University of Cambridge

Department of Earth Sciences

CRUISE REPORT

RRS CHARLES DARWIN 129

SOUTHWEST INDIAN OCEAN PALAEOCEANOGRAPHY

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DEPARTMENT OF EARTH SCIENCES

R.R.S. CHARLES DARWIN

Cruise 129

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History of the Deep Western Boundary Current in the Madagascar and Mascarene Basins

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Abstract

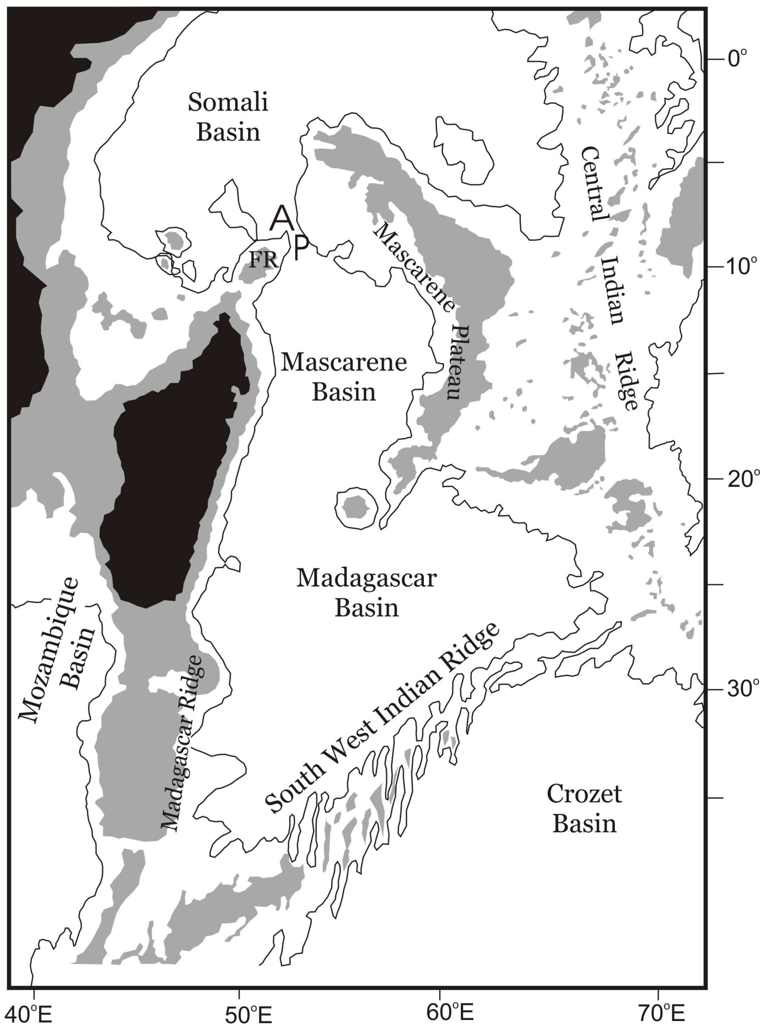
Cruise 129 of the RRS Charles Darwin was designed to investigate the history of the Deep Western Boundary Current in the Madagascar and Mascarene Basins and make hydrographic and biological measurements in support of those objectives. Swath bathymetry (10 kHz) and 3.5 kHz sub-bottom profiles were recorded continuously. Kasten (16) and box (29) cores were recovered and one piston core. 16 CTD casts with transmissometer and fluorometer, and plankton net hauls at 9 stations (generally 3 tow depths per station) were also deployed. The topography proved to be quite rugged on the ridges to the north and south of Madagascar, as was the western flank of the Mascarene Ridge. This made it impossible to find coring targets at the depths of AAIW. Furthermore, much of the sediment apron east of Madagascar is made of turbidites and only a few contourite deposits, none forming a significant sediment drift. It appears that the deep Western boundary current is not particularly strong here, and recent work has shown that the dominant current is related to Rossby waves in the basin with a period of 60 days. Nevertheless sufficient material has been obtained in order to examine aspects of the paleoceanography and flow history in this basin, especially from the flow constriction in Amirante Passage.

Introduction

The view of the Oceans circulation expressed in the Broecker/Gordon view of an "ocean conveyor" has a significant deep inflow to the western Indian Ocean flowing northward into the Somali and Arabian Basins. There, through mixing processes, the properties of the inflowing water are altered, it rises and flows out to the south. At shallower levels intermediate waters enter from the south and east (Schmitz 1995, 1996). These water masses are important in providing the water that upwells around the Arabian Sea supporting the high productivity there. Deep inflow to the Indian Ocean (IO) is anticipated to have changed in vigour and chemistry on glacial to interglacial time-scales. It is now fairly well established that one response to glacial climate was reduced dense North Atlantic Deep Water (NADW) outflow from the Nordic seas and its (partial) replacement by an intermediate water homologous with present day Labrador Sea Water (LSW) (Boyle 1995). It has further been suggested that the supply of deep water from northern and southern sources is linked in an opposing manner termed the "bi-polar see-saw", (strong north/weak south source and vice versa), at least on short time scales (Broecker 1998). It appears from sediment studies in the S.W. Pacific that deep flow into the Pacific was more vigorous during glacials (Hall et al. 2001). It is of the highest importance to understanding of the ocean system response to climate change to establish the glacial/interglacial variation in input strength to the major deep ocean basins.

The focus of the work in the Indian Ocean was to take cores from sediment drifts in the western IO under the Deep Western Boundary Current (DWBC) north and south of Madagascar and to analyse them for sedimentary and chemical properties indicative of current flow strength, hydrography and nutrient status of water masses. These data will provide the basis for understanding the climatically-driven hydrographic changes in deep and intermediate waters of the IO inflows on glacial to interglacial time scales

There has been considerable oceanographic interest in the Indian Ocean in recent years because it lies under the path of the so-called 'Indonesian through-flow' which is hypothesised to feed into the Agulhas Current and flow into the Atlantic to replace the water flowing out of the Atlantic as NADW. Schmitz (1996) comments that "the Indian Ocean's contribution to the global thermohaline (inter-basin) circulation needs to be clarified in order to resolve the outstanding questions concerning the replacement flow for NADW". The role of the Indian Ocean's past circulation also needs to be investigated and clarified. Schmitz suggested a possible link between the NADW replacement and meridional overturning from Circumpolar Deep Water (CDW) to (IW) in the Indian Ocean. A further source of Antarctic Intermediate Water (AAIW) is from the south, and Robbins & Toole (1997) estimated 10 Sv of IW of circumpolar origin moving northwards across 32° S. This AAIW inflow can be seen marked by a salinity minimum at a depth of about 1200 m along the upper flanks of the Madagascar Ridge.



It is a matter of considerable palaeoceanographic importance to determine whether that Intermediate Water expanded at times in the past in the same way as North Atlantic intermediate water (LSW) also expanded during the glacials. Thus if we could core the sediment bodies in the depth range 1000-2000 m on the east side of the Madagascar Ridge we would obtain a sediment record relating to the AAIW as well as to the southward flowing North Indian Deep Water (NIDW) with low oxygen content to the south beneath it (Fig.1). At greater depths on the flanks of the Madagascar Ridge Toole & Warren (1993) show a high salinity inflow of NADW-influenced water from the Mozambique Basin which forms an upper level of the DWBC between about 2000 and 3000 m depth, and below that the inflow of Circumpolar Deep Water which has entered the Basin via several fracture zones in the Southwest Indian Ridge. These different water masses, filling the basin to nearly 2000 m, flow northwards as a DWBC along the Madagascar Ridge, the Madagascar continental margin and the Farquhar Ridge before leaving the Basin via the Amirante Passage. The bottom potential density map of Mantyla & Reid shows the flow entering the Madagascar Basin to progress diagonally across it to the Madagascar Ridge and then flow northwards into the Mascarene Basin.

The distribution of sediments suggests that some part of that inflow makes a clockwise circuit of the southern end of the Basin and flows all the way along the Madagascar Ridge. The sediments under the Deep Western Boundary Current are plastered up against the Madagascar Ridge south of Madagascar, and the Farquhar Ridge north of the island. Seismic data from Schlich (1974) and the Lamont-Doherty archives demonstrate satisfactory sediment cover for coring with evidence of low amplitude mud-waves indicating current controlled deposition in the region. The sediments comprising these drifts are dominantly of carbonate whose content decreases from 80-90% shallower than about 4000 m down to zero at about 4800 m (Kolla et al. 1976a). In the area of interest there is also about 7-10% quartz and a clay suite dominated by illite with very strong kaolinite on the Madagascar Margin, but elsewhere up to 40% of smectite (Kolla &Biscaye 1977, Kolla et al. 1976b). We therefore anticipated no difficulty in locating sediments with adequate planktonic and benthic foraminifera for palaeo-chemical estimates of surface and bottom water conditions, but the extraction of the terrigenous silt component will require processing a considerable amount of sediment for relatively small yield. The lithogenic sediment is partly of aeolian origin and partly from submarine erosion and, particularly to the north of Madagascar, is derived from run-off from the eastern Madagascar river systems yielding ~10 Mt/a (Milliman et al. 1996). The geostrophic flows and the seismic evidence of current controlled sedimentation suggested that the size distributions of this material are very likely to display a signature from which estimates of past current strength may be obtained.

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Narrative of Cruise

At the beginning of the cruise we met to decide what to call this suite of cores. It has been my practice to give a four letter designator, e.g. CHAT for the Chatham Rise (NZ) or BOFS for the Biogeochemical Ocean Flux Study cores. Here we toyed with SWIN (SW INdian, no - a bit swinish), WINO (Western INdian Ocean, no - might seem self-accusatory), but settled on WIND (Western INDian) as the designator. Not that a different name would have changed things, but it did turn out to be prescient….

We sailed at noon on 6 July from Durban and turned to the SE into a heavy swell resulting from the recent passage of a depression to the south. It prepared us for the next week where, as the Captain was not slow to remind us 'if you must come down here in winter', the southerly swells are ill-suited to coring. With a long run across to the Madagascar Basin, we decided to take a shake-down station on the western margin of the Mozambique Basin on a ridge whose bathymetry resembled a detached sediment drift, similar to southern Feni Drift in Rockall Trough. It lies under the deep western boundary current (DWBC) that flows into the basin along the foot of Mozambique Plateau. We ran a couple of swath/3.5 kHz lines across the 'drift', enough to confirm that it was an erosional feature. On 8 July we took a box core followed by a CTD cast between the ridge and Plateau, the only depositional patch seen in the area. The weather (wind 6 + swell) ruled out further coring opportunities so the chance of a Kasten core here was sadly missed.

Our next target was to find a place to obtain a core under Antarctic Intermediate Water (AAIW). Despite several tries at various locations on the Madagascar Ridge this ultimately proved fruitless, the results of our attempts being several bags of washed sediment from thin scrapes acquired by the box corer. The first was on the west side of Walters Shoal. We then went over to the east side of the shoal and identified a possible core site but the weather did not allow us to get the equipment over the side. With poor weather and forecast, we surveyed the slope down to the Madagascar Basin along 33^{o} 30'S to 4000 m depth, intending to core up the slope when the weather improved. This never came and by the time we reached the foot of the slope, was forecast to be no better for several days.

Our cruise plan was to go north and so we did, but also there was no real alternative as we could not afford to wait around for the weather to change. We occupied 4 coring stations – 4 box cores and 2 kasten – plus deployment of two of Brian King's ARGO floats on the deep edge of Madagascar Basin. One kasten core was excellent, but being at 4500m it had carbonate at the surface that disappeared downcore due to glacial dissolution. The other core with a 7m barrel somewhat ominously only stuck in 2.7 m. Now we set off up into the highlands of Madagascar Ridge where in 5 stations only one box core was full, and at that station the kasten (4m barrel) recovered only 2.7 m again. All the other box cores obtained thin scrapes less than 25 cm thick. It was by now clear that this ridge was covered in carbonate sand, frequently winnowed by strong currents and that there were no little pockets of rapidly accumulated finer sediment.

So it was with some relief that we continued north, away from the southern swell and off the Ridge into deeper water to stations 12 and 13 under the DWBC and welcoming softer sediment for coring. At this point I need to observe that Sods Law is alive, well and immutable. Station 12 was off the northern Madagascar Ridge/ southern Madagascar continental rise whereas station 13 lay in a depression on the rise guarded by low ridges to north and south. At the first station a full box core gave no hint of any difficulty and the

kasten went down with a 7 m barrel (this is made up of 4 and 3 m sections linked by 4 steel plates). The pull-out was weak and at the surface we discovered the barrel broken with the lower section hanging on by a couple of bolts. This was recovered (a nail biter in a 3m swell). Examination of the barrel showed it had penetrated only 3 m and 2.75 m of sediment were recovered.
It had been stopped by a layer of pure rippled foram sand. We supposed this to be a turbidite of the material we were familiar with from the Ridge. At the next station the full weight of the Law became apparent. Despite a full box core and the expectation that if there were turbidites they would be terrigenous muddy sand, exactly the same thing happened. It stopped in foram sand; 1.2 m of sediment, broken barrel held by one remaining bolt, nails down to the quick. Sterling work by the crew recovered the barrel (but it's a bit knackered).

This second foram sand layer in a place where a turbidite of that composition would not be expected causes us to surmise that both layers might actually be caused by current winnowing, possibly in the last glacial, leaving a foram lag. Were currents here really strong at the last glacial maximum?

Our next target, providing another manifestation of the Law was to take cores along 20° S at the locations of the WOCE ICM3 line of current meters. In this way we could examine sediment properties and foram preservation in situations where one key variable, mean flow speed, was known. It turned out that the line is also the locus of a turbidite channel, the sediments are mainly sandy muds deposited by turbidity currents with huge amounts of mica and very few forams. Aaaaaargh! At station 16 on the WOCE line, being a bit gun-shy, we had taken a kasten core with a 4 m barrel which, now in terrigenous sandy mud turbidites, had overpenetrated. So we started using longer barrels, 6 m at sta 24 and 7 m at sta 25, both of which came up full. We regretted the demise of our other 4 m barrel which would have given us 8m. Such is life. Stations 21 to 25 were taken on the NE Madagascar continental rise. This has a great many turbidity current channels of a wide range of sizes. It is not clear whether the occurrence of mud waves is controlled by proximity to channels i.e. turbidity current overflow, or has an influence of the DWBC. Our cores from mud waves, although inevitably often near channels, were not dominated by turbidites. Despite a determined effort to avoid likely sites of turbidite deposition, inevitably some crept into the cores. We will have to see whether they have had a significant direct effect on sedimentary parameters. We can be fairly certain that there is no contourite drift under the DWBC along the Madagascan rise. The main structure is a turbidite apron.

