. The weather deteriorated significantly for the first time and we experienced strong squalls for

most of the day. On occasions the rain was so heavy it was impossible to work on deck. Third and fourth dredge stations recovered more basalt and chalk. In the evening we successfully recovered a 3m piston core at the very edge of the top of the seamount under the most appalling weather conditions. Again tribute must be paid to the dedication of the technicians.

16th October. About 0100 we began SCS profiling at 6kts to the northeast and north of the seamount to complete a regional data coverage. A peaceful day was shattered with the news of the illness of Tony Cumming's wife. Tony decided to see out the cruise, for which we were extremely grateful.

17th October. The weather started to deteriorate with force 6 winds from ENE in addition to the ever-present swell. In the morning another successful piston core station was occupied (4m recovered) on the southern, plateau-like part of the seamount. We were working our way southwestwards back to the southern end of the MCS traverse. To gain some time part of this passage was carried out at full speed without SCS.

18th October. Just after midnight, in rough seas, we deployed the SCS and began a grid survey to the west from the southern end of the MCS traverse. Two 40cu.in. airguns were used for the sound source and profiling was at the slower speed of 4-4.5kts in an attempt to improve the resolution of these profiles aimed at clarifying the details of the intra-plate faulting. With the smaller guns, firing intervals were 8-9s depending on TWT (two-way time) to the basement, which gave shots at about 20m spacing.

19th October. This was a relatively uneventful day as we continued westwards across the grid. The weather was still poor.

20th October. Much like the 19th to begin with. However, in the early evening the tow cable of the 3.5kHz fish parted without warning and the fish was lost. A report on this loss, submitted to Dr Francis, IOS Deacon Laboratory is given in Appendix 1.

21st October. The weather improved slightly overnight; as luck would have it, since at about 1300 we changed from SCS profiling to MCS. This was in order to profile over the crest of one of the long-wavelength undulations in the deformation and over a fracture zone predicted from magnetic anomaly data. We hoped we might see that the crestal region is offset across the fracture zone. There was some concern in the engine room over the nearness of the airgun array to the ship, but no action was taken.

22nd October. This was a rather disappointing day. The weather deteriorated to gale force conditions overnight before improving to about force 4. We had difficulty keeping the shot spacing even as the ship's speed changed over the waves. We also had several problems with the airguns and one compressor, the 466cu.in. gun parting in the middle as bolts sheared and a pipe fracturing on the compressor.

23rd October. By 0230 most of the previous days problems had been solved, and we enjoyed a day of improved weather as we profiled on north-south lines, working our way westwards. Plans were made for

plotting the data processed on the Level C computer, which could be conveniently done on transit to Mauritius.

24th October. Serious overheating occurred in the electric motor driving the compressor that we had had all the problems with before. With only 20hrs working time remaining it was clear that we would have to finish the profiling on one compressor. This we did by using only 466+300+160cu.in. airguns. Another sonobuoy profile was obtained in the afternoon, again after having problems with keeping the buoys clear of the array astern.

25th October. Scientific work was brought to an end at 0400. The MCS system was recovered and scientific watches were suspended on all instruments. By 0600 we were underway for Mauritius in moderately good weather, making 8-9kts through the water. Much of the day, and of the following days, was spent tidying up laboratories, carrying out maintenance on equipment, rewinding tapes and replaying sonobuoy records for extra hard copies. Pete Mason made a first class job of producing profiles and charts of the Level C processed data.

26th - 31st October. On passage southwestwards to Mauritius in mixed weather, sometimes with heavy seas from the southeast. Work continued in the labs as on the 25th, the RVS staff in particular having to work long hours to have the maintenance and packing of their equipment virtually complete by arrival in Mauritius.

1st November. Dropped anchor off Mauritius in the early morning. The scientific and technical personnel, except John Strangward and Tony Poole, disembarked. An end-of-cruise gravity base station reading was taken in Durban when the ship arrived there on 6th November.