We moved on to Amirante Passage to core the mud waves under the DWBC along its western margin and at two sites away from the margin (stations 26 to 31). An unwelcome feature of this region was the culmination of the strengthening ESE trade winds that had been experienced along the NE Madagascar margin. At times the ship was barely able to sustain 6.5 knots when sailing between south and east. It also made for difficult coring, the final straw being two failed attempts (pre-trips in heavy 3-4 m swell) to get a box core at a second visit to Station 27 where a good kasten had been obtained two days earlier. The DWBC passes along the foot of Farquhar Ridge. Being volcanic, this has pretty rugged topography and the attempt to find an upslope depth transect was perhaps always doomed to failure, demonstrated by three basalt pebbles as the only return from box core 29. The mud wave coring was much more successful with 5 cores of over 6.2 m recovery, though some contain a lot of foram sand. Sparsely foraminiferal mud is achieved only by going closer to the CCD, but this often means losing forams altogether in glacial intervals.

The passage SSE towards Mascarene Ridge directly into the trades started at around 6.5 knots and lasted over 2 days. Speed picked up to 8 knots with decreasing winds as we got further from the influence of the Seychelles, but we were still in the trades with a steady wind from the ESE that rarely seemed to go below force 5. Still, it was a relief from the force 6 to 7 in Amirante Passage. We intended two transects up the Ridge but time lost to winds meant that the northern transect (11° S) was curtailed to two stations so that a complete job could be achieved at the southern one. At the first of these a full box core again failed to warn us that the bed was very tough. The kasten core went down with a two-section 7 m barrel but returned with one 4 m section, the lower 3 m section having broken off completely and rather cleanly. With the benefit of hindsight the observation of many diatoms in the plankton tow could have alerted us to future difficulties. The 4 m core barrel at the second station came up full, having been uncompromisingly put in at 50 m/min.

Finally we headed south to 16½° S for a depth-transect up the side of Mascarene Ridge to the Cargados Caragos Shoals, but as the island of St Brandon lies on top of it we refer to this as the Brandon transect. Well, actually it turned out to be a non-transect as far as coring was concerned. The bed was acoustically hard almost everywhere. In the few areas with limited penetration the surface echo was very sharp. In 6 stations we managed no kasten cores, two bags of sediment from thin scrapes in the box corer, 3 CTD casts and several plankton net hauls. It appears that the bed is limestone with karstic topography in several places and possible debris flows in others. The topography at the base of the slope suggests a strong southward current scouring the slope. The CTD data will allow a check on this. So finally we were not able to get bottom sediments to match the excellent collection of forams acquired in the nets.

This was disappointing at the end but, given the conditions, we were very successful in obtaining a useful suite of cores from around the basin. This amounted to 35 box cores (28 good), 16 kasten cores, totalling ~75 m, and one piston core plus 16 CTD casts that will fuel our efforts to decipher the history of the deep basin and its water masses over the next few years.

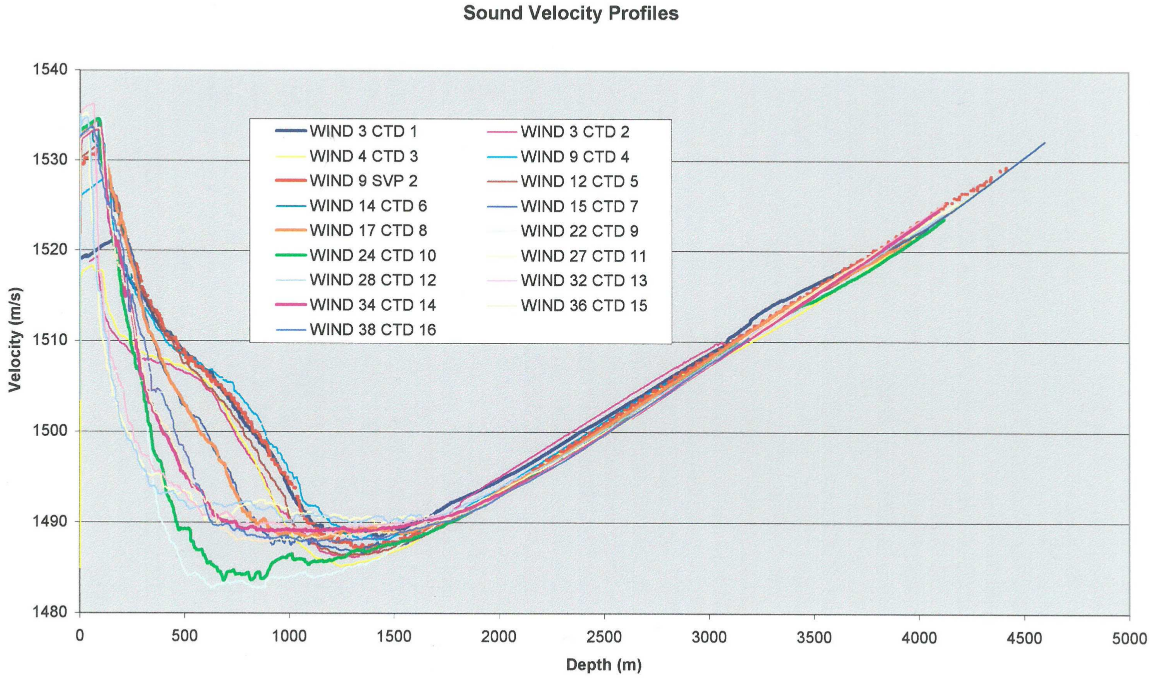
The coring and other over side operations were very smoothly managed by the UKORS staff and the ship's crew, and the bridge officers held us on station, often in some rather bouncy conditions. As ever the research community owes them a debt of gratitude, for otherwise we would be empty handed. Thank you to all.

INMcC

Topography and 3.5 kHz profiler records

(a) Swath Bathymetry

For appraisal of the terrain the Simrad EM-12 swath system was used continuously. The 10 kHz Simrad sounder was also operated and used for assessment of anticipated bottom hardness through its reflectivity facility. The swath system is quite sensitive to changes in sound velocity. The shifts in hydrography of the upper 1000 m of the water column from AAIW dominance in the south to Red Sea and Persian Gulf Water in the north gave a large range of velocities (from 1483 to 1507 m s^{-1} at 650 m depth). Velocities were computed from T and S measured in CTD dips and were also measured directly on a few occasions. Below ~1500 m the range is about ± 1 m s^{-1}.



The attention to sound velocity yielded good swath data, but even so a few plots initially resembled dried bread – curled up at the edges. Navigation was by GPS and the track is plotted over the new (as yet unpublished) GEBCO bathymetry on track charts at the end of this report. This was also made available in large plotting sheets by Dr Meirion Jones of British Oceanographic Data Centre (BODC) and Dr Bob Fisher of Scripps Inst^{n} of Oceanography to whom go our thanks.

A significant proportion of the swath coverage was processed. In general, maps around all the coring sites and several of the passage legs between them were processed. These are listed in Table 1 and the location of the stations is given in the station log and plotted on the track charts. All the swath bathymetry, both processed and raw has been deposited with BODC.

TABLE 1: PROCESSED SWATH BATHYMETRY

1	E. Mozambique Ridge/Station 1
2	Station 2
3	33^{o} 30' Downslope #1, to sta 3
4	33^{o} 30' Downslope #2, to sta 3
5	Station 3 to Station 4
6	Station 3
7	Station 6
8	Station 6 to Station 7
9	Station 7 to Station 8
10	Station 8
11	Station 8 to Station 9
12	Station 9 and Station 10
13	Upslope to Station 11
14	Station 11 to Madagascar Basin
15	Edge of Madagascar Basin to Station 12
16	Station 12
17	S. Madagascar Rise and Station 13
18	Station 13
19	20^{o} S Line. Stations 14-20
20	Station 21
21	Stations 22-24
22	Station 25
23	N.E. Madagascar Rise to S. Farquhar Ridge
24	S. Farquhar Ridge to Station 26
25	Stations 27-29 and Station 31
26	Station 30/Central Passage
27	N. Amirante Passage
28	Stations 32-33
29	Bump 1
30	Bump 2
31	Stations 34-35
32	Lower Brandon Slope
33	Up to Brandon shelf edge
34	Brandon Downslope

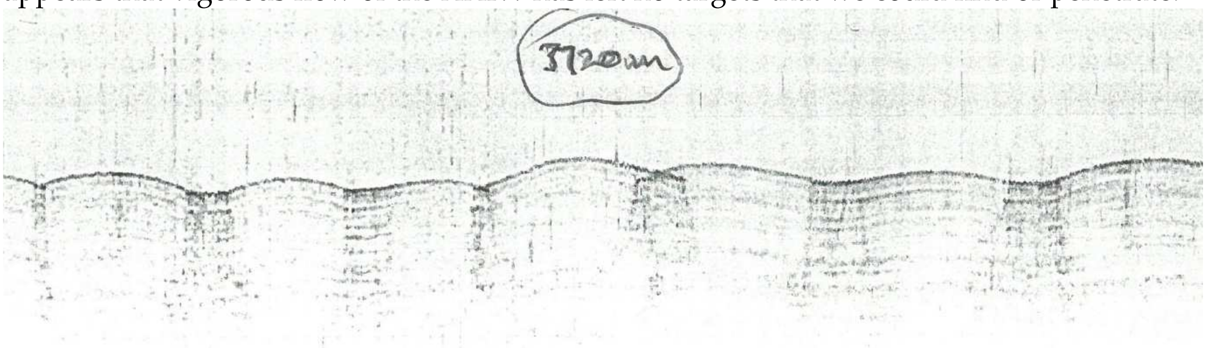
All the plots are at least A1 in size and most are A0

(b) 3.5 kHz Profiler data

The 3.5 was run continuously from the Mozambique Ridge (~ 35° E) to the end of the cruise just N of Mauritius. In general results were poor due to rough conditions with bubbles affecting the transducer. That was coupled with long sections of hard ground where penetration was limited. Occasionally imaging down to 50 m sub-bottom was achieved. The selection of records shown in this section illustrates the problems and results. As will be seen from the account of coring, detection of impenetrable bottom was not always successful! On a few occasions there were lock-on problems in deep water, particularly across the Mozambique basin (>5000 m) where no results were recorded.

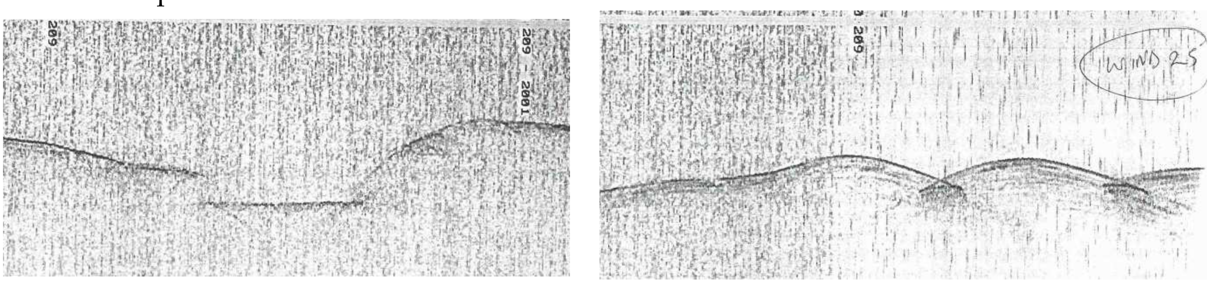
Topographic and shallow acoustic character

On leaving Durban we steamed SE over the Natal Valley to Mozambique Ridge and made the first station at the foot of the ridge on the W. edge of Mozambique Basin. We proceeded directly east across the basin to Madagascar Ridge where we spent 9 days on the irregular topography of the ridge and on its eastern flank in southern Mascarene Basin. These slopes are in places mantled with mud waves (see below) but these are often of tough carbonate ooze and pass upslope into winnowed sand and steep scarps up to ridge crests at ~ 500 m depth. These are the 'slopes' where it was hoped to core sediment under AAIW. It appears that vigorous flow of the AAIW has left no targets that we could find or penetrate.



Mudwaves near WIND-3, SW Mascarene basin. Penetration is ~50 m.

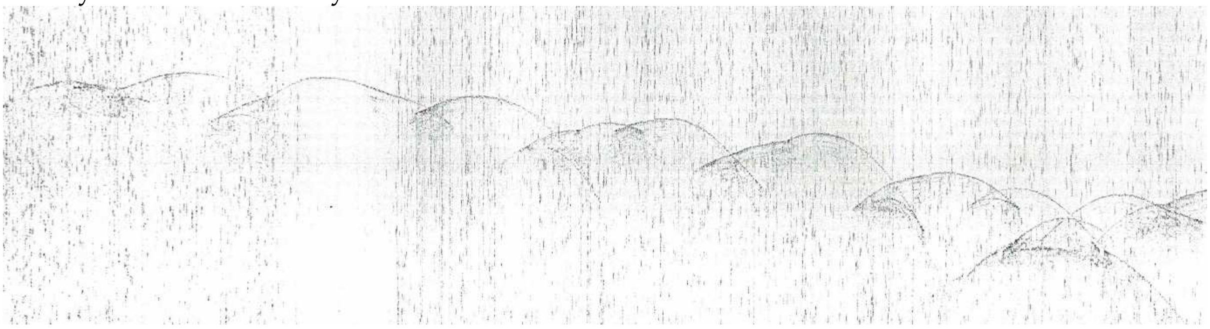
The continental margin of Madagascar occupied the next 8 days (JD 201 to 210). This is an accretionary apron dominated by turbidite channels and some probable turbidite mud waves. Some detailed portions of the margin were surveyed where channels and the DWBC interact with seamounts around 12° S. The northern slope apron of Madagascar is wider than in the south, a fact which initially suggested deposition of sediment stripped off the slope to the south. Our survey suggests that it may actually be simply due to more vigorous turbidite deposition.



Turbidity current channel near WIND-25. Mudwaves are probably of turbidite origin, amplitude up to 20 m. Channel relief is ~ 70 m, flow towards you, higher left bank levee (S. hemisphere).