DATA AND RESULTS

During the course of 18.5 days working time the following quantities of data were collected.

Bathymetric profile	4116km
Magnetic profile	4116km
Gravity profile	4116km
3.5kHz sediment profile	3091km
SCS reflection profile	**2220km**
MCS reflection profile	1300km

10 wide-angle reflection profiles with sonobuoys
4 dredge stations
2 piston core stations

The locations of the data are shown on maps in Figs 3-5 and in Table 1.

The quality of the results is in general good, and apart from the loss of the long profile northwards into the thick Bengal Fan and some economising on work over the Afanasy Nikitin Seamount, all the objectives were met. Brief comments on the quality of each data set are now given. Comments on equipment problems is mentioned in

passing in the Narrative and a full report will be provided by RVS technical staff.

Navigation data. An error crept into the EM log towards the end of the cruise, and there were usually jumps in position fixes between SATNAV and GPS, otherwise the quality was good.

Bathymetry. Good quality throughout.

Magnetic data. This showed cross over errors ranging from zero to over 100nT. Inspection of the values revealed that they are heading dependent such that a cosine function could be used to correct for heading error and reduce cross over errors to everywhere less than 40nT. Two sets of magnetic anomaly data were produced, one uncorrected for any errors, the other with a heading error correction.

Gravity data. Good quality throughout. Drift was very low and cross over errors were never greater than 3mGal.

SCS profiles. Apart from the bubble pulse effect of the airguns reducing resolution as might be expected, the quality was satisfactory. Use of a wave shape kit helps with resolution but reduces energy significantly.

MCS profiles. With the equipment available, all the planned data collection was completed. However, the data have suffered from the lack of a time base caused by the failure of channel 14 on the Store 14. When the tapes are replayed we will be dependent on tape drives operating at constant specification speed. However, there is a good signal:noise ratio on the taped data, although we will have to wait until some processing has been done to judge the quality.

Sonobuoys. The only problem here was the poor performance of a new type of buoy, model SSQ 904B, which required a strong high-cut filter on the demodulated signal. The older Ultra models performed well (see Table 1).

Sampling. This programme was shortened due to time restrictions but was otherwise successful.

GENERAL CONCLUSIONS

The work carried out at sea on this cruise was a success, and the scientific objectives have been met, if not completely satisfied.

The major problems with the cruise arose partly through cruise programme changes, which not only reduced the working time available but more than doubled the expense of joining and leaving the ship. As it happens, these changes were beyond the control of RVS. The reduced speed of the CHARLES DARWIN on passage also cut down working time. Scientifically, the major problem was the non-availablity of the Sercel MCS facility, which dramatically reduced the quality of the seismic data.

Moral amongst scientific and ship's personnel on the cruise was remarkably good considering the arrival of some terrible news from home for some of the RVS staff. Some discipline problems were

handled expertly by the Master. The ship performed well, although even in only moderately poor weather the deck aft was frequently awash. There were no mechanical problems that seriously affected the science.

ACKNOWLEDGEMENTS

Everybody on the ship deserves acknowledgement for patience and good humour on long passages and an altogether lengthy cruise. The staff at RVS, Barry very ably supported the cruise and the Master and Officers were dedicated to the success of the science, inter alia. However, special thanks must go to Jon Taylor and Tony Cumming who, despite personal worries and family problems at home, worked as hard as ever to make sure the cruise was a success.

APPENDIX 1 Report on loss of 3.5kHz towfish

The fish was lost in 5000m of water at 1510z 20th October at 04 53.7S, 80 15.2E. We were steaming at 10km/hr carrying out seismic reflection profiling. There was a fishing boat in the area at the time and it seems likely the fish had snagged on a net, although the tow cable clearly parted at a point where it was corroded. Subsequent inspection showed that there were corrosion points in the cable strain member and that these had been taped over.

The method of deployment of the fish was as established on previous cruises. The crane starboard aft was used to support the faired tow cable in a V-block while the crane port aft lifted the fish over the side on the starboard quarter until the weight of the fish was taken on the other crane, the inboard end of the tow cable being secured to the davit from which the fish is towed. After unhooking the port crane the fish was lowered into the water until the weight came off the starboard crane and onto the davit. The faired cable was then released from the block on the starboard crane and the davit swung out from the ship's side. The tow cable was not damaged by this proceedure.

The loss of the fish was noticed almost simultaneously by the watchkeeper in the lab., where there was a loss of signal, and by the Bo'sun, who had been sent aft by the Mate on watch to check the towed gear. The Mate had noticed a fishing boat some eight miles away and was aware that the towed equipment snagged on nets on the previous cuise, which showed itself by strumming of the tow cables. The Bo'sun must have arrived aft only a minute or two after the fish was lost. We have no definite evidence that a fishing net was responsible for the loss since no other towed gear was affected, but it is a definite possiblity.

Immediately after the loss the transmitting electronics were switched off and the remaining cable recovered. The spare fish was not deployed for fear of a similar fate. We subsequently tested the transmitter on dummy load and found it to be functioning normally.

The spare fish on board also showed evidence of ware in the tow cable. The cable was taped where it enters the flexible sleeve at either end, there was tape just above the fairing, and the armouring was exposed at a scuff below the top anchor point. Sea water entering through scuffs corrodes the steel webbing strain member.