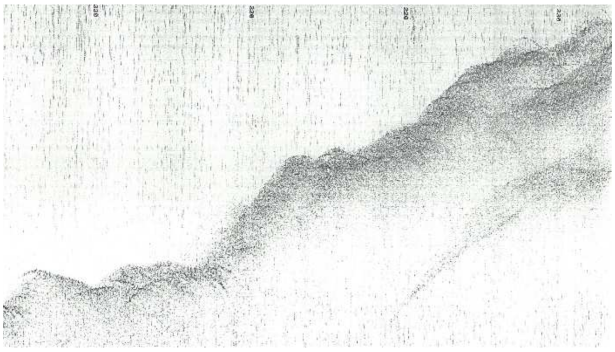
This slope, dominated by terrigenous deposits and gentle slopes then runs into the rugged volcanic topography of Farquhar Ridge running N.E. of Madagascar. There is over 4000 m of relief here as the ridges break surface in the Farquhar Islands (part of the

Seychelles archipelago). The sediments become more carbonate-rich and are shaped into contourite mud waves by the DWBC around the base of the slope. The upper slopes are rugged and, with almost no 3.5 kHz penetration, lack the hoped-for coring targets in shallower water. Amirante passage is similarly covered in irregular mud wave fields, mainly of carbonate sandy muds.

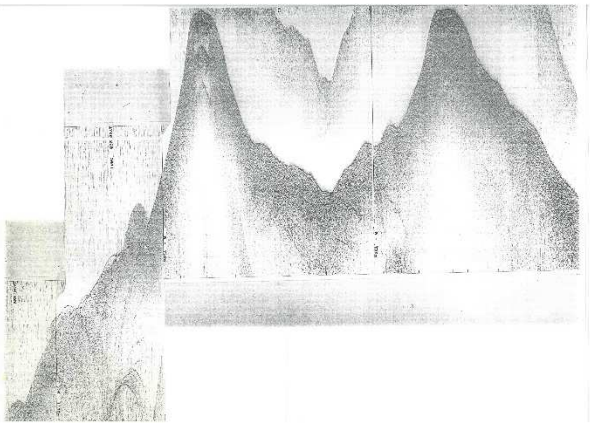


Mudwaves on the W side of Amirante Passage, amplitudes 30-70 m (Johnson & Damuth, 1979) record up to 100 m). Very weak returns at 4150 m depth, next to a steep cliff.

The passage across the northern Madagascar Basin was slow, steaming SSE into the trade winds, and gave rather poor 3.5 kHz records. Mud waves and turbidites are the principal features. We made a short transect up part of Mascarene Ridge at 11° S where mud waves were cored (and a barrel was lost). The passage south to the Brandon transect took us over a couple of ridges (14° 10' and 15° 30' S) with sediment piled up on the North and scour on



Rough lower slope of Brandon transect (2500 to 1500 m depth, leading to rugged top (0-1000 m)



the South side (similar on a lesser scale to Carter & McCave, 1994, fig.8a) suggesting vigorous southward flow. The Brandon transect itself was disappointing because no suitable coring targets were found. The 3.5 kHz showed almost no penetration, most of the area having hard prolonged echoes, and the swath map resembles karstic topography of dissected scarps and plateaux.

With the benefit of hindsight maybe we should have spent more time at the 11° 10' S transect, but we had a deadline to make in Mauritius and the Brandon transect appeared to be attractive. Next time …!

Coring

(a) Box Coring

We took 35 box cores (of which 25 were good, 4 were poor through flushing and 6 were scrapes) with a 0.25 m^2 box corer of the type used by Hessler and Jumars (1974) with spring-loaded upper flaps, open on impact and closed on retrieval, to minimise bow wave and subsequent scouring of the top during hauling. [Taxonomic note: All box corers descend from Reineck's (1963) original design. The one we used derives from the redesign supported by the US Navy Electronics Lab. (USNEL) associated with Bouma, Rosfelder and Marshall which had a 20 x 30 cm sample area (see Bouma, 1969). Hessler and Jumars (1974) increased that to 50 x 50 cm, and subsequent modifications funded by the US Sandia Laboratories make the corer we used a "Sandia Mark II" in the terminology of the cognoscenti. At RVS the instrument is known as the SMBA (Scottish Marine Biological Association) corer because that is where they got it from, but the design has nothing to do with the Association.] Details of the numbers, positions, lengths and operational aspects of each core are in the log at the end of this section.

The sub-sampling procedure was as follows:

1. Two 100 (i.d.) x 500 mm "drainpipe" tubes were first inserted in the mud followed by three 60 (i.d.) x ~250 mm piston core liner tubes. All of these were aimed at providing a suitable sediment archive for post-cruise work.
2. Three further drainpipe tubes of about 200 mm height were also inserted in the mud for immediate shipboard processing.
3. The remainder of the box core surface was divided up in ~1/3 where the topmost 2 cm was scraped and bagged mainly for sedimentological analyses and 2/3 where the topmost 1 cm was scraped and bagged for geochemical determinations.
4. Starting from box core WIND-21B, the 330-mm styrene trays also employed for kasten core sub-sampling were now routinely used to obtain two vertical sub-samples (one "working" and one "archive") from the top section of each box core once the side panel had been removed and before the extraction of the sub-cores of points 1 and 2 above. Shipboard processing of box core material was limited to either two or three (depending on foraminferal abundance) of the short drainpipe tubes (point 2 above). Each sub-core was sliced at 0.5 cm intervals for the upper 5 cm and then at 1 cm spacing between 5 and 10 cm depth. The remainder of the sub-cores was disposed of. The coarse fraction from each of the equivalent 15 sub-samples obtained from all sub-cores was combined. At this stage the combined samples were either simply saved in polyethylene bags or wet sieved with a 63 μm mesh size and stained with Rose Bengal following the methods outlined by Murray (Murray, J.W., 1991, Appendix A, Methods, in *Ecology and Palaeoecology of Benthic Foraminifera*, pp. 313-322, Wiley, New York) to identify benthic foraminifera alive at or near the time of sampling (cores with these samples are denoted by an "*" in Table 2).

The main purpose of the detailed, shipboard sub-sampling of the upper 10 cm of each box core will be to measure Mg/Ca ratios on living benthic foraminifera to assess the effect of pore water geochemistry on this parameter in shallow dwelling species when compared to data obtained on epifaunal specimens.

TABLE 2: BOX CORE LOG

BOX CORE†	LAT (S)	LONG (E)	DEPTH (m)	LENGTH (cm)	REMARKS
WIND 1B	35° 07.31'	35° 32.12'	4156	41	

WIND 2B/A	33° 38.99'	44° 21.01'	978	scrape	bagged
WIND 2B/B	33° 38.82'	44° 21.10'	976	scrape	bagged
WIND 3B	32° 38.65'	48° 29.64'	3731	12	
WIND 4B*	31° 18.72'	48° 30.07'	4570	40	
WIND 5B*	31° 34.14'	47° 34.15'	3684	35	
WIND 6B*	31° 16.40'	47° 33.86'	4150	45	
WIND 7B	30° 17.18'	46° 17.94'	1904	23	severely washed.
WIND 8B	29° 59.41'	45° 57.73'	1070	scrape	hardground, bagged.
WIND 10B*	29° 07.49'	47° 32.94'	2871	46	very good surface.
WIND 11B*	28° 31.72'	48° 10.97'	2382	25	very sandy.
WIND 12B*	25° 50.79'	47° 55.37'	4196	47	
WIND 13B*	23° 56.32'	48° 59.91'	4065	44	
WIND 14B	19° 58.88'	50° 48.92'	4834	46	
WIND 15B	19° 59.97'	50° 19.96'	4629	40	
WIND 16B*	19° 57.75'	49° 55.68'	4189	44	part washed, top not closed
WIND 17B*	20° 00.00'	49° 46.93'	3991	41	
WIND 18B*	20° 00.00'	49° 29.92'	3319	31	hard sand layer, one side flushed out
WIND 19B*	20° 00.01'	49° 21.75'	2697	44	
WIND 20B*	20° 03.64'	49° 11.42'	2274	45	
WIND 21B*	15° 07.09'	51° 26.97'	3924	46	
WIND 22B*	13° 36.85'	51° 11.38'	3838	44	rt. levee
WIND 23B	13° 07.21'	51° 02.59'	4004	48	
WIND 24B	13° 04.45'	51° 20.01'	4163	44	lot of surface fauna
WIND 25B	11° 48.14'	50° 34.43'	3935	48	
WIND 26B	10° 30.24'	51° 16.04'	4093	49-45	sand ripple, over foram ooze
WIND 28B	10° 09.33'	51° 46.22'	4147	48	
WIND 29B	10° 00.91'	51° 29.30'	3057	-	few basalt fragments, bagged
WIND 30B*	07° 58.69'	52° 07.00'	3950	48	
WIND 31B	09° 40.36'	51° 47.91'	3893	45	
WIND 32B*	11° 14.19'	58° 13.18'	4117	44-46	
WIND 33B*	11° 12.71'	58° 46.24'	3520	38	
WIND 34B	16° 29.42'	57° 49.52'	4139	scrape	bagged
WIND 35B	16° 25.33'	58° 03.94'	3934	39	
WIND 39B	16° 46.24'	57° 22.04'	4198	scrape	CO_3 turb., bagged

† Note that under this numbering system the core and station numbers are the same. *

Cores for which forams were stained with Rose Bengal.

(b) Kasten (and piston) coring

Kasten coring. The CD 129 kasten coring programme utilised the successful 15 cm square core barrel, extended to a maximum length of 7 m by fitting together a 3m and 4m section. The Cambridge sections (4 m + 3 m) were supplemented by a suite of four barrels (1, 2, 3 and 4 m) on loan from the Department of Earth Sciences at Cardiff University, all of which were built to the design of Zangger and McCave (1990). The 1.5 tonne core head provided worked satisfactorily. It took 7 m cores in terrigenous material with enough clay to lubricate penetration, but was not sufficient to push the corer in more than ~3 m in tough carbonate ooze. However under those conditions we tended to bend or even rip off the doors of the core catcher, so it is not obvious that a heavier core head would have led to greater success.

All cores were sub-sampled in four different ways. The first, was with the same specially moulded styrene trays (330 x 15 x 25 mm) employed on cruise CD88 for the NEAPACC project (McCave, 1994). The second, employed pre-cut, 1 m long electrical conduit pipes like those used during Discovery Cruise 184 of the BOFS project (McCave, 1989). The third method was based on the collection of 1.5 m sub-cores with conventional U-channel tubes for palaeomagnetic work to be undertaken by Dr. A. Roberts at the University of Southampton. The fourth and final method consisted of small (~10 cm^3) sub-samples taken at 4 cm spacing collected with cut-off syringes for determination of water content and stored in air-tight containers. The standard kasten core sub-sampling routine was:

1) Following the removal of the lid on the kasten core section, the uppermost few millimetres were scraped off and a continuous succession of 330 mm trays was pressed along the length of the core barrel. These were individually labelled before the core was extruded upwards by the double-bottom plate (see Zangger & McCave, 1990). The mud was separated from the remainder of the core using a cheese wire and the slabs were removed sideways and bagged in polythene. This first set of sub-samples constitutes the archive material.
2) A second set of "working" trays collected in an identical manner will the material first used for post-cruise work.
3) The core was described after carefully scraping its surface to highlight sedimentary structures.
4) The electrical pipes and U-channels were pressed in the sediment on opposite sides of the core surface (~1 cm off the sidewalls) and water content samples were then collected at 4 cm intervals from the sediments lying between the two sets of sub-cores.
5) The core was extruded to remove electrical duct and U-channels which were simply covered with lids and cleaned.

The poor weather conditions accompanied by the paucity of suitable coring targets meant that the first opportunity to collect a kasten core only presented itself on the 9th day of the cruise at ~4600 m in the SW Madagascar Basin on a sediment apron at the foot of the Madagascar Ridge. The 4 and 3 m Cambridge sections were combined with steel plates (the same arrangement employed on previous cruises) to successfully recover a nearly full core of heavily bioturbated sediments characterized by almost rhythmic colour alternations. About 1,000 m upslope a second coring site was identified in a field of mudwaves on the edge of the DWBC. Despite successfully recovering a box core here, the 7 m rigging only penetrated 2.7 m into the sediments because of an ~80 cm-thick and extremely stiff layer of mud (probably diatomaceous).

Station WIND-5K set the scene for several of the subsequent attempts to recover long sediment sequences with the kasten core, which were marred by the presence of tough foraminiferal ooze or turbiditic layers. The various attempts at recovering 7 m of sediment in such adverse conditions resulted in the damaging, and in one instance loss, of the core catcher doors. More importantly, though, on two occasion we only just managed to save the 3 m section from becoming part of the deep-sea sedimentary record as it perilously hung by a single bolt to the upper 4 m barrel. Irreparable damage to the two Cambridge kasten sections forced us to use the Cardiff hardware after station WIND-13K. Initially, a more cautious single barrel (4 m) rigging was employed. However, when we reached ~13^{o}S, our confidence was bolstered by the recovery of three consecutive cores in excess of 3.5 m along the deep eastern margin of Madagascar. Unfortunately, these contained sediments dominated by the direct terrigenous supply from the island as turbidites with little evidence of foraminifera being present in any useful quantity. We first combined a 4 and 2 m Cardiff barrels for WIND-24K fitting new U-shaped steel connectors which appeared to provide a more solid structure than that achieved with the earlier arrangement. This core was nearly full to the brim and the six subsequent deployments using the 7 m rigging always recovered over 6 m of sediments. As we moved beyond the northern tip of Madagascar the turbidite-rich sediments gave way to progressively more foraminifera-rich muds. The sediments from the northernmost station in the Amirante Passage (WIND-30K) contain alternating layers of bioturbated dark and light brown mud with gradational boundaries and rich in foraminifera.

As we moved across the Mascarene Basin to collect a suite of cores along the slope of the western Mascarene Plateau disaster struck, as the lower 3 m section with the core catcher was lost and no sediment whatsoever was recovered at our first deployment in this area (station WIND-32). At the next station we used only the 4 m section with a core catcher borrowed from RSU, collecting a nearly full core of carbonate ooze. An attempt to collect a core at station WIND-35K proved unsuccessful as the barrel arrived on deck empty.

Therefore, WIND-33K was our last kasten core in what proved to be a challenging coring environment. Considering the difficulties encountered we can be satisfied with the 80.25 m of kasten core sediments recovered which will no doubt provide a rich supply of material to unravel the palaeoceanographic history of the SW Indian Ocean of the last glacial-interglacial cycle.