R A Scrutton
Principal Scientific Officer
CHARLES DARWIN Cruise 28

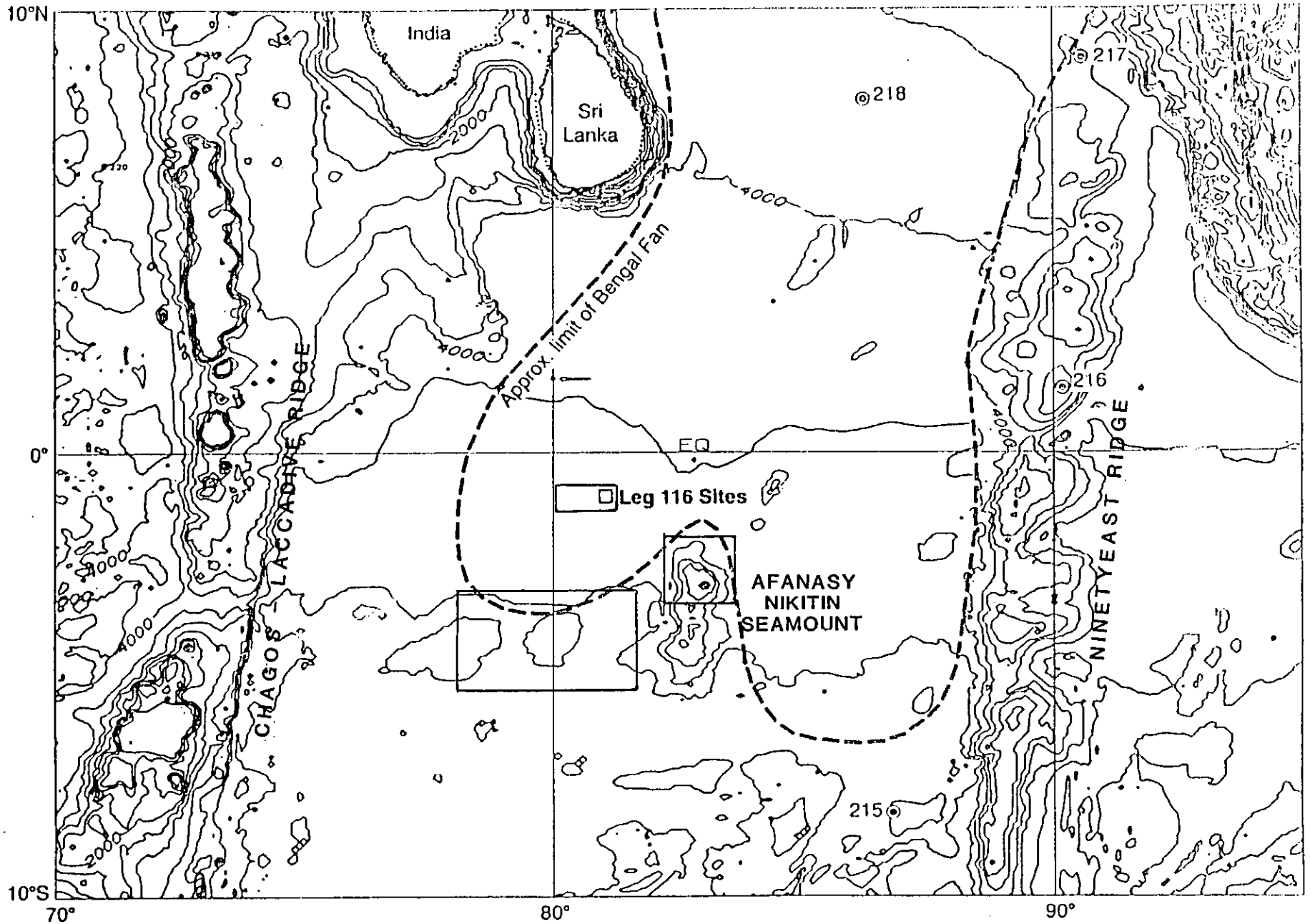


FIGURE 1. Bathymetry of the Central Indian Ocean with the principal working areas of the cruise outlined by boxes.

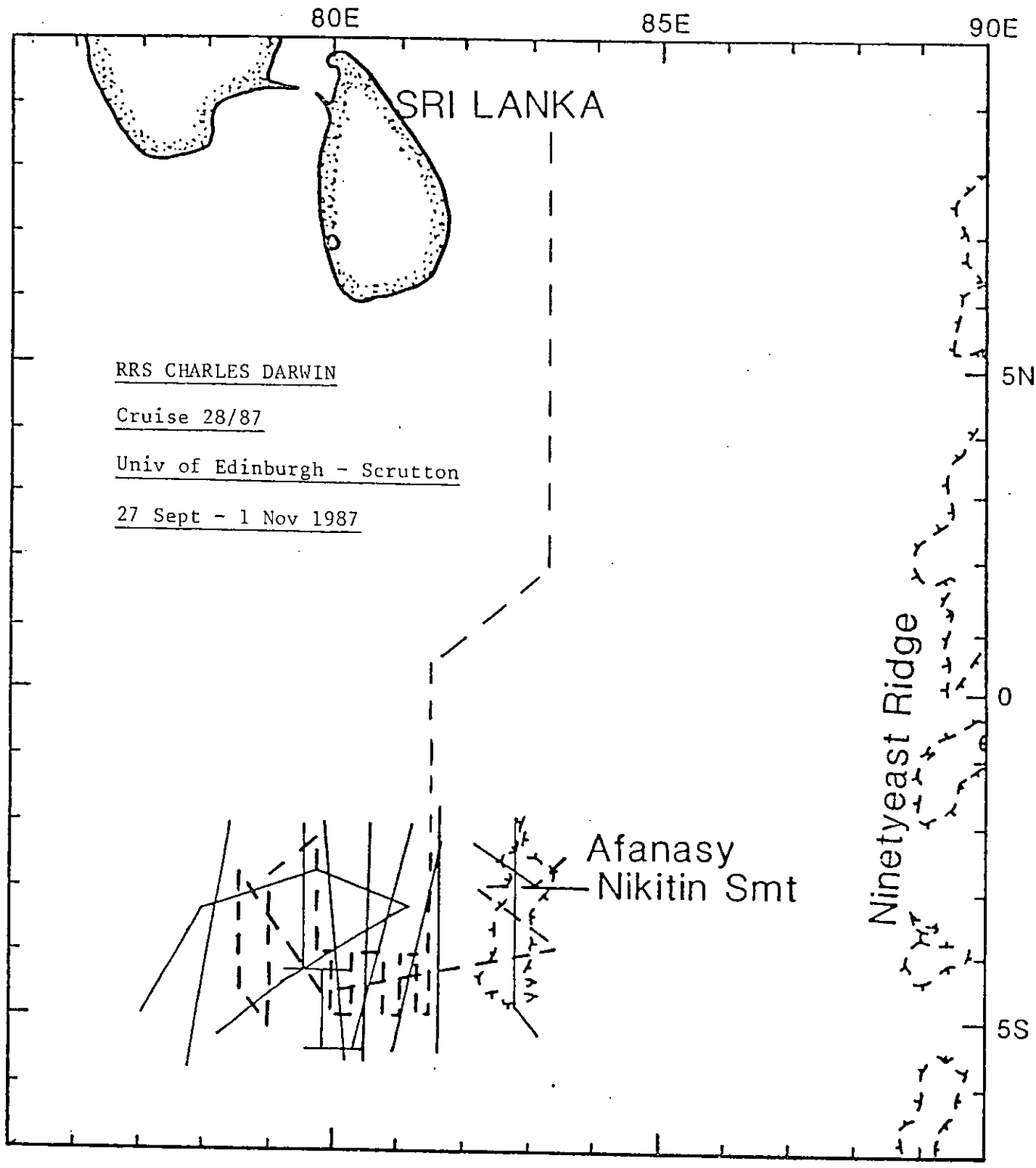


FIGURE 2. Sketch map of the proposed cruise tracks (dashed lines). Thin soild lines are existing tracks, other than those shown in Fig 4 in the ODP Leg 116 area. Pecked lines define the Afanasy Nikitin Seamount and the Ninetyeast Ridge.