Piston coring. On the Madagascar Ridge we encountered conditions of tough carbonate ooze where we were not getting more than ~2.5 m penetration with the kasten corer. So at station WIND 11 we decided to try a piston corer with 6 m free fall. The corer is an old-style Kullenberg design with a standard narrow gauge (6.6 cm i.d. liner. A 1.2 m gravity corer is employed on the end of the trigger chain, yielding a surface pilot core. This proved to be no more successful than the kasten and obtained a core only 2.28 m long, so we put it away and did not use it again.

INMcC, GGB

TABLE 3a: KASTEN CORE LOG

KASTEN[†]	LAT (S)	LONG (E)	DEPTH (m)	LENGTH (m)	BARREL	REMARKS
WIND 4K	31° 18.63'	48° 30.08'	4567	6.13	7	
WIND 5K	31° 34.34'	47° 33.47'	3682	2.74	7	
WIND 10K	29° 07.50'	47° 33.57'	2848	2.65	4	bent doors, 2 tries
WIND 12K	25° 50.77'	47° 55.33'	4192	1.59	7	broken barrel
WIND 13K	23° 56.31'	48° 59.85'	4060	1.16	7*	broken barrel
WIND 16K	19° 57.88'	49° 55.65'	4180	4.14	4	over-penetrated
WIND 22K	13° 36.56'	51° 12.29'	3853	3.68	4	
WIND 23K	13° 06.80'	51° 03.27'	4014	3.78	4	
WIND 24K	13° 04.60'	51° 20.44'	4176	5.75	6	
WIND 25K	11° 48.05'	50° 34.48'	3930	6.75	7	
WIND 26K	10° 30.36'	51° 16.25'	4095	6.76	7	mud wave
WIND 27K	10° 11.61'	52° 07.91'	4199	6.33	7	poss. over penetrated
WIND 28K	10° 09.23'	51° 46.15'	4157	6.15	7	mud in top, over-pen?
WIND 30K	07° 58.60'	52° 07.88'	4062	6.33	7	
WIND 31K	09° 40.71'	51° 48.75'	3867	6.78	7	mud wave
WIND 33K	11° 13.76'	58° 45.95'	3518	3.78	4	mud wave

[†] Note that under this numbering system the core and station numbers are the same.

*Prior to this, 7 m is Cambridge 3 and 4 m, but for 13K and subsequent it is Cambridge 3 m and Cardiff 4 m barrels.

TABLE 3b: PISTON CORE LOG

WIND 11P	28° 31.96'	48° 11.17'	2422	2.28	6	6m free-fall
WIND 11PG	28° 31.96'	48° 11.17'	2422	?.??		

CTD Operations, Calibrations and Sampling

(a) Operations

The CTD package comprised a Seabird CTD with dual pumped sensor streams, each comprising temperature and conductivity sensors. The primary stream also has an oxygen sensor. Auxiliary equipment included transmissometer, fluorometer, light scattering, altimeter, 10 kHz pinger and 12 x 10 l sample bottles. The CTD data are all lodged with the Britist Oceanographic Data Centre. No problems were recorded with th temperature sensor. The oxygen values were not calibrated and are thus not accurate. However there are very large differences in oxygen concentration which are of great value in water mass identification

Cast 01/WIND 01. This was taken as a shake-down station to check systems before we arrived in the main area of operations. Deployment was smooth with everything looking OK until 3100m on the downcast when the primary salinity jumped by 1.5 PSU higher. This appeared to be a problem with the conductivity sensor. The sea cable fuse blew at 3990m on the upcast, at which stage only bottle 1 had been fired. The fuse was replaced and software restarted. All bottles fired on ascent. Recovery was difficult due to rough sea and having to lift high over the corer bomb holder. 2 bottles were damaged during the recovery. The cable between BOB AUX4 and CTD JT6 was damaged by a recovery line chafing through to the cores. Terminal JB3 had cable ripped from bulkhead connector bending all the pins. No bottles had fired due to incorrect lanyard rigging. The Sound Velocity Probe (SVP) failed to gather any data due to suspected battery fault. The altimeter proved unreliable. Altogether a very necessary shakedown!

Cast 02/WIND 03. The lanyards were re-set after a failed test firing. All bottles then fired during the full cast. Primary salinity jumped as in cast 1, at 2000m. The pinger was used to determine altitude with the cast going to 20m above bottom (mab). Altimeter again unreliable.

Cast 03/WIND 04. The fluorometer was replaced with new unit #088195. The primary salinity problem occurred once again at 2000m. The sensor stream had previously been re-aligned, cleaned and bench checked. The conductivity frequency output was satisfactory with reference to the calibration sheet at the surface. It is suspected that the sensor was damaged in transit or during deployment of cast 01. Following this cast, both the primary sensors (temperature and conductivity) were replaced with units #2728 and #2164 respectively.

Cast 04/WIND 09. Pinger B11, suspected of having low batteries, was replaced with B8 after poor bottom tracking. Also, a bottom contact switch was fitted with a 10m line. The altimeter scale was changed to 50m, but with no better results. The pinger worked well as did the bottom contact switch.

Cast 05/WIND 12. The transmissometer displayed large spikes approaching the surface. The instrument checked out satisfactorily on deck, so fouling was suspected.

Cast 06/WIND 14. This was a shallow cast to collect water samples. The transmissometer once again displayed spikes. This was traced after the cast to a slight leak at BOB bulkhead connector.

Cast 07/WIND 15. No problems. Transmissometer now electronically OK (but see Casts 8 & 10). The bottom contact switch was used with a 10m line.

Cast 08/WIND 17. Cast OK, but the transmissometer was suspect. On checking after the cast, this was shown to have been due to a cable labelled wrongly. It was also noted that the instrument was not performing well as the clear water beam attenuation minimum values were far too low. (It had not been appreciated by technical staff that values less than ~0.350 m^{-1} are physically impossible). It was decided on the next cast to fit a spare transmissometer and run a comparison. The bottom contact switch was used satisfactorily with a 10m line.

Cast 09/WIND 22. Transmissometer #T1011D with a low gain cable was fitted. The original unit, #T1018D was used with a high gain cable. Comparison showed that T1011D was producing more realistic values and was also much more stable during calibration. These are the first properly taken transmission data of the cruise. The bottom contact switch failed, allowing the CTD to touch the seabed. This was later traced to a poor construction of the switch which was remedied.

Cast 10/WIND 24. The cast was OK with 2 transmissometers again used, but with T1011D set on high gain. This configuration was used from here on, but with unit #T1018D left on for comparison purposes. It continued to perform poorly. Bottom contact switch worked OK, 10m.

Cast 11/WIND 27. Cast OK, no pinger bottom trace, bottom contact switch good, 10m.

Cast 12/WIND 28. Cast OK, changed back to pinger B11 with new batteries, no improvement with bottom trace. The contact switch worked fine, but on retrieval its weight was missing. The switch was intact and functioning.

Cast 13/WIND 32. The cast was fine but the bottom switch failed and the unit skimmed the seabed with no apparent damage. The bottom contact switch was found to stick when cam is at full extension.

Cast 14/WIND 34. Cast OK, to 10m from bottom.

Cast 15/WIND 36. Cast OK, to 10m from bottom.

Cast 16/WIND 38. Cast OK, to 10m from bottom.

(b) Salinometer calibration data

A Guildline Portasal was used to calibrate the CTD salinities (data in table 4). One point is clearly in error and has been ignored (Cast 07, bottle 8, salinometer error). Linear regressions of ΔS_n on S_n shows very weak negative trends: $\Delta S_2 = -0.00227 - 4.9 \times 10^{-5} S_2$, $r^2 = 0.046$, n= 43, which is not significant even at 90%. (**$\Delta S_n = S_{Nctd} - S_{salinom}$**, where n=1 for the primary and n=2 for the secondary sensor). The mean of ΔS_1 is –0.0066, and that for ΔS_2 is –0.0034 with a s.d. of 0.0030 in each case. The secondary sensor gives the smaller deviation and the regression equation could be used, but alternatively and preferably a simple **mean correction of +0.0034 should be added to the secondary S value**

TABLE 4. SALINITY CALIBRATION DATA

Cast	Bottle	Month	Day	Year	Pri Sal	Sec Sal	Bottle	Salinometer	Pri-Salin	Sec-Salin
2	5	Jul	13	2001	35.4347	34.7364	25	34.735	0.6997	0.0014
	6	Jul	13	2001	35.3919	34.7362	26	34.736	0.6559	0.0002
	7	Jul	13	2001	35.4504	34.7643	27	34.77	0.6804	-0.0057
	9	Jul	13	2001	35.0924	34.3841	28	34.384	0.7084	1E-04
3	2	Jul	14	2001	34.7766	34.7076	29	34.706	0.0706	0.0016
	6	Jul	14	2001	34.6829	34.6156	31	34.616	0.0669	-0.0004
	7	Jul	14	2001	34.4631	34.3972	32	34.398	0.0651	-0.0008
4	1	Jul	17	2001	34.7397	34.7437	33	34.743	-0.0033	0.0007
	2	Jul	17	2001	34.7666	34.7703	34	34.77	-0.0034	0.0003
	3	Jul	17	2001	34.7665	34.7703	35	34.78	-0.0135	-0.0097
	5	Jul	17	2001	34.4343	34.4378	36	34.438	-0.0037	-0.0002
5	1	Jul	19	2001	34.705	34.709	37	34.708	-0.003	0.001
	4	Jul	19	2001	34.7209	34.7245	38	34.724	-0.0031	0.0005
	6	Jul	19	2001	34.4373	34.4402	39	34.44	-0.0027	0.0002
	9	Jul	19	2001	35.6821	35.6864	40	35.694	-0.0119	-0.0076
6	1	Jul	21	2001	35.6878	35.69	27	35.691	-0.0032	-0.001
	7	Jul	21	2001	35.308	35.3096	25	35.312	-0.004	-0.0024
	8	Jul	21	2001	35.3077	35.3093	26	35.312	-0.0043	-0.0027
7	5	Jul	22	2001	34.7115	34.7157	28	34.716	-0.0045	-0.0003
	6	Jul	22	2001	34.7115	34.7156	29	34.715	-0.0035	0.0006
	8	Jul	22	2001	34.6823	34.6853	31	34.524	0.1583	0.1613
8	1	Jul	23	2001	34.7072	34.7113	34	34.711	-0.0038	0.0003
	10	Jul	23	2001	35.2943	35.298	33	35.304	-0.0097	-0.006
	12	Jul	23	2001	35.3062	35.3087	32	35.311	-0.0048	-0.0023
9	2	Jul	26	2001	34.7117	34.7126	35	34.72	-0.0083	-0.0074
	4	Jul	26	2001	34.733	34.7336	36	34.741	-0.008	-0.0074
	6	Jul	26	2001	34.6334	34.6337	37	34.637	-0.0036	-0.0033
	8	Jul	26	2001	35.2207	35.2256	38	35.236	-0.0153	-0.0104
	10	Jul	26	2001	35.2022	35.2042	39	35.211	-0.0088	-0.0068
10	3	Jul	27	2001	34.7385	34.7403	42	34.746	-0.0075	-0.0057
	5	Jul	27	2001	34.5852	34.5864	40	34.59	-0.0048	-0.0036
	12	Jul	27	2001	35.2571	35.2576	43	35.263	-0.0059	-0.0054
11	2	Jul	30	2001	34.7277	34.7306	27	34.733	-0.0053	-0.0024
	7	Jul	30	2001	34.8224	34.8246	26	34.828	-0.0056	-0.0034
	10	Jul	30	2001	35.2213	35.2244	25	35.232	-0.0107	-0.0076
12	1	Jul	30	2001	34.7064	34.7101	28	34.711	-0.0046	-0.0009
	6	Jul	30	2001	34.7159	34.7186	29	34.721	-0.0051	-0.0024

	12	Jul	30	2001	35.5089	35.5128	31	35.518	-0.0091	-0.0052
13	12	Aug	5	2001	34.7186	34.7209	32	34.724	-0.0054	-0.0031
	4	Aug	4	2001	34.7323	34.7349	33	34.738	-0.0057	-0.0031
	6	Aug	5	2001	34.77	34.7727	34	34.777	-0.007	-0.0043
	11	Aug	5	2001	35.13	35.1331	35	35.138	-0.008	-0.0049
14	1	Aug	7	2001	34.7109	34.7156	36	34.722	-0.0111	-0.0064
	6	Aug	7	2001	34.7024	34.7059	37	34.709	-0.0066	-0.0031
	12	Aug	7	2001	34.974	34.9771	38	34.982	-0.008	-0.0049
15	8	Aug	8	2001	34.6862	34.6902	39	34.693	-0.0068	-0.0028
	9	Aug	8	2001	34.6935	34.6976	40	34.701	-0.0075	-0.0034
	12	Aug	8	2001	35.4305	35.4385	42	35.437	-0.0065	0.0015
16	1	Aug	9	2001	34.7257	34.7305	43	34.733	-0.0073	-0.0025
	6	Aug	9	2001	34.6512	34.6556	44	34.659	-0.0078	-0.0034
	12	Aug	9	2001	34.7669	34.7712	45	34.776	-0.0091	-0.0048

Pri Sal and Sec sal refer to the primary and secondary conductivity sensors.

INMcC, TE

(c) Transmissometer, Nephelometer and Fluorometer

Transmissometer. The instrument employed was from SeaTech with path-length l = 20 cm. (This differs from the familiar 25 cm path length SeaTech instruments.) The attenuation coefficient c is given by $I_l = I_o\, e^{-cl}$ where I is light beam intensity. Transmission is I_l/I_o, generally expressed as a percentage (%T), and 0-100 % is linearly proportional to instrument output on a 0-5 V DC scale. It uses a 660 nm wavelength LED red light source. The calibrated output voltage V_c, which must be < 4.655 V (corresponding to c = 0.358, the lowest reported value for particle–free seawater), is given by the following equation for low-gain (low resolution) operation:

$$\mathbf{V_c = (V_a/V_b)\ .\ K\ .\ (V_x.V_z)}$$

in which K is the water calibration constant, V_a is factory measured transmission voltage in air, V_b is shipboard measured in air, V_x is data output and V_z is offset voltage measured with the light path blocked. %T = V_c/5. For high-gain operation the full scale is equivalent to 80-100 % of the range; the scale is multiplied by five and the zero is offset to 80%. For this range %T is given by:

$$\mathbf{\%T = A\ .\ V_e + B}$$

in which V_e is the measured expanded-scale voltage, and the slope (A) and offset (B) values are obtained from offset value $\%T_{os}$, (here V_{os} is voltage in low gain mode with an attenuator in the light path and $V_{e\text{-}os}$ is the same but in high gain mode):

$$\%T_{os} = 20(V_a/V_b)\ .\ K\ .\ (V_{os} - V_z);\quad A = (\%T_{air} - \%T_{os})/(V_{e\text{-}air} - V_{e\text{-}os}),\ \text{and}\ \ B = \%T_{os} - (A.\ V_{e\text{-}os})$$

Manufacturer's values:
Unit 1018D: K = 0.9996, V_a = 4.669 V, V_z = 0.002 V.
Unit 1011D: K = 1.010, V_a = 4.670 V, V_z = 0.000 V.