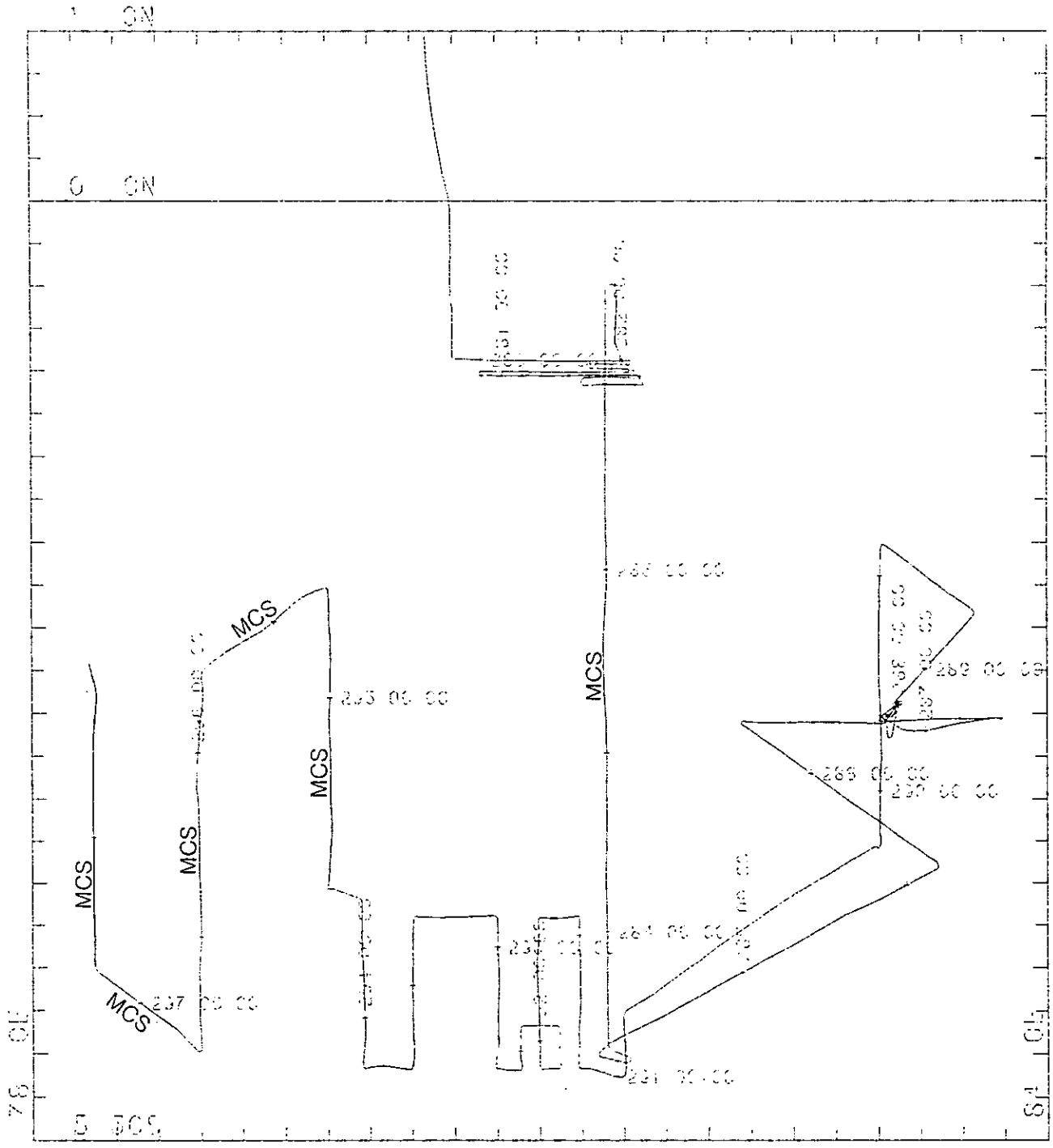


FIGURE 3. Track chart of RRS CHARLES DARWIN Cruise 28. Bathymetry, gravity and magnetic data were recorded along all tracks. Single-channel seismics and 3.5kHz sediment profiler were recorded along most tracks. Multi-channel seismics were recorded along tracks labelled MCS.

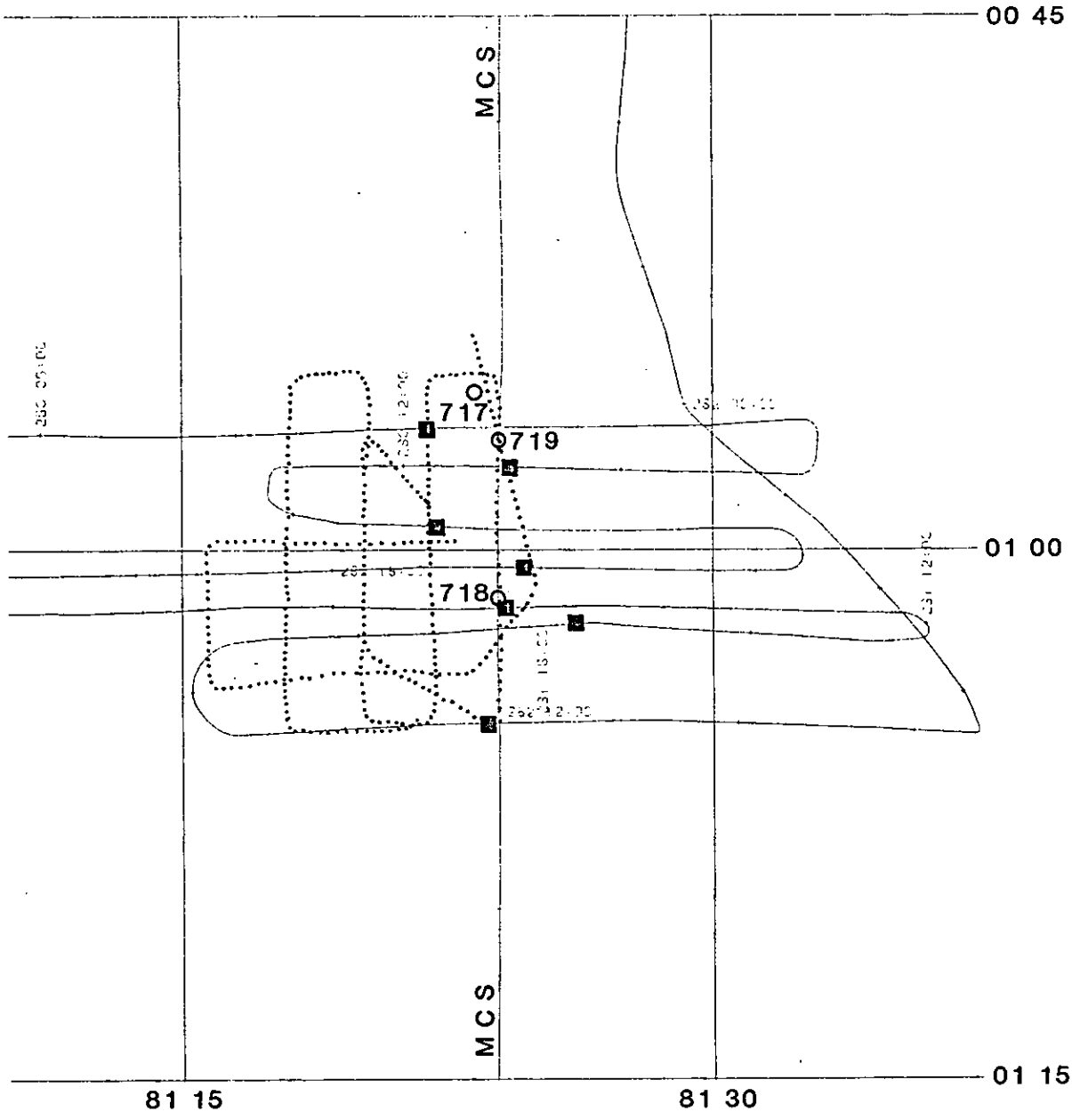


FIGURE 4. Detailed track chart of the area of the Leg 116 sites. Thin solid lines - DARWIN survey tracks: dotted lines - Lamont site survey lines: open circles - ODP sites: solid squares - DARWIN sonobuoy stations.