At least half the transmissometer data from this cruise are unlikely to be useful (casts 1-8). This is because it was not realised that the new instrument had two gain settings of which only the high gain (HG) is suitable for the turbidity values encountered in the deep sea. This instrument should **always** be used on high gain in the deep sea. The first 8 casts were on LG. Once this was resolved, the benchmark of clear water minimum attenuation coefficient was reasonably consistent, but values appear to be too high by 0.010 to 0.020 m^{-1}.

Light Scattering. The Seatech Light Back-Scattering Sensor (LSS) unit no. 338, was mounted on the CTD frame. This also has a 0-5 V DC readout which, at least at the very low concentrations encountered in the deep sea, is linear. This behaved well and, given the low concentrations, is likely to be more use than the transmissometer. It was operated throughout the cruise on the low gain setting. Although it displays greater sensitivity than the transmissometer even with the latter on high gain, it is recommended that the LSS should also **always** be used on high gain in the deep sea.

Fluorometer. A Chelsea Instruments Aquatraka Mk III (no. 088195) was also part of the CTD instrument suite. This yields chlorophyll-a concentration C_{chl} in mg m^{-3} from output voltage V as: $C_{chl} = 0.0108. 10^{V} – 0.018$.

Transmissometer Deck Calibrations

Deck calibrations were carried before every cast and afterwards when possible. The following tables detail these calibrations. These figures were used to calculate beam attenuation coefficient.

TABLE 5: TRANSMISSOMETER CALIBRATION DATA

Casts 1-8 inclusive used T1018D on low gain.

Cast Number	Vb (v) before	Vb (v) after	Vz Volts	CW min* (m^{-1}) Atten. coefft
1	4.407	N/a	0.00	0.304
2	4.404	4.402	0.00	0.294
3	4.408	4.397	0.00	0.294
4	4.394	4.392	0.00	0.296
5	4.392	4.393	0.00	0.294
6	4.393	4.391	0.00	shallow cast
7	4.392	4.388	0.00	0.306
8	4.392	4.388	0.00	0.320

*All these values for casts 1-8 are physically impossible (min. should be ~ 0.36)

Cast 9, T1018D was High Gain and T1011D was Low Gain. T1018D values were used in the beam attenuation calculations.

Cast 9	Vb (v) before	Vb (v) after	Vz (v)	CW min (m^{-1}) Atten. coefft
T1011D/LG	4.763	4.770		0.402

Cast 9		Ve-air	Ve-os	Vos	Vb	Vz	CW min*(m^{-1}) Atten. Coefft
T1018D/HG	Before	2.210	0.200	3.99	4.403	0.00	0.402

Cast 10 onwards, T1011D was used set at high gain, these figures being used to calculate the beam attenuation.

Cast 10	Before	4.131	0.040	3.917	4.761	0.00	0.397
T1011D	After	4.082	0.060	3.903	4.755	0.00	
Cast 11	Before	4.112	0.004	3.916	4.761	0.00	0.394
T1011D	After	4.115	0.040	3.918	4.759	0.00	
Cast 12	Before	4.123	0.035	3.915	4.762	0.00	0.387
T1011D	After	4.126	0.023	3.915	4.761	0.00	
Cast 13	Before	4.120	0.091	3.938	4.741	0.00	0.388
T1011D	After	N/a	N/a	N/a	N/a	N/a	
Cast 14	Before	4.339^{+}	0.070	3.918	4.795	0.00	0.443^{+}
T1011D	After	N/a	N/a	N/a	N/a	N/a	
Cast 15	Before	4.085	0.072	3.919	4.748	0.00	0.392
T1011D	After	N/a	N/a	N/a	N/a	N/a	
Cast 16	Before	4.109	0.032	3.915	4.759	0.000	0.393
T1011D	After	4.109	0.082	3.926	4.756	0.000	

$^{+}$ Clearly incorrect value, probably due to (unlikely) 4.339 predeployment voltage. In fact all the clear water minima, although consistent from cast 9 onward, are probably too high.

(d) Filtration for Particulate Matter Concentration and Thorium-Protactinium

Filtration for PMC. Water samples were collected for the gravimetric determination of the particulate matter concentration (PMC) in layers of high optical turbidity and intervening clear waters at a total of 25 depths and 12 CTD stations.

The samples were collected using 10 litre Niskin bottles fired in pairs within clear water layers and individually in intervals of high PMC. Shipboard filtration was accomplished using filters in an in-line filter holder under vacuum. Filter handling and loading was under clean conditions using individually pre-weighed (to 10^{-6} g) 0.4 µm pore-size, polycarbonate (Cyclopore) membranes. The filters were rinsed with 8 washes of Milli-Q water to remove sea salt, air dried and stored in polystyrene petri dishes for shore based laboratory analysis. All critical handling steps were undertaken in a Class-100 laminar flow hood in the ship's clean chemistry container.

The loaded membranes will be reweighed in Cambridge and employed to attempt a calibration of the transmissometer data to PMC. The analytical blank will be determined from a total of 15 membranes subjected to identical handling procedures but no sample filtration.

Th-Pa. Samples of 8-10 l for thorium and protactinium analysis were transferred directly into pre-cleaned cubitainers. Screw cap lids were sealed with parafilm. Two sampleswere filtered as described in section (c) in order to assess the particulate to dissolved proportions.

GGB, LFR

(e) O&C isotopes and other chemicals in water samples

The CTD/rosette was operated on 14 stations, in most cases collecting water samples from all twelve 10-litre Niskin bottles.

Details of the sampling carried out are given in Table 7 together with data on sample depths, dissolved oxygen, temperature, salinity and density recorded by the CTD sensors at the depths at which the bottles were fired. The Niskins were subsampled for up to seven different samples types: $\delta^{18}O$, $\delta^{13}C$, Mg, Si, Sr/Ca, Th-Pa and nephelometry.

Oxygen and carbon isotopes

Samples of 10 ml for $\delta^{18}O$ were stored in glass bottles with screw caps and sealed with parafilm to minimise evaporative loss. Samples for $\delta^{13}C$ were filtered through 0.4 µm Nuclepore filters into glass ampules containing 10 µl of a saturated solution of mercuric chloride and the ampules sealed with a blow torch.

Mg

Samples of 20 ml for Mg analysis were filtered through 0.4 µm Nuclepore filters into glass bottles with screw caps.

Si

Samples of 125 ml to 1 L for DSi (dissolved Si) and $\delta^{30}Si$ analysis were filtered through 0.6 µm polycarbonate filters (Millipore) into acid-cleaned plastic bottles. Filters were folded, dried in air, and stored for analysis of BSi and LSi (biogenic and lithogenic Si) if the interest arises. Preliminary results show that bottom DSi is around 130 µmol, indicative of an Antarctic source.

Sr/Ca

Water samples of 2-5 l collected from depths across the euphotic zone were filtered through 0.2 µm polycarbonate nuclepore filters. The filters were transferred into 1.5 ml micro-centrifuge tubes and allowed to dry in a laminar flow hood before sealing. The particles collected will be analysed for Sr/Ca. 15 ml of the filtrate were decanted from the collection carboys into polypropylene bottles for subsequent Sr/Ca analysis.

HE, SB, CDLR, FMIH, PJ

TABLE 7 : WATER SAMPLING LOG

BOTTLE NO	DEPTH	pH	$\delta^{18}O$	$\delta^{13}C$	Mg	Si	Sr / Ca	Th-Pa	Neph
Date	13/7/01				Yc	= 5 l of each sample combined			
Station	WIND 3				Yf	= filtered			
Cast	2								
Lat	32.39.05								
Long	48.28.16								
Water Depth (m)	3728								
1	Practice firing								
2	3753		Y	Y	Y	Y		Yf	Y
3	Practice firing								
4	3753		Y	Y	Y	Y			
5	3250		Y	Y	Y	Y		Yf	Y
6	3250		Y	Y	Y	Y			Y
7	2750		Y	Y	Y	Y		Y	
8	1700		Y	Y	Y	Y		Y	
9	1200		Y	Y	Y	Y		Y	
10	450		Y	Y	Y	Y		Y	
11	150		Y	Y	Y	Y	Y	Yc	
12	100		Y	Y	Y	Y	Y	Yc	

Date	14/7/01								
Station	WIND 4								
Cast	3								
Lat	31.18.75								
Long	48.29.97								
Water Depth (m)	4562								
1	4555		Y	Y	Y				Y
2	4400		Y	Y	Y			Y	
3	3500		Y	Y	Y				Y
4	3500		Y	Y	Y				Y
5	2700		Y	Y	Y				
6	1700		Y	Y	Y				
7	1200		Y	Y	Y			Y	
8	450		Y	Y	Y				
9	125		Y	Y	Y			Y	
10	100	7.7	Y	Y	Y		Y		
11	50	7.9	Y	Y	Y		Y		
12	25	8.0	Y	Y	Y	Y	Y		

Date	16/7/01
Station	WIND 9
Cast	4
Lat	29.24.27
Long	47.22.25

Water Depth (m)	3334							
1	3333	Y	Y	Y				Y
2	2700	Y	Y	Y				Y
3	2700	Y	Y	Y				Y
4	1750	Y	Y	Y			Y	
5	1200	Y	Y	Y			Y	
6	750	Y	Y	Y			Y	
7	500	Y	Y	Y			Y	
8	250	Y	Y	Y			Y	
9	100	Y	Y	Y		Y	Y	
10	75	Y	Y	Y				
11	50	Y	Y	Y		Y		
12	25	Y	Y	Y	Y	Y		

Date	19/7/01
Station	WIND 12
Cast	5
Lat	25.50.53
Long	47.55.17

Water Depth (m)	4186							
1	4232	Y	Y	Y				Y
2	4000	Y	Y	Y			Y	
3	3600	Y	Y	Y				Y

4	3600		Y	Y	Y			Y
5	2700		Y	Y	Y		Y	
6	1100		Y	Y	Y		Y	
7	650		Y	Y	Y		Y	
8	500		Y	Y	Y			Y
9	170	8.0	Y	Y	Y		Y	
10	100	8.2	Y	Y	Y	Y		
11	50	8.2	Y	Y	Y	Y	Yc	
12	25	8.3	Y	Y	Y	Y	Yc	

Date 21/7/01

Station WIND 14

Cast 6

Lat 19.58.62

Long 50.48.79

Water Depth 4887 (m)

1	150					Y		
2	125					Y		
3	100					Y		
4	75					Y		
5	60					Y		
6	30					Y		
7	13					Y		
8	5					Y		

9						
10						
11						
12						

Date 22/7/01

Station WIND 15

Cast 7

Lat 20.00.01

Long 50.19.93

Water Depth (m) 4629

1	4677	Y	Y	Y		Y
2	4400	Y	Y	Y	Y	
3	4000	Y	Y	Y		Y
4	4000	Y	Y	Y		Y
5	2500	Y	Y	Y	Y	
6	1750	Y	Y	Y	Y	
7	1250	Y	Y	Y	Y	
8	900	Y	Y	Y	Y	
9	500	Y	Y	Y	Y	
10	178	Y	Y	Y	Y	
11						
12						

Date	23/7/01						
Station	WIND 17						
Cast	8						
Lat	19.59.16						
Long	49.47.08						
Water Depth (m)	3986						
1	4022		Y	Y	Y		Y
2	3750		Y	Y	Y		Y
3	3750		Y	Y	Y		Y
4	2500		Y	Y	Y		
5	1700		Y	Y	Y		
6	1200		Y	Y	Y		
7	785		Y	Y	Y		
8	500		Y	Y	Y		
9	200	8.3	Y	Y	Y		
10	100	8.4	Y	Y	Y	NB	
11	75	8.3	Y	Y	Y		
12	25	8.3	Y	Y	Y		

Date	26/7/01
Station	WIND 22
Cast	9

Lat	13.35.77					
Long	51.11.92					
Water Depth (m)	3845					
1	3875	Y	Y	Y		Y
2	3700	Y	Y	Y		
3	3000	Y	Y	Y		
4	3000	Y	Y	Y		Y
5	2000	Y	Y	Y		Y
6	750	Y	Y	Y		
7	550	Y	Y	Y		
8	300	Y	Y	Y		
9	200	Y	Y	Y		
10	100	Y	Y	Y	Y	
11	50	Y	Y	Y	Y	
12	25	Y	Y	Y	Y	

Date	27/7/01
Station	WIND 24
Cast	10
Lat	13.04.33
Long	51.19.33
Water Depth (m)	4157

1	4183		Y	Y	Y		
2	3400		Y	Y	Y		
3	2500		Y	Y	Y		
4	1000		Y	Y	Y		
5*	650		Y	Y	Y	*loose cap-may be contaminated	
6	250		Y	Y	Y		
7	150		Y	Y	Y		Y
8	100		Y	Y	Y		Y
9	75	8.4	Y	Y	Y		Y
10	50	8.3	Y	Y	Y		Y
11	25	8.3	Y	Y	Y		Y
12	10	8.3	Y	Y	Y		Y

Date 30/7/01

Station WIND 27

Cast 11

Lat 10.11.59

Long 52.08.15

Water Depth (m) 4202

1	4249		Y	Y	Y
2	3500		Y	Y	Y
3	2500		Y	Y	Y
4	2000		Y	Y	Y
5	1450		Y	Y	Y

6	1000	Y	Y	Y			
7	900	Y	Y	Y			
8	650	Y	Y	Y			
9	250	Y	Y	Y			
10	100	Y	Y	Y			
11	50	Y	Y	Y			
12	10	Y	Y	Y	NB		

Date	30/7/01						
Station	WIND 28						
Cast	12						
Lat	10.09.85						
Long	51.45.74						
Water Depth (m)	4137						
1	4181	Y	Y	Y			Y
2	4000	Y	Y	Y		Y	
3	3000	Y	Y	Y			Y
4	3000	Y	Y	Y			Y
5	2000	Y	Y	Y		Y	
6	1400	Y	Y	Y		Y	
7	900	Y	Y	Y		Y	
8	300	Y	Y	Y		y	
9	100	Y	Y	Y		y	
10	75	Y	Y	Y	Y		

11	50		Y	Y	Y	Y		
12	25		Y	Y	Y	Y		

Date	4/8/01							
Station	WIND 32							
Cast	13							
Lat	11.15.35							
Long	58.10.78							
Water Depth (m)	4138							
1	4189		Y	Y	Y			Y
2	4000		Y	Y	Y		Y	
3	2750		Y	Y	Y			Y
4	2750		Y	Y	Y			Y
5	1800		Y	Y	Y		Y	
6	950		Y	Y	Y		Y	
7	600		Y	Y	Y		Y	
8	350		Y	Y	Y			
9	123	8.1	Y	Y	Y		Y	
10	75	8.3	Y	Y	Y	Y		
11	50	8.4	Y	Y	Y	Y		
12	25	8.4	Y	Y	Y	Y		

Date	7/8/01							
Station	WIND 34							
Cast	14							
Lat	16.28.38							
Long	57.49.08							
Water Depth (m)	4114							
1	4160		Y	Y	Y			Y
2	3950		Y	Y	Y		Y	
3	3200		Y	Y	Y			Y
4	3200		Y	Y	Y			Y
5	2600		Y	Y	Y		Y	
6	1050		Y	Y	Y			
7	650		Y	Y	Y			
8	450		Y	Y	Y			
9	100	8.3	Y	Y	Y		Y	
10	75	8.3	Y	Y	Y	Y		
11	50	8.3	Y	Y	Y	Y		
12	25	7.9?	Y	Y	Y	Y		

Date	8/8/01
Station	WIND 36
Cast	15
Lat	16.25.59
Long	58.12.47

Water Depth (m)	3846			
1	3878	Y	Y	Y
2	3550	Y	Y	Y
3	3000*			
4	2750	Y	Y	Y
5	2250	Y	Y	Y
6	2000	Y	Y	Y
7	1750	Y	Y	Y
8	1500	Y	Y	Y
9	1200	Y	Y	Y
10	900	Y	Y	Y
11	300	Y	Y	Y
12	150	Y	Y	Y

Date	9/8/01
Station	WIND 38
Cast	15
Lat	16.15.48
Long	58.18.42
Water Depth (m)	
1	3230
2	2856
3	2400
4	1600

5	1400
6	750
7	550
8	400
9	200
10	125
11	35
12	15

Plankton Tows

Live planktonic foraminifera were collected at various depths between 25-100 m by towing a nylon net (1-m diameter opening, 180 μm mesh) with a close-open-close mechanism such that the net was only open at depth, but not during ascent or descent. Samples were collected at or close to stations where mixed layer pH was measured (using a hand held pH meter) from water sampled by the CTD rosette, and were obtained with the ship moving forward at 0.5 knots.

Foraminifera were picked from the tows as soon as possible (most within the first 8 h and none after 24 h) and set aside for isotopic ($\delta^{11}B$, $\delta^{44}Ca$, $\delta^{13}C$, $\delta^{18}O$), genetic, and/or trace element (Sr/Ca, Mg/Ca) analyses. Foraminifera for isotopic and trace element analysis were dried in air at room temperature in a laminar flow hood. Foraminifera for genetic analysis were preliminarily identified and placed in Tris buffer. Samples for $\delta^{44}Ca$ and $\delta^{11}B$ analysis are held by C. De La Rocha (Cambridge). Samples for trace element and $\delta^{18}O$ and $\delta^{13}C$ analysis are held by R. Rickaby (Oxford after January 2002). Samples for genetic analysis are held by C. Vargas (Harvard).

CDLR

PLANKTON TOW LOG

Date	Station	Tow	Line Out[a]	Starting Position	Start Time[b]	Duration	pH [c]	Comments
14/7/01	WIND 4	4A	25 m	31º18.4545 S 48º30.0774 E	08:55	15 min	8.03	Forams found in all tows.
		4B	50 m	31º18.41 S 48º29.97 E	09:30	15 min	7.91	Most abundant in A.
		4C	100 m	31º18.3482 S 48º29.7724 E	10:05	15 min	7.68	
18/7/01	WIND 11	11A	25 m	28º31.34 S 48º10.92 E	01:36 (22:36 UTC)	15 min	-	Tow A botched-garbage in net. Remainder of Sta 11 tows OK.
		11B	25 m	28º31.43 S 48º11.14 E	02:05 (23:05 UTC)	15 min	-	Predominant species: *G. menardii, G. truncatulinoides, G. inflata*
		11C	75 m	28º31.55 S 48º11.55 E	02:40 (23:40 UTC)	22 min	-	Sometimes *G. truncatulinoides* is pink, sometimes brown/green
		11D	100 m	28º31.65 S 48º11.82 E	03:20 (00:20 UTC)	25 min	-	*G. menardii* at 100 m full of symbionts. At 75 m smaller, not so full of symbionts.

19/7/01	WIND 12	12A	100 m	25º50.84 S 47º55.00 E	10:42 UTC	30 min	8.18	No plankton in either tow.
		12B	25 m	25º50.41 S 47º55.00 E	11:51 UTC	20 min	8.25	Net hanging up on itself (too much swell?)
22/7/01	WIND 14	14A	30 m	19º58.62 S 50º48.76 E	23:36	20 min	8.33	A modest amount of forams in these tows.
		14B	60 m	19º58.62 S 50º48.85 E	00:14	25 min	8.33	Most forams in B (fluorescence max and base of mixed layer)
		14C	100 m	19º58.40 S 50º49.28 E	01:01	30 min	8.33	
23/7/01	WIND 17	17A	25 m	20º00.09 S 49º46.96 E	11:21 UTC	20 min	8.28	Not a resoundingly successful two tows
		17B	75 m	20º00.15 S 49º46.88 E	11:56 UTC	30 min	8.29	
28/7/01	WIND 24	24A	25 m	13º04.71 S 51º18.75 E	01:31 (22:31 UTC)	30 min	8.33	
		24B	75 m	13º05.07 S 51º19.01 E	02:23 (23:23 UTC)	30 min	8.35	
		24C	50 m	13º05.30 S 51º19.38 E	03:09 (00:09 UTC)	25 min	8.32	
4/8/01	WIND 32	32A	75 m	11º14.92 S 58º11.24 E	00:56 UTC	30 min	8.33	Net open on ascent (broken messenger)
		32B	bet. 25-40 m	11º15.02 S 58º11.73 E	01:48 UTC	30 min	8.42	Excellent tow (full of zooplankton)
		32C	50 m	11º15.05 S 58º12.36 E	-	20 min	8.42	
7/8/01	WIND 34	34A	25 m	16º28.41 S 57º48.96 E	08:51 UTC	30 min	7.98	No forams found at this depth
		34B	50 m	16º28.67 S 57º49.15 E	09:35 UTC	30 min	8.27	
		34C	75 m	16º29.00 S 57º49.36 E	10:23 UTC	30 min	8.27	

8/9/01 ?	WIND 37	37A	75 m	16º25.04 S 59º09.19 E	21:46 (17:46 UTC)	30 min	-
		37B	50 m	16º24.88 S 59º09.12 E	22:42 (18:42 UTC)	30 min	-
		37C	25 m	16º24.94 S 59º09.51 E	23:38 (19:38 UTC)	30 min	-

a. refers to length of wire between the open end of the net and surface of water; wire angle not estimated
b. local time (unless noted otherwise)
c. measured on water from CTD rosette

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CD 129 STATION LOG

Station No.	Activity No.	Day	Date	Time (Z)	Latitude (S)	Longitude (E)	Depth (PDR)	Remarks
WIND-1	WIND-1B	189	8/7	16.30	35° 07.31'	35° 32.15'	4156	4196 wire
	CTD 01	189	8/7	19.50	35° 07.35'	35° 32.14'	4158	no bottles; fuse blown
WIND-2	WIND-2B/A	192	11/7	08.38	33° 38.99'	44° 21.01'	978	mostly washed out; sand
	WIND-2B/B	192	11/7	09.39	33° 38.82'	44° 21.10'	976	ditto; one bag of each
WIND-3	WIND-3B	194	13/7	11.40	32° 38.65'	48° 29.64'	3731	3752 wire; scrape, much washed out
	ARGO#359	194	13/7	13.28	32° 38.84'	48° 29.06'	-	ARGO reset time 13.16
	CTD 02	194	13/7	16.53	32° 39.02'	48° 28.22'	3728	
WIND-4	WIND-4B	195	14/7	07.26	31° 18.72'	48° 30.07'	4570	full, part eroded
	WIND-4K	195	14/7	11.00	31° 18.63'	48° 30.08'	4567	7 m barrel, 6.13 m core
	CTD 03	195	14/7	15.31	31° 18.76'	48° 30.11'	4556	no pinger signal, poss. 50 mab (poss. 20)
	NET 1	195	14/7	17.55	31° 18.45'	48° 30.08'	-	25 m, 15 min
	NET 2	195	14/7	18.30	31° 18.41'	48° 29.97'	-	50 m, 15 min
	NET 3	195	14/7	19.05	31° 18.35'	48° 29.77'	-	100 m, 15 min
	ARGO#358	195	15/7	02.41	31° 31.93'	47° 41.03'	-	float reset @ 01.52
WIND-5	WIND 5B	196	15/7	06.26	31° 34.14'	47° 34.15'	3684	mistake, ran in @ 50 m/min
	WIND 5K	196	15/7	10.30	31° 34.34'	47° 33.47'	3682	

Station No.	Activity No.	Day	Date	Time (Z)	Latitude (S)	Longitude (E)	Depth (corr m)	Remarks
WIND 6	WIND 6B	196	15/7	15.42	31° 16.40'	47° 33.86'	4150	
	ARGO#357	196	15/7	22.25	30° 41.77'	46° 49.10'		reset at 22.15
WIND 7	WIND 7B	197	16/7	04.32	30° 17.18'	46° 17.94'	1904	severely washed-out
WIND 8	WIND 8B	197	16/7	09.43	29° 59.41'	45° 57.73'	1070	hardground! Few shells
WIND 9	CTD 04	197	16/7	23.43	29° 24.27'	47° 22.25'	3333	
WIND 10	WIND 10B	198	17/7	07.06	29° 07.49'	47° 32.94'	2871	
	WIND 10K	198	17/7	11.41	29° 07.50'	47° 33.57'	2848	second try, bent doors
WIND 11	WIND 11B	198	17/7	20.11	28° 31.72'	48° 10.97'	2382	v. sandy, only 17 cm
	NET A	198	17/7	22.35	28° 31.34'	48° 10.92'	-	25 m cable; NBG, contamination
	NET B	198	17/7	23.01	28° 31.43'	48° 11.14'	-	25 m cable, 15 min
	NET C	198	17/7	23.35	28° 31.55'	48° 11.55'	-	75 m cable, 22 min
	NET D	199	18/7	00.20	28° 31.65'	48° 11.82'	-	100 m cable, 25 min
	WIND 11 P & PG	199	18/7	07.50	28° 31.96'	48° 11.17'	2422	2 barrel, 6 m, only 2.28 m core
WIND 12	CTD 05	200	19/7	08.30	25° 50.44'	47° 55.18'	4184	prob. bottom @ 15 mab
	NET A	200	19/7	10.42	25° 50.84'	47° 55.41'	-	100 m cable, tangled, empty, 30 min
	NET B	200	19/7	11.51	25° 50.41'	47° 55.00'	-	25 m cable, 25 min
	WIND 12B	200	19/7	14.23	25° 50.79'	47° 55.37'	4196	good, full, 39 cm
	WIND 12K	200	19/7	17.52	25° 50.77'	47° 55.33'	4192	broke barrel, 1.59 m sand
WIND 13	WIND 13B	201	20/7	16.02	23° 56.32'	48° 59.91'	4065	some surface debris; 36 cm
	WIND 13K	201	20/7	18.55	23° 56.31'	48° 59.85'	4060	broke barrel, sand, 1.16 m

Station No.	Activity No.	Day	Date	Time (Z)	Latitude (S)	Longitude (E)	Depth (corr m)	Remarks
WIND 14	CTD-6	202	21/7	22.25	19° 58.62'	50° 48.79'	4832	shallow, 250 m, cast
	NET A	202	21/7	23.36	19° 58.70'	50° 48.76'	-	30 m, 20 min
	NET B	203	22/7	00.14	19° 58.62'	50° 48.76'	-	60 m, 25 min
	NET C	203	22/7	01.01	19° 58.40'	50° 49.28'	-	100 m, 30 min
	WIND 14B	203	22/7	04.07	19° 58.88'	50° 48.92'	4834	full, 46 cm
WIND 15	WIND 15B	203	22/7	11.07	19° 59.97'	50° 19.96'	4629	
	CTD-7	203	22/7	14.58	20° 00.01'	50° 19.90'	4630	10 mab, bottom contact switch
WIND 16	WIND 16B	203	22/7	22.03	19° 57.75'	49° 55.68'	4189	top door not closed, some scour, 36cm
	WIND 16K	204	23/7	00.55	19° 57.88'	49° 55.65'	4180	overpenetrated
WIND 17	WIND 17B	204	23/7	05.24	20° 00.00'	49° 47.10'	3991	41 cm
	CTD-8	204	23/7	09.25	19° 59.16'	49° 47.08'	3986	
	NET A	204	23/7	11.21	20° 00.09'	49° 46.96'	-	25 m, 20 min
	NET B	204	23/7	11.56	20° 00.15'	49° 46.88'	-	75 m, 30 min
WIND 18	WIND 18B	204	23/7	16.22	20° 00.00'	49° 29.92'	3319	31 cm, half washed out
WIND 19	WIND 19B	204	23/7	19.59	20° 00.01'	49° 21.75'	2697	44 cm
WIND 20	WIND 20B	204	23/7	23.57	20° 03.64'	49° 11.42'	2274	45 cm
WIND 21	WIND 21B	206	25/7	18.56	15° 07.09'	51° 26.97'	3924	46 cm
WIND 22	WIND 22B	207	26/7	12.40	13° 36.85'	51° 11.38'	3838	36 cm
	WIND 22K	207	26/7	15.20	13° 36.56'	51° 12.29'	3853	3.68 cm
	CTD-9	207	26/7	18.50	13° 35.77'	51° 11.92'	3845	big drift due to 1 kt SEC, touched bottom
WIND 23	WIND 23B	208	27/7	04.04	13° 07.21'	51° 02.59'	4004	50 cm
	WIND 23K	208	27/7	07.29	13° 06.80'	51° 03.27'	4014	3.78 m

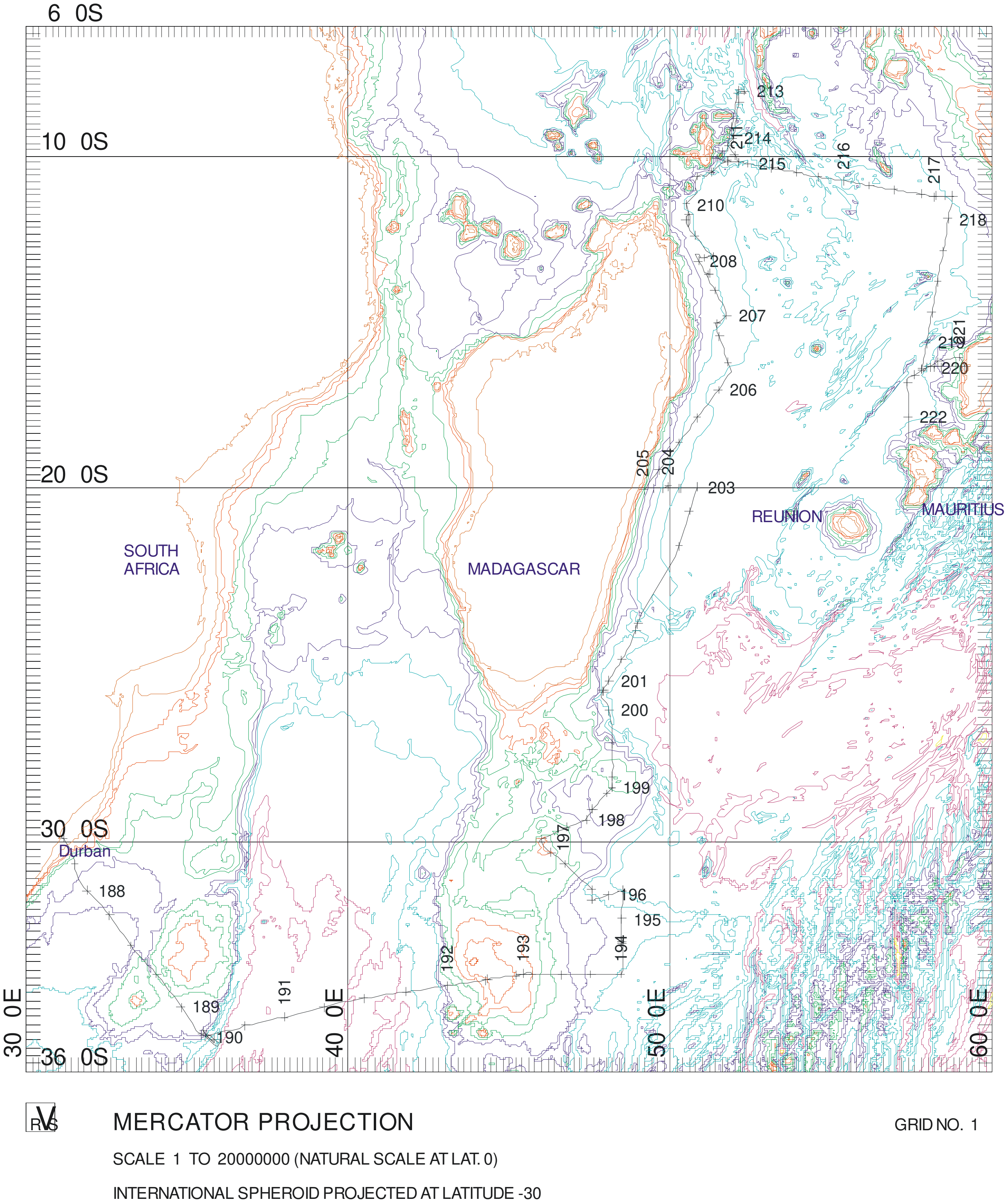
Station No.	Activity No.	Day	Date	Time (Z)	Latitude (S)	Longitude (E)	Depth (corr m)	Remarks
WIND 24	CTD-10	208	27/7	13.34	13° 04.33'	51° 19.33'	4155	
	WIND 24B	208	27/7	17.16	13° 04.45'	51° 20.01'	4163	
	WIND 24K	208	27/7	20.12	13° 04.60'	51° 20.44'	4176	6 m barrel. 5.75 m
	NET A	208	27/7	22.31	13° 04.71'	51° 18.75'	-	25 m, 30 min
	NET B	208	27/7	23.23	13° 05.08'	51° 19.01'	-	75 m, 30 min
	NET C	209	28/7	00.09	13° 05.30'	51° 19.38'	-	50 m, 25 min
WIND 25	WIND 25B	209	28/7	11.00	11° 48.14'	50° 34.43'	3935	48 cm, perfect.
	WIND 25C	209	28/7	13.52	11° 48.05'	50° 34.48'	3930	7 m barrel
WIND 26	WIND 26B	210	29/7	12.13	10° 30.24'	51° 16.04'	4093	45-49 cm, sand ripple on surface
	WIND 26K	210	29/7	15.10	10° 30.36'	51° 16.25'	4095	7 m barrel, 6.77 m
WIND 27	CTD-11	211	30/7	02.02	10° 11.59'	52° 08.15'	4202	
	WIND 27K	211	30/7	05.46	10° 11.61'	52° 07.91'	4199	7 m barrel, 6.33 m. Some mud in adaptor.
WIND 28	WIND 28B	211	30/7	11.50	10° 09.33'	51° 46.22'	4147	46 cm
	WIND 28K	211	30/7	15.00	10° 09.23'	51° 46.15'	4157	6.33 m, penetrated to top.
	CTD-12	211	30/7	19.01	10° 09.85'	51° 45.75'	4157	
WIND 29	WIND 29B	212	31/7	02.54	10° 00.91'	51° 29.30'	3057	few basalt fragments. Mn coated.
WIND 30	WIND 30B	212	31/7	20.12	07° 58.69'	52° 07.00'	3950	48 cm, sandy
	WIND 30K	213	01/8	04.57	07° 58.66'	52° 08.06'	4062	probably in a trough, sandy 6.33 m
WIND 31	WIND 31B	214	02/8	03.15	09° 40.36'	51° 47.91'	3893	45 cm
	WIND 31K	214	02/8	05.56	09° 40.71'	51° 48.75'	3867	6.78 m
WIND 32	CTD-13	216	04/8	22.19	11° 15.35'	58° 10.78'	4138	

	NET A	217	05/8	00.56	11° 14.92'	58° 11.24'	-	75 m, 30 min
	NET B	217	05/8	01.48	11° 15.02'	58° 11.73'	-	25-40 m, 30 min. Rich!
	NET C	217	05/8	02.40	11° 15.05'	58° 12.36'	-	50 m, 20 min
	WIND 32B	217	05/8	05.06	11° 14.19'	58° 13.18'	4117	44-46 cm

Station No.	**Activity No.**	**Day**	**Date**	**Time (Z)**	**Latitude (S)**	**Longitude (E)**	**Depth (corr m)**	**Remarks**
WIND 33	WIND 33B	217	05/8	15.21	11° 12.71'	58° 46.24'	3520	38 cm
	WIND 33K	217	05/8	17.44	11° 12.96'	58° 46.04'	3518	3.78 m
WIND 34	CTD-14	219	07/8	06.51	16° 28.38'	57° 49.08'	4109	
	NET A	219	07/8	08.51	16° 28.41'	57° 48.96'	-	25 m, 30 min
	NET B	219	07/8	09.50	16° 28.67'	57° 49.15'	-	50 m, 30 min (mid tow time)
	NET C	219	07/8	10.23	16° 29.00'	57° 49.36'	-	75 m, 30 min
	WIND 34B	219	07/8	13.04	16° 29.42'	57° 49.52'	4139	scrape, bagged
WIND 35	WIND 35B	219	07/8	20.15	16° 25.33'	58° 03.94'	3934	39 cm
WIND 36	CTD-15	220	08/8	05.26	16° 25.59'	58° 12.47'	3843	
WIND 37	NET A	220	08/8	21.46	16° 25.04'	59° 09.19'	~300-500	75 m, 30 min, big wire angle
	NET B	220	08/8	22.42	16° 24.88'	59° 09.12'	(just off shelf	50 m, 30 min
	NET C	220	08/8	23.38	16° 24.94'	59° 09.51'	edge)	25 m, 30 min
WIND 38	CTD-16	221	09/8	05.47	16° 15.48'	58° 18.38'	3212	bott. press. 10 mab, 3230 db
WIND 39	WIND 39B	221	09/8	14.40	16° 46.24'	57° 22.04'	4198	scrape, CO_3 sand turb.

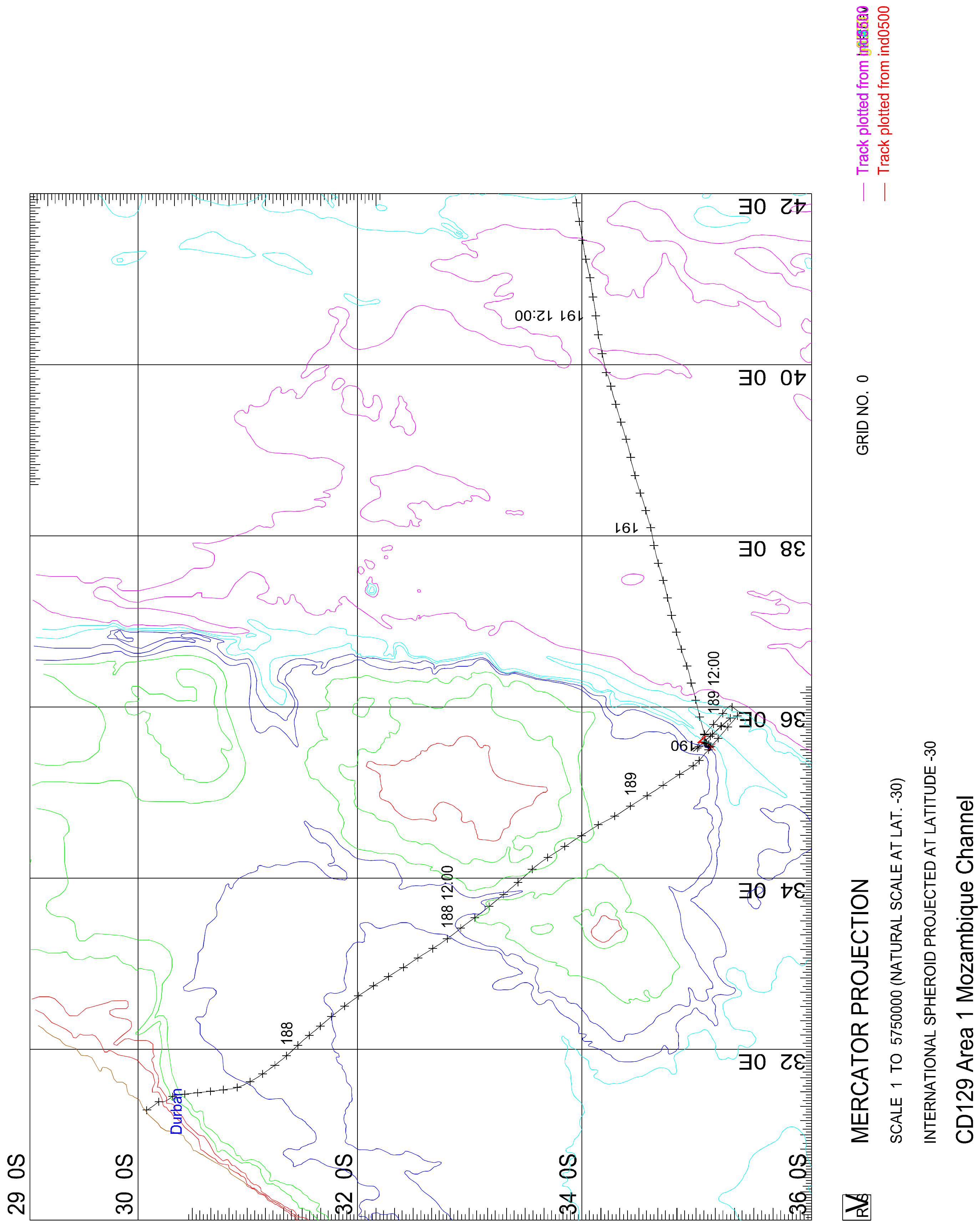
Track Charts

1. Whole cruise: Durban to Mauritius

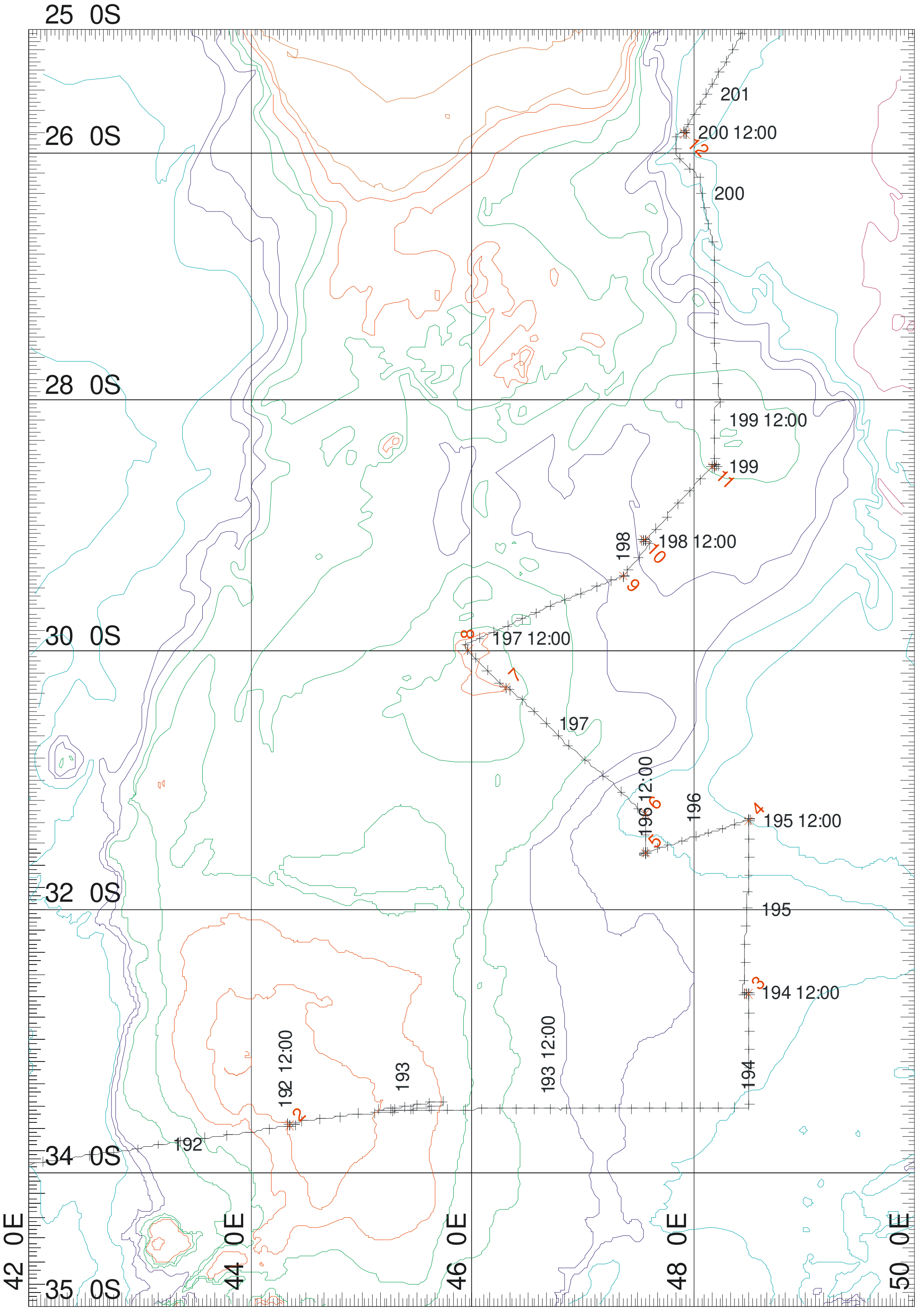


CD129 Cruise Track Chart

2. Durban to Madagascar ridge



3. Madagascar Ridge, W. Mascarene Basin



MERCATOR PROJECTION

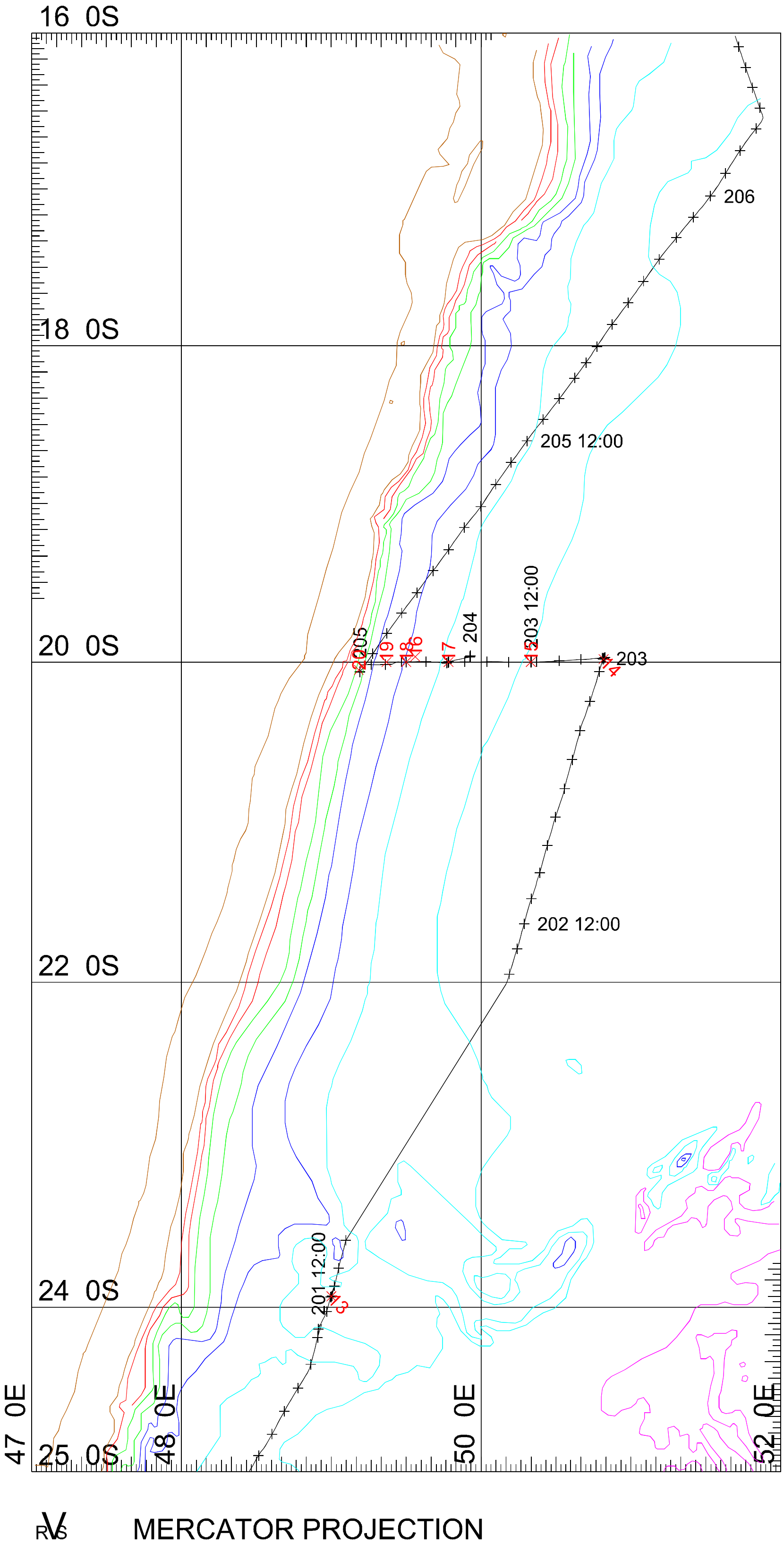
SCALE 1 TO 6500000 (NATURAL SCALE AT LAT. 0)

INTERNATIONAL SPHEROID PROJECTED AT LATITUDE -30

GRID NO. 1

CD129 Area 2 Madagascar Ridge

4. Western Madagascar Basin



MERCATOR PROJECTION

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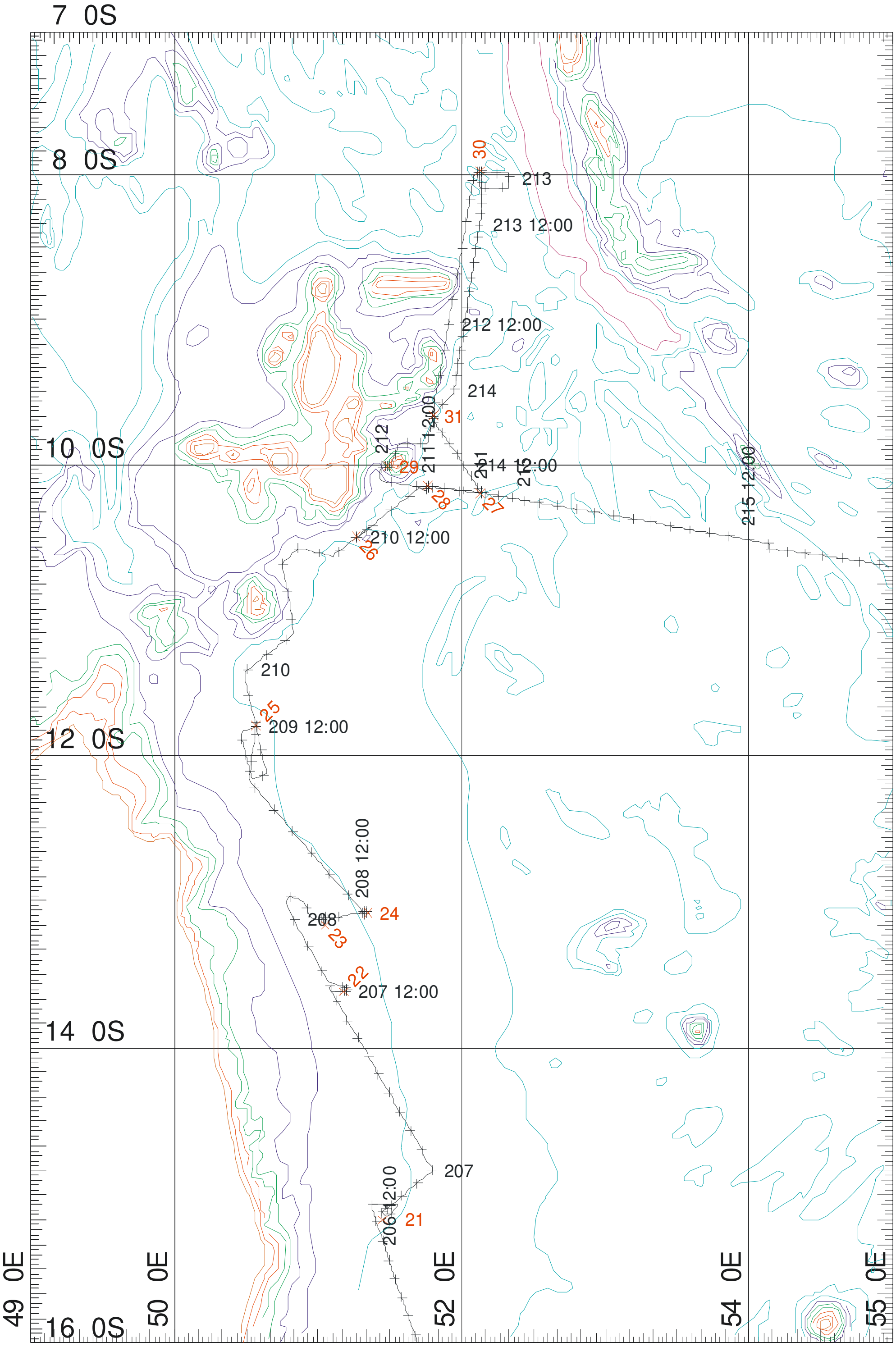
CD129 Area 3 East Madagascar

5. NW Madagascar Basin to Amirante Passage



MERCATOR PROJECTION

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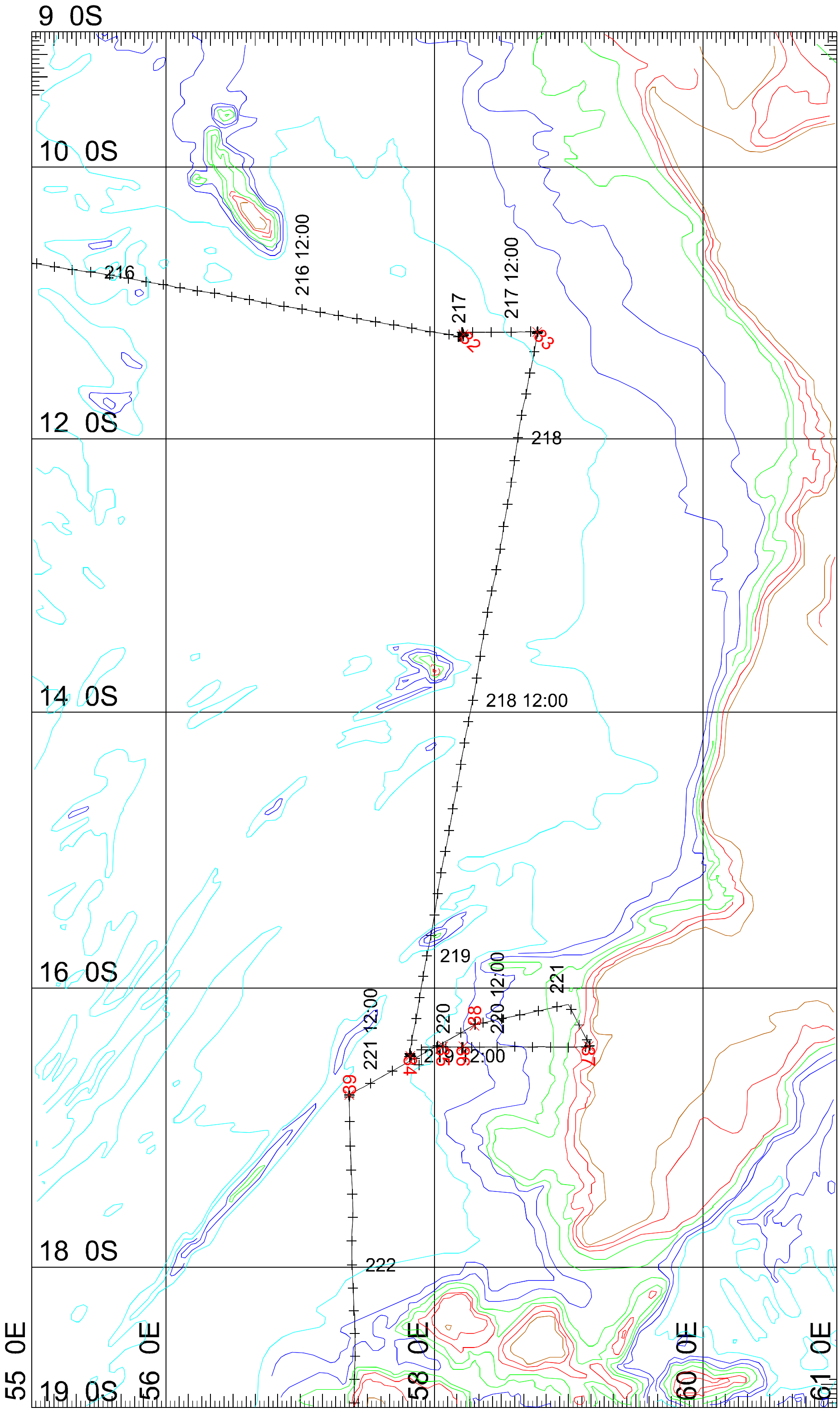
CD129 Area 4 Amirante Passage

6. SE Madagascar Basin to Mauritius



RVS MERCATOR PROJECTION

SCALE 1 TO 5500000 (NATURAL SCALE AT LAT. 0)

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GRID NO. 1

CD129 Area 5 East Mascarene Ridge