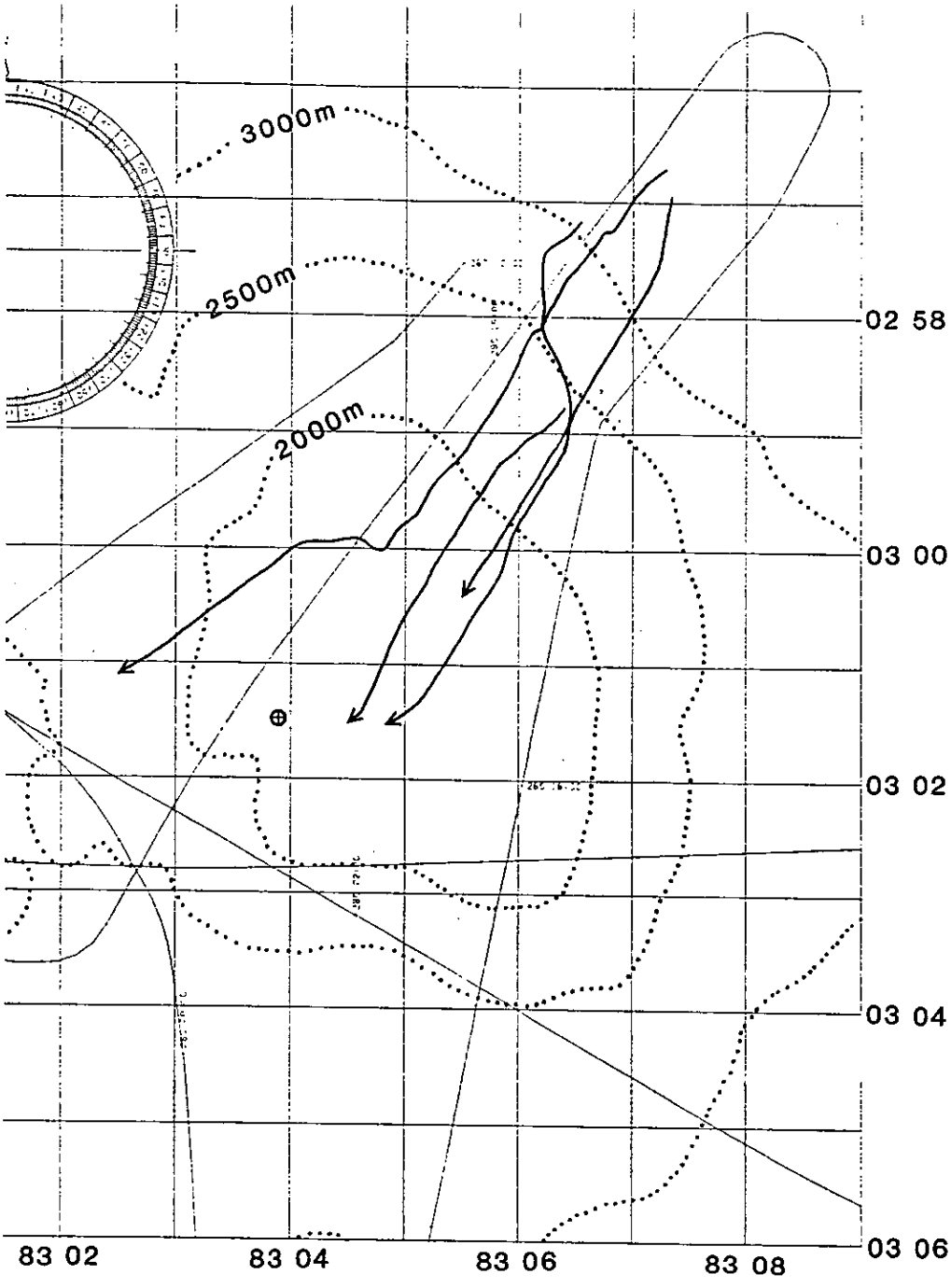


FIGURE 5. Detailed track chart over the summit of Afanasy Nikitin Seamount. Thin solid lines - DARWIN survey tracks: heavy solid lines - dredge tracks (dredge would have been about 2km astern): circled cross - piston core station: dotted lines - isobaths from Soviet source.

TABLE 1

RRS CHARLES DARWIN Cruise 28

STATIONS OCCUPIED

Sonobuoys

Sonobuoy	Time	Latitude	Longitude	Quality
1	0759z/280	00 56.6S	81 22.0E	Good
2	1130z/280	00 57.7S	81 24.3E	Poor
3	1345z/280	00 59.3S	81 22.2E	Good
4	1705z/280	01 00.5S	81 24.6E	V. good
5	1903z/280	01 00.7S	81 13.4E	Test-fail
6	0955z/281	01 01.7S	81 24.2E	Good
7	1353z/281	01 02.1S	81 26.1E	Good
8	1745z/281	01 05.0S	81 23.8E	Good
9	0440z/284	04 42.1S	81 24.2E	Good
10	0836z/297	04 02.3S	78 22.0E	Good

Core stations

Station	Latitude	Longitude	Water depth
1	03 01.5S	83 03.9E	1720m
2	03 47.1S	82 59.7E	3859